The “Recreation Boom” on Public Lands in Western Washington: Impacts to Wildlife and Implications for Treaty Tribes

A Summary of Current Literature

The Tulalip Tribes
Natural Resources Department
Treaty Rights Office
6406 Marine Drive
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" It's important that we never lose our right to access our traditional foods and our materials that we gather, our fish and our game, and all those things from the land and the water that our people remain spiritually connected to which defines us and our living culture."

Ray Fryberg, Sr., Tribal Research Historian, Tulalip Tribes Natural and Cultural Resources Department

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Introduction

Recreation across public lands in western Washington is growing rapidly as the population in the Puget Sound Region expands, and as the popularity of outdoor activities among a growing and younger demographic surges (Balk, 2019). Social media is likewise playing a role in introducing and drawing people to natural areas, as well as funneling them to particular areas (Simmonds et al. 2019; Solomon, 2018).

Tribes have witnessed this increasing recreational pressure across the landscape, and its strikingly dramatic growth over the last two decades. The pressures on public lands and waterways were made all too clear this past year (2020) during the COVID-19 pandemic. News sources as well as reports from land managers in our region described extreme crowding and heavy use across all seasons, overflowing parking areas at trailheads and boat launches, litter, human waste, erosion and a near total lack of enforcement. Tribes and many agency staff view last year's large numbers of recreationists less as an anomaly than a *preview* of what the future holds in our region.

Population growth scenarios for western Washington also suggest these challenges will only increase in the future. The expanding volume of recreational users on public lands in recent years across Tribes' treaty areas has been fueled, in part, by rapid growth in the technology industry in the Puget Sound Region (Balk, 2019). This 'tech boom' has led to a significant increase in spending on recreation and associated recreation-related jobs, such that the outdoor recreation industry is a major economic driver in our state (Mojica

2020). Current federal, state, and local policies calling for maximizing recreational opportunities and associated revenue on public lands contribute to these trends (Thomas & Reed 2019). Many federal and state funding programs for restoration and acquisition require projects provide public access, thereby increasing recreational capacity and implying that human use is always appropriate and compatible with restoration and protection goals.

Tulalip and other western Washington tribes are concerned about recreation's impacts on the environment, and in turn, implications for the exercise of treaty rights on public lands and waters, now and for future generations. In responding to this increased demand, land managing agencies have expanded parking lots, added new river and marine access points and launches, increased miles of new trails and improved existing ones, installed more pit toilets as well as other recreation infrastructure. However, we have seen little in the way of agency evaluation of the intensifying human footprint on the health of these public lands in western Washington, and in turn, the impacts recreation may be having on tribal treaty rights and lifeways that depend on healthy and diverse ecosystems.

A mounting body of scientific literature nationally bears out tribal members' concerns locally: recreation, both motorized and non-motorized, can and does have a significant environmental impact. Cumulatively, recreational activities can influence the range and health of fish and wildlife species and habitat, degrade vegetative communities, and result in human presence and disturbance throughout even the most remote areas of public lands and treaty areas, regardless of season. Researchers report that outdoor recreation is a leading cause of species endangerment on public lands in the United States, and on at-risk bird species worldwide (Losos et al. 1995, Steven and Castley 2013). Several recent studies synthesize both national and international research on recreation impacts to wildlife, and outline

the specific impacts of outdoor recreation and nature-based tourism (Larson et al. 2016, 2018, 2019; Miller, A.B. et al. 2020; Naidoo and Burton, 2020; Monz et al. 2013; Sato et al. 2013; Steven and Castley 2013; Hammitt et al. 2015). In light of the already diminished resources and access challenges in our area, and the uncertainty associated with a changing climate, these findings and trends are concerning.

Tribes possess rights reserved by treaties with the United States. As a signatory to the Point Elliott Treaty of 1855, Tulalip and other signatory tribes have reserved rights to take fish and shellfish at usual and accustomed areas, as well as to hunt and gather plants and wildlife throughout open and unclaimed lands, including state and federal public lands. These treaty-reserved rights were upheld in the landmark legal decision, U.S. v. Washington (Boldt decision) and numerous other federal cases. In deciding tribal treaty rights issues, the courts have noted treaties are agreements between sovereign nations and are the supreme law of the land. The federal court decisions apply tribal treaty canons of construction and have interpreted the treaties as the Indians would have understood them, giving significant weight to the testimony of elders and the records of treaty discussions. Documentation shows that the continuation of fishing, hunting and gathering was of central importance to the Tribal leaders who signed the treaty (Wilkinson 2006). It is improbable that Tribal signatories to the treaty in 1855 could ever have imagined the widespread conversion of lands, habitat loss, and diminishment of fish and wildlife populations that we see across Western Washington today. The protection of ecosystems and habitat on which the exercise of these off-reservation treaty rights depend is essential to fulfilling the treaty obligations to the Indian tribes. In the absence of research and actions to address recreation's environmental impacts across our treaty areas, which coincide with these same public lands experiencing intensifying recreational pressure, State and federal land-managing agencies are not adequately addressing their obligations to treaty tribes.

Recreational impacts can affect a multitude of natural and cultural resources of importance to tribes, both terrestrial and aquatic. This report focuses on a review of scientific literature of recreational impacts on *terrestrial wildlife*. Other reports have similarly synthesized available research on this topic, on a national or international scale, though our intent is to view this research through the lens of tribal treaty rights, and from a more local and regional perspective. A review of literature and research findings related to aquatic species is needed in order to better understand the broader impacts of recreation on treaty resources here in western Washington.

While clearly not representative of *all* the research that is available on this topic, this report provides a bibliography of key research discovered, and a summary of findings applicable to tribal concerns here in western Washington, highlighting specific impacts to select wildlife species. Examining effects of recreation on wildlife, and conservation of biodiversity more generally, will allow tribes to consider strategic protective efforts needed, and serve as a potential framework for guiding future research in our region.

Outdoor Recreation: Soaring Popularity, Thriving Business

In the United States, the outdoor recreation economy generates $788 billion in consumer spending, over 5.2 million direct jobs and billions of dollars in federal and state tax revenue, and continues to grow annually (U.S. Bureau of Economic Analysis 2020).

Public demand for outdoor recreation has long been an economic driver and many federal, state, and municipal conservation strategies aim to ensure recreation access to public lands (Cordell 2012; White et al. 2016; Riddle 2019). However, as demand increases, these policies, management programs, and funding initiatives are often at odds with natural resource protection and conservation objectives (Thomas and Reed 2019). While it has often been assumed that participation in outdoor recreation creates a commitment to the environment and can drive conservation of lands, research is inconclusive. Studies have shown that outdoor recreation is only weakly correlated with environmental concern, and that the fact that a person recreates in the outdoors is not a lone predictor of their environmental attitudes (Berns and Simpson, 2009, Dunlap and Heffernan, 1975).

> *"The challenge we have right now ……is you have marketing strategies pushing to get everybody out to the woods and people trying to manage the woods going, 'oh my goodness, what do we do with all these people?'"*
>
> -Cheryl Friesen, Wildlife Biologist and Science Liaison, Willamette National Forest *in* Kantor et al.. 2019

The economic importance of recreation has been well studied, and has informed much of the historical and recent recreation-related legislative and executive efforts (Riddle, 2019). Likewise, studies on human health benefits of recreation and studies to quantify it have also proliferated (e.g. Perrins and Bratman, 2019; Frumkin et al. 2017). Less central to this debate, it appears, is consideration of recreation's *environmental* impacts, particularly those previously considered 'passive' or 'low impact' (Thomas and Reed 2019), or recreation's impacts to tribal treaty and cultural rights.

> *"The least-studied mammal in Yellowstone is the most abundant: humans….Our own species is having the greatest impact on the park…"*
>
> -Dan Wenk, former superintendent of Yellowstone National Park *IN* Simmonds et al. 2018

Between 2000 and 2009, the number of participants in outdoor recreation increased nationally by 7.5% and total visitor days increased by 32.5% (Cordell 2012). In 2017 alone, data showed federal lands had an estimated 596 million visits (Riddle 2019). U.S. national parks have been experiencing record high numbers of visitors, and in 2017 there were over 331 million visitors, and some parks, like Yellowstone, have seen over a 40% increase in visitation since 2008 (NPS 2018; Simmonds 2018). Future recreation user projections continue to show a greatly accelerated rate for the next 50 years. For example, the potential number of users at

'developed sites' (e.g., campgrounds, picnic areas, interpretive sites, ski areas, etc. on public lands) is expected to climb from a little more than 190 million in 2008 to between 272 and 346 million by 2060, representing a 40 to 77 % increase (Bowker et al. 2012; White et al. 2016). In light of increasing recreational demand across federal public lands, the U.S. Forest Service recently completed two studies devoted to addressing sustainable recreation through a proposed national research strategy (Cerveny et al., 2020) and a collection of perspectives on new research methods, planning tools, and management approaches and paradigms with the intent of linking science and policy (Selin et al.,2020). Both publications give detailed insight into agency approaches to current recreation management challenges on public lands.

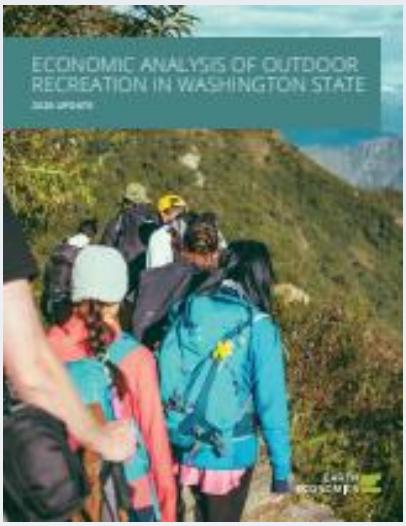
Walking or hiking continues to be the fastest growing form of recreational use on public lands, however many other forms of recreational activities are gaining in popularity too, including wildlife viewing, photography, trail running, rock climbing, biking, off highway vehicle (OHV) riding, skiing, and hunting (Outdoor Foundation 2016). For example, mountain biking grew by 22% between 2006 and 2015 to 8.3 million U.S. riders (Outdoor Foundation 2016). The number of hikers increased even more during the same time period – up 24 percent, to 37.2 million participants. The number of off highway vehicle (OHV) riders reached 36 million in the early 2000s (Cordell, 2012) and is projected to increase 30–60% (to 62–75 million participants) by 2060 (Bowker et al. 2012).

Across the American West especially, outdoor recreation has long been popular and is a rapidly expanding and lucrative industry. For example, Colorado, with its abundance of public lands, has ranked among the highest in promotion of outdoor recreation. According to a recent report released by Gov. John Hickenlooper (Goodland 2020), outdoor recreation's economic impact in Colorado has more than doubled in just the past four years, adding $62.5 billion to the state's economy and supporting 511,000 direct jobs. In that time period, the outdoor-recreation sector grew from having a $28 billion impact to its current $62.5 billion mark, making it a main economic driver of the state's economy (Bastone et al. 2019). Employment in the recreation sector has jumped 83 percent, from 299,000 to 511,000, comprising 19 percent of the labor force in Colorado (Goodland 2020). It is estimated that 69% of Coloradans log some form of outdoor recreation one or more times per week. Many of the state's 84.7 million annual visitors come to do the same. In Vail, a popular recreation area, trail use has more than doubled since 2009 negatively affecting elk (Peterson 2019). Some trails host as many as 170,000 people in a year and *night* trail use in some areas has increased by 30% in the past decade. People are reportedly traveling even deeper into woods and higher in the alpine areas in part because of improved technology, trail notoriety, and to escape crowds (Colorado 2019 Statewide Comprehensive Outdoor Recreation Plan).

Recreation in Washington

Like Colorado, Washington's outdoor recreation industry is also robust and increasing along with the State's recent and significant population growth, as well as state policies and funding that support its continued expansion. A report by Earth Economics, a Washington-based nonprofit organization, estimated direct consumer spending on outdoor recreation to be $26.5 billion annually, with associated secondary effects, or multiplier effects, estimated to be $40.3 billion. This spending supports, directly or indirectly, and estimated 264,000 jobs throughout Washington (Mojica 2020). Based on a comparison

Recreation in Washington is Big Business



According to a recent report analyzing recreation's economic impact in Washington (Earth Economics, 2020), Washington receives **$26.5 billion annually from direct consumer spending, supporting 264,000 jobs**

"… Washington is known as a premiere destination for outdoor recreation. We should think strongly about continuing to invest in our outdoor assets -- to maintain our trails, re-design overcrowded boat launches, repair deteriorated campgrounds and build new places to recreate …."

— Director, Washington State Recreation and Conservation Office *in* 'Outdoor Recreation Generates Big Money in Washington' July 30, 2020

with similar data in 2015, the industry has shown strong growth, and places outdoor recreation on par with Washington's aerospace industry (Briceno and Schundler, 2015; Mojica, 2020).

With recreation having become a major economic driver in our state, and with two thirds of those economic benefits reported to be derived from State and federal public lands and waters (https://www.governor.wa.gov/issues/economy/outdoor-recreation), tribes are concerned about how recreation dollars may affect public lands management and policy choices in Washington. Where outdoor recreation was already very popular, a booming technology industry in Seattle has fueled growth of new users to the landscape.

According to recent surveys, the number of hikers from the Seattle area has doubled in the last eight years (*see text box, p. 11*). Sales of the Discover Pass for Washington state parks and natural areas increased by 55% in the past five years (Balk, G. 2018). In 2018, a pilot public transportation program called "Trailhead Direct," began shuttling hikers from urban centers to and from state and federal trails. In the second year of the two-year pilot, an additional 18,000 trips annually were made (between 2018 and 2019), constituting a 75% growth in ridership (Lloyd 2019). The vast majority of these trips, nearly 100,000 hikers per year, were to Mount Si on State public lands in the Snoqualmie watershed, one of the region's most popular hikes (Lloyd 2019).

Research on the benefits of recreational hiking and biking trails commissioned by the Washington Recreation and Conservation Office (RCO, 2019) highlighted the economic benefits of trails to the State, by county, and the associated physical and mental health benefits. RCO's policy recommendations on trails stressed building more trails, especially multi-day trails that bring in more revenue, improving existing trails, and developing more uniformity in permitting requirements to streamline new trail development (*see text box, p. 10*).

Beyond the rapid growth in recreational use over the last years, a marked increase in visitation and new users to public lands occurred during the 2020 COVID-19 outbreak. In response, limits were placed on social gathering and recreation, and the United States Forest Service (USFS) issued a public notice urging people to stay home. The Mt. Baker-Snoqualmie National Forest was responding to a record number of recreationalists and peak numbers of visitors even during expected low times mid-week (Godwin 2020). Popular hikes were documented to have over 1,500 recreationists on a single day as the USFS struggled to maintain emergency services (Clarridge 2020), trash and human waste removal, and increased negative interactions with wildlife. The pressures across public lands were noted in news articles describing extreme crowding (Frame 2020; Scruggs 2021), environmental degradation (Mapes 2020), and lack of enforcement in many public recreational areas on national forests, state forests, and parks in our area (Connelly 2019).

Source: *Economic and Health Benefits of Walking, Hiking and Bicycling on Recreational Trails in Washington State, Recreation and Conservation Office, 2019*

Recreation and Conservation Office (RCO) Recommendations on Trails

1. **Encourage Development of New Trails & Improve Quality of Existing Trails**
2. **Develop more uniform trail building permitting across state to ease regulatory burden for new trail development**
3. **Conduct Comprehensive Planning for Trails**
4. **Encourage Development of Trails that Promote Multi-Day Trips—More dollars spent on overnight trips than on day trips**
5. **Encourage Visitation by Adding New and Improving Existing Amenities**
6. **Use Trails as a Health Intervention Strategy**
7. **Improve Data Collection of Trail Usage and Create Consistency**

Research on Environmental Impacts of Recreation in Washington

While the economic and health benefits of outdoor recreation have been well-analyzed in Washington State, research on the environmental impacts of recreation to fish, wildlife, plants and their habitats is very limited. Apart from small, local independent studies and planning efforts that look at habitat requirements for specific species (Snetsinger & White 2009), there remain large data gaps. Washington's Recreation and Conservation Office (RCO) is the state's largest public funding source for "outdoor community projects". Through the RCO, funding for recreation and wildlife conservation are combined into one funding program (Mojica 2020). While highlights from the RCO 2020 report describe outdoor recreation's large economic contribution to the State, little or no evidence is given to suggest a positive correlation between this this economic contribution and wildlife. Despite their stated responsibility to

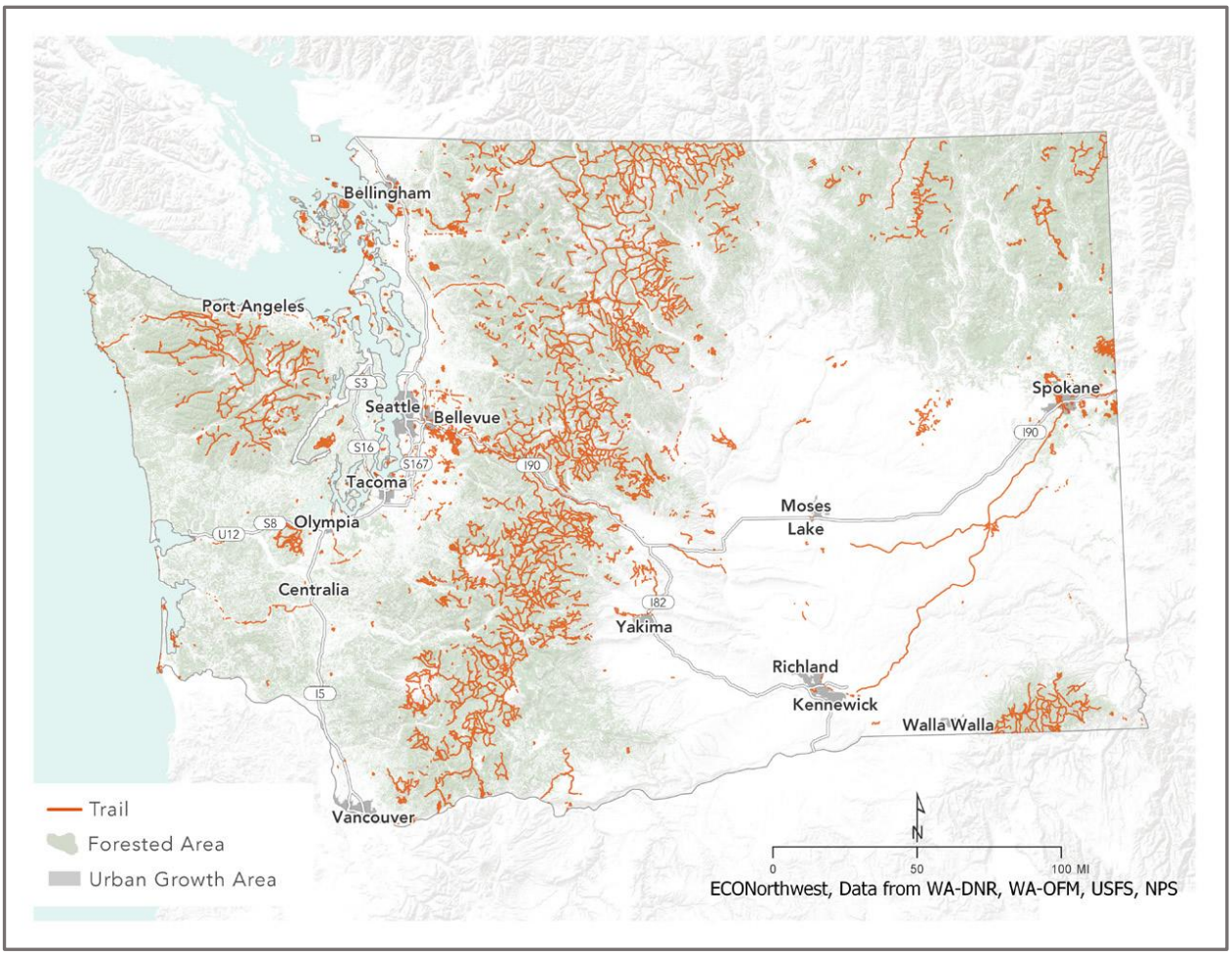
work with sovereign nations to ensure areas are preserved and enhanced, the RCO merely asserts that Washington Tribes rely on the recreation economy, with little mention of other potential effects (Mojica 2020). Consideration of treaty rights in recreation studies and planning in Washington has been minimal or absent, even though it is often concentrated in areas where tribes have reserved treaty rights.

Source: Balk, G. Seattle Times. April 2, 2018.

Washington is home to some of the most popular federal parks, forests and monuments in the country, multi-state trail systems like the Pacific Crest Trail, and an abundance of lakes, ski resorts, and natural areas that are easily accessible to its large urban centers. Visitation to protected areas, like North Cascades National Park, was recently estimated at 8 billion visits per year by local and out of state residents, and boosted by international ecotourism visits (Balmford 2015). Though recreational impacts can be seen across the landscape, including those from non-consumptive uses like hiking, a recent survey of 640 backcountry trail users showed that 50% of those surveyed felt that their form of recreation (i.e., hiking) was *not* having a negative effect on wildlife and tended to blame other user groups for stress to wildlife (Taylor and Knight 2003; Sterl et al. 2018).

These same Washington federal and state parks and forests that draw large numbers of visitors from the U.S. and abroad constitute the ever shrinking area of remaining undeveloped lands in the Puget Sound basin, critical for wildlife and for tribes exercising their reserved treaty rights. Of the approximately 6.5 million acres ceded by tribes under the 1855 Treaty of Point Elliott, an area stretching from the Canadian border south to Mt. Rainier, vast areas have been converted for agriculture, industry, transportation networks, hydropower projects and reservoirs, and a highly developed and populous retail and residential urban corridor. Consequently, wildlife ranges have been greatly diminished, wildlife habitat fragmented, and wildlife abundance greatly reduced.

While this paper summarizes impacts of recreation on wildlife, based on a broad literature review of existing research findings, our focus is on impacts to Point Elliott Treaty wildlife resources and their habitat, and on the role that research, management, policy and user education might play in addressing them. A thorough understanding of these impacts will enable tribes to advocate more effectively for the protection and recovery of these vital treaty resources, as well as for healthy habitats needed to support and recover them.



Map of Washington Trails. *Source: Washington Recreation and Conservation Office (Note: The trails reflected on this map include both motorized and non-motorized trails) IN: Economic, Environmental, and Social Benefits of Recreational Trails in Washington State* https://rco.wa.gov/wpcontent/uploads/2020/01/HikingBikingStudy.pdf

Wildlife Impacts

Overview

For the past few decades, the popularity of recreational activities on public wild lands has increased substantially in North America (Hammit 1998; Boyle and Samson 1985, Knight and Gutzwiller 1995, Buckley 2004, Naylor et al. 2009). Activities such as wildlife watching, hiking, skiing, mountain biking, and riding all-terrain vehicles (ATVs) often bring people into close proximity with wildlife and can negatively affect sensitive habitats (Miller 2001). These non-consumptive activities have the potential to affect ecological communities by lowering vertebrate richness and abundance (Larson et al. 2019), disturbing, redistributing, and causing animals to actively avoid parts of their native range (Hamr 1988,

Gander and Ingold 1997), decreasing fitness and changes in activity patterns (Ordiz 2013), and reducing the carrying capacity of public lands (Light and Weaver 1973).

Although visiting wild places may help raise awareness of environmental conservation (Buckley 2004), recreational activities in the wild have detrimental effects on wildlife, from individual animals to populations (Duchesne et al. 2000, Boyle and Samson 1985, Knight and Cole 1995, Naylor et al. 2009, Naidoo and Burton, 2020). Recreational activities may have short-term impacts on individuals (Figure 1), such as diverting animals from fitness-related behaviors (e.g., feeding, parental care) and displacing them from safe habitats to areas where they might be more vulnerable to predation (Lima and Dill 1990, Knight and Cole 1995, Papouchis et al. 2001).

Human disturbance, in general, has consequences for wildlife, whether it be direct habitat destruction (Czech et al. 2000), indirect habitat loss through displacement (Bender et al. 1998), or habituation (Geist 1978, Hammit and Cole 1987, Knight 2009). Repeated disturbance may cause animals to avoid affected areas spatially (i.e., animals move to a different area following disturbance), or temporally (i.e., animals avoid an area when the disturbance is occurring and return when the disturbance has ended) (Hamr 1988, Yarmoloy et al. 1988, Lusseau 2004, Wakefield and Attum 2006). Some studies documented that even a small number of visits to an area can have a disproportionate impact (Cole 1995). Displacement of wildlife to less desirable and often ecologically inferior areas may be as detrimental to wildlife populations as harassment or habitat changes (Hammitt and Cole 1987) due to reduced foraging efficiency (Knight and Gutzwiller 1995) and increased predation risk (Geist 1978, Lusseau 2004) resulting in overall decreased fitness (Miller et al. 2001). These effects can be difficult to detect, especially at large spatial scales. Unfortunately, the reality is that land managers often lack baseline site-specific formal wildlife surveys to inform their work in development of recreational sites and access.

Researchers continue to develop methods to quantify the impacts of different user groups more effectively, and determine how these effects are seen on the landscape. The U.S. Forest Service reviewed 238 articles on human disturbance of wildlife and found that a high percentage among the almost 400 species studied showed displacement or avoidance (Gaines et al. 2003), and more recently, completed a broad synthesis of research findings and needs (Miller et al., 2020). A review in 2016 investigated over 274 studies internationally on recreation and wildlife with 93% showing at least one effect on wildlife with 59% of those effects negative (Larson 2016). While all forms of recreation impacted wildlife, this study found, counter to public perception, that *non*-motorized activities and snow-based activities overall showed more negative effects than did motorized activities, with effects observed 1.2 and 1.3 times more frequently across all recreation types and seasons (Larson 2016). Researchers have found hiking and biking have the same impact on wildlife responses (Taylor and Knight 2003) because it appears, based on their movement, humans on foot are as threatening as humans associated with vehicles, bicycles, cars, or noise alone (Stankowich 2008). Previous studies have indicated that animals react adversely to spatially unpredictable activities (Schultz and Bailey 1978, MacArthur et al. 1982, Hamr 1988, Miller et al. 2001). On-trail recreation may appear more predictable to wildlife because it occurs frequently and along a particular line of movement, in comparison to off-trail recreation. For example, ungulates flee at greater distances from off-trail hikers compared to on-trail hikers (Knight and Cole 1995a, Whittaker and Knight 1999). Other studies indicate that animals will shift movement patterns altogether by becoming more nocturnal.

In general, research shows that larger animals and larger groups of animals tend to be more sensitive to human disturbance (Stankowich and Blumstein 2005). Studies outline speed and directness of approach as key factors in whether an animal elicits a stronger flight distance response (Knight and Cole 1995).

When animals show no apparent behavioral response, studies have nonetheless shown that they may experience physiological stress (Creel et al. 2002). Increased stress, over time, may cause greater susceptibility of animals to disease, lower reproduction rates, and other negative consequences (Creel et al. 2002). Even though wildlife responses vary across recreational type and spatial extent, different species react differently to recreational infrastructure and users. It is therefore important to understand several key factors that influence wildlife response, such as those identified by Knight and Cole (1992):

- type of disturbance (e.g., hikers, mountain bikers or equestrians)
- timing (e.g., dawn/dusk; during breeding season disturbance may affect productivity; during other seasons it may affect foraging/survival)
- location (e.g., animals avoiding areas where they can easily be seen)
- frequency/volume of recreational users (e.g., more visitors can reduce avian nest productivity; we would also include duration here)
- predictability (e.g., on-trail visitors are less disturbing than off-trail visitors)
- characteristics of wildlife (e.g., habituation or sensitization)

TRIBAL IMPACT

In the 90s, when Tulalip Tribal member Jason Gobin was a teenager, he would hunt for elk and black bear off the unpaved, less used Middle Fork Snoqualmie Valley with his family. Today, this easily accessible and now paved valley road has become a popular destination as Seattle's population has grown.

CREDIT: FLICKR PHOTO/MATT KOWALCZYK (CC BY NC 2.0)/HTTPS://FLIC.KR/P/6UNAK9

Despite treaty-protected rights to hunt and gather across these treaty lands, Jason hasn't hunted in this valley since the 90s. "This is an example of an area that just basically got overrun, and now nobody goes up here and really hunts anymore," he said. "It's become harder and harder to find areas where you can truly hunt."

Studies of the local and landscape-wide recreational effects to treaty resources are needed. Understanding wildlife species behavior and spatial distribution is a powerful tool to direct management decisions made by tribes, state, and federal land managers. The next sections will briefly highlight recreation impacts specifically on elk, deer, bear, mountain goat and birds – just a few of the wildlife species of importance to tribal communities in the Pacific Northwest.

Tribal Impact

"Too many people moving around"
Tulalip tribal member, and hunter Amanda Shelton has recently noticed more people recreating in the area where she had hunted for many years - GMU 466 (Lester, WA). She describes the area now as too busy, parking scarce, and crowded with mushroom pickers and others, requiring her to go much farther into the backcountry to find wildlife, and shifting from walk-in hunting to using horses. At first, she changed the days she went hunting, avoiding Thursday through Sunday, but still ran into many hikers and mountain bikers. Noise from cars customized to be extra loud and using nearby Forest Service roads were also a disruption. For these reasons, she recently decided that this area was no longer suited to elk hunting, and did not return this year, as she considers other more suitable areas that are less disturbed.

Elk

Elk (kʷagʷičəd; *Cervus Canadensis*) are an important cultural and subsistence resource to Washington Treaty Tribes. Elk are one of the largest terrestrial mammals in North America and rely on a wide range of habitat, such as dense forest, wetlands, and grasslands. Non-consumptive recreational effects on ungulates, as described in the literature, are primarily based on negative impacts from direct disturbance. Disturbance levels are often measured in terms of observed behaviors, alert and flight distances, and distance moved (Stankowich 2008). Differences in body condition can also confound these disturbance measures as animals in poor condition, with less energy reserve, may flee at shorter distances than healthier animals (Stankowich 2008). A detailed study by Cook et al. (2013) showed that a strong interaction existed among level of summer nutrition, lactation status, and probability of breeding that was little affected by winter conditions. According to their research, adequacy of summer nutrition dictated reproductive performance and growth of female elk as well as growth and development of their offspring in the Northwest and Rocky Mountains. This study signals the need for greater emphasis on summer habitats in land management planning on behalf of elk. Because non-consumptive recreation greatly increases during the summer, the negative impacts to elk reproduction, fitness and recovery of elk in areas of recreation would be higher.

There have been a number of substantial and robust studies conducted on elk behavior and responses to recreation, with some of the most thorough occurring at the U.S. Forest Service Pacific Northwest Research Station in the enclosed Starkey Experimental Forest and Range, Oregon. Wisdom (et al. 2018) implemented controlled and uncontrolled recreational treatments in large sections of forest and compared observed and GPS-recorded responses to elk behaviors. Early research identified distances at which specific activities result in a flight response. Sensitive reactions (flight responses) are shown at 650m (2132 ft) for skiers (Cassirer et al. 1992), 1500m (4921 ft) or less for bikers, 500m (1640 ft) or less for horseback riders, and 500m or less for hikers (Wisdom et al. 2004). Using GPS data,

researchers refined these results by showing mean distance avoidance of elk from a nearest trail vs. mean minimum separation distances that elk maintain from recreationists (Wisdom et al. 2018). For example, elk avoid ATV trails at a mean distance of 311m (1020 ft) however, if a recreationist is using the ATV trail, mean separation from that person will increase to 879m (2884 ft) (Wisdom et al. 2018). This research highlights two important findings that elk avoid ATV trails regardless if people are present and when people are present those avoidance distances increase dramatically. Table 1 summarizes literature-supported recreational impact distances, for popular recreation types. It is important for wildlife practitioners to understand these avoidance differences as they pertain to the local landscapes that they manage.

Habitat "Compression"

When elk avoid recreation trails and recreationists, their habitat is compressed. This is a form of habitat loss, similar to the well-documented effects of forest roads and traffic on elk and other wildlife. (Kantor, Wisdom and Johnson 2019)

Motorized recreationists often comment that elk populations do not avoid ATVs because elk are observed while riding. However, Wisdom et al. 2018 demonstrated that a large percentage of telemetered elk were present beyond distances at which visual observations were possible, and elk consistently maintained these longer distances. Additionally, they showed elk had a flight or hiding response that persisted temporally after recreation passed. This means recreationists may be able to observe a small portion of the elk in view of trails, but are unable to see the majority of the elk population that remains hidden from view during recreation activities as well as its lasting effects. Mean and median avoidance distances are significantly farther during ATV riding, mountain biking, and horseback riding compared to control periods (Wisdom et al. 2018). While one researcher noted ATV activity alone may not be as impactful as previously thought (Larson et al. 2019), this author noted the cumulative effects may still be higher than non-motorized recreation, because ATVs can impact more

Resorts vs. Elk Herds

In the resort town of Vail, Colorado, the local elk population numbered over 1,000, but researchers have seen that number fall to a mere 50 with recreation increasing across all seasons. It is estimated that recreation around Vail has more than doubled since 2009 with some trails hosting as many as 170,000 people in a year.

Researcher Bill Alldredge studied this elk herd in the 1980s by deliberately sending people hiking into calving areas until radio-collared elk showed signs of disturbance. This study show that about 30% of the elk calves died when their mothers were disturbed an average of seven times during calving. Additionally, their models showed that if each cow elk was bothered 10 times during calving, all their calves would die (Peterson 2019).

area per unit time due to their faster speeds (Wisdom et al. 2018). Distance responses by elk to recreationists during their study mirrored the general avoidance distances of 0.5-1.5km (~.3 to .9 mi), farther than were documented in many roads studies. Other studies suggest recreation can have adverse effects on elk during critical calving times by increasing starvation, predation, and decreasing a mother's ability to produce milk. One author has shown that females with offspring exhibited greater flight responses from recreational users compared to those without offspring (Stankowich 2008). Additionally, this researcher found that recreation activities often follow elk herd patterns, which can lead to decreased fitness. Recreation at high elevations and in remote areas can affect migrating elk in their summer range as they prepare for the rut, while at lower level elevation in the winter, can affect important feeding areas (Stankowich 2008). Elk have strong olfactory cues that can affect and increase flight response, such as the distinct gasoline scent emitted by ATVs or the scent of horses (Stankowich 2008). Because herd animals exhibit known behavior and social dynamics, the size of group of elk may affect response distances (Taylor and Knight 2003). Researchers have noted that many individuals may feel more protected being part of a larger group (Knight and Cole 1995a), but entire sub-herds may exhibit an area avoidance altogether (Wisdom et al. 2018).

"Photographer getting too close" Source: Deposit Photos. https://mycoloradoparks.com

Deer

Black-tailed deer (sqigʷəc; *Odeocoileus hemionus columbianus*), like elk, are an important subsistence and cultural resource to tribes. While generally somewhat less sensitive to disturbance and typically more abundant on the landscape, there remain noted impacts to deer from recreationalists. Managers may need to consider local impacts of high use trails that limit hunting opportunities and create habitat fragmentation. Studies show winter and early spring are critical times of impact because body condition is at its weakest and seasonal activities such as snowmobiling may enhance mobility of deer, forcing unwanted movement, increasing energy demands (Richens and Lavigne 1978 in Boyle and Samson 1985). Researchers in Germany found recreation can shift seasonal and daily patterns in red deer (*Cervus elaphus*), a European ungulate species similar to elk and deer, because of increased avoidance of daytime foraging habitats near high use recreational trails within their core home range (Coppes et al. 2017). Increased recreation may spread noxious weeds into backcountry areas which can lower forage quality for deer and reduce nutritional condition, making animals more vulnerable during winter and other critical times during the year (Canfield et al. 1999).

Researchers Scott Miller and Richard Knight (2001) looked specifically at how deer are affected by on-trail hikers with and without dogs. They found deer became alert at 46 meters (150 feet) and flushed at 34 meters (112 feet) from on-trail hikers without a dog. For hikers with a dog on a leash (on-trail), those distances increased to 85 meters (280 feet) and 49 meters (160 feet) respectively (Miller 2001). Deer activity was noted to be significantly lower within 100m (328 ft) of trails in areas that allow dogs, in comparison to those areas that prohibit dogs (Lenth and Knight 2008). For Mule deer (*Odeocoileus hemionus*), researchers have noted similar impacts by looking at the probability of flushing as distance from trail increases. Mule deer showed a 96% probability of flushing within 100m (328 ft) of recreationists located off trails and their probability of flushing did not drop to 70% until perpendicular distance reached 390m (1280 ft) (Taylor 2003). Refer to Table 1 for additional information on known recreational impacts to deer.

Dogs on the trail: Off-leash vs. on-leash Impacts

As might be expected, researchers in Colorado noted that wildlife show high trail avoidance of areas where dogs wander off-leash, likely a result of the unpredictability of the dogs' spatial behavior. Additionally, off-leash dogs are more likely to cause direct impacts to wildlife, such as flushing responses, even if dogs do not give chase. Researchers also noted, however, a high trail avoidance even where dogs were maintained *on*-leash.

Management strategies to minimize dog impacts to wildlife may not be as simple as requiring dogs to be on leash. High trail use, especially with dogs, can create small 'dead zones' on the landscape, by decreasing the density of burrows and dens within 25m (82 ft) of trails, as seen in prairie dogs, bobcats, and red foxes (Lenth and Knight 2008).

Black Bear

Black bears (sčətxʷəd; *Euarctos americanus*) are culturally important to many Washington tribes. While populations are sustaining, human population growth, silviculture practices, and recreation impact bear habitat, denning, and behavior (Peyton et al. 1999). Recreationalists are increasing the human footprint (Gore et al. 2006), inhabiting and exploring remote areas and fragmenting bear habitat (Schoen 1990). Bear disturbance can affect energy gain by altering optimal foraging and resting periods, threatening to impose energetic costs (Preisser, Bolnick and Benard 2005).

Researchers have found that bear encounters can affect daily movement patterns by increasing distance avoidance and sporadic behavior. The immediate reaction can cause a 26% increase in distance travelled by bears when compared to a 'normal' day. This increase in travel distance was found to be immediately followed by a 10% reduction in movement, and with continued effects on distance travelled up to two days later (Ordiz et al. 2013). In response to recreation, affected bears may lengthen the period of inactivity during the daytime by relying on cover and shifting movement patterns spatially

and temporally (Ordiz et al. 2013). For example, a study on a newly developed non-motorized pathway in the Grand Teton National Park showed bears did not necessarily shift home ranges or their frequency of the corridor crossing, but instead showed greater selection for steep slopes and for areas farther from the corridor (Costello et al. 2013). Bears may decrease their daytime activity by 35% and increase crepuscular (i.e., twilight) and nocturnal activity by 40% to avoid high human use times (Costello et al. 2013). Researchers also showed that within 500m (1640 ft) of the corridor these areas held the lowest probability of habitat selection and effects were seen beyond 2km (1.24 mi) (Costello et al. 2013). In Sweden, a study showed that bear activity rose substantially with increasing distance from towns and resorts. Additionally, the study documented that, on average, younger bears were more likely to be found within 10km to any major settlement as compared to older, primarily male, individuals further away (Nellemann et al. 2007). Sex and age demographic shifts such as these may lead to increased problem bears and less productive older bears on the landscape.

Spatial shifts in habitat selection and use can also be seen when looking across seasons. Bears may become more active during shorter light days because typical foraging activities are disrupted during peak recreation and hunting seasons, further increasing diurnal behavior (Ordiz et al. 2013). Researchers documented that the presence of roads and trails can affect bear habitat selection across seasons. Black bears avoid habitat within 274m (~900 ft) of open roads in the spring and 914m (~3000 ft) in the fall (Kasworm W.F and Manley, T.L. 1990). Black bears avoid trails (including closed roads) within 122m (400 ft) in the spring and 305m (1000 ft) in the fall (Kasworm W.F and Manley, T.L. 1990). These findings show managers the importance and value of using a road closure system in bear management.

Road use and elevation can affect black bear denning chronology and den site selection in the Cascades. According to a 2003 study, bears selected dens less than 500m (1,640 ft) from nearest open road, 1-2km from human activity (Linnell et al. 2000), and at an elevation of 1500-2000m (~5000-6500 ft) (Gaines 2003). This elevation encompasses a high use area for roads and recreation. Denning disturbance can have large energetic costs and result in den abandonment, especially when activity occurs within 200m (656 ft) of den site (Linnell et al. 2000). Den abandonment may increase cub mortality, however this normally occurs with higher industrial uses, such as seismic shots, drilling, and repeated vehicle noise (Linnell et al. 2000). In Washington, denning occurs primarily through Dec-February during high winter use activity periods. Spatially, denning occurs on north-facing slopes ranging from 30-50degrees with higher average snow accumulations (Linnell et al. 2000), which can conflict with optimal ski runs (Goodrich and Berger 1993).

Even at small scales, recreationalists can impact bear movement. A study of black bear responses to hikers, small power skiffs, kayakers and overnight campsites within coastal salt marsh foraging areas, recommended a minimum approach distance of 116m (380 ft) for hikers to minimize bear displacement by visitors (Smith et al. 2012). Evidence of human activity, especially people with dogs near denning sites has shown disturbance can lead to abandonment and new dens are found within mean 5.1km (~3.2 mi) of old dens (Linnell et al. 2000). In general, bears tolerate passive hikers and maintain a minimum distance between observers of 100m (328 ft) (Table 1), but repeated disturbance will increase their use of covered habitats (Fortin et al. 2016) and increase their minimum distance between observers by four times larger than visible (Ordiz et al. 2013).

Mountain Goat

In Washington, mountain goat (sx̌ʷíƛ̓əyʔ *Oreamnos americanus*) are harvested for ceremonial uses, food, blankets, and other textiles. Harvest opportunity has been extremely limited to tribes over the last half decade. Decreased population numbers across the Cascade Mountains from historic hunting and slow population growth in isolated habitats has led to declines, and mountain goats are no longer harvestable in many cases (Rice and Gay 2010). Recent translocations within the Cascade Range present the opportunity to re-establish groups and boost population numbers over the long term. Land managers should consider the impact of high use recreation and industrial activities in crucial habitat areas. Researchers have demonstrated that mountain goats show strong site fidelity to specific salt licks and game access trails, and demonstrate traditional use over multiple generations (Hengeveld and Caldwell 2004). Their inability or unwillingness to access a lick could result in a deficiency of essential resources, possibly leading to decreased fitness, cardiac responses (Stemp 1983), and eventually decreased population viability (Gosling 2003). Buffer areas of 1.5 km to 2.0 km (.93 to 1.24 miles) have been used to limit the impact of helicopter and industrial activities on mountain goats (Foster and Rahs 1983, Côté 1996, Mountain Goat Management Team 2010, Cadsand 2012). Other research indicates ATVs can cause high levels of disturbance in mountain goats, especially when ATVs approach the animals directly and at high speeds (St-Louis et al. 2012).

High elevation hiking and camping often overlaps with preferred mountain goat habitat which can lead to the habituation of goats to humans and their recreational activities. Habituation occurs when animals are exposed to the same stimuli repeatedly, and eventually stop responding to that stimulus. Habituation can lead to unnaturally close encounters between wildlife and recreational users that pose risk to both. In addition to direct conflicts between people and goats, Mountain Goat habituation may also lead to impacts from a phenomenon known as the 'human shield effect' (i.e., when animals are not as vigilant for predators when they know humans are nearby) making them more vulnerable (Atickem et al. 2014; Berger 2007). More investigation is needed to determine if this effect is, or is likely to be, a future impact to Mountain Goats in the Cascades.

For *non*-habituated goats, strong reactions to disturbance are noted to occur at distances less than 100m (328 ft). Researchers found a similar European mountain goat species avoided areas <100 m (328 ft) from an established trail (Pépin et al. 1996). Richard and Cote (2016) found that in disturbances within 1km (.62miles) of mountain goats, the average goat reaction was noted to be alert, actively seeking cover, or for females to run away and for males to move away slowly.

In another study, mountain goats appear to be able to learn the boundary of high use areas such as ski areas, which can affect their home range selection across seasons. Researchers documented that in winter, when ski activity is high, mountain goats completely avoid areas of high probability of use within the ski area, but continue to use the rest of the mountain (Richard and Cote 2016). During the summer, mountain goats were found within the ski area boundaries, but within high quality habitat areas were seen 2 and 9 times less often than outside the ski area by males and females, respectively (Richard and Cote 2016). Given a range of different mountain goat behaviors in response to recreation, goat research in the Cascades will be needed to monitor potential impacts. Land managers should consider the long-term impacts of high use recreation areas, such as permitted ski areas, as goat populations within the Cascades continue to expand.

Birds

Many avian species are valued by local tribes for cultural, ceremonial, and subsistence uses. Birds also serve as an important indicator species for the overall health of an ecosystem. Recreational birdwatching is a fast growing, multi-billion dollar ecotourism industry (Withrow 2019) and while it may have benefits for local place-based conservation efforts, it is known to have environmental impacts on avian communities (Sekercioglu 2002). From a conservation biology perspective, high-use recreation areas (e.g., rock climbing areas), campgrounds, hiking, and biking can all have negative impacts on birds, including on nesting success (Larson 2016), predator prey interactions (Knight 1988; Delap and Knight 2004), and habitat selection (Knight and Cole 1995). A review of impacts of non-hunting recreation on wildlife showed that 77 of 166 studies found negative effects on birds (Boyle and Samson 1985). In a study in the Netherlands, low-impact activities such as hiking and biking were also found to negatively affect breeding bird densities for 8 of 13 species (Van der Zande et al. 1984).

A recent study across 49 U.S. National Parks demonstrated significant changes in avian vocalizations in response to overhead airplane noise (Fristrup 2019). Other recent research on aircraft noise and birds suggested that noise may affect survivability by causing hearing impairment, diminished ability to attract mates or safeguard territory, or decreased useable energy for important tasks, such as foraging (Wolfenden 2019). In addition to impacts to birds from increases in air traffic, recreational use of drones, and perhaps other 'noisier' forms of recreation on public lands may negatively affect birds, though additional research is needed.

Recreational activities can disrupt the spatial distribution of birds in high-use and mixed-use recreation areas. In Colorado, researchers observed that the nesting success for songbirds was lower within a 100-meter (328 ft) radius of mixed-use trails (Knight 1995). Researcher S.K. Finney (2000) documented golden plovers avoid areas within 200m (656 ft) of a loosely defined footpath during the chick-rearing period. During this period, 30% of people strayed from the footpath and the movement of people was widespread and unpredictable. After resurfacing/defining of the path, 96% of walkers remained on the path. This led to golden plover avoiding these new defined paths within 50m (164 ft) of the footpath, instead of 200m (656 ft), significantly reducing the impact of recreational disturbance.

Management Recommendations in the Literature

This section briefly outlines existing management recommendations and strategies used to reduce recreational impacts documented within the literature. In 2016, researchers conducted an extensive literature review of effects of non-consumptive recreation on animals across all geographic areas, taxonomic groups, and recreation activities (Larson et al. 2016). As part of their review, they categorized and reported on the types of management recommendations that were found, and represented their frequency in the literature as a percentage (of studies):

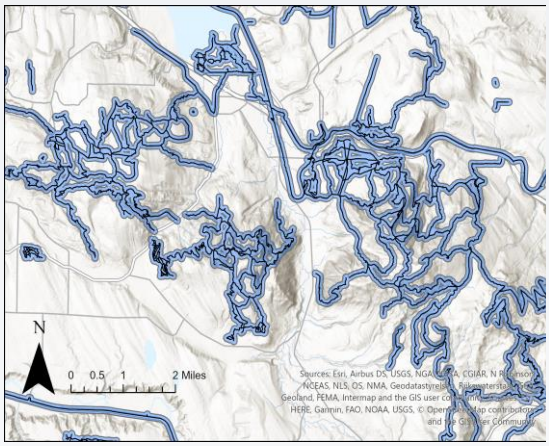
- Spatial restrictions 32.1%
- Visitor education 15%
- Cap visitation 14.2%
- Temporal restrictions 13.1%
- No recommendations 40.5%
- Rule change 9.9%
- Physical improvements 9.5%
- Species translocation 8.8%
- Enforcement 6.9%

Many studies propose spatial restrictions when investigating flight response distances and suggest the 'area of influence' around trails is of importance. By creating buffer areas, managers can calculate the amount of area potentially unsuitable for specific species due to current or proposed disturbance from recreation (Taylor 2003). Using buffers provides managers with opportunities to address spatial zonation in conjunction with temporal restrictions and the creation of suitable foraging habitats away from recreation trails and high use areas (Coppes et al. 2017).

Land managers often lack the ecological and trail inventory data to make informed management decisions (Thomas and Reed 2019; Switalski, A. 2018). Researchers highlight the need to identify known species distribution, habitat, and population numbers. As an example, based on a review of literature, Linnell et al. (2000), found that bears in dens respond negatively to human activity within a 1 km (.62 mi) radius. They recommended

Mapping Buffer Distances: Snoqualmie Example

Mapping the affected wildlife distances supported in literature with known trail networks is a powerful tool managers can use to visualize impacted areas. The example below shows how a simple 100m buffer area **('area of influence')** on a network of trails would look in part of our region (area below from Snoqualmie watershed). Highlighting the potential affected habitat and physical barriers that these trails can pose to species like elk, could allow for visual as well as quantitative assessment of the impacts.



Landscape Level Habitat Modeling Approaches

In Oregon, scientists examined forest cover across 66 watersheds regardless of public or private ownership to assess forest conditions and biodiversity (Stanfield et al. 2002). By simulating changes in forest conditions over the next 100 years, Spies et al. (2007) predicted a loss of young, early seral-stage forest on public lands, which could reduce populations of big game species like elk and deer that feed there. Having knowledge of wildlife habitat conditions and projections over time will aid efforts to recover and enhance suitable habitat, and will need to go hand in hand with actions to address recreation's impacts to wildlife.

that bear den concentrations be identified, den trees and structures protected, winter recreational activity and off-road recreation minimized, and recreational activity confined to regular routes, avoiding slopes and restricted to the valley floor.

Understanding local species and their habitats and behaviors will improve managers' ability to assess existing or potential impacts. These actions may require funding to procure up-to-date population numbers for species such as elk and bear as well as for species that pose logistical challenges to study, such as mountain goats.

Another approach researchers recommend is utilizing seasonal/temporal restrictions on high-use recreation areas during critical times for specific species. Knight (1988) advocates closing climbing routes near nesting areas during nesting seasons, in addition to prohibiting access to trails through critical winter habitat. In Colorado, county land managers closed popular trails from one hour after sunset until one hour before sunrise and closed sensitive areas from December 15th through June 30th in order to improve wildlife habitat use (Bastone 2019). Examples of effective local level management decisions to minimize impacts to wildlife can be seen across the literature (Snetsinger and White 2009; Macdonald, S. et al. 1998).

Additional recommendations found in the literature include educating trail users and land visitors of their impact on the environment, including wildlife, in order to help change recreation behavior or timing (Thomas and Reed 2019). Researchers have found signage and education were effective in decreasing off-trail behavior by 25% (Hockett et al. 2010). Increasing user knowledge is a key gap in addressing recreational impacts and improving their acceptance of management strategies (Thomas and Reed 2019). For example, in northwestern Washington, river recreationists demonstrated little support for recreation restrictions, ostensibly because they did not understand bald eagles were affected by their actions (Stalmaster and Kaiser 1998). If broader education efforts were made to ensure recreation users understood their potential environmental impacts, land managers may see greater public support for policies that modify or limit recreation, where it is needed. Engaging and utilizing the public for a citizen science monitoring approach may offer a long-term monitoring protocol for specific protected areas (Kays et al. 2017). Physical alterations to trails, such as re-routing trails around sensitive and high biodiversity areas or increasing trail vegetative cover are strategies noted to significantly decrease wildlife flushing response (Taylor and Knight 2003).

Managers should consider the effects on wildlife of unauthorized user-created trails, which often are created to enable more scenic views, more proximity to rivers, to avoid other users, or to create trails to

accommodate bathroom breaks (Wimpey and Marion 2011; D'Antonio et al. 2016; Van Winkle 2014), or in response to social media postings (Solomon 2017). Trail widening and the establishment of spur trails increases the size of ecological and wildlife impact areas and edge effects, increasing overall negative impacts on wildlife (Hennings 2017).

Understanding and modeling recreational impacts at a variety of scales may be beneficial to managers when considering proposals for continued recreation, or expansion. Establishing and maintaining adequate sampling strategies for monitoring visitation on both large and small scales, and tracking levels of recreation and impacts, can help develop standards for addressing recreation limits (Watson et al. 2000; D'Antonio et al. 2016; Thomas and Reed 2019). For example, researchers in Alaska used the Bayesian Network Model to examine potential impacts of human recreational activities on brown bears (Fortin et al. 2016). This model allows managers to test hypothetical management scenarios and estimate a percent change in the probability of nutritional intake, energetic costs, and bear survival relative to a specific form of recreation (Naidoo and Burton 2020). Similarly, Gutzwiller et al. (2017)

***From the literature*:** Frequently used management tools to reduce or avoid wildlife impacts from recreation

- Develop a solid baseline knowledge of recreational patterns, types, volumes and trends
- Conduct ongoing monitoring of recreation at frequent intervals and modeling of different recreation scenarios (a growing number of methods and models found in the literature presented here may provide more accurate, detailed and less cumbersome tools for use by land and wildlife managers)
- Target user behavior through outreach and education; improve user knowledge of their own impacts on the environment, including to wildlife
- Plan spatial distribution of recreation access points and trails; utilize geospatial analysis tools; make physical trail alterations to limit wildlife visibility
- Introduce spatial and temporal restrictions of recreation and recreation visitor numbers to avoid periods of highest wildlife sensitivity/vulnerability; consider development of "disturbance thresholds" based on visitor monitoring (Thomas & Reed 2019)
- Enforcement to monitor and minimize direct impacts to wildlife and habitat (e.g., enforce permitting conditions, parking, leash laws, camping rules, trail limits, unsanctioned trail making, etc.)
- Understand landscape *scale* when making management recommendations about an area. For example, trail configuration can affect large landscapes with dispersed activities, while smaller areas may be more influenced by proximity to urban development and heavy public access (Taylor & Knight 2003; Reed & Merenlender 2008).
- Use multiple management approaches (e.g., combine strategies of enforcement with user education, capacity limits, etc. for greater effectiveness)
- Analyze research and policy data gaps and inconsistencies due to multiple jurisdictions, and varying responsibilities and authorities

proposed a broad-scale spatial analysis model to demonstrate how metrics commonly measured by landscape ecologists quantify broad-scale patterns of recreation. Closer to home, the University of Washington recently began using social media as a source of data, or 'proxy', to evaluate visitor levels, distribution, behavior, and preferences on public parks and forest lands based on recreational users' postings to online platforms such as Twitter, Flickr and Instagram (Wood et al. 2020). The continued and further development of such models and tools may allow managers to predict how recreation disturbance can affect wildlife responses across larger areas, and contribute significantly to better informed decision-making on public lands.

> *"Given the limited capacity for enforcement of management policies, the most important decision a western land manager can make is whether or not to open a site for recreation in the first place."*
>
> *"….land managers report that it is much more challenging to change access or restrict use once a site has been opened."*
>
> *(Thomas and Reed 2019)*

Wisdom (2018) recommends land managers increase local area data collection, understand impacts to health of individuals within a population, and realize that *unseen* animals can still be negatively affected. As population and recreational demand continues to increase, Farrell and Marion (2002) suggest that land managers apply the concept of 'population carrying capacity of humans' in recreational settings. This refers to the amount of recreational users a trail or area can support beyond which excessive environmental and biological damage, social and managerial issues, or decreased visitor experience may occur. Such an approach would identify social and ecological thresholds to trigger specific management actions needed (Leung and Marion 1999; Thomas and Reed 2019). As an example in western Washington, Mount Rainier National Park recently announced that it will shift to a fully-online advance reservation and lottery system for backcountry hiking and camping in order to address the high demand and protect fragile natural resources (National Park Service 2021). Developing models, proposing spatial and temporal restrictions, and experimenting with additional management recommendations outlined in the literature will most often require a multi-agency approach and an adaptable management strategy.

Summary

As described by many of the research studies cited in this literature review, recreation and nature-based tourism on public lands impacts wildlife, and can be at odds with wildlife conservation objectives. Recreational activities can impact the range and health of wildlife species, degrade habitat, damage vegetative communities, and result in human presence and disturbance across seasons and throughout even the most remote areas of public lands and treaty areas. Increasing volumes of recreational users can be expected to exacerbate wildlife impacts by increasing the number of encounters and resulting disturbance, as well as the extent of wildlife habitat affected.

A growing body of research demonstrates that recreational activities, even quiet non-consumptive forms, have significant impacts to wildlife and biodiversity as a whole. From the literature reviewed, we know:

- Recreation affects wildlife *behaviorally, physiologically, and reproductively*
- The *spatial distribution* of recreation activities and infrastructure is an important determinant in type, degree and extent of direct and indirect impacts to wildlife and wildlife habitat.
- The *predictability* of recreation activities is an important factor in type, degree and extent of impacts to wildlife; in general, animals respond more strongly to less predictable patterns of recreation.
- Recreation *type* and *seasonality* influence the degree of wildlife disturbance
- As the *volume of recreational users* increases, so too does the frequency of interactions and disturbances to wildlife, and the overall impact of recreation on wildlife

With continued rapid population growth throughout the Puget Sound region, impacts from recreation are expected to increase. Tribes recognize the popularity of recreation here in the Pacific Northwest, its health and economic benefits, and its potential to inspire public support for land conservation. However, the *sheer volume* of recreational use in our region threatens to undermine efforts to sustain the health of these same natural areas that are so valued.

Tribes have repeatedly expressed to public land managers concerns over growing recreation and its negative and accumulating effects on wildlife, the environment, and on Tribes' ability to access and exercise treaty-reserved rights. With recreation as a major economic driver in our state, and with two thirds of those economic benefits reported to be derived from State and federal public lands and waters, tribes are also concerned about how recreation dollars may affect public lands management and policy choices in Washington.

As sovereign governments and natural resource co-managers with reserved rights over treaty resources, it is critical that treaty tribes are involved early in the planning, funding, and development of any new recreation opportunities or the expansion or 'improvement' of existing recreational infrastructure, as well as in the development of recreation policy and legislation. Tribes need to ensure that recreation impacts to natural resources, tribal interests and treaty rights are being evaluated holistically, addressing cumulative impacts across public lands and treaty areas on a landscape scale. In addition, Tribes may benefit from working with academic institutions and non-governmental organizations to address research gaps and to conduct needed environmental outreach and education.

Washington State and federal land managers must begin to assess the growing impacts associated with its recreation industry. Understanding and confronting the inherent conflicts between recreation and natural resource conservation, including wildlife, will be an important first step toward actions needed to protect biodiversity on public lands, and honoring obligations to treaty tribes.

Figure 1: Short term and long term effects to wildlife: individuals, populations, and communities (Knight and Gutzwiller 1995).

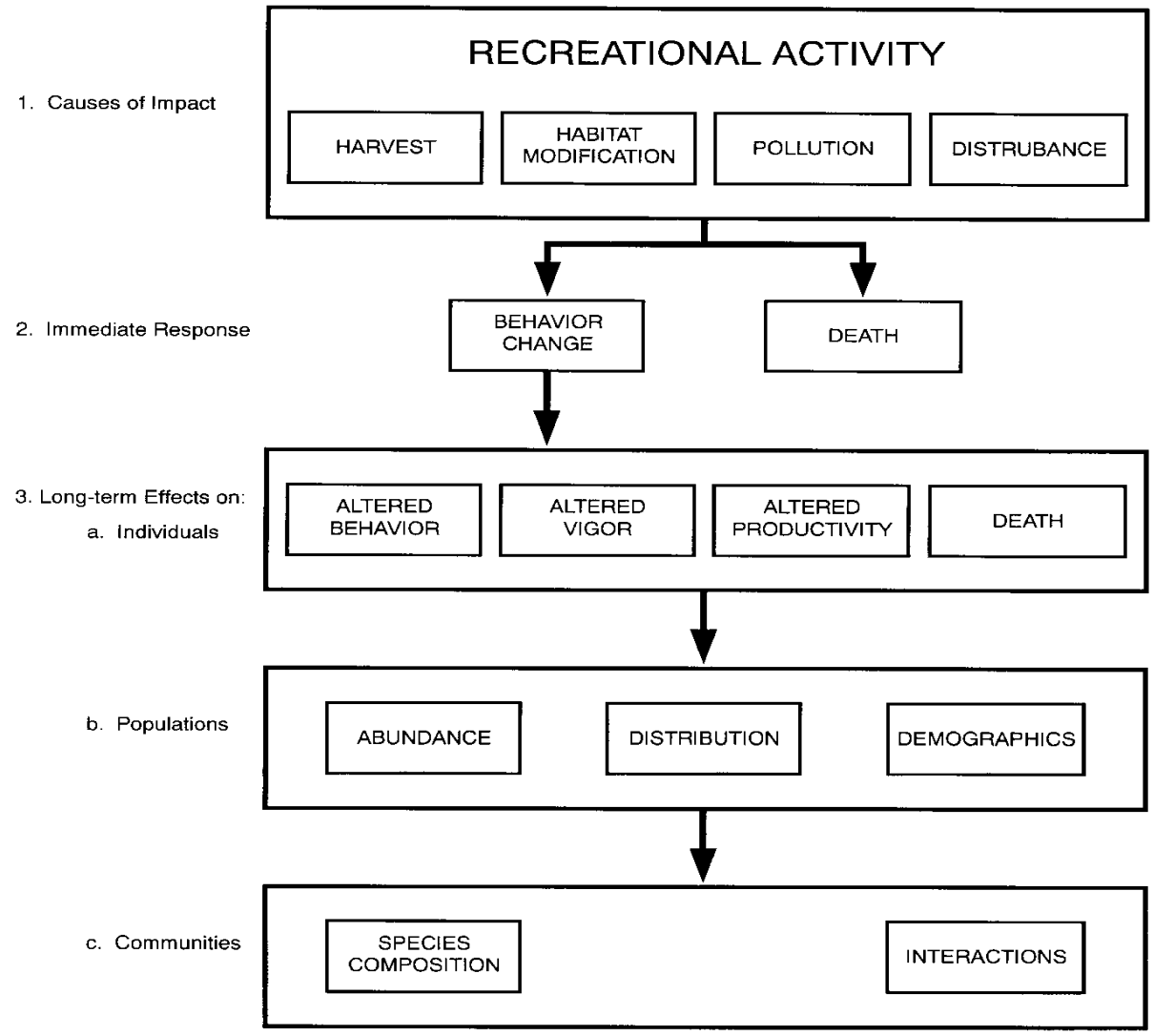


Table 1: Wildlife Distance Impacts for Deer, Bear, Elk and Mountain Goat

Species	Distance approach					Affected area in WA	Spatial Considerations	Literature
	Hiking	Biking	Skiing	ATV	Other			
Elk	276m[2]	286m[2]	650m[1]	311m[2]	240m Horse back riding[2]	Hiking - 3,554 mi[2]	~65m trail avoidance increase when recreations on trails compared to controls; Spatial avoidance to human is 3x as high when a person is present	[1]Cassirer et al. 1992; [2]Wisdom et al. 2018
Deer	46m[3] 200m off-trail[4]	NA	NA	NA	85m Hiking w/ dog	690mi[2]	High spatial influence when recreationists are off-trail	[3]Miller 2001 [4]Taylor 2003
Mt. Goat	100m strong reactions[5] 1 km alert, slowly moving away[6]	NA	Winter: complete avoidance, Summer: males 2x and females 9x less likely[6]	High Avoidance[7]	2km Helicopter[8]		Representing reactions rather than distances, larger effects to avoiding certain areas/zones than specific trails	[5]Pépin et al. 1996 [6]Richard and Coté 2016 [7]St-Louis et al. 2012 [8]Foster and Rahs 1983
Bear	100m hikers[9, 10, 11] 120m hiking trail in Spring 305m in Fall[10]	NA	Affects denning habitat[12]	NA	25m Hiking w/dog can cause den abandonment[12]		Bear encounters affect daily and long-term movement patterns, within **500m** of high use corridor, these areas had lowest probability of habitat selection and effects are seen **beyond 2km**[11,13] Spatially, denning occurs **1-2km** away from roads, trails etc. on mean slopes ranging from 30-50degrees, at altitudes 850-3000ft[12]	[9]Fortin et al. 2016 [10]Kasworm W.F and Manley, T.L. 1990 [11]Ordiz et al. 2013 [12]Linnell et al. 2000 [13]Costello et al. 2013

Bibliography

Attarian, A. and Keith, J. 2008. A Guide to Climbing Issues and the Production of a Climbing Management Plan. Access Fund, Boulder, CO.

Atickem, A. and Loe, L., Stenseth, N. 2014. Individual Herogeneity in use of human shields by mountain Nyala. International Journal of Behavioural Biology. Ethology V 120, 7:715-725. https://doi.org/10.1111/eth.12242

Balk, G. "Instagram Effect? Number of Seattle-area hikers has doubled in less than 10 years, Data Show". Seattle Times. April 2, 2018.

Balk, G. "The decade in demographics: Top 5 changes in the Seattle Area". Seattle Times. Dec. 30, 2019.

Balmford A, Green JMH, Anderson M, Beresford J, Huang C, Naidoo R, Walpole, M. and Manica, A. Walk on the Wild Side: Estimating the Global Magnitude of Visits to Protected Areas. PLOS Biol. 2015;13: e1002074 10.1371/journal.pbio.1002074

Bastone, Kelly, et al. "Are Trails in Colorado Harming Wildlife?" 5280, 26 July 2019, www.5280.com/2019/07/are-trails-in-colorado-harming-wildlife/.

Bateman, P, Fleming, P. 2017. "Are negative effects of tourist activities on wildlife over-reported? A review of assessment methods and empirical results". Biological Conservation 211:10-19.

Berns, G.N. and Simpson, S. 2009. "Outdoor Recreation Participation and Environmental Concern: A Research Summary". Journal of Experiential Education. vol. 32, 1: pp. 79-91. https://doi.org/10.1177/105382590903200107

Berger, Joel. 2007. Fear, human shields and the redistribution of prey and predators in protected areas. Biol. Lett. (2007) 3, 620–623. 10.1098/rsbl.2007.0415

Briceno, T., Schundler, G. 2015. Economic Analysis of Outdoor Recreation in Washington State. Earth Economics, Tacoma, WA.

Bowker, J.M., Askew, A.E., Cordell, H.K., Betz, C.J., Zarnoch, S.J., Seymour, L., 2012. Outdoor recreation participation in the United States – projections to 2060. U.S. Forest Service Gen. Tech. Rep. SRS-GTR-160, Asheville, NC, USA

Boyle, S.A. and F.B. Samson. 1985. Effects of non-consumptive recreation on wildlife: a review. Wildlife Society Bulletin 13:110-116.

Canfield, J. E., L. J. Lyon, J. M. Hillis, and M. J. Thompson. 1999. Ungulates. Pages 6.1-6.25 in G. Joslin and H. Youmans, coordinators. Effects of recreation on Rocky Mountain wildlife: A Review for Montana. Committee on Effects of Recreation on Wildlife, Montana Chapter of The Wildlife Society. 307pp.

Cassirer, E. F., D. J. Freddy, and E. D. Ables. 1992. Elk responses to disturbance by cross-country skiers in Yellowstone National Park. Wildlife Society Bulletin 20(4):375-381. \

Cessford, G. and Muhar A. 2003. Monitoring options for visitor numbers in national parks and natural areas. Journal for Nature Conservation. Volume 11, Issue 4, 2003, Pages 240-250. ISSN 1617-1381. https://doi.org/10.1078/1617-1381-00055.

Cerveny, Lee K.; Derrien, Monika M.; Miller, Anna B., eds. 2020. A research strategy for enhancing sustainable recreation and tourism on public lands. Gen. Tech. Rep. PNW-GTR-991. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 102 p.

Cole, D.N. 1995 Experimental trampling of vegetation: I. Relationship between trampling intensity and vegetation response J. Appl. Ecol. 32 203–14

Cole, David N.; Wright, Vita. 2003. Wilderness visitors and recreation impacts: baseline data available for twentieth century conditions. Gen. Tech. Rep. RMRS-GTR-117. Ogden, UT: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 52 pp.

Connelly, Joel. "A Population Explosion on Popular Trails: One More Impact of Growth." Seattlepi.com, Seattle Post-Intelligencer, 25 Sept. 2019. www.seattlepi.com/local/politics/article/A-population-explosion-on-popular-trails-One-14453808.php.

Cook, R.C., Cook, J.G., Vales, D.J., Johnson, B.K., Mccorquodale, S.M., Shipley, L.A., Riggs, R.A., Irwin, L.L., Murphie, S.L., Murphie, B.L., Schoenecker, K.A., Geyer, F., Hall, P.B., Spencer, R.D., Immell, D.A., Jackson, D.H., Tiller, B.L., Miller, P.J. and Schmitz, L. 2013. Regional and seasonal patterns of nutritional condition and reproduction in elk. Wild. Mon., 184: 1-45. https://doi.org/10.1002/wmon.1008

Coppes, J. Burghardt, F., Hagen, R., Suchant, R., and V. Braunisch. 2017. Human Recreation affects spatio-temporal habitat use patterns in red deer (Cervus elaphus). PLoS One. 2017; 12(5): e0175134. doi: 10.1371/journal.pone.0175134

Cordell HK. Outdoor recreation trends and futures [Internet]. Southern Research Station, Asheville, NC, USA: U.S. Department of Agriculture Forest Service; 2012.
Available: http://www.srs.fs.usda.gov/pubs/gtr/gtr_srs150.pdf

Costello, C., Cain, S., Nielson, R., Servheen, C. and C. Schwartz. 2013. Response of American black bears to the non-motorized expansion of a road corridor in Grand Teton National Park. Ursus. 24. 54-69. 10.2307/41932787.

Clarridge, Christine. "Overcrowding Forces Closure of Lake Cushman Access, Staircase Entrance to Olympic National Park." The Seattle Times, Aug. 21, 2020, www.seattletimes.com/seattle-news/citing-overcrowding-olympic-national-park-shuts-all-roads-to-lake-cushman-staircase-entrance/.

Creel S., J. E. Fox, A. Hardy, J. Sands, B. Garrott and R. O. Peterson. 2002. Snowmobile activity and glucocorticoid stress responses in wolves and elk. Conservation Biology 16(3): 809-814.

Czech, B., P. R. Krausman, and P. K. Devers. 2000. Economic associations among causes of species endangerment in the United States. BioScience 50:593–601.

D'Antonio, A., Monz, C., Larson, N., and A. Rohman. 2016. An application of recreation resource assessment techniques to inform management action in an urban-proximate natural area. Journal of Outdoor Recreation and Tourism. 2016. 14: p. 1221.

Delap, J. H. and Knight, R. L. 2004. Wildlife Response to Anthropogenic Food. Natural Areas Journal 24: 112-118.

Dunlap, R., and Heffernan, R, 1975. Outdoor Recreation and Environmental Concern: An Empirical Examination, Rural Sociology 40(1).

EcoNorthwest and University of Washington. 2019. "Economic, Environmental and Social Benefits of Recreational Trails in Washington State" for Washington State Recreation and Conservation Office.

Farrell, T.A. and J.L. Marion, 2002. The Protected Area Visitor Impact Management (PAVIM) Framework: A simplified process for making management decisions. Journal of Sustainable Tourism. 10(1): p. 3151.

Fortin JK, Rode KD, Hilderbrand GV, Wilder J, Farley S, Jorgensen C, and B. Marcot. 2016. Impacts of Human Recreation on Brown Bears (*Ursus arctos*): A Review and New Management Tool. PLoS ONE 11 (1): e0141983. doi:10.1371/journal.pone.0141983

Frame, Susannah. "Crowds Flock to Beaches, Hiking Trails despite Inslee's Plea to Stay Home." king5.Com, Mar. 23, 2020, www.king5.com/article/news/health/coronavirus/crowds-flock-to-beaches-and-hiking-trails-despite-plea-from-governor-to-stay-home/281-343a4436-8018-4028-9a9b-805f40ed60cd.

Fristrup, K. "Exploring the effects of aircraft noise on bioacoustic activity in national parks," National Park Service. Presentation to the 178th Meeting of the Acoustical Society of America, Dec. 4, 2019. San Diego, CA.

Frumkin, H., Bratman, G. N., Breslow, S. J., Cockran, B., Kahn, P. H., Lawler, J. Levin, P., Tandon, P., Varanasi, U., Wolf, K., and S. Wood. 2017. Nature contact and human health: A research agenda. Environmental Health Perspectives. doi:http://dx.doi.org/10.1289/EHP1663

Gaines, W.L., P.H. Singleton, and R.C. Ross, 2003. Assessing the cumulative effects of linear recreation routes on wildlife habitats on the Okanogan and Wenatchee National Forests. Portland, OR. p. 1-79.

Gaines, William L. 2003. Black Bear, Ursus americanus, denning chronology and den site selection in the northeastern Cascades of Washington. Canadian Field-Naturalist 117(4) 626-633

Gander, H., and P. Ingold. 1997. Reactions of male alpine chamois Rupicapra r. rupicapra to hikers, joggers, and mountainbikers. Biological Conservation 79:107–109.

Godwin, Mandy. "National Forest Trailheads Close after 'Stay-at-Home' Prompts Rush to the Outdoors." Crosscut, Apr. 1, 2020, crosscut.com/2020/04/national-forest-trailheads-close-after-stay-home-prompts-rush-outdoors.

Goodland, Marianne. Colorado Gov. John Hickenlooper Celebrates Economic Impact of Outdoor Recreation. June 18, 2020, gazette.com/news/colorado-gov-john-hickenlooper-celebrates-economic-impact-of-outdoor-recreation/article_eda3a0fc-d967-11e8-8779-e38513991cc7.html.

Goodrich, John M. and Berger, Joel. 1993. Winter Recreation and Hibernating Black Bears Ursus americanus. Biological Conservation 67: 105-110.

Gore, M.L., Knuth, B.A., Curtis, P.D. & Shanahan, J.E. 2006. Education programs for reducing American black bear-human conflict: indicators of success? Ursus, 17, 75-80.

Gutzwiller, K. J., D'Antonio, A.L., and Monz, C. A. 2017. Wildland recreation disturbance: broad-scale spatial analysis and management. Front Ecol Environ 2017; 15(9): 517–524, doi: 10.1002/fee.1631.

Hall, Troy E.; Heaton, Heather; Kruger, Linda E. 2009. Outdoor recreation in the Pacific Northwest and Alaska: trends in activity participation. Gen. Tech. Rep. PNW-GTR-778. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 108 p.

Hammitt, William E., Cole, D.N. 1998. Wildland Recreation: Ecology and Management, 2nd Edition. ISBN: 978-0-471-19461-3. 376 pp.

Hamr, J. 1988. Disturbance behavior of chamois in an alpine tourist area of Austria. Mountain Research and Development 8:65–73.

Hennings, Lori. 2017. Hiking, mountain biking and equestrian use in natural areas: A recreation ecology literature review. Oregon Metro Parks and Nature Report.

Hockett, K., Clark, Y. Leung, J. Marion, Par, L. 2010. Deterring off-trail hiking in protected natural areas: Evaluating options with surveys and unobtrusive observation. Final Management Report. Department of Forest Resources & Environmental Conservation, Virginia Polytechnic Institute and State University: Blacksburg, VA.

John D. C. Linnell, Swenson, J., Andersen, R., & Barnes, B. 2000. How Vulnerable Are Denning Bears to Disturbance? Wildlife Society Bulletin (1973-2006), 28(2), 400-413. Retrieved January 16, 2020, from www.jstor.org/stable/3783698

Kantor, S. Wisdom, M. and Johnson, B. 2019. Seeking Ground Less Traveled: Elk Responses to Recreation. Science Findings 219. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 5 p.

Kays, R., Parsons, A.W., Baker, M.C., Kalies, E.L., Forrester, T., Costello, R., Rota, C.T., Millspaugh, J.J. and McShea, W.J. 2017. Does hunting or hiking affect wildlife communities in protected areas?. J Appl Ecol, 54: 242-252. https://doi.org/10.1111/1365-2664.12700

Knight, R.L. 1988. Effects of supplemental food on the breeding biology of the black-billed magpie. Condor 90:956-958.

Knight, R.L. and D.N. Cole. Effects of recreational activity on wildlife in wildlands. 1992. In Transactions of the 56th North American Wildlife and Natural Resources Conference

Knight, R.L. and D.N. Cole. 1995. Wildlife responses to recreationists, in Wildlife and Recreationists: Coexistence through Management and Research, R.L.G. Knight, Gutzwiller, K.J., Editors. Island Press: Washington, D.C. p. 51-70.

Knight, Richard L, and Kevin J. Gutzwiller. 1995. Wildlife and Recreationists: Coexistence through Management and Research. Washington, D.C: Island Press.

Larson, C., Reed, S., Merenlender, A., Crooks, K. 2016. "Effects of Recreation on Animals Revealed as Widespread through a Global Systematic Review." PloS one vol. 11,12 e0167259

Larson, C., Reed, S., Merenlender, A., Crooks, K. 2018. Accessibility drives species exposure to recreation in a fragmented urban reserve network. Landscape and Urban Planning. Volume 175, 2018, Pages 62-71. ISSN 0169-2046. https://doi.org/10.1016/j.landurbplan.2018.03.009.

Larson CL, Reed SE, Merenlender AM, Crooks KR. A meta-analysis of recreation effects on vertebrate species richness and abundance. Conservation Science and Practice. 2019; 1:e93. https://doi.org/10.1111/csp2.93

Lenth, B. and Knight, R. 2008. The effects of dogs on wildlife communities. Natural Areas Journal 28: 218-227.

Leung, Y.-F. and J.L. Marion. Recreation impacts and management in wilderness: A state-of-knowledge review. 1999. U.S.D.A. Forest Service

Light, J. T. Jr., and R. Weaver. 1973. Report on bighorn sheep habitat study in the area for which an application was made to expand the Mt. Baldy winter sports facility. U.S. Forest Service, San Bernardino National Forest, California, USA.

Losos, E., J. Hayes, A. Phillips, D. Wilcove, and C. Alkire. 1995. Taxpayer-subsidized resource extraction harms species. BioScience 45:446–455.

Lloyd, Sarah Anne. “Trailhead Direct Performance Shows Demand for Transit to Trails.” Curbed Seattle Curbed Seattle, 30 Oct. 2019, seattle.curbed.com/2019/10/30/20940218/seattle-hiking-trail-shuttle-bus-ridership.

Macdonald, S. and Hellmund, P.C. 1998. Planning Trails with Wildlife in Mind. Trails and Wildlife Task Force, Colorado State Parks, and Hellmund Associates. Report. https://www.recpro.org/assets/Library/Trails/trails-for-wildlife-handbk.pdf

Mapes, Lynda V. “Recreation Becomes 'Wreckreation' as Careless Outdoor Adventures Turn Destructive, Spark Wildfires.” The Seattle Times, Sept. 10, 2020, www.seattletimes.com/seattle-news/environment/recreation-becomes-wreckreation-as-careless-outdoor-adventures-turn-destructive-spark-wildfires/.

Miller, A.B., King, D., Rowland, M., Chapman, J., Tomosy, M., Liang, C., Abelson, E.S., Truex, R. 2020. Sustaining wildlife with recreation on public lands: a synthesis of research findings, management practices, and research needs. Gen. Tech. Rep. PNW-GTR-993. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 226 p.

Miller, S. G., R. L. Knight, and C. K. Miller. 2001. Wildlife responses to pedestrians and dogs. Wildlife Society Bulletin 29:124–132.

Mojica, J., Fletcher, A., 2020. Economic Analysis of Outdoor Recreation in Washington State, 2020 Update. Earth Economics. Tacoma, WA.

Monz, C., Cole, D.N., Leung, Yu-Fai, and J. Marion. 2010. Sustaining Visitor Use in Protected Areas: Future Opportunities in Recreation Ecology Research Based on the USA Experience. Journal of Environmental Management, Vol 45.

Monz, C. and Yu-Fai Leung. 2006. 44. Monz, C.A. and Y-F. Leung. 2006. Meaningful measures: Visitor impact monitoring and the NPS I&M program. George Wright Forum. 23 (2) 17-27.

Nabhan, G. P., ed. 2002. Safeguarding the Uniqueness of the Colorado Plateau: An Ecoregional Assessment of Biocultural Diversity. Center for Sustainable Environments, Northern Arizona University, Flagstaff, AZ.

National Park Service. News Release: *Mount Rainier Summer 2021 Wilderness and Climbing Reservations Available Online Through Recreation.gov*. Contact: Dan van der Elst. Date: February 17, 2021. https://www.nps.gov/mora/learn/news/2021-wilderness-permit-reservations.htm

National Park Service. News Release: *National Park System Sees More Than 330 Million Visits*. February 28, 2018. https://www.nps.gov/orgs/1207/02-28-2018-visitation-certified.htm

Pepin, D., Lamerenx, F., Chadeland, H., Recarte, H.M. 1996. Human-related disturbance risk and distance to cover affect use of montane pasture by Pyrenean chamois. Applied Animal Behaviour Science 46(3):217-228. DOI: 10.1016/0168-1591(95)00661-3

Perrins, S., and G. Bratman. 2019. Health Benefits of Nature Contact, A Literature Review. University of Washington, College of Forest Resources, prepared for the Washington State Recreation and Conservation Office.

Peterson, Christine. "Americans' Love of Hiking Has Driven Elk to the Brink, Scientists Say." The Guardian, Guardian News and Media, Aug. 25, 2019, www.theguardian.com/environment/2019/aug/25/hiking-elk-driven-to-brink-colorado-vail.

Petyon, B. Servheen, C., Herrero, S. 1999. An Overview of Bear Conservation Planning and Implementation. Bears IUCN Action Plan. Chapter 2. http://wildpro.twycrosszoo.org/000ADOBES/Bears/Bears_IUCN_ActionPlan/bearsAP_chapter2.pdf

Rice, C.G. and Gay, D. 2010. Don Gay "Effects of Mountain Goat Harvest on Historic and Contemporary Populations," Northwestern Naturalist 91(1), 40-57, (1 March 2010). https://doi.org/10.1898/NWN08-47.1

Richard, J.H and CÔTÉ, S.D. 2016. Space Use Analyses Suggest Avoidance of a Ski Area by Mountain Goats. The Journal of Wildlife Management, Vol. 80, No. 3 (April 2016), pp. 387-395. https://www.jstor.org/stable/24764970

Ricketts, T. H., E. Dinerstein, D. Molson, and C. Loucks. 1999. Who's where in North America. BioScience 49: 369-381.

Riddle, A. A. 2019. The Outdoor Recreation Economy (pp. 1-20, Rep. No. R45978). Washington, D.C.: Congressional Research Service. https://fas.org/sgp/crs/misc/R45978.pdf

Schoen, J. 1990. Bear Habitat Management: A Review and Future Perspective. Bears: Their Biology and Management, 8, 143-154. doi:10.2307/3872914

Scruggs, Gregory. Overcrowding, No Parking, LONG Waits: Western Washington's Snow Accessibility Issues Were Exposed in THIS COVID-19 Winter. Feb. 19, 2021.

www.seattletimes.com/life/outdoors/overcrowding-no-parking-long-waits-western-washingtons-snow-accessibility-issues-were-exposed-in-this-covid-19-winter/.

Sekercioglu, Cagan. 2002. Impacts of birdwatching on human and avian communities. Environmental Conservation. 29. 282-289. 10.1017/S0376892902000206.

Selin, Steven; Cerveny, Lee K.; Blahna, Dale J.; Miller, Anna B., eds. 2020. Igniting research for outdoor recreation: linking science, policy, and action. Gen. Tech. Rep. PNW-GTR-987. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 257 pp.

Schultz, R.D.; Bailey, J.A. 1978. Responses of national park elk to human activity. Journal of Wildlife Management. 42(1): 91–100

Simmonds, C., McGivney, A., Reilly, P., Maffly, B., Wilkinson, T., Canon, G., Wright, M., and Whaley, M. "Crisis In Our National Parks: How Tourists Are Loving Nature to Death" The Guardian, November 20, 2018.

Sisk, T. D. 2002. Eliciting perceptions of biocultural diversity on the Colorado Plateau: a methodology for defining threats and response options. Pp. 13-26 in Nabhan, G.P., ed. Safeguarding the Uniqueness of the Colorado Plateau: An Ecoregional Assessment of Biocultural Diversity. Center for Sustainable Environments, Northern Arizona University, Flagstaff, AZ.

Smith, Tom S., Oyster, J., Partridge, S.D, Martin I., and A. Sisson 2012. "Assessing American black bear response to human activity at Kenai Fjords National Park, Alaska," Ursus 23(2), 179-191, (1 November 2012). https://doi.org/10.2192/URSUS-D-11-00020.1

Snetsinger, S.D. and K. White. 2009. Recreation and Trail Impacts on Wildlife Species of Interest in Mount Spokane State Park. Pacific Biodiversity Institute, Winthrop, Washington. 60 p.
Spies, T.A., B.C. McComb, R.S.H. Kennedy, M.T. McGrath, K. Olsen, and R.J. Pabst. 2007a. Potential effects of forest policies on terrestrial biodiversity in a multi-ownership province. Ecological Applications 17:48-65.

Solomon, C. "Is Instagram Ruining the Great Outdoors?" Outside Magazine, March 29, 2017.

Spies, T.A., K.N. Johnson, K.M. Burnett, J.L. Ohmann, B.C. McComb, G.H. Reeves, P. Bettinger, J.D. Kline, B. Garber-Yonts. 2007b. Cumulative ecological and socioeconomic effects of forest policies in coastal Oregon. Ecological Applications 17: 5-17.

Stalmaster, M. V., and J. L. Kaiser. 1998. Effects of recreational activity on wintering bald eagles. Wildlife Monographs 137.

Stankowich, T. and D.T. Blumstein, 2005. Fear in animals: A meta-analysis and review of risk assessment. Proceedings of the Royal Society of Biological Sciences. 272(1581): p. 2627-2634.

Stankowich, T. 2008. Ungulate flight responses to human disturbance: A review and metaanalysis. Biological Conservation 141: 2159-2173.

Stanfield, B.J., J.C. Bliss, and T.A. Spies. 2002. Land ownerships and landscape structure: a spatial analysis of sixty-six Oregon (USA) Coast Range watersheds. Landscape Ecology 17: 685-697.

Stein, B. A., L. S. Kutner, and J. S. Adams, eds. 2000. Precious Heritage: The Status of Biodiversity in the United States. New York, NY: Oxford University Press.

Sterl, P., C. Brandenburg, and A. Arnberger. 2008. Visitors' awareness and assessment of recreational disturbance of wildlife in the Donau-Auen National Park. Journal for Nature Conservation. 16: p. 135-145.

Steven, R. and Castley J.G., 2013. Tourism as a threat to critically endangered and endangered birds: global patterns and trends in conservation hotspots Biodiversity Conservation 22 1063

Stevens, L. E., and G.P. Nabhan. 2002. Biodiversity: Plant and animal endemism, biotic associations and unique habitat mosaics in living landscapes. Pp. 41-48 in Nabhan, G.P., ed. Safeguarding the Uniqueness of the Colorado Plateau: An Ecoregional Assessment of Biocultural Diversity. Center for Sustainable Environments, Northern Arizona University, Flagstaff, AZ.

St-Louis, A., Hamel, S., Mainguy, J., Cote, S.D. 2013. Factors Influencing the Reaction of Mountain Goats Towards All-Terrain Vehicles. The Journal of Wildlife Management 77(3):599—605; 2013; DOI: 10.1002/jwmg.488

Switalski, A. 2018. Off-highway vehicle recreation in drylands: a literature review and recommendations for best management practices. Journal of Outdoor Recreation and Tourism. 21: 87–96.

Taylor, A. R. and Knight, R.L. 2003. Wildlife responses to recreation and associated visitor perceptions. Ecological Applications, 13(4), pp. 951–963.

Thomas, S.L and S.E. Reed 2019. Entrenched ties between outdoor recreation and conservation pose challenges for sustainable land management Environ. Research Letters, Vol. 14 Number 11.

U.S. Bureau of Economic Analysis, “Outdoor Recreation Satellite Account, U.S. and States, 2019”, News Release, November 10, 2020, https://www.bea.gov/news/2020/outdoor-recreation-satellite-account-us-and-states-2019

Van der Merwe, Jh and U. Joubert, 2014. Managing environmental impact of bouldering as a niche outdoor-climbing activity. South African Journal for Research in Sport, Physical Education and Recreation 36(1):229-251

Van Winkle, J., 2014. Informal trails and the spread of invasive species in urban natural areas: Spatial analysis of informal trails and their effects on understory plan communities in Forest Park, Portland, Oregon. Portland State University: Portland, OR.

Walls, M.A.,2018. “The Outdoor Recreation Economy and Public Lands” . Resources Magazine, Sept. 25, 2018. https://www.resourcesmag.org/archives/the-outdoor-recreation-economy-and-public-lands/

Watson, A., Cole, D., Turner, D., Reynolds, P., 2000. Wilderness recreation use estimation: A handbook of methods and systems. General Technical Report RMRS-GTR-56. U.S.D.A. Forest Service, Rocky Mountain Research Station: Ogden, UT.

White, Eric M. Bowker, J.M., Askew, Ashley E., Langner, Linda L., Arnold, J. Ross, English, Donald B.K. 2016. Federal outdoor recreation trends: effects on economic opportunities. Gen. Tech. Rep. PNW-GTR-945. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Station. 46 p.

Wilkinson, C. The Salmon People, Judge Boldt, and the Rule of Law, Experience, Winter 2006, at 35, available at http://scholar.law.colorado.edu/articles/463/.

Wilson, S. and D. M. Shackleton. 2001. Backcountry Recreation and Mountain Goats: A Proposed Research and Adaptive Management Plan. B.C. Minist. Environ., Lands and Parks, Wildl. Branch, Victoria, BC. Wildl. Bull. No. B-103. 27pp

Wisdom, M. J., A. A. Ager, H. K. Preisler, N. J. Cimon, and B. K. Johnson. 2004. Effects of off-road recreation on mule deer and elk. Transactions of the North American Wildlife and Natural Resource Conference 69: 531–550.

Wisdom, M. J., Preisler, H., Naylor,L., and Anthony, G. 2018. Elk responses to trail-based recreation on public forests. Forest Ecology and Management, ISSN: 0378-1127,Vol: 411, Page:223-233.

Withrow, Brandon. "Birding (Yes, Birding) Is a Multi-Billion Dollar Ecotourism Industry." The Daily Beast. January 18, 2019. Online. https://www.thedailybeast.com/birding-yes-birding-is-a-multi-billion-dollar-ecotourism-industry

Wolfenden, A. D., Slabbekoorn, H., Kluk, K., & de Kort, S. R. 2019. Aircraft sound exposure leads to song frequency decline and elevated aggression in wild chiffchaffs. Journal of Animal Ecology, 88(11), 1720–1731. doi:10.1111/1365-2656.13059

Wood, S. A., Winder, S. G., Lia, E. H., White, E. M., Crowley, C. S. L., & Milnor, A. A. 2020. Next-generation visitation models using social media to estimate recreation on public lands .Scientific Reports , 10 (1), 15419.

Wright, Lisa. 2017. The Outdoor Recreation Economy. Boulder, CO: Outdoor Industry Association, https://outdoorindustry.org/wp-content/uploads/2017/04/OIA_RecEconomy_FINAL_Single.pdf

Appendix 1: Future Research Questions

Quantifying recreational impacts to wildlife is an under-examined researched field, which proves challenging when making policy or technical changes to local Western Washington landscapes. However, with a growing population in Western Washington, addressing research gaps may provide beneficial opportunities for Treaty Tribes, State and Federal Agencies, Universities, and other land managers to collaborate and investigate.

1. Understand recreation types, users, trends, and activities
    - 1.1. What are the most common types of recreational uses? What are the most common types of recreational uses by season?
        - 1.1.1. How do people recreate within a given area?
        - 1.1.2. How is yearly recreation divided by activity (%)? How are activities combined?
        - 1.1.3. Where are the most common recreation areas by activity type?
    - 1.2. What are the demographics of recreational use now? Previously? By recreation activity type?
        - 1.2.1. Where are recreation users in coming from? How many people recreating are from out of state? Out of the country? What % from Seattle metropolitan area?
        - 1.2.2. How many people (total) recreate yearly or by season within a given area?
        - 1.2.3. For recreation users camping, how long is the average number of nights? Is it at an organized campground or dispersed?
        - 1.2.4. What is the most common group size of recreational users? What is the range of group size?
    - 1.3. What do we know about recreation levels ten years ago, twenty years ago, etc.? How are trends changing annually or across seasons?
        - 1.3.1. Where do people recreate? Where are most common areas by season (i.e. month)?
        - 1.3.2. What is the frequency of users on a given trail?
        - 1.3.3. What is the average duration of recreation activities?
    - 1.4. Are there areas that are clearly showing signs of overuse as of today? What are the signs?
    - 1.5. Can we develop recreation thresholds for a specific area or species?

2. Understand existing spatial information
    - 2.1. How can human population trends and distribution data be used to determine changes in recreation levels? How are these changes potentially impacting specific species or habitat areas?
    - 2.2. Are their federally endangered, listed, or culturally important species within an area?
    - 2.3. How many miles of road or trails are within a given area?
    - 2.4. How many acres of critical habitat, such as for Northern spotted owl, are within a given area? How many miles of roads and trails intersect critical habitat?
    - 2.5. Are there important habitat corridors within a given area?
    - 2.6. What are land management restrictions on a given area, such as Wilderness designations or other classifications that limit the ability to manipulate or change the landscape?

3. Understanding recreation legislation, policy, and funding nationally and in Washington State, and differences in goals and objectives and regulations of different land-managing agencies.

4. Engage and collaborate with existing partners and data
    4.1. Who are the existing researchers within Washington State and beyond that are knowledgeable on this issue?
    4.2. How can existing universities and research programs, such as the Washington Cooperative Fish and Wildlife Research Unit or the Outdoor Recreation and Data Lab, be leveraged to better understand impacts?
    4.3. How can regional non-governmental recreation and conservation organizations (NGOs) help to augment recreation data collection and education to their memberships to address recreational growth and its environmental impacts?
    4.4. How best can we use existing datasets, such as Instagram®, Flicker®, and Strava®, for better real- time user information (Wood et al. 2020)?
    4.5. How can we utilize existing tribal and non-tribal wildlife data from deployed tracking collars to answer questions about how specific species react to changes in recreation?

5. Understanding local impacts specifically to tribes
    5.1. Understanding how crowds are potentially affecting tribal hunting access and opportunities by overlying harvest data with recreational information.
    5.2. Developing a record of tribal impacts: Can hunters and other tribal members be interviewed to document and understand localized impacts to wildlife to see where problem areas can be addressed?
    5.3. How can tribes engage more directly in recreation legislation, policy, planning, funding and research, and at all levels of decision-making with State and Federal elected leaders as well as land managers and planners?