THE POTENTIAL FOR CAPITOL STATE FOREST AS A WILDLIFE CORRIDOR BETWEEN THE WILLAPA HILLS, OLYMPIC PENINSULA AND CASCADE MOUNTAIN RANGE,

AND HOW IT CAN BE STRENGTHENED.

by

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ABSTRACT

The potential for Capitol State Forest as a wildlife corridor between Willapa Hills, Olympic Peninsula and Cascade Mountain Range and how it can be strengthened

Vanessa Lyn LaValle

This pilot study of Capitol State Forest's potential for habitat connectivity monitored 10 camera traps over a three-month period within Legacy Forest parcels. WSDOT data shows a statistically significant number of wildlife vehicle collisions in the area surrounding Capitol State Forest which covers over 100,000 acres of mixed topographical forested and riparian habitat and is bordered by State Highway 8 to the north and State Highway 12 to the south and west, and Interstate 5 lies around 10 miles to the east. This initial study captured more images of people than wildlife, which shows a human interest in mature forests. Further study is merited to understand how resident and transient wildlife populations might be utilizing Legacy Forest parcels or more broadly Capitol State Forest and potential benefits for humans.

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Introduction

Washington has long prided itself on its iconic image of beautiful landscapes dotted with magnificent species. Nicknamed the Evergreen State, Washington manages wildlife species including elk, deer, bears, wolves, coyotes, fishers, beavers, pika, eagles, owls, marbled murrelets, many fish and a multitude of pollinator insects through the Department of Fish and Wildlife and their habitats through the Department of Natural Resources (WA - DNR, 2024; WDFW, 2024). Federal and State Habitat Management programs attempt to provide for such requirements (WA - DNR, 1997).

In 1933, when the Federal government granted Washington statehood that came with forested lands to produce ongoing revenue for the public good, a small portion of these lands would later become Capitol State Forest (DNR, 2024). While various timber interests boomed and busted, more land was added to this initial territory eventually creating the boundaries of Capitol State Forest as they are known today (Felt, 1975). The various cycles of timber harvest in Capitol State Forest have provided opportunities for scientists to study patterns of disturbance and regrowth (Kennedy et al., 2012). Although used for timber by white settlers, local indigenous groups such as the Chehalis and Nisqually peoples utilized this area since time immemorial for foraging and hunting (Markham, 1998; Felt, 1975).

The term ‘Legacy Forest’ is not an official definition but is understood as forest regenerated naturally after harvest and typically the harvest was before the 1940s. Before the 1940s, logging equipment was less heavy and destructive on soil than our current earth-moving equipment (Duffy et al., 2020). The soil compaction that comes with today’s heavy equipment damages the soil, inhibiting natural regeneration due to crushing out oxygen and important microbial life essential to soil and forest health (Cambi et al., 2015). Selective logging practices such as thinning and utilizing animal labor have shown better outcomes in post-harvest, forest-soil health (Chen et al., 2021; Eroğlu, 2016). A recent judgment found that logging these parcels was unnecessary for their purpose "to be used for the public good" to be fulfilled (Conservation Northwest, 2020). Citizens, environmental advocates, and groups such as the Center for Sustainable Economy, Center for Responsible Forestry and Legacy Forest Defense Coalition are calling for a halt to logging of these valuable forests which we need for carbon sequestration and safeguarding biodiversity (Talberth, 2024; Karpilow, 2024;).

In June 2023, in King County Superior Court, DNR was criticized for trying to circumvent climate impacts of logging Legacy Forests by saying their overall agency land holdings absorb more carbon than release – which is a violation of State Environmental Policy Act (SEPA) (Talbert, 2024). A temporary injunction was granted in 2024 by Jefferson County judge in response to a different lawsuit brought by Legacy Forest Defense Coalition over the Last Crocker Legacy Forest, where data showed from DNR's Public Disclosure Office that they are not meeting their own goal to preserve 15% of the forests under its management (Karpilow, 2024). At the direction of the legislature, DNR has agreed to convene a "carbon and forest working management group" created of stakeholders and appointed by DNR; however, they are not bound to follow this body's recommendations (DNR, 2024). Advocacy groups such as Legacy Forest Defense Council and Center for Responsible Forestry advocate for mature forest preservation and for DNR to utilize the budgetary funds that will be available in the Natural Climate Solutions Act to purchase these parcels for preservation and value their ecosystem services such as carbon sequestration, land stabilization, preserving watersheds and soils while regulating climate (Daily, 1997; Talberth, 2024; Wohlleben, 2023).

The potential movement of both plants and animals between natural areas is often referred to as connectivity (sometimes 'landscape connectivity' or 'habitat connectivity') and is an important aspect of biodiversity preservation (Beckman et. al, 2010). Preserving potential corridors for species movement now will increase the possibility of future species preservation (Schloss et al., 2022; Roe, 2019). Promoting connectivity to enhance populations' health is important and many scholars are looking ahead to how climate change will reshape the habits of wildlife (Haight & Hammill, 2020; Morelli et al., 2020; Stewart, 2020).

Wildlife needs a variety of habitats for their specific purposes (nursing young, foraging grounds etc.) within a larger range to maintain optimum health; these habitats need to remain connected or uninterrupted to promote movement, migration, and healthy genetic populations (Beckman et. al, 2010, Quammen, 2014). Wildlife and their predator/prey relationships typically maintain balance within habitats (Dorst, 1991). Wildlife select habitat based on a variety of factors and their interaction with their habitat results in beneficial "ecosystem services" (Morrison, Daily, 1997). Ecosystem services describe the functions performed in nature that are essential to sustaining human life that produce "ecosystem goods" such as clean air, water, timber, pollination of food crops, and biodiversity maintenance (Daily, 1997).

Our understanding of how roads impact wildlife and habitats, primarily through creating pollution, roadkill, and interrupting migration routes, has deepened recently through 'road ecology' (Goldfarb, 2023). In cases where connections between habitats are broken by human infrastructure such as roads, they can be healed through various interventions called wildlife corridors and/or crossings (Beckman et. al, 2010, Bennett, 2003).

Crossings are a diverse set of interventions meant to make passage possible for species to bypass human infrastructure including culverts, fish passages or highway overpasses while a corridor emphasizes a path of connectivity (Goldfarb, 2023). Current projects to preserve remaining wildlife populations emphasize natural land preservation and restoring connectivity between existing natural areas (Bennett, 2003). Conservation Northwest (CNW) is a nonprofit in Washington State that seeks to improve and expand habitat connectivity from the coast of Western Washington to the Rockies by improving permeability across roads, preserving land and reconnecting land fragments (Stewart and Swedeen, 2022). Conservation Northwest is currently performing a feasibility study along Interstate 5 by monitoring remote cameras on a privately owned property in South Thurston County in an area with naturalness where wildlife-vehicle collisions have indicated there is wildlife traffic.

Camera trapping is the use of capturing images remotely with game cameras (also known as trail or wildlife cameras) to understand wildlife presence and behavior (Fisher, 2023). With the development of inexpensive consumer models and a need for wildlife monitoring, the field of camera trapping is rapidly growing in users with its many applications such as estimating presence, population density, diet, and changes over time (Burton et al., 2015; Ridout & Linkie, 2009). For my thesis, I placed 10 camera traps in 6 Legacy Forest parcels in Capitol State Forest from January 2024 to March 31, 2024.

Chapter 1. Literature Review

Introduction

Capitol State Forest (near the State's capitol of Olympia, Washington) is a working forest, a state-managed source of timber that also hosts recreational opportunities with features for campers, hikers, equestrians, mountain bikes and on off-road vehicles (Deal & White, 2005; DNR, 2024). For the scope of this project, I am focusing on six Legacy Forest Parcels within the 100,000 acres of Capitol State Forest which is under a habitat management plan with the Washington State Department of Natural Resources (WA-DNR) that was completed in 1997 (WA-DNR,1997). I chose Legacy Forest sites I could easily access for camera placement because of their structural complexity. I installed 10 game cameras across 6 Legacy Forest parcels within Capitol State Forest hoping for wildlife observations.

Legacy Forest parcels are understood as forests that naturally regenerated and typically were logged prior to World War II before the heaviest machinery and most aggressive logging practices such as clear cutting and stumping were introduced. A relationship has been shown between harvest technique and post-harvest soil health such as stand conditions, microbial community, yard logistics and the road network within the forest (Cambi et al., 2015; Chen et al., 2021; Eroğlu, 2016; Picchio et al., 2020). The extractive technology utilized has an impact on soil's chemical, biological and physical features which has serious implications for forest regeneration and health (Cambi et al., 2015; Eroğlu, 2016; Picchio et al., 2020). Clear-cutting and heavy-equipment, ground-based mechanized extraction has increased negative effects on soil while using traditional animal-power showed the lowest impact (Picchio et. al, 2020; Chen et al., 2021; Rähn et al., 2023)

Mature, naturally regenerated forests tend to be a structurally complex mix of species, with rich understory layers, complex canopies, and high carbon storage (Anderson-Teixeira et al., 2021; Chaudhary et al., 2016; Kennedy et al., 2012; Ozanne et al., 2003; Zhou et al., 2022). The last remaining in Thurston County and are slated to be harvested by 2026 (DNR, 2024). Some Legacy Forests parcels are conservatively estimated to be 70-80 years old and if left to further mature would eventually fall under protected old-growth status (Duffy et al., 2022; DNR, 2024). Research has shown older, mature forests are more resistant to wildfire (USFS, 2024). Many species value mature forested habitats and protecting these spaces safeguards biodiversity (Oktavia & Jin, 2019; Brandt et al., 2014; Liu et al., 2023; Roe, 2019; Ozanne et al., 2003). We, as people, need the trees in these forests to continue to store carbon (Anderson-Teixeira et al., 2021; DNR, 2024). Logging not only ends tree's ability to store new carbon but disturbs the soil which releases additional stored carbon, becoming vulnerable to invasive non-native species (Wohlleben & Billinghurst, 2023; Chen et al., 2021).

Roadmap

First, we explore habitats and then connectivity so we can understand the potential functions Capitol State Forest could be playing in the Cascades to Olympics wildlife corridor. Further, we will consider an example of a large-scale wildlife crossing on I-90 and discuss modeling connectivity corridors. Then we cover how climate change is influencing habitats, animal movements and requirements. Lastly, we will review wildlife monitoring and camera trapping studies with contemporary methods and strengths in the field.

Understanding Habitats

Today Capitol State Forest covers an area of just over 100,000 acres and is nestled in between the Chehalis River Basin, the Olympics, and Cascades Mountain ranges (“Capitol State

Forest," 2023). Mature forested parcels exhibit Big leaf maples, Douglas fir, Red alder and Western red cedar trees cross over several watersheds in mixed-elevation forest with an understory layer of vascular and non-vascular native plants such as ferns, Indian plum, salal, and lichens (Brandt et al., 2014). The canopy layer of the mature forest hosts specialized invertebrates and birds and may play a larger role than previously understood in carbon storage (Perry et al., 2018; Ozanne et al., 2003). It is known that there are resident populations of mammals, birds, reptiles and amphibians, fish and invertebrates including a resident Roosevelt Elk herd through citizen science crowd-sourced apps like eBird and iNaturalist and monitoring by WDFW (WDFW, 2024). Within the Eld inlet watershed, McLane Creek hosts several species of salmonids that return annually to spawn (Thurston Conservation District, 2016). The Federal and State Endangered Species Act includes Oregon Spotted Frog and Marbled Murrelets both of which are present within Capitol State Forest's boundaries and should be provided for within DNR's 1997 "Habitat Conservation Plan" (DNR, 1997; USFW, 1973).

Wildlife, like people, need a variety of habitats across time for their species-specific purposes (nursing young, foraging grounds etc.) within a larger range to maintain optimum health; these habitats need to remain connected or uninterrupted to promote movement, migration and healthy genetic populations (Morrison et al., 2006; Beckman et. al, 2010; Quammen, 2014). Wildlife and their predator/prey relationships typically maintain balance within habitats (Dorst, 1991, Morrison et al., 2006).

Habitat conservation is one method for species management; however, setting aside land is only one component in preservation (WA-DNR, 1997). Spurred by the Endangered Species Act, many States created habitat conservation plans (HCP) in the 1990s; Washington State's was finalized in 1997. At the time there was an outcry of scientists warning that not enough scientific input was used and little was being done to protect suitable habitat for targeted species (Kaiser, 1997). Many scientists had not reached agreement on the best methods for species recovery or reached agreement on assessing recovery making HCPs meaningless (Kaiser, 1997). Kaiser argues that habitat conservation plans tended to benefit developers more than the habitat it was intended to protect. What makes a habitat healthy, functioning, and attractive to diverse species must also be considered for successful conservation; for example, to host enough biodiversity to maintain healthy populations, habitats must be of a certain size with connections to other types of habitats for seasonal or migratory uses (Soukup et al., 2022; Morrison et al., 2006). Private land ownership is often a barrier to providing interconnected habitat types large enough to create suitable ranges for many species (Kaiser, 1997). This creates a unique opportunity when discussing conservation within Capitol State Forest as it is still contiguous DNR land. Preserving potential corridors for species movement now will increase the possibility of future species preservation, genetic diversity, continued ecosystem services and climate resilience (Schloss et al., 2022; Haight & Hammill, 2020). Lastly, anthropogenic land use changes have increased the rate of infectious diseases; habitat conservation can have positive outcomes for nearby human populations such as reducing zoonotic diseases and improving cardiovascular health (Karjalainen et al., 2010; Kilpatrick et al., 2017).

Understanding Habitat Connectivity

Understanding the size and scope of habitat needs for various species is critical for creating corridors that are fully functional (Hof & Flather, 1996; Lehmkuhl et al., 1999). By focusing on experimental projects with habitat improvement in Australia, Bennett (2003) found that linkages have many advantages such as improving movement throughout a species lifecycle; increasing species diversity; providing habitat and restoring ecosystem services. If conserved lands are isolated without connectivity to other habitats, they become islands where species may go locally extinct (Quammen, 2014; MacArthur and Wilson, 1967). This unintended consequence of protecting and setting some land aside can be remedied by reconnecting habitats with linkages, crossings, or wildlife corridors (Bennett, 2003). There are several nonprofits that support crucial crossings and corridor work within the study area of this project such as The Nature Conservancy, Conservation Northwest and subsequent work groups brought together by multi-agency partnerships such as the Cascades to Coast Landscape Collaborative and Washington Wildlife Habitat Connectivity Group (WHCWG, 2010).

There are critics of connectivity, including an early one focused on the Florida panther that highlighted the high cost of building and maintaining corridors and planning for connectivity with no promise of panther population stability (Simberloff & Cox, 1987). However, thoughtful responses were published the same year such as the contention of Noss (1987) that all original habitats had connectivity; and when used as one strategy within a larger framework, corridors are cost-effective and beneficial. Contemporary scientific thought has shifted to supporting connectivity, although there is not a true census; projects are expensive, time and resource intensive and may not always deliver on its promises in a world changed by climate extremes (Bélisle, 2005; Costanza et al., 2020; Green & Sandbrook, 2021).

Road Ecology

In “Crossings”, Goldfarb introduces the reader to road ecology, a field that has grown with the number of roads. Throughout this book, there are examples of how roads are changing and reshaping wildlife behavior in California, Tasmania, and Washington State. Research shows that understanding species-habitat relationships improves the design, construction, and utilization of crossings and/or corridors (Goldfarb, 2023).

A successful example of a recently constructed, science-led crossing highlighted in Goldfarb's book is at Snoqualmie Pass between Hyak and Easton, on the I-90 interstate. Conservation Northwest, in partnership with the United States Forest Service, WSDOT, USDOT, and many others completed the first two phases of the I-90 Snoqualmie Pass East in 2019 which involved reworking highway bridges to allow for underpasses at Gold Creek, adding additional lanes for traffic and a wildlife overpass at Hyak (Giles et al., 2010). Beyond connectivity, this project was driven by safety concerns for drivers; reducing wildlife vehicle collisions and improving avalanche flow around the roadway (Conservation Northwest, 2022). Once the initial construction phase was complete, crews installed native plants, streambeds, false snags and other flora to improve wildlife use (Giles et al., 2010). WSDOT wildlife cameras have captured its entire target species utilizing this complex within the first two years (Conservation Northwest, 2022). Phases 3 and 4 will continue to combine installing underpasses, culverts and overcrossings to cater to the variety of target species buoyed by a coalition of supporters from WSDOT, Central Washington University, Washington Department of Fish and Wildlife, US Forest Service and Conservation Northwest among others (WSDOT, 2023). This data-driven, coalition-built project provides a model for reintroducing connectivity into even the busiest transportation corridors.

Stewart prepared a report for Conservation Northwest that outlines specific tasks within the Interstate 5 corridor that could improve connectivity. His passage assessment system evaluates based on guild structure like that used by WWHCWG but expanded from the five of WWHCWG into eight: Cover obligates; openness obligates; semi-aquatic obligates; medium structure generalists; large structure generalists; Specialists conditional; specialist arboreal; specialist aerial (Stewart, 2020).

Modeling Connectivity

The Cascades to the Olympics geographic area within Washington State encompasses several habitat types and a diverse array of wildlife species (Johnson & O'Neill, 2001). From alpine peaks and subalpine meadows to temperate rainforests and rocky shorelines, each habitat hosts species that fulfill crucial niches and provide ecosystem services to the region (Soukup et al., 2022).

In 2019, Brian Stewart, the program manager for Conservation Northwest's Cascades to Olympics program, completed his Master's in Environmental Studies thesis at The Evergreen State College: "*Assessing the permeability of large underpasses and viaducts on Interstate 5 in Southwest Washington State for local wildlife, with an emphasis on ungulates"*. Stewart presented a "passage assessment system (PAS)" to survey viaducts and underpasses for their structures' permeability and potential effectiveness as habitat corridors considering species characteristics. Further this system can rank structures and recommend potential improvements to enhance wildlife movement through the Interstate 5 corridor (Stewart, 2019). The wildlife-vehicle collision data from WSDOT shows that wildlife crossings and fencing reduce wildlife-vehicle collisions (Stewart, 2019). Stewart's thesis led to his report, "Recommendations for Improving and Maintaining Habitat Connectivity Over/Under I-5 in Southwest Washington" published online by Conservation Northwest in 2020. This work is ongoing, five sites have been assessed along the I-5 corridor and an ongoing feasibility study continues (Swedeen et al., 2020).

Habitat connectivity projects are increasingly being implemented and studied globally. Five projects across several countries UK, Sweden, Canada, and Spain were assessed in one case study by Patterson et al. (2023). Shared challenges were found to be a lack of resources; guidance; requirements; "knowledgeable practitioners" and understanding of connectivity's importance within a landscape-scale vision highlighting the global need for growth and further advancement in this field with a critical need for inclusivity – of governments, practitioners, and willing community partners to truly advance connectivity (Patterson et al., 2023). The processes of connectivity projects are often long, expensive and there are no universal metrics for success which can make a project difficult to evaluate, particularly for the average taxpayer (Patterson et al., 2023; Keeley et al., 2018).

Here in Washington State, there is the Washington Wildlife Habitat Connectivity Group comprised of representatives from state and federal agencies such as DNR, WDFW, WSDOT, USDFW, USFS and USDA Forest Service as well as groups like Conservation Northwest, Washington Conservation Science Institute, Climate Impacts Group, SAH Ecologia and the Conservation Biology Institute. WWHCG is currently finalizing a report that chose 5 focal species to model connectivity around species guild habitat preferences: Cougar (generalist); Western Gray Squirrel (grassland, prairie and oak woodland habitats); Mountain beaver (early-stage Coastal forests), Pacific Fisher (late state coastal forests); and American beaver (riparian and wetland habitats) (WWHCG, 2022). This group's report utilizes habitat concentration areas in combination with cost-weighted surfaces to identify least cost pathways and associated linkages (WWHCG, 2022). The synthesis of their analysis shows that Capitol State Forest has high potential and may already be serving as a habitat corridor from Cascades to Olympics for many species but requires improved connectivity to become fully realized (WWHCG, 2022).

The interplay of connectivity and climate change

As anthropogenic-induced climate change increases the likelihood of droughts, mega-fires, extreme temperatures and floods, species ranges and temporal variation will be impacted (Bachelet et al., 2011; Fontaine et al., 2009). The unpredictability of exactly how and when climate crisis events unfold makes it difficult to plan, budget and implement in advance

(Littlefield et al., 2019; Vos et al., 2008). Connectivity is believed to be crucial for the survival of migratory species to move freely as needed; for example, low altitude to high altitude or corridors along waterways (Patterson et al., 2023). However, species range shifts are already occurring at a rate faster than expected and are assisted where altitude range shifts enable species to escape increasing temperatures (Chen et al., 2011). Heller & Zavaleta (2009) reviewed 22 years of biodiversity management recommendations and found 4 key themes: need for regional reserve management and planning for biodiversity; promoting resilience; considering climate change from the beginning; and include socio-cultural responses. Research into biodiversity management has recommended increasing landscape connectivity as a form of protecting biodiversity by identifying “resilient sites” that can become refugia for wildlife while another is reconnecting fragmented habitats (Haight & Hammill, 2020; Morelli et al., 2020).

At every stage of management, there are difficulties from site assessment and invasive species management to administrative capacity and financial longevity; meanwhile climate change’s unpredictability hampers long-range planning efforts (Haight & Hammill, 2020; Heller & Zavaleta, 2009; Schloss et al., 2022) Functionally modeling connectivity between present range and potential future ranges by examining climate analogs, which are topographically connected areas where the future climate will be more similar to current climate, has been found beneficial in California where geophysical features are found to play an important role in species movement in crisis and over time (Schloss et al., 2022).

Recent studies in how climatic shifts will impact the Cascades to Olympics region discuss increasing wildfire, decreasing snowpack, temperature variations, and changes to stream flow which in turn will shift wildlife behavior and threaten crucial habitats for species such as salmon, pollinators, and frogs (Halofsky et al., 2020; Bachelet et al., 2011; Bond et al., 2015).

State and Federal forests in the Pacific Northwest vary in topography, tree composition and habitat types ranging from dry to moist and will be impacted differently by climate change (Gaines et al., 2022). In 1994, a shift to restoring habitats and preserving biodiversity occurred in the federal forestry management practices; however, a renewed update is required to reflect the dynamic realities of climate change beyond reducing wildfire fuel including prioritizing landscape-scale preservation and resiliency (Gaines et al., 2022; Barrows et al., 2020; Weiskopf et al., 2020).

Wildlife monitoring

Innovative technologies and methods are improving the capacity for wildlife, habitat and biodiversity monitoring such as Geographic Information Systems (GIS), Light detection and Ranging (LiDAR), Radio Detection and Ranging (RADAR), and remote wildlife cameras and unmanned aerial vehicles (UAV or drones; Kerry et al., 2022). These methods provide insights into habitat sizes, habitat characteristics and changes in flora and fauna abundance across large spatial scales. Camera trap units are increasing in popularity and provide a low-impact way to monitor or assess wildlife in a variety of environments (Wearn & Glover-Kapfer, 2019; Burton et al., 2015). Combined with GIS, and sometimes even drone imagery, these images can be used to create visualizations of complex spatial-temporal relationships of species and habitat (Fisher, 2023; Robinson et al., 2022).

In a review of camera trap literature, Cole et al. (2013) found that remote sensing cameras increase the availability of data and the need for thorough protocols, data management and sampling designs. The value of camera trap data is called into question without transparency into methods, assumptions, and study design available for review (Burton et al., 2015). Newey et. al (2015) found that there are a wide variety of practical problems inherent in camera trap studies throughout study duration and the higher quality camera and casing will have a higher price associated. Although the most camera models deployed in the case studies examined were low-cost, the benefits of a higher-grade professional model can be beneficial over a study's lifetime (Newey et al., 2015). By pairing GPS-collar sampling (which works at an individual level) with camera traps (which work at a population level) one study found general agreement between the two methodologies (Wearn & Glover-Kapfer, 2019). These and other studies conclude that individual-based sampling methods are good at estimating overall population patterns but less successful at describing relationships between habitat and wildlife (Bassing et al., 2023; Burton et al., 2015; Neilson et al., 2018; Saunders et al., 2023; Tanwar et al., 2021).

Analyzing Camera Trap Data

Camera traps are used to assess species presence and abundance in a variety of habitat types; camera placement design strongly influences number of captures (Fisher, 2023; Ridout & Linkie, 2009) By placing camera traps in two groups (random or data-informed trail camera positions), both camera groups detected similar species richness but at different rates with the data-informed group resulting in higher number of captures (Tanwar et al., 2021; Fonteyn et al., 2021). Attractants and/or scent lures can be used near camera traps, but they can also decrease overall effectiveness while hair snags can be incorporated for mammals (Monterroso et al., 2014; Wearn & Glover-Kapfer, 2019).

Camera traps yield data about time, location and frequency that can be used to perform statistical analysis such as occupancy modeling, relative abundance, and density (Hepler et al., 2018; Rovero et al., 2013). Accurate wildlife assessment has always been a challenge which explains the enthusiasm for camera traps despite issues such as imperfect detection and placement bias (Burton et al., 2015; Kolowski & Forrester, 2017). With the large-scale level of biodiversity monitoring required globally, many studies support increasing the scale of use with camera traps and involving more community science volunteers (Fisher, 2023; Wearn & Glover-Kapfer, 2019).

Conclusion

Capitol State Forest has a long history as a working forest and a limited supply of mature growth remaining. With increasing global scientific focus on promoting habitat connectivity for biodiversity preservation and climate change preparation, now is the time to understand our local mature forest's role as a wildlife corridor within the larger Pacific Northwest landscape. In addition to potentially functioning as biodiversity refugia, these mature forests have real value to our community for their carbon storage, climate regulation, recreation, and public health benefits. Hopefully, this area can avoid further fragmentation and receive inclusive crossing structures to improve any corridor function it might perform now or in the future. Habitat for linkages and corridors within Capitol State Forest can be preserved, such as Legacy Forest Parcels, before development driven by population increases and land use shifts shatter these crucial connections.

Chapter 2. Methods

Introduction

This thesis topic originated when I was introduced to the concept of road ecology and the recently completed I-90 wildlife overpass in the book, “Crossings” by Ben Goldfarb (2023). Listening to the audio book on my way to class, a female elk leaped across Delphi Road in front of my car. The synchronicity made me decide to pick this topic, which had local and personal significance.

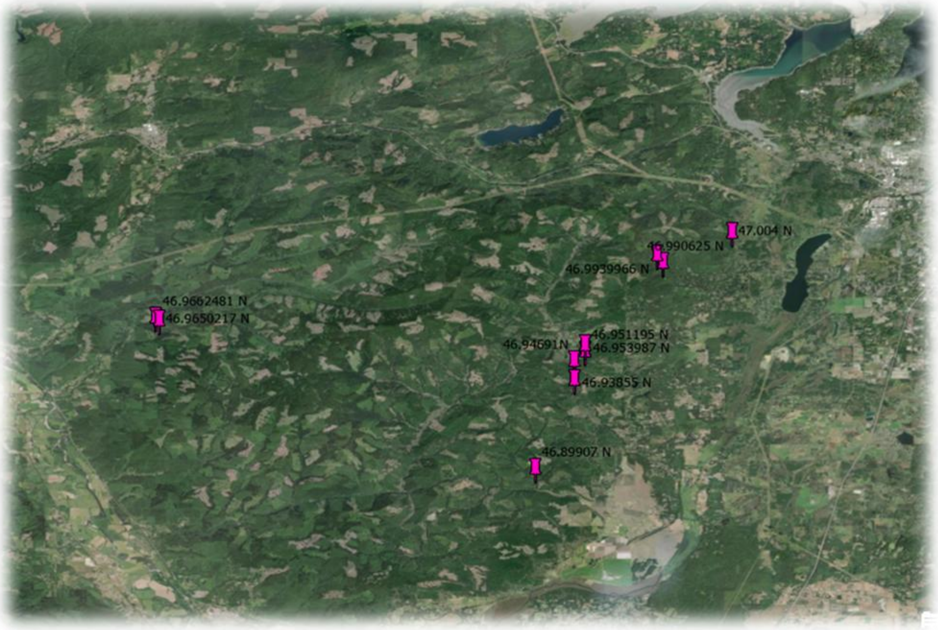
While learning more through online research about the I-90 wildlife crossing, Conservation Northwest emerged as the leader of the multi-agency project. Within their website, I saw they have additional campaigns, such as planning crossings over I-5 to assist in the Cascades to Olympics corridor. The idea of working on crossings and corridors in my region was exciting and I reached out to the Conservation Northwest coordinator for the Cascades to Olympics program, Brian Stewart (MES ’21). He stated that they have WSDOT wildlife vehicle collision data to assess where crossings should be installed but do not have any forest monitors for the Capitol State Forest area. I volunteered to install 10 wildlife cameras in Capitol State Forest.

Study design

Capitol State Forest covers over 100,000 acres of mixed topographical forested and riparian habitat. I found helpful studies on the variety of options for camera trap placement and read the Conservation Northwest Wildlife Monitoring protocol and watched their training videos. I wanted to find a focus within these larger areas for camera placement and found a previous graduate project of creating an Esri Field Map for “Visiting a Legacy Forest” and decided to utilize this app/map and Legacy Forests as the sites for camera trapping. I chose sites that were accessible for continued monitoring and obtained a Land Use License from DNR South Puget Sound regional office.

Figure 1

Camera Trap Locations



Note. Landsat image from Esri with geolocated points for camera traps added by author in ArcGIS pro.

Cameras were placed north-facing on trees about 2-3 feet from the base across 6 areas within Capitol State Forest:

1. Camera 1: “Class Dismissed” timber sale; facing north towards a seasonal spring and “Leave Tree” near the top of a high ridgeline. Model used: MiniTrail Cam noglow 940 NM by Outdoor Expert
2. Camera 2: “Class Dismissed” timber sale; 1km further up former Brown Road logging extension. This parcel is bordered by residential area to the south and logged recreational areas to the north. Model used: MiniTrail Cam noglow 940 NM by Outdoor Expert
3. Camera 3: “Bears” timber sale; 300 yards past the viewing platform bridge in McLane creek. North facing at wash on game trail. Model used: Bushnell Trophy Cam HD

Figure 2

Pileated Woodpecker near Camera Trap 3

Note. Image taken by author on Nikon DSLR in McLane Creek area.

4. Cameras 4: “Class Dismissed unit 2”; Off Sherman Valley Road turnout, where game trail meets mountain biking trail in SW corner. Model used: WoSports MiniTrail Camera G100

Figure 3

Tree along the trail to Camera Trap 4

Note. Image taken by the author on Nikon DSLR.

Figure 4

Mountain and/or dirt bike trails near Camera Trap 4

Note. Image taken by author on Nikon DSLR.

5. Camera 5: “Class Dismissed unit 2”; Off Sherman Valley Road turnout in NE corner off trail 30 feet near creek. Model used: WoSports MiniTrail Camera G100
6. Camera 6: “Sparrowhawk”; off trail near Triangle pit. Model used: WoSports MiniTrail Camera G100

Figure 5

Positive detection of deer from Camera Trap 6

Note. Camera Trap image captured by author with Camera Trap 6.

7. Camera 7: “Sparrowhawk”; off Waddell creek basin trail down the trail Waddell Creek campground, parallel to Waddell Creek. Model used: WoSports MiniTrail Camera G100

Figure 6

Positive detection of human from Camera Trap 7

Note. Image captured by author's Camera Trap 7.

8. Camera 8: "Juneau"; Left side of trail by fallen tree facing narrow game/hiking trail. Model used: HCO ScoutGuard SG560C

Figure 7

Trail to Camera Trap 8

Note. Image taken by author with Nikon DSLR.

9. Camera 9: "Twisted Tops". Followed a deer trail from parking pull-out to grove with zombie stumps and deer carcass. Model used: WoSports MiniTrail Camera G100

Figure 8

Deer carcasss remains by Camera Trap 9

Note. Image taken by author with Android cellphone during camera trap installation.

Figure 9

Scat by Camera Trap 9

Note. Image taken by author with Android cellphone during camera trap installation.

Figure 10

Zombie Stump near Camera Trap 9

Note. Image taken by author with Android cellphone during camera trap 9 installation.

10. Camera 10: “Twisted Tops” On opposite side of road from camera 10, followed game trail to grove of cedars. Camera parallel to game trail where it intersects with another. Model used: WoSports MiniTrail Camera G100

Figure 11

Panorama of Camera Trap 10 site

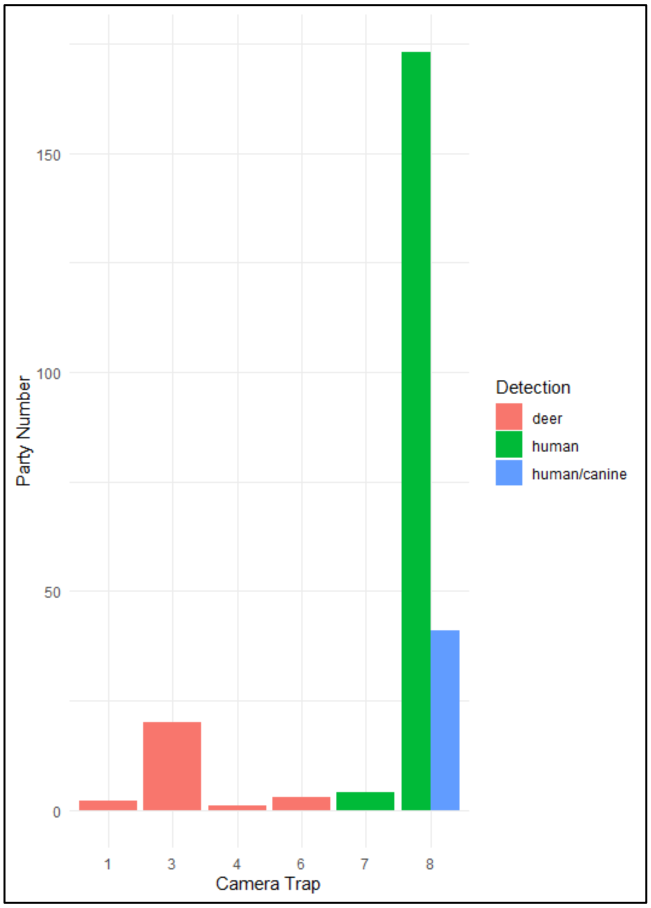
Note. Image taken by author with Android cellphone during camera trap installation.

Chapter 3. Results and Discussion

This is a pilot study of Capitol State Forest and for the scope of this thesis we will review recommendations for future study design. Capitol State Forest is home to a variety of wildlife as evidenced by WDFW data and citizen science apps such as eBird and iNaturalist. My cameras captured 600 images, mostly false triggers, resulting in 130 positive detections across all sites resulting in many people, their dogs, and deer. Many of the people were in parties of 2 or more and often with dogs.

Figure 12

Positive detection results from camera traps



Note. There were no positive detections of species, only false triggers at Cameras 2, 5, 9 and 10.

Overall, camera traps captured more images of people than wildlife. Camera site 8, in the planned timber sale of “Juneau” had the highest number of detections. The northern portion of “Sparrowhawk” where cameras 6 and 7 were placed and “Class Dismissed” where Cameras 1, 2, 4 and 5 sit are heavily trafficked by mountain bikers - evident by tread prints and constructed features along trails. All these sites could be considered for State Trust Land Transfer process whereas parcels are preserved for recreation purposes; these sites already have recreation users and accessible parking which could account for the higher number of human detections.

The detections in sequence highlight the shortcomings of working with camera traps. People with visible, uniquely identifying clothing were detected walking up the trail but often not captured returning; especially larger parties with small children or dogs. It is not to be assumed that people are overnight camping or leaving their children and dogs out in the forest, but rather the camera was less consistent with capturing downhill approaches due to lighting, angle, foliage, and timing speed. However, they needed to be visited and maintained less often than I anticipated, which highlights the strengths of camera trap studies. There was plenty of room on the SD cards and battery life for the observation window.

Future research could focus on the people rather than wildlife. Why are so many people visiting these sites over others? Since people tend to visit in groups, is it a social activity? What value are they gaining from visiting these specific mature forests over other green space options within Thurston County? Could there be measurable benefits to human visitors? Due to the high number of dogs at Juneau and its creek-side terrain, could this be a potential site for pet waste education? By conducting surveys of visitors before and after forest visits, what could be learned? Camera traps could be installed to track visitor information such as party number, time, and length of visit to give a more complete picture of how these areas are used for recreation.

Site Selection

Road conditions varied and were not well-represented on maps. Many portions of Capitol State Forest are inaccessible to visitors due to safety concerns, even with a completed Land Use License. Large areas are inaccessible due to private land buffer, lack of roads or closed gates. With advance private landowner permission/access or utilizing an off-road vehicle, areas deeper within the core of the park could be accessed for wildlife monitoring.

This was my first time working with game cameras and installing them for wildlife observation. I tried to place cameras alongside game trails; however, they can be difficult to differentiate from human paths and are limited to wildlife use by seasonality. If animal tracks and droppings were observed, I had high confidence in the game trail; however, that did not always result in successful detections. If this study were to be continued, placing two cameras at the same spot, different heights and facing different angles could improve detection totals and allow for capture-recapture analysis. I installed all cameras facing north to avoid the sun’s glare; however, in areas with intact canopy cover it would not be an issue and optimum view should be prioritized over north-facing.

I did not trim the surrounding flora which would have reduced the number of false triggers and improved detection view because it also increased the visibility of the camera installations. I was concerned about the possibility of theft or vandalism due to the high volume of traffic in Capitol State Forest. If placing cameras deeper into the park, foliage trimming could occur without overexposing the camera site; however, the further into the park cameras are placed the more difficult they are to reliably access for battery and SD card changing. The cameras installed all had python brand locks, but with the cameras smaller size, it was easy to remove SD cards without disturbing the locks. Smaller size locks could be used on the higher-end camera models to prevent SD card theft.

There is an elevated level of disturbance in Capitol State Forest due to logging and recreational activities. The limited number of detections is consistent with CNW's habitat connectivity model. The areas I could consistently access for this project were closer to roads, campgrounds, residential and hunting areas and thus less likely to present wildlife population abundance. If attempted again using cameras in more remote areas and monitoring them with less frequency could be an option or working with private landowners to install cameras on their property. Installing cameras in both Legacy Forest parcels and replanted timber stands might yield interesting results to add to this discussion. Another study could place game camera traps within recently logged areas, to learn about wildlife movement post-logging operations. Cameras in areas that have been recently logged would have less false triggers as the understory is often decimated post-harvest and capture fewer human detections.

Camera Models

Theft was a concern in this pilot study so low-end consumer models were used but may have limited successful captures due to decreased lens sensitivity and timing mechanisms. The two sites where high-end cameras I had borrowed from TESC's Science Support Center were used had more detections and captured video which gives an expanded time-based view of wildlife-habitat interactions. This could be due to increased sensitivity to movement with better lenses, enhanced lighting, and better camera placement. None of my cameras were vandalized, damaged or stolen so perhaps theft is not as likely as initially thought.

Observation Window

Having a longer observation window could improve both the number of detections and number of species represented due to the seasonal relationship wildlife has with their associated habitats. If cameras were placed for a year of observation, it would improve the window but create potential risks of theft, camera dysfunction and seasonal vegetation overgrowth. Temperature variations impacted one of the game cameras with heavy lens fogging obscuring view but that was limited to a period where the weather was extremely cold.

Conclusion

Capitol State Forest has viable habitat options for various wildlife within its boundaries and some evidence of wildlife populations. Currently Interstate 5 and State highways 8 and 12 represent major barriers for wildlife movement. Improving connectivity and preserving a wildlife corridor within Capitol State Forest would result in many benefits for a variety of wildlife, both resident and transient, including improved health and genetic diversity. Habitat integrity, species guild needs, and climate change awareness should be considered when selecting sites. A wildlife corridor could be achieved by focusing on connecting existing spaces with high habitat integrity in conjunction with improving permeability along Interstate 5, State highways 8 and 12.

It is significant that so many images were captured of people, particularly given that winter is not considered peak outdoor recreation season and there are no public transit options. Juneau, Sparrowhawk and Class Dismissed all parcels would be ideal for the State Trust Land Transfer process to be preserved for recreation. Regional interest has been building support for connectivity projects with the multi-agency Washington Wildlife Habitat Connectivity Working Group final report pending publication.

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