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Allyson Jayne Miller for the degree of Masters of Natural Resources presented on June 19, 2020.

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The Cougar, The Tick, and Human Wellbeing:

The Social, Economic, and Ecological Valuations of Living with Cougars in Oregon

by
Allyson Jayne Miller

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I understand that my capstone will become part of the permanent collection of Oregon State University libraries. My signature below authorizes release of my capstone to any reader upon request.

Allyson Jayne Miller, Author

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DEDICATION

To Steven

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Abstract

In 2019 the Oregon State Legislature House Committee on Natural Resources announced that the state must develop tools for which to balance the social, economic, and ecological concerns of human's proximity with the cougar (*Puma concolor*). Prior to this statement, 150 years of Oregon's Euro-American land management, policy-making, and natural resource extractions had succeeded at extirpating two of Oregon's apex carnivores, the grizzly bear *(Ursus arctos horribilis)* and the gray wolf *(Canis lupus)*, while also suppressing a third, the cougar. These three represent a predator guild that may be necessary for sustaining biodiverse landscapes. The loss of these species' ecosystem services has likely contributed to declining ecosystem health as well as a potential loss of social well-being and economic stability. However, these effects may be reversible.

Of the three apex carnivores, cougar appear to be the most resilient towards adapting to anthropocentric pressures of modern man. Areas of ecosystem-service restoration that lack the self-regulating ecoengineering of the cougar run the risk of a slower recovery progress, failure, or weakened natural capital return. For Oregon to find a balance between human populations and the cougar, the general public and resource management agencies need to deemphasize Euro-American perspectives of this large carnivore. This will require "reverse eco-engineering" over 150 years of anthropogenic perspectives, a reduction in native and domestic ungulate populations, and revised land use laws. The overarching objective of this paper is to identify how the three tiers of human well-being (i.e., economics, ecosystems, and social) are linked to healthy landscapes and a species-rich ecosystem mediated by healthy cougar populations. Does the cougar help mitigate Oregon's Lyme disease, chronic wasting disease (CWD), or elements of

climate change? Are there risk assessments of living with, or without them? What can apex predators do for Oregonians and what could our societies look like if we protected the cougar?

Objective

The goal of this paper is to raise awareness of possible benefits that co-existing with the cougar (*Puma concolor*) may offer, as well as potential problems that might be associated with these relationships. While the cougar is scientifically understood to represent a keystone and umbrella species, there has been little rigorous or interdisciplinary scientific inquiry evaluating the puma's provisioning influences for human well-being. This paper will also suggest several moral and ethical missing links, social benefits, and economic valuation connections between Oregon's cougar and human well-being. For the content of this paper, the word apex predator, cougar, puma, or American lion will be used to reference Oregon's cougar.

Identifying with Cougar

> *To understand someone, especially someone who hails from a very different background, it is necessary to withhold judgment, to stand in his or her shoes, and see the world through his or her eyes, to empathize – indeed, to almost become the other individual* (Rivas et al., 2001, as cited in Bradshaw, 2017, p.1).

As far back as oral stories began, the value of words explained, interpreted, reasoned, and concluded what was happening. Oral, pictorial, and later written words helped individuals and communities understand ambiguous experiences. Words brought order and enhanced the critical thinking, observation skills, and insights of various individuals. For example, hidden in the meaning of "puma" may be a range of observations that relate to the well-being of communities that were mindful of living with this predator. It speaks volumes that across cultural differences, humans have proclaimed at least eighty-six names upon one complex species for which we have shared the earth for thousands of years. No other animal known has received as many titles as the cougar. What could eighty-six names say about human relationships with the puma that may matter today? Out of the twenty-five North American names, the Chickasaws called cougar *Koe-Ishto*, Cat of God. South American native's *Cuguacuarana*, the most popular of their eighteen names for this species, was changed to cougar by French naturalist George Buffon. Not to be outdone, the English bestowed forty-three names upon this American lion we also call puma (Jackson, 1961).

Ancient Sedona Native American petrographs suggest that cougar co-habituated with humans for perhaps thousands of years before falling out of favor with the Euro-American culture (Figure 1). Five-hundred years of Western Euro-American words developed a culture of hierarchical systems that valued noncommunal wealth, and a spiritual status that demanded they conquer and overcome not only nature, but those of different cultures, spiritual views, and wealth systems. Native Americans believed their kindred relationship with animals shaped their lives and created a sense of place in the universe, and on land that was communally owned. Animals played a central role in spiritual, individual, and communal cultural identity for which they expressed through their words and in ceremonial dances. Tools, clothing, lodges, and weapons made from animals were held in great reverence. But to this day, the origins of Western Euro-American values demand that only the money made from the exploitation of animals and nature is of value.

Until that is, a cougar crossed two major California freeways to make his home in Hollywood California's Griffith Park, and got his picture on the cover of National Geographic Magazine (Chadwick et al., 2013; Keefe et al., 2013; Curwen et al., 2017; Sabana Films, 2017). Citizens of Los Angele's were thrilled to share edges of cityscapes with their beloved cougar, Puma 22 (P-22). And the combined efforts of California Department of Fish and Wildlife (CDFW) and university labs began extensive research into co-existing with this American lion. Some Native cultures considered the cougar to be a god, while others valued the puma as powerful totems. Today, scientific inquiry is unlocking the American lions amazing ecological secrets and their linkage to human well-being. From petrograph to the cover of National Geographic Magazine, the citizens of Los Angeles, as may have Native Americans and their cougars, consider elements of P-22's life and journey to his home in their city as near mystical. In retrospect, this single cougar may have changed forever California's social, economic, and ecological perspectives of living with cougar (Chadwick et al., 2013; Keefe et al., 2013; Curwen et al., 2017, Sabana Films, 2017). Good, bad, or indifferent, attached to the cougar's name is the umbilical cord of cultural connections to nature, community values, spiritual awareness, and reflection of identity, all of which intertwine with people's lives, economies, and well-being.

Cougar Biology and Social Behaviors

Adult female cougars' range in size from 80 to 120 lbs (35-55 kg), and adult males will range from 130 to 190 lbs (59 kg – 86 kg). Pumas range in color from a grey-brown to tawny gold. Their entire body is normally between six to eight ft (1.8 – 2.4 m) in length. Cougar tails, important for balance and maneuvering, make up about a third of their long and slender body size. Their hind limbs are lighter than their shorter and heavier forelimbs. One of their many evolved prey advantages besides their limbs are flexible wrists for handling prey (Beck et al., 2005; Hornocker et al., 2010).

Although cougars can give birth at any time of the year, the mother's timing usually coincides with the birth pulse of their prey (Beck et al., 2005). The mean age for females to begin breeding is roughly 29 months with an approximate mean litter size of 2.7 kittens born once every two years. Kitten survival rates can range between 0% to 95%, but in heavily hunted areas, it is typically low. Reliable information on cougar mortality rates and population responses toward environmental changes usually requires more long-term monitoring, rather than the short-term data derived from hunting them (Beck et al., 2005; Hornocker et al., 2010).

Cougar mortality can occur from various causes, including hunting, road kills, disease, starvation, self-regulating population kills, infanticide, injuries sustained during prey capture, and wolves. Bradshaw's (2009, 2017) research suggests that human-induced stress on cougar can cause Post Traumatic Stress Disorder (PTSD) and trauma. Historically, most cougars lived long lives in the wild, reaching more than ten years old. Today, few cougars reach or exceed the age of five due to higher fatalities from hunting, poisoning, trappings, and road kills. In areas that are not hunted or otherwise influenced by humans, cougar mortality self-regulates their social structure. Conflicts with reintroduced wolves also contribute to cougar mortality (Beck et al., 2005; Hornocker et al., 2010; Ruth et al., 2019; Wielgus, 2019).

Cougar kittens are born with spotted coats, closed ears and eyes, and they are highly dependent on their mother. Usually weighing about 500 gms, within two weeks their eyes open, displaying vivid blue irises. At five months old, their eyes become a golden brown, they are agile at climbing trees, and their coats begin to lose their spots. Although they can become independent at approximately 18 months, they normally do not disperse until they are nearing 24 months of age. Male kittens are usually the first to disperse to seek territory of their own. It is not unusual to see female kittens staying within their mother's proximity or dispersing much later than their male siblings. Sometimes one out of two females may remain close to their natal populations and even periodically socialize with loosely knit groups of nearby females. Cougars have a complex social structure within their species, but outside of immediate family members, they are solitary, usually hunt alone, and are normally shy of humans (Beck et al., 2005; Hornocker et al., 2010).

Communications

Olfactory, visual, postural, and vocal are four currently known types of communication that cougar rely upon. Olfactory and visual signals consist of scrapes or scratching into the soil, logs, or trees with the use of back or front paws, and sometimes defecating on or near the site. Male cougars are more inclined to use this form of communication. Least understood at this time are the postural body languages between cougars. Cougar vocalizations gain the attention of not only their species but also that of human lore and science. Four types of puma vocalizations have been identified: neonatal, sexual, agonistic, and integrative. From purring, hissing, whistling, and birdlike chirps to a bone-jarring hair-raising caterwaul yawl, their variations of vocalizations convey threats, anger, contentment, calling for mates, and maternity care. All of these vocalizations convey the unique social structure and family bonds indicative of the puma (Hornocker et al., 2010).

Diet

Cougar are selective meat-eaters. Deer (*Odocoileus* spp.), mesopredators, young cohorts of large ungulates, birds, mice, rodents, and wolves, if separated from their pack, are sources of food. Using their raspy tongues, they will strip bones clean and leave them along with the intact stomach as vital resources for scavengers. Unlike coyote (*Canis latrans*) and wolves (*C. lupus*) that may feed upon their prey while it is still alive, cougar efficiently and instantly kill their prey (Beck et al., 2005; Laundre et al., 2007; Hornocker et al., 2010; ODFW 2017c; Laundre et al., 2018a).

Neurology

In recent years, cross-species psychobiological research has yielded important understanding regarding shared neural coding in the subcortical and cortical midline neurological development and processing of young animals and humans. Animals and humans develop patterns of response to outside stimuli, such as trauma, through the same neurological pathways (Bradshaw, 2017). Shifting cultural perspectives and land use changes, from those of Native Americans to Euro-Americans, have often dramatically changed the social structure, stress, and neurological development in the lives of the cougar. As a result of aggressive Euro-American hunting policies and land use changes, the cougar is more susceptible to disease, starvation, social and family structure loss, and PTSD (Bradshaw, 2017; Bradshaw, 2018).

Neurological studies are beginning to show that similar structures in animal brains integrate information (fear, joy, compassion, etc.) in a way that is analogous to processes in the human brain. What may have influenced our historical thinking about the cougar (and animals in general) is the concept that humans are the only beings capable of cognitive-emotional attributes that somehow evolved separately from other species. This concept fueled initially by religious beliefs, economics, and policies, has been a significant factor shaping cultural relationships with predatory species, such as the cougar. There is growing evidence that humans are not the only species with the ability reason and feel (Bradshaw, 2017).

Territory and Behavior

Territory size for cougars is determined by the cumulative effects of prey abundance, fragmented landscapes, roadless areas, human disturbances, and the presence of other cougar or wolf populations (Beck et al., 2005; ODFWc, 2005; Peebles et al., 2013; ODFW, 2017a; Wilmer, 2018; ODFWb, 2019). The more prey, the smaller the territory, the less prey, the larger the territory. Female territory may be enlarged while they are raising their young. Other predators can indirectly influence prey base distribution and abundance of species that cougar consumes. Predator overlap can pressure puma to establish bigger or smaller territories. Moreover, if cougar sense humans are near, they will normally abandon their kills and seek food in areas less populated by humans (Peebles et al., 2013; Wilmer, 2018; Figure 2). This response is known as the Anthropocentric Landscape of Fear reaction towards humans (Wilmer, 2018). Thus, human encroachment on cougar territory will apply pressure on cougar to kill more deer. As humans thin out or remove cougar from the landscape, deer can sense a reduced predation risk in these human-disturbed areas. In landscapes where deer feel "safe," their populations can increase and eventually exceed vegetation's carrying capacity. These landscapes are at risk of poor ecosystem resiliency and nutrient feedback (Wilmer, 2018). They are also at increased risk for exposing humans to the emerging effects of Lyme disease and deer to chronic wasting disease, or CWD. Current research hypothesizes that with time and exposure to CWD, humans could become vulnerable to this disease. However, unlike Lyme disease, CWD currently cannot be transmitted to humans (Patz et al, 2005; Krumm et al., 2009; Waddell et al., 2017).

As with all large carnivores, cougars need vast amounts of land and high-quality habitat to establish territorial niches and distribution patterns. They are obligate carnivores, which requires they have access to extensive and diverse landscape ranges. Such requirements contribute towards self-organizing and self-regulating ecosystems that also offer cover and adequate prey. Preservation of the cougar on large landscapes increases trophic structure, nutrient flow, and the relationships that define the nature of ecosystems (Ripple et al., 2005; Ripple et al., 2008). Landscapes enhanced by cougar's ecosystem services increase species diversity, which is linked to enhancing forests, watersheds, soil, and pollinators that support agricultural land productivity.

Establishing large landscapes for cougars also supports the health of wildlife and wild places for future generations (Shaw 1994; Hornocker et al., 2010; Peebles et al., 2013).

The natural habitats of cougars historically covered much of North America (Figure 3; Hornocker et al., 2010). In Oregon, cougars, wolves, and grizzlies once roamed coastal forests, the Cascade Range, high deserts, and Klamath Mountains (including the Siskiyou), the Southern Cascades, and the Blue/Wallowa Mountains (including Hells Canyon country). However, due to land use changes, policies, and depredation incidents (e.g., livestock, public safety) puma have lost much of their historic range in Oregon and across the United States (Figure 4). In Oregon, grizzlies have been extirpated, wolves were extirpated but in recent years have been making a slow comeback, and cougar populations have been suppressed. Furthermore, current cougar populations occur over only a portion of their original distribution.

The territory of an adult male cougar can range from approximately 100 to 150 mi^2 (260-390 km^2), but some have been recorded up to 400 mi^2 (1,040 km^2). Adult males are more mobile than female cougars. Established adult males spend much of their travels marking their territory by scraping and otherwise removing young transitioning male pumas who are seeking territory and breeding rights of their own (Shaw, 1994; Hornocker et al., 2010).

Although male cougars do not assist with raising their young, they inadvertently do so by defending their territory from other male cougar's infanticide-induced breeding pressures. The ranges for the female adult cougars are smaller than that of males. Unlike male ranges that will overlap, female ranges rarely overlap more than one male range. Once pregnant, female ranges normally are reduced but, depending on the food source, can expand to ensure adequate prey availability and safety. In a given area, the number of female cougars will often exceed the number of males (Beck et al., 2005).

Managing Suitable Cougar Habitat and Effective Research

There is considerable contention regarding how many cougars Oregon has, or should have. Some suggest that the current computer-generated population model of 6,000 cougars (adults and hypothetical kitten count) in Oregon does not adequately reflect the landmass necessary for the biological functions and social structure, or provide an accurate population estimate. Inaccurate population numbers and their solitary wide-ranging nature are why it is difficult to monitor and survey this large predator. To address these inherent shortfalls, researchers have turned to identifying suitable cougar habitat as the basis for understanding population dynamics.

Successful cougar management normally includes three objectives: 1) identify high-quality habitats based on variables such as suitable cover, diversity of prey, and land uses, 2) preserve sufficient habitat for cougar population resiliency, and 3) conserve habitat as an umbrella effect for biological diversity. Managing cougars through the management of their habitat, as opposed to population management (e.g., manipulation of populations to serve hunting, captive propagation, or predator control), is a conservation tool that can increase the population resiliency of cougars as well as help to maintain species richness of other wildlife. Although wildlife agencies typically manage game animals such as ungulates or birds by annual harvesting, for cougars it is essential to manage for maintaining large areas of high-quality habitat based on the following guidelines (Beck et al., 2005):

1. Create a geographically explicit database of cougar habitat and behavior response to changes in habitat quality that includes seasonal changes and their historic range.

2. Within a metapopulation, map and identify subpopulation networks as either sinks or sources. Cougar source populations allow for positive population growth, social development, subadult dispersion, and genetic integrity. These source populations represent “biological savings

accounts" that can augment exploited subpopulation sink areas and cougar harvest. Sink subpopulations are habitat areas surrounded by non-habitat or marginal habitats such as urban areas, reservoirs, freeways, and areas of low prey base or cover. Good source population habitat areas, or natural refugia (areas of little cougar harvest or human impediments), can become habitat patches due to these neighboring impediments, causing subpopulation sinks to occur and restrict migration. Understanding landscape's history and potential for subpopulation area sinks or sources enables effective management of cougar populations and reduction of conflict issues. Geographical mapping of subpopulation areas can assist with managing cougar metapopulations.

3. Try to preserve metapopulation source areas that have low human conflict and low cougar mortality. This requires large protected landscapes managed for natural refugia where spatial and temporal evolutionary and ecological processes can occur without significant human interference. For example, to assist in maintaining cougar metapopulation resiliency, the density of roads, livestock, and hunting cougar and their prey species would need to be minimized or significantly reduced in source subpopulation areas.

4. Because cougars can be found in remote corners of Oregon, on both public and on private lands, it is important to use spatially explicit information that will help tailor management regimes to the characteristics of the landscape. For example, Geographical Information System (GIS) mapping can be used to help characterize areas with a source or a sink subpopulation. Such mapping is essential for identifying linkages between metapopulations, high hazard areas such as highways or canals, conflict areas such as livestock grazing allotments, or the distribution and status of protected areas. Land use and zoning maps also can help with identifying land conversions or housing developments, which may create cougar genetic bottlenecks or limit connectivity between subpopulations. GIS mapping can also assist with

helping to identify where human disturbances might influence the distribution and numbers of cougar and their prey.

5. Landscape-scale genetic connectivity and linkages are essential towards maintaining the metapopulation community and structure of cougars (Beck et al., 2005; Hornocker et al., 2010). Global Positioning System (GPS) collars may assist with identifying suitable linkages and areas in need of improvement. Currently, Oregon Department of Fish and Wildlife relies on sports hunter sightings and kill evaluations, which offer very limited spatial and temporal information regarding suitable habitat and linkages (ODFW, 2005a; ODFW, 2005c; ODFW, 2016a).

6. Corridor and linkage quality assessments depend on prey abundance and diversity, land uses, suitable vegetation coverages, and whether they are travel corridors or live-in corridors. Travel corridors offer enough resources for a short journey to new territory, whereas live-in corridors can become part of the home range.

7. Successfully creating, designing, and funding for long-term habitat conservation as well as the restoration of subpopulation linkages, depends upon several factors: a) How restorable is the habitat? b) What is the quality of the area to be linked? c) How resilient are the areas original habitat? d)What is the size and capacity of the linkage? e) Will the public support the corridor and the long-term costs to purchase needed land, implement restoration, and manage for future wildlife linkages? Subpopulation linkages and corridors may require decades of collaboration among land management agencies, wildlife managers, regional and county planners, private landowners, and transportation agencies to develop. As a result, comprehensive political and social efforts are usually needed to establish, restore, and maintain functional corridors.

8. There are several options for successful conservation of cougar. Current tools to help foster thriving and ecologically effective populations of cougar and their habitat can include

financial incentives and changes in public perspectives through education and widespread stakeholder participation. Corridor developments over heavily used road infrastructures increase genetic gene pools, reducing fatalities, and reconnecting fractured landscapes. Private land grant incentives, land conservation policies, and involving Non-Governmental Organizations (NGOs) can help to attain private and public conservation easements, grant incentives, or land purchases (Beck et al., 2005).

Cougar Ecology: Ecological Benefits and Trophic Cascades

To understand human social, economic, and environmental provisioning assets of cougars *via* trophic cascades, it is essential to understand the benefits of the "ecology of the fear" (Eisenberg, 2010). Due to their all meat diet, cougars are considered at the top of the food chain in most ecosystems. This position makes them not only a keystone species, but an umbrella species that may eventually influence ecological processes such as pollination, seed dispersion, nutrient cycling, and others, thus affecting the structure and functioning of ecosystems (Beck et al., 2005; Laundre et al., 2007; Wilmer, 2018). Predators influence prey species in two major ways, behavior mediation and predation. Altered behavior is often associated with the ecology of fear, which influences the movement and use of habitats by prey species when cougars are present (Eisenberg, 2010). Cougars thus help support the balance, structure, and successional processes that help to maintain the integrity of ecosystem metacommunities. By doing so, they help structure the stochastic demographic process of the food web interactions and interdependencies found in Oregon's diverse ecological communities (Eisenberg, 2010; Laundre, 2012; Wilmer, 2018). Cougar presence may also ensure that processes which create species diversity, niches, and ecosystem functions are maintained, thus influencing Lyme disease hosts and potential human exposure to this disease. For example, cougars consume deer and wood-rats (*Neotoma fuscipes*), and by that very process, can reduce exposure and spread of the disease.

Density Dependent Processes and Carrying Capacities

Oregon Department of Fish and Wildlife (ODFW) management of ungulate species for sports hunting has increased deer and elk (*Cervus* spp.) populations in Oregon. For example, Oregon elk population has grown to be the fifth-largest in the Western States. Currently, approximately 70,000 Rocky Mountain elk (*C. elaphus nelsoni*) and 55,000 Roosevelt elk (*C. canadensis roosevelti*) now share Oregon's ecosystems, along with 340,000 mule deer (*O. hemionus*), over 2 million cattle (*Bos taurus*), and 200,000 domestic sheep (*Ovis aries*) (USFWS, 2014; ODFW, 2016b; ODFW 2016c, ODFW, 2018; USDA, 2018; ODFW, 2020). The ecological impacts of the livestock industry alone have far greater significance than do roads, timber harvest, and wildfires combined (ODFW, 1987; Beschta et al., 2012; ODFW 2015-2019; ODFW, 2016c; USDA, 2018; Figure 5; Figure 6; Figure 7; Figure 8).

Little is left of Native American knowledge or documentation that might clarify what early predator/prey carrying capacities were prior to Euro-American settlement in Oregon. There has been little research regarding their historic behavioral patterns and interactions, but it is believed that grizzly bears *(Ursus arctos horribilis)* primarily inhabited the forests, wolves the plains, and cougars the rivers and forests (Laundre, 2012). Due to human demand on natural resources, land use changes, altered prey abundance, and loss of predator controls, over time the ecological interactions and social structures of apex predators and their prey were upended (Beck et al., 2005; Laundre et al., 2007; Laundre, 2012). Overall, the structure and diversity of the ecological links between cougars and other carnivores such as the wolf and grizzly represent a complex set of environmental interactions (Laundre et al., 2007; Laundre, 2012).

One indicator of carrying capacity exceedance by ungulates is their physical condition. At peak capacity, population competition for food can reduce nutrition and increase disease. In such conditions, cougar predation can influence prey populations by lowering their densities, reducing competition, decreasing disease, and increasing food sources, thus enhancing recruitment and survival of the remaining prey. Ungulate predation also decreases damage to plant communities from ungulate prey and enhances the stability of those communities (Beck et al., 2005). Managing cougar for increased ungulate hunting requires an understanding of factors such as successional population shifts due to prey abundance, species carrying capacity, and the spatial and temporal human disturbances associated with landscape fragmentations, desertification, climate change, and others.

The ebb and flow of prey abundance and behavior can increase large carnivore numbers (e.g., bear, wolf) and their competition for food with cougars. In many cases, human presence and land use can adversely affect cougars and cause them to increase predation rates. To help avoid stress on cougar populations, managers need to understand and create options for different prey and alternative habitats suitable for cougars. Although predation numbers can vary due to climate, location, age, sex, and whether the cougar has kittens, on average a cougar often kills 48 large mammals and 38 small mammals annually (Beck et al., 2005).

History, Politics, and Willingness to Coexist

Looking back at pre-Euro American influences in Oregon, one may wonder how long have humans benefited from and lived with cougar? Ecologically healthy ecosystems have historically provided benefits to “early Oregonians.” During the Pleistocene, receding glaciers enabled species migration that included Homo sapiens from Asia into North America. What these early Oregonians found were beavers (*Castoroides ohioensis*) the size of bears, and bears

(*Arctotherium angustidens*) that could run like racehorses. Animals of mythical proportions filled trophic levels and niches alongside saber-tooth cats (*Smilodon fatalis*), American lion (*Panthera atrox*), the original massive Mountain Lion (*Pantheraatox*), and the American cheetah (*Miracinonyx*); the genetic split of which became the half lion/half cheetah we know today as the cougar. Only one-sixth the size of a saber-tooth cat, the cougar and the jaguar (*Panthera onca*) were the only large cats to survive the mysterious decline of large predators during the late Pleistocene. The Holocene wolf and cougar symbiotic relationships contributed to thousands of years establishment of successional ecosystem networks, functions, mechanisms, and adaptations, from which Oregonians still benefit today. Like seed "legacies" dropped from dying pine trees in a fire, cougar survived climate and ecosystem disturbances, and thus became a living Pleistocene legacy (ODFW, 2006).

Fast forward from traditional ecological knowledge of Native Americans to the Western-World paradigm of benefit-cost economic analyses and homocentric theory, "The greatest good for the greatest number of people." Cougars became part of Oregon's politics in the 1843 "Wolf Meetings" when one of the first laws enacted by the Provisional Government of Oregon was to put a bounty on cougars and wolves (Porter et al., 1849). The act was based on Euro-American concepts of livestock protection and subsistence farming. Membership fees to the Oregon Wolf Organization paid the bounties on wolves, and later the county treasurer paid bounties on cougar (Porter et al., 1849) giving the fledging pioneers a form of income until their farms became productive. Because of the money made from these bounties, the public grew a government supportive of livestock, timber, and market hunting, thus replacing the stability of fully functioning ecosystems mediated by an intact apex predator guild. If not for the wolf and cougar, it may have taken longer for Oregon to obtain Statehood. From 1928-61, the annual number of cougars for which a bounty was paid was as follows (ODFW, 2006):

Year	No.	Year	No.	Year	No.	Year	No.
1928	254	1937	163	1946	130	1954	148
1929	288	1938	187	1947	145	1955	116
1930	337	1939	194	1948	187	1956	80
1931	243	1940	222	1949	201	1957	103
1932	295	1941	166	1950	177	1958	56
1933	177	1942	101	1951	143	1959	48
1934	139	1943	77	1952	154	1960	36
1935	149	1944	98	1953	123	1961	27
1936	167	1945	123				

In 1967, conservationists lobbying on behalf of the cougar succeeded in changing the status of cougar from “unprotected” to “game animal”. In the process, they urged consideration of the cougar’s spatial and temporal effects on the dynamics of biological systems and ecological processes (Shaw, 1994). At this time approximately 200 cougars remained in Oregon. The government bounty program was stopped and ODFW took over management of the species (ODFW, 2017c; ODFWb, 2019). Nearly thirty-three years later, the cougar population had increased to ~3000, and so has the number of hunting tags and allotted areas for hunting them (ODFW 2017b).

Public awareness of cougars increased in 1994 when 52% of the public voted in favor of Measure 18, an initiative put on the ballot by Oregon citizens which stopped hunting bear and cougar with dogs (*Canis familiaris)* (Measure 18, 1994). Measure 18 was intended to reduce the number of cougars being killed by eliminating a tool used to kill them, dogs. Because hound hunting tags represented one of ODFW’s sources of income, ODFW changed cougar hunting policies. The price of cougar tags was dropped, the species were incorporated onto other hunting tags, and legislative bills were initiated that allow selected parties to hunt cougar with dogs. Moreover, the estimated cougar population has grown beyond the biological threshold limits of the cougar's territorial requirements (Wielgus, 2010).[1] ODFW sold 937 cougar tags in 1997, but by 2003 over 34,000 cougar tags were sold. Currently, the rate of killing cougar, with or without dogs, has returned to pre-Measure 18 levels. For the first time in approximately 150 years of cougar control by Euro-Americans, ODFW's new initiative for killing cougar now included public safety and administrative kills (ODFW, 2017a).

Social, Economic, and Environmental Consequences of Oregon's Cougar Management Plan

The trophic cascade disruption and altered food webs from apex predator removal and the subsequent ungulate irruption can impact much of Oregon's social, economic and environmental concerns. Furthermore, the loss of such keystone species can complicate the social and economic choices society makes when managing ecosystems and interconnected species for which the cougar previously helped to regulate.

ODFW Cougar Hunting Policies

Complex biological systems require considerable management and financial support from the public. Unfortunately, evaluations have found that 60% of global wildlife management plans do not address sufficient science or contain the four fundamental hallmarks of research: measurable objectives, evidence, transparency, and independent reviews (Hornocker et al., 2010; Artelle, 2018). Instead, vested parties can promote biased ecological concepts and politically motivated wildlife populations, with the intent of benefiting themselves and not the ecosystems. These are known as "political populations" (Lambert et al., 2006; Wielgus, 2010; Artelle, 2018).

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1) Page 2, para 5. The statewide cougar population (including area sub-populations) is estimated as 5,101 – based on a model from Keister and Van Dyke (2002). The modeled estimates for each area must be verified by empirical data and this was not done here. The estimates for these treatment and control areas have no scientific validity because of this lack of verification. See point 4.
Page 3, para 1. cougar depredation removals increased from 23.4/yr (pre-ballot initiative) to 116.9/yr (post ballot initiative). This may correspond to the socio-political fallout from the ballot initiative – not increased numbers of cougars as implied here (same as occurred in WA). The jump in total cougar removals from 75 in 1995 to 123 in 1996 implies a cougar population increase of 64% in 1 year – a biological impossibility. http://orecat.org/dr_wielguss_cougar_peer_review (Wielgus, 2010).

Oregon's public trust and investment in the management of their State wildernesses, public State lands, wildlife, and mechanisms that sustain Oregon's biodiversity are assigned to ODFW. Most of their funding comes from hunting tags along with some State and Federal tax funds. Oregon's Wildlife Policy directs ODFW and their board to manage wildlife "… to prevent serious depletion of any indigenous species and to provide the optimum recreational and aesthetic benefits for present and future generations of the citizens of the state" (ORS, 2017a). Policies appear to collide when it comes to the widespread occurrence of invasive livestock and the maintenance of large ungulate populations for sports hunting. "Because of the social constraints resulting from wildlife impacts to private or public land management, population objectives are not normally set at biological carrying capacity. A key objective in Oregon's cougar management strategy involves minimizing conflict between humans and cougars. ODFW is obligated to manage the state's wildlife (ORS, 2017a), and respond to situations where wildlife poses a threat to human safety or inflict property damage" (ORS, 2017b; ORS, 2017c).

Referenced in Oregon Revised Statute (ORS, 2017a) are value-laden terminology: To maintain all species of wildlife at optimum levels (what is optimum and for whom?); To permit an orderly and equitable utilization of available wildlife (what is equitable utilization?); To regulate wildlife populations and the public enjoyment of wildlife in a manner that is compatible with primary uses of the lands and waters of the state (primary for ecological or anthropocentric usages?); To make decisions that affect wildlife resources of the state for the benefit of the wildlife resources and to make decisions that allow for the best social, economic and recreational utilization of wildlife resources by all user groups (who is really benefiting?).

Oregonians assume their government is managing their natural resources and wildlife from a foundation of science, but this may not always be the case. Most state wildlife managers, including those in Oregon, claim to rely on the North American Model of Wildlife Conservation, but cannot consistently articulate what their science-based programs mean or how they relate to the four fundamental hallmarks of research (Artelle, 2018). Hierarchical representation of private vested parties and levels of government can create public trust issues, inefficient accountability, inequitable access to natural resources, ecosystem decline, and politically derived apex predator population counts. Overlooked in Oregon's bundled hierarchical system of livestock, timber, and hunting land use and wildlife management plans are cougar's sustainable and resilient ecological benefits and the hallmarks of science (ODFW, 2017a; Bradshaw, 2018).

ODFW Cougar Management Plan Core Values and Science

Words convey meaning, outcome, and results, yet the words in Oregon's current cougar management plan hold little incentive for public understanding of the importance of conserving the cougar. However, in ODFW's 1987 Cougar Management Plan the agency expressed efforts to protect cougar territory by reducing roads and human encroachment (ODFW, 1987; ODFW, 2017a). "Ecology" is mentioned forty-five times in the plan's literature citations, three times informing the reader to seek other sources to learn about the cougar's ecological values, and twice in the appendices (ODFW, 1987; ODFW, 2017a). Outside of mentioning trophic cascades seven times in the plan's literature citations, trophic cascades are not mentioned at all in the body of the plan. The word "damage" is mentioned 271 times and only in the context of homocentric deer, elk, livestock, and pet depredations (ODFW, 2017a; Table 1). In contrast, California uses words that also reflect public perspectives regarding their cougars. Undoubtedly, word choices used to describe cougar may shape public perspectives of cougar management, as well as the social, economic, and ecological consequences of this carnivore (Table 2).

The neglect of ecological accountability in ODFW's cougar plan, tends to indicate it represents a "forester's fig leaf" more focused on political agendas than sound science (Fortmann et al., 1989; ODFWc, 2005; Lambert et al., 2006; Wielgus, 2010; ODFWa, 2017). ODFW's cougar plan appears to be implying that a simplified system of far fewer species is better than a complex natural ecosystem. Critical aspects appear missing from ODFW's cougar management plan, such as the processes that restore, create, and maintain the synergies of a fully operating ecosystem with an intact large carnivore guild. Current management plans for cougar instead emphasize ungulates, cattle, sports hunting, and human safety (ODFWc, 2005; ODFWa, 2017; ODFWb, 2019). While the ODFW cougar management plan suggests a strong 2 to 5-year repopulation response by cougar in targeted kill zones, the ecological damage and biological damage associated with low or high survival traits of this predator are not adequately accounted for (Peebles et al., 2013; Bradshaw, 2017). Changes in land use and fragmentation complicated by anthropogenic global warming and resulting alterations of abundance and distribution of environmental services also appears not accounted for in ODFW's statement or financial budgets (Figure 9).

The Case of Oregon's Cougar Kittens

> *We hypothesize that some governments and other organizations justify politically preferred policies by over or underreporting without empirical justification the size or other population data of carnivore populations, creating what we term political populations (populations with ecological attributes constructed to serve political interests)* (Darimont et al., 2018, p. 1).

By including cougar kittens, ODFW's cougar population estimates are three times higher than most other states. Although ODFW tells the public that Oregon has approximately 6,600 cougars, its 2017 Cougar Management Plan states there are about 3,300 adult cougars in Oregon (ODFW, 2017a, p. 51). Using kittens to over-estimate the numbers of cougar becomes an issue when determining kill ratios. Due to the high mortality of any wildlife young, other wildlife management programs do not count cougar kitten's population quotas. Only ODFW counts cougar kittens, a practice they do not do with fawns and other young game animals.

The consequences of over-estimating cougar populations typically increase hunting quotas, which can disrupt cougar social structure and result in additional conflict with people and livestock (Beck et al., 2005; Peebles et al., 2013). Moreover, ODFW manages for a "minimum desirable" population of 3,000 cougars statewide. ODFW does not clarify if this number reflects adult cougar only or includes kittens. Once ODFW determines that cougar populations have dropped to 3,000 or less, then hunting will cease to occur. However, ODFW statistical reports indicate that killing more cougar creates more cougar conflict issues and livestock depredations (ODFW, 2005b). Young cougars dispersing from their mother are less inclined to have conflict issues than are cougar orphaned from their mother (Figure 10; Figure 11). Studies indicate that a high magnitude or frequency of kills has an evolutionary effect on cougars (loss of genetic diversity or bottlenecking), that influence the development of life-history traits, body size, infanticide, and PTSD (Shaw, 1994; Hornocker et al., 2010; Peebles et al., 2013; Bradshaw, 2017).

Studies of altered cougar biology and social structure have found that adults and kittens can acquire PTSD as a result of habitat loss and from being hunted (Bradshaw, 2017). Moreover, unlike ODFW's 1987 cougar management plan, ODFW's current cougar hunting policies do not appear to consider pressure on cougar populations from human density, livestock numbers, habitat conditions, or behavior and biological response associated with wolf populations

(ODFW, 1987; Beck et al., 2005; ODFWc, 2005; Peebles et al., 2013; ODFWa, 2017; ODFWb, 2019). Some studies suggest that removal of the older male cougar, sex-age structure, immigration, and orphaned kittens are responsible for increased cougar conflict and livestock depredation (Peebles et al., 2013).

> *Ecology is now teaching us to search in animal populations for analogies to our own problems. By learning how some small part of the biota ticks, we can guess how the whole mechanism ticks. To sum up, wildlife once fed us and shaped our culture* (Leopold, 1949, p. 187).

What does Oregon's Cougar Population mean for Lyme Disease, Public Safety, and Ecosystem Functions?

Identifying a diversified Wall Street financial portfolio risk and returns as an analogy of resilient, diversified ecosystems may help illustrate the effects of altering the ecological role of cougar. Diversified portfolios are, like species-rich ecosystems, more capable of producing stable returns than simple portfolios or simplified ecosystems. Using the financial portfolio as an example of cougar's potential social and economic valuations, risks (public safety) and returns (Lyme disease mitigation) may encourage managers to maintain the keystone umbrella dynamics of cougars that help to mediate ecosystems and influence human well-being (Table 3; Figure 12; Figure 13).

Lyme Disease

Most Oregonians will not experience a cougar conflict or even see a cougar in their lifetime. However, thousands will have a tick conflict because vectors can carry ticks into communities, backyards, and eventually, the ticks may travel on pets into homes. Among the many motivating factors for social, economic, and environmental entities to consider regarding the complexity of ecosystems is an improved understanding of Lyme disease ecology and its possible prevention. In the Northern Temperate Zone, Lyme disease has become one of the twenty-first century's primary vector-borne diseases (Ostfeld, 2012).

Chapter 14 of the 2004 Millennium Ecosystem Assessment Report provides a summary of global concerns associated with Lyme disease (Patz et al., 2005). Using weighted evaluations, the report concluded, with medium certainty, that North American Lyme disease tick's unique pathogen complexities are a result of biodiversity loss. Moreover, functional ecosystems are a critical regulating factor for the transmission of many infectious diseases, in addition to Lyme disease. The report indicates that the primary causes of Lyme disease in North America are: fractured habitats, altered environments, simplified ecosystems, changes in vector population numbers, and loss of predator controls, such as those the cougar offer. Due to environmental factors such as climate change, irrupted numbers of deer, trophic cascades, and removal of apex predators such as cougar, Lyme disease is migrating across the nation. Human-induced ecosystem disturbances, hunting preferences, social/economic land use changes, missing hallmarks of science, and failure to recognize the complexities of ecosystem functions have led to poor environmental, economic, and social management outcomes for Lyme disease (Sigal, 1996; Patz et al., 2005). In the Eastern states, one of the main contributors to increased Lyme disease was the removal of the eco-mitigating services, via trophic cascades, of the cougar (Velasquez-Manoff, 2016; Figure 14).

Without the mediating effects of apex predators on deer populations, such as those of cougars and wolves, greater numbers of deer in the Eastern states have become an increased hazard on roads, with hundreds of people dying each year from deer-auto collisions. In these communities, deer are also considered to be a primary factor contributing to increased exposure of humans to Lyme disease (Laundre et al., 2018). Yet any political efforts towards allowing cougar to return to this region are met by resistance from the hunting society.

The first diagnosis of Lyme disease began in 1975 in Lyme, Connecticut, in a community of children and adults suffering from Lyme induced arthritis. However, it was not until 1985 that the bacterium, *Borrelia burgdorferi*, was discovered as being the root cause of Lyme disease (CDPH, 2020). Although significant Lyme disease studies did not begin in Oregon until approximately the 1990s, tick surveys in 1967 indicated that the distribution of this arachnid extended from the western slope of the Cascade mountain range to the Pacific Ocean, and east of Oregon's major metropolis, Portland (Burkot et al., 1999; Doggett et al., 2008). Currently, Oregon and Northern California have some of the highest rates of Lyme disease reported exposure on the West Coast. Unlike Oregon, California has a ban on killing the cougar, and their numbers have self-regulated at about 4000 (CDFW, 2020). California's Lyme disease has been primarily associated with environmental disturbances such as aggressive Sudden Oak Death, thus causing a shift in vectors that carry the diseases. Fragmented landscapes have kept cougar numbers down in these areas and may contribute to the growing populations of ticks (Swei et al., 2011).

Oregon is currently home to a significant "host reservoir" for ticks of approximately 340,000 mule deer, and uncounted numbers of black-tailed deer (ODFW, 2016a; ODFW, 2016b; ODFW, 2018). The host reservoir also contains the Dusty footed woodrat (*Neotoma fuscipes*), also known as packrats, or trade rats, with ranges that extend throughout the western United States. These species are nocturnal rodents in the family of *Cricetidae,* and they prefer a wide range of habitats (Doggett et al., 2008). Elk and moose (*Alces alces*) can also host ticks (ODFW, 2009; Durrani, 2011; VFW, 2020; Figure 15).

According to Ostfeld et al. 2008, there are four attributes necessary for Lyme disease ecology: 1) the vector must be a generalist with the capacity to infect a range of host species, 2) there must be an abundance of host species (reservoir competence) that can be present in both species-poor and species-rich communities, 3) there must be a variation between reservoir competence and host species, and 4) a large populace of infected vectors must acquire their infection by an infected host, rather than transovarial from infected vectors of the previous generation (Ostfeld et al., 2008). Not all ticks are infected with *B. burgdorferi,* but studies show that the critical connection for the risk of infectious exposure to humans is the density of infectious nymphs (Ostfeld, 2012).

Altered Ecosystems

Studies indicate that a landscape of fear reduces ungulate effects on plant communities (Beck et al., 2005; Laundre et al., 2007; Beschta et al., 2009; Beschta et al., 2012; Laundre et al., 2018a). If Oregon's apex predators, including cougar, were allowed to self-regulate their populations, Oregon's wilderness ecosystems might well adjust in ways we have not experienced in over 150 years, or knew existed. More functional ecosystems could be inhabited by more vigilant deer, rather than complacent deer. Landscape-scale renewal of degraded ecosystems would enhance Oregon's "biological savings accounts." It would increase riparian ecosystem functions and the services of natural refugia as well as species diversity that have long been suppressed from Oregon's ecosystems (Beck et al., 2005; Laundre et al., 2007; Beschta et al., 2009; Eisenberg, 2010; Laundre, 2012; Wilmer, 2018).

Oregon's Cattle Greenhouse Gasses (GHG)

According to the annual Intergovernmental Panel on Climate Change (IPCC) assessment reports, American agriculture is part of the global climate change threat and potential loss of global mean temperature controls (IPCC, 2017; EPA, 2018). The industrial agriculture sector accounts for 10% of the total GHG emissions in the United States. Methane is produced by the ruminant digestion process of cattle, accounts for approximately one-quarter of the total industrial agriculture's 10% GHG. Cattle manure management accounts for about 12% of GHG emissions (EPA, 2018).

Additionally, the external environmental costs of Oregon's expansive land use conversions for livestock are prone to a host of socio-economic and environmental issues such as inequitable property rights, scarcity rents, inefficiencies in carbon "leakage" (cow carbon GHG), inefficient governmental actions, as well as the decline in ecosystem services (Tietenberg, et al., 2016; Ripple, et al. 2005). These negative externalities of landscape management may be accentuated by the loss of cougar. The ecological damage and GHG concerns from millions of Oregon's livestock methane emissions are significant. Species diversity decline, albedo and photosynthesis disruptions, plant nutrient decline, soil compaction and reduced moisture-holding capacities, stream erosion, and other desertification concerns may be mitigated by reducing livestock operations and the ensuring ecologically functional populations of apex predators (Ripple, et al., 2005; Perry, et al., 2008).

Wildlife Disease

Cougar may choose to conserve energy and avoid the risk of injury by selecting prey that are vulnerable or otherwise in poor condition. Young, old, or deer infected with the naturally occurring prion CWD are more susceptible to cougar predation than deer that are healthy or in their prime. Studies of this CWD "sanitation effect" due to cougar predation preferences indicate that puma can be selective and sensitive to the subtle behavior changes of an infected deer long before the body condition noticeably declines (Krumm et al., 2009; Shivik, 2014).

Public Safety: What are some of the Risks

There is a risk that killing more cougar may destroy the incentive to protect them, and also increase negative encounters with them, as in the case of the words ODFW and CDFW use to shape public perspectives in the management of their cougar. According to Dr. Robert Wielgus's testimony at a 2019 Oregon State Legislature public hearing on cougar, wild puma once lived to be ten years old. However, because they are intensively hunted in Oregon, it has become rare to find a puma that is older than five years. The loss of this hierarchical social monarch is critical to help avoid a source-sink shift in cougar population structure towards younger, inexperienced cougars with a propensity for human conflict. Intense management and hunting of cougars often create populations with relatively young immigrant cougars that are often orphaned (Peebles et al., 2013). ODFW statistics indicate that it is not the cougar kitten dispensing from its parent that causes conflict; instead, it is often the orphaned cougar. Fragmentation of cougar populations can also negatively change their genetic connectivity by risking sink-genetic structure, contribute to low genetic diversity, and cause genetic extinction in certain areas.

Ecosystems managed to sustain a healthy population of cougars and their social dynamics can be more diversified, and thus more resilient towards disturbances, diseases, and climate changes. Without the mediating effects of cougars, Lyme disease, CWD, and ecosystem decline may increasingly become a social, environmental, and economic concern.

Cougar's Social Economic Stakeholder Benefits

Oregon Lyme Disease Cost Reexamined

The general consequence of Oregon's economic land use that favors livestock and hunting are simplified ecosystems (Beschta et al., 2009). For example, the highest institutionally driven harvest of cougar synchronizes closely with the State's highest poverty rates, the lowest access to health care, and highest rates of Lyme disease reports (ODFW, 2019a; Weber, 2020; Figure 16). Even though thousands of deer are killed each year in Oregon by hunters, this has not stopped the slow advancement of Lyme disease (ODFW, 2005a; ODFW, 2016b; ODFWb, 2017; ODFW, 2018).

In 2015, Oregon's 78th Session of the Senate Committee on Health heard testimony from the Oregon Medical Board and Oregon State Board of Nursing that rules regarding diagnosis and treatment of Lyme disease were long overdue. Diagnosing Lyme disease is not without controversy. Misdiagnosing Lyme disease and the lack of understanding regarding the unique complexities of ecosystem functions and trophic connections associated with the Lyme agent spirochete bacterium has retarded progress towards treating and diagnosing the disease. Unlike the Eastern states which began tracking the disease in the 1970s, it has only been since the 1990s that the Oregon State Health Division has assimilated data from incident reports on tick-induced bacterium that cause Lyme disease (Zhang et al., 2006; Adrioin et al., 2015; Committee on Health Care, 2015).

The national cost of Lyme disease is significant and over 3.2 billion dollars annually are spent on medical expenses for the disease. This money does not cover economic opportunity losses incurred by indirect costs and incidentals. Also, not included in the national costs are reproductive issues, sleep disorders, chronic heart conditions, magnetic resonance imaging (MRI), cognitive deterioration, arthritic disabilities, Lyme induced autism special education, loss of productivity, and hospitalizations. Undiagnosed or misdiagnosed Lyme disease can cost a patient tens of thousands of dollars, including lost economic productivity that negatively impacts social and economic stability. In 2015, the total lost productivity and treatment costs for Lyme disease in Oregon were approximately $16.5 billion, $13.1 billion for lost productivity and $3.4 billion for treatment (Committee on Health Care, 2015).

Wildlife Watching Dollars vs. Hunting Dollars

U.S. Department of Interior surveys, done at 5-year intervals since 1955, showed substantial increases in outdoor participation and profits from wildlife-watching. Between 2001 and 2016, profits rose from $60 billion to $76 billion as participants simultaneously rose from 72 million to 86 million. Community wildlife-watching increased from 69 million participants in 2011, to 82 million in 2016. Gains were also made from wildlife watchers who were willing to travel. Between 2011 and 2016, travelling wildlife watchers increased from 22.5 million to 23 million participants. Many of these activities generated income for rural community infrastructures such as hotels, restaurants, equipment, transportation, and jobs. The ecological attributes of cougars, as well as healthy populations of this apex predator, can also contribute to local economies by drawing in wildlife watchers and their money. For every dollar the U.S. Government spent on wildlife watching, wildlife watchers spent $10 in rural communities (USFWS, 2006; USDI, 2017).

The Valuations of Cougar (Figure 17)

Economic, social, and ecological values of cougars are only applicable if humans associate obligatory, spiritual, or financial values associated with sustaining this apex predator. Western Euro-American concepts use benefit-cost analyses, "the greatest good for the greatest number of people," as a foundation for expressing these values and creating policy-making decisions that are supposed to reflect the best benefits for society. All too often benefit-costs economics fall short of sound environmental care and interactions. Valuation economic techniques are a series of vested interests networking methods for evaluating ecological worth in an anthropomorphic world. They are composed of use values, option values, and nonuse or passive values (bequest and existence) (Tietenberg et al., 2016). Nonuse valuations reflect the economic willingness to pay for the future eco-service and eco-benefits the cougar offer, and the willingness to pay for protecting these interconnected communities regardless if the public ever witnesses or benefits from these processes or not. Cougar's nonuse environmental valuations are both supportive and culturally important for human wellbeing.

An example of use value are the social benefits derived from cougar's regulating services such as mitigating Lyme disease, whereas an option value is the value placed upon cougar's ecosystem provisioning services' effects that benefit future generations. Nonuse or bequest values are more complicated. Regardless, if a person has never visited a wilderness or will ever see a cougar in the wild, it is the knowledge that cougars are out there mitigating the ecosystems for human well-being that is of value. Bequest values, use values, and use options values of wildlife watching according to studies done of Yellowstone National Park's reintroduction of wolves and cougar indicate the public and federal financial gains are significant (USFWS, 2006; Tietenberg, et al., 2016). With regard to Oregon, a U.S. Fish and Wildlife (USFWS) report, "Watching Economic Impacts on National and State Economies" 2006 survey, page 9, wildlife watching raised $176 million in retail dollars, $503 million in salaries and wages, 16,000 jobs, $124 million in state and local taxes, lastly, $120 million in Federal taxes, and $1.4 billion in multiplier effects (USFWS, 2006). Dean Runyan Associates 2009 survey review of Oregon's wildlife dollars shows that 2.8 million Oregonians and nonresidents participated in Oregon's recreational activities. Of these, wildlife watching involved 1.7 million local and out-of-state participants, hunting 282,000, shellfishing 175,000, and fishing 631,000. Collective travel-generated trips to Oregon and local recreation expenditures, and equipment layout for wildlife watchers totaled over a million dollars, hunters $500,000, shellfish harvesters $172,000, and fishermen $800,000 (Runyan, 2009; Figure 18).

This data shows that it may be more optimal to co-exist with the apex predators than the current expenses and public risk that ODFW incurs managing them. Cougar is a keystone apex known for promoting elements that wildlife watchers seek, fully functioning ecosystems that are rich with species diversity. It may be advantageous for ODFW to develop a cougar management plan that promotes wild open spaces and reduced ungulate populations, and other anthropocentric effects, in exchange for the financial and eco-benefits generated by the wildlife watchers' willingness to pay for them.

Desirable outcomes for vested parties are those where benefits exceed the costs. ODFW could use available economic data along with land use laws or hedonic (the value of property as reflected by its characteristics) property valuation models to define a new ecological paradigm for the management of ecosystems and apex predators (Tietenberg et al., 2016). Unfortunately, comparative studies assessing the positive or normative economic outputs and evaluations of co-existing with the apex predators by investing in ecosystem wildlife watching have not yet been undertaken (Tietenberg et al., 2016).

Ecological and Economic Valuations

The cascading trophic effects of cougar suppression or removal can have irreversible impacts on ecosystem services and resiliency. On the surface, we understand that cougar is a keystone species capable of shaping the ecosystem services of a landscape and the biodiversity that sustains it. In an environment rich with cougar, ungulates move more and eat less, allowing trees to grow canopies that cool streams to just the right temperature for salmon to spawn, and bears to eat them, who in turn fertilize the forests with their mineral rich scat. Water follows trees, and mineral rich streams become rivers, and rivers become gateways for salmon to swim to the sea. The movement of ungulates in the world of cougar's ecosystem services is called the Ecology of Fear. The top-down pressures of cougars, via an ecology of fear, allow them to influence ungulate populations and foraging patterns, thus allowing diverse plant communities to be sustained. This contributes towards protecting eco-services and eco-function system structures of plant communities, which in turn protect hydrologic cycling, primary productivity, fish habitat, and nutrient cycling that are factored into use values (Beschta et al., 2012; Tietenberg et al., 2016). This ecology of fear also helps protect ecosystem services associated with pollinators, bees, birds, bats, and other wildlife species that ensure the propagation of plants, both wild and domestic. Follow the footsteps of the cougar and you may find an emerging presence of trees and understory, and a wealth of minerals, nutrients, fungus, and biota in the soil. (Eisenberg, 2010; Tietenberg et al., 2016; Ruth et al., 2019).

Currently, Oregon profits $181 million on pear crops and $79 million on cherry crops as part of their dependence on pollinators (USDA, 2018). Not only do the puma contribute to pollination, but also ecosystem composition that includes seed dispersion, species richness, nutrient cycling, and other ecosystem processes. Tree canopies provide photosynthesis, respiration, gross primary productivity (GPP), net primary productivity (NPP), carbon balance, and interconnected habitat niches rich with species diversity (Perry et al., 2008; Beschta et al., 2009; Eisenberg, 2010). The apex ecology of fear moves ungulates, thus allowing keystone plants such as trees to develop spatial and temporal successional values necessary for connecting interrelated biogeochemical cycling links between landscape and global ecological processes. The cougar also contributes towards protecting the web of interaction and successional processes that creates the genetic structure of species diversity, niches, and ecosystem functions. More needs to be researched about the ecosystem services and power of the Ecology of Fear shaped not only by a species with eighty-six names, but also the combined effects of their fellow apexes, the wolf, and the bear.

Social and Economic Combined Valuations

Linking ecology and public health through bequest values, use values, and option values may help maintain protections of the cougar's indirect effects on mediating CWD and Lyme disease ecology. Heightened human risk and vulnerability for receiving transmissions of the *Borrelia burgdorferi* bacterium cost U.S. citizens and the medical industry billions of dollars. Growing numbers of Lyme disease reports in Oregon have health communities scrambling to network and design screening as well as ways to eradicate the source of the infection.

The spatial clustering of Lyme disease in the United States is highest where there are lots of deer and few cougars. Ironically, this includes some of the more popular areas for tourist wildlife watching (U.S. Fish and Wildlife 2006). The Northeast, Mid-Atlantic, and upper Midwest areas of the United States, void of the cougar, have the highest incidents of Lyme disease in the Nation (Forrester et al., 2015). Comparing ODFW's map of planned cougar kills in areas known as "cougar target area" zones for public and livestock safety to that of Oregon's Lyme disease reports shows an interesting correlation. Except for Multnomah County, the number of Lyme disease reports in the cougar target zones areas appear greater than in the non-target areas (Weber, 2020; Figure 19; Figure 20; Figure 21)

As obligatory predators, cougars eat mice, deer, and other vectors that carry the ticks responsible for Lyme disease. Shifting the deer, mice, and the tick's ecological adaptive cycle feedback to include the missing mediating effects of the cougar could help reduce human exposure to Lyme disease. Such effects could reduce health insurance costs and auto insurance costs, as well as income opportunity losses associated with deer/vehicle collisions.

A Path Forward

Public Survey

To prevent further harm to biophysical and socio-economic systems, stakeholder involvement in a sustainable cougar management program is critical. Understanding stakeholder attitudes and knowledge toward cougars could be achieved through a statewide phone survey. In 2012, Washington State hired the research firm Responsive Management to conduct a statewide phone survey regarding public knowledge and values associated with coexisting with cougar. The study was used to assess public educational needs on cougar ecology, safety, behavior, and management. This information was then used for developing Washington State Department of Fish and Wildlife's Cougar Outreach Project management plan (WDFW, 2020).

According to Responsive Management, an Oregon survey would cost approximately $35,000 and would evaluate the ecological, economic, and social importance of cougars to Oregonians. Some of the topic areas the survey would assess include the general knowledge of Oregonians regarding cougar populations, biology, and their umbrella effect as ecosystem regulators (Responsive Management, 2019). As referenced from a recent Responsive Management quotation, a survey of theirs would address the following topics:

- Public awareness of and attitudes toward wildlife and wildlife management issues.
- Attitudes toward wildlife law enforcement and opinions on regulations and laws.
- How people value wildlife.

• Public perceptions of wildlife populations and cultural carrying capacity issues—that is, how much is enough and what are people willing to sacrifice for the sake of wildlife conservation.

• Public attitudes toward endangered species.

• Public attitudes toward wildlife reintroductions.

• Opinions on invasive species.

• Attitudes toward habitat, habitat protection, and development.

• Landowner attitudes toward wildlife management issues.

• Information and education about wildlife issues.

• Where the public receives their information on wildlife issues.

• Public awareness of agency funding, and support for and opposition to various funding mechanisms for wildlife management.

Education

Oregon's cougar management plan could follow that of California's and adopt extensive, research and public education goals. Various stakeholders – wildlife managers, ranchers, hunters, policymakers, wildlife watchers, and the general public - could be trained and encouraged to think like an ecologist. The public could become citizen scientists through education, greater public inclusion, youth vocational guidance, and citizenship training. There would be increased focus on ecosystem paradigms and environmental ethics inclusive of the cougar's wellbeing when determining cougar policymaking, and while recognizing cougar's ability to enhance human economics, social and environmental benefits. Further research into the human neurological similarities and responses to traumatic life stimuli would also be encouraged.

Policy

Oregon Cougar Action Team (OreCat), a 501c3 educational grass-roots foundation established in 2004, developed the "License to Protect" (LTP) program in 2011. It is a response to ODFW policies usurping M18 and the lack of public funding for wildlife. The hypothesis was that if ODFW received more funds from the public rather than hunters, they would be able to manage for the benefit of biodiversity and ecosystem services, rather than for livestock production, hunting, and forest harvesting. Forests provide important cover and suitable habitat for cougars. LTP was introduced as a draft at Oregon's legislative assembly to help support the intents of M18, provide funding, and help address our public and livestock conflict issues with cougar (OreCat, 2020; Figure 22). In 2019, Oregon State Senator Roblan was seeking a way to remedy ODFW's wildlife funding inequity and introduced a tax on birdseed to help connect public funding for wildlife. However, the bill failed.

Institution

ODFW could become Oregon Department of Resilient Ecosystems (ODRE) and would focus on managing Oregon's landscapes for the benefit of biodiversity and ecosystem services, rather than for livestock production, hunting, and timber production. ODRE, stakeholders, and science would collaborate to design a functional and timely political agenda, based on the hallmarks of science and prudent economic profits. Similar to California's cougar research and monitoring methodologies, testing criteria would continually address transformability, adaptation, and resiliency of co-existing with the puma, and preferably the wolf and bear in fully functioning ecosystems (ODFW, 1987; CDFW, 2020). Using ecological economic valuations (use, option, and nonuse values) would help define adaptation methodologies for economic switch point calculations, ecosystem transformability, and social resiliency (Tietenberg et al., 2016).

ODRE could have two options for managing cougars. One, using California as an example, ODRE would do away with its cougar management plan and instead implement university research programs to better understand how to co-exist with the cougar (CDFW, 2020). Two, ODRE would eliminate the wolf, cougar, and bear plans and instead develop a single plan encompassing the ecological benefits of the apex predator guild. Regardless of either approach, ODRE would need to validate an accurate cougar population model count, develop ecological management tools, and work with scientists to design and monitor models which quantify the effects of cougar predation on prey populations, on public incidents or conflicts, and any shifts in ecosystem services. They would also need to incorporate critical anthropomorphism into cougar management plans (Masson, 2014).

Livestock Guardian Dogs

> *Remember: Your farm as part of a larger community, locally, nationally and internationally; we now know we are part of outside the environment. We need to remember that the global market is looking at us. There is very little protection for predators, therefore we need to reconsider our way of thinking and become more scientific and ethical in our approach to human wildlife conflict resolution* (Schumann, 2004, p. 32).

As with Oregon's cougar, the two driving elements that directly impact Namibia's cheetah's (*Acinonyx jubatus*) biological factors are human population growth and resulting cheetah removal (Marker et al., 2004; Marker et al., 2005). However, one of the simplest tools that have been used for thousands of years to protect investments in livestock and human well-being is the livestock guardian dog (LGD). These breeds can consist of cross-over or purebred Akbash, Great

Pyrenees, Spanish Mastiffs, Miramma, Komondor, and Yugoslavian's Sharplaninak. Livestock dogs have proven themselves to be efficient livestock protectors, replacing expensive and often lethal measures to reduce predation of livestock. However, they can in certain circumstances, be dangerous for humans unknowingly advancing through areas the dogs are protecting. It is therefore advised that livestock owners provide postings that LGDs are in the area (Mosley et al., 2020). With the use of dogs, more cougars, as with Namibia's cheetahs, may co-exist around livestock operations and human wilderness activities.

An excellent example of the importance of LGD use is identified in Namibia's constitutional environmental bylaws and conservation programs "Guide to Integrated Livestock and Predator Management" (Namibia, 1995; Schumann, 2004). Their programs are deeply connected to the social, economic, and ecological factors associated with cheetahs, as well as ongoing struggles to protect cheetahs from extinction. By the innovative use of dogs to protect not only livestock but also cheetahs, conservation programs and both commercial and subsistence farmers have been able to co-exist with this predator, thus contributing to a sustainable economy (Marker et al., 2004; Marker et al., 2005; Figure 23).

Influenced by Namibia's LGD program, in 2018, concerned citizens implemented a similar program in Oregon (OreCat, 2020). The Great Pyrenees/Miramma mix breed puppies were chosen to protect livestock and, ultimately the cougar. This mixed Spanish/Italian breed has a lineage of protecting livestock that exceeds six thousand years. The dogs are large, radiant white, with an aggressive bark, strong traits of protective behavior, and are fast runners. On average, they weigh between 90 to 150 lbs (41 – 68 kg). The breed is attentive, trustworthy, and capable of living alone with livestock on vast commercial or small livestock operations without harming the herd. From a pup, they are raised with the livestock and, by instinct, place themselves between the livestock and danger, but never herd them. They can become good family dogs, but most are used for protecting livestock, working and living most of their lives independent from humans. (OreCat, 2020; Figure 24)

OreCat trains members to be citizen scientists capable of holding public presentations about the cougar (Figure 25). They are also taught to carefully analyze potential farming operations before establishing puppies with these families. Periodic visits are established, allowing OreCat opportunity to collect data from the farmers regarding any changes in livestock predations. As donations permit, OreCat gives puppies away to qualified operations. Since 2018, OreCat has placed puppies on five small Oregon subsistence family farming operations (OreCat, 2020).

Conclusion

This paper suggests that the greatest good for the greatest number of Oregonian stakeholder safety issues and economic concerns is to adopt California's cougar plan. Their plan does not include the harvesting of cougars by hunters but instead is based on research, education, and collaborations to co-exist with the American Lion (Sabana, 2017; CDFW, 2020). Instead of focusing on the harvesting of pumas, ODFW would emphasize research studies and expansive landscape scale restoration management of ungulate-altered ecosystems inclusive of their 1987 reduced road plans throughout Oregon's wildlands (ODFW, 1987; Laundre et al., 2018a). To ensure fully functioning ecosystems, this paper suggests creating an overarching management plan for all three apex carnivores--cougar, wolf, and bear.

This paper also recommends that conservation plans need to support networks of habitat connectivity that help maintain landscape-scale ecosystems such as wildlife freeway crossings. Efforts to manage, monitor, and maintain habitat connectivity may ensure decreases in cougar conflicts while increasing the resiliency of ecosystem services during disturbances, changing climate conditions, and human activities. Furthermore, an improved understanding is needed regarding the socioeconomic opportunity losses, the biological mechanisms of cougar's trophic effects on human exposure to Lyme disease, and other ecosystem alterations that may have occurred under ODFW's current cougar management plan.

By familiarizing the reader of the cougar's nature and biology and addressing Oregon's history of public perspectives regarding puma policy and management, this paper will hopefully inspire more research into the dynamics of the puma's ecological services and their economic and social consequences. Maintaining an abundant cougar population in Oregon depends on understanding the relationships between humans, the cougar, and the three tiers of human well-being: social, economic, and environment.

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Appendix

Table 1

State Cougar Management Plan Word Comparisons, California, Washington, Oregon.

THE THREE PILLARS	Cougar Management Plan CALIFORNIA* Ecocentric	Cougar Management Plan WASHINGTON Homocentric	Cougar Management Plan OREGON Egocentric
SOCIAL			
Public		163	151
Public Safety		11	7
Coexisting		28	0
Education		193	27
ECOSYSTEM			
Ecology		57	48
Conservation		17	24
Ungulate		2	67
Elk		5	344
Deer		43	352
Cougar		1130	2680
ECONOMIC			
Damage		1	271
Livestock		83	200
Hunting		39	350
Cattle		2	6
Cattlemen's Association		16	0

***Note:** Since 1972, there has been no funding for hunting cougar in California, and there is no cougar management plan. In place of hunting and a plan, is a statewide effort to understand the cougar. University involvement includes extensive research by Dr. Seth Riley who is a National Park Service urban wildlife expert for Griffin Park and Ventura County. The famous L.A. cougar P22 is part of his study area. U.C. Davis Dr. Winston Victors manages the Santa Monica cougar research project. Dr. Chris W. Wilmers operates the Orange County San Diego cougar research lab at the University of California, Santa Cruz.

Source: ODFW, 2017a; WDFW, 2020, CDWF, 2020.

Table 2

Oregon "conflict" and California "incident" cougar public safety comparisons.[a]

California Cougar *Incident* describes encounters with cougars Between the years: 2009-2013[b]	Cougar Incident 739	Public Safety Kills 20
Oregon Cougar *Conflict* describes encounters with cougars Between the years: 2009-2013[c]	Cougar Conflict 2189	Public Safety Kills 149

[a] These comparative stats indicate that killing more cougar creates more human and livestock safety threats. In comparison to Oregon, California's lack of a cougar management plan and ban on killing cougar has reduced incident and public safety issues and their management expense. California is a larger state with more livestock, people, and wildlife than Oregon, yet they have fewer issues with cougar. Words help create public perspectives and opinions and the words "incident" and "conflict" are used to describe a cougar encounter in completely different contexts. Conflict is described as a clash of interests and a loss of harmony, whereas incident indicates a chance occurrence, event, or episode.

Source:

[b] https://www.wildlife.ca.gov/Conservation/Mammals/Mountain-Lion/Trends

[c] ODFW 2017a, p. 23; https://www.dfw.state.or.us/wildlife/cougar/docs/2017_Oregon_Cougar_Management_Plan.pdf

ODFW statistician Dr. Richardson held a public forum in Corvallis, Oregon, where he informed the audience that ODFW stats indicate kittens dispersing from their parent were not the conflict cougars. It was the orphaned kittens that were the conflict issues. Hunting, policy, and shoot-and-shovel create large populations of orphaned cougar kittens (ODFW, 2005b).

Table 3

What are the risks or the benefits of living with, or without cougar and their effects on Lyme disease?

Risks	**Lyme Exposure**	**Social well-being**	**Economic decline**	**Ecosystem decline**
Cougar	Low	High	Low	Low
No Cougar	High	Low	High	High

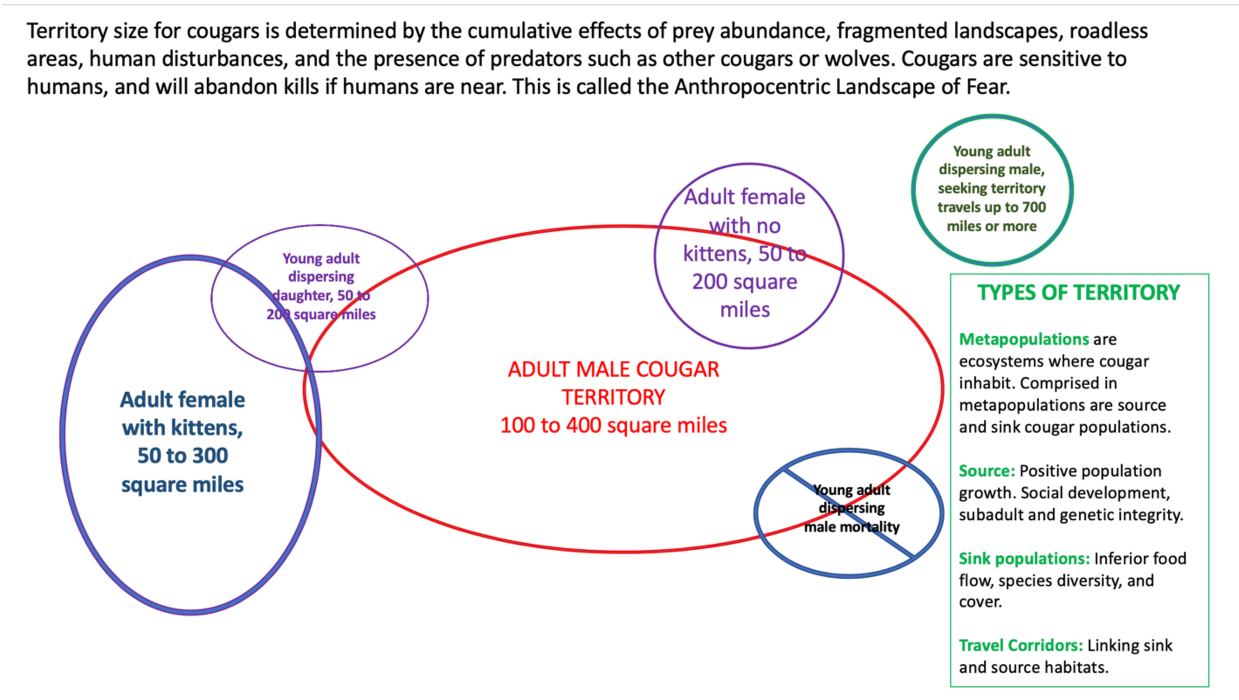
Figure 1

Petroglyphs of cougar hunting with humans.

Source: (National Park Service 2020).

Figure 2

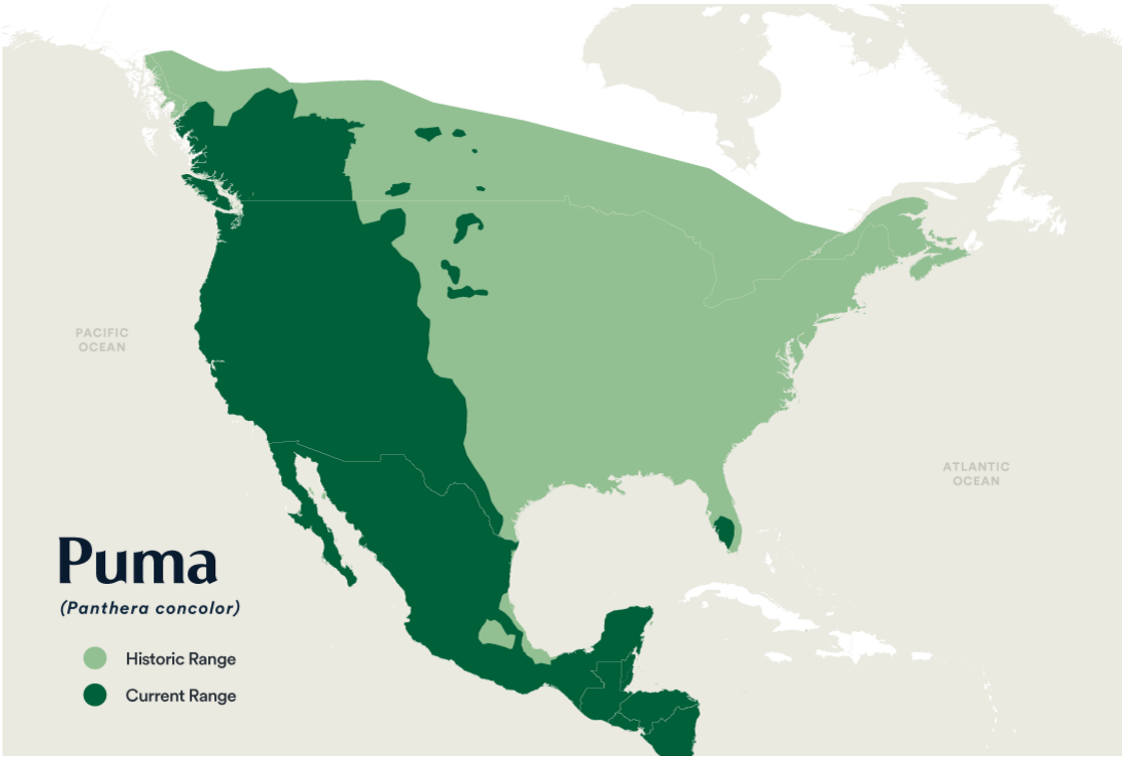
Cougar Territory Size.



Source: (Beck, et al., 2005).

Figure 3

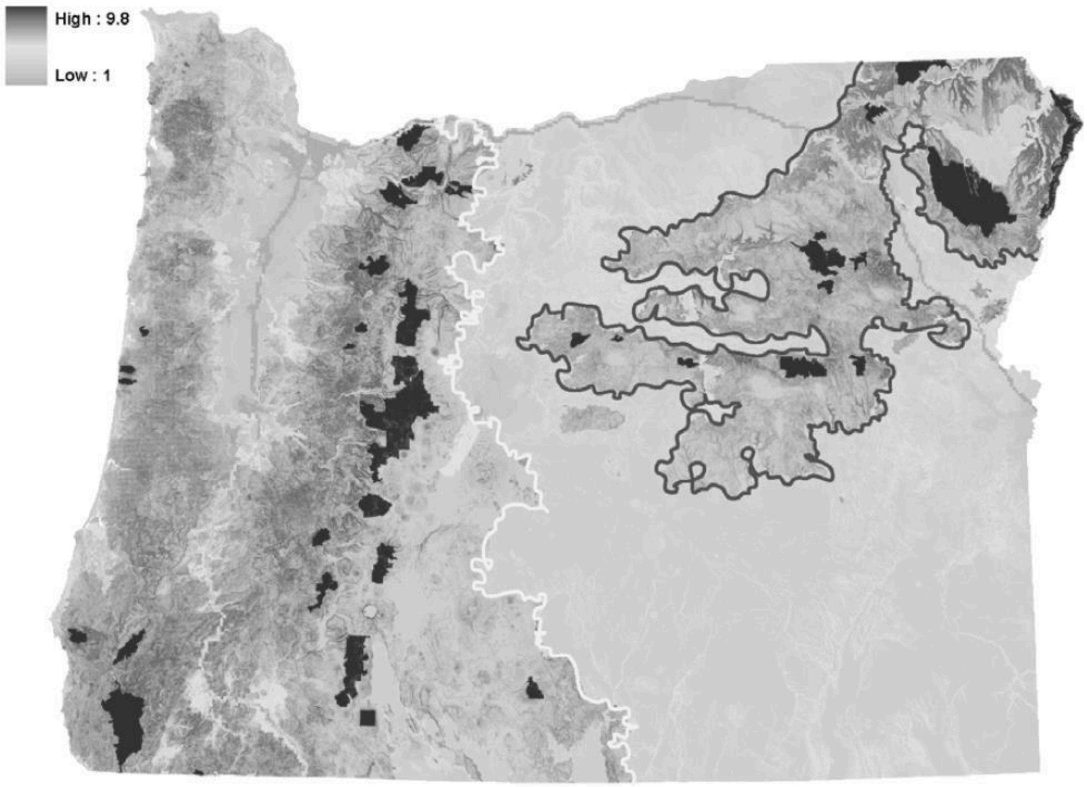
Current and historic cougar range across North America.



Source: www.Panthera.org.

Figure 4

Cougar habitat in Oregon.

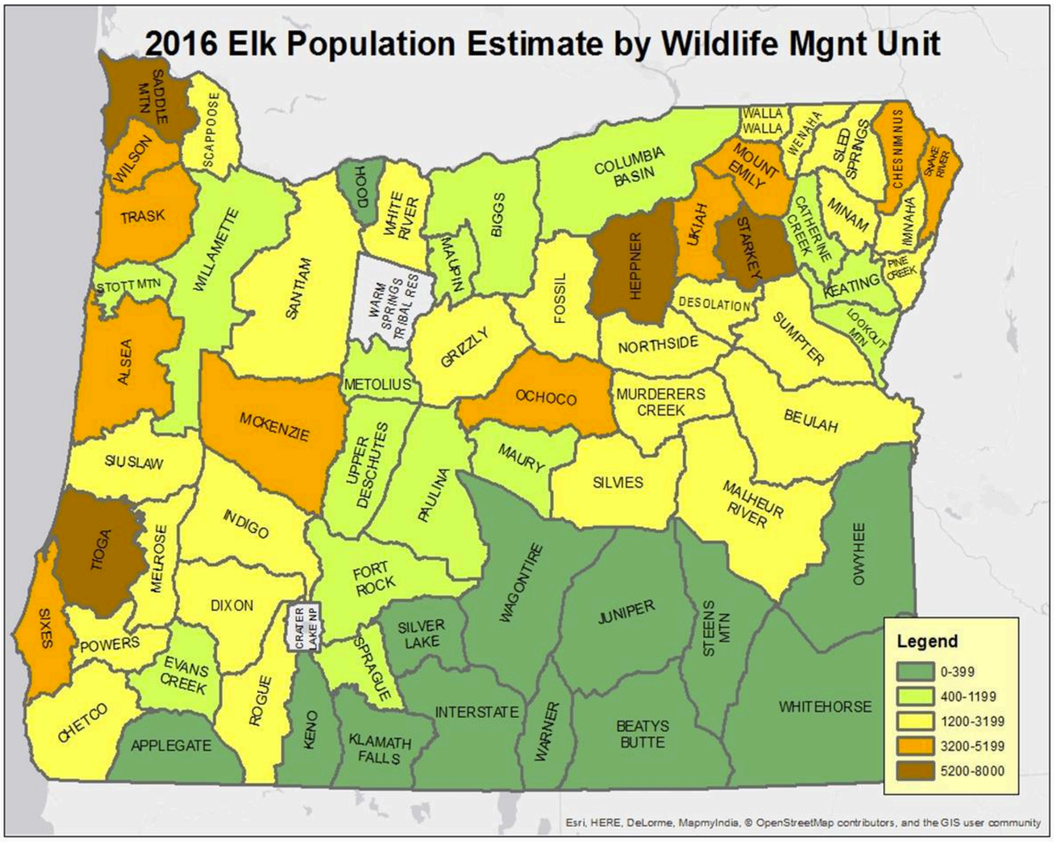


Habitat variables do not include human density, major roadways, lost forest cover, and reduced wilderness areas. Darker areas designate more suitable cougar habitats whereas lighter areas are less suitable habitats.

Source: (ODFW, 2017).

Figure 5

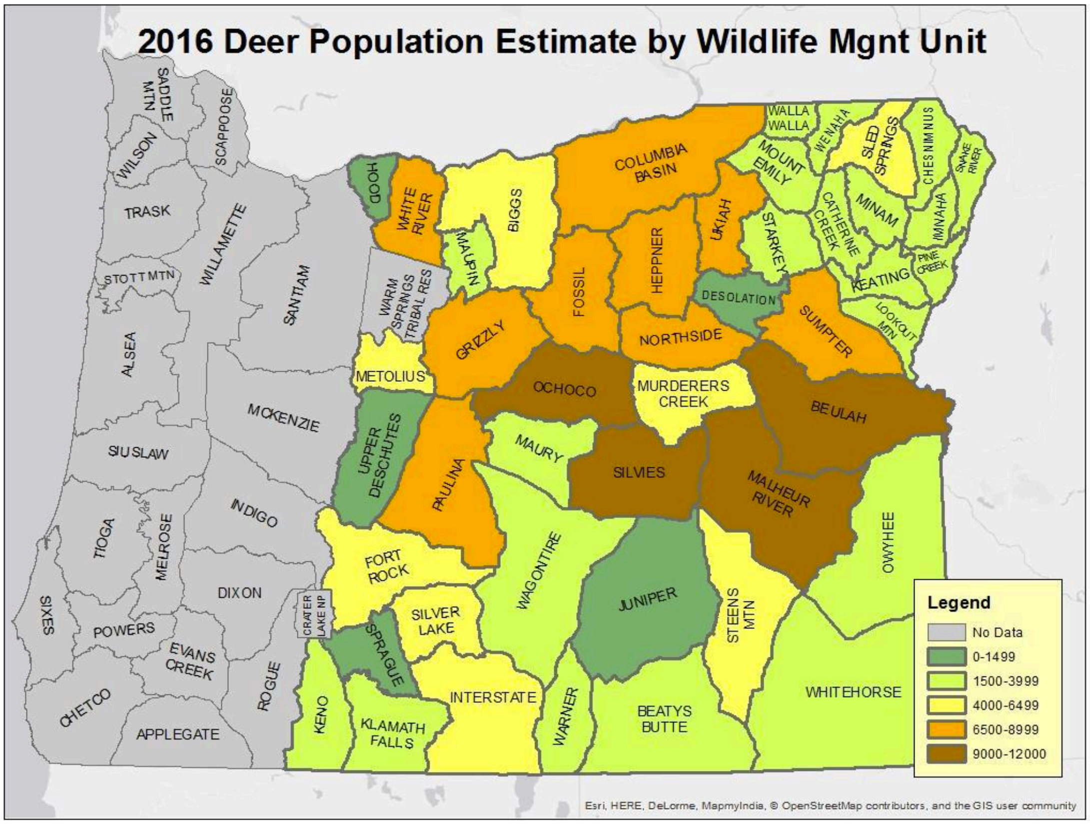
Elk population estimates in Oregon, by wildlife management unit.



Source: **(**ODFW, 2016).

Figure 6

Mule deer population estimates in eastern Oregon, by management unit.

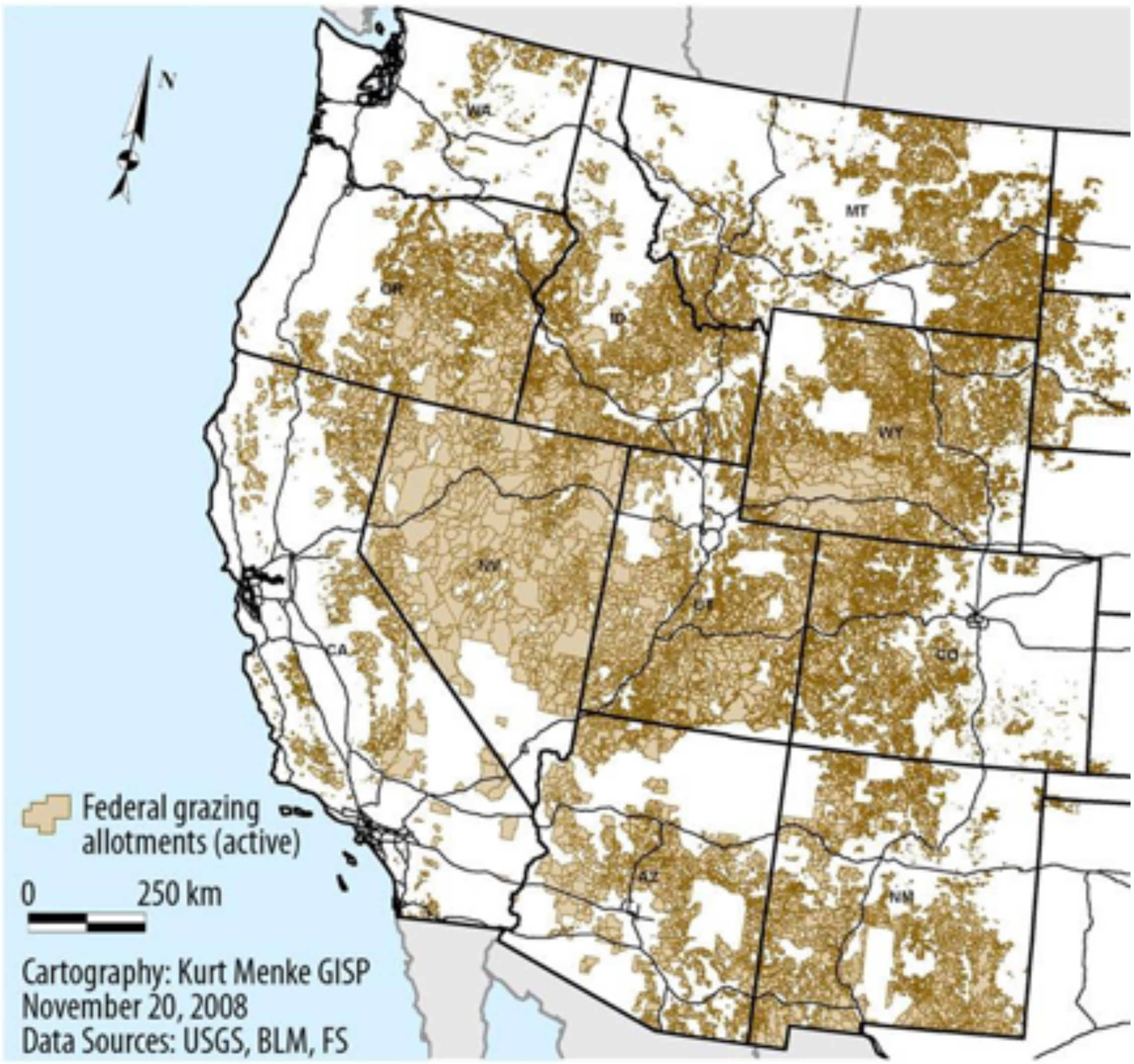


Black-tail deer estimates are not available for westside units.

Source: (ODFW, 2016).

Figure 7

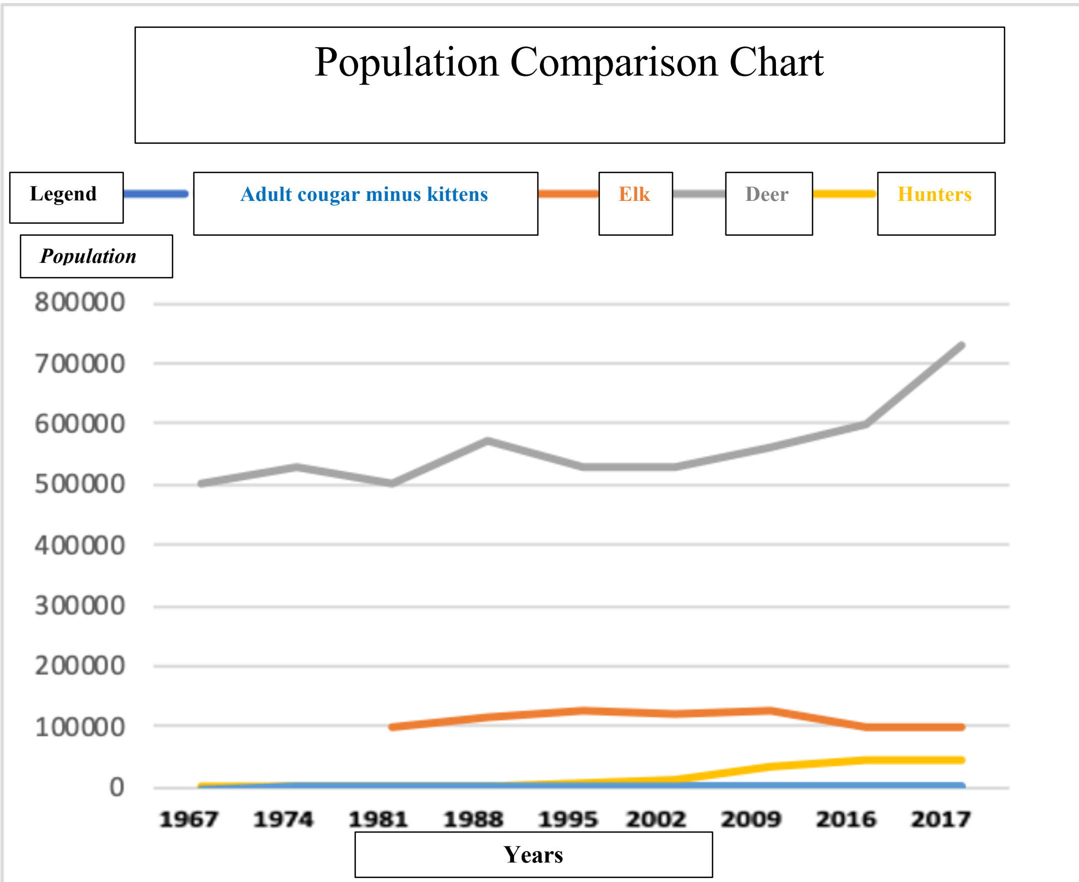
Federal grazing allotments in the western United States.



Source: (Beschta et al., 2012).

Figure 8

Populations of cougar, deer, elk and hunters in Oregon.



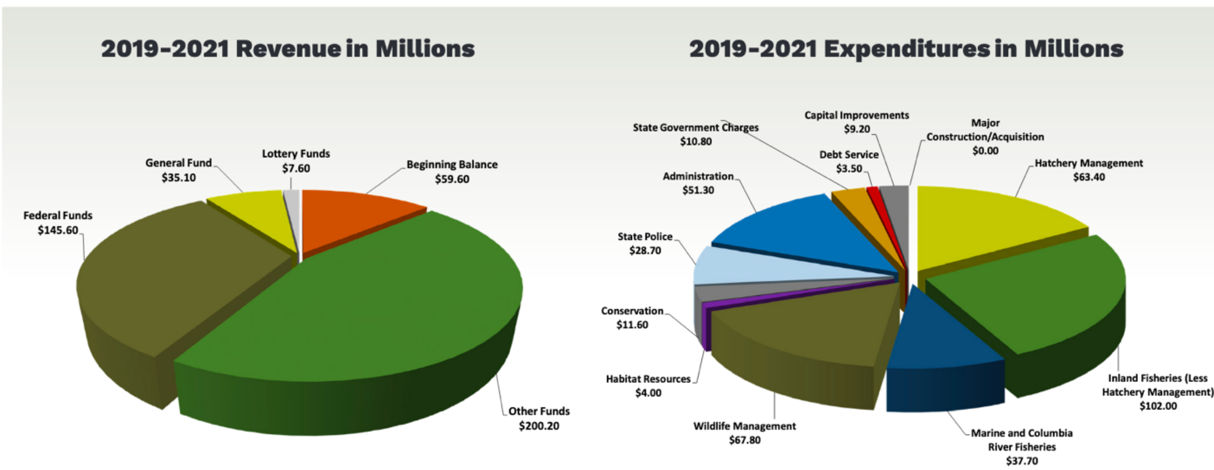
Source: (ODFW, 1987; ODFW, 2006; ODFWa, 2017).

Figure 9

ODFW 2019-2021 Legislatively Adopted Budget.

2019-2021 Legislatively Adopted Budget

	2017-2019 Legislatively Approved	2019-2021 Legislatively Adopted Budget
General Fund	$ 29,458,285	$ 35,094,508
Lottery Funds	$ 5,326,259	$ 7,621,405
Other Funds	$ 193,825,411	$ 202,770,148
Federal Funds	$ 135,922,685	$ 144,438,993
Total Funds	$ 364,532,640	$ 389,925,054
Positions	1,375	1,357
Full Time Equivalent	1,154.05	1,154.69



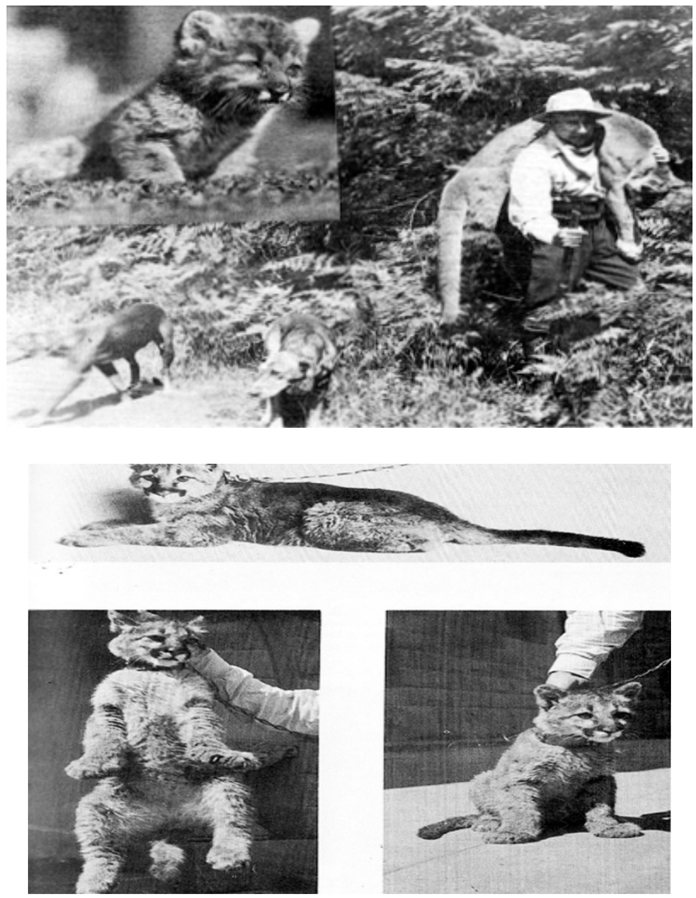
Revenue	Expenditures	Balance
$ 448,142,851	**$ 389,925,054**	**$ 58,217,797**

Source: ODFW 2019-2021 Legislatively Adopted Budget.

https://www.dfw.state.or.us/agency/budget/docs/19 21_GB/Budget%20backgrounders_ODFW%20Budget%20summary.pdf

Figure 10

The domestication of cougar kittens.

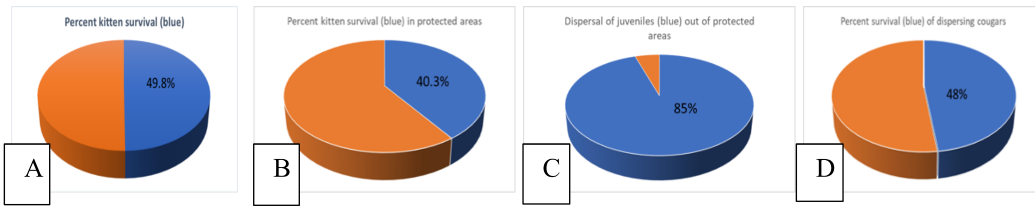


Cougar, if taken young enough from the wild can be immediately domesticated, as indicated in these two 1940 photos taken in Oregon. Cougar kittens taken from the wild are exposed to traumatic experiences and can be sold on wildlife black markets.

Source: (Young et al., 1946, p.p. 79, 156; Bradshaw, 2018).

Figure 11

Dr. John Laundre Cougar Kittens Survival Rate Graphs.



A - On average across the Western states, about 50% of the kittens born do not reach dispersal age. The range is from as high as 71.5% to a low of 21%. Three of the studies in Figure A come from protected cougar populations (no sport hunt). They include one from California, one from New Mexico and one from Yellowstone National Park. These can be considered to be stable populations (that is could be considered to be at carrying capacity). On average, the kitten survival is 40.3% or almost 60% of the kittens born in a saturated population (which ODFW says Oregon is approaching), will not reach dispersal age. ODFW is literally counting dead kittens (or soon to be) in their total population estimate

B - Of kittens that do reach dispersal age (40-50% of those born), 85% of those (90% males and 80% females) disperse from their natal area and thus should NOT BE COUNTED in the total population for that area.

C - Of those that do disperse out of their natal area, almost 50% of them die within the first year after dispersing. This includes six studies from hunted and protected areas. In hunted areas, many of these dispersers are killed by hunters. However, hunters are actually killing “dead cougars walking” as they would probably die anyway!

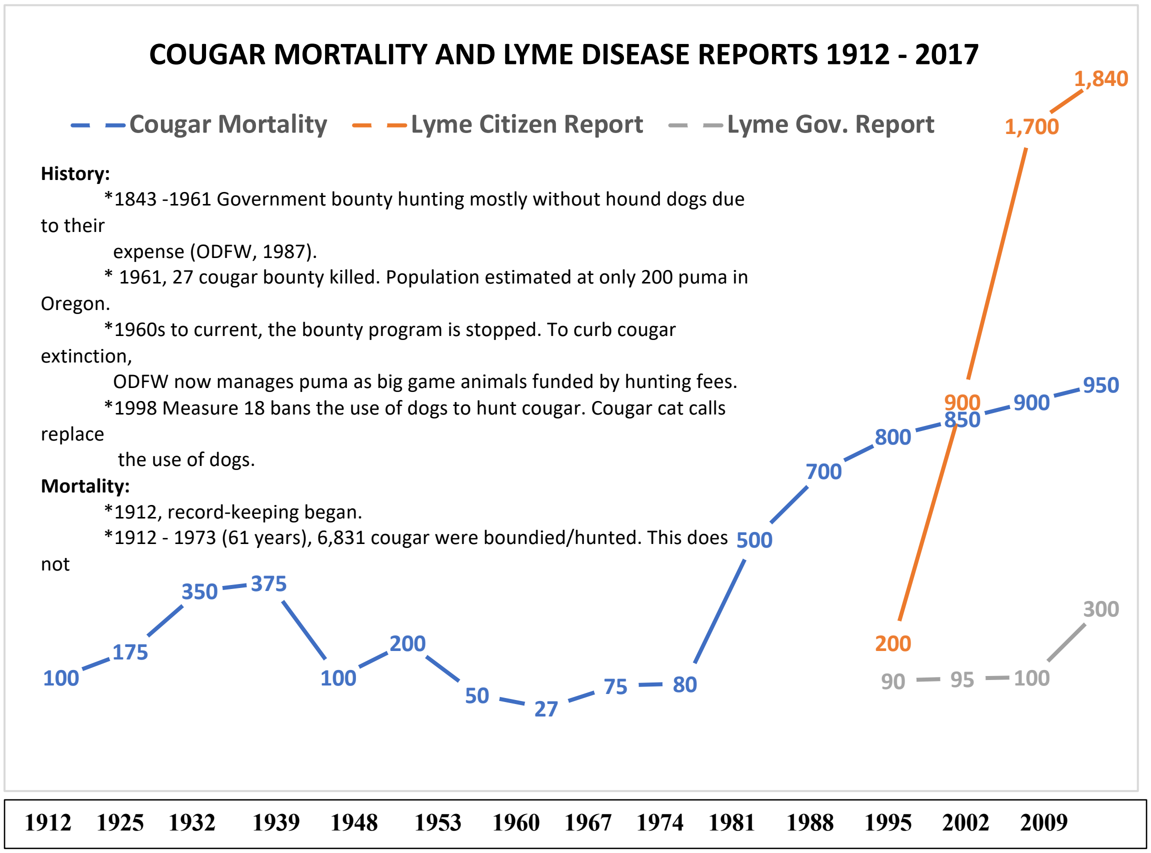
D - Of those that survive, 50% of 50% or 25%, replace those adults that would normally die. Average overall survival rate of adult cougars (male and female) in protected and unprotected areas is 79% but has been reported as low as 50%. Primary causes of non-hunting deaths are disease, interactions with other cougars, and accidents.

The conclusions to be drawn for these data from all these studies is that the ODFW estimate of the total cougar population (including resident adults, kittens, and dispersing animals) consists of approximately 50% of combined kittens and dispersing animals, 75% of which will die before becoming part of the resident population. The other 25% will basically replace normal losses of adult resident ones. As with other game animals, these expected losses should not be counted or reported as part of the actual number of cougars that are in Oregon. Based on the science, there is no reason to think that cougar populations are acting any different than any other predator population and are internally controlled by prey availability and social structure.

Source: (Laundre, 2018b, quoted).

Figure 12

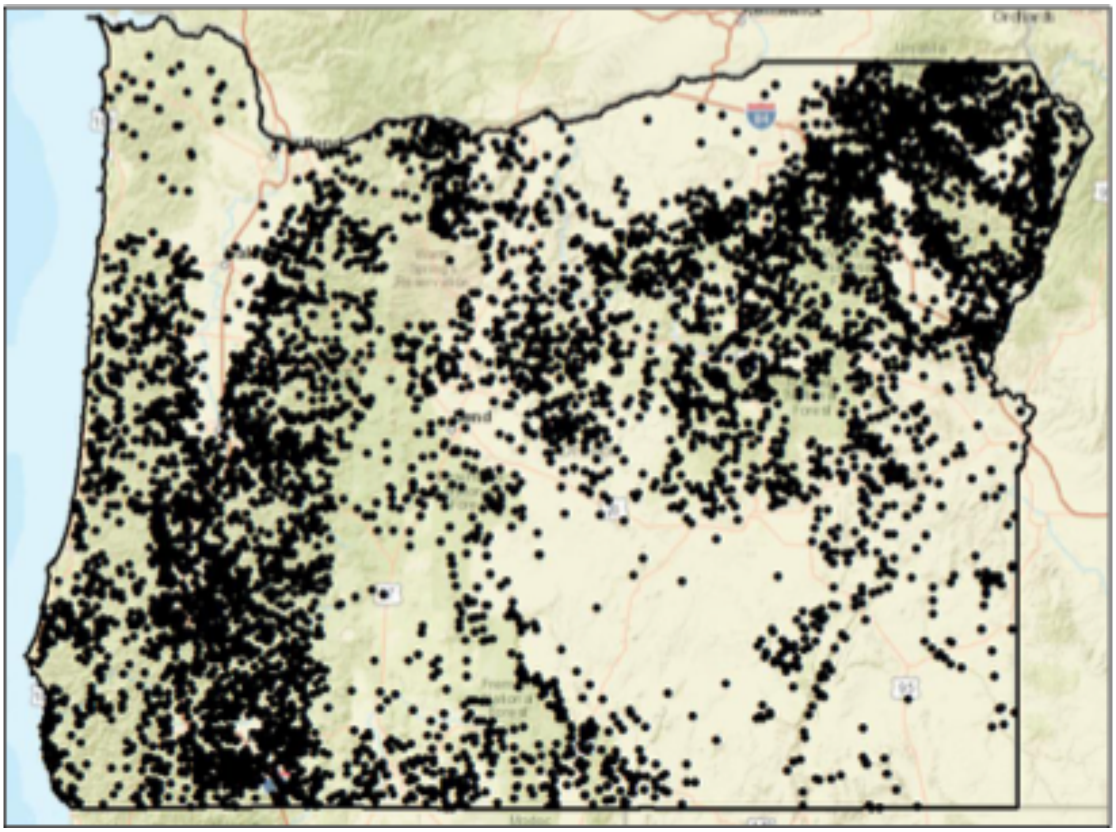
Cougar mortality and Lyme disease reports for 1912-2017.



Source: (ODFW, 1987; ODFW, 2007; ODFWa, 2017).

Figure 13

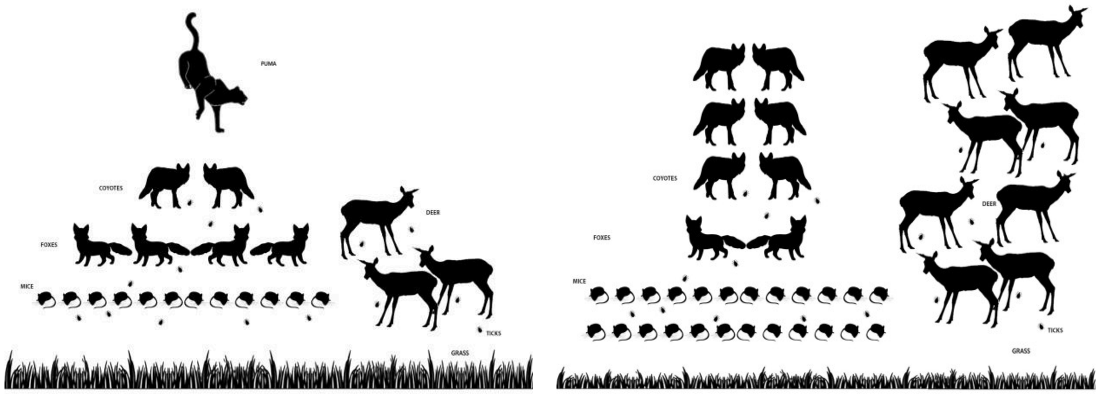
Locations of known cougar mortalities in Oregon for 1987-2015.



Source: (ODFW, 2017c).

Figure 14

Cougar's regulating controls.



In the left panel, cougar predation reduces the population of tick vectors, deer, and mice. Doing so, decreases the numbers of vectors, disrupt the tick's life cycle, and limits food sources, thus reducing human exposure to infected Lyme disease ticks. The right panel indicates an ecosystem void of cougar's mediating effects. In this scenario, deer and mesopredator populations such as coyote increase and so do the tick's reproductive cycles and access to food. This suggests that human risk for Lyme disease may be higher in ecosystems void of cougar.

Source: (Kennerknecht, 2014).

Figure 15

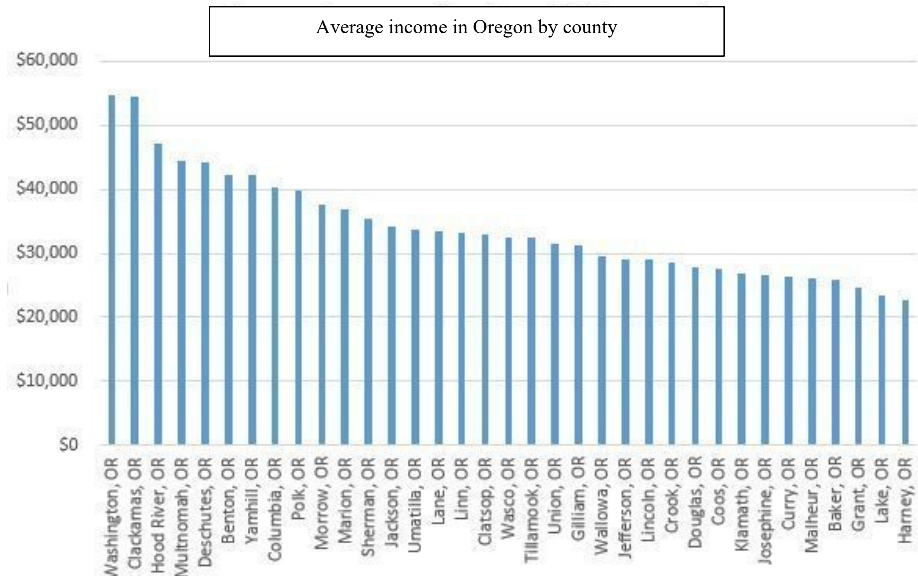
Winter tick infestation decreases Moose populations.

A three-year study of moose in Vermont indicated that chronic high winter tick loads caused their health to be very poor, with about half of moose calves dying each winter, primarily due to heavy winter tick loads.

Source: (VFW, 2020).

Figure 16

Oregon's average income by county.



Source: (Mack, 2019).

Figure 17

Potential Cougar Valuations.

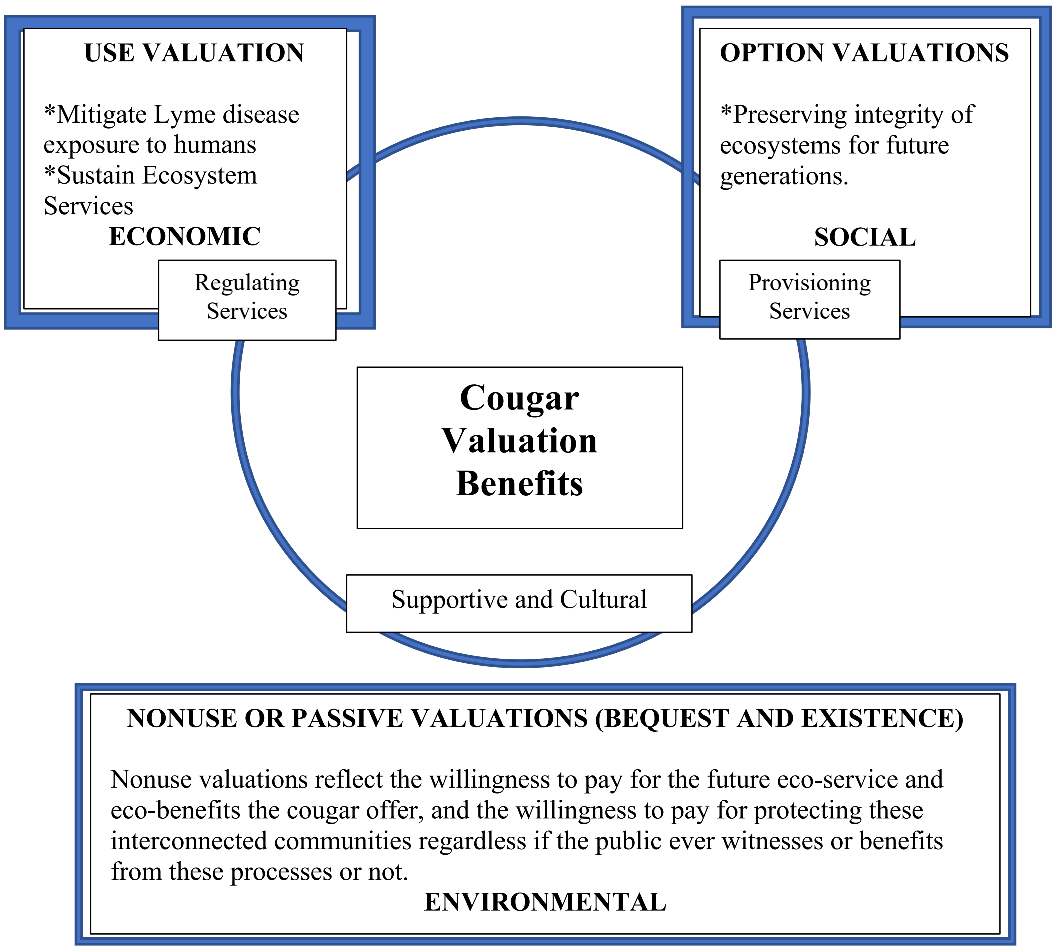


Figure 18

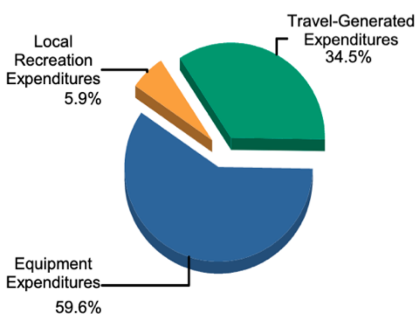
Estimated expenditures for fishing, hunting, wildlife viewing, and shellfishing in Oregon.

Statewide Participants, Trips and Expenditures in Oregon, 2008

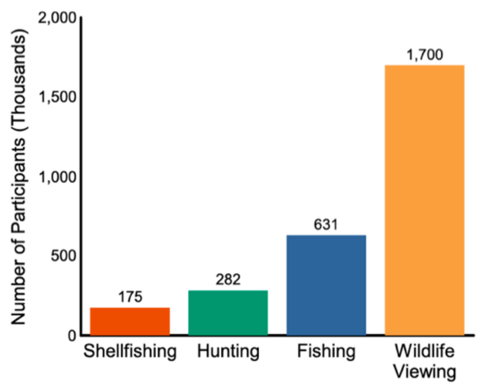
Total	***(in thousands)***
Participants in Oregon	2,788
Trips in Oregon	21,163
Travel-Generated Expenditures	$862,188
Local Recreation Expenditures	$146,908
Equipment Expenditures	$1,486,932

Notes: Resident and nonresident expenditures associated with all reported activities in Oregon. Travel-Generated expenditures associated with overnight and day trips 50+ miles (one-way).
Source: Dean Runyan Associates.

Fish and Wildlife Recreation Expenditures in Oregon, 2008
(Total: $2.5 billion)



Total Participants by Activity, 2008

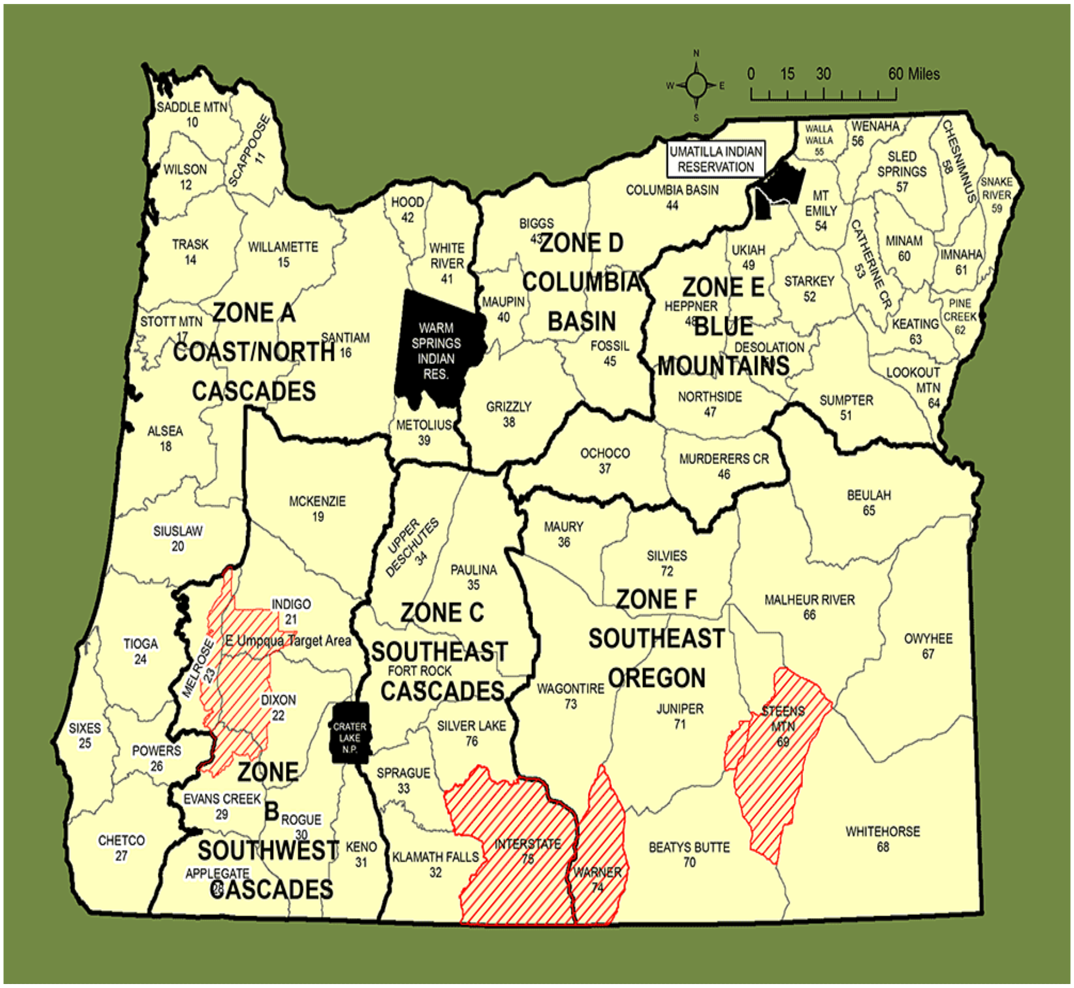


Page 6 **Dean Runyan Associates**

Source: (Runyan, 2009).

Figure 19

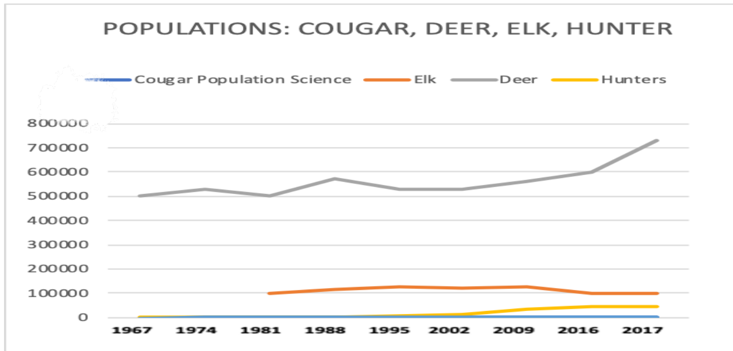
Cougar target zones (areas in red hatching) identified by Oregon Department of Fish and Wildlife (ODFW).



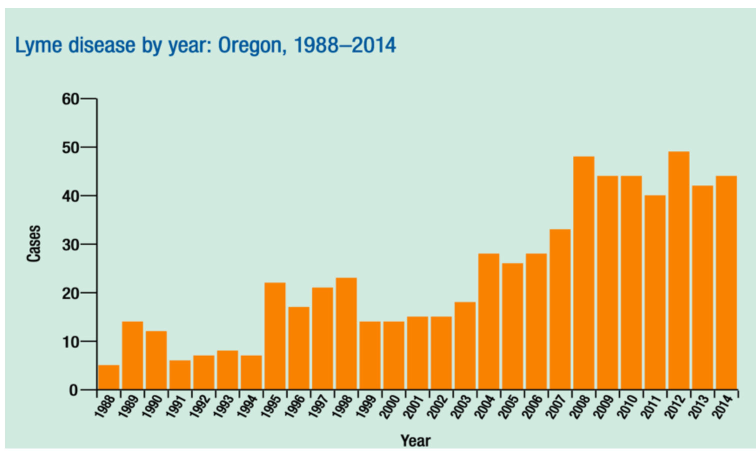
Source: (ODFW, 2019a).

Figure 20

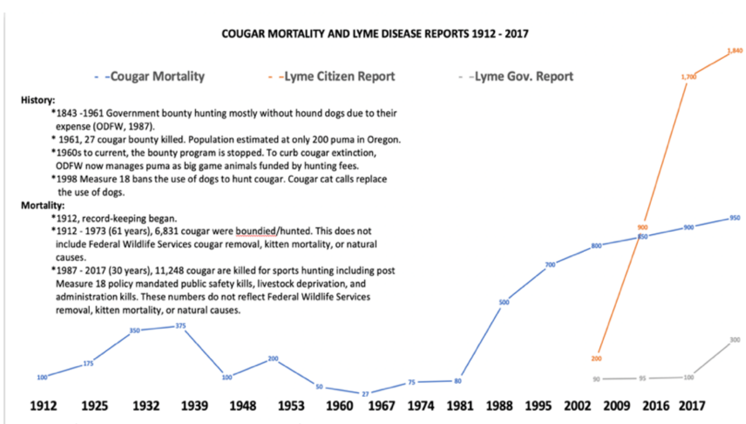
Population correlations in Oregon of Lyme disease, cougar mortality, and deer from 1912 - 2017.



A. *Deer population numbers increased between 1967 and 2017.*



B. *Increased Lyme disease reporting.*

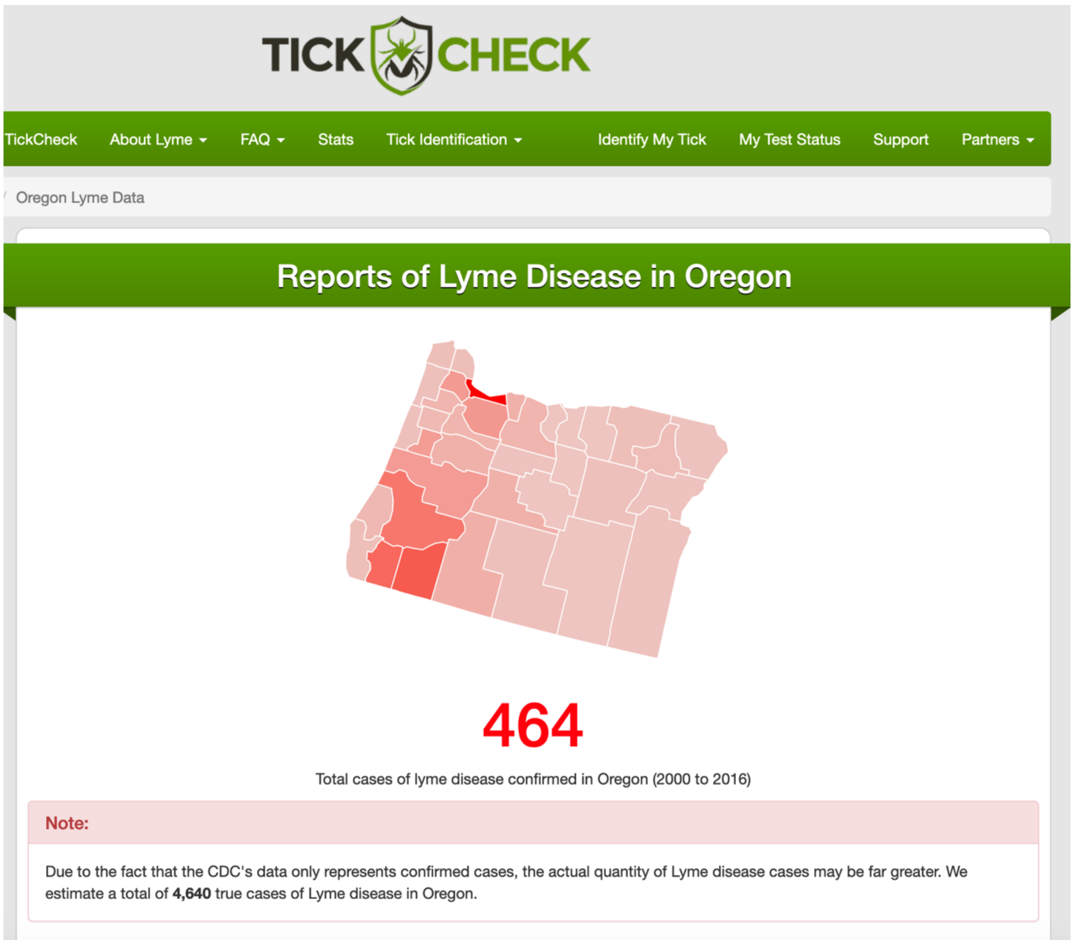


C. *Lyme disease and cougar mortality correlations.*

Source: (ODFW 1987; ODFW 2007; ODFW, 2017a).

Figure 21

2016 Tick Check website reports on Lyme disease outbreaks in Oregon counties.



Between 2000 and 2016, Oregon governmental health and insurance regulators recognized approximately 464 Lyme disease cases. Researchers believe Lyme disease cases may be closer to 4,640 in Oregon. Cougar harvest zones closely correlate with areas of Lyme disease cases.

Source: (Hilton, 2014; Committee on Health Care, 2015; Weber, 2020).

Figure 22

2011 legislative draft of License To Protect (LTP).

DRAFT

SUMMARY

Requires Stateadsrre and Wildlife Commission to provide means for persons to make voluntary contributions to be used for programs that promote livestock safety and wildlife protection.

Establishes Oregonians for Wildlife and Livestock Safety Subaccount in Fish and Wildlife Account.

A BILL FOR AN ACT

Relating to the State Fish and Wildlife Commission; creating new provisions;

and amending ORS 496.303.

Be It Enacted by the People of the State of Oregon:

SECTION 1. (1) The State Fish and Wildlife Commission shall provide a means for persons to make voluntary contributions to be used for outreach and educational programs that promote livestock safety and wildlife protection.

(2) The commission shall seek voluntary contributions in conjunction with the sale of licenses, tags and permits and by such other means as the commission considers appropriate. The commission shall establish a means by which persons who do not hunt wildlife but who desire to support the programs described in subsection (1) of this section may make voluntary contributions.

(3) If the commission implements an electronic licensing system, the commission shall include in that system a means for persons to make voluntary contributions to support the programs described in subsection (1) of this section.

LZCTION 2. ORS 496.303 is amended to read:

496.303. (1) The Fish and Wildlife Account is established in the State

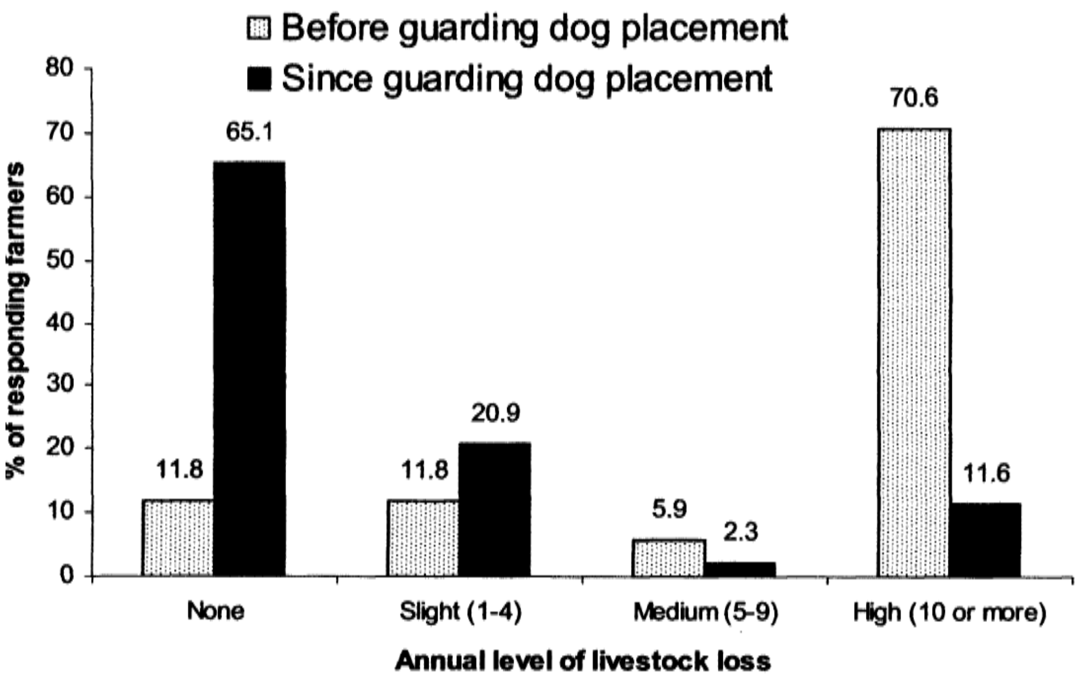
NOTE: Matter in boldfaced type in an amended section is new; matter [italic and bracketed] is existing law to be omitted. New sections are in boldfaced type.

LTP was designed by a grass roots nongovernmental not for profit Oregon Cougar Action Team to help connect rural and urban responsibility and funding for protecting Oregon's cougar. This policy effort was to ensure equitable citizen investment, and understanding of living with Oregon's cougar.

Source: (OreCat, 2020).

Figure 23

Effects of guardian dogs on livestock loss in Namibia.



Source: (Namibia, 1995; Marker et al., 2004).

Figure 24

OreCat's Great Pyrenees/Maremma guardian dog program helps reduce livestock losses from predators.

Oregon small subsistence farmer is awarded a livestock guardian puppy.

Source: (OreCat, 2020).

Figure 25

OreCat public cougar education presentation.

Oregon Cougar Action Team members offer free public cougar presentations throughout Oregon.

Source: (OreCat, 2020).