Interactions between people and carnivores in Washington State

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Abstract

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Human-wildlife interactions have become a central focus of conservation research and policy. Interactions between humans and large carnivores are especially challenging because these species typically require large landscapes, compete for prey, and may pose a threat to some livelihoods, meaning that their presence is often incompatible with anthropogenic land use priorities. Protected areas are important for the conservation of large carnivores, but even the largest protected areas cover only a small percentage of the landscape that is required by these species. Therefore, large carnivores often interact with humans away from protected areas and within human-dominated landscapes. The challenges of large carnivore conservation in human-dominated landscapes are both ecological and social. As large carnivores move about for daily,

seasonal or relocation movements they require movement habitat and space. It is unknown whether having connected habitat that enables carnivore movements could increase human-carnivore interactions in human dominated landscapes. Therefore, I used GPS-collar data and Circuitscape software to assess whether landscape connectivity influenced interactions between cougars (*Puma concolor*) and humans in areas of western Washington, USA. I found a higher incidence of cougar-human interactions in areas of low landscape connectivity, closer to roads and rivers, and farther away from public forests. These results suggest that in human dominated landscapes intact landscape connectivity may have the advantage of discouraging interactions between cougars and humans.

Where human-carnivore interactions occur, it is important to understand what the humans who share space with the carnivores think of nonlethal ways to prevent negative interactions and economic ways to realize benefits from carnivores that can promote coexistence. Thus, I also conducted interviews with stakeholders concerned with wolves (*Canis lupus*) to document what motivates ranchers to participate in cost-shared nonlethal strategies, and whether predator-friendly beef would be a feasible economic measure to increase positive coexistence between ranches and wolves.

Through this interview process I found that both economic and social factors motivate and constrain ranchers from participating in cost-shared nonlethal strategies to better coexist with wolves. Ranchers were already participating in nonlethal strategies that were recommended in the cost-shared programs and therefore were not motivated to enroll in similar programs. Furthermore, participating in cost-shared programs was not consequential for ranchers because all ranchers are eligible for compensation for livestock lost to wolves whether or not they are enrolled in nonlethal programs. Interviews investigating predator-friendly beef as an economic

benefit to enable ranchers to better coexist with wolves revealed that ranchers could be motivated to participate because of the opportunity to communicate to non-ranchers. The constraints to predator-friendly beef label, however, included competition on the market with other certified products and underlying social factors that would dissuade ranchers from participating in predator-friendly beef certifications.

The findings from the two qualitative chapters suggest that rural residents might participate better in cost-share programs if those programs were led by their local leaders, and more streamlined to reduce the regulatory burden to the ranchers. Mitigation strategies could be localized to enable ranchers to work with their neighbors and local associations to implement socially acceptable and adaptable nonlethal measures to better coexist with wolves and other large carnivores.

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DEDICATION

To mom, Jane Namusisi Mbaziira: I did not become a medical doctor, but I am a doctor nevertheless.

INTRODUCTION

Interactions between people and carnivores in Washington State

Humans care for wildlife because of its attraction and awe, ecological role, utilitarian value and symbolic meaning. Moreover, wildlife is a barometer measuring people's concern for environmental sustainability (Manfredo 2008). Humans interact with wildlife in a variety of ways including intentional ways such as recreation and tourism (Curtin 2010; Reynolds and Braithwaite 2001), and coincidental ways due to spatial overlap between humans and wildlife (Woodroffe et al. 2005), that we are referring to as human-wildlife interactions. Coincidental interactions between humans and wildlife are often termed as human-wildlife conflicts but this terminology is misleading as it frames human-wildlife interactions as solely negative (Redpath et al. 2015, Fisher, 2016). The term 'human-wildlife conflict' construes wildlife as being simultaneously aware of their own goals, aware of human goals, and purposefully seeking to undermine human goals (Peterson et al. 2010). Furthermore, using the term human-wildlife conflict labels wildlife as inherently threatening and antagonistic to humans which leads to misunderstanding, negative perceptions and ultimately negative consequences for wildlife (Redpath et al. 2015). In order to avoid framing all human-wildlife interactions as conflicts, some organizations, researchers and managers have used different terminologies to refer to the interactions that happen when humans and wildlife share the same landscape. The terminologies include human-wildlife coexistence (Madden 2004) which encompasses benign coexistence, enjoyment of backyard wildlife, and negative interactions such as damage to crop and livestock, human-wildlife competition (Bruskotter et al. 2014, Matthiopoulos et al. 2008, Treves 2009) that includes tensions that may arise when for example when carnivores and

hunters compete for ungulates, and human-human conflicts (Hill 2015, Marshall et al. 2007) which arise between conservation and other human activities over how to manage the wildlife. Framing all interactions between humans and wildlife as conflicts leads managers and researchers to focus on technical solutions to address these 'conflicts', thereby attempting to resolve the wildlife damage but not addressing the underlying conflict between the humans concerned with the wildlife (Hill 2015, Peterson et al. 2010, Redpath et al. 2015). In this dissertation, I address coincidental interactions between humans and wildlife as human-wildlife interactions, or more specifically human-carnivore interactions, in order to investigate the different ways that human and wildlife interact when they share the same landscapes.

Challenges of wildlife conservation in human dominated landscapes are both ecological and social; usually the social acceptability of wildlife is more challenging to solve than is providing the appropriate technical and ecological solutions (Frank 2016, Madden and McQuinn 2014). In regions where wildlife species have been absent for a long time, their recovery presents new challenges and therefore new solutions have to be devised. For example, during the 20 years of civil war in Northern Uganda the human population moved out of their villages and lived in Internally Displaced People's camps, leaving the villages, farmlands, and nearby wildlands to be recolonized by elephants (*Loxodonta Africana*) and other wildlife. With the end of war people returned to their villages and human-wildlife interactions ensued (Gorsevski et al. 2012). Another example comes from North America where ongoing gray wolf (*Canis lupus*) recovery after this predator was extirpated from over 70% of its former range in the contiguous United States has brought new interactions both positive and negative while rekindling old ones (Mazur and Asah 2013). In both these situations the recovery and conservation of charismatic wildlife species with the potential to negatively affect local livelihoods requires novel ways to mitigate negative interactions and promote coexistence with the

recovering animal populations. Studies that attempt to understand both wildlife and human needs in these shared landscapes are necessary to investigate ways to achieve both conservation and human livelihoods in shared landscapes (Marshall et al. 2007, Redpath 2015).

In this dissertation I focused my research on interactions between people and carnivores in Washington State. Washington was an ideal setting for this work because it is the smallest western state, but has the second largest human population while retaining a full suite of large carnivores including cougars (*Puma concolor*), wolves, black bears (*Ursus americana*), and grizzly bears (*Ursus arctos horribilis*). Places like Washington, where relatively high human density in residential areas can cause land use changes in nearby wildlands containing large carnivores, would benefit from research that investigates the drivers and implications of human-carnivore interactions. Large carnivores roam widely and need vast landscapes and this can present challenges for humans (Ripple et al. 2014, Woodroffe et al. 2005). Protected areas are important for the conservation of carnivores, but even the largest protected areas provide only a small percentage of the landscape that is required to conserve biodiversity (Athreya et al. 2013). With an increase of more than 50% human population since 1990 (United States Census Bureau 2017), Washington State has experienced wildlands conversion and increased reports of human-carnivore interactions (Washington Department of Fish and Wildlife 2018). Consequently, Washington represents the acute challenges of maintaining landscapes for carnivores and people.

In areas where humans and wildlife live in close proximity, it is critical to consider human values and needs to reduce negative interactions and increase positive coexistence. Integrating ecological and social science methodologies can help to identify trade-offs and optimal solutions for both wildlife and humans (Bennett et al. 2017, Dickman 2010) in both terrestrial (Chan et al. 2012) and marine ecosystems (Sala et al. 2002). In this dissertation I address both the ecology of large

carnivores as well as the human dimensions of the people living among them. The objective of this dissertation is to utilize an interdisciplinary approach to study both carnivores and humans as a means to understand human-carnivore interactions and develop strategies to increase positive coexistence.

In CHAPTER ONE I use approaches from landscape ecology to understand the mediating role of landscape connectivity on cougar-human interactions in exurban areas. Although we know that large carnivores use and access human-dominated landscapes through forest corridors (Kertson et al. 2011b, 2013), we do not know whether landscape connectivity influences human-carnivore interactions. Furthermore, where landscapes are under mixed management as either private or public forests they tend to be structurally similar making it challenging to conserve carnivores in wildlands so close to human-dominated areas. Therefore, carnivore conservation and management decisions in human-dominated landscapes need to address local scale human-carnivore interactions in order to better inform land owners.

In order to catalyze change for better carnivore conservation that aims to identify common interests, human dimensions of carnivore conservation have been promoted as one of the tools to better understand human-carnivore coexistence (Mattson and Clark 2009). To effect lasting changes, however, scholars need to move beyond only social surveys and outreach/ education programs and promote the structural solutions that address policy and governance-oriented professionals (Dickman 2010, Heberlein 2012, Mattson and Clark 2009). Therefore, for my next two chapters I utilized qualitative interviews with different stakeholders concerned with wolf recovery ranging from ranchers to policy-makers to assess the social and economic feasibility of wolf recovery in Washington State. In CHAPTER TWO I attempt to understand, from ranchers' perspectives, what factors influence their participation in mitigations to better coexist with wolves.

In CHAPTER THREE I describe the different perceptions of stakeholders about predator-friendly beef as an economic strategy for encouraging ranchers to better coexist with wolves.

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Chapter 1. THE ROLE OF HABITAT CONNECTIVITY AND TRAVEL CORRIDORS IN COUGAR-HUMAN INTERACTIONS IN EXURBAN AREAS

ABSTRACT

Habitat connectivity is a cornerstone of wildlife conservation, especially for large carnivores whose extensive home ranges sometimes include human-dominated landscapes. While maintaining connectivity among suitable habitats is critical for large carnivore persistence in the face of increasing anthropogenic landscape conversion, its role in facilitating or mitigating potentially detrimental interactions with people is unknown. To better understand this dynamic, I investigated the relationship between landscape connectivity and the interactions of a generalist predator, the cougar (*Puma concolor*), in a wildland-urban environment in western Washington State, USA, to determine what, if any, relationship exists. I used landscape connectivity models from Circuitscape and spatial statistics tools for measuring geographic distribution and analyzing patterns to assess the influence of local and regional landscape connectivity on reported cougar-human interactions. I found that cougar-human interactions were associated with areas closer to rivers and roads, and farther from public forests. At both the regional and local scales, cougar-human interactions were most likely in areas of low landscape connectivity. By identifying local drivers of cougar-human interactions at a fine scale, findings of this research could be used as a means of guiding management and preventing negative interactions. My findings suggest maintaining or increasing landscape connectivity locally within exurban residential development could reduce cougar-human interactions. Consequently, there appears to be little downside for both wildlife managers and urban planners in maintaining and increasing connectivity for large carnivores in human-dominated landscapes.

1. INTRODUCTION

As the human population expands into formerly wild lands, wildlife habitat is often fragmented (Crooks 2002, Marzluff 2001, Riley et al. 2003) and converted into residential areas (Bateman and Fleming 2012, Gehrt 2010, Marzluff et al. 2008) with negative consequences for wildlife conservation (Lindenmayer and Fisher 2006, Prugh et al. 2008). Specifically, for wide-ranging species such as carnivores, land use change and fragmentation can negatively impact their daily and seasonal movements and dispersal (Lindenmayer and Fischer 2006). Movement is important for large carnivores because they typically forage, seek mates, and maintain territories over vast areas (Beckmann and Hilty 2010). In order to enable critical carnivore movements, wildlife biologists and managers encourage the maintenance of travel corridors or wildlife habitat restoration with consideration for connected habitats (Beckmann and Hilty 2010, Lindenmayer and Fischer 2006). However, where these connected habitats and travel corridors are near human-dominated landscapes, facilitating carnivore movement could increase their interactions with people (Bateman and Fleming 2012). Various studies have investigated factors that influence human-carnivore interactions in human-dominated landscapes including dense forested areas, proximity to natural vegetation, prey availability, and distance to wilderness, water sources, and roads (Matalvo et al. 2016, Kaartinen et al. 2009, Kertson et al. 2011a, Teichman et al. 2013). Other factors that have been associated with increasing livestock-carnivore conflicts include spatial and temporal distributions of the carnivore, landscape features, and livestock management practices (Teichman et al. 2013). Whereas our understanding of the role of landscape characteristics has increased substantially, the potential of local landscape permeability (Buttrick et al. 2015) to influence human-carnivore interactions is unknown.

As carnivores move through connected landscapes to meet their ecological needs they may use residential areas (Bateman and Fleming 2012). During these forays carnivores usually go undetected but they may occasionally engage in negative interactions with people or their property (e.g. Kertson et al. 2013). These negative interactions can include frightening encounters, pet and/or livestock depredations, or even attacks on humans (Young et al. 2015, Athreya et al. 2013), thereby creating negative attitudes and perceptions towards all carnivores and retaliatory killings (Treves et al. 2006). Thus, studies identifying drivers of interactions are needed to increase our understanding of patterns of interactions and prevent these negative events in the interest of minimizing threats to humans and the need to conserve the carnivores.

The western region of Washington State provides an ideal setting in which to investigate how connectivity in a rapidly expanding exurban landscape influences human-carnivore interactions. Washington is emblematic of many western states with a human population that has grown more than 50% since 1990 (US Census Bureau 2017), translating into fast developing exurban areas and an expanding wildland-urban interface (Clark et al. 2009, Robinson et al. 2005). Exurban areas, the fastest growing land use type along gradients from wild lands to residential areas (Radeloff et al. 2010, Theobald 2005), are defined as low-density residential areas typically comprising single-family houses on plots averaging 0.2 – 20 ha surrounded by natural vegetation (e.g., forests, Robinson et al. 2005). Western Washington is located close to wild areas of the Cascade mountains containing both designated protected areas (National and State forests) as well as large swaths of privately-owned commercial forest that contribute substantially to wildlands (Forterra 2016). I took advantage of this setting to examine the influence of connectivity on interactions between humans and cougars (*Puma concolor*).

The cougar is the second largest cat in the family Felidae in the Americas and has the largest geographic distribution of all terrestrial carnivores in the western hemisphere, stretching from northern Canada to southern Chile (Hornocker and Negri 2009). Cougars can exploit a diversity of habitats including human-dominated landscapes (Beier et al. 2011, Dickson et al. 2005, Kertson et al. 2013). Their use of these lands can bring them into negative interactions with humans when they prey upon domestic animals or encounter people (Beier et al. 2011, Kertson et al. 2013). Amounts and patterns of forest habitat and residential development can help to predict where these interactions are most likely to occur (Burdett et al. 2010, Kertson et al. 2011b, Knopff et al. 2014, Maletzke et al. 2017). However, the relationship between landscape connectivity and cougar-human interaction has not been directly assessed.

In this study, I modeled landscape permeability for cougars to assess how landscape connectivity and associated features such as rivers, roads and powerline rights of ways were related to human-cougar interactions in western Washington. Because cougars are known to use forest-covered areas in order to access human-dominated landscapes (Kertson et al. 2011b), I hypothesized that interactions between cougars and people would be close to highly connected landscapes. Under this hypothesis, I predicted that geographic distribution patterns of cougar-human interactions would be clustered close to areas of high landscape connectivity at both large regional scale and fine local scales. Because cougars use linear land use features (such as dirt roads, trails, streams, and powerline right of ways) to facilitate their movements within human-dominated landscapes (Dickson et al. 2005), I further predicted that cougar-human interactions would occur near these linear features.

2. MATERIALS AND METHODS

2.1 Study area

I examined the influence of landscape connectivity features on cougar-human interactions in a 3500 km^2 area on the interface of wildland and residential areas comprising portions of King and Snohomish Counties in Washington State, USA (area coordinates: 47º50'26.14''N, 122º05'19.94''W; 47 º 49'31.83''N, 121 º 09'21.06''W; 47 º 16'45.80''N, 121 º 26'06.16''W; and 47 º 25'52.68''N, 121 º 57'01.48''W). Human population density in this region is characterized by a gradual east-west gradient spanning wildland, exurban (< 2.5 residences/ha), suburban (2.5-10 residences/ha), and urban (205 – 210 residences/ha) environments (Robinson et al. 2005, Kertson et al. 2011b). This area has been described at length in prior studies (Kertson and Marzluff 2010; Kertson et al. 2011a, 2011b, Kertson et al. 2013, Maletzke et al. 2017).

2.2 Capture, collaring and monitoring of cougars

Cougar capture and data collection techniques for these animals have been previously described in detail (Kertson et al. 2011a, 2011b, Kertson et al. 2013, Maletzke et al. 2017). Briefly, cougars in the study area were captured using trained dogs or cage traps, chemically immobilized, fitted with a GPS collar, and released at the point where they were captured. I used GPS data from 23 cougars (15 females and 8 males) that were captured and monitored during two different periods: 2004 to 2008 and 2013 to 2015. Collars were programmed to attempt a satellite fix for 180 seconds every 4 hours in an attempt to maximize both battery life and data acquisition, and cougar location data were collected for as long as the collars remained functional. All cougar capture and handling

events were performed in accordance with the University of Washington's Institutional Animal Care and Use Committee (IACUC) protocol #3077-07.

2.3 Landscape Features

I derived elevation and landscape slope from a mosaic United States Geological Survey 30m digital elevation model (DEM) of UTM zone 10 available from Washington State Geospatial Data Archive (WAGDA). I mapped roads, including public roads (Washington All Public Roads; WAPR), trails and railroads, orphaned and abandoned forest roads from data maintained by the Washington State Department of Transportation (WSDOT). I downloaded hydrography datasets, including major areas, streams, and water bodies from the National Hydrography Dataset from the Washington State Department of Ecology, and land use and Washington county boundaries data from the Department of Natural Resources (https://www.dnr.wa.gov/). I downloaded landcover data from the NOAA Coastal Change Analysis Program (C-Cap 2011) and residential density data from Kertson et al. (2011a). In addition to environmental variables, I downloaded powerlines data from OpenStreetMap (2017). Powerlines data were limited to 3-line powerlines with voltage ranging from 55,000 to 500,000. For protected lands and land use data, I obtained the 2015 Central Puget Sound Public, Tribal and Protected Land Database (CPS-PLDB, 2015) and Working Forest Land databases for King, Pierce, and Snohomish counties from Forterra (http://forterra.org/). I processed data in ArcGIS 10.3 (ESRI, Redlands, CA, USA), projected to WGS_1984_UTM_Zone_10N and clipped to the study area boundaries. Within the Spatial Statistics toolkit, I used measures of geographic distribution (to measure mean center, standard distance and standard deviation ellipse), pattern analysis tools (Moran's I and Ripley's K), and mapping clusters tool (for optimized hotspot analysis).

2.4 Quantifying Landscape Connectivity

Landscape connectivity is defined as the capacity of a landscape to facilitate movement of wildlife across a matrix of varying resistance (Taylor et al. 1993, Tischendorf and Fahrig 2000). For this analysis, I defined the matrix as exurban areas interspersed with patches of forested habitat. For cougars to traverse the matrix, they must move from one forest patch to the next facing varying levels of resistance provided by residential development, high-speed roads, and agricultural areas (Kertson et al. 2011b). Steps to quantify landscape connectivity are summarized in Figure 1.1 and described in sections 2.4.1 and 2.4.2.

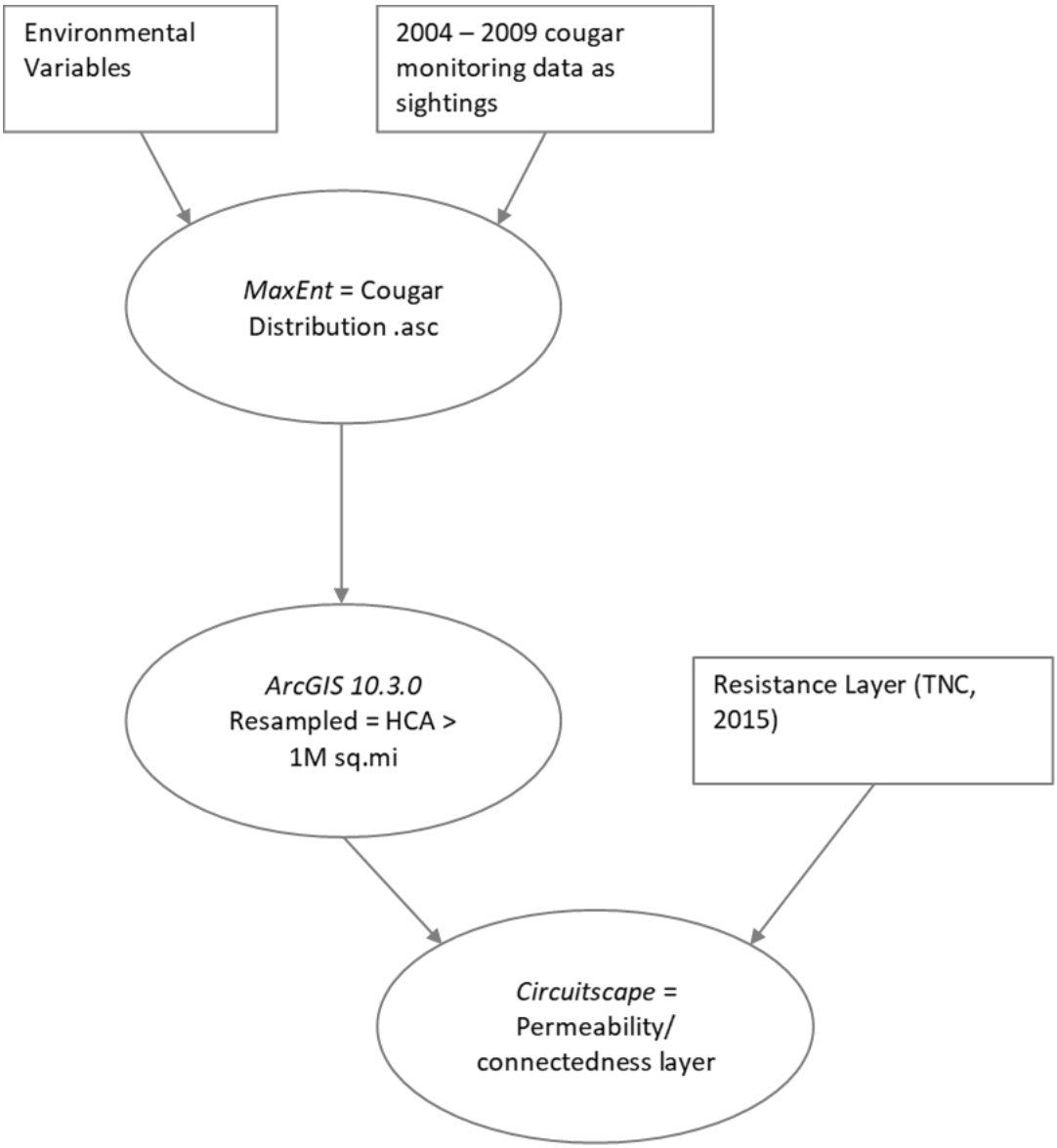

Figure 1.1: Steps followed to quantify landscape connectivity. *Italicized terms* are the software packages that were used whereas the other text indicates the data inputs and outputs from each software package.

2.4.1 Creating Habitat Patches for cougars in the study area

Habitat patches that are needed to define landscape connectivity in Circuitscape (McRae and Shah 2011) and in this study I used the habitat suitability model to define the cougar habitat patches between whose connectivity I quantified. I used a MaxEnt modeling framework (Elith et al. 2011, Phillips et al. 2004) to create a habitat suitability model by incorporating landscape features (e.g., elevation, slope, distance to public roads, distance to abandoned forest roads, distance to rivers, and land cover in accordance with the findings of Kertson et al. 2011b), and the cougar GPS data collected between 2004 and 2008 as sightings data to model cougar habitat suitability. To customize the model and fine tune model results for easier interpretation, I selected the following settings in MaxEnt in accordance with Phillips et al. (2006) and Phillips and Dudik (2008): I set 25% of the data for testing the data. If no testing data are selected, MaxEnt uses the same data to feed and evaluate the model, potentially introducing bias in the model by exaggerating model performance. I ran four replicate models whereby MaxEnt averages the results from all four to produce the final model for this study. I ran1000 iterations to improve model fit and help the model to converge. Multiple model replicates and iterations enable the model in MaxEnt to converge (Elith et al. 2011, Phillips and Dudik, 2008). I chose a logistic output instead of raw or cumulative output because probabilities as the logistic outputs are better calibrated models and are scaled up in non-linear ways for easier interpretation (Elith et al. 2011, Phillips and Dudik, 2008). MaxEnt assumes that the Tau for occurrence of the species = 0.5 (Elith et al. 2011); for this study this tau was acceptable as we know that indeed cougar use the area being modeled and therefore logistic output was an appropriate output. The resulting prediction map provided a model of cougar habitat suitability for western Washington (Appendix A).

I imported the prediction map of the habitat suitability model from MaxEnt into ArcMap 10.3.1 to define cougar habitat patches. I reclassified the habitat suitability layer into a binary layer whereby areas with suitability equal to or greater than 90% were considered habitat, while the other areas were classified as non-habitat. I used a 90% threshold instead of 100% because the cougars and other generalist mammals can use marginal habitat for movement (Keeley et al. 2017). The minimum habitat patch was no less than 1 km^2 in area; substantially less than the minimum for a typical cougar home range (238.6 km^2 for adult female and 678.2 km^2 for males; Kertson et al. 2013) and consistent with space use by cougars as they traverse their home range. Furthermore, 1 km^2 is low enough to account for small areas (e.g., residential forested backyards), into which cougars may wander temporarily but do not occupy permanently. The reclassification resulted in 61 habitat patches (Appendix A).

2.4.2 Developing a landscape connectivity layer using Circuitscape

Circuitscape software is fed with the habitat patches and a resistance layer through which current flow to reach the different habitat patches (McRae and Shah 2011). I used a resistance surface developed by Buttrick et al. (2015) to model wildlife connectivity for a broad region including western Washington. Although Buttrick et al. (2015)'s resistance layer was not specific to cougars, it is useful in our model because it was based on values for focal wildlife species including lynx (*Lynx pardinus*), bears (*Ursus americanus*), and deer (*Cervus* spp), among others (details in WHCWG, 2012) whose landscape barriers in the wild are similar to those faced by cougars.

I input the resistance surface and the cougar habitat patches into Circuitscape v4.0.5 (McRae et al. 2008) to estimate connectivity for cougar movement between the 61 reclassified cougar habitat patches. I chose the pairwise setting using the stand-alone Circuitscape tool to model all connections

between the 61 habitat patches. Under the pairwise mode, resistance, current and voltage are calculated iteratively between all pairs of the habitat patches in all directions (McRae and Shah 2011). By using pairwise mode I assumed that cougar could move in any direction from one patch to another (as opposed to unidirectional movement). Habitat patches data were resampled from the resolution of 30M to 90M to facilitate computational analysis and maintain consistency with the resistance surface (Buttrick et al. 2015). I imported the resulting conductance map (Appendix B) into ArcGIS 10.3.0 to assess whether landscape connectivity influenced cougar-human interactions.

2.5 Cougar-human interactions

I acquired 45 confirmed reports of cougar-human interaction (i.e., sightings, encounters, or depredations of livestock or pets) within the study area from a database maintained by the Washington Department of Fish and Wildlife (WDFW) for the periods 2005 to 2008 and 2013 to 2017. The reliability of cougar reports is limited (Kertson et al. 2013), so I focused on reports that were investigated and confirmed by WDFW staff with information on the type of interaction, date, time, location (UTM coordinates), and whenever possible, the demographic characteristics of the offending animal recorded in an Access database (Kertson et al. 2013).

2.6 Prediction 1: Testing whether patterns of reported cougar-human interactions were clustered or dispersed throughout the study area.

I input the locations of reported cougar-human interactions and environmental data into MaxEnt to create a visual distribution of the probability of interactions occurring in the study area. I imported the model with the lowest ΔAICc and highest R^2 diagnostics into ArcGIS 10.3 and used the

Spatial Analyst Tool extension to further visualize and assess geospatial distribution characteristics including mean center, standard distance, and standard ellipsoid (de Smith et al. 2007). To test whether the distribution of reported interactions was random, clustered or dispersed, I used Ripley's K function (Ripley 1976, Wiegand and Moloney 2004) in the Spatial Statistics Toolbox of ArcGIS 10.3.0. Ripley's K function measures the expected number of events within a distance from an arbitrary event for stationary processes. It is a multi-scale distance measure used in point pattern analyses to determine whether the points being analyzed have significant underlying patterns (Wiegand and Moloney 2004). I determined that 2062.5m was the observation distance at which clustering occurred (observation distance is where the spatial processes promoting spatial clustering are most pronounced without spatial autocorrelation). Observation distance was an intermediate result of Ripley's K analysis calculated using an iterative process that considered incremental spatial autocorrelation distances to eventually determine a maximum clustering distance (de Smith et al. 2007).

2.7 Prediction 2: Testing whether cougar-human interactions occurred equally in areas of low and high landscape connectivity at regional scale.

To assess the influence of landscape connectivity on reported cougar-human interactions, I compared landscape connectivity for areas where interactions were observed to areas where no interactions were observed. I tested the null hypothesis that landscape connectivity values would be the same for areas where cougar-human interactions were reported as for those with no reported interactions. I used a two-sample t-test to compare the average landscape connectivity values of the 45 reported cougar-human interaction points recorded from 2006 to 2017 with 45 randomly selected points of tracked cougars between 2012 and 2015.

To investigate the relationship between landscape connectivity and cougar-human interactions, I quantified the distribution of various landscape features that facilitate cougar movement in residential areas relative to interaction reports. Specifically, I quantified the Euclidean distance between interaction reports and power lines, forest trails, railway lines, and public land and private land parcels. I then used Geographic Weighted Regression (GWR; Wheeler and Paez 2010) in ArcGIS 10.3 to assess any relationship between the likelihood of interaction and the distance to these features. Geographic weighted regressions are particularly useful because they account for the local geographic variation at each cougar-human interaction location by generating independent equations for each interaction and determining the relative significance of each covariate (De Smith et al. 2007).

2.8 Prediction 3: Testing whether at a fine scale (500M buffer) areas where cougar-human interactions occurred have the same landscape characteristics as those where no interactions occurred.

Because cougars hunt at a fine scale (Beier 2009, Kertson et al. 2013), using geoprocessing tools in ArcGIS 10.3, I created 500 m buffers around each of the 11965 GPS relocations for 13 cougars that were involved in interactions. These 13 cougars were individually known from their GPS-collars and where involved in 22 confirmed interactions. A buffer is an area drawn at uniform distance around each location point to represent a critical zone in this case, a critical zone in which a cougar would hunt, depredate or be visible to humans to be reported as an interaction. Creating buffers around each location point allowed for comparison of spatial relationships among landscape connectivity and linear features within those buffers. Locations in the wild areas were not considered because cougar-human interactions occur much less frequently in wildland landscapes (Kertson et al.

2011b). The 11965 buffers were in two categories: 22 with interaction, and 11943 with no-interaction. For each buffer, I employed geoprocessing tools in ArcGIS 10.3 to extract by intersect the variables of interest for each buffer. Thus, for each buffer I extracted from the following layers: landscape connectivity, rivers, roads, other transport roads, powerlines, private forests, public forests and wildland-urban interface. After extracting the layers, I calculated the average landscape connectivity and average distance to each of the other features within the buffers. Using the Student two-sample two-sided t-test with confidence interval 0.95 in R (R Core Team 2013) I compared the means of the features in the two buffer categories: features in locations where interactions occurred vs features in locations where no interactions occurred. I used Levene test (Carroll and Schneider 1985) if variance for each of the variables' means was equal. I tested the null hypotheses that landscape connectivity and distance values for locations with interactions and those without interactions would not differ.

3 RESULTS

3.1 Characteristics and patterns of reported cougar-human interactions

Ripley's K analysis showed that observed patterns were above and not overlapping the 95% Confidence Envelope indicative of a clustered distribution in the western section of the study area (Figure 1.2). Consequently, I failed to reject the null hypothesis that cougar-human interactions are clustered in western Washington. Spatial locations of the reported cougar-human interactions were significantly clustered from 2000 meters to 11000 meters, meaning that as the distance from the center of the clustering increased, cougar-human interactions were likely to tend toward random or dispersed distributions. Thus, as distance increased away from the wildland-urban-interface in either urban or wildland direction, cougar-human interactions were more likely to become more dispersed than clustered. Interactions were clustered in the center-to-west side of the study area, the area that is also characterized as the WUI (Figure 1.3). The orientation of where interactions were reported was generally in the north-south direction (Standard Ellipsoid Rotation = 2.395), aligning along the contour of the western slopes of Cascades mountains (Figure 1.3).

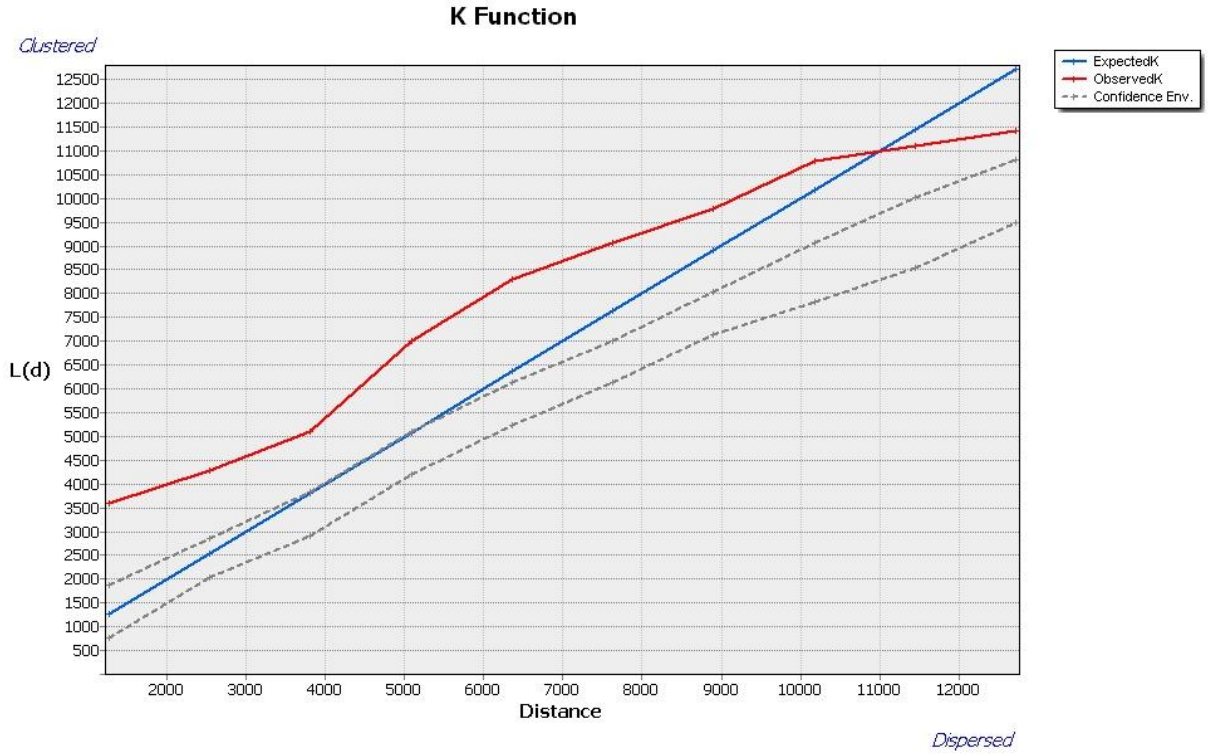

Figure 1.2: Results of the Ripley's K analysis for reported cougar-human interactions. Ripley's K function measures the expected number of events within a distance from an arbitrary event for stationary processes.
The L(d) is a variance-stabilizing transformation correcting for increasing variance (hence reduced precision) as the distance from the starting event increases. Having the expected or observed line inside the Confidence Envelope (dashed line) would mean complete randomness. The observed (red) solid line lies above the expected line and confidence envelopes, showing that the reported cougar-human interactions were significantly clustered from 1000 to 11000 meters above which clustering continues but not greater than what is expected. The expected (blue) line starts as completely random but tends to clustering as the distance increases.

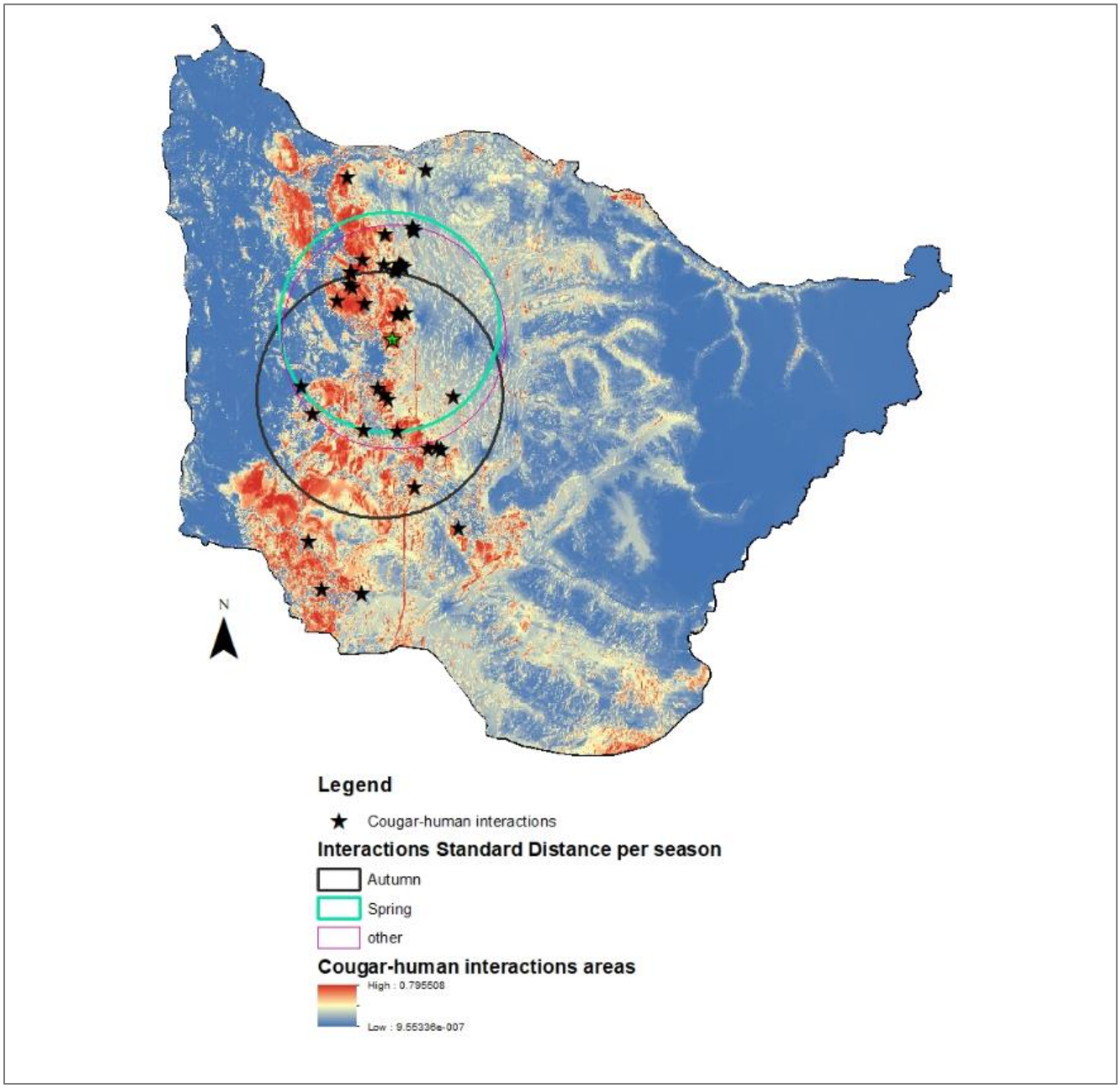

Figure 1.3: Gradient of predicted cougar-human interactions based on the reported cougar-human interactions (n=45) and environment data of the study area modeled in MaxEnt. Figure further shows the geographic distribution of the cougar-human interactions in the study area and the standard distance shows trends of the cougar-human interactions seem to shift in the south-north direction from autumn to spring respectively.

3.2 Influence of landscape connectivity on reported cougar-human interactions at a regional scale

Areas where cougar-human interactions occurred had significantly lower landscape connectivity values than areas within the region where interactions did not occur (Figure 1.4; Welch two-sample t-test: $t = -6.67$, $df = 87.51$, $p < 0.001$). Inquiry on whether the landscape connectivity variables could explain the presence of cougar-human interactions showed that the model with the lowest ΔAIC from the Geographic Weighted Regression analysis included distance to power lines, distance to private forests, and distance to public lands, but explained only 12.4% of the variation in the distribution of cougar-human interactions at the landscape level. At the regional scale therefore, cougar-human interactions were significantly more likely in the areas of lower landscape connectivity however the variables we tested were weak at explaining this variation.

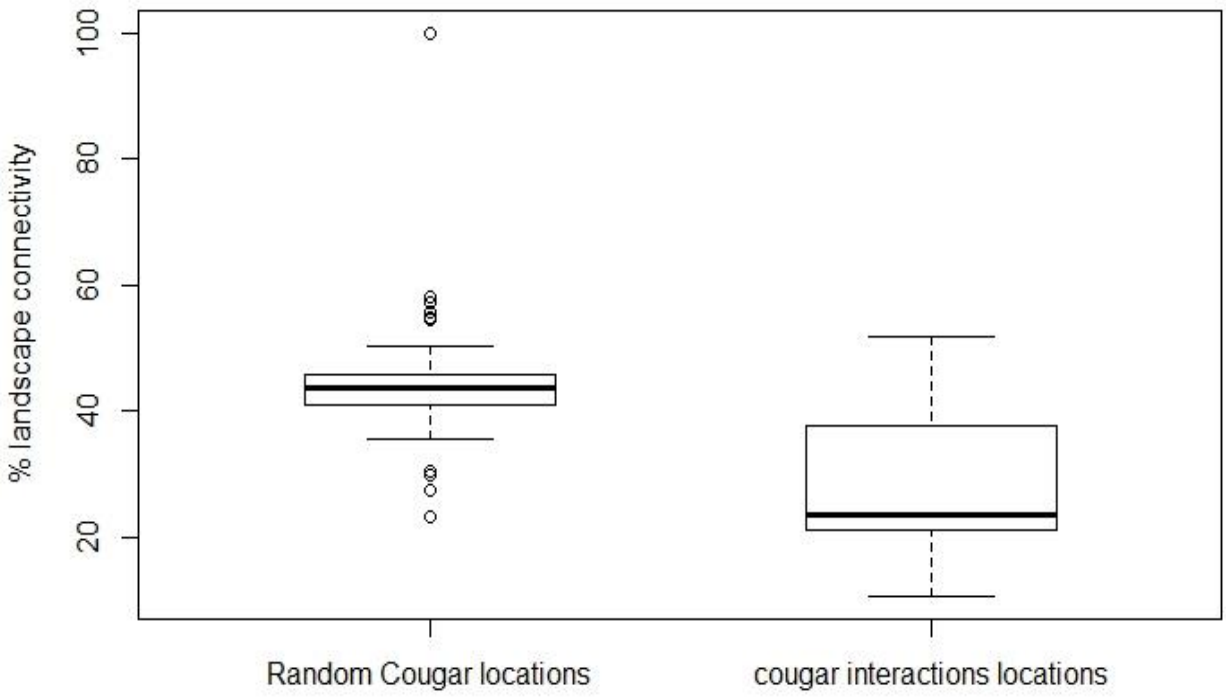

Figure 1.4: Comparing mean landscape connectivity values for areas where cougar-human interactions did and did not occur showed that cougar-human interactions occurred significantly more in areas of low landscape connectivity than at higher landscape connectivity. Data used for random cougar locations were randomly extracted from the study area's landscape connectivity layer, whereas cougar interaction locations were values from the areas where reported cougar-human interactions occurred.

3.3 Characteristics of the local fine scale areas (500-meter buffers) associated with reported cougar-human interactions.

Fine scale locations where cougar-human interactions occurred had lower landscape connectivity (t-value = 6.09 (df = 11963), $p < 0.0001$) and were closer to roads and the WUI, and farther from powerlines and public forests than were areas without cougar interactions (Table 1.1). In particular, areas with 3% to 6% landscape connectivity were most commonly associated with interactions. There was an 18.7% increase in the likelihood of cougar-human interactions for every reduction of one percentage unit in landscape connectivity. The likelihood of interaction increased by 0.189% for every 100m a point was closer to a road. There was a 0.49% increase in chances of cougar-human interactions for every 100m increase in proximity to the wildland-urban interface. Distances to trails, railways, and private forests were not significantly different for locations with or without interactions (Table 1.1).

Table 1.1 Influences of landscape features on cougar-human interactions at the fine scale (500m).

Variable	**Interaction locations, mean value for variables at (n = 22)**	**No-Interaction locations, mean value for variables at (n = 11943)**	**t-value (df)**	**p-value**
River, distance to (m)	176.9	409.33	7.96 (22.75*)	<0.0001
Connectivity	1467.91	2267.38	6.09 (11963)	<0.0001
Roads, distance to (m)	74.57	145.87	2.83 (11963)	0.0046
Public forest, distance to (m)	275.93	102.11	-2.44 (21.03*)	0.024
Powerline, distance to (m)	2606.03	1878.72	-2.15 (11963)	0.032
WUI, distance to (m)	705.27	1339.78	2.01 (11963)	0.045
Private forest, distance to (m)	742.86	321.28	-1.94 (11963)	0.052
Trails & rails, distance to (m)	3699.35	4151.41	0.72 (11963)	0.473

Results of the unpaired two-sample t-test for the variables and mean values where human-cougar interactions did and did not occur. The dependent variable was the occurrence of cougar-human interactions whereas the independent variables were quantified landscape connectivity, distances from rivers, roads, forests, powerlines, and trails. *indicates the calculated degrees of freedom for the variables whose means had unequal variances. R-script used for this table's calculation is shared in Appendix E.

4. DISCUSSION

Keeping habitats connected across unsuitable lands is a cornerstone principle of modern conservation biology (Lindenmayer and Fischer 2006). For large carnivores, maintaining landscape connectivity is essential for the survival of many species in the face of rapidly expanding human populations (Bateman and Fleming 2012). While the presence of features that facilitate movement in human-modified environments is largely considered a net positive for carnivores (Beckmann and Hilty 2010, Fischer and Lindemayer 2007, Lindenmayer and Fischer 2006), these same features may increase carnivore proximity to people and contribute to negative interactions. My results are not consistent with this notion for an adaptable large carnivore, the cougar. Rather, they indicate that maintaining landscape connectivity likely has limited ecological costs for both carnivores and people with the added benefit of potentially reducing the chances of a human-carnivore interaction.

4.1 Distribution patterns of the reported cougar-human

This research extends the understanding of where human-cougar interactions are likely to occur by considering the attributes within 500 m of where interactions were and were not reported. The Ripley's K clustering results agrees with previous studies showing that cougar-human interactions are a function of presence of humans in or near wildland (Kertson et al. 2011b). Areas in which cougar-human interactions were clustered are also characterized in previous studies as wildland-urban interface (Hansen et al. 2005, Radeloff et al. 2005, 2010, Kertson et al. 2011b). I found that cougar-human interactions were associated with lower landscape connectivity within 500 m of the interaction location. Areas with the lowest connectivity were not used by cougars, and those with greater connectivity likely contain features that facilitated movement through the landscape while limiting cougar exposure to people or domestic animals. My findings suggest that landscape connectivity constrained where cougar-human interactions were reported to areas of low landscape

connectivity but did not control the occurrence of those interactions. These findings concur with previous studies (e.g. Kertson et al. 2011a, 2011b, Teichman et al. 2013) that indicated cover as one of the primary factors that enable cougars to occur in exurban areas.

The standard distance of where cougar-human interactions occurred changed across the seasons from autumn to spring (Figure 1.3). This shift could suggest that the cougars responsible for interactions used in this study spent relatively short periods of time within the human-dominated landscapes (Kertson et al. 2013). Reported cougar-human interactions were significantly clustered in the study area. I infer that this clustered pattern may have been driven by other processes such as the presence of livestock because the most frequently reported form of cougar-human interactions were depredations (consistent with Kertson et al. 2011b for this same study area). This study supports the findings of Kertson et al. (2011b, 2013) and further demonstrates the importance of landscape characteristics in cougar use of residential areas and interactions with people. Specifically, the presence of forest patches and corridors in the study area could have provided prey and undetected use by cougars, whereas areas where forest corridors were limited cougars were forced to cross the residential matrix thereby interacting with humans.

4.2 Role of the Wildland-Urban Interface (WUI) and associated features on the reported cougar-human interactions

I found that reported cougar-human interactions were significantly associated with being close to the WUI. This result is not surprising given that a large portion of the exurban study area is located within the WUI of western Washington (Radeloff et al. 2005, Theobald et al. 2011, Robinson et al. 2005). Characteristics of the WUI include low-density residential areas interspersed within natural vegetation land cover and 89% of the WUI is privately owned land (Theobald and

Romme 2007). Private forests and water features (river, streams, creeks, culverts) in the study area were ubiquitous and therefore unrelated to the occurrence of interactions. Consequently, many of the reported cougar-human interactions occurred on private forest land.

Some of the landscape features examined in this study are described using more management language than ecological language (e.g., public forest vs evergreen or mixed forest) because these are the delineations used by policy-makers and land use planners when parsing out plots of land for developing (e.g., for new residential areas). However, cougars do not follow the management boundaries of these features and they are just as likely to use public, private or forested backyard lands that have the right amount of vegetation cover and access to prey (Kertson et al. 2011a, 2013, Knopff et al. 2014).

Distances to public forest and to roads variables were unique in that the locations which had reported cougar-human interactions were found to be statistically closer to roads and further away from public forests. Distance to roads, specifically less busy roads in exurban areas, could be associated with increased cougar interactions because cougars are known to use low grade roads for movement (Dickson et al. 2005). In some ways, the results of distance to public forest align with the theory of Island Biogeography (MacArthur and Wilson 1967) with habitat patches representing islands in a sea of human-dominated matrix (Laurance 2008, Cook et al. 2002). Large tracts of public forest closer to well-connected suitable habitat are representative of bigger connected islands with ample habitat for carnivores to avoid humans, whereas areas farther away from the highly connected public forests provide smaller unconnected islands of suitable habitat in which carnivores are more likely to interact with people (Moss et al. 2016).

With respect to management this study has some caveats specifically limited sample size for the cougar-human interactions data used. I used reports from people as the cougar-human

interactions data which were few (low sample size) and potentially biased towards negative incidences such as depredations, and those interactions occurring when people were active on their property. Low sample sizes limited the statistical analyses I could use to further understand the role of landscape connectivity on cougar-human interactions. However, by using data from human reports for interactions instead of tracked cougars, we, albeit indirectly, involved humans living these areas in the active conservation of the cougars in the study area which is one of the future directions that will ensure successful conservation of carnivores (Dickman 2010, Treves and Karanth 2003). The agency responded to the reports of the interactions, and I have followed up by using those reports as my cougar-human interactions data. Humans living in close proximity to wildlife should be involved, whenever possible, in the studies concerning th wildlife (Treves and Karanth 2003).

4.3 Management and conservation implications

My research represents the first investigation to date examining the role of landscape connectivity in cougar-human interactions. My findings further our understanding of cougar habitat needs in human-dominated landscapes and a novel strategy for reducing the risk for cougar-human interactions. More specifically, maintaining or increasing landscape connectivity in exurban landscapes could provide a means to reduce interactions as greater connectivity facilitates cougar movement through exurban landscapes away from people (Beier et al. 2011) while maintaining stalking cover and available prey, thereby reducing the probability of cougars to depredate on livestock. Additionally, wildlife managers can use my findings to pro-actively inform relevant stakeholders of areas with a greater probability of interactions allowing urban planners, policy makers, and private citizens to implement local and regional strategies that adequately account for

carnivores and thereby reduce the potential for negative interactions. For example, urban planning that clusters new residential development within exurban areas would help to maintain landscape connectivity for carnivores while providing for human needs (Robinson et al. 2005, Maletzke et al. 2017). Providing humans with sufficient information on the likelihood of having cougar interactions on their property may also spur improved animal husbandry practices and potentially reduce depredations among humans who owns livestock and pets.

Expansion of human population into and near wild lands often results in conversion or loss of natural land types and habitat fragmentation of the remaining natural cover (Fahrig and Rytwinski 2009). Human development fragments habitats through perforation, incision, or dissecting of natural landscapes which disrupts wildlife life cycles and life process (Shrestha-Bajimaya 2012). Large carnivores dependent on the large landscapes can suffer population decline and the resulting loss of predators can have negative cascading effects on ecosystem composition and function that extend beyond the wildland-urban interface (Terborgh and Freeley 2010). It is therefore important to re-state the benefits of conserving and increasing wildlife habitat connectivity. Connected habitats provide for both highly mobile organisms to move across landscapes for short term daily/ seasonal needs and less mobile species' movement for longer term shifts in geographic range thereby enabling genetic dispersal (Fahrig 2003). Habitat connectivity provides for wildlife to acquire their needs including food and mates, and when their needs are depleted they are able to move to new habitat patches to supplement their needs. Habitat connectivity enables organisms to recolonize sink populations from source populations thereby helping naturally recolonize areas where wildlife are locally depleted (Taylor et al. 1993). Maintaining connected habitat can support a larger diversity of robust wildlife populations and species thereby increasing the species capacity to adapt to both climate and non-climate threats such as land use change and level of protection of the species (Heller

and Zavaleta 2009). Beier (2012) documented riverine habitats as valuable natural habitat connectivity features which when preserved can facilitate movement of wildlife and help wildlife to adapt to impacts of climate change. My study showed that proximity to rivers can increase the incidences of cougar-human interactions. It would be beneficial to both humans and wildlife if the riverine areas were preserved devoid of human structures and maintained for wildlife movements. Furthermore maintaining riverine natural vegetation intact has extra benefits besides wildlife movement, including maintaining cool water temperature for native aquatic species, and keeping river banks intact prevents silting of the water (Richardson et al. 2007). My study attempts to further illustrate functional connectivity for cougars in this study area although the focus was on assessing the role of connectivity in cougar-human interactions. With these benefits of habitat connectivity, therefore little downside for landscape and urban planners in maintaining connectivity for large carnivores with many benefits that go beyond just reduced interactions.

4.4 Conclusion

I explored the role of landscape connectivity in reported cougar-human interactions in an exurban setting. My findings indicated that cougar-human interactions were associated with areas of low landscape connectivity, closer distance to WUI, closer to roads, and further distance from public forests. These findings provide practical functional recommendations for wildlife managers and the public to understand where human-carnivore interactions occur and consequently prevent negative interactions by vigilantly using those areas and managing their livestock animals in those areas accordingly. This study further highlights the importance of extending conservation planning to private lands and integrating ecological principles in land-use planning and zoning decisions that maintain key habitats and the corridors that connect them (Athreya et al. 2013, DeFries et al. 2010,

Radeloff et al 2005, Treves and Karanth 2003). Preventing and solving human-carnivores with ever-expanding human residences in formerly wild areas will require landscape-level planning across ownership boundaries (Raddeloff et al. 2005) while providing practical advice to landowners that can be implemented at the local scale as provided in this study.

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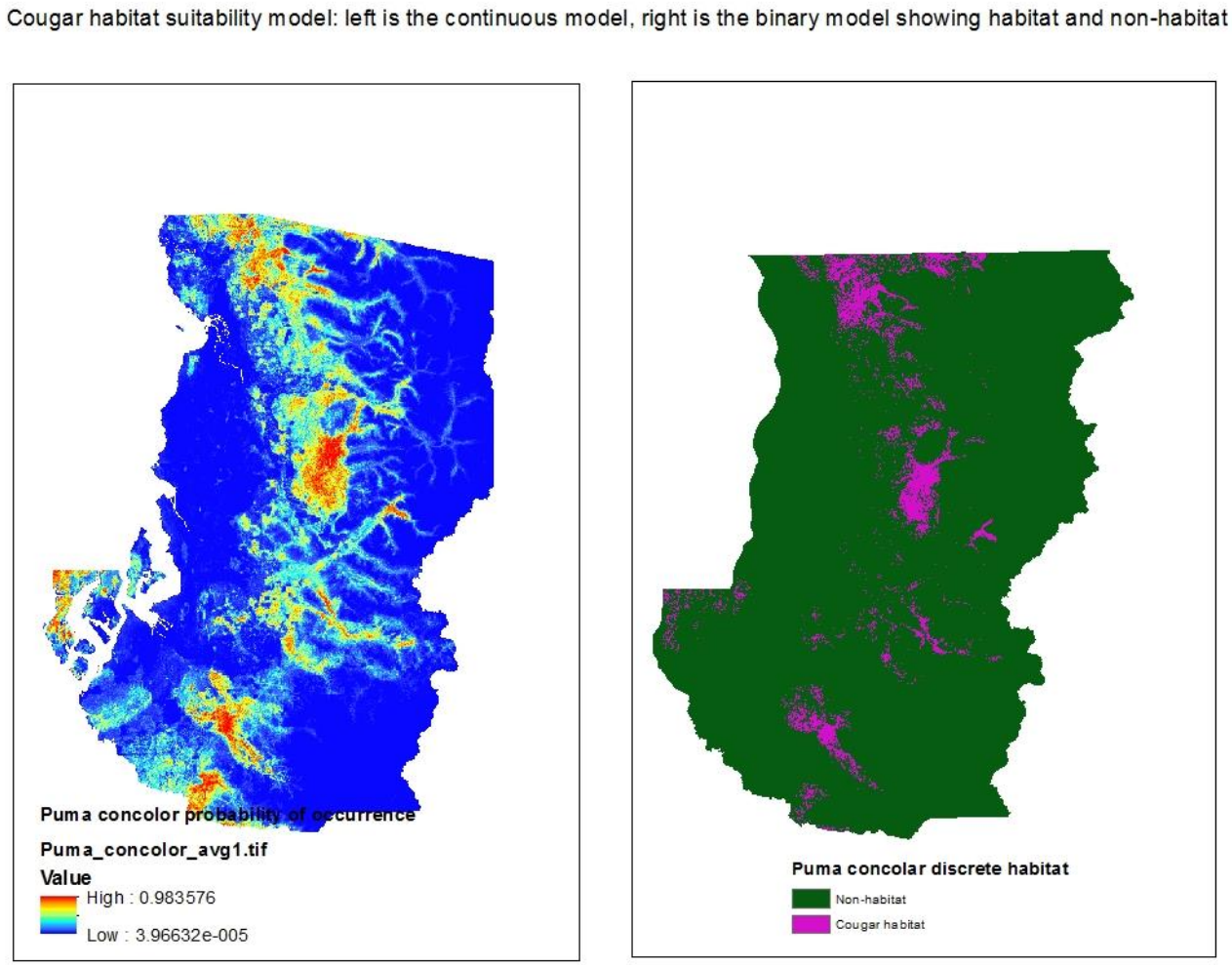
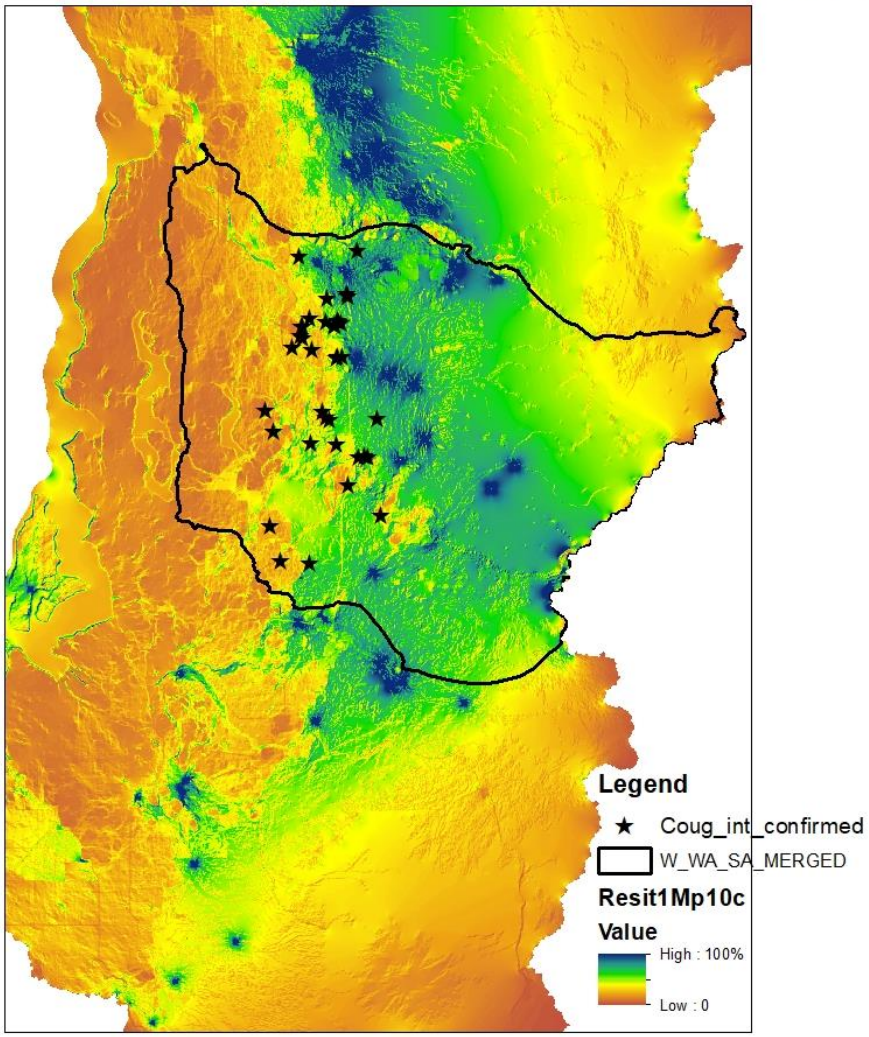
APPENDIX

Appendix A – Habitat suitability model (left) output from MaxEnt and exported to ArcGIS 10.3.0 and resampled to create 61 Habitat Concentration Areas (HCA, right)



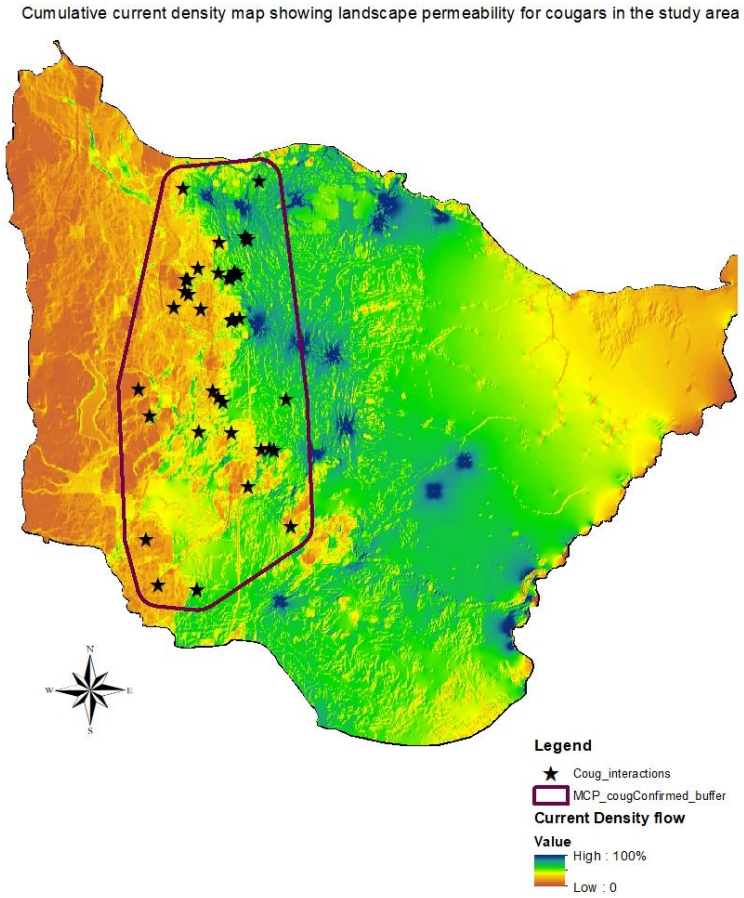
Appendix B:

Cumulative current density map from Circuitscape showing landscape permeability for cougars in western WA



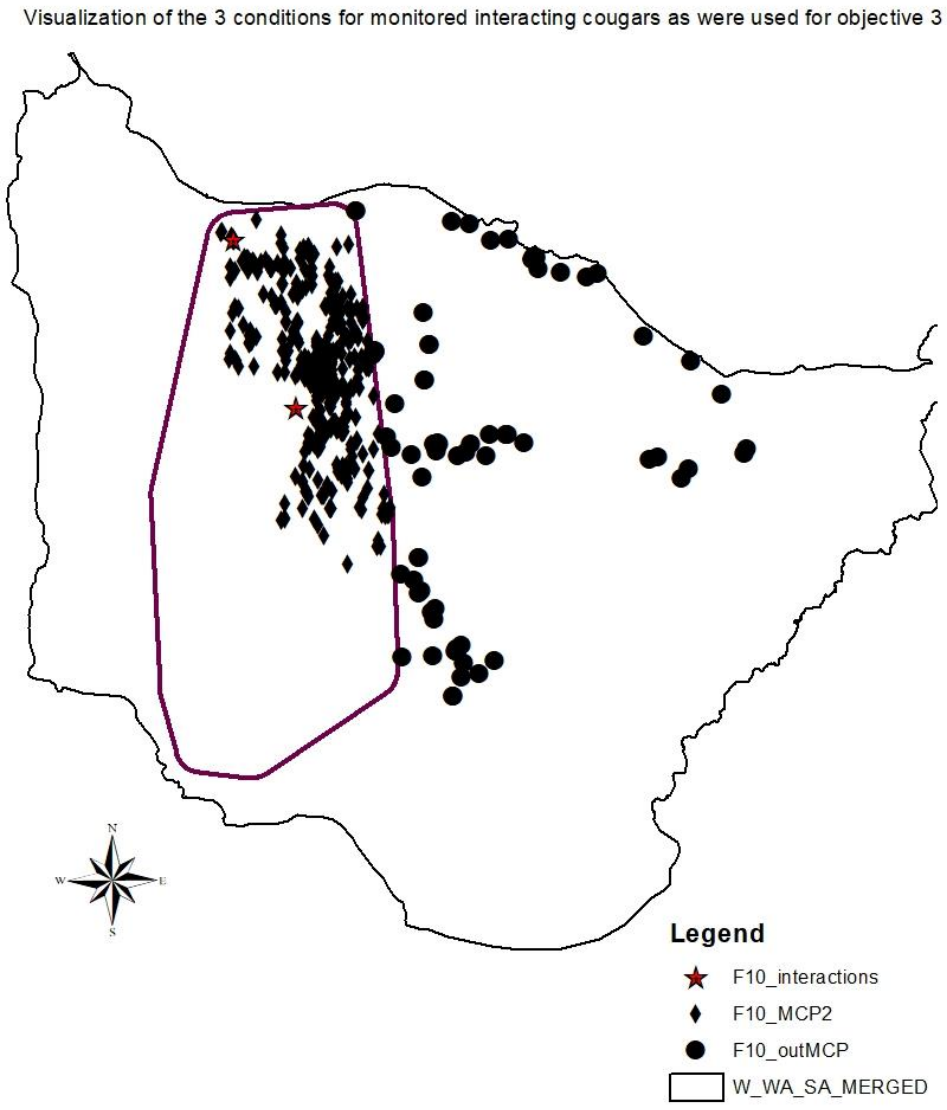
Appendix B: presents cumulative current density map created by including resistance layer and Habitat Concentration Areas for a region greater than the study area. The highest current density indicates highest landscape connectivity most commonly observed between nodes/HCAs that are close together. This is because Circuitscape tool assigns full current to habitat patches and allows it to dissipate as it moves across the resistance surface during the circuitscape run (Namrata, 2012.) The well-connected HCAs retain higher current density revealing their high contribution to landscape connectivity whereas the isolated HCAs lose the most hence low to no landscape connectivity for cougars in those areas.

Appendix C



Appendix C: Well-connected areas are most distinct in the north, moderate current density areas which reflect possible dispersal pathways for cougars to move across this landscape are most distinct in the south areas while the least connected areas are in the central region (Appendix C). The low connectivity of east and central-south region may be a result of absolute barriers such as concrete structures in cities and I-90 highway running SE direction, while presence of large tracts of Mount Baker national forest in the north section accounts for low resistance hence high landscape connectivity in the north and most of the east of the study area.

Appendix D:



Appendix D: Illustrating the design used for analyzing objective 3. MCP is the minimum convex polygon surrounding all the reported cougar-human interactions used in this study.

APPENDIX E: R script used to assess prediction 3 on whether fine-scale landscape characteristics differed for areas with and without cougar-human interactions.

```
#full dataset
library(readr)
cougars <- read_csv("RawData_DistVars.csv",
                    col_types = cols(Sex = col_character()))
names (cougars)

cougars$y <- 0
cougars$y[cougars$Location=="at_interaction"] <- 1

cougars$mcp <- 0
cougars$mcp[cougars$Location=="at_interaction"] <- 1
cougars$mcp[cougars$Location=="Inside"] <- 1

table(cougars$y)
table(cougars$mcp)

c2 <- subset(cougars, mcp==1)

yes <- subset(cougars, y==1)
summary (yes)

############################re-run analysis for inside MCP only
m0 <- glm(y~1, family=binomial("logit"), data=c2)
summary(m0)
exp(-6.2969) #probability of interaxn within mcp, from 0-1

library(ggplot2)

#H0: mean LC-value of interaction = mean LC_value of non-interaction
#two-sided test
#assume non-equal variance

t.test(LC_value~y,data=c2, mu=0, alt="two.sided", conf=0.95, var.eq=F,
paired=F)
t.test(LC_value~y,data=c2, mu=0, alt="two.sided", conf=0.95, var.eq=T,
paired=F)

t.test(Roads_dist~y,data=c2, mu=0, alt="two.sided", conf=0.95, var.eq=F,
paired=F)
t.test(Roads_dist~y,data=c2, mu=0, alt="two.sided", conf=0.95, var.eq=T,
paired=F)

t.test(othrTrspt_Dist~y,data=c2, mu=0, alt="two.sided", conf=0.95,
var.eq=F, paired=F)
t.test(othrTrspt_Dist~y,data=c2, mu=0, alt="two.sided", conf=0.95,
var.eq=T, paired=F)
```

```
t.test(Pwrln_Dist~y,data=c2, mu=0, alt="two.sided", conf=0.95, var.eq=F,
paired=F)
t.test(Pwrln_Dist~y,data=c2, mu=0, alt="two.sided", conf=0.95, var.eq=T,
paired=F)

t.test(Rivers_Dist~y,data=c2, mu=0, alt="two.sided", conf=0.95, var.eq=F,
paired=F)
t.test(Rivers_Dist~y,data=c2, mu=0, alt="two.sided", conf=0.95, var.eq=T,
paired=F)
#Distance to rivers variance is different, therefore command with
var.eq=F remains correct.

t.test(WUI_Dist~y,data=c2, mu=0, alt="two.sided", conf=0.95, var.eq=F,
paired=F)
t.test(WUI_Dist~y,data=c2, mu=0, alt="two.sided", conf=0.95, var.eq=T,
paired=F)

m3 <- glm(y~WUI_Dist, family=binomial("logit"), data=c2)
AIC(m3)
BIC(m3)
summary(m3)

exp(-5.8906848) #intercept probability of interaxn, probability =
0.00511209
exp(-5.8906848+10*-0.0004142) #probabilty as rd distace ==10m 0.00462
exp(-5.276147+100*-0.0004142) #100m probability == 0.001894791


t.test(PvtFor_Dist~y,data=c2, mu=0, alt="two.sided", conf=0.95, var.eq=F,
paired=F)
t.test(PvtFor_Dist~y,data=c2, mu=0, alt="two.sided", conf=0.95, var.eq=T,
paired=F)

t.test(PLDB_Dist~y,data=c2, mu=0, alt="two.sided", conf=0.95, var.eq=F,
paired=F)
#Distance to Public forest has unequal variance, therefore analysis with
var.eq=F holds.

##How to know if the variances are not equal, use Levene's Test
#Ho: Population variances are equal

library(car)
leveneTest(LC_value~Location, data=c2)
leveneTest(Roads_dist~Location, data=c2)
leveneTest(othrTrspt_Dist~Location, data=c2)
leveneTest(Pwrln_Dist~Location, data=c2)
leveneTest(Rivers_Dist~Location, data=c2)
leveneTest(WUI_Dist~Location, data=c2)
leveneTest(PvtFor_Dist~Location, data=c2)
leveneTest(PLDB_Dist~Location, data=c2)

m1 <- glm(y~Roads_dist, family=binomial("logit"), data=c2)
```

```
summary(m1)
m1 <- glm(y~Roads_dist, family=binomial("logit"), data=c2)
#probability of interaxn within mcp
exp(-5.276147) #intercept probability of interaxn, probability =
0.00511209
exp(-5.276147+10*-0.009925) #probabilty as rd distace ==10m 0.00462
exp(-5.276147+100*-0.009925) #100m probability == 0.001894791

m2 <- glm(y~PLDB_Dist, family=binomial("logit"), data=c3.1)
AIC(m2)
BIC(m2)
summary(m2)

m3 <- glm(y~WUI_Dist, family=binomial("logit"), data=c3.1)
AIC(m3)
BIC(m3)
summary(m3)

m4 <- glm(y~Pwrln_Dist, family=binomial("logit"), data=c3.1)
AIC(m4)
BIC(m4)
summary(m4)

m5 <- glm(y~Sex, family=binomial("logit"), data=c3)
summary(m5)
AIC(m0)
AIC(m5)


c3 <- subset(c2, LC_value < 2812) #use c3 for later models
c3.1 <- subset(c3, LC_value>608)


#####################################################################
m000 <- glm(y~1, family=binomial("logit"), data=c3.1)
m5.1 <- glm(y~LC_value, family=binomial("logit"), data=c3.1)
AIC(m000)
BIC(m000)
AIC(m5.1)
BIC(m5.1)

summary(m000)
summary(m5.1)

#m0000 intercept -6.1469
#m5.1 intercept -1.6777916
#m5.1 lc_value -0.0024975

exp(-1.6777916)
exp(-1.6777916+-0.0024975)

range(c3$LC_value)
```

```
#####################################################################
m00 <- glm(y~1, family=binomial("logit"), data=c3)
AIC(m00)
BIC(m00)
summary(m00)
exp(-6.2923) # prob 0.001850499


m5 <- glm(y~LC_value, family=binomial("logit"), data=c3)
AIC(m5)
BIC(m5)
summary(m5)
exp(-1.431516) # probability of interaxn when LC value <2812 = 0.2389464
```

Chapter 2. PARTICIPATING IN NON-LETHAL WOLF MITIGATION STRATEGIES: RANCHERS' PERSPECTIVES

ABSTRACT

In rural and exurban areas, sharing space between humans and wildlife increases interactions between these groups. Potential disruption of rural livelihoods due to large carnivores, such as wolves (*Canis lupus*), increases economic liability and fear among residents, resulting in social conflicts over wildlife issues. Nonprofit organizations and government agencies in charge of wildlife make efforts to alleviate the economic losses attributable to wolves through compensation and by recommending cost-shared non-lethal mitigation strategies to affected rural dwellers. Existing studies have recommended cost-sharing programs, but provide incomplete knowledge as to motivations for why rural dwellers (e.g., ranchers) choose to enroll in non-lethal strategies. In this study, I examine ranchers' own words and frame of reference to explore what they participated in, and why some agree to participate in mitigation strategies whereas others do not. Ranchers mentioned five broad types of mitigation strategies that include: legal measures (e.g., calling the state agency in charge of wolf management), biological measures (e.g., use of guard animals), physical measures (e.g., fences), cowboys and cowgirls, and indirect measures (e.g., husbandry practices). Ranchers mentioned that wolves were necessary for a well-functioning ecosystem and that is one of the reasons they participated in non-lethal mitigation strategies. Other ranchers cited moral obligation of humans to restore extirpated biodiversity, including wolves in the wild given their intrinsic value. The reasons ranchers mentioned for the negative attitudes towards wolf recovery included fear of wolves, and the perceived damage that wolves will have on their lives. Many ranchers did not approve of government participation in wolf management. I suggest that in addition to providing economic benefits of the mitigation measures, wildlife managers should address the intangible social costs that are more likely to deter ranchers'

participation in mitigation strategies through continued dialogue and discussion. This study provides information that can be used by managers to design interventions and solicit participation in interventions based on the in-depth information that may be used to increase wolf-livestock coexistence on shared landscapes.

1. INTRODUCTION

In rural areas where humans' livelihoods and lifestyles share space with wildlife, large carnivores have the potential to disrupt livelihoods such as ranching. This potential increases economic liability and creates fear among residents, resulting in social conflicts over wildlife issues (Frank 2016, Manfredo et al. 2017, Redpath et al. 2013). Conservation of carnivores such as wolves (*Canis lupus*), is often based on the notion that they are important because they provide ecological value on the landscape (Beschta and Ripple 2009, Newsome et al. 2015, Prugh et al. 2009, Wirsing et al. 2012), intrinsic value (Soulé 1985, Vucetich et al. 2015) and cultural values (Chan et al. 2012, Naidoo and Adamowicz 2005, Nie 2002). However, because of the likely threats to rural livelihoods, nonprofits and government agencies in charge of wildlife have made efforts to alleviate loss due to wolves through a number of ways including monetary compensation and recommending non-lethal mitigation strategies to affected rural dwellers (Linnell et al. 2001, Ravenelle and Nyhus 2017, Treves et al. 2016).

Mitigation is defined as the process of diminishing negative consequences of wildlife while maintaining or enhancing their positive aspects (Woodroffe et al. 2005). Previous studies have sought to understand how effective mitigations are based on expert understanding of carnivore population ecology, and have recommended physical preventative strategies to reduce depredation (Karanth and Sunquist 1995, Wagner and Conover 1999, Graham et al. 2005), as well as quantifying costs (Muhly and Musiani 2009) and compensating for the economic loss (Dickman et al. 2011, Karanth et al. 2012, Wagner et al. 1997). In addition to ecological methods, researchers have utilized interdisciplinary studies that engage sociology and psychology to understand the human-dimensions of interaction with wildlife and what would motivate ranchers to participate in various management measures (Hill 2015, Manfredo 2008, Kansky and Knight 2014, Nyhus 2016,

Drinkhouse 2018). Implementation of non-lethal mitigation strategies has been documented as effective in reducing livestock damage (Kansky and Knight 2014, Scasta et al. 2017, Treves et al. 2016) although other studies reported ineffectiveness of such mitigation strategies (Eklund et al. 2017). One motivation for implementation of these non-lethal mitigation measures includes cost-shared programs so as to incentivize ranchers to participate (Bruskotter 2013, Drinkhouse 2018).

Cost-sharing of technical and financial resources to help ranchers adopt and implement non-lethal measures may motivate ranchers to participate in nonlethal measures (Drinkhouse 2018, Eadie 2018). However, our understanding about rural people's perception of cost-shared mitigation strategies and why certain mitigations are actually adopted over others is poor (Dickman 2010, Kansky and Knight 2014). Existing studies have recommended cost-sharing programs but provide incomplete knowledge as to motivations for why rural dwellers (e.g., ranchers) choose to enroll in non-lethal strategies. Studies that stop at recommending cost-sharing programs provide incomplete knowledge about why rural dwellers would enroll in those cost-sharing programs or not, and are therefore insufficient to increase participation in mitigations. In this study I extend knowledge on rancher participation in non-lethal measures by investigating the perspectives of ranchers towards participating in cost-shared non-lethal strategies.

With the recent return of wolves to the state, ranchers in Washington provides an opportunity to investigate perspectives about cost-shared mitigation strategies to increase coexistent with these native carnivores. Wolves naturally returned to areas of Washington from Idaho and British Columbia, Canada after being extirpated for more than 70 years (Wiles et al. 2011). The first successfully breeding wolf pair was recorded in 2008, and by the end of 2017 there were 22 recorded wolf packs comprising an estimated 122 wolves in the state (WDFW et al. 2018). Areas now with wolves coincide with those supporting beef cattle ranching, so their recovery has also been a source

of contention over livestock depredations. Some ranchers lease public lands to graze their livestock; but large private ranches provide open spaces which can be used by wildlife including wolves. As such, wolves and livestock share the landscape and wolves sometimes depredate on livestock. Livestock depredations can threaten the affected rancher's livelihood (Muhly and Musiani 2009) and contribute to negative attitudes towards carnivore species because ranchers perceive wolves as threats. Historically, ranchers reduced chances of depredations by lethally removing carnivores from the landscape (Treves and Naughton-Treves 2005), but with the changing lifestyles and demographics of the US population as well as the recovering status of wolf populations, killing of wolves is no longer preferred by the public as a wildlife management tool (George et al. 2016). Contention over lethal control has led to conflicts over wolf management and polarization of attitudes towards wolves (Mazur and Asah 2013, Treves et al. 2013). Whether these contentions are realized or perceived, they have resulted in conflicts over wolf management and attitudes towards wolves on public lands have been polarized (Mazur and Asah 2013, Treves et al. 2013).

The Washington Department of Fish and Wildlife (WDFW) is responsible for recovering wolves in the state of Washington and as such discourages ranchers from killing wolves and encourages use of non-lethal strategies to mitigate depredations. To encourage ranchers to implement non-lethal strategies, WDFW invited ranchers to sign a Damage Prevention Cooperative Agreement (DPCA) that enrolls them in a cost-sharing program that would provide financial and technical resources for the implementation of non-lethal measures that prevent wolf depredations. In addition, Washington State compensates ranchers for losses/damages due to wolves (WDFW et al. 2018). Despite these efforts, many ranchers are reluctant to participate in this cost-shared program.

For example, at the end of 2017 only 37[1] out of more than 8420 livestock ranches (Census of Agriculture 2012) had signed a DCPA (WDFW et al. 2018). This low participation demonstrates the discrepancy between mitigation efficiency and mitigation adoption (Miller et al. 2016). I aim to understand what affects ranchers' participation in cost-shared mitigation strategies to help foster human-wolf coexistence, which is a key step in conserving wolves (Manfredo and Dayer 2004).

I anticipate that through a better understanding of the motivation and needs of ranchers, more informed decisions can be made by both ranchers and the agencies that seek their participation in these cost-shared non-lethal mitigation programs. I shed light on the problem by addressing the following research questions: (1) What do the ranchers feel about the current return of wolves to Washington State? (2) What mitigation strategies are currently utilized by ranchers in Washington State? (3) What motivates ranchers to use their mitigation strategies? And (4) What discourages ranchers from participating in mitigation strategies? By understanding what affects participation we can consequently be able to address how to reduce the discrepancy between mitigation efficiency and adoption.

[1] By end of 2017 there were 37 DPCAs signed with ranchers, but by mid-2018 writing of this paper current number of DPCA is 31. This number fluctuates because ranchers can choose to leave the agreements at any time. One of the reasons the ranchers leave the agreements is when the wolf pack close to them is removed and they therefore find no use in remaining in the agreement if they no longer have to share the landscape with nearby wolves.

2. METHODS

2.1 General Approach

In order to explore in-depth the ranchers' perspectives about mitigation strategies to coexist with wolves, I used non-directive interviews. I adopted this qualitative research design because I assumed that our understanding of wolf recovery and mitigation measures to increase human-wolf coexistence might differ from those of the ranchers who live and work locally on the landscape shared with wolves. Quantitative studies are more limited in revealing the social context and nuanced responses of the participants because survey questions have a priming effect on the respondents (Asah et al. 2012, Krueger and Casey 2000). The explorative nature of qualitative approaches can reveal the social context of ranchers' attitudes and motivations allowing beliefs to emerge that would otherwise be missed by the researcher (Krueger and Casey 2000, Schüttler et al. 2011). I used Grounded Theory (Charmaz 2014) to relate the observed patterns in the responses to broader themes that better explained the data. Grounded Theory is a qualitative data analysis method with systematic guidelines for gathering and analyzing data to generate theory from empirical data such as interviews (Charmaz 2014). The analytic process consists of comparing, coding, developing, checking the data and integrating it into theoretical categories. During the coding of the data certain responses that appear more frequent that others are assumed greater analytic power than less frequent responses. These frequent responses can form the middle-range theories induced from the raw interview data, however less frequent responses are also important as they provide additional nuance and richness to this study method. Grounded theory methodology is appropriate for investigating uncharted areas or to gain a fresh perspective on a familiar situation (Corbin and Strauss 2014). More detail about how I utilize grounded theory process in this study area explained in the data analysis section 2.3.

2.2 Recruitment and interviews

I recruited participants by first contacting the presidents of the Washington Cattlemen's Association and Stevens County Cattlemen's Association. I contacted them by phone, briefly explained my study, and sought their participation and that of their members to be interviewed at a place and time of their choosing. Additionally, I recruited ranchers using a snowball method (Goodman 1961), whereby an interviewee recommended people who I subsequently recruited and interviewed. Some ranchers were contacted directly from information provided on their websites. I scheduled interviews at the date, time and venues suggested by the ranchers so as not to disrupt their work schedules, and to ensure that they had time to be interviewed unhurriedly.

I developed a list of questions about wolves and mitigation strategies, and pretested the questions for relevance and appropriateness prior to implementation in the field (Kvale and Brinkmann 2008) with two ranchers outside the study area in Idaho and Montana. After pretesting and revising the questions, I developed the interview script outlining the main questions that we asked the ranchers. Questions answered in this study were part of a longer interview script (Appendix A). This study was approved by the Institutional Review Board (IRB) at the University of Washington (Human Subjects Division study #45684).

Eligible participants read and signed an informed consent form (Appendix B) with the understanding that there was no monetary compensation for participation. I encouraged ranchers to participate in the interviews because their opinions would contribute to the discussion about wolf recovery and conservation in Washington. Interviews were audio recorded. During the interviews I recorded rancher demographic information including age, gender, and location by county. Other rancher characteristics recorded included the size of the ranch, the type of operation, whether they graze on private or public land or both, whether they had experienced any wolf interactions by 2013,

and finally whether their children would inherit the ranching operations for the future. All rancher characteristics are summarized in (Appendix C). I interviewed ranchers until theoretical saturation was reached (Charmaz 2014, Saldaña 2015). Theoretical saturation is the phase during qualitative study in which the researcher has continued sampling and analyzing data until no new data appears i.e. the new respondents are not giving any additional new information (Charmaz 2014).

2.3 Data Analysis

All interview recordings were transcribed verbatim (Poland 1995) and analyzed with NVivo v.11 (QSR International Pty Ltd 2014). Prior to coding all the interviews, two researchers coded a sample of interviews to test inter-coder reliability of the interviews. Using the *Coding Comparison Query* in NVivo v.11, I determined the intercoder reliability *Kappa* coefficient for the data to be >96% across the two coders, meaning their understanding and coding of the data were consistent and reliable, and then I proceeded to code the rest of the interviews. NVivo software allows for the grouping and organizing of data across themes, individuals, and groups (i.e. coding) which is a valuable process in Grounded Theory. Coding is a system of classification, a process of noting what statements are of interest with respect to a specific question, identifying the phrases, sentences and paragraphs that convey similar response to each question, and then grouping them under labels (called codes) to organize the data into researcher-generated themes/constructs (Saldana 2015, Bazeley and Jackson 2013, Bloomberg and Volpe 2016). A code is a construct or theme that attributes meaning to the data phrases contained within that specific code, and codes are what are used for detecting patterns, categorizing data and building theories out of the data (Bloomberg and Volpe 2016).

I used inductive data analysis process of Grounded Theory (Charmaz 2014). Inductive data analysis begins with a wide range of individual interviews from which the researcher forms patterns that form the foundation of the themes used to answer the research question. After reading and re-reading the interview data, I coded/grouped together similar responses categorized either as positive or negative responses toward participating in cost-sharing program offered by the wildlife agency. These broad groups of responses are termed 'narratives.' Narrative is a story that emerges from the critical look at codes of repeated or similar responses to the question (Charmaz 2014, Ryan and Bernard 2003). Interpreting the meaning of each narrative and merging the narratives that have a similar meaning results into new categories which are termed as constructs. A construct is the meaning of, or the reason why several narratives are grouped together in the same category (Ryan and Bernard 2003). Patterns of constructs based on either similarity or differences among respondents are grouped together into themes. Themes can be broad or specific depending on the needs for the study (Ryan and Bernard 2003). I formed themes that were broad to include the constructs that linked several narratives to a single meaning. Themes can be used to form middle-range theories and are comparable to literature on similar studies (Charmaz 2014). An example of how I conducted inductive Grounded Theory analysis to form themes that are reported in my results in this research chapter is as follows:

> *Interview question example*: what is your experience using cost-shared mitigation strategies to prevent depredation from wolves?
> *Responses*: these include several narratives about the question asked. For example a rancher mentions an experience where they encountered a wildlife official walking on their property without permission and the official was not apologetic about the trespassing because he was doing official state work, that rancher decided then that they don't want to ever work with wildlife officials. Another rancher mentions hearing of how unsocial wildlife biologists are compared to forest service officials and prefers interacting with forest service officials than wildlife. And another rancher mentions that they met one friendly wildlife official who was very helpful in explaining how the collared wolves' data was being used, this rancher thinks they can enroll in a program that official recommends to them.

> *Constructs*: this is the deeper meaning that the researcher sees emerging from the narratives above. In this example ranchers seem to care about the previous experience they have had with wildlife officials and that seems to determine whether they would participate in cost-shared programs with the department or not.
> *Theme(s)*: the broad meaning of the constructs which encompasses the narratives and can be compared to other similar themes in the literature. In this example the theme is that social interactions between agency and ranchers affects whether the rancher enrolls to participate in wildlife sponsored cost-shared programs.

During the initial coding I used the open-coding process whereby I read and re-read the text line-by-line to determine whether text was meaningful to our understanding of what motivates and constrains ranchers' participation in mitigation strategies. I organized all 1408 pages of transcribed interviews into 154 codes. As the analysis progressed, I compared the different codes for content and meaning and then merged, revised, or excluded some codes to better represent the interpretation of the coded text fragments results in a total of 120 codes.

In the next round of analysis, I used the *Query tool* in NVivo to contrast the ranchers' coded responses to the research questions and to rancher demographic attributes (shown in the Classification sheet Appendix C). Querying the response codes enabled us to identify relationships, attempt to recognize logic to connect them, and realize emerging patterns from the data about what ranchers felt about wolves and mitigations to better coexist with wolves.

3. RESULTS

In this study I used ranchers' own narrative to explore their perspectives about non-lethal strategies to better coexist with wolves and about their participation in WDFW's DPCA. I interviewed 45 ranchers in Washington State using 27 key informant interviews and four focus group interviews between August 2013 and May 2014. All ranchers were older than18 years of age and included both men and women, all representing separate households. Where the interview respondents were wife and husband, they felt the same way about the wolf issues and were thus counted as a single respondent. The number of ranchers interviewed from each county was as follows: Kittitas (n = 11), Okanogan (n = 7), Spokane (n = 1), Stevens (n = 18), Walla Walla (n = 1), and Yakima (n = 7). The interviews ranged in duration from 35 to 159 minutes (Appendix C). The majority of ranchers interviewed were 55 to 65 years old; 10 were below the age of 45, 12 between 45 and 55 years old, 14 between 55 and 65, and 9 above 65 years old. Eighty percent (n = 36) were males whereas 20% (n = 9) were females. Most of the ranchers were at least third generation ranchers (29/45); eight ranchers each from first- and second-generation ranching families were interviewed.

In summary: I found that the motivations for participating included: (i) previous positive interaction with wildlife agency staff; (ii) clearly outlined actions guided by the agency on how to deal with wolves; (iii) strategies that improved or encouraged what ranchers were already doing to coexist with wolves e.g. guard dogs, fences and cowboy/girls; and (iv) measures that focused more on wellness of the livestock than on wolves. The barriers included: (i) disdain for regulation both regarding the Federal Endangered Species Act, and Washington State's regulations required to get compensation; (ii) perception that by participating in nonlethal strategies ranchers give up all rights to use lethal-control even when need to; (iii) insufficient monetary compensation; (iv) unpleasant

past experience with wildlife agency staff; (v) added economic cost of implementing the new strategies (e.g., purchasing, training and feeding new guard dogs); and (vi) logistically challenging strategies (e.g., fencing around large grazing allotments or having range-riders riding at night). Ranchers suggested two enhancements that would increase their participation in non-lethal strategies: (i) working with or in collaboration with local agriculture-related agencies, and (ii) streamlining the compensation process.

3.1 Attitudes of ranchers towards the current return of wolves to Washington State

Ranchers had a range of attitudes towards the return of wolves to Washington from positive and tolerant to negative and completely intolerant. Many of the ranchers interviewed were opposed to the recovery of wolves in Washington, citing various reasons including fear and the inconvenience wolves would bring to their ranching lifestyles. Most of the ranchers felt that the return of wolves was an inconvenience that they wished they did not have to deal with but could tolerate unless they depredated their livestock. Some ranchers were positive and accepted that wolves were recovering in the wild in Washington and did not mind coexisting with them. Some ranchers mentioned that while they do not want wolves on their ranch they were tolerant of the wolves recovering in the wild. Qualitative method of analysis revealed a wider range of attitudes of what ranchers felt about wolf recovery, similarly Browne-Nuñez et al. (2015) documented that qualitative focus groups revealed positive attitudes which are missed in survey questionnaires.

Among the ranchers I interviewed, those who were more tolerant of the wolves had small- to medium-sized ranch operations, and some of them were also ranching as their second profession in retirement. Few large operation ranchers who were more willing to tolerate wolves had experienced wolf interactions on their ranches, whereas the most intolerant ranchers had never had direct

experience with wolves on their ranches. Notably, I found that ranchers with large operations and who had been ranching for multiple generations and were dependent on ranching as their business and only source of income were least willing to participate in mitigation measures. Reimer et al. (2012) documented that farmers who were more focused on economic profitability were less likely to participate in conservation strategies.

Ranchers mentioned that wolves were necessary for a well-functioning ecosystem, which helped inform their positive attitudes towards wolf recovery and participation in non-lethal mitigation strategies. Other ranchers cited the moral obligation of humans to restore extirpated biodiversity including wolves in the wild for intrinsic value that wildlife have. The quotations below depict the positive attitudes ranchers had towards wolves:

> "*The reintroduction. Well [pause] that's pretty important to re-establish a natural ecosystem, but that can't be just the wolves you've got to have the elk and even the beaver...create an ecosystem in the creeks and river valleys.... and when you restore the deer and the elk, the grazing animals will defeat it unless you have wolves to keep them dispersed and moving.*" [Respondent 19, November 2013]

> *"I think is a good thing. They were here for many centuries I assume, and there is lots of habitat for them here and of course not as much as there used to be so I personally think that it is a good thing that wildlife exists in as many places as possible especially if it used to, and it is too bad that it was brought to such close to extinction from their normal land, due to probably more than just misunderstanding in our State than anything else."* [Respondent 1, August 2013]

The reasons ranchers mentioned for the negative attitudes towards wolf recovery included fear of wolves, and the perceived damage that wolves will have on their lives. Many ranchers did not like that the government was involved in wolf management. The following quotations portray the negative attitudes that ranchers held towards the return of the wolves in Washington State:

> *"We cannot coexist! There's no coexistence. If somebody's trying to kill you, you cannot let them do that! You either kill him or he's going to kill you. That's what this wolf is going to do to us. And it was probably, who knows why they brought them back.* [Respondent 34, November 2013]

> *"So, it's really about all of that government, you know, overshadowing everything. To me, that, there's nothing to do with the wolf itself, even though the wolf tends to, you know, it's a pretty vigorous species. So it's definitely a threat."* [Respondent 39, November 2013]

3.2 Mitigation strategies that ranchers in Washington are using: motivation and constraints

Almost all ranchers we interviewed implemented some form of mitigation strategy to protect their livestock from predators, including wolves. None of the ranchers interviewed practiced nor knew anyone who used lethal control to mitigate for wolf depredation. Ranchers mentioned five broad types of mitigation strategies that included: legal measures (e.g., calling WDFW), biological measures (e.g., use of guard animals), physical measures (e.g., fences), cowboys and cowgirls, and indirect measures (e.g., husbandry practices). The mitigation measures are not exclusive to each rancher; that is, a single rancher could discuss and participate in none, one or a combination of more than one of the strategies.

Working with State Officials

The most common mitigation strategy ranchers mentioned was to contact the Washington Department of Fish and Wildlife (WDFW). Informing a WDFW official of an incident mitigated conflict in two ways: one, the department was expected to translocate or eliminate the offending wolf; and two, in case of a depredation the department provided compensation to cover their monetary loss. Some participants discussed compensation as one of the existing mitigation strategies, however, only one had actually received compensation, another had refused the

compensation and the remaining never experienced any depredation that required compensation. Ranchers identified several positive aspects of contacting state officials. They participated with WDFW to show support for the Department's willingness to reduce ranchers' economic losses due to wolves. Some ranchers considered compensation an advantage because it covered the direct economic loss of livestock due wolves. Furthermore, ranchers who signed the Damage Prevention Cooperative Agreement (DCPA) with WDFW found it to be an advantage because it offered a step-by-step protocol that ranchers could follow to protect their livestock. Some ranchers referred to the depredation of cattle in Steven's County by the Wedge Pack in 2012 as an example of the advantage of reporting wolf incidents to WDFW because the Department eliminated this pack. By removing the pack, the ranchers perceived this as a sign that the WDFW was to some extent attentive to the ranchers' plight and acted in the ranchers' favor. This act by WDFW was perceived by some ranchers as positive past experience with the ranchers.

Some ranchers felt that it was too much government regulation in their day-to-day affairs telling them how and when to manage their ranch, for example, by recommending the age at which ranchers should release their cows out to graze or what type of cowboy they should hire. Some ranchers felt that agreeing to the recommended non-lethal measures prescribed by the DPCA would reduce their ability to utilize lethal control when needed. Some ranchers noted that there were many endangered species affecting the ways they managed their ranches and grazing lands (e.g., spotted frog, *Rana pretiosa*, and bull trout, *Salvelinus confluentus*) and that mitigation for wolves would encourage more restrictions and regulations on behalf of these other species.

Another major reason some ranchers did not contact WDFW after a wolf incident was inadequacy and difficulty in obtaining compensation. Ranchers reported that the compensation value given for lost livestock was insufficient to cover the actual impact, for example weight loss

caused by reduced grazing in the presence of wolves. Ranchers further cited regulatory burden and elaborate paperwork as a deterrent to contacting WDFW. For example, in response to suspected depredation, ranchers are required to file an account and treat the location as a criminal site. Finally, previous working relationships between ranchers and state agency officials influenced reporting. Ranchers referred to past experiences where reported depredation incidents were either overlooked or ignored by WDFW officials. These past interactions produced a lack of trust of the WDFW and a reduction in reporting incidents. Some ranchers preferred working with local existing agriculture-related agencies such as the farm bureau, conservation districts or county commissioner's offices. The following quotations illustrate the perceptions ranchers held about reporting wolf incidents to WDFW:

> "*This wolf management shouldn't come up from officials in the State, they all divert us all off to a side road every time. It's got to be either individuals or small groups or better yet, far better is our county commissioners and our local elected officials take care of it.*" [Respondent 30, November 2013]

> "*For ranchers to be willing to accept them (wolves), I think a compensation program were it would pay for any wolf kill. But that program and process has to be streamlined. Boom! Done. If there's paperwork and conversations then and a couple meetings and phone calls, it is just going to be more screwing around than I think most people would want to contend with. Certainly more than I would want to contend with.* " [Respondent 1; August 2013]

Use of guard animals

Ranchers cited the use of guard dogs as their primary mitigation strategy. Some ranchers actively kept guard dogs or cattle dogs that were used to protect their livestock at all times, whereas others suggested that they would get a guard dog when wolves recolonize areas near their properties. Some ranchers also had llamas (*Llama llama*) or donkeys (*Equus asinus*), which acted as guard animals in case wolves came near their ranches.

Having guard animals was easy for ranchers because they often maintain these animals for a variety of ranch duties besides preventing wolf depredation (Scasta et al. 2017). However, the financial cost of purchase, training and maintaining new guard animals is substantial and entirely borne by the rancher (Gehring et al. 2010). Ranchers also feared that their dogs could hybridize with wolves, which would cause complexities in the local wolf population. Some ranchers were wary about the possibility of domestic stray dogs in the community forming packs with cattle dogs and together depredating smaller farm animals such as chickens and lambs, while others worried that wolves would kill their guard dogs.

Physical barriers (e.g., fences)

Ranchers regularly constructed and modified fences to reduce predation by carnivores, such as coyotes (*Canis latrans*), and several believed that these structures would also help deter wolves. For example, one rancher constructed a modified fence to protect free-range chickens from predators by extending the fence-wire vertically and horizontally several feet underground thus the modified fence prevented canids from digging below the fence to prey on the chickens. Ranchers who had sheep operations mentioned that they used fences effectively to graze their sheep while protecting them from predators. Other physical deterrents were often mentioned, such as having bells on cows that would frighten wolves and allow the rancher to better track his/her stock. Other mitigation measures that were suggested but not currently implemented by any of the interviewed participants included: fladry, Radio Activated Guard (RAG) boxes, and lethal control (Bangs et al. 2006, Brown 2011, Shivik 2006).

Ranchers were motivated to have physical barriers such as fences that are easy and effective for some types of livestock operations, such as chicken rearing and sheep herding. Most small- to

medium-sized ranches already had fences in place, so it was easier for them to improve on the existing fences than build completely new fences. However, ranchers mentioned that implementing specialized fences to prevent negative interactions with wolves would require increased operating costs and time incurred on the ranch, thereby reducing their already meager profits.

Cowboys, cowgirls and ranch hands

Another mitigation strategy mentioned was the employment of cowboys and/or cowgirls, commonly known as ranch hands. The primary purpose of these ranch hands was not always to deter wolves, but to help with the daily activities on the ranch. Ranch hands rode horses to check on the livestock out in the allotment(s), and as they ran the day-to-day affairs of the ranch, they kept wolves and other predators away from the livestock. Some ranchers occasionally hired a cowboy/girl to ride the ranch when they thought there might be predators on the land. The hired hands rode at least once to several times a week and regularly checked on the livestock to ensure that predators did not prey on them.

In addition to ranch hands, WDFW and NGOs offered range rider programs for which they solicited the ranchers' participation. A range rider is an individual who keeps a constant presence, either through riding a horse or driving an ATV, on a landscape where both wolves and livestock occur in order to reduce wolf-livestock conflicts (Parks and Messmer 2016). If a rancher agreed to have a range rider on their ranch, the WDFW would provide the range rider with real time locations of wolves so that the range rider could keep the wolves and cows apart. Two WDFW/NGO-supported range-rider programs were active among the ranchers we interviewed while one rancher had discontinued the program on his ranch.

Ranchers were motivated to use cowboys as a mitigation strategy because it was already part of their cultural lifestyle and livelihood. However, some challenges to this strategy were noted, including: riders cannot be with the herd at night when wolves often hunt, the difficulty of navigating forested mountainous landscapes, and the potential habituation of wolves to non-threatening ranch hands. Some ranchers stated that they did not need to ride because their operations were small enough for them to respond quickly by ATV to the threat of a wolf in their livestock. Some ranchers despised the use of the term 'range rider' rather than cowboy, perceiving this as an appropriation of the ranchers' culture by environmentalists as expressed in the quotation below:

> "*No, we don't have range riders. Not really no, but I have people that help with the livestock, and they were up there helping at the time they saw them go across. …cowboys, when you need to get your cattle in, off the pasture wherever they are, the cowboys come and help gather the cattle and bring them up to the corrals.*" [Respondent 5; September 2013]

Some ranchers stated that government-led programs including the range rider program were less favored than locally-led ones. For example, the rancher who quit the range-rider program mentioned that they had been on the WDFW DPCA program in 2012 but had decided to discontinue their participation in DCPA and thus giving up access to wolf GPS-collar data in 2013 because they did not trust the intentions of the WDFW and did not want to work with them anymore (the rancher continued riding in the traditional way without GPS data guidance).

Husbandry practices

A few ranchers mentioned that they employed specific husbandry practices that reduced the likelihood of depredation. For example, rotational grazing is a husbandry practice where cattle are temporarily constrained to a specific paddock of pasture for a period of time, and after grazing that paddock are moved to another paddock, eventually returning to the first paddock with newly grown

pasture (Butterfield et al. 2006). This is different from where cattle are allowed to freely graze the entire allotment without restriction (Butterfield et al. 2006). Keeping cattle in a smaller area enables the rancher to inspect his/her herd more frequently and monitor the conditions of his/her cattle more closely. Other ranchers waited until their calves reached an ideal heavier weight before releasing them to the summer grazing allotment in order to increase the calves' chances of defending themselves against wolf attacks thereby reducing negative interactions with wolves. The ranchers mentioned that bigger calves have a higher chance of surviving the wild allotment, can run faster, and thus have a better chance of defending themselves against wolves than smaller calves. One rancher mentioned that he raises aggressive cow breeds that are able to defend themselves and their calves from wolves.

Ranchers were motivated to do husbandry practices focusing on the wellness of their livestock instead of confronting wolves, and ranchers seemed to be more willing to implement these measures than others. Some ranchers mentioned that as they increased vigilance over their livestock, it enabled them to remove the sick and injured animals and return them to the safety of the ranch, thereby reducing livestock losses (Parks and Messmer 2016). Such as the ones who expressed these quotations:

> "*...here* [referring to the geographical area] *if you want to be a good rancher in top rate with good animal husbandry you bet, a lot more time you spend with cattle. And in course of doing that you run out horse shoes, burning gasoline or diesel whatever you know, and ah, if you got a very big territory, and they are bothering you real bad you need an extra man to be there with them*" [Respondent 31, November 2013]

> "*I get nervous if I don't see them for too long of a time it's like what are they doing so and with the wolves now it's just made us just a little bit more cognizant of showing up and making sure everybody's doing alright. To see if there's anybody weaker or slower and so cattle run and probably stepped in*

> *somewhere and had a hurt ankle, we kind of just look for that and then you know. And then if anybody is vulnerable then we'll try to get them. Our idea is either really keep a close eye on them and try to check those cattle closer or try to bring an animal that might look a little slower than the others, try to bring them back a little closer to the house or something.*" [Respondent_49, November 2013]

A few ranchers mentioned that they participated in farm tours and horse-riding tours to increase customer involvement and thereby prevent wolf presence on their ranch. Ranchers who mentioned farm tours were small-sized boutique/hobby farms and had regular farm tours for their clients. Their clients could participate in picking fruit or seeing how chickens and other livestock were managed on a day-to-day basis. Some ranchers regularly invited hunters on their ranch to hunt for deer and elk, and one participant invited recreationists to ride horses on their dude ranch. This mitigation practice allows ranchers to focus their attention on livestock and the ranching operations while the tourists increased human presence that deters predators. This improved the quality of the livestock while earning extra income for the rancher.

4. DISCUSSION

Sharing the landscape with wildlife, and especially large carnivores, can threaten human safety, destroy property, and instill fear and psychological anxiety in rural residents and recreationists (Peterson et al. 2010). Negative interactions between people and wildlife also increase interpersonal tensions resulting from disagreement over how to manage problematic wildlife thus human-human conflicts over wildlife management (Dickman 2010, Hill 2015, Madden 2004, Marshall et al. 2007). Indeed, we found these human-human disagreements over wolf management were common themes among ranchers who are now living with an expanding wolf population in eastern Washington. Among the ranchers we interviewed, wolves were viewed as divisive of rural community relations, turning ranchers against each other when they did not have a consensus on how to coexist with wolves.

In this study, I found that ranchers' motivations as well as barriers for participating in mitigation strategies included both sociopolitical and economic factors. An example of a sociopolitical barrier, ranchers avoided participating in WDFW programs because they did not want government interference on their ranch. Similarly, Inskip et al. (2014) documented that people in the Sandarbans, Bangladesh, were more likely to retaliate and kill tigers (*Panthera tigris*) because of socio-psychological factors including values, history and ideologies, risk perceptions, and perceived failings of the local wildlife authorities, than because of actual loss of livestock or damage to people. Economic and technical barriers are tangible costs whereas social and political barriers are intangible costs (Kansky and Knight 2014). It is more common and easier for government agencies and NGOs to address the quantifiable tangible costs like depredations damage through cost-sharing or compensation programs than to address intangible social costs (Nyhus et al. 2003). However, it has been shown that intangible costs cause significantly higher negative consequences for human-

wildlife interactions than tangible costs (Kansky and Knight 2014). Intangible costs, for example when ranchers feel that having to coexist with wolves will get them ostracized by their neighbors, contribute to the ineffectiveness of tangible solutions like enrolling in the Damage Prevention Cooperative Agreement to receive cost-shared assistance to coexist with wolves. Furthermore, Naughton-Treves et al. (2003) found that paying for the cost of depredation did not improve attitudes towards wolves in the US mid-west. Wildlife managers should realize that compensation may not improve attitudes towards wolves, and that providing tools that reduce wildlife damage is not the only factor that affects whether or not ranchers adopt mitigation measures (Redpath et al. 2015). It is important too for wildlife managers and NGOs to consider and address the socio-political factors that may influence ranchers' participation when soliciting rancher participation in mitigation programs. The Washington Department of Fish and Wildlife employs conflict specialists to address social conflicts (WDFW et al. 2018). This is a good start that could be enhanced by collaborating with agriculture agencies that ranchers trust and work with routinely.

There are two findings that contradicted the constraint/deterrents that ranchers gave against participating in cost-shared programs. One, the role of monetary contribution to encourage the ranchers to enroll in the programs. Although some ranchers mentioned that they did not want monetary support from the agency through the DPCA, others suggested ways to improve and streamline compensation programs to make them easier for the ranchers to file for. Rather than discuss payment scheme, some ranchers suggested that the compensation program should be improved to have less paperwork burden involved and be streamlined so that they do not have to wait too long before they receive compensation. Other ranchers felt that the compensation program should be changed to a wolf insurance plan so that ranchers who experience depredation apply for reimbursement from a private insurance company, like they do for all other incidents, instead of

going to WDFW. These suggested enhancements indicate that addressing economic loss for ranchers due to predators is still a valuable component in seeking their participation in other non-lethal mitigation programs the DPCA has and should not be removed in lieu of addressing social and political barriers. Instead, I suggest that in addition to monetary compensation, addressing social and political barriers will increase adoption and effectiveness of the technical and economic mitigation measures at foster coexistence between ranchers and wolves. One way of addressing social and political barriers would be to work in collaboration with the agencies like agriculture agency that ranchers trust.

The second contradicting constraint I found regards the role of WDFW as the central agency that ranchers have to work with to participate in the cost-share non-lethal mitigations. Although some ranchers found working with the WDFW generally inconvenient for them as farmers, most of the ranchers reported that their primary action when faced with wolf depredation is to call WDFW. This could indicate that ranchers will still work with the agency even if they are not very comfortable doing so. In their study investigating the preferences of small forest landowners to enroll in forest conservation contracts, Rabotyagov and Lin (2013) found that the Washington Department of Ecology was not a significant factor to explain farmers' preference to enroll or not in forest conservation contracts. This finding could imply that rural dwellers may be less picky about who implements conservation livelihood programs as long as the implemented programs are effective. However, because there are some trust issues, and suspicion from ranchers towards WDFW in wolf management, we suggest that cooperation between WDFW and an existing agriculture-related government agency could increase rancher trust and participation in wolf mitigation measures. Previous work on farmer participation in conservation programs showed that multilevel distributed decision making was more effective than top-down approaches in managing

natural resources in complex social-ecological systems (Ostrom 2015, Scarlett 2011). Furthermore Brain et al. (2014) indicated trust in the organization or agency as one of the variables that explained why ranchers would engage in Conservation Easements in Florida, USA. Therefore, the wildlife agency partnering with an agency that ranchers trust may increase participation in the non-lethal measures to better coexist with wolves. Caution should be taken however, because even though some ranchers expressed willingness to work with existing agricultural-related agencies to implement nonlethal strategies to coexist with wolves, their actual enrollment may be low. In their survey of ranchers in Ontario, Canada, Eadie (2018) found no significant relationship between willingness to participate in new environment sustainable program and involvement in current programs. In spite of the uncertainty on whether ranchers will actually enroll in the collaborative programs, my findings suggest that effort to work with agriculture agencies might increase the participation in cost-sharing programs by some ranchers. Scarlett (2011) listed participatory structure as a characteristic for effective conservation at a landscape level. The Farm Bill, for example, uses local councils, conservation districts, and state technical committees to strengthen collaborative efforts. This collaboration could be applied to wolf and large carnivore conservation and implemented at local levels. For example, the conflict specialists could act as the link to collaborate with Conservation Districts to see how to case-by-case incorporate carnivore conservation with other conservation programs that the rancher might already be participating in through the Conservation Districts.

Generally, ranchers were participating in strategies to reduce depredation of their livestock from not only wolves but other predators as well. When discussing mitigation strategies, ranchers referred not only to wolves but to other predators including mountain lions (*Puma concolor*), coyotes, bobcats (*Lynx rufus*), birds of prey, and free-roaming/stray domestic dogs (*Canis lupus*

familiaris). Many ranchers reported having coyotes on their property and that they easily coexisted with them. Some ranchers mentioned that they had more conflicts with free-roaming/stray domestic dogs destroying their properties and spooking their livestock than they did with coyotes and other larger predators. Negative interactions with different predators including domestic dogs being mistaken for wild wolves has been previously documented (e.g. Green et al. 1984, Smith et al. 2000, Waters et al. 2018).

The mitigation strategies that that DPCA encourages the ranchers to enroll to participate in are similar to those recommended in the literature (Linnell et al. 2001, Miller et al. 2016, Musiani et al. 2003, Shivik 2014, Young et al. 2015) including deterrence measures such as guard dogs and range riders. These programs are similar to those that ranchers use both in Washington and other states where wolves are fully recovered (e.g. Montana; Brown 2011). In fact, some of these strategies such as fladry, guard dogs and range riders/ cowboys are thousand-year old methods that are in renaissance since the recent modern day recovery of predators both in Europe and the United States (Drinkhouse 2018). My findings suggest that the reluctance of ranchers to enroll in the WDFW DCPA program is because the program does not add anything new to what the ranchers are currently doing. On the contrary, enrolling in DPCA would add regulatory and logistical burdens to the ranchers to participate. This additional regulatory burden is a disincentive to enroll and could be one of the reasons that ranchers are reluctant to join a new program. Additionally, the benefits of compensation for depredated livestock are available to all ranchers including those not enrolled in the DPCA, as well as available to ranchers who are not intentionally implementing non-lethal measures. Therefore, there is no new benefit to incentivize enrollment into the program. The new disincentive (regulatory burden) is greater than the lack of new reward/incentive (since payments already exist for everyone) and therefore ranchers do not enroll. Strategies that ranchers did not

report to participate in, such as fladry, created time limitations that hinder their ability to enroll and learn new strategies. In addition to time limitations, there are also financial limitations because those programs are cost-shared and not free.

4.1 Positionality of researcher and limitations of study

Positionality is the researcher's worldview on their research topic and it shapes the scope of study, methods used and interpretation of qualitative data (Coghlan and Brydon-Miller 2014). It is important for researchers to be conscious of and acknowledge the possible causes of bias in the analysis of their study, and thereby try to be as neutral and objective as possible in qualitative study. I, the researcher, is from the ecological and natural sciences background interested in studying wildlife habitats close to human-dominated landscapes, and in rural community development programs that encourage human-wildlife coexistence. While my professional training is from the ecological background, I grew up depending on a mixed farm for my livelihood. This background places me in a position where I am genuinely interested in learning about ranchers' options for coexisting with wolves while maintaining their ranching livelihoods. Furthermore, as an international student researcher talking to ranchers in eastern Washington, I was received by ranchers with a sense of curiosity and neutrality as I did not carry any preconceived ideas from urban Washington to tell ranchers what to do. Through using in-depth interviews to discuss participation in cost-sharing programs to prevent wolf depredation on livestock and increase coexistence, I found that ranchers appreciated being listened to and having their opinions considered in discussions of wolf recovery and management. By letting the ranchers know that the interviewer was a neutral researcher genuinely interested in learning their opinion, ranchers openly discussed wolf issues without expecting to be interrupted nor judged. This neutral position has been documented as an

effective step in holding complex conversations in conflict resolution Redpath et al. 2013) that could be used by state agencies in trying to identify working mitigation strategies from ranchers.

An important limitation of this qualitative study is that participants were not randomly selected, so it is not possible to generalize these results to all ranching populations. Generalizability is not the goal of qualitative research; rather, the focus is on transferability – the ability to apply findings in similar contexts or settings (Bloomberg and Volpe 2016). I used purposeful sampling and snowballing to recruit ranchers to interview; this sampling method could have limited the variety of ranchers that I interviewed. I was unable to use any stratification, as such rancher attributes are not mutually exclusive. For example, many ranchers use both private and public lands but were categorized as public since part of their grazing land was public. These limitations can be overcome by corroborating the results with existing literature. Furthermore, qualitative results from this study can be used to develop hypotheses to be tested in a quantitative survey so that the results can be generalizable across the rancher population in Washington State.

4.2 Conservation and Management Implications

This study builds on literature to further understand factors that influence participation (or lack thereof) in mitigation programs. Cost-sharing has been documented as one of the possible motivations for ranchers to participate in non-lethal measures (Drinkhouse 2018). This study, therefore, adds to the literature by asking ranchers in Washington what they perceived of enrolling in DPCA, a cost-sharing agreement that would support ranchers to implement non-lethal programs to better coexist with wolves in Washington State. While this study focuses on wolves, these results can be applicable to other regional carnivores that get in various forms of interactions with humans

because ranchers repeatedly mentioned other predators in responding to questions about their perspectives on non-lethal mitigation strategies.

After assessing the factors that influence participation, I found that not all ranchers are against coexisting with wolves. However, ranchers expressed a need for more local means of promoting mitigation rather than top-down approach from the state wildlife agency to the individual ranchers, many interviewed ranchers preferred to work with their local community leaders. Accordingly, it would be helpful to categorize ranchers into sub-groups that are relevant for their interests rather than being generalized as 'all ranchers'. These sub-groups could include: geographic location of ranch, size of ranch cooperation, motivation for ranching (e.g., economics vs identity), and marketing of the ranch products (e.g. calf sellers vs niche beef sellers). Soliciting for participation through these subgroups harnesses a culture-level component which has the potential to enable ranchers to enroll in the programs that address their interests (Manfredo and Dayer 2004) and save the agencies resources of trying to enroll all ranchers in all programs. Encouraging such ranchers to self-organize could promote greater adoption of mitigation measures (Brown 2011). Participating in specific programs as a group provides a greater sense of community with others thereby increasing participation (Berkes 2004). Examples of such self-organized rancher groups include Montana's Blackfoot Challenge, as well as the Tom Miner Basin Association and the Centennial Valley Association in Montana.

Based on the findings of this study, I suggest that in addition to providing economic benefits of the mitigation measures, wildlife managers should address the intangible costs that are more likely to deter ranchers' participation in mitigation strategies through dialogue and discussion. I recommend investigating novel mitigations and economic incentives that reward the ranchers' values and benefit in wildlife conservation such as performance payments (Albers and Ferraro 2006,

Zabel and Holm-Muller 2008). Zabel and Holm-Muller (2008) defined conservation performance payments as monetary or in-kind payments that a conservation agency makes to individuals or groups of individuals in exchange for achieving specific conservation outcomes. The payments are conditional on achieving specific conservation outcomes, such as number of surviving offspring in a certain area. Through performance payments, the agency can ensure that they are accurately paying for achieving conservation goals instead of the ex-post compensation which pays for dead livestock and does not reward the landowner for living carnivores. Furthermore, I suggest a quantitative survey of ranchers based on the results of this study in order to provide generalized results that can be applied to other regions experiences interactions between humans and predators that can interfere with livelihoods such as wolves. The survey would help generalize what the ranchers would prefer to participate in as well as elucidate on the social processes of organizing and working with ranchers to participate.

Ranchers expressed that in addition to identifying effective mitigation to protect their livestock, they wanted the non-ranching communities to be educated about the importance of ranchers in preserving wild lands and their importance in the society. This need for increased respect and awareness of ranchers' work could be used as an opportunity to develop additional resource streams such as agritourism where urban dwellers can travel to farms and ranches to interact with ranchers on ranches to learn more about ranching and preservation of private wildlands through ranching. The agritourism would provide an opportunity for ranchers to educate urbanites, provide some extra income for the ranchers, and enhance conservation of wolf habitat on private lands adjacent to wild public lands.

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APPENDIX

APPENDIX A: Interview Guide for ranchers:

Can environment market services offset/mitigate for human-wolf conflict in WA State?

Intro: *Many forms of human-wolf conflict have been documented (references). Our research focuses on the economic aspects.*

Purpose: to contribute to improving coexistence between humans and wolves in WA State.

Goal: To investigate potential mechanisms to offset or lessen economic loss due to wolves in WA State.

Objectives:

1. To document the existing social and economic costs of coexisting with wolves that ranchers in WA State are incurring.

2. To document the realized and unrealized economic benefits of coexisting with wolves.

3. To determine the feasibility and constraints to offset costs with benefits of coexisting with wolves.

4. To present results on the practices and alternatives to reduce economic loss due to wolves, to citizens of Washington State, ranchers in WA State are using to mitigate against economic losses due to wolves.

Recruitment of Ranchers as primary stakeholders:

- **i.** Word of mouth; Dr. B. Kertson, and Ms. Stephanie from WDFW know some cooperative ranchers whom we shall approach first and then snowball to others.
- **ii.** Before approaching the ranchers in WA State, we shall contact and meet with ranchers in Montana to test this questionnaire to make it more relevant for the study.

Ranchers (one-on-one interviews):

Personal intro (2 mins): *My name is Carol Bogezi. I am part of a University of Washington study investigating economic approaches that can be used to help offset economic losses due to wolves. I took on the position in this study so as to learn from farmers and ranchers here about the possibility of mitigating economic losses caused by wildlife. Back home we inherited a farm where we grow crops – tomatoes and corn; we have problem with vervet monkeys that destroy our crops. We are in the stages of trying to investigate how to protect our investment while protecting the wildlife. This study will greatly help to inform ways in which to mitigate economic losses due to wildlife and improve coexistence between humans and wildlife in my country and I hope in yours as well. We hope that through this research the opinion and ideas from ranchers will be documented, and considered for implementation.*

This conversation has been approved by the IRB and all that we talk about here will be kept in strict confidentiality. We shall summarize the findings for the public and scientific community but your identity and ranch location will not be revealed unless you so desire. (GIVE CONSENT FORMS FOR SIGNING AT THIS POINT.

Theme: Current state of wolf conflict, benefits and emotions	
1. What do you think/know/or hear about the recent return of wolves in WA State?	
b. Describe, where they are, how many they are, where they came from, what you perceive them as; what others perceive them as.	
c. How do you characterize your experience with wolves?	
d. Firsthand experience? From friends and neighbors? From media, internet, press? Form culture such as childhood stories?	
e. In what ways do wolves affect your livelihood? Directly or indirectly.	
f. Do you think you are currently coexisting with wolves now? (Do you think you are having conflict with wolves? What level of conflict, if so? How much conflict?)	
g. Do you anticipate your intention with wolves to change in the future? How?	
h. What are some of the positives (and negatives) of living with wolves?	

Theme: Background info on the rancher and rancher experience	
2. Can you please tell us about the ranching experience in your life? (Aim to learn how long have you been in ranching? Generations? Recently bought? Inherited?)	
b. Will your children take on the ranch and ranching? What do you think can keep the family/children ranching the land?	
c. What is your product? (Mutton, beef, dairy, lambs, or wool?)	
d. Which processes of the product-chain to you manage as a rancher? (Do you grow your pasture, grow your animals, slaughter, sell? Or breed and sell lambs only? Or grow sheep for wool only?)	
e. What are your thought on certification? Do you have any special certification for your products? Is there a local outlet for your product that can certify your product as organic or grass fed for example?	

f. Are all your operations on your property or do you use lease some extra from BLM, or Forestry Services or private individual? How much do you lease? How long a year do your animals stay out in the leased land? (PS. We could get some of this info from BLM and/or Forest Services)	
Theme: Existing practices, known alternatives, limitations	
3. How are you currently coexisting with wolves? What measures? How effective are they? What more would you do? What limits you from doing more? Why do you think some other people have more conflict and negative experiences with wolves than others in the same region?	
b. If negative; - What would make it impossible to coexist with wolves? Have you heard about some mitigations measures? What do you think about the measures?	
c. Can you please tell us about the inconveniences you incur as a result of wolves? (These can be economical, social, etc. Aim for detail: no. of animals lost; how much extra operating costs? How much is lost in weight of beef animals? Try to quantify it to $$). (Are you bothered by wolves in anyway?)	
d. Can any measures be used to mitigate these inconveniences without killing the wolves? (What limits using these?	
e. Would you welcome assistance in implementing the measures mentioned in 3d? What forms of assistance? From whom would you accept this assistance?	
f. In what ways do you think the whole community can benefit from coexistence with wolves? E.g. through education opportunities, or information centres?	

4. Theme: Alternative ideas for offsetting social and economic	
In order to offset for losses we have learnt of ideas of selling the products at a premium, or having additional income through wolf tourism; what other alternatives do you have to suggest?	
% increase in price per pound of beef?	
Certification considerations?	
Would they welcome tourism opportunities?	
Social inconveniences? How can those be offset?	
Wolf Fund for the community?	
Designated Range-riders?	

Wolf Hotline, and website maintenance?	

Summary of issues raised (2 mins): Ending Questions (5 mins): *Can you please share with us anything that we should have talked about but missed?*

Concluding Remarks: *Thank you for participating in this conversation, if you think there is anything that could help us with this study, please feel free to reach us by phone (425-628-4058) or email: cbogezi@uw.edu*

APPENDIX B:

Key Informant Consent Form

(Sign 2 copies; keep one for your records)

Investigating the feasibility of economic services to offset human-wildlife conflict in WA State

You are invited to participate in a research study that will explore the feasibility of using economic services to mitigate and offset economic losses due to wolves, with the overall purpose of understanding of human-wildlife interactions in Washington State. You have been selected as a potential participant because of the insight that you may be able to provide on this particular subject. We ask that you read this form and ask any questions you may have before agreeing to be in the study.

This study is being conducted by: John Marzluff and Stanley Asah, Professors, Carol Bogezi, and Catherine Gowan, graduate students, all of the School of Environmental and Forest Sciences at the University of Washington.

Background Information

The purpose of this research is to contribute to improving coexistence of ranchers and wolves in Washington State through investigating measures to mitigate for economic losses and inconveniences due to wolves. The objectives include - to document ranchers' experiences with predators; to document the existing social and economic costs of wolves that ranchers are incurring; to identify ideas of offset measures and their feasibility to improve coexistence with wolves.

Procedures:

By agreeing to participate in this study, we will ask you to do the following things:

- In a key informant interview, you will be asked questions regarding your knowledge of wolves in Washington State; the economic costs of wolves, and the ways in which these costs can be mitigated using both realized and unrealized benefits.

The entire session is anticipated to take roughly one hour.

Risks and Benefits of being in the Study

Your participation will help to identify participants for focus group interviews, as well as create a template for a future public survey.
There are no risks for participating in this study.

Confidentiality:

The records of this study will be kept private. Information that would make it possible to identify you will not be included in any report or publication that may result from this study and the audio-records will be destroyed as soon as they are transcribed. Information will be stored securely and only researchers will have access to the records.

Voluntary Nature of the Study:
Participation in this study is voluntary. Your decision whether or not to participate will not affect your current or future relations with the University of Washington. If you decide to participate, you are free to not answer any question or withdraw at any time without affecting those relationships.

Contacts and Questions:
This study has been approved by the Internal Review Board (IRB) for Human subjects Division (HSD study # 45684). hsdinfo@uw.edu, 206-543-0098.

The researchers conducting this study are: Prof. John Marzluff, Prof. Stanley Asah, Carol Bogezi, and Catherine Gowan. You may ask any questions you have now, and if you have questions later, **you are encouraged** to contact them in Seattle at 206-616-6883; 206-685-4960; 425-628-4058; 352-494-4125 or corvid@uw.edu, stasah@uw.edu, cbogezi@uw.edu, and cgowan13@uw.edu accordingly.

Printed name of study staff obtaining consent	Signature	Date

Subject's statement

This study has been explained to me. I volunteer to take part in this research. I have had a chance to ask questions. If I have questions later about the research, I can ask one of the researchers listed above. If I have questions about my rights as a research subject, I can call the Human Subjects Division, of the University of Washington, at (206) 543-0098. I will receive a copy of this consent form.

Printed name of respondent	Signature of subject	Date

APPENDIX C: Characteristics of the interviewed ranchers.

Appendix C: Showing the summary of respondents interviewed so far and some of their attributes

Respondent ID	Age of respondent (years)	County	Date of interview	Duration of Interview (minutes)	Generation of Ranching in WA State	Ranching all life in WA State	Type of ranch/ operation
R1	55-60	Kittitas	12 Sept, 2013	81	first	no	organic finisher
R2	55-60	Yakima	13 Sept, 2013	51	first	no	organic finisher
R3	>65	Kittitas	13 Sept, 2013	35	fourth	yes	tradition cow/calf
R4	60-65	Kittitas	15 Sept, 2013	77	second	yes	organic finisher
R5	>65	Kittitas	16 Sept, 2013	49	fourth	yes	tradition cow/calf
R6	>65	Kittitas	16 Sept, 2013	72	third	yes	tradition cow/calf
R7	40-45	Yakima	20 Sept, 2013	41	second	no	tradition cow/calf
R8	>65	Yakima	20 Sept, 2013		fourth	yes	tradition cow/calf
R9	60-65	Yakima	20 Sept, 2013		fourth	yes	tradition cow/calf
R10	>65	Yakima	20 Sept, 2013		fourth	yes	no longer active
R11	>65	Kittitas	20 Sept, 2013	148	third	yes	tradition cow/calf
R12	<40	Kittitas	20 Sept, 2013		second	yes	organic finisher
R13	>65	Kittitas	20 Sept, 2013		fourth	yes	tradition cow/calf
R14	50-55	Yakima	20 Sept, 2013		third	no	no longer active
R15	60-65	Kittitas	23 Sept, 2013	60	third	yes	tradition cow/calf
R16	55-60	Yakima	30 Sept, 2013	75	second	yes	organic finisher
R17	45-50	Kittitas	30 Sept, 2013	50	second	yes	tradition cow/calf
R18	40-45	Kittitas	30 Sept, 2013	47	second	yes	organic finisher
R19	40-45	Stevens	7 Nov, 2013	66	fourth	yes	tradition cow/calf
R22	50-55	Stevens	7 Nov, 2013	107	third	yes	tradition cow/calf
R23	>40	Okanogan	9 Nov, 2013	154	second	no	orchards
R24	55-60	Okanogan	9 Nov, 2013		fourth	yes	tradition cow/calf
R25	50-55	Okanogan	10 Nov, 2013	59	first	yes	sheep
R26	40-45	Okanogan	10 Nov, 2013	65	third	yes	organic finisher?
R27	60-65	Okanogan	11 Nov, 2013	70	First homeste	yes	tradition cow/calf
R28	45-50	Lincoln	11 Nov, 2013	79	fourth?	yes	tradition cow/calf
R29	60-65	Spokane	12 Nov, 2013	45	first?	yes	organic finisher
R30	>65	Stevens	12 Nov, 2013	105	third?	yes	organic finisher
R31	40-45	Stevens	12 Nov, 2013		fourth	yes	stocksman
R32	40-45	Stevens	12 Nov, 2013		second	yes	tradition cow/calf
R33	40-45	Stevens	13 Nov, 2013		third	yes	No longer active, cow/calf, horses, sheep
R34	45-50	Stevens	13 Nov, 2013		second	yes	subsistence
R35	<40	Stevens	13 Nov, 2013			yes	Helps R36 with his ranch
R36	50-55	Stevens	13 Nov, 2013	159	First	no	Organic Cow/calf
R37	60-65	Stevens	13 Nov, 2013		Third?	yes	tradition cow/calf
R38	60-65	Stevens	13 Nov, 2013		second	yes	tradition cow/calf
R39	45-50	Stevens	13 Nov, 2013		Third?	yes	tradition cow/calf
R42	60-65	Stevens	15 Nov, 2013	50	third	yes	tradition cow/calf
R43	>65	Stevens	15 Nov, 2013	49	third	yes	no longer active
R44	50-55	Stevens	17 Nov, 2013	47	third	yes	dude ranch, stocksman
R45	60-65	Okanogan	20 Mar, 2014	129	First	yes	tradition cow/calf
R46	60-65	Walla Walla	22 Mar, 2014	125	Third	yes	tradition cow/calf
R47	50-55	Stevens		99	Third	yes	tradition cow/calf
R48	60-65	Okanogan	21 Mar, 2014	56	First	yes	Organic Cow/calf
R49	40-45	Colville	10 May, 2014	53	First	yes	Organic, custom exempt

Chapter 3. COMPARING PERSPECTIVES OF STAKEHOLDERS ON PREDATOR-FRIENDLY BEEF LABELING AS AN ECONOMIC STRATEGY FOR RANCHERS TO BETTER COEXIST WITH WOLVES

ABSTRACT

Economic loss is the most frequently mentioned reason for people's negative attitudes and lack of tolerance towards carnivores, such as wolves (*Canis lupus*). Therefore, alleviating economic losses through compensation and market-based strategies is one of the common tools for addressing negative wolf-human interactions. In spite of general support for market-based economic incentives to improve coexistence with predators, they are not popular as evidenced in the rare representation of predator-friendly products on the mainstream market. The purpose of this qualitative study is to explore a sample of stakeholders' perspectives regarding whether or not they would support certification of predator-friendly beef as a market-based economic incentive to enable ranchers to better coexist with wolves. I utilized semi-structured interviews to understand the perspectives of ranchers, wildlife agency personnel, environment NGO employees, beef industry workers, hunters, range riders, agency commissioners, county politicians, state politicians, and Future Farmers of America (FFA) members. Both economic and social factors motivated and constrained ranchers to participate in a program creating a predator-friendly beef label for the market. Ranchers perceived that marketing their products as predator-friendly to be more of an education/ outreach opportunity for them to reach the general public than as a new source of income. All stakeholders except county commissioners, hunters and FFA perceived an economic opportunity for predator-friendly beef facilitated by existing pro-environmental markets and existence of a private beef processing plant. Based on these results, I discuss the design of a market for predator-friendly beef. The design

recommendations include: focusing on the type and objective of the rancher; consideration for local accessible beef processing facilities to process small volumes of custom beef; consideration for the name of product that is favored by the rancher and beef processors; the pricing of the labeled beef on the market; and finally the regulatory process for a potential predator-friendly beef label on the mainstream mass market.

1. INTRODUCTION

Large carnivores can provide ecological (Beschta and Ripple 2010, Ripple et al. 2014, Schmitz et al. 2000), recreational (Chan et al. 2012, Naidoo and Adamowicz 2005), intrinsic (Soulé 1985, Vucetich et al. 2015), and health (Bratman et al. 2015, Frumkin 2001, Wilson 2001) benefits to human society. However, they can also depredate livestock resulting in economic loss (Muhly and Musiani 2009), emotional distress (Barua et al. 2013) and retaliatory killing that minimizes their conservation impacts (Bradley and Pletscher 2005, Naughton-Treves et al. 2003). This situation is exacerbated where protected areas or public wildlands are in close proximity to human livelihoods in rural and exurban areas because large carnivores use private lands as part of their habitat (Treves and Karanth 2003, Athreya et al. 2014, Treves 2009).

Wide-ranging large carnivores do not recognize protected area boundaries and are therefore prone to roam surrounding anthropogenic landscapes (e.g., private property as part of their extended available habitat) where they may destroy property and cause economic loss (Athreya et al. 2013, Muhly and Musiani 2009). By not 'obeying' anthropogenic boundaries, large carnivores are a fugitive resource (a resource that moves beyond artificial borders drawn by people; e.g., protected areas boundaries) that comes into contact with local people causing positive and negative interactions (Meguro 2008). It is a challenge to manage fugitive resources because they sometimes reside on private lands while still accruing benefits for the entire society. Wolves, (*Canis lupus*), for example, roam wild lands providing benefit to the public as they improve riparian habitats and reduce overgrazing by their prey (Beschta and Ripple 2010), yet the presence of wolves on the landscape (both private and public land) may accrue costs to rural dwellers. The costs include fear, loss of pets, and foregone livestock production whether by depredation (Muhly and Musiani 2009) or weight loss through behavior-mediated responses of cattle to wolves (Laporte et al. 2010). Thus,

rural dwellers, and especially ranchers may not acknowledge the ecological benefits of wolves (Goldstein et al. 2011).

There are various ways in which society either through government agencies or non-profit organizations tries to encourage rural dwellers to coexist and conserve carnivores, such as wolves. These include payments to encourage coexistence including compensation, revenue sharing schemes, and performance payments (Dickman et al. 2011, Defenders of Wildlife 2015, Nyhus et al. 2003). Effectiveness of payments to encourage coexistence is debated. Some studies suggest that paid compensation results in alleviating financial loss (Stone et al. 2009) while others have documented that payments do little to increase coexistence or improve attitudes towards wildlife and wolves in particular (Bulte and Rondeau 2007, Naughton-Treves et al. 2003). Beside failure to change attitudes, payments to encourage coexistence have other shortcomings including being prone to abuse, not being related to conservation outcomes and being too dependent on external funding (Dickman et al. 2011). Generally public attitudes towards environmental issues including wolf conservation has become more positive since the 1970s (George et al. 2016, Jackman and Rutberg 2015). Majority of the public preferred non-lethal management tools for carnivores like wolves (Slagle et al. 2017, Jackman and Rutberg 2015). Furthermore, besides compensation consumers have exhibited a willingness to pay for socially responsible, environmentally sound and economically viable ranch products through certifications (Early 2012, Davis et al. 2015, Wong 2009). However, a very specific portion of the public who live in close proximity with wolves and have rural livelihoods such as ranching do not have improved attitudes towards wolves even where compensation programs are implemented (Agarwala et al. 2010, Bruskotter et al. 2010, Naughton-Treves et al. 2003, Treves et al. 2013). Therefore there is a need to investigate alternative economic incentive to improve coexistence between carnivore and rural dwellers.

Market-based economic incentives are one promising avenue for increasing coexistence with biodiversity including carnivores (Badgley 2003, Early 2012, van Eeden et al. 2018) as has been documented for forestry (Overdevest and Rickenbach 2006), coffee (Mendez et al. 2010, Schau et al. 2009) and fisheries (Bush et al. 2013, Chaffee et al. 2003). There have been successful certifications for nature and food resources such as organic food (Hughner et al. 2007, Janssen and Hamm 2012, Yiridoe et al. 2005) and grass-finished beef (Enser et al. 1998, Melton et al. 1982, Umberger et al. 2009). For predator-friendly beef, however, efforts for the product to be sustained on the market have been limited as evidenced by lack of predator-friendly meats in the mainstream market. Currently some ranchers sell predator-friendly beef directly to consumers but face challenges such as situations where the rancher cannot meet the consumers' demand for the entire year (Forero et al. 2014). By contrast, some ranchers may have plenty of beef but few willing consumers (Forero et al. 2014). Consumers buying large quantities of beef directly from a rancher need to have adequate storage facilities, which limits the number of consumers who can buy directly from ranchers. Other challenges include high shipping costs to individuals and transportation of frozen meats (Forero et al. 2014). Depending on the distance the rancher has to ship the large chunks of frozen niche beef, it is not only expensive but sometimes the beef arrives to the consumer in un-fresh conditions (*Pers. comm. from rancher, and a former buyer of niche predator-friendly meats,* June 2018). Some ranchers have successfully sold certified meats at farmers' markets and schools (e.g., JBarL ranch in Montana, USA), but many large-scale ranchers are 'cattlemen' meaning that they sell cattle and not beef and it would be difficult to change from cow-calf operations to niche beef markets, which entail new skills such as effective and widespread advertising (Forero et al. 2014).

While there are studies that have investigated certification of predator-friendly beef as a way to increase ranchers' coexistence with wolves, there are gaps such that the knowledge about

predator-friendly beef for wolf coexistence is incomplete. Most of the previous studies have focused on the demand side and limited studies to understand the supply side of the predator-friendly beef. Aquino and Falk (2001), Eadie (2018), and Wong (2009) each compared consumer preference for predator-friendly beef to non-certified beef, but these studies did not investigate the other involved stakeholders along the beef market life cycle such as beef processors. Furthermore, those previous studies on niche beef markets were based on quantitative surveys (Aquino and Falk 2001, Davis et al. 2015) and economic benefit-cost analyses (Lee et al. 2012, Wong 2009) that did not incorporate the social context of predator-friendly beef as an economic incentive for ranchers to better coexist with wolves. Without understanding the social context there is a lack of in-depth understanding of why ranchers and other stakeholders would be willing (or not) to participate in a predator-friendly beef market. In other words, the previous studies did not provide adequate knowledge on willingness of the supply side (e.g. ranchers) of predator-friendly beef to adopt economic strategies for wolf conservation. Finally, in many decisions regarding natural resources management in rural areas, politicians have a prominent voice in decisions such as wolf conservation and ways to coexist with wolves. Yet, there are no previous studies comparing the perspectives of politicians and the people they represent (ranchers in this study) about predator-friendly beef as an economic market-based strategy to increase human-wolf coexistence.

Wolves have recently recolonized Washington, a state where cattle ranching contributes between $705 million and $3.6 billion dollars to the economy (Neibergs et al. 2014, National Agricultural Statistics Services 2017). The areas where wolves have recolonized include those with the highest density beef cattle production in the state (Maletzke et al. 2016, Hanley et al. 2018). This setting of beef cattle overlapping with a top predator provides a research opportunity to investigate the feasibility of a predator-friendly certified beef market in Washington State.

In this study I attempted to fill these knowledge gaps by using a qualitative approach to investigate how various stakeholders concerned with wolves perceived a market-based economic strategy along the entire market chain from the rural producer to the retailer to enable better coexistence with wolves. I assessed the perspectives of various stakeholders concerned with wolf recovery concerning the feasibility of developing a market for predator-friendly beef in Washington State, ranging from ranchers to state politicians and then compared their perspectives. To meet this goal, I addressed three research questions: (i) what factors motivated or facilitated support for predator-friendly beef? (ii) What were the constraints for a predator-friendly beef market?; and (iii) how did the stakeholders compare with regard to their perceptions towards predator-friendly beef?

2. METHODS

Quantitative methods with prepared questions tend to be limited in revealing the social context and nuanced responses of the participants because survey questions have a priming effect on the respondents (Asah et al. 2012, Krueger and Casey 2000). Thus, I used a qualitative research design suitable for investigating how experiences are interpreted and understood in a particular context and a particular point in time (Bloomberg and Volpe 2016). I used Grounded Theory (Charmaz 2014) because little is known about multiple stakeholder perspectives on predator-friendly beef on the mass market. Grounded theory moves beyond description to generate or discover a theory of process, actions, or interactions imbedded in the views of the participants (Corbin and Strauss 2014). Grounded theory analysis is based on narratives, patterns and themes from the data. A narrative is a story that emerges from the critical look at categories of repeated or similar responses to the question (Charmaz 2014, Ryan and Bernard 2003). Patterns are the similarities or differences between the narratives whereas a theme is a classification of discrete concepts after comparing these concepts against one another and finding that the concepts relate to a similar phenomenon (Ryan and Bernard, 2003). I detailed the process of how I analyzed data using inductive grounded theory to identify narratives, patterns and themes from the interview data of this research in section 2.2 of this chapter. Based on the themes formed from the data, I then synthesized the findings to discuss broader implications including the considerations that need to be addressed to make predator-friendly labeled beef feasible on the mass market. The research design and protocol were reviewed and approved by UW Internal Review Board (IRB) to conduct research on human subjects (HSD study #45684).

2.1 Research sample and data collection

The primary characteristic of all participants was that they had to be concerned with, or affected by, wolf recovery in Washington State. I used purposeful sampling procedure (Bryant and Charmaz 2010) to select the sample. Unlike random sampling that assumes that all potential subjects in the population will know or have an opinion about the research topic, purposeful sampling ensures that the sample meets the conceptual/informational needs of the study. Excellent participants for grounded theory are those who have been through or observed the experiences of wolf recovery and management in Washington State. In addition to having direct experience, participants must be willing and have the time to participate, must be reflective and have the ability to articulate their experience (Bryant and Charmaz 2010). Therefore purposeful sampling was the best way to choose suitable participants for this study. I employed snowballing methods (Bryant and Charmaz 2010) by asking interviewees at the end of their interview to suggest some other people they thought I should interview about the topic. Snowball sampling strategies effectively provide a small but concentrated group of individuals with deep and intense knowledge of the relevant subject matter, in our case through their inclusion in the social processes of wolf recovery and conservation in Washington State. Thus, the sample included ranchers, hunters, wildlife agency officials, wildlife agency commissioners, elected officials, environmental NGOs executives, beef processors, range riders and members of Future Farmers of America (FFA) student club in a university in eastern Washington.

Within the framework of a qualitative approach, I used semi-structured interviews as the method for data collection. I developed and used an interview guide (Appendix A) to facilitate more focused exploration of the specific topic of predator-friendly beef labeling. I pre-tested the interview guide with ranchers and range riders in Montana to ensure that the wording of the questions was open-ended, polite, and meaningful to the interviewees. There were no ethical threats to the

participants of this study. Participating in this study was voluntary; even after participants signed the consent form (Appendix B) to start the interview, they were free to skip any questions and stop the interview if they wanted. All participants' identities were kept confidential and no names or direct descriptions were used in reporting the findings from the interviews. All data and other research-related records were stored securely and only the researcher had access to this material.

The individuals who agreed to participate were asked to choose a date, time and place of their convenience for the interviews to take place. Interviewees were given this choice to schedule the interview meetings so that they would not be rushed for time during the interviews, thereby facilitating extensive conversation about the research questions. Engagement with participants in their social worlds is essential to understanding subjective meanings, and it is important that the study's findings are informed by the data rather than the researcher's own preconceptions. Where participants preferred to be interviewed along with their colleagues or friends, I held focus group interviews. Like interviews, focus groups help one discuss particular topics with flexibility to explore often-unanticipated issues as they rise in the discussion (Bloomberg and Volpe 2016). One strength of the focus group method is that it is socially oriented to study participants in an atmosphere that is often more natural and relaxed (in the company of people they know) than a one-on-one interview (Bloomberg and Volpe 2016). I conducted most of the interviews in person, though one interview with an NGO employee was conducted over Skype®, and another was conducted over the telephone. All interviews were carried out from August 2013 to May 2015 and were audio-recorded.

2.2 Data analysis

I began the process of data analysis by listening to and transcribing the interview recordings verbatim (Charmaz 2014, Poland 1995). The transcriptions were then uploaded into the software package NVivo v.11 (QSR International 2014) for further analysis. I established validity and reliability of the study design and data analysis using Inter-coder reliability (Miles and Huberman 1994). Inter-coder reliability was performed in NVivo by having two researchers code a sample of the same interviews – one to two interviews from each stakeholder group – and the intercoder reliability index was 96.8% which is a valid index for semi-structured interview qualitative research (Campbell et al. 2013, Miles and Huberman 1994). In NVivo v.11 the first stage of data analysis was line by line coding (Saldaña 2015) of transcribed responses into categories that closely corresponded to the research questions through coding. Coding is the process of fragmenting interview phrases into separate categories with similar response to a given question (Charmaz 2014, Saldaña 2015). The purpose of coding is to come up with a number of collective categories of responses to specific questions (e.g., all stakeholders' responses that are positive about predator friendly labeling were be placed in one code). During the first phase of line by line coding, codes were formed until Theoretical Saturation (Charmaz 2014, Saldaña 2015) was reached. Theoretical saturation is the phase during qualitative study in which the researcher has continued sampling and analyzing data until no new data appears (i.e., the new respondents are not giving any additional new information; Charmaz 2014).

Grounded theory inductive data analysis begins with a wide range of individual interviews from which the researcher forms patterns that form the foundation of the themes used to answer the research question. After reading and re-reading the interview data, I grouped together responses from the stakeholders either as positive or negative responses toward predator friendly beef label.

These broad groups of responses are termed as the narratives (a story that emerges from critical comparison of codes of repeated or similar responses). Interpreting the meaning of each narrative and merging the narratives that have a similar meaning results into new categories that are termed as constructs. A construct is the meaning of several narratives grouped together in the same category (Ryan and Bernard 2003). Patterns of constructs based on either similarity or differences among respondents are grouped together into themes. Themes can be broad or specific depending on the needs for the study (Ryan and Bernard 2003). I formed themes that were broad to include the constructs that linked several narratives to a single meaning. Themes can be used to form middle-range theories and are comparable to literature on similar studies (Charmaz 2014).

An example of how I conducted inductive Grounded Theory analysis to form themes that are reported in my results in this research chapter is as follows:

> *Interview question example*: What do you think about predator-friendly beef label as an incentive to help ranchers better coexist with wolves?
> *Responses*: include several narratives about the question asked. For example, several stakeholders give responses about how the existing market for grass-fed beef inferred that the public market would purchase the beef labeled predator-friendly as well and that would provide extra income for ranchers to coexist with wolves. Other stakeholders responded that predator-friendly label would be similar to organic label on the market and that people would buy it hence providing ranchers extra income. A rancher stakeholder mentioned that making the non-ranchers pay extra for their beef would be a good thing that makes the non-ranchers realize that ranchers are making an effort to coexist with wolves.
> *Constructs*: this is the deeper meaning that the researcher sees emerging from the narratives above. In this example two constructs arise from the positive narratives: one is that urban-dwellers value the predators like they value grass-fed and organic beef enough to pay a premium price for predator-friendly beef and hence ranchers will benefit from the predator-friendly label by getting more income from the premium price. The second construct is that the rancher stakeholder interprets that by non-ranchers paying extra for their predator-friendly beef, the non-ranchers is appreciating the ranchers' efforts to raise livestock while coexisting with wolves.
> *Theme(s)*: broad meaning of the construct which encompasses the narratives and can be compared to other similar themes in the existing literature. In this example two themes arose from the constructs: one is economic incentive – the income gained would make the ranchers participate in predator-friendly beef label. The second themes is the need for social acceptability or desirability that ranchers would like to

> get from the non—ranching public would make some ranchers participate in labeling their beef as predator-friendly.

I repeated this processes of identifying narratives, constructs and themes for all the interview responses that were about predator-friendly beef labeling. The second phase of coding was axial coding whereby I queried and compared the themes to see if they were similar or different for the various stakeholders. The process of coding, querying and comparing is iterative and eventually forms the thematic categories according to stakeholder groups that formed the findings for this chapter.

3. RESULTS

I held a total of 78 meetings (67 individual interviews and 11 focus group interviews with 37 people) to interview 104 people. Stakeholder groups interviewed included ranchers (n = 45), NGO employees (n = 11), WDFW staff (n = 19), WDFW commissioners (n = 2), beef industry (n = 4), hunters (n = 9), FFA (n = 5), elected officials (state politicians, county commissioners; n = 4), and range riders (n = 2). From the interviews data, I deduced five major findings (visualized in figure 3.1). (1) Both economic and social factors were mentioned as motivating or dissuading ranchers to participate in predator-friendly beef programs. (2) Most ranchers who responded positively towards predddator-friendly beef labeling perceived marketing their products as predator-friendly to be more of an education/ outreach opportunity for them to reach the general public than as a new source of income. (3) Some ranchers expressed that labeling their ranch products as predator-friendly would make them more socially accepted by the general public, but at the cost of them getting ostracized by their neighbors and fellow ranchers who may not participate in the labeling program. (4) Predator-friendly labeling was considered to be inferior to grass-finished or organic beef labels, and many ranchers interviewed feared being burdened to prove their beef is legitimately predator-friendly especially if their neighbors were not participating in the certification program. (5) All stakeholders except county commissioners and FFA perceived an economic opportunity for predator-friendly beef facilitated by existing pro-environmental markets and existence of a private beef processing plant.

	Motivations				BARRIERS/ CONSTRAINTS:								
Participant	Communication and outreach opportunity	Processing facility	Potential New market	Conditional on existing natural/health beef labels	Limited market for voluntary certified meets	*Predator-friendly considered inferior*	*Accountability/ verification of this market*	Veganism	Branding not good	Socially unacceptable label/ social modification	Historic perspectives	Emotional attachment	Negative Introspection Illusion
Ranchers	X	X	X	X	X	X	X	X	X	X	X	X	X
Beef Industry					X	X	X		X		X		
Hunters					X	X	X		X	X		X	X
FFA					X	X	X				X	X	X
Range Riders			X										
Elected Officials: (County Commissioners & State Politicians)				X							X		
WDFW			X	X	X	X	X*		X		X		
WDFW Commissioner			X				X				X		
NGO employees			X		X			X			X	X	

Figure 3.1: Summary of the motivations and barriers that stakeholders had towards predator-friendly beef labeling as a way to enable ranchers to better coexist with wolves in Washington State. The gray-shaded checked [X] cells indicate the motivation or barrier (in the columns) that stakeholders (the rows) responded to.

3.1 Factors motivating and facilitating support for predator friendly beef as a strategy for coexistence

Stakeholders mentioned factors that they perceived predator-friendly beef labeling as a feasible program for ranchers with positive outcomes for their coexistence with wolves. These factors included using the predator-friendly label as the vehicle for communication, monetary benefits, and a potential new market.

Ranchers discussed predator-friendly marketing as an opportunity for outreach to the public. They mentioned that by having a label that shows that ranchers take the extra effort to coexist with predators, consumers will know that ranchers make efforts to take care of the environment and wildlife. Ranchers further mentioned that the added price tag may remind consumers of the cost of producing beef in coexistence with predators and thereby communicate the ranchers' struggles to the consumer.

> *"That's interesting. Ah, you know, I kind of like it, I think that's a good way of being able to communicate to the consumer that cattlemen are at risk for having predators and with that in mind, we've gone to the extent that it takes to make sure that ours are in a safe environment, and that we've had to do extra work in order to achieve that. I think it would communicate that there is a threat to people's livestock and livelihood and that we have to do extra work too; I think that is a good idea, I do."* – Rancher Interview #1.

Ranchers, Range-riders, WDFW staff, WDFW commission, and NGO employees discussed economic incentive as a motivation based on two approaches: (1) to provide additional income to the participating rancher; and (2) to create a pool of money that can be used for wolf-livestock management initiatives (e.g., insurance funds against wolf predation) and provide extra funds to WDFW to manage wolves as well.

Only ranchers mentioned the new beef processing plant in Odessa, WA, as an economic incentive that could be a positive development for a new predator-friendly beef program because that

processing facility could be used to butcher and cure specialty-label beef to ensure that the labeled meats are not mixed with unlabeled meats. These ranchers mentioned the increased need in the market where consumers are more interested in the source of their meats, and so having local processing facilities could enable local ranchers to grow, process and supply consumers with predator-friendly meats for which the chain of custody is certain.

Another aspect of economic motivation was that there was potential for new markets that would consume the new predator-friendly labeled products. Both ranchers and WDFW staff especially emphasized environmentally aware urban-centered markets that would buy these labeled products. Non-government organization (NGO) employees had the most emphasis on the potential of this market group. This emphasis by NGOs could be valuable because their memberships could be the initial market for this product. Marketing predator-friendly meats for cats and dogs could reach potential buyers who do not eat meat. Environmentally-conscious new markets are an opportunity for ranchers to take advantage of the increasing "Green Pro-Environment Markets" (Goldstein et al. 2011) and as expressed in the following quotation:

> "*I think that's ripe for movement and evolution in that direction. I think we are still a long way away from being able to say um wolf friendly beef and have that be a positive reaction within the livestock community. Some folks get it. And maybe we'll need to work on the name [laughs] but um I mean it is no different than just the you know grass fed, I mean just the grain fed versus grass fed movement, organic um its uh, I can see where that will play an important role. Too early still to raw of an issue here in Washington. I think that we can get there eventually, I think we'll have to work on our naming [laughs] or labeling of that product um and but there are opportunities there.*" – WDFW Staff

Ranchers, WDFW staff, and state politicians mentioned that motivation to participate or purchase predator-friendly meats would be a positive if it were attached as a requirement to existing labels such as animal welfare, organic or free-range. This way in addition to the health benefits marketed by theses labels, the predator-friendly label could add environmental value to these products. WDFW staff mentioned that predator-friendly labeling is not as high as organic and other labels on the market, but they acknowledged that because organic and local are increasing in popularity on the market, there may be some potential for predator-friendly labelling.

> *"The [predator-friendly] premium market is probably not as high as some of the other markets, although organic stuff continues to do well and everybody likes buying and eating locally, and that's another, another movement, if you will. But anyway, and so, so there's a positive from that perspective if that's the way it goes, um, I think it'll be interesting to see how this plays out."* - WDFW staff

The WDFW commissioners compared the predator-friendly label to the Forest Sustainability Certification (FSC) label and suggested having agencies work together in partnership with the local commerce board and ranchers to see if such a certification would work.

> "*I think we could bring parties together but um since we don't do anything remotely like that, I would think that we would not want to really get into the business of trying to promote that kind of economic development. I mean, maybe form some partnerships with um their community economic development councils. The advisory, the department of commerce had some innovation zone options, so there are departments within state government to try to promote economic development (Interviewer_2: mhm) uh so they would be the leads in doing something like that. We might try to bring people together but uh, Fish and Wildlife wouldn't have much of a role in trying to create marketing networks (laughing) or anything like that.*" - WDFW commissioner

3.2 Constraints and barriers to support for predator friendly beef as a strategy for coexistence

Barriers and constraints were factors that stakeholders mentioned would hinder the ranchers from participating in raising or marketing their products as predator-friendly beef. These factors included competition on the market, a rigid beef industry, auditing/ verifying predator-friendly ranchers, lack of or limited interested in marketing beef by ranchers, and underlying social factors.

Competition

Dependence on niche market for selling predator-friendly labeled beef was also mentioned as one of the constraints as some stakeholders perceived that predator-friendly label is not as popular as the organic and grass-fed labels and would suffer from competition. Ranchers, FFA, beef processors, hunters, WDFW staff, hunters, FFA members, and NGO employees mentioned that predator-friendly beef would be constrained by competition on the market. They cited existing certifications such as organic and grass-fed beef as superior labels to predator-friendly (also documented by Wong 2009). Ranchers mentioned that the market for selling beef directly to the consumer is a small niche market and is flooded with organic meats leaving no room for predator-friendly items. Beef processors mentioned such a market is limited to Whole Foods, Metropolitan market and the like, located mostly in western Washington and rare in eastern Washington. The predator-friendly beef market was compared to the predator-friendly wool market in Montana which is saturated thus causing low and unprofitable prices (Early 2012, Eadie 2018). Given the limited market, ranchers would have to sell large quantities of highly priced beef thus limiting the individuals who can buy it to those with more money and adequate storage facilities. FFA members mentioned that if meats in Washington are so expensive because of their predator-

friendly label, then individual consumers would purchase meat in Idaho, and bulk buyers (e.g., beef processors) would buy from producers in Canada instead of Washington.

Some hunters mentioned that to be feasible, predator-friendly products should have continuous volume in the supply chain and not just a one-off marketing stint. Some hunters mentioned that price of beef is the factor that most consumers consider when buying beef, and that having a high price on predator-friendly labeled beef would limit the people in the population who can purchase it. Some hunters mentioned that a predator-friendly label would only work when it is new because people will be curious about its novelty but once they get used to it, they won't buy it anymore. Finally, to emphasize the limitations of a market for predator-friendly beef, ranchers, NGOs and WDFW staff asserted that the people who are supportive of predator-friendly meat are vegetarians and vegans, so the market is all words and not reality as reflected in the following quotations:

> *"You know there are people who really know the beef business, you know the niche for people who care about that is tiny. I mean there are people who care about it, but unfortunately a lot of people who really care about wolves are vegetarians. So they are not going to be buying beef."* – NGO employee

> *"I think most of the predator-friendly people probably live with in the town limits and have never seen a predator, or know what a predator can do. [Laughter, laughter]…. They eat vegetables, they are probably vegetarians or something like that. But most importantly is that there are not enough to put their money where their mouth is, and actually pay more for that product."* – Rancher respondent

Complex and rigid beef industry beef life cycle

Some ranchers, beef processors, hunters, FFA members, and WDFW employees mentioned that the market for predator-friendly beef will be limited because the beef industry values quality

of beef and not the biodiversity conservation practices of the rancher. Beef goes through different grading systems for quality and healthy attributes such as organic, grass-fed and Omega 6:3 ratio (Lusk and Parker, 2009). Wong (2009) documented that the market for organic grass-fed beef was driven by the human health assumption of the grass-finished beef whereas environmental attributes (which would include predator conservation) were not ranked highly among the attributes that appealed to consumers when purchasing beef.

As cattlemen, ranchers mentioned that they are not interested in looking for markets for individual beef buyers. Ranchers, beef processors and WDFW staff mentioned that the process of the beef lifecycle is a tightly streamlined and rigid process whereby ranchers are constrained from diverting from the norm to investigate new beef markets. Beef processors mentioned that they cannot logistically purchase predator-friendly beef because their market chain is controlled by a corporation and not individual buyers and sellers. Large scale ranchers who sold calves once a year to a finisher (such as a feedlot) perceived that diverting from their conventional mainstream market for cow-calf ranch operations was a high business risk that would cause financial losses for the ranchers. This quotation reflects ranchers' thoughts on seeking a market for predator-friendly beef:

> "*The thought that there was a market out there on predator friendly that if we're gonna do it. Okay, if we sold three steers today at a price of $400 apiece, I was going to offer the professors to pay me $1200 and you take care of taking them to a special plant so they can be federally inspected so you can sell it. You take the cost and market it to Pike Place market is somewhere in Seattle where there is predator friendly market, you do it and you can have all the profits. I don't want to go to Pike's Place market or go into all the work that it takes for [*other rancher's name*] to get his grass fed beef. I'm not, I don't want to do that, so if they really do think that there is a predator-friendly market out there, if people think that, then just pay me my $1200 and I get out right now and have you take it over right guys.*" – Rancher respondent #14

Beef processors and FFA members perceived that producing predator-friendly beef would be more complicated husbandry than what ranchers are currently using. They mentioned that to achieve perfect coexistence with wolves, ranchers would have to lock up their animals as in a feed lot setting instead of having them free range. This would then contradict with the popular free range, organic, grass-fed market. While this perception may be generally incorrect, because there are ranchers who are free range and predator-friendly, the ranchers were expressing that it would be lower cost to avoid free-raging so as to better coexist with wolves. This claim is supported by proponents of intensive cattle management (Phalan et al. 2011).

Challenges of auditing and verifying the predator-friendly beef label

Ranchers, hunters, beef processors, FFA members, WDFW staff, and WDFW commissioners expressed concern about accountability and the verification processes to ensure that only qualified ranchers get the predator-friendly beef certification benefits. Ranchers expressed concern about which predators would be included in the certification of ranches to qualify as suppliers of predator-friendly beef. Many predators including wolves, cougars (*Puma concolor*), eagles (*Haliaeetus leucocephalus*), coyotes (*Canis latrans*), and domestic dogs (*Canis lupus familiaris*) depredate livestock. Larger ranching operations mentioned that they would be at a disadvantage of higher costs of verification than many smaller ranches due to the sizes of their ranch that they have to monitor to qualify to be predator-friendly. Smaller ranches could manage to sell all their products on the niche predator-friendly market but larger ranches would incur more costs and they probably would not sell well on the niche predator friendly market because of the scale of their production.

The certification process requires a third-party certifier and this can add cost to the product, making it harder to sell on the mainstream market. WDFW staff mentioned that a predator-friendly label would be hard because there is not infrastructure in place to monitor compliance to the label. WDFW staff mentioned that such a label would have to be initiated by the local ranchers themselves. When asked about whether WDFW would be an appropriate agency to certify predator-friendly ranches, WDFW staff and commissioners were cautious about being a statutory body for certifying predator-friendly meats because they felt like ranchers who do not agree to get certified will refuse to work with WDFW on other projects too. Wildlife agency staff compared their certifying stand to the fact that NOAA do not certify sustainable fisheries, and so they do not expect to certify predator-friendly beef.

> "*First of all I'd want to think about what our statutory authority is to do that. Whether we even have the authority to do it and then I would want to think about how does that set us up out in the livestock community. For example, 'you certified my ranch, but you didn't mine, so to heck with you, I'm not going to work with you'. Or is it an incentive? Well, you certified him and he's getting more money for his so gee, I'd like to do that same thing. What kind of a response would you get? To, essentially, taking sides or being willing to do something that would result in a monetary gain for one person and not the other. I think that would be difficult position for the agency to be in. And I don't know whether we have the authority to do it.*" – WDFW staff

WDFW mentioned that it would be hard to maintain the standards of the predator-friendly certification label. For example, if a rancher who uses non-lethal measures and is certified predator-friendly ever experiences an incident where wolves need to be removed lethally from his/her property, then the rancher would by definition no longer be predator-friendly, and then the predator-friendly meat buyers would be confused about whether the label is rigorous enough to completely protect wolves from lethal control. Like WDFW staff, WDFW commissioners

mentioned that it would be hard to have a government agency be in charge of the certification process and that they would prefer a non-profit or another third-party auditor of sorts, because both ranchers and environmental groups distrusted the wildlife agency. WDFW commissioners also mentioned that by WDFW getting into certification, they would be alienating a proportion of their constituents who do not want to be part of the certification program. Verification is important as it shows the certified rancher meets the indicators of achieved certification, however it has been documented as a barrier in other environmental certifications as well (e.g., Eadie 2018).

Underlying Social factors

Attitudes towards predator-friendly beef could not be separated from stakeholders' attitudes towards wolves and wolf management in general. Some ranchers perceived the name predator-friendly to imply stray and lost cattle living in the wild with their meat is tough because they are being chased about by wolves, and those ranchers did not want their cattle to be associated with being friendly to wolves. Some ranchers sarcastically called it wolf-scared beef. Beef-processors wondered about what would be an appropriate name that would not offend their ranchers or buyers (e.g., called it Predator-neutral beef). Some rural stakeholders generally had a negative perception about urban preferences, for example, hunters mentioned that "*the predator-friendly label would be scary except if it were placed besides a Starbucks label then urban markets will want to buy the product*". Ranchers and hunters mentioned that the name predator-friendly was deceptive to buyers of certified beef by falsely insinuating that the wolf is friendly to cattle.

Personal, societal and historical factors were seen as limiting support for predator-friendly beef, too. Ranchers and beef processors mentioned that wolves were removed in the first place to protect the interests of livestock producers; based on this history some ranchers could not justify

participating in any strategy to coexist with wolves. Some beef industry stakeholders interviewed perceived wolves as a threat to beef production and therefore coexistence between livestock producers and wolves would be difficult to achieve. Adopting the predator-friendly label would depend on individual ranchers' social and personal factors. Ranchers, FFA, and NGOs mentioned that they invest and care for their livestock as part of the rancher lifestyle and do not just work for the money. They therefore do not want to see their animals eaten by wolves just because the remaining animals will receive a premium price. Some hunters mentioned that cows are more valuable to them than wolves and as such they would not support a predator-friendly label to increase coexistence. WDFW staff, WDFW commissioners and NGO employees mentioned that some ranchers would not participate in the predator-friendly label because ranchers do not want to be ostracized by their fellow ranchers. Some ranchers were ostracized by their communities for participating in wildlife/ NGO-led range-rider programs, so others were reluctant to participate in any coexistence strategies for fear of being ostracized too. For example, one of the interviewed ranchers positively coexists with wolves on their ranch in eastern Washington however, when the rancher was asked what they felt about labeling their meats predator-friendly to get a premium price from the Seattle market, and the rancher responded that he would not like to be ostracized by his neighbors and fellow ranchers. WDFW commissioners mentioned that there may be a few ranchers who will be early adopters, but more ranchers would rather be late adopters because they do not want to get ostracized by their friends as expressed by these quotations:

> *"[Interviewee name] brought it up to the guy who sells grass-fed beef at a [popular] market and other farmer's markets on the west side and he's real niche market. But [rancher] just looks at me when I brought it up because it is that ostracization that others have already felt just by having range riders or whatever or accepting money. The [rancher said] that it would be even worse, to say my beef is wolf-friendly. So that's a huge hurdle."* – Wildlife agency person

> "*The potential to be ostracized for being part of the predator-friendly thing. The situation I described here where, you know the, the, person is, is getting, is getting lots of attention and maybe getting a premium price, when in fact it's because their neighbors are killing all the carnivores, that leads to a lot of resentment where the neighbor is going: 'you're benefitting because I'm killing carnivores, but you're getting extra money, I really don't like that and, you're judging me at the same time"*. – NGO employee

Some ranchers, hunters, and FFA members mentioned that ranchers tend to have anti-government sentiments and would prefer not to have government involvement in their businesses. Because ranchers perceived that the predator-friendly label would be too unpopular to make it on the market, they supposed that to have a predator-friendly label would require much government input and subsidies. The ranchers who do not want to be involved in government programs were therefore reluctant to participate in this mitigation strategy. As part of the anti-government theme, the ranchers mentioned that for a predator-friendly label to hold, there would have to be government money that would only come through taxes. Ranchers did not want to pay more taxes and hence were reluctant to support the predator-friendly labelled beef on the market.

Finally, as part of the societal constraints, the state politicians' perception of predator-friendly beef label was dichotomously divided along political party ideology. The Democratic Party state politicians were generally supportive of a predator-friendly label for beef if it would increase ranchers' coexistence with wolves whereas the Republican Party state politicians were unsupportive of the certification label as well as other incentives to increase ranchers' coexistence with wolves.

4. DISCUSSION

In this study I presented a hypothetical market-based scenario, predator-friendly beef, to be discussed and evaluated by stakeholders as a possible solution to increase wolf-rancher coexistence and, ultimately, serve the objective of conserving wolves while maintaining thriving rural livelihoods in Washington. Each stakeholder expressed what they perceived as positive motivations that would support a predator-friendly product and market in Washington State. They also expressed the barriers and concerns that would hinder such a product being realized on the market. Overall support for predator-friendly beef was high from WDFW staff, NGO employees, range-riders, democratic state politicians and some ranchers. Moderate support was expressed by FFA members and most ranchers, while lowest support was from hunters, county politicians and republican state politicians. Republican Party affiliation and political ideology has been associated with expressing less environmental conservation concern and can be a hindrance to implementing practical conservation efforts (Cruz 2017, Czech and Borkhataria 2001).

The most universal motivation across all stakeholders was the assumption that the population of Greater Seattle area with its general environmentally-conscious behavior could purchase predator-friendly given the success of other value-added food labels such as natural, free-range and organic on the market. The target consumer markets in urban areas are interested in knowing about the source and process of their food (McKendree et al. 2014) and would like to know that their consumption behaviors in restaurants are supporting wildlife conservation and rural livelihoods at the same time.

Ranchers' motivation for participating in production of predator-friendly beef could either be to make money or educate the consumer. Ranchers who expressed positive attitudes about predator-friendly beef were motivated by the opportunity to use their product to communicate to

the market. Communication and outreach as a purpose of certifying ranch products has been previously documented for wool and beef (Early 2012, Wong 2009). Because ranchers' valued communicating about their environment stewardship to the public, using this predator-friendly beef product as a means of communication would be a better way to solicit ranchers' participation than wolf conservation. By caring to share their story of rancher lifestyle and good environmental stewardship through their beef, ranchers are in a way seeking social acceptability from the non-rancher often urban population.

It is not surprising that generally there were several barriers recorded for a predator-friendly certification program; this is not limited to beef but also relevant to other natural resources such as forestry, fisheries and coffee (Eadie 2018). For the consumer certification can also serve various purposes that make the consumer feel that they are participating in conservation through supportive, protective and persuasive labels (Treves and Jones 2010). However, for the supplier/ rancher, selling predator-friendly certified beef for a premium is similar to compensation in that it can help ranchers reduce the monetary costs to predators.

Naming of the product was a frequently mentioned constraint by ranchers as an ideological and social barrier (Bennett et al. 2017, Hurley and Kliebenstein 1999, Thilmany et al. 2006). Many ranchers sell cattle and not beef and therefore do not have control of what the beef from their product is finished and branded as at the time of sale to the retailer. For ranchers who finish their cattle and control the processing of the beef, naming the product is part of the rancher's individual and social identity. Ranchers' innate attitudes about wolf management, and the perceived value of wolves in nature and could not easily separated from their attitudes about participating in a predator-friendly beef strategy (Garnette 2013, van Eeden et al. 2018). Those attitudes seem to affect how ranchers feel about naming their ranch products.

Veganism/ vegetarianism was an unexpected potential barrier to realizing a market for predator-friendly beef. Some stakeholders were supportive of the idea of predator-friendly beef, but when asked if they would buy and/or eat it, they said they did not eat meat. This sort of nuance is hard to assess from a quantitative analysis, but was possible through the qualitative interview process as one can probe about responses further so that the respondent fully explain themselves. Such nuances suggest that individuals can support a strategy but in reality their own behavior would not promote that strategy. This confirms that people's environmental attitudes do not always inform their behaviors (Heberlein 2012). Realizing this barrier can help implementers decide what populations would buy this product - if the environmentalists who were the original target market are vegans or vegetarians then maybe the market that would buy it care for the predators but want to pay a smaller price.

4.1 Cultural barriers within stakeholder groups

Social factors cannot be ignored in investigating the feasibility of strategies for predator coexistence. For example, the culture of the various stakeholder groups, the underlying and historic assumptions of making effort to coexist with wolves, emotional attachment to their livestock, negative affect towards wolves, and negative attitudes towards government are social factors that stakeholders mentioned a barriers to participating in predator-friendly labeling. Considerations to participate in predator-friendly beef would depend on the ranchers' values and ideology about the role of wolves in the ecosystem and the rancher's relationship with nature (Garnette 2013, Van Eeden et al. 2018) and not on the monetary benefits of the predator-friendly beef. As part of the lifestyle, some ranchers do not want to be different from their friends and neighbors in order to avoid being ostracized. Fear of being ostracized was not limited to the

ranchers; some NGO employees mentioned that if they made choices that were not popular with their funders or fellow environmental NGOs, they would face anger and loss of income.

Culture was not just a barrier for ranchers as stakeholders: other stakeholders too indicated that their institutional cultures would be a barrier to the predator-friendly beef program. For example, some stakeholders pointed to the objective and culture of WDFW agency to provide recreational hunting opportunities, suggesting that with hunting being an important source of funding for the WDFW as well as personal hunting culture of some WDFW staff, the staff would not be inspired to fully support initiatives that promote wolf conservation. This cultural consideration further suggests that some wolf coexistence programs could remain a low personal priority for the WDFW staff even if they might rank high for their organization's objectives consequently this would undermine the success of the coexistence program. This discrepancy between agency objectives and personnel culture has been documented by Mattson and Clark (2009) as a constraint on other carnivore conservation issues as well.

4.2 Recommendations for design to make predator-friendly label beef feasible on the market

Although the goal of this study was not to develop a predator-friendly beef market, I compared stakeholder perspectives and then deduced possible design recommendations for such a market. From the stakeholder responses, two market designs could be further investigated for a predator-friendly beef market in Washington State: niche markets and mainstream mass marketing. These two designs are hereby discussed along with the five design elements that were recurring themes in the results: (1) focus on the rancher, (2) beef processing, (3) naming of the product, (4) marketing and pricing, and (5) regulatory process.

Focus on the rancher type

Ranchers are not a uniform group of people, there are many types of ranchers and their purpose for ranching varies. Some ranchers are hobby ranchers who do not depend on the income from the ranch for their livelihood, while others may be cow-calf producers whose entire livelihood depends on their ranch (Goldstein et al. 2011). In this study I found that small scale ranchers who do not depend on their ranch for their entire livelihood might be more willing to try new marketing channels like predator-friendly beef than large-scale ranchers who depend on the ranch for entire livelihood. The nature of operation/ life cycle of livestock on their ranch is also different: some ranchers sell off calves at auction yards while others finish their cattle and sell beef at various niche markets (Goldstein et al. 2011). I found that ranchers who finish their cows and sell beef can easily control the entire cattle lifecycle and be more flexible with trying predator-friendly beef than ranchers who do not finish their cows. Furthermore, ranchers have varying ideological and ethical reasons for using the ranching practices they use (Early 2012, Ervin and Frank 2001); for example, some ranchers expressed anti-feedlot attitudes while many ranchers sell their cattle to feedlots. From the interviews held for this study, I found that ranchers who do not like feedlots were more supportive of alternative new marketing avenues like predator-friendly beef than ranchers who preferred selling to feedlots. This variety in the nature of ranchers and purpose of ranching directly influences what they felt about predator-friendly beef, and should be considered in soliciting their participation in new strategies.

Focusing on the rancher would better be achieved through the niche market model than mass marketing. Niche markets have the advantages of directly connecting the consumer to the producer thereby aiding communication and helping narrow the rural (producers) and urban (consumers) divide (Goldstein et al. 2011). This attribute of niche markets would be appealing to

some ranchers who were more motivated about using marketing beef as an outreach vehicle about ranchers' environmental-friendly practices more than extra monetary benefits.

Naming of the product

To many interviewed ranchers the name of their beef product reflects the ranchers' identity and some ranchers did not want their identity to be associated with being 'wolf or predator-friendly'. Some certification labels aimed at addressing consumer desires, are not generally prestigious to the beef industry where the most prized certifications include Certified Angus Beef, and Kobe beef. These valued beef certifications are rated based on how tender and fatty the meat is and not on how environmentally/ predator friendly the ranching practices are. The most prized attribute of beef to a beef producer is the amount of marbling (fat) in the cut (Nutritional Business Journal 2004), but many ranchers I interviewed perceived predator-friendly beefs as likely to produce leaner beef that may not sell for the price of higher marbling meats. While there is market for lean meats, those are usually identified by distributors, because the rancher is concerned with selling their cattle as fat as possible since the cost of cattle is based on how fat and heavy it is.

During data collection, I used the terms predator-friendly beef and wolf-friendly beef interchangeably and many ranchers did not favor either name. The ranchers suggested that the name predator-friendly or wolf-friendly beef implied cattle that are chased by wolves, and consequently chased cattle are stressed and have tough less fatty meat that is lower in quality on the beef market. Unfortunately, the ranchers who were opposed or even offended by the names I used for the product did not suggest alternatives. This step therefore remains an important element in the design: the ranchers and other directly involved stakeholders in beef industry, not the

researcher nor environmentalists, should choose a name that communicates their story, and value of the product.

Meat processing facilities

Beef processing is an important step in the life cycle of turning cattle to beef. By law, ranchers cannot slaughter their livestock on the ranch and sell to the public directly (Gwin et al. 2013). They instead have to go through an authorized slaughter house and processing facility (USDA, 2016, Lupo et al. 2014, Gwin et al. 2013). It is not surprising that only ranchers noted the availability of the custom beef-processing plant (called Livestock Producers Cooperative Association, Odessa, Washington), as a factor that would enable a predator-friendly market. From this finding I deduced that ranchers have to be pragmatic about the solutions they choose to participate in. Therefore, thinking of the steps along the cattle-to-beef timeline (e.g., beef processing before the consumer receives the beef) is a necessary consideration for ranchers unlike other stakeholders that I interviewed.

The presence of the meat processing plant in Odessa, WA, would make it possible for ranchers to process their meats aimed for a specific certification label thus more suitable for the niche market than mass market. The plant is small and in order to keep the certified meats separated from others, there can only be scheduled days for processing predator-friendly meats. Mass marketing would require high volumes of meats processed daily which the processing plant cannot currently handle.

Marketing

Most stakeholders perceived that the urban, environmentally conscious population would be the primary market targeted for predator-friendly labeled beef. While it is possible that the environmentally conscious market may embrace this product, many of the stakeholders acknowledged the amount of competition there is for the certified beef market. Namely, there are at least eight certified labels for beef on the market including Grass Fed Beef, Grass Finished, Organic Beef, Natural Beef, Kosher/ Halal Beef, Whole Foods, Humane handling, Certified Wildlife Friendly and Fair Trade. Therefore, some stakeholders perceived that adding another label may not compete well in the crowded marketplace.

One solution to addressing this saturation of labels on the market would be to merge labels that meet the consumer desires by having a comprehensive certification that addresses human health, animal welfare and environmental values. A few merged labels exist on the market, for example the NOSH (Natural Organic Specialty Healthy) label in some grocery stores. There is potential for merging grass-finished, lean natural beef with predator-friendly beef if the operation meets all the standards of both natural and predator-friendly on their ranch.

Besides creating and/or merging new marketing labels to get more buyers, there is a gap because many consumers do not directly connect their beef protein to predators. Consumers' preferences when purchasing beef are for taste, human health, animal welfare, and environmental concern against pollution and carbon footprint (Hughner et al. 2007, Wandel and Bugge 1997), not specifically for predator conservation. The consumer demand should be assessed to explore the feasibility of certifying and marketing predator-friendly beef. Efforts have to be made to inform consumers of the connection between their beef and predators to increase chances of consumers considering predator-friendly beef over other meats on the shelves in grocery stores.

Another potential new market option for predator-friendly beef could be the pet food industry. Some stakeholders, especially NGO employees, supportive of predator-friendly beef as a strategy would, unfortunately, not purchase predator-friendly beef because they did not eat meat being vegan or vegetarian. However, many of those respondents had pets, and suggested they could purchase predator-friendly meats for their pets. The pet food industry is therefore a potential market to harness for predator-friendly meat.

Retail pricing of predator-friendly beef

Value addition labels that are maintained by increasing prices of products (e.g., meat in this case) have a weakness of excluding low economic demographics from accessing these products (Oyewole 2001). As such, the wealthier people who can afford to express their values through their purchasing power perceive themselves as 'righteous' saving the planet while judging the poorer people who may not afford these products although poorer people too care for the environment (Broad 1994, Oyewole 2001). It would help if food value additions could receive appropriate structural and government support so that the end product is the same price as the conventional ones, that way all people can make a choice based on other attributes of the product instead of price alone. Involving a wide range of stakeholders including policy makers in the design process of environmentally-friendly markets (Amit and Jacobson 2018, Oyewole 2001) could help with price regulation especially on the mainstream mass market. If by regulation, money assigned for wolf conservation is contributed towards the process of getting predator-friendly meat on the mainstream mass market, the predator friendly beef could therefore be able to sell for prices as low as the conventional beef. Price point is an important decision for most consumers who purchase beef (Aquino and Falk 2001, Wong 2009). Especially in non-specialty grocery stores, the price of

predator-friendly beef should be comparable to other beef so that it can be considered by lower income population too. One way of keeping predator-friendly labeled beef prices low would be by some policy changes therefore exploration of the regulatory process could help get predator-friendly beef on the mainstream mass market.

Regulatory process

Certification process of ranches as predator-friendly was suggested as a barrier that would limit the adaptation of the predator-friendly label by some ranchers. Predator-friendly beef labeling would be a form of voluntary certification whereby inspecting the ranch, auditing and verification processes are done by a third-party (Eadie 2018). It is assumed that annual auditing and inspecting increases the time and financial cost to ranchers who would participate in this certification. Larger ranchers have large herds of cattle that are not easily converted into niche markets over a short time period because of the large production, whereas certification and verification costs/ procedures can be limiting to small-scale ranchers who may find it difficult to make changes on their production due to economies of scale (Smithers and Furman 2003). According to one predator-friendly certifying organization (Wildlife Friendly Enterprise Network; WFEN 2013) guidelines for verifying certified predator-friendly beef include that the ranch has native predators, the predators do not have to be full-time resident on the ranch, but space should be available for them to use it when they (predators) need to. The rancher must have evidence of using nonlethal strategies to protect their livestock. While some guidelines are fairly easy to meet, limitations on hunting even for non-predator wildlife could disqualify one from being predator-friendly (*WFEN pers. comm., 2016*). Furthermore, if one rancher has several farms that are not contiguous with each other, all the ranches should meet all the standards for them to qualify their brand as predator-

friendly (*WFEN pers. comm., 2016*). Many ranchers do not want to follow any more regulations than they already have to from the government agencies.

The challenge of verification of predator-friendly products on the market could be addressed by using private and government institutional protocols to accurate verify what ranchers qualify to be predator-friendly certified. Scarlett (2011) recommended that the Farm Bill develop technical guidelines for quantifying, reporting, registering, and verifying environmental benefits of land management to facilitate development of environmental markets. If this recommendation could be applied to predator-friendly beef then the Farm Bill, in conjunction with USDA, WDFW, and a third-party could undertake a pilot to register, verify, and create an experimental predator-friendly market. A private-public verification process (Cashore et al. 2004) would help address the concerns ranchers had about the traceability of the beef to ensure that it truly came from areas with wolves.

4.2 Conclusion about predator-friendly market design

Based on the design elements discussed for this study, predator-friendly beef would best be established as a niche market. Niche meat markets are the fastest growing segment of the overall meat market (Goldstein et al. 2011, Nutritional Business Journal 2004) and this was acknowledged by most of the stakeholders as they mentioned the availability of new and merging environmentally-friendly markets that can be harnessed in western Washington. Because most buyers from niche markets voluntarily choose to offset their environmental impacts or fund conservation efforts for personal reasons, there could be an opportunity for niche products to sell for a much higher price than mass marketed meats for as long as the consumers are willing to pay. The disadvantages of niche markets are that they are still relatively small, location dependent and

can be difficult for ranches to transition into (Goldstein et al. 2011). This challenge was expressed by ranchers who preferred not to interact with consumers directly nor go out of their way to find new markets for their products. A mainstream mass marketing of predator-friendly beef is still an alternative model that ranchers who prefer not to sell directly to the consumer could utilize. However, the mainstream market would have to be slightly modified to what USDA refers to as a regional-aggregated chain supply model (Gwin et al. 2013) whereby several ranchers sell their predator-friendly finished animals to a central entity (e.g., a distributor brand, or co-op) that arranges for processing and distribution and handles marketing in compliance with predator-friendly guidelines thus reducing the tasks for the ranchers. This distributor middle-buyer would be similar to the way organic beef producers sell to organic meat distributers such as Mountain beef, and Rocky Mountain Organic Meats thereby saving the rancher the step of having to look for individual consumers to sell to.

4.4 Limitations of the study

Qualitative research's primary limitation is the concern for researcher bias, which may introduce subjectivity in the analysis of issues due to the researcher's experience and involvement with the phenomenon under investigation (Bloomberg and Volpe 2016). In this study researcher bias was minimized as, I, the researcher did not belong to any of the stakeholder groups interviewed for the study. My positionality is from the ecological background and assert that wolves and other top predators (although sometimes destructive to rural livelihoods) belong to the natural landscape and that measures can be taken to ensure that rural dwellers and carnivores can share the landscape amicably.

Using interviews for data collection is a good qualitative tool (Charmaz 2014), but there are limitations to this approach. One limitation was that interviewees were not mutually exclusive in one stakeholder group or the other (e.g., a rancher who is also on committee to establish a beef processing plant, or a range-rider who is also an NGO employee). Because stakeholders were not mutually exclusive it was sometimes challenging to get their specific opinions as a specific stakeholder representative. This was overcome to some extent because in qualitative interviews the interviewer could ask them to clarify under which hat they were speaking during the interview. Limitations of focus groups include issues of power dynamics (some views held by a minority of participants could be minimized), group think (there might be a tendency for participants to agree with others and reflect the collective views of group members). I overcame these limitations by being a researcher with strong facilitation skills and I specifically encouraged quieter members of the group to share and encouraged participants to give their honest opinions and not just agree with the rest of the group.

Another limitation is that many stakeholders' responses were mostly their perceptions not empirical studies, for example, the perception that the public does not care for predator conservation as one of the attributes considered when buying beef. This perception could stem from the fact that no studies have specifically asked the public to rank beef attributes including predator-friendliness. Many previous studies looked as environmental concern and not specifically predator-friendly so we don't know details about how the market ranks predator-friendly certification among the beef attributes. Further studies specifically asking the public to rank predator conservation/ predator-friendliness among other attributes documented for beef would elucidate on how the public market truly perceived predator-friendly beef labeling.

4.5 Conclusion: Comparing/ relationships among stakeholder responses

One confluence of perceptions I noted was that WDFW agency was a common point of blame for inconsistent wolf management (specifically lethal removal) in the state among various stakeholders, specifically ranchers and NGO employees. Both NGO employees and ranchers seemed to place high stake in the behavior of, and placed a certain degree of blame on, the WDFW. This might be because the wildlife agency personnel have power over carnivore management and control who gets to participate in management decisions (Mattson et al. 2006).

Common interests among some stakeholders were generally rare. Elected officials, for example, discussed issues in support of or against predator-friendly beef depending on whether they were liberal or conservative leaning, respectively (Cruz 2017, Manfredo et al. 2017). Sometimes politician's opinions were not reflective of their constituents' perspectives. The negative perceptions of the ranchers I interviewed towards predator-friendly beef were for pragmatic reasons that could be addressed. On the other hand, the ranchers' political representatives were negative based on political ideological inclinations. This suggests how a discrepancy between the political representatives and those who they represent can hinder the development of working solutions (Cruz 2017, Czech and Borkhataria 2001, Czech et al. 1998). This could have implications if a bill suggesting predator-friendly beef were proposed, some political representatives might shut it down even if it could have been considered positively by the constituents they represent.

My findings also speak to the Standpoint Theory (Harding 1991, Clark and Wallace 1999, Wallace et al. 2002), which proposes that subordinate stakeholders feel that expressing their opinions will be overlooked by the dominant groups because of the dominant group's difference in experience and social contexts. Standpoint theory can be used to analyze inter-subjective

discourses; concerned with the ways that authority and power exerted over an issue is rooted in individuals' knowledge, experience, and epistemology (Mazur and Asah 2013, Clark and Wallace 1999). According to Standpoint theory, the individual's perspectives are shaped by their life experiences forming a point of view through which the individual understands the world. When it comes to wolf conservation, every stakeholder group feels as if they are the 'minority' with the other group(s) dominating over them. For example, ranchers feel that NGOs and WDFW are dominant and that the rancher opinions are ignored, whereas NGO employees feel that the WDFW sides with ranchers and hunters and wolf management programs appease the rancher/ hunter interests rather than the public. With such a setting of perceived majority/minority or dominant/marginalized stakeholders, it helps to have each stakeholder create their objective accounts of the wolf world because they feel that the group dominating the wolf management are so immersed in the dominant group culture that they are unable to recognize the positions of other groups. Based on the standpoint theory and outsider-insider theory (Merton 1996) approaches, marginalized individuals are placed in a unique position to point to patterns of behavior that those immersed in the dominant group culture are unable to recognize. An example in this research was ranchers mentioning that while the NGO employees they supported predator-friendly beef labeling, many NGO employees were vegetarians or vegans and would not buy the very product they are supporting from ranchers. Standpoint theory gives voice to the marginalized groups by allowing them to challenge the status quo as the outsider within. Quoting Clark and Wallace (1999), "Being explicitly aware of the standpoint a professional assumes in endangered species work or in other conservation efforts is one way to improve performance, and it can significantly aid in getting the species recovered."

The findings in this chapter suggest that to design a predator-friendly beef program for ranchers in Washington, multiple-stakeholders including the beef industry should be consulted to have a product that can get into and persist on the mainstream beef market. The program managers should consult ranchers primarily so that the program can be an avenue for ranchers to reach out and educate the public about the ranching lifestyle as education was the unique opportunity that ranchers mentioned as a motivation for this incentive. The ranchers and beef processors should also be consulted for a name that they would be proud to associate their beef product with. Finally, political representatives' perspectives aligned with political ideology of the people they represented but did not align with practical solutions that ranchers held about coexisting with wolves through the economic incentive of predator-friendly beef. Misalignment between the politicians and those they represented emphasizes the complexity of the wolf issues even when people appear to be on the same side e.g. ranchers and their political representatives.

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APPENDIX

Appendix D: Interview Guide for Non-rancher Stakeholders e.g. Environmental NGO People

Can environment market services mitigate human-wolf conflict in WA State?

Purpose To contribute to improving coexistence between humans and wolves in eastern WA State

Goal Provide mechanisms to reduce economic loss due to wolves in WA State.

Introduction: This research aims to investigate the feasibility of an economy based on wolves in Washington State. The research design is to ask the ranchers the measures they think will offset economic costs to wolves, and then investigate the avenues, and willingness to pay for those measures by the public, and the means of implementing such measures that will ensure that the wolf economy is a feasible mitigation measure.

Interview Guide for Non-rancher Stakeholders e.g Environmental NGO People

In interviewing the conservation people we seek to learn the following:

1. The NGOs/ department's current involvement in economic offsets for ranchers' losses to wolves.
2. Their plans and/or recommendations for such offsets.
3. Their opinion of suggested economic measures to offset for losses to wolves.
4. How best can the offsets be implemented to protect ranchers' livelihoods

Ranchers: How do [*Non-rancher Stakeholders*] officials feel about ranchers?

1. What do you think the return of wolves means for ranchers in Washington State?
    - What impacts do ranchers' and other rural dwellers in wolf country are facing as a result of wolves?

2. How are you currently involved in issues of mitigating human-wolf conflict for ranchers?
    - What is the organization's experience in working with ranchers?
    - How effective do you feel your organization is at resolving carnivore conflict with the ranchers?

Economics: How do [*Non-rancher Stakeholders*] feel about economic programs for ranchers to coexist with wolves and their feasibility?

3. What do you think about economic programs to help ranchers pay for increased costs from wolves?

4. What such economic programs are you currently involved in?
    - What does your organization/ department suggest about protecting the livelihoods of ranchers?
    - Which measures work, and why? Which don't work and why?

- Do you think there is more that can be done to reduce ranchers' economic losses to wolves?
- What future plans do you have in addressing issues of rancher-wolf interactions?

5. How can the urban counties, which are typically less affected by wolves, help offsets for rancher's costs and to share the burden of wolves to ranchers? (aim: wolf-free urban counties i.e. King, Pierce, Snohomish, Kitsap as a source of funds)
    - Collect funds in form of licenses
    - Donations
    - Wolf plates
    - Supporting wolf agri-tourism
    - Paying premiums for Washington-produced ranch products

6. How do you feel the money collected should be used?
    - Besides the research that WSU on mitigation measures, how else more can such money be used to offset costs of wolves to ranchers?
    - How can the collected funds be used to provide alternative supplementary sources of income for ranchers in order to protect their livelihoods from threat by predators specifically wolves? (*listen out for options in 8)*

7. What do you think would be the most effective avenue for the collected funds to reach the ranchers in order to offset wolf costs?
    - How do you think your organization and others like yours can work with ranchers to ensure that these funds are effectively covering costs for wolves?
    - A lot of the ranchers expressed distrust in conservation NGOs and the science behind wolf reintroduction, what do you think about that?

8. We have been talking with ranchers about several economic options that the funds collected from the urban areas could be used to protect rancher's livelihoods. What do you feel about the following? *(ask about options that are not mentioned in 6 above)*
    - Agri-tourism (viewing wolves and wolf habitat)
    - Seasonal hunting of wolves as a game animal when sustainable numbers are reached
    - Certification of their ranches
    - Premium beef
    - Range riding (trained, facilitated and wages paid from the fund)
    - Community services e.g. College scholarships to students in communities coexisting with wolves
    - Annual check to ranchers to use towards offsetting costs for wolves (in order to protect the rancher, who btw lives off a very small profit margin from his ranch, from incurring extra operating costs as a result of wolves)?

9. What do you think can be done to strengthen existing economic programs?
    - For example, the Land Use agreements with the WDFW seem like a working deal, why are they opposed by most ranchers?
    - What can be done to make them work?

- How else could economic programs be initiated, implemented and supported?

Organizational issues: How do [*Non-rancher Stakeholders*] view the role of their agency/ office/ organization and its effectiveness in rancher-wolf coexistence?

10. Can you tell us about some of your outreach efforts regarding wolf recovery?
    - Note: ranchers feel that outreach should be for the western side, who the ranchers feel are ignorant of the reality of living with wolves.

11. What are your organization's goals for wolf recovery?

Summary of issues raised (2 mins):

Ending Questions (5 mins): *Can you please share with us anything that we should have talked about but missed during our conversation?*

Concluding Remarks: *Thank you for participating in this conversation, if you think there is anything that could help us with this study, please feel free to reach us by phone (425-628-4058), (352) 494-4125 or email: cbogezi@uw.edu, cgowan13@uw.edu*

CONCLUSION

Humans interact with carnivores in various ecological, recreational, cultural and intrinsic ways. Where humans and carnivores have to share landscapes, negative interactions can occur. Understanding the physical/ technical as well as sociological factors that are associated with human-carnivore interactions is important in order to proactively prevent and/ or reduce the negative interactions. In this dissertation, I used interdisciplinary approaches from landscape ecology and sociology to further our understanding of human-carnivore interactions in Washington State.

In chapter one I used landscape connectivity modeling and geospatial analysis tools to investigate the role of landscape connectivity on cougar- human interactions in human dominated landscapes. I found that cougar-human interactions were more likely to occur in areas of low landscape connectivity, closer distance to rivers and roads, and farther away from public forests. Because most interactions reported were depredations of livestock within the Wildland-Urban Interface (WUI) areas, humans living in areas close to wildlands should consider proactive measures to prevent depredation. This chapter shows that having intact habitat connectivity for cougars is not only good for cougar conservation, but can also reduce the incidences of cougar-human interactions.

In chapter two we aimed to extend knowledge on rancher participation in nonlethal strategies beyond recommending cost-sharing to revealing what motivates participation in those cost-shared programs. I investigated these motivations by asking ranchers questions about what nonlethal mitigations they implemented, why they did (or did not) participate in other mitigations, and what suggestions they had for improving participation in nonlethal strategies to better coexist with wolves. I analyzed the responses using Grounded Theory and found that both economic and

sociopolitical factors influenced ranchers' participation in nonlethal cost-sharing programs. It was important for wildlife agencies to address both economic and social barriers when soliciting ranchers' participation. Ranchers suggested improving compensation programs so that they are more streamlined to pay ranchers' losses in a shorter time. Furthermore, ranchers suggested that collaboration between wildlife agencies and agricultural agencies that ranchers are more frequently working with as one of the ways to increase rancher participation. I recommend dialogue with ranchers and collaboration with other natural resources and agriculture agencies working with ranchers to improve participation. I further recommend investigating novel economic strategies such as performance payments that reward ranchers for achieving conservation outcomes. Chapter two showed that there was opportunity to build on ranchers' existing efforts and to support self-organized rancher groups (similar to Blackfoot Challenge group in Montana) to implement case by-case strategies that would reduce negative interactions and social conflicts while increasing positive coexistence with carnivores in their proximity.

Chapter two contributes to the field of conservation by moving beyond recommending cost-sharing to articulating the mechanisms that can make cost-sharing programs more effective. I described what factors motivated or deterred ranchers from enrolling in WDFW's cost-sharing programs. Given that ranchers mentioned economic cost as a deterrence to participating in nonlethal methods, even when they are cost-shared, shows that sharing financial cost was not sufficient to ensure rancher participation in WDFW's programs. This study contributes to understanding how cost-sharing programs could be designed to solicit rural dwellers' participation. By highlighting the motivations, barriers and suggestions for participating in cost sharing, I contributed in describing some social processes that influenced what and why technical solutions (especially cost-shared programs) get adopted by rural dwellers. I attempt to describe some

procedural steps that could be implemented by agencies to improve participation in the cost-shared nonlethal programs.

Chapter three I compared the perspectives of various stakeholders towards predator-friendly beef as an economic strategy to help increase coexistence between ranchers and wolves. By using qualitative interviews of various stakeholders I contributed empirical research on the factors that could motivate/ facilitate or dissuade/ constrain establishment of predator-friendly beef as a strategy for rancher-wolf coexistence in Washington State. My contribution, was to provide mechanisms as suggested by various stakeholders on that market recommendations would work under what circumstances. Both motivations and constraints were economic and social factors. Motivations included monetary benefit, and opportunity to communicate to non-ranchers, while constraints included competition for market, lack of verification infrastructure and underlying social factors.

On several accounts the perspectives of political representatives were not aligned with the ranchers they represented: while both were not overly optimistic about predator friendly beef, ranchers gave practical reasons on what would make the program feasible for them to participate, whereas their political representatives were more pessimistic and gave no suggestions for enhancing the program. For many ranchers the constraints were pragmatic, whereas for many of their political representatives the constraints given were ideological. Overall political representatives' perspectives were strongly aligned to their political leanings whereby Republican representatives did not support programs for wolf conservation while the Democrat representatives supported programs for wolf recovery and conservation.

In this dissertation I used interdisciplinary approaches from landscape ecology and human-dimensions of wildlife to contribute to our understanding of interactions between human and

carnivores in Washington. Throughout this research I attempted to use the term human-wildlife interactions instead of human-wildlife conflicts in order to acknowledge that humans interact with wildlife in a variety of ways and not all of them are conflicts. By not constraining the definition of human-wildlife interactions to only conflicts, researchers, wildlife managers and conservation organizations are able to expand their solutions of increasing positive wildlife-coexistence beyond technical solutions to include sociopolitical solutions. Technical solutions can successfully minimized damage from wildlife but because conflicts about wildlife are fundamentally between people, technical solutions alone are unlikely to focus on the underlying problems that conflicts humans might have. For example in chapter two of this dissertation, I showed that previous experience working with the wildlife officials either motivated or deterred ranchers from participating in cost-shared programs by the wildlife agency. This example shows that some ranchers' participation was not dependent on effectiveness of the cost-shared mitigation strategies but on the social interactions they had had with the wildlife officials. In conclusions, in order to fully understand and improve human-wildlife interactions I urge that human-human conflicts should not be misrepresented as human-wildlife conflicts. By addressing challenges of humans coexisting with wildlife under the human-wildlife interactions it provides an opportunity to address both the physical damage wildlife can sometimes cause as well as the underlying social conflicts between humans that are conflicted over the management objectives of the wildlife.

VITA

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Carol Bogezi is a PhD candidate in the Wildlife Science program in the School of Environment and Forest Sciences (SEFS), University of Washington, Seattle. An international student from Uganda, Bogezi was awarded the prestigious Beinecke Africa Wildlife Conservation scholarship by the Wildlife Conservation Society to pursue her graduate studies in the USA, and additional support from SEFS and Wildlife Conservation Network (WCN) for her studies. In 2016 Ms. Bogezi was awarded the 10th annual Environmental Leadership Award by the Bullitt Foundation to complete her PhD, and was named one of the 'Top 40 Women Under 40' most influential women in Uganda by the Sunday Monitor in Uganda. She was one of the UW Husky 100, 2018.

Born and raised on a farm, Ms. Bogezi is intimately aware of the needs of humans and wildlife competing for natural resources. Her objectives are to use interdisciplinary science-based approaches to inform human-wildlife interactions to encourage human-wildlife coexistence and biodiversity conservation. She also strives to support rural youth education and economic development programs without compromising environmental integrity.