ROOSEVELT ELK HABITAT ASSESSMENT IN THE SKOKOMISH GAME MANAGEMENT UNIT

by

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ABSTRACT

Roosevelt Elk Habitat Assessment in the Skokomish Game Management Unit

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The Skokomish Game Management Unit (GMU) is located on the southeast side of the Olympic Peninsula and has been designated by Washington State for the purpose of managing harvest and wildlife populations. The population of Roosevelt elk within the Skokomish GMU has shown signs of decline over the past 30-40 years, likely caused by land management changes, over-harvest, human development, and forestry practices. Since 2008, the Skokomish Tribe's Department of Natural Resources has been conducting an elk monitoring project collaring cow elk within the Skokomish GMU to collect population and mortality data. This thesis builds on that existing monitoring project to analyze the current status of elk herds in the GMU and to determine the annual home range and habitat availability for two herds: the South Fork and Beeville herds.

Ground and aerial surveys were conducted in 2010 to derive counts of population size and composition ratios of marked elk herds. Bull/cow and calf/cow ratios were at acceptable levels to allow for population growth. The study herds' populations show a slight increase in numbers compared to 2008 estimates. A home range analysis was conducted using Hawth's Tool to derive Kernel density estimates of 95%, 90%, and 50% for the study herds in the GMU. Over one year, the South Fork herd used an area of approximately 75 square kilometers and the Beeville herd used an area of approximately 67 square kilometers. A vegetation analysis within the two herds' home ranges identified forage availability associated with seven sampled habitat types. There was a high presence of forage species in the sampled plots within the study herds' home ranges. The most frequent grass forage species found was *Poa Pratensis* and the most common shrub species was *Mahonia nervosa.* The most common forage forbs species found was *Oxalis oregana* and the most common fern species was *Blechnum spicant.* Private agricultural fields were important to both study herds' winter home ranges. Wetlands and riparian areas were vital habitat within the herds' year-round home ranges.

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INTRODUCTION

This study was conducted within the Skokomish Game Management Unit (GMU) 636 in the range of Skokomish Tribe's ceded lands. The analysis of the general status and trend of elk and herd management in the Skokomish GMU was completed through the use of interviews, previous studies, harvest reports, and population and composition analysis. A further study was conducted on two southeast elk herds in the unit using home range analysis and vegetation surveys to assess habitat use and forage availability.

Major depletions in elk herds over the last 30-40 years, in the Skokomish ceded areas, have occurred mostly because of human disturbance factors. The Skokomish GMU has been heavily logged for many decades, which has severely changed the dynamic and complexity of the habitat. The original logging activity in the area opened up areas for foraging and created a boom in elk numbers by the 1970s (WDFW 2005). Burning practices in clear-cuts allowed for recycled nutrients and increased forage species (WDFW 2005). Currently, forestry practices in the area have created more even-aged mid-seral tree stands that offer the least valuable habitat for elk and herbicide spraying has been more commonly used, limiting forage species growth.

This thesis analyzes the types of habitats most used by the two study herds and the forage present in seven common Roosevelt elk habitat available in the Skokomish GMU. Also, data collected from the Skokomish Department of Natural Resources (DNR) Elk Monitoring Project was used to determine population size, composition, and home range of two elk herds in GMU 636. This thesis will add to the limited research about elk in GMU 636 and can benefit the Skokomish Department of Natural Resource's Wildlife Program, Washington Department of Fish and Wildlife (WDFW), Northwest Indian Fisheries Commission (NWIFC), the United States Forest Service (USFS), The Evergreen State College, and other interested parties. This is an interdisciplinary study using aspects of biological science, cultural studies, natural resource management, wildlife management, wildlife ecology, wildlife tracking, forestry, and geographical information systems. Both qualitative and quantitative assessments are used to analyze the status of elk and their habitat in the Skokomish GMU. Lastly, a large variety of research and previous studies were used to complete this study.

Chapter 1 covers historical information about Roosevelt elk herds on the Olympic Peninsula, about the Skokomish Tribe's ceded lands, about the location and management of the traditional Skokomish lands and the Skokomish GMU, and about historical management of elk in the study area. Chapter 1 describes the background information and studies used as the basis for analysis of the general status of the Skokomish herd, including an interview with the Skokomish Tribe's hunting committee members. Information derived from previous research and ecological literature helped to determine variables other than habitat that could be affecting population growth and helped create the habitat assessment described in Chapter 2. Chapter 2 explains the habitat assessment of the sampled study area and study herds. This chapter covers the Skokomish Elk Monitoring Project, methods used for the study, population results for the whole GMU 636 and composition ratios for the two study herds, and home range and vegetation analysis of the habitat use and forage availability for the two southeast elk herds. Chapter 3 concludes the thesis with a discussion about management practices that could improve the future population growth of the study herds, future research that would be valuable to elk management in the area, and with a final discussion and assessment of the study's findings.

CHAPTER 1
HISTORY AND BACKGROUND

HISTORICAL ROOSEVELT ELK POPULATIONS

Elk or *Cervus elaphus* have reportedly existed in Washington for at least 10,000 years (McCorquodale 1985; Harpole and Lyman 1999). Roosevelt elk or *Cervus elaphus roosevelti* have reportedly existed in western Washington for at least 7,000 years (Harpole and Lyman 1999), and on the Olympic Peninsula for at least 3,000 years (Croes and Hackenberger 1988). Studies of western Washington elk habitat use show they are most commonly found in patchy habitats where forest canopies provide security and thermal cover and forest openings provide the highest quality forage (Harpole and Lyman 1999; Maser 1998). Traditional Native American practices involved burning large sections of forest to improve berry and ungulate production (McClure 1989). However, modern fire prevention and land management practices have lessened the natural forest openings causing more limitations to elk habitats.

Roosevelt elk on the eastern side of the Olympics have typically been in smaller more isolated groups and the herds on the western side of the Olympics generally reside in larger groups (WDFW 2005). Native American people influenced distribution and population of elk herds through the use of fire and hunting (McCabe 2002). The general distribution of elk in the Olympic Peninsula has stayed relatively similar to historical distribution, while population size has varied more because of human influences (WDFW 2005; WDFW 2008).

Native Americans are believed to have existed in Washington for at least 9,000 years (WDFW 2008). The native people of the Olympic Peninsula have most likely been hunting these animals in their historic range for thousands of years. By the early 1900s, European settlement brought about the use of modern firearms and more hunters. This greatly reduced elk populations in western Washington (WDFW 2004), and eliminated most elk in eastern Washington (WDFW 2008). From 1905-1915, it was unlawful to hunt elk. Elk predators, like cougars and bear, were targeted for hunting instead in Washington State. In 1909, Theodore Roosevelt protected all elk residing in the Olympic National Park. This ban is still in effect today. The 1909 ban led to an overpopulation of elk by 1915 in parts of the Olympic Peninsula, causing depletions in available elk forage (Schwartz 1945). The populations improved again on the Olympic Peninsula through the 1970s, because of changes to habitat conditions largely resulting from forest management practices that opened up forest floor through logging. However, over time the changes in hunting regulations, forestry management, and human development decreased the total carrying capacity for Roosevelt elk (WDFW 2008).

The Olympic Elk Herd is one of the ten major elk herds managed by the Washington Department of Fish and Wildlife (WDFW). The herd is estimated at about 8,600 animals (WDFW 2005, WDFW 2008). This estimate does not include the population of the herd located in the Olympic National Park. The Olympic Elk Herd is believed to be limited by a loss of habitat, increased human development, and timber management on private and federal lands (WDFW 2008). The Skokomish GMU is a part of the 15 GMUs that make up the area surrounding the Park containing the Olympic Elk Herd.

SKOKOMISH TRIBAL LANDS

In 1855, the Treaty of Point No Point was signed by members of the Skokomish Tribe or Twana people. The Treaty ceded the historic lands of the Skokomish people, “to the United States Government in exchange for a small reservation on the mouth of the Skokomish River on the base of the Hood Canal” (Wray 2002). Prior to the signing of the Treaty, the Twana people hunted and fished in the lands surrounding the designated reservation for hundreds of generations. Governor Isaac Stevens assured the tribal members that they would be able, “to continue to harvest foods from their traditional (ceded) areas”, as long as they resided on the reservation (Wray 2002).

The Skokomish way of life was highly altered by the arrival of European settlers and the challenges created by these changes continue into present-day.

The priorities for the Skokomish Tribe remain the same: protection of their marine, freshwater, and land resources, all of which make-up the backbone of their lifestyle (Wray 2002). However, land management by the Federal Government, Washington State Government, and other private landowners has had overwhelming effects on the status of resources in the traditional use areas of the Twana people.

Figure 1 shows the location of the Skokomish Indian Reservation, which is approximately 5,000 acres or 7.5 square miles at the delta of the Skokomish

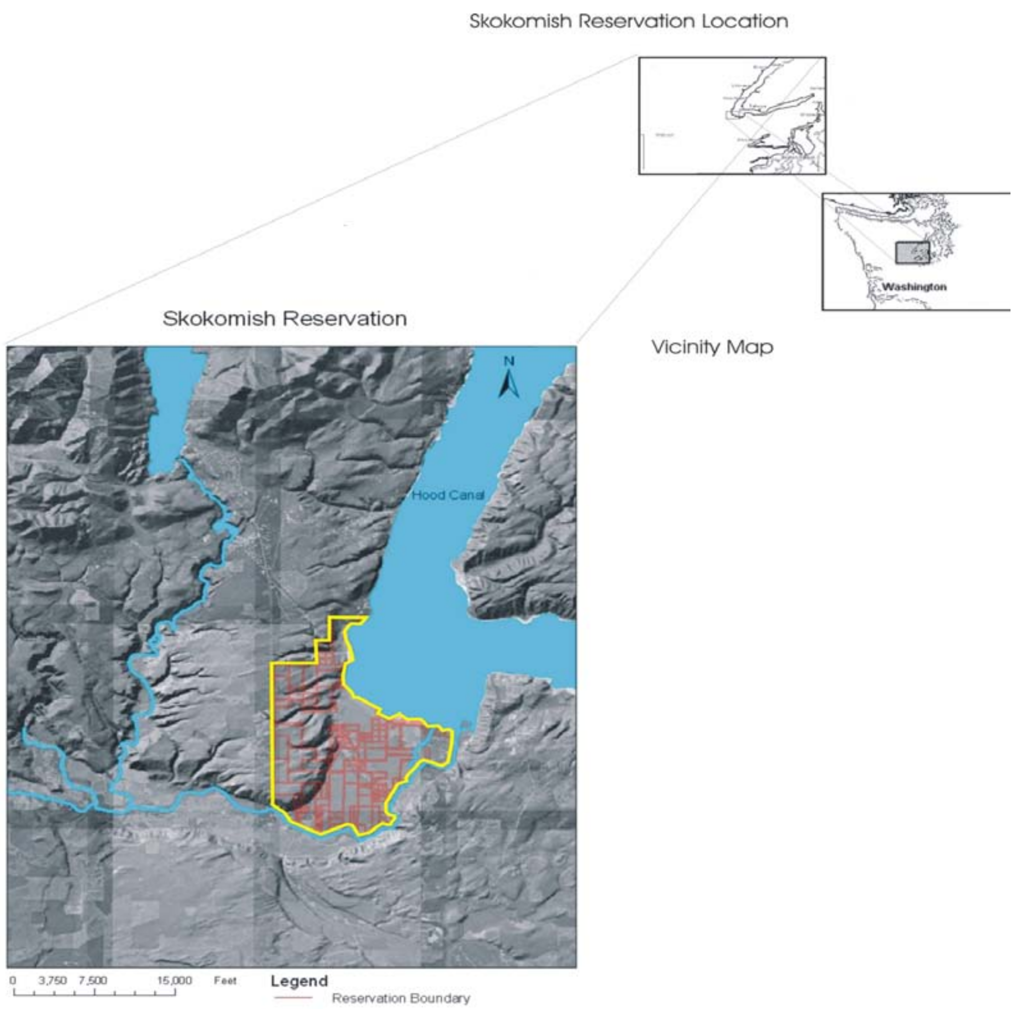


Figure 1: Skokomish Reservation Location and Vicinity Map
Source: Skokomish Department of Natural Resources

River where it empties into the Great Bend of the Hood Canal. The Reservation is bounded on the south by the Skokomish River, on the west by the Olympic Mountains, on the east by the Puget Lowlands, and on the north by the Hood Canal. The reservation resides in Mason County, Shelton, Washington.

The ceded lands created by the Point No Point Treaty were described as the following:

> Commencing at the mouth of the Okeho River, on the Straits of Fuca; thence southeastwardly along the westerly line of territory claimed by the Makah tribe of Indians to the summit of the Cascade Range; thence still southeastwardly and southerly along said summit to the head of the west branch of the Satsop River, down that branch to the main fork; thence eastwardly and following the line of lands heretofore ceded to the United States by the Nisqually and other tribes and bands of Indians, to the summit of the Black Hills, and northeastwardly to the portage known as Wilkes' Portage; thence northeastwardly, and following the line of lands heretofore ceded to the United States by the Duwamish, Suquamish, and other tribes and bands of Indians, to Suquamish Head; thence northerly through Admiralty Inlet to the Straits of Fuca; thence westwardly through said straits to the place of beginning.

The historical traditional use areas for hunting and fishing purposes have been negotiated further between the Peninsula tribes. Washington State now takes part in the enforcement of Peninsula tribes' traditional use areas; assuring the proper tribal members are hunting within their designated areas. Negotiations over actual historical, traditional use areas continue today between Washington State, Puget Sound tribes, and Olympic Peninsula tribes.

SKOKOMISH LAND MANAGEMENT

Roosevelt elk have been a historically significant species to the people of the Skokomish Tribe for thousands of years (WDFW 2008). Native American people used elk for many vital reasons including food, clothing, weapons, and spiritualism (McCabe 2002). In the early 1900s, there were stories of tribal members traveling in hunting parties to the hills near Mount Ellinor and Mount Washington, near Lake Cushman, to hunt large groups of elk (Wray 2002). Maintaining sustainable elk herds in the Skokomish area is important to the Skokomish people for cultural, personal, environmental, and subsistence purposes. Therefore, the Skokomish Tribe has taken steps to protect this important species.

The Skokomish Tribe reserves the right to co-manage all natural resources within their traditional use areas along with the federal and Washington State governments. Ownership and management of the traditional use or ceded areas of the Skokomish are now divided among the Green Diamond Resource Company (formerly Simpson Timber Company), United States Forest Service (USFS), Washington Department of Natural Resources, Tacoma Power, and private landowners. The Skokomish Department of Natural Resources (DNR) now works with all of these entities to manage resources in their traditional lands.

After the Treaty of Point No Point was signed, Washington State was responsible for managing natural resources in the areas surrounding the Skokomish Reservation. During this time the State and tribal managers did not collaborate well on resource management projects (Nickelson et al. 2001) and much of the management was carried out by State Government. In 1974, the US vs. Washington (Boldt decision) reaffirmed Washington tribes' treaty rights to co-manage natural resources (NWIFC 2009). From 1974-2001, natural resources in the Skokomish area were managed by the Point No Point Treaty Council (PNPTC) and the Northwest Indian Fisheries Commission (NWIFC) that help support natural resource programs for tribes mostly surrounding or in the Puget Sound area (NWIFC 2007). The Skokomish Tribe left the PNPTC in 2001 and established their own Department of Natural Resources in 2003 on the Tribal Reservation, "to protect Skokomish treaty rights through effective management that will perpetuate tribal resources for this and future generations" (Skokomish 2010). The Skokomish DNR and other tribal, state, and federal wildlife programs seek to ensure long-term sustainability for all wildlife using the best available science (WDFW 2008).

Olympic Peninsula tribes like the Skokomish Tribe have Hunting Committees to regulate harvest practices and develop management strategies. The tribes maintain their own hunting regulations, governance, and enforcement. The tribes and the state work together through management agreements for harvest management such as harvest reports, hunting seasons, and enforcement regulations (NWIFC 2007).

With the assistance of the PNPTC, the Washington Department of Fish and Wildlife (WDFW) have conducted much of the monitoring of elk in the Skokomish area, except for hunters and the Hunting Committee for the Skokomish that conduct undocumented observations of the herds. Currently, WDFW and the Olympic Peninsula tribes are combining efforts to manage the Olympic Peninsula Elk Herd for hunting purposes and improve the herd's population and composition. A Cooperative Elk Management Group (CEMG) was established in 1996, with representatives from the Olympic Peninsula tribes and WDFW, in an effort to better manage the Olympic Elk Herd. The objective of the CEMG is to, "reverse the decline in Olympic Herd elk numbers and ensure elk populations throughout the Olympic Peninsula are sustainable for hunting purposes" (WDFW 2008).

A Wildlife Program was created in 2008 through the Skokomish Tribe's Department of Natural Resources and is still operating today. To accomplish wildlife management objectives in the area, the Wildlife Staff does cooperative projects with other entities such as the WDFW, the USFS, and Olympic Peninsula tribes. Appendix A shows the division of land management in the range of the Skokomish Reservation. As indicated, the majority of the area is split between the USFS making up about 75% of the GMU and 25% private land divided between residential areas and commercial/private forest, which is mostly managed by the Green Diamond Resource Company.

PAST RESEARCH

Research and analysis of the habitat and wildlife in the Skokomish Game Management Unit has been limited and inconsistent because of changing resource managers. The Washington Department of Fish and Wildlife 2005 Olympic Herd Elk Plan set desired elk population objectives for the Olympic Peninsula Herd. The Skokomish GMU 636 is included in the fifteen GMUs, shown in Figure 2, which make up the area containing the Olympic Elk Herd. The population objectives were based on historic population estimates in the designated GMUs (WDFW 2005) and the desirable population sizes to allow for sustainable harvest of the Olympic Herd, while maintaining healthy herd sizes for reproductive purposes. The population objective for GMU 636 was set at 500 animals in 2005.

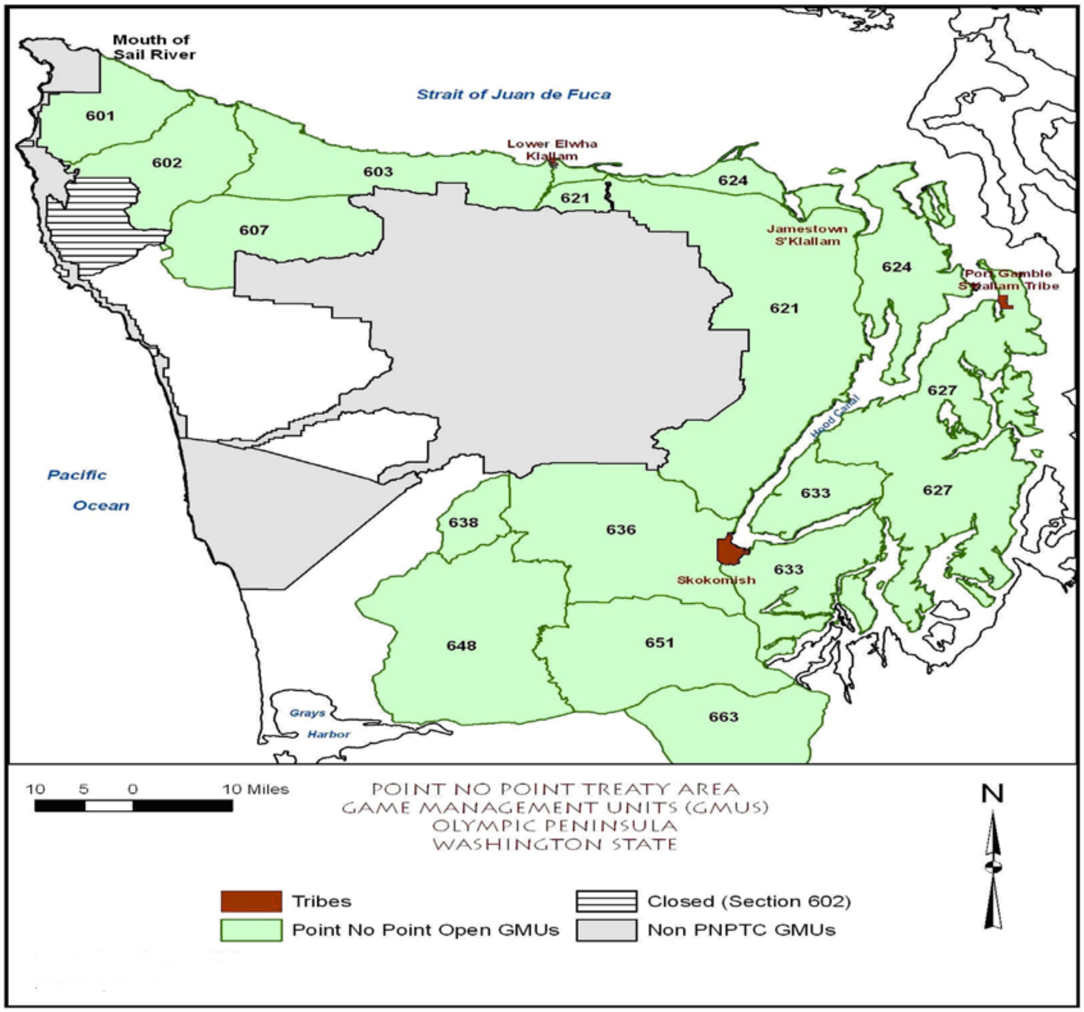


Figure 2: Game Management Units in the Point No Point Treaty Area
Source: WDFW

Some of the oldest known studies on Roosevelt elk in the Olympic Peninsula were “Roosevelt Elk of the Olympics” Skinner (1936), and “The Roosevelt Elk on the Olympic Peninsula” Schwartz (1945). Skinner’s study was an early introduction to elk in the Olympic Peninsula. Schwartz’s research involved a three-year study of elk and their habitat preferences. Some of the first population estimates of the Olympic Elk Herd were made during this study. Also, Schwartz (1945) conducted a forage study on elk herds on the Olympic Peninsula. Forage preferences found in Schwartz study can still be used as a basis for forage studies in the area today.

Many studies show the possibility for limited habitat availability and forage quality to be a leading factor in diminishing Roosevelt elk populations (Jenkins and Starkey 1991; Happe et al. 1990; Cook et al. 2001; Perez 2006); on the eastern side of the Olympic Peninsula growing human development creates a high possibility for human encroachment and a loss of habitat availability to affect elk populations (WDFW 2005). Forest management practices on the eastside of the Olympics have created an abundance of mid-seral even aged stands, which have been documented to offer the least amount of nutritional forage for elk (Jenkins and Starkey 1991; Happe et al. 1990; Schroer et al. 1993). Some studies have shown early-seral stands and private agricultural lands will offer a better quality of forage than coniferous forest stands over 16 years-old (Cook et al. 2001; Perez 2006; Happe et al. 1990).

Elk population studies have shown how changes in land management, human development, and forestry practices have influenced populations and changed the dynamic of the Olympic Peninsula Elk Herd (WDFW 2005; Jenkins and Starkey 1991; Happe et al. 1990). The Olympic Peninsula elk herds have adapted to habitat types, such as clear-cuts, which can offer more openings with more nutritious forage species, near forested areas with cover (Weckerly 2005; Schroer et al. 1993). However, historical forest management practices on the Olympic Peninsula involved burning undergrowth plant species to encourage tree growth. More recent forestry practices are instead treating clear-cuts with herbicides, which may reduce the amount and quality of forage in clear-cuts, especially winter forage species (Strong and Gates 2006). Clear-cuts may also increase the amount of tannins in plant species and protein in plants can be significantly reduced (Happe et. al. 1990; Cook 2002). The quality of the forage species in clear-cuts could be less than desirable and other habitats could be more beneficial to elk, because quality and nutrition of forage can limit elk more than abundance of forage (Happe et al. 1990; Cook et al. 2004; Perez 2006).

STUDY AREA

Game Management Units (GMUs) are used by the WDFW as a means of managing harvest and wildlife populations. The GMUs often have natural and manmade features rivers, ridges, and roads as boundaries. However, these boundaries are set based on human recreational use of the area and are not boundaries for wildlife, which can freely cross in and out of GMUs. Figure 3 shows the borders of the Skokomish GMU 636 as designated by the 2008/2009 hunting regulations for the WDFW.

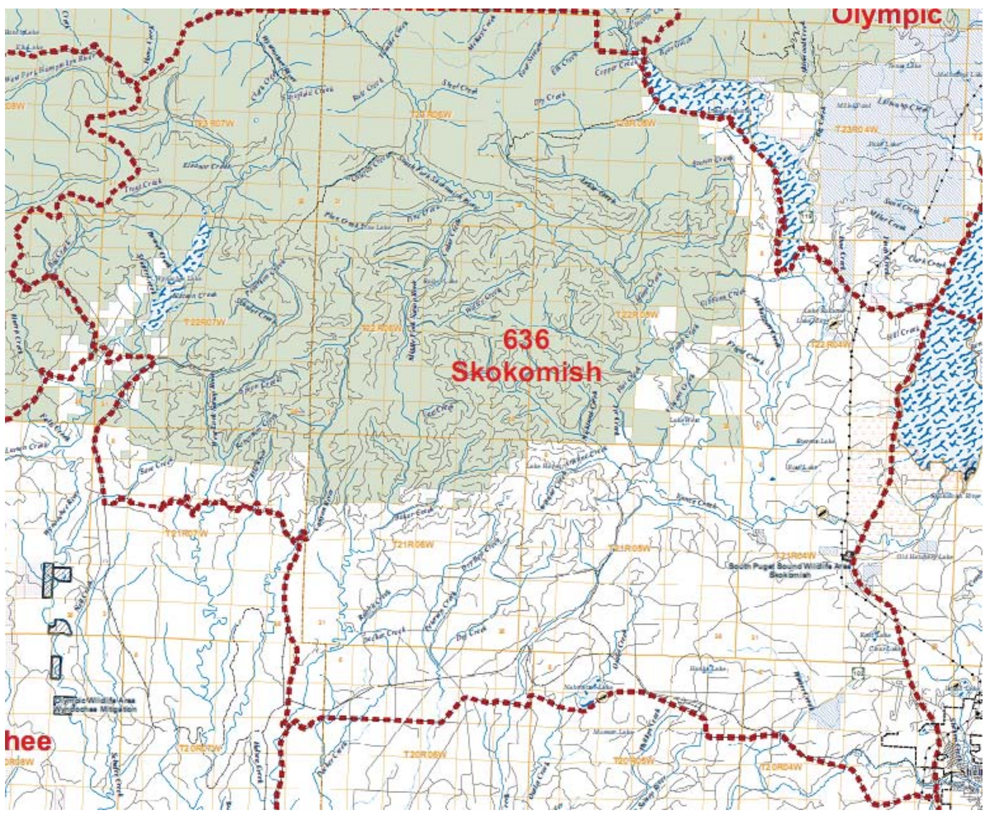


Figure 3: Game Management Unit 636-2008/2009 Hunting Season
Source: WDFW

The Skokomish Game Management Unit (GMU) 636 is the main study area for this project. As defined in the 2010 Washington state hunting regulations, the GMU is approximately 976 square kilometers in area. GMU 636 is located in both Mason and Grays Harbor Counties. As shown in Figure 3, the unit begins at the Olympic Park boundary and the North Fork Skokomish River; goes South along the North Fork of the Skokomish River to Lake Cushman; heads Southeast along the west shore of Lake Cushman to Standsill Dr. (Power Dam Rd.) at the Upper Cushman Dam; East on Standstill Dr to SR 119; Southeast on Lake Cushman Rd to US Hwy 101 at the town of Hoodsport; then South on US Hwy 101 to Shelton-Matlock Rd. to the town of Shelton; West on the Shelton-Matlock Rd to the Matlock-Brady Rd to Deckerville Rd south of the town of Matlock; West on Deckerville Rd to Boundary Rd; Southwest on Boundary Rd to Kelly Rd; North on Kelly Rd to US Forest Service (USFS) Rd 2368 (Simpson Timber 500 Line); North on USFS Rd 2368 (Simpson Timber 500 line) to USFS Rd 2260 (Simpson Timber 600 line) to Wynoochee Rd (USFS Rd 22); Northwest on USFS Rd 22 to USFS Rd. 2294, ¼ mile East of Big Creek; Northwest on USFS Rd 2294 which parallels Big Creek, to junction with USFS Rd 2281; West on USFS 2281, to the watershed divide between the Humptulips River watershed and the Wynoochee River watershed; North on the ridge between the Humptulips River watershed and the Wynoochee River watershed to Olympic National Park boundary; East along the Olympic National Park boundary to the north fork of the Skokomish River and the point of beginning.

The average snowfall for the study area falls between November and March with the highest averages in December and January at 1.2 centimeters (cm) and 3.05cm respectively, with extremes ranging up to 38cm. Average daily precipitation for the study area ranges between 0.76cm and 1.5cm, between November and April and between 0.0025cm and 0.38cm, from May through October. GMU 636 like Western Washington has a Mediterranean climate that has a relatively heavy rain/snow season and then a drier, warmer summer. The average temperature of the study area is between 1.6°C and 21.1°C, with extremes at -1.1°C minimum and 29.4°C maximum (Western Regional Climate Center 2010).

The main coniferous forest overstory species in the area are Douglas fir (*Pseudotsuga menziesii*), Western hemlock (*Tsuga heterophylla*) and Western

Red Cedar (*Thuja plicata*). The main deciduous forest species is Red alder (*Alnus rubra*) and is most present in the riparian areas of the unit. The understory is mainly composed of shrubs, ferns, moss, fungi, grasses, and small forb species (Franklin and Dryness 1973).

HISTORICAL SKOKOMISH HERD POPULATIONS

Population estimates have been inconsistently kept on the elk herds in the Skokomish GMU. WDFW and the Point No Point Treaty Council have conducted some population studies over the past 30-40 years. Based on the observations in these population studies, herds in the Skokomish GMU have been in decline the past few decades (Schirato 1996). Figure 4 shows estimated populations calculated various ways in GMU 636. Without historical surveys and population estimates in the area, most of the estimates were calculated by multiplying estimated harvest by 12.5.

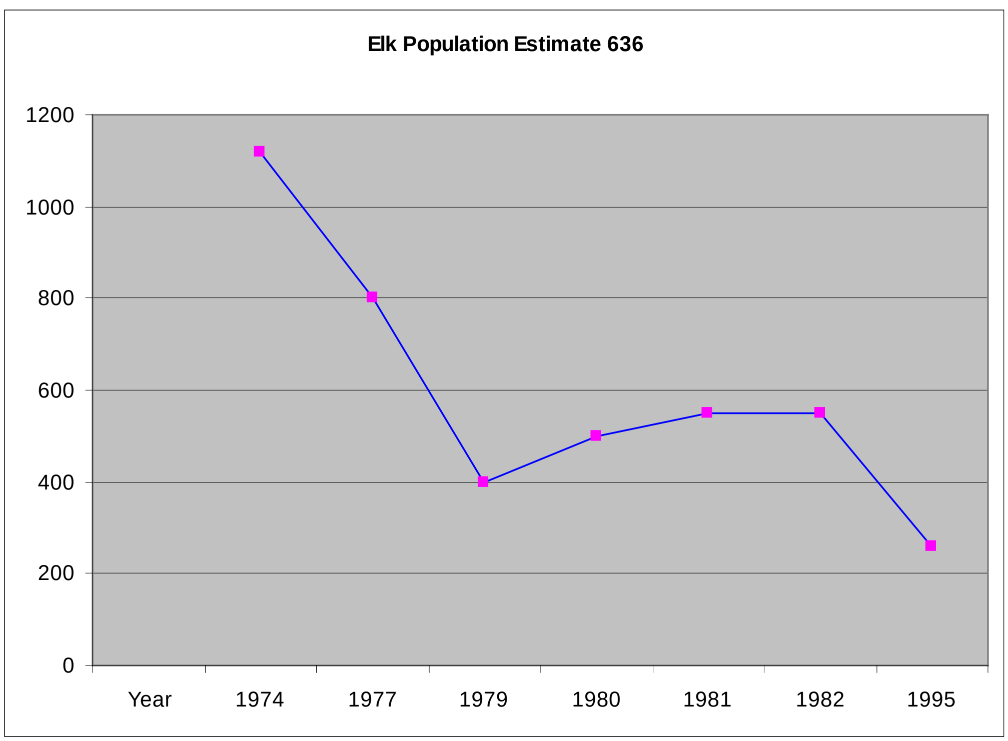


Figure 4: GMU 636 Elk Population Estimate 1974-1995
Source: WDFW-PNPTC-Skokomish DNR

The two historically monitored herds in the area were the South Fork herd and the North Fork herd. Other smaller groups reportedly existed in the North Fork-South Fork confluence area of the Skokomish River until at least 1995. More recent studies have documented a third herd in the vicinity of the Skokomish River known as the confluence herd (Nickelson 1996). Table 1 shows the population estimates documented for these herds by the PNPTC and WDFW. In 1945, Schwartz documented 100 elk in the South Fork Skokomish River area. 150 elk were documented in the North Fork Skokomish herd. In 1977, the population in the North Fork was over 100 animals and around 100 for the South Fork herd. Just under 20 years later, there were only 2 elk seen during spring surveys in the confluence herd, only 26 elk seen in the South Fork Skokomish area, and the North Fork herd was not located (Nickelson 1996). Then by spring 1996, only 17 elk were found in the South Fork herd, no mature bulls, only one spike and one calf. The confluence herd has not been found in surveys since before 1996, and was believed to be extinct from the area. The North Fork herd has mostly relocated to the Olympic National Park north of Lake Cushman. The believed low numbers in these three herds led to a complete harvest closure of GMU 636 for both state and tribal hunters.

Table 1: Historic Population Estimates for Skokomish River Herds in GMU 636

Historical Skokomish River Herd Population Estimates for GMU 636		
Date	Herd	Estimate
1929	North-South Fork	150
1930	South Fork	200-100
1930	North fork	150
1960	North-South Fork	210
1977	South Fork	100
1977	Confluence	100+
1984	North-South Fork	60
1990	North-South Fork	60
1992	South Fork	60
1992	North fork	15
1992	Confluence	28
1995	South Fork	30
1998	South Fork	25

Source: WDFW-PNPTC-Emily Wirtz

Previous closures in nearby GMUs showed prohibiting hunting alone may not be an effective way to assist a herd's recovery once they have reached extremely low population levels (Nickelson 1996). In 1997, 24 elk were relocated into the South Fork Skokomish River area by the WDFW and PNPTC to supplement the Skokomish herd. These efforts were mostly unsuccessful. There were high mortality rates post-relocation and some of the relocated animals chose to disperse towards their previous home ranges causing only a slight increase in the South Fork herd (Nickelson et al. 2000).

A total population estimate for GMU 636 calculated in 1994-1995 by the Point No Point Treaty Council biologists using mark-resight counts estimated 258 animals with 95% Confidence Intervals (CI) of the population being between 191 and 325. From 1997-2003 some population counts were conducted by WDFW and PNPTC. These were mostly varied and inconclusive. The best recorded observations during this time were from a March 1998 aerial survey documenting 161 elk for the unit. In 2008, the Skokomish wildlife biologist and WDFW biologists conducted an aerial paintball mark-resight survey estimating a minimum of 148 elk in GMU 636, and only 16 elk were observed in the South Fork herd.

HUNTING EFFECTS

Historical population observations of the Skokomish herds showed dramatic declines since the 1970s (Schirato 1996). There are many factors that can affect elk herd size. A major mortality factor is legal harvest, which causes an averaged 80% mortality in the Olympic Peninsula Elk Herd. Only about 10% of mortality in cows and 14% in bulls in the Olympic Peninsula come from all other causes including poaching and natural mortality (Nickelson 1997).

European settlement brought more hunters and more advanced weaponry to the Olympic Peninsula. Historical records of harvest totals are incomplete. The earliest known estimate in the area is from 1920 (Schirato 1997). According to the limited hunting records kept by the WDFW, harvest of elk in the Skokomish GMU peaked until the 1970's and then fell in the 1980's. Most likely the decline in elk population led to lower harvest numbers (Schirato1997). Harvest estimates from 1960-1995 are shown in Figure 5. Because of the believed population decline, the State added more restrictions to hunting the Skokomish herds. In 1983, the Skokomish GMU was limited to bulls with three or more points because fewer bulls are needed than cows within a herd to maintain healthy populations. There was a complete harvest closure for elk in GMU 636 by both state and tribal hunters from 1996-2003 to assist the herds' recovery (Nickelson et al. 2000). However, there was not a noticeable improvement in population size coinciding with the closure (Nickelson et al. 2000). This suggests there could be other causes limiting the herds' population size.

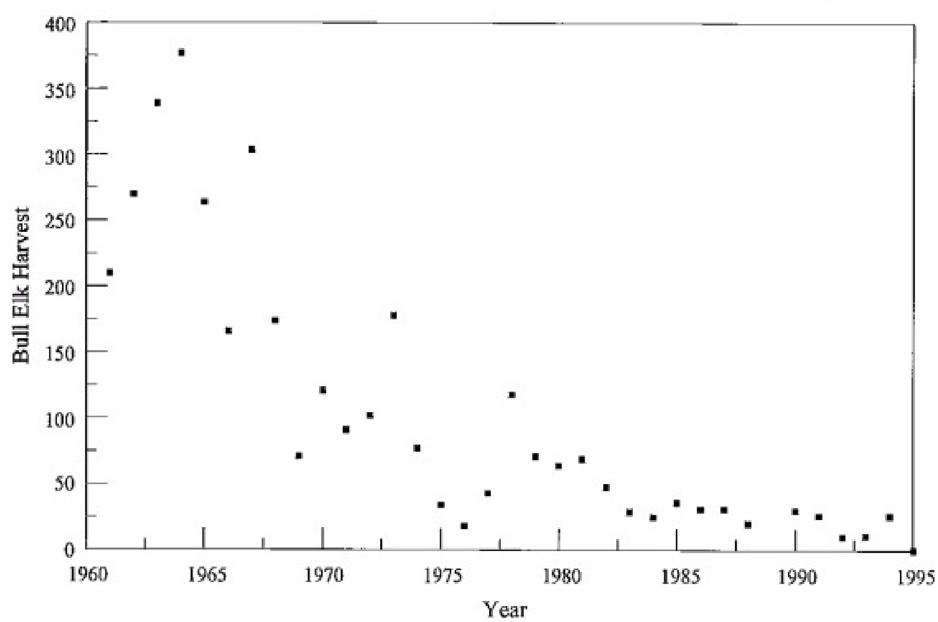


Figure 5: WDFW Skokomish GMU Bull Elk Harvest Estimates
Source: WDFW

In GMU 636, hunting has been limited to special permit only since 2003 for both state and tribal hunters. The Olympic Peninsula tribes are given extended hunting seasons. The Skokomish tribe's season runs from mid-August to the end of January. The Skokomish tribal members are allowed to harvest cows for ceremonial purposes only.

Table 2 shows totals for elk harvested from the Skokomish GMU since 2003. The reported 63 harvested animals over the course of six years is a fairly low amount. From 2003-2009 over 1,000 animals were harvested from the Olympic Peninsula GMUs (NWIFC 2009).

Table 2: NWIFC Elk Harvest Total in GMU 636 from 2003-2009

Sex	2003	2004	2005	2006	2007	2008	2009
Bulls	8	5	9	10	10	9	8
Cows	1	0	2	0	1	0	0

Source: NWIFC-Skokomish DNR-Emily Wirtz

The increase of roads accessible by hunters can limit habitat areas for the elk and increase mortality. The effects of increased road distribution on elk behavior have been well documented (Cole 1997; Skovlin et. al. 2002, Irwin 2002, WDFW 2008). High road densities can cause elk to abandon areas they would usually inhabit, which can reduce the available range for the population (Cole 1997). Condensing the amount of roads available to human transportation can lower the amount of energy used by elk avoiding vehicle movement and human disturbance and lessen mortality rates because of hunting and poaching (WDFW 2008).

The USFS and WDFW have been working together to lessen the amount of accessible roads in GMU 636. Many gate closures exist now, limiting access for about 6-7 months out of the year as well as year round closures to reduce human disturbance of elk, especially during breeding season. The USFS map in Appendix B shows the current elk security areas, current road decommissioning projects, and plans for future projects in the South Fork Skokomish River watershed. The Green Diamond Resource Company will also close many gates on logging roads when logging operations are not underway in the Skokomish GMU.

Poaching is another possible cause for lower population numbers. It is difficult to understand the effect poaching has had in GMU 636, as in most areas, because those totals are not well documented. Some poaching activity has been reported by hunters to the Skokomish wildlife staff in the recent past, but it is difficult to know exactly how much has actually occurred. According to Smith et al. (1994) poaching attributes to 15% of mortality statewide, while 59% of mortality was reportedly caused by legal harvest.

A study by Schirato and Murphie (1997) showed that 27% of all mortalities (n=40) on the eastside of the Olympic Peninsula were caused by poaching. This study was conducted in a GMU just northeast of the Skokomish GMU, but it could show that the area has a slightly higher rate of poaching than other parts of the state. Local hunters and community members have discussed at least three other poaching incidents in the past year to the Skokomish DNR wildlife staff.

NATURAL MORTALITY EFFECTS

Mortality studies have not been historically conducted on elk in GMU 636. The current Elk Monitoring Project carried out by the Skokomish DNR and WDFW will assist in deriving better estimates for causes of mortality in the Skokomish herd. The main known causes of natural mortality for Roosevelt elk are malnutrition, predation, disease, parasite infestation, and injury.

Malnutrition has been the highest reported cause of natural mortality for cow elk in the Olympic Elk Herd (Nickelson 1996). Malnutrition can occur because of an insufficient availability of high quality forage within a herd's home range (Cook et al. 2004). For example cow elk may not find enough spring forage species to rebuild fat supplies after a harsh winter, when elk will generally lose significant weight (Cook 2002). Forage in areas like the Skokomish GMU is influenced by forest management practices that can have appreciable effects on forage quality and quantity (Cook et al. 2004). Early growth in timber harvested areas can often increase use and foraging by elk herds in those areas, but the quality of forage species can reduce with age of forest stand eventually leading to less nutritional foraging areas (Cook 2002). Another reason for malnutrition could be disturbance factors, cows with calves may choose to protect their calf over eating if there are security threats and rapid movement by elk can reduce foraging efficiency (Cook 2002).

Predator populations are unknown in the GMU. Cougars, bears, bobcats, and coyotes are the four main predators of elk in the study area (Schwartz 1945; WDFW 2008). Cougars are the most active elk predator in the area. Cougars and bear would be the only two predators capable of taking down an adult elk and it is likely only large cougars and bears would be able to do this successfully (Maser 1998). But all predator types mostly focus their efforts on calves. Also, it is believed cougars feed more on deer than elk, because cougars are more versatile at hunting deer than elk (Schwartz 1945; Maser 1998).

Complete population estimates for predatory species in the unit have also not been conducted. Logging and forestry management practices that changed forest dynamics in the Olympic Peninsula opened up forest floor and habitat for predators, as well as elk (Maser 1998). Harvest for these species is also generally very low. Washington state harvest reports over the last ten-years have only been between 0-5 cougars and for black bear between 10-20 animals. State reconstruction methods found an increasing trend in cougar populations in the Olympics from 1987-1994 (WDFW 1999). Cougar studies carried out by Olympic Peninsula tribes in next few years may provide more knowledge on the effect these predators have on deer and elk ecology.

Other natural mortality factors are injury, disease, and parasite infestation. It is unknown how these have affected the Skokomish herds. Currently, there are no major diseases known to affect elk herds on the Olympic Peninsula. Multiple parasites inhabit elk on the Olympic Peninsula, such as ticks, lice, lungworms, and tape worms (Schwartz 1945). Other parasites positively identified in the Olympic Peninsula, such as Capillaria, Trichuris, and Dictyocaulus, have only shown up in low quantities (WDFW 2005).

COMPETITION

The Skokomish GMU has historically offered higher quality habitat for deer than elk (Schwartz 1945). Deer may be more predominant on the eastern side of the Olympics than on the western side. Schwartz 1945 suggested managing for deer over elk in the South Fork Skokomish river area, because the habitat favored deer. However, deer and elk ecology can overlap to some degree and both species can share an area containing enough available forage. Population counts for deer have not been well documented in GMU 636, but if they are more abundant than they could compete with elk for food and habitat (McCullough 1971).

HUNTING COMMITTEE INTERVIEW

Interviews and surveys were conducted with the Skokomish Tribe's Hunting Committee members. There are 5 members of the committee, who took part in the qualitative discussion. All members began hunting in the Skokomish GMU over 20 years ago and most have been hunting for 30-40 years in the GMU. They have watched the herds change in size and behavior over many decades. Unlike biologists studying elk herds in the area, the Skokomish Hunting Committee members rarely get to express their observations about the local herds to people outside of the tribe. Through the interview and survey, they were able to communicate their insight about the study area and their thoughts on the status of elk and their habitat in GMU 636. A table showing the results of the interview can be found in Appendix C.

Overall, the Hunting Committee members still have much concern about the status of elk in GMU 636. They have watched the population dramatically decline during their lifetimes. The main consensus about the causes for the decline are logging and over-harvesting of elk. They believe adding to forage and habitat in the area would be greatly beneficial to the herds' population growth. The Hunting Committee members feel making adjustments to hunting in the GMU could be necessary to improve growth. For example, closing down the unit for both state and tribal hunters as it was from 1996 to 2003 or eliminating the mature bull only permits for the state. As discussed in Chapter 2 surveys of the South Fork herd found a very minimal number of branched bulls. A lack of mature bulls within a herd during breeding season could be highly influential on the success of reproduction in the herd (Schirato 1996, Noyes et al. 2008).

CHAPTER 2

ANALYSIS OF ELK POPULATION/HOME RANGE /HABITAT

INTRODUCTION

Elk are a social species living in matriarchal herds or groups led by a mature cow (Maser 1998). It is presumed that collaring a cow will assist in locating the entire herd or group. Female cows will generally only leave the herd when giving birth (Maser 1998). A Cooperative Elk Monitoring Project was carried out in September-October 2009 by the Skokomish Tribe's DNR and the WDFW. The goal of the Elk Monitoring Project is to derive consistent population and composition data, home range, and habitat use information on elk within the Skokomish GMU and surrounding areas. Also, the project involves conducting a long-term study of mortality causes to assure a sustainable herd for harvesting, cultural, recreational, and ecological purposes (Tropp 2009).

Through the 2009 Skokomish Elk Monitoring Project, population counts and herd composition data was collected for herds in the Skokomish GMU. Home range analysis was conducted on four collared elk representing two distinct elk herds in the southeast portion of GMU 636. Vegetation surveys were conducted in the home range of the two groups to document forage species present within seven known habitat types. This study can assist wildlife managers in the area to understand the current status of elk in GMU 636, the most important areas used by the southeast groups, the size of their home range over the course of a year and daily and seasonal use patterns. The vegetation surveys help identify high quality forage areas within the herds' home ranges and the most important forage species present within each of the sampled habitat types.

Through the home range and vegetation analysis a connection between high use areas and higher composition of forage species was expected. A trend in the herds' habitat selection connecting grass and shrub species availability during the late autumn through early spring habitats and forb and grass availability being connected to their habitat selection from late spring through early autumn was expected (Jenkins and Starkey 1991). More movement and variability in habitat preferences during the late spring through early autumn home ranges was anticipated. Also anticipated was a higher availability of forage species and biomass of species within the private farms and open meadow or wetland areas than within the clear-cut or replanted forest areas (Perez 2006).

METHODS

Elk Capture and Monitoring

Cow elk were captured through the use of a helicopter (Northwest Helicopters, Olympia, WA, USA) and tranquilized with 3cc (cubic centimeters) of concentrated Xylazine HCI (Hospira Inc., Lake Forest, IL, USA). Animals were vaccinated with 10cc of Penicillin (Combi-Pen-48, Bimeda Inc., Le Sueur, MN, USA) and 5cc Clostridium (Clostidium Perfringens Types C & D Tetanus Toxoid, Boehringer Ingelheim Vetmedica Inc., St. Joseph, MO, USA). Cow elk were outfitted with either Lotek (Lotek Wireless Inc., Newmarket, Ontario, Canada) collars with Global Positioning System (GPS) and Very High Frequency (VHF) capabilities or ATS (Advanced Telemetry Systems, Isanti, MN) collars with only VHF capabilities. The goal was placing at least one of each type of collar into each herd located. Animals were reversed using 20cc of Tolazaline HCI (Lloyd Inc., Shenandoah, IA) and were released on site.

We monitored VHF radio-collared elk from October 2009-October 2010 once a week for survival status, location, and population counts using a hand-held receiver (Communications Specialists, Inc., Orange, CA, Model R-1000) and a 2-element “H” type antenna (Telonics, Inc., Mesa, AZ, Model RA-14K from ground or Model RA-2AK from the air) to locate the marked animals. The Lotek collars were programmed to take a point location with x, y coordinates and time every four hours or six times a day beginning at 0800. Through the use of ARGOS Satellite technology (CLS America Inc. Largo, MD, USA) the x, y point locations and times taken by the collar were sent to the Skokomish wildlife biologist biweekly. The Skokomish wildlife biologist entered the data points into Microsoft Excel 2003 (Microsoft Corporation, Redmond, WA, USA), and projected them into maps in ArcGIS9.2 using the Universal Transverse Mercator

(UTM) system. Orthographic and US Geological Surveys topographic maps in datum NAD83 were used to allow for better understanding of the herds' home range and for better analysis of the herds' habitat selection.

Population and Composition

Population counts and herd composition data were collected over the course of a year by ground and aerial observations of the herd located using radio (ATS) telemetry equipment. Aerial counts were collected in spring and fall 2010 using a Hughes 500 helicopter (Northwest Helicopters, Olympia, WA, USA). Ground counts were attempted weekly by the Skokomish DNR. Both total animals seen and composition of the herd (cow, bull, and calves) were recorded whenever sighted.

Home Range

Only the Beeville and South Fork herds' home ranges were used for home range analysis in this study, because it was presumed they would remain within 636 all year and more data points have been collected on these two herds than any other in the unit, which would allow for a more complete home range estimate. This study used a year's worth of data collected by the collared elk in the two study herds, from October 2009-2010. Determining the estimated home range of elk herds and the daily movement of the marked elk within GMU 636 was done using the GPS locations recorded by the Lotek collars and by using ArcMap9.2 and Hawth's tools 3.72. The home range was found using Fixed Kernel estimates with a standard deviation of n=2, with 95%, 90%, and 50% contour lines and Fixed Kernel utilization distributions (UD) for each elk (Samuel et al 1985, Worton 1989, Kernohan et al 1998). The size of the home range and the amount of area used was found for the two study herds.

Vegetation Surveys

For the purposes of this study only the habitats supporting the South Fork herd and the Beeville herd were sampled for vegetation make-up and availability.

I assessed the quality of forage present within each home range by comparing species present during this survey with forage quality values from other studies conducted on the Olympic Peninsula (Jenkins and Starkey 1991; Perez 2006). The vegetation analysis conducted for this study assessed the availability of forage species within seven habitat types in the home range of two residential herds in GMU 636 from mid-April until mid-August 2010. The methods for this analysis were derived from the forage study done by Perez in 2006, "Natural selenium and planted forages: Effects on mule deer and elk in Washington", Bonham's 1989, "Measurements for Terrestrial Vegetation", and a former vegetation study completed with the Nature Conservancy of Oregon on the Clatsop Coastal Prairie in 2006. All of the plant species were identified in the field using personal botanical knowledge and/or Pojar's "Plants of the Pacific Northwest Coast", or species were collected and identified using Hitchcock and Cornquist, the University of Washington Herbarium or the US Department of Agriculture (USDA) Plant Database (plants.usda.gov).

Available habitat types were divided into 7 categories riparian, wetlands, private agricultural fields, clear-cuts (0-5 years), early-, mid-, and late-seral coniferous forests (5-15=early, 15-30=mid, and 30-50=late). The categories of habitat were determined by previous research on elk habitat use and by looking at the use of habitat by the collared elk during the first six months of point data collection. The presence of the habitat types in the study area were determined using Orthographic maps from USGS 2007 projected using ESRI 2006 from the Green Diamond Resource Company and verification of the habitat type at the site of the survey, including forest tree height and age. Each habitat type within the known home ranges was selected randomly.

Plant species present were recorded within $50m^2$ plots using four transects each following one of the four cardinal directions North, South, East, and West. The central point in the plot was chosen using a random number generator in Microsoft Excel 2003, which randomly selected one of the data points collected from the Lotek GPS collars. The geographic location of the point would be found using ArcMap9.2 and the habitat type would be verified using maps or by traveling to the actual point location.

A 1 meter² quadrat was placed at 5 randomly selected points on each transect, chosen based on the last number on the minutes of a digital watch. For example if the time was 11:13, the lower-left side corner of the quadrat was placed at the 3m mark. If the time was 11:10 the corner was placed on the 0. This was repeated starting again at meters 10-19, 20-29, 30-39, and 40-49. The quadrat was placed on the right side of the tape from the central point. All species within the quadrat were recorded and samples of unknown species were collected for identification purposes. The number of individual plant species per unit area of plots containing the species was determined through the use of Microsoft Excel 2003.

If when laying out the 50-meter tape, part of it ended up in a stream or on a road or in some other scenario where vegetation cover was not present, then whatever was on that spot was recorded instead and another number was chosen, unless it was large vegetation. For example if a large Douglas fir was covering the entire quadrat then that species was recorded. If the whole 10-meter mark was over non-vegetation cover then what was in that section was recorded. If the entire tape fell out of vegetation coverage then 50m in the opposite direction was measured and a transect was set-up there. If the entire plot landed somewhere without vegetation data, such as a river, then another random point was chosen to navigate to within the same habitat type. If when laying out a transect within a plot, part of the 50m ended up in a different vegetation type, then another spot in the middle of the transect was chosen to run a 10-meter line out to the right and then a random number was chosen for the point to sample.

Biomass samples were taken within each plot. Much of the land within the study area was under private ownership or managed by the Green Diamond Resource company. Permission was granted before taking clippings within the plot areas. A $0.25m^2$ plot within the larger $50m^2$ plot was clipped and dried at 60º for 24 hours and weighed. Total wet weights were compared to total dry weights in grams for each plot and then compared within each habitat type.

The location of the biomass sample was determined randomly by designating numbers to the North, South, East, and West transects. N was 0-14, S was 15-29, E was 30-44, W was 45-59; the minutes on a watch corresponding to these numbers decided, which transect to clip. The frame was set-up at the central random point on the transect or point 3 to clip the 0.25 m² plot. The vegetation present within the 0.25 m² plot was recorded before clipping. Only vegetation within four feet of the ground was clipped, because elk feed mostly within this range (Bonham 1989; Perez 2006).

RESULTS AND ANALYSIS

Elk capture and monitoring

Eight mortality sensitive collars were fitted to cow elk within four herds in the Skokomish GMU 636, by the end of September 2009. We were able to locate herds on a weekly or bi-weekly basis using radio telemetry and tracking equipment. Survival of the radio collared elk was identified once the transmitters were in range of the receivers. A mortality signal (faster than the normal signal), would transmit if the collar stopped moving for 24 hours. Only one of the collared elk in the Beeville herd died during the course of this study and the mortality was determined to be poaching.

Population and Composition

Elk population counts and composition ratios were collected by the Skokomish DNR and the WDFW through the use of helicopter flights and ground surveys from the October 2009-October 2010. Only marked groups were found during aerial or ground surveys. A best available estimate of the number of herds and numbers within those herds was calculated for 2009-2010. Figure 6 shows the locations of the marked groups counted during the surveys. There were approximately 128 elk counted in three residential herds within the boundaries of 636, including a fourth herd that moves in and out of the unit into southern units is composed of approximately 33 animals, which gives a total population count of 161 animals for the unit. This count is only a slight increase from the 2008 estimate of 148 animals calculated using an aerial paintball mark-resight survey

(Tropp 2008). The highest numbers observed in the 2008 survey were 50 total elk in the Beeville Herd, 16 in the South Fork Skokomish Herd, 52 in the Lake Cushman (North Fork) Herd, and 30 in the Wynoochee Reservoir Herd (Tropp 2008). The Deckerville Herd was not sighted, possibly because it was in a GMU south of 636 at the time of the survey. These numbers are greatly reduced from the 258 total estimated population calculated in 1994-1995 by the Point No Point Treaty Council biologists using mark-resight methods (Nickelson 1996). However, the population surveys were conducted using different methods and study area sizes within 636, which could have influenced the results. There are other partial residential herds that have not been identified during aerial or ground surveys that would add at least 50 animals to the count (Murphie 2011), but it seems the five-year population goal for GMU 636 of 500 animals set by the "Olympic Herd Plan" WDFW (2005) is still far from being reached.

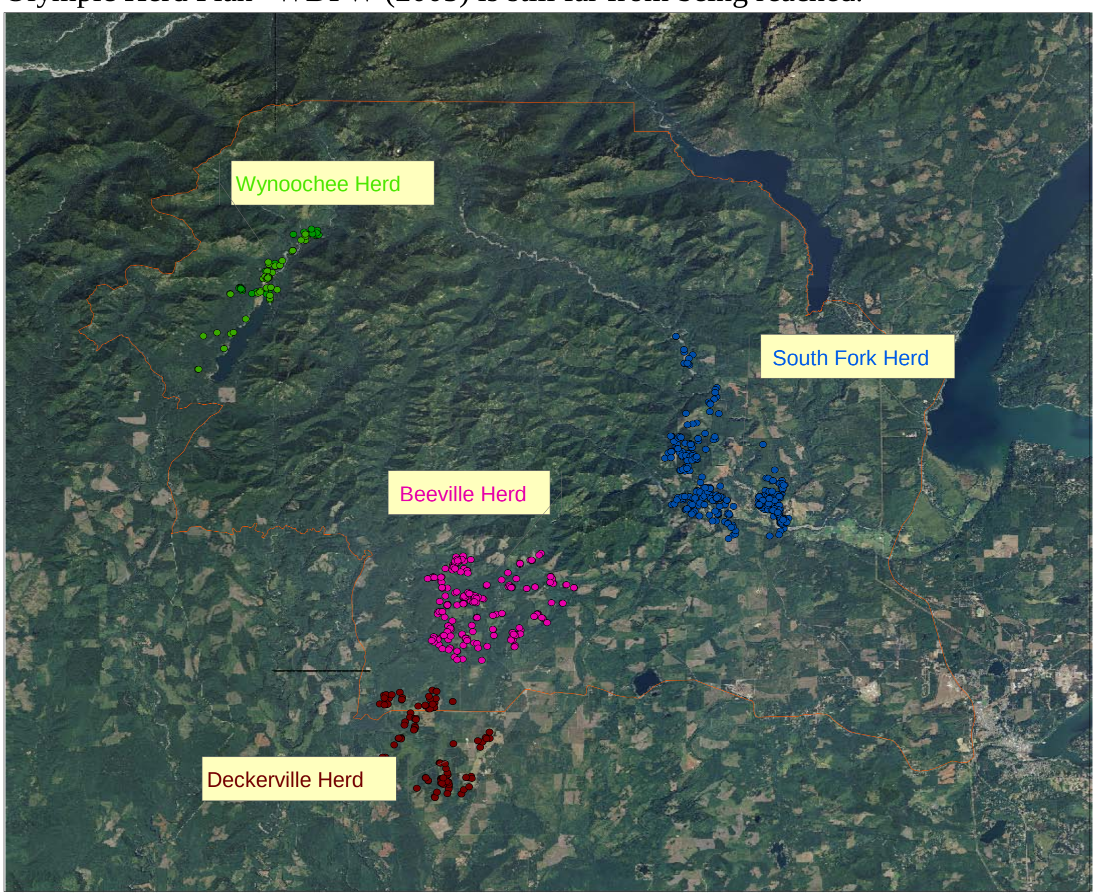


Figure 6: GPS Points of Collared Elk within GMU 636
Source: Skokomish DNR

Table 3 shows the results of ground and aerial counts conducted throughout the year. There was not a large enough sample size to create confidence intervals for the population estimates. There are currently three main residential herds that have been identified in 636 from east to west; they are: 1) the South Fork Herd residing mostly near the South Fork of the Skokomish River and Vance Creek with approximately 43 animals, 2) the Beeville Herd that resides mostly near Dry Bed Lakes, Dry Bed Creek, and Rabbit Creek with approximately 50 animals, and 3) the Wynoochee Herd residing in the Wynoochee Reservoir with approximately 35 animals. In addition, 4) the Deckerville herd, which are partial-residents moving in and out of 636 following the Decker Creek, has approximately 33 animals. Hunters have reported seeing about 40 elk in the area around Lake Cushman. This group is believed to move between GMU 636 and the Olympic National Park. The Lake Cushman herd would be a partial-residential herd and would increase the elk population in GMU 636 to a minimum of 201 animals.

Table 3: Counts of Elk Population in GMU 636

Herd	Counts	Date	Survey type
South Fork Skokomish Herd	43	8/31/2010	Aerial
Beeville Herd	50	9/3/2010	Aerial
Wynoochee Herd	35	3/5/2010	Aerial
Deckerville Herd	33	3/25/2010	Ground
Total	161		

Source: Skokomish DNR-WDFW

Composition ratios especially calf/cow ratios are important for quantifying reproductive success of elk herds and understanding the general health of the herds (Hutchins 2006). Healthy bull/cow ratios in the Olympic Peninsula Herd will vary depending on hunting regulations in the area and time of year the surveys are collected. On average a healthy elk herd should be at least 15-35 bulls/100 cows to be considered sustainable (WDFW 2008), but post hunting season a reasonable number could be closer to 12-14 bulls/100 cows (WDFW 2008), especially in a bull only hunting area like GMU 636. Both of the composition ratios for the two study herds were collected during early hunting season. The compositions found in the fall 2010 aerial surveys of the two study herds are shown in Table 4. The South Fork Herd has a bull/cow ratio of about 19 per 100 cows and the Beeville Herd bull/cow ratio is about 25 bulls per 100 cows. No branch bulls were seen with the South Fork Herd, and only one has been sighted with the herd in the past year. Continual monitoring of the South Fork Herd will be important to identify if there is a problem with branch bull numbers and reproductive success. It is uncertain how skewed sex-ratios within herds affect the reproductive success of the herd (Cook 2004). Population growth within an elk herd is more dependent on the calf/cow ratios than on bull numbers, but low mature bull escapement could limit reproductive success of the herd (Schirato 1996; Noyes et al. 2008). The number of branch bulls seen with the Beeville Herd is within an acceptable range (WDFW 2008). The calf/cow ratios are currently in acceptable ranges for the Olympic Peninsula Elk Herd, which ranges from 30-50 calves per 100 cows, for preseason surveys (WDFW 2008). The South Fork herd had 46 calves per 100 cows and 31 calves per a 100 cows in the Beeville Herd.

Table 4: Composition Data for Study Herds

Herd	Calf/100 Cow	Bull/100 Cow	%Spike Bull	%Branch Bull
South Fork	12:26 or 46%	5:26 or 19%	5:5 or 100%	0:5 or 0%
S Beeville	10:32 or 31%	8:32 or 25%	6:8 or 75%	2:8 or 25%

Source: Skokomish DNR/Emily Wirtz

Discussion of Population and Composition

Aerial and ground surveys are only minimally effective in finding actual population numbers. Often not all animals in an area will be observed during surveys, especially in Western Washington where densely forested areas can hide many individuals and small groups. Continual monitoring of these groups will allow for more counts that could lead to enough observations to create a population estimate of statistical significance. It does seem there has been slight growth in the South Fork and Beeville herds, based on observations made over the last 10 years. However, the goal of an elk population of 500 animals within the Skokomish GMU is still far from being reached.

Home Range Analysis

From October 2009 to October 2010, the two collared elk in the South Fork Herd had only about a 54% success rate of points sent and the Beeville group only a 36% and 27% success rate respectively. However, the amount of data sent was still more then could have been collected by the wildlife staff using tracking equipment only and the collars took points during non-work hours that would have not been easily collected otherwise, such as 4AM. There are many possible reasons for a GPS collar to not take data points, for example there could be a satellite positioning or visibility problem, something could obstruct the point from being taken such as vegetation characteristics like canopy cover, time of year, animal activity, or slope of the landscape (Friar 2004; WDFW 2001), or there is some other factor affecting the GPS or satellite technology. Figure 7 shows points that were collected using GPS collars placed on two cow elk in each of the herds over a year. Each color represents a different collared elk.

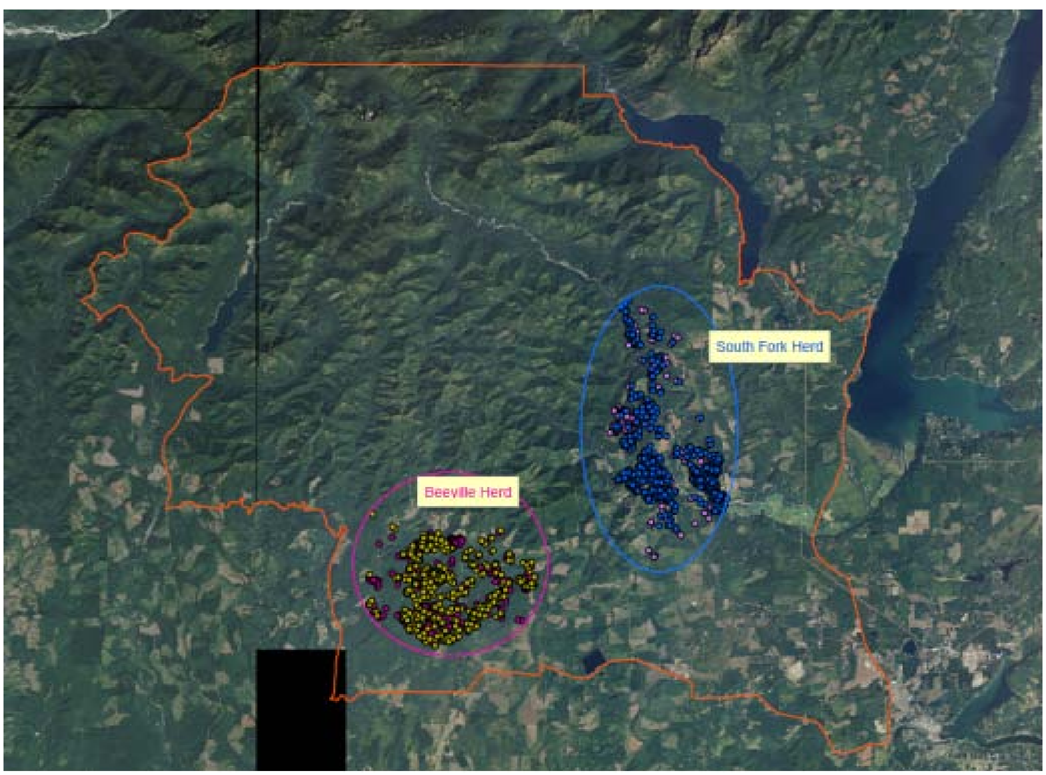


Figure 7: GPS Points for Marked Elk in Study Herds
Source: Skokomish DNR

One of the GPS collars within the Beeville Herd had a slight malfunction and was not sending data points for about 3 or 4 months from May until August. It is unknown why this occurred. There may have been some bias with points taken by the working collar within the Beeville Herd possibly being used more for random data point selection than the malfunctioning collar, but it is assumed that both collared animals within a herd will be together a majority of the time and use similar habitats and ranges throughout the year. The recorded points for the two elk in each herd were always found within 250 meters of each other during the course of the year, with the average distance between the two elk at 50 meters.

Figure 8 shows the home range over the course of a year, from September 2009-2010, the South Fork Herd used an area of approximately 75 square kilometers and the Beeville Herd used an area approximately 67 square kilometers. The central, red buffered areas in Figure 8 indicate 95% point density locations with the highest amount of point locations take by the GPS collars. The year round high density areas for the collared South Fork elk were about $14km^2$ and the Beeville Herd's highest density areas were approximately $20km^2$. Therefore, the South Fork Herd used only about 22% of its home range the majority of the year and the Beeville Herd used about 30%.

On a daily basis the collared elk in the South Fork Herd moved anywhere from 0.75 to 4 km and the Beeville collared cows moved from 0.5 to 3 km per day; on average the groups appeared to travel about1.5 km a day. The lowest overall averages for distance travelled occurred during the winter. The highest distances were recorded during the late summer months. Therefore, the South Fork herd and the Beeville Herd may only use about 2% of their overall home range on average per day, although the daily use can vary depending on time of year.

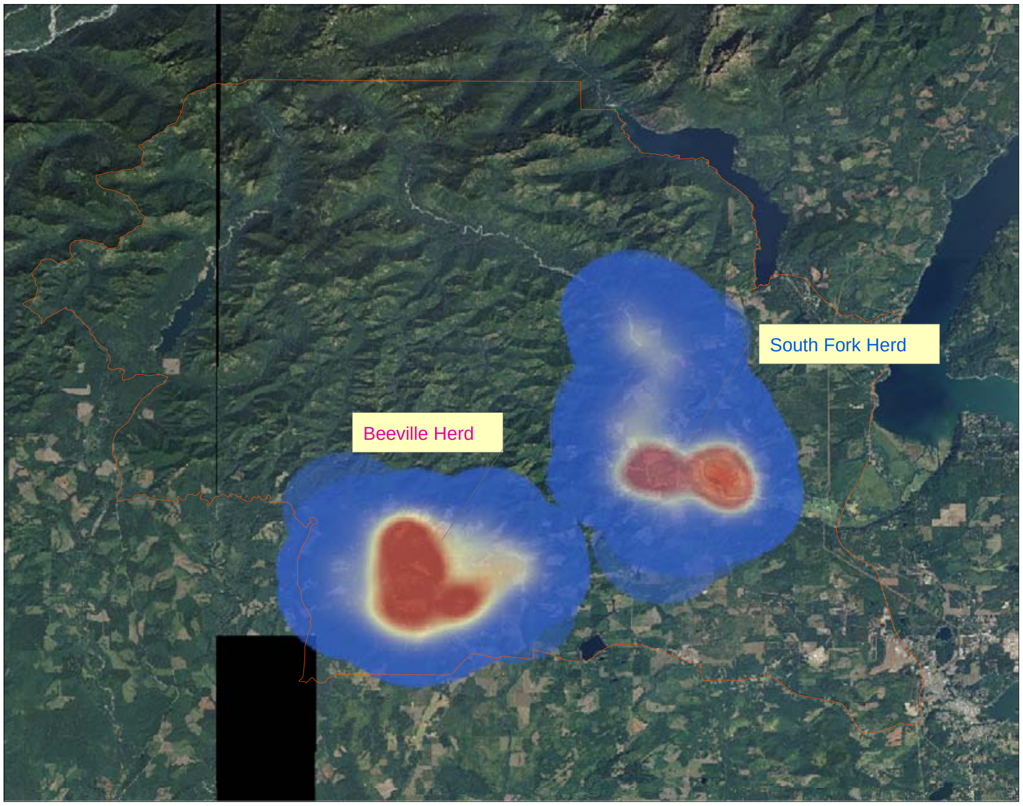


Figure 8: Kernel Density Estimates for Beeville and South Fork Herds
Source: Skokomish DNR-Emily Wirtz

The spring green-up is an important time to analyze habitat use, because cows need high quality forage to support calving and recover body fat lost during winter (Cook 2002; WDFW 2005). Figure 9 shows the home ranges for the two herds during the spring from March 20th-June 20th. The high point density areas for this time of year are mostly centered on drainages. The Beeville Herd's collared elk were focused around Dry Bed Creek, Rabbit Creek, and Bingham Creek. The South Fork Herd's collared cows centered on Vance Creek, the South Fork of the Skokomish River and other small creek offshoots of the South Fork; these drainages are shown in Figure 10. The Beeville Herd used a high percentage of wetlands and riparian areas, while the South Fork Herd used mostly riparian areas. It is common for elk herds to spend time in drainages, because of the quality of forage and cover offered in these habitats.

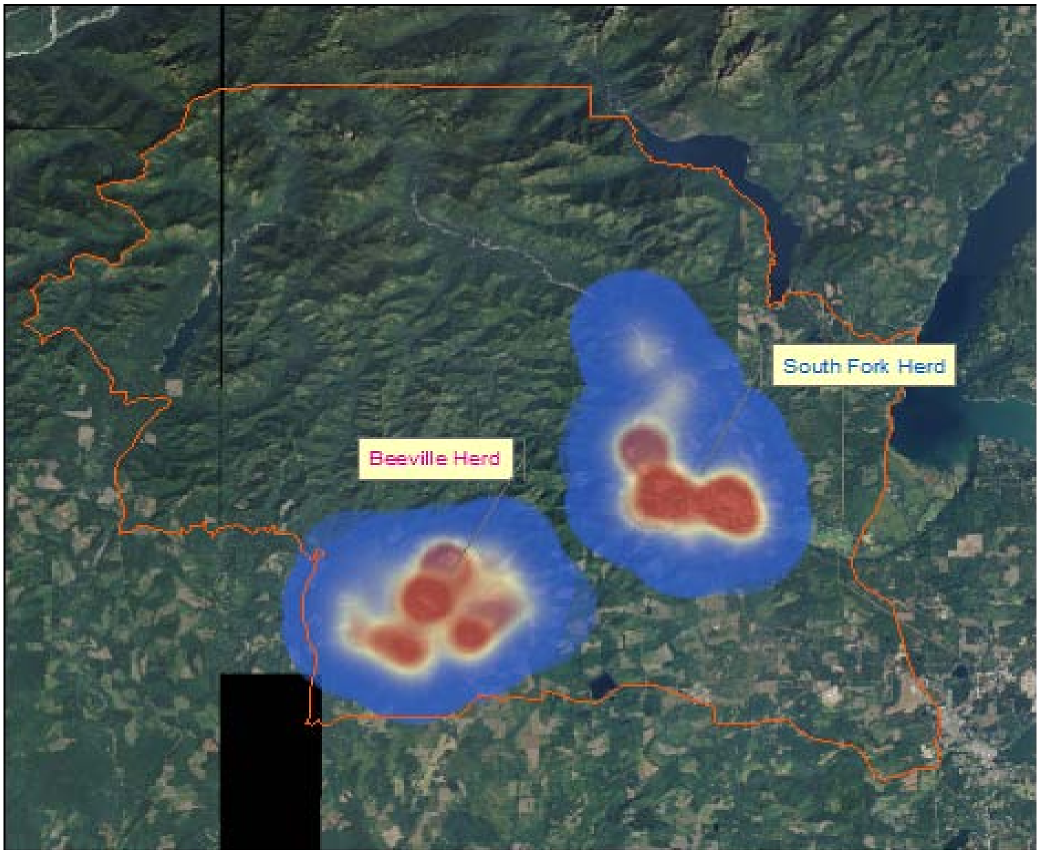


Figure 9: Spring Kernel Density Estimates for the Study Herds
Source: Skokomish DNR

During the winter the Beeville Herd continued to use an area about the same size as the spring high density area, but the South Fork's high density area was reduced to about 7 km² and was mostly centered on the private agricultural field of the Skokomish Farms. Beeville Herd's range during winter months seems to concentrate around private fields and wetlands.

<u>Discussion of Home Range Analysis</u>

Home range analysis assists land managers in understanding habitats that are most important for elk. In the case of the study herds, the areas surrounding drainages appear to be most important. During the study the South Fork Skokomish Herd spent the majority of the winter months from November until March in the Skokomish Valley on the Skokomish Farms and surrounding riparian and clear-cut areas. The Beeville Herd traveled through a variety of habitat types, including riparian and wetland areas during the winter, but increased time spent on private agricultural lands, and shows preference to a private agriculture and tree farm on the North section of the Beeville Loop. However, the landowner does not favor the presence of the herd damaging his crop and the group is often deterred from the area.

Figure 10**:** Major Drainages in the Skokomish GMU
Source: WDFW

Protecting habitat availability in the home range high use areas and adding to forage in areas less used surrounding high use areas could be important to assist the Skokomish herds' population growth. Changes to the highest use areas would probably be the most influential to the status of the herds. There has been a reduction of timber harvest in riparian areas in the past few decades to protect for salmon habitat (WDFW 2005; WDFW 2008), which could affect elk habitat in riparian areas and be reflected in elk population growth in the area.

Vegetation Analysis

The vegetation survey conducted for this project was on a relatively small scale. Minimal availability of time and resources only allowed for a simple look at the plant species composition for seven of the main habitat types within the study herds' home range. Twenty-eight 50m² plots with 560 1m² quadrats were sampled or 4 plots per habitat type. The plots were sampled from mid-April through early August and all sites had evidence of elk use. Precipitation during this time in 2010 ranged between 5-8 centimeters above normal average. Also, 4 biomass samples per habitat type were sampled. The biomass samples were taken during the highest period of growth for most vegetation species (Perez 2006). This is the time of year Roosevelt elk are believed to primarily eat grasses, forbs, and new growth on shrubs and trees (Cook 2002).

The results from the sampled plots are similar to results found by other vegetation studies in similar landscape types. Figure 11 shows the distribution of the vegetation classes found within the 7 habitat types. 169 different plant species were divided into vegetation classes composed of 36 grass species, including sedges and rushes, 90 forb species, flowering and non-flowering herbaceous plants, 27 shrub species were identified and 10 tree species were recorded. Additionally, there were 6 species classified as ferns including horsetail. Lichen, moss, and fungi species were located in the plots, but were not documented regardless of being a possible forage species for Roosevelt elk, because of time and sampling constraints. Appendix E has a full list of species found within the sampled plots.

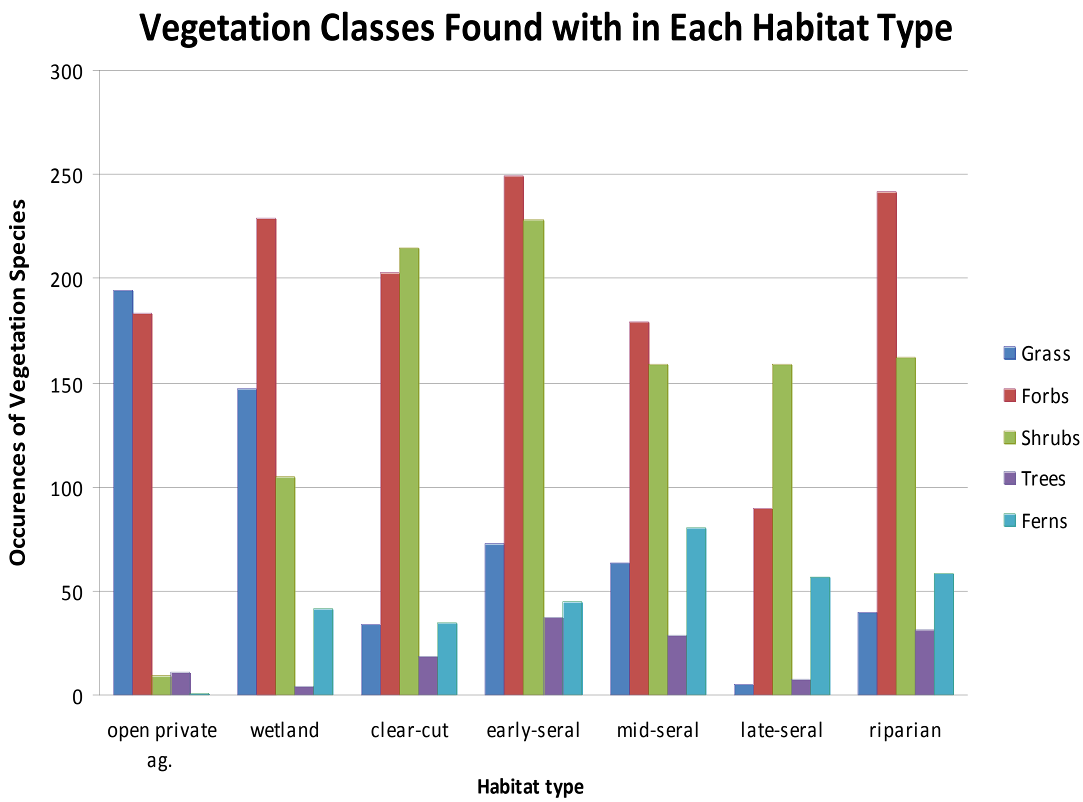


Figure 11: Vegetation Distribution in Seven Habitat Types
Source: Skokomish DNR-Emily Wirtz

The presence of grass species was highest in open agricultural fields and wetlands; grass species presence diminished with increasing age of forest stands. Forbs also diminished with increasing age of forest stands, possibly reflecting the effects of lower light availability coming through the forest canopy (Cook 2002). There was a higher presence of forbs than other species throughout most of the habitats with the lowest being in the late-seral forests, while shrubs held the second highest availability in almost every habitat except for agricultural fields where they were relatively low. Forbs species were highest in early-seral, riparian, and wetland habitats, respectively. Results for grass species in clear cuts were low, but were noticeably higher than in late-seral forests. Forb species in the clear-cuts were significantly high.

Jenkins and Starkey's "Food habits of Roosevelt Elk" (1991), was used as a reference to understand the importance of forage species identified within the vegetative plots. Based on forage preference studies of Roosevelt elk, this species of *Cervus* consumes a variety of vegetation types and their forage selection may vary even more depending on the time of year. Many forage studies like Jenkins and Starkey (1991), have quantified the quality of the forage species based on use, amount available, and amount sought out by elk within a habitat.

The dominant forage species in the Olympic Peninsula found by Jenkins and Starkey's study are listed by vegetation type: Preferred grass species are bent-grass (*Agrostis* spp.), sweet vernal grass (*Anthoxanthum odoratum*), and orchard grass (*Dactylis glomerata*). Forb species preferred are fireweed (*Epilobium angustifolium),* hairy cat's ear (*Hypochaeris radicata*), Redwood sorrel (*Oxalis oregana*) and foamflower trefoil (*Tiarella trifoliata*). Especially important in winter diets, are the shrub species such as salal (*Gaultheria shallon*), huckleberry (*Vaccinium* spp.), trailing blackberry (*Rubus ursinus*), and salmonberry (*Rubus spectabilis*). Preferred forage trees species for Roosevelt elk diets are red alder (*Alnus rubra*), cottonwood (*Populus trichocarpa*), Western hemlock (*Tsuga heterophylla*), and Western Red Cedar (*Thuja plicata*). Important fern species identified are sword fern (*Polystichum munitum*) and deer fern (*Blechnum spicant*). All of these species were present in some proportion within the sampled plots. Table 5 shows the proportion of each of these preferred forage species found within each habitat type.

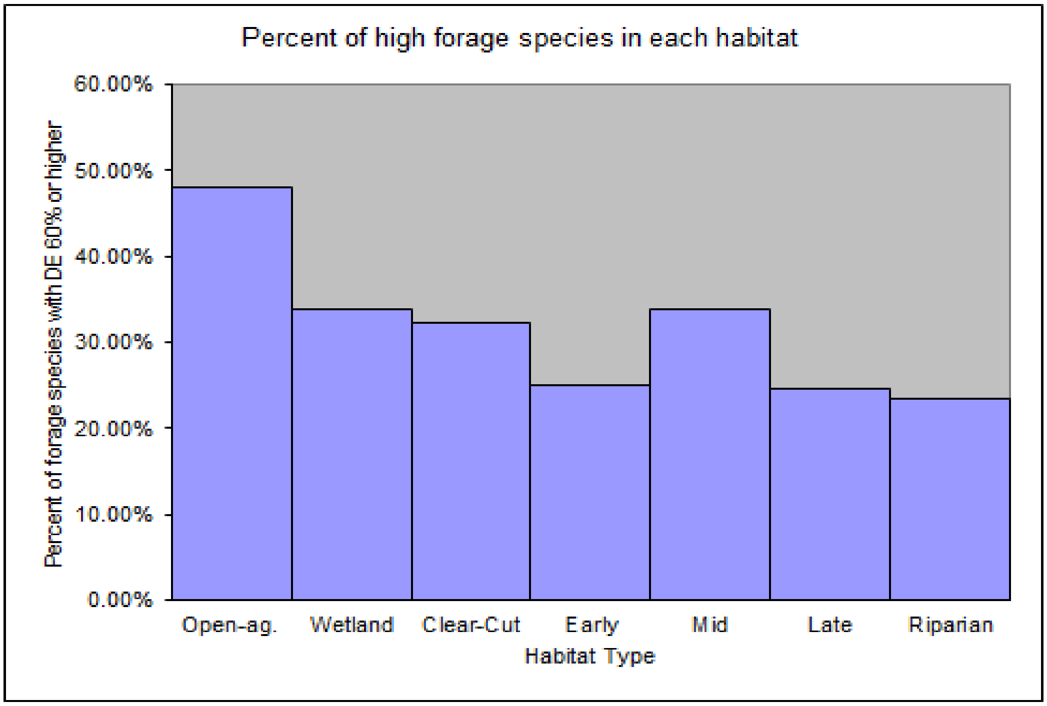
Of the vegetation species identified in all of the sampled plots at least 80% could be considered desired forage species for elk. Within each of the different habitat types there were between 89-96% forage species present in the sampled vegetation. The habitats sampled were almost the same for forage distribution. Depending on the time of year and growth status of the plants, some forage species are less significant to elk diet than others. Some of the available forage species have overall less quality nutrients to offer to elk year round. Therefore, percentages of highest quality forage would be lower for all habitats sampled.

Table 5: Proportion of Preferred Forage Species within Each Habitat Type

Type	Scientific Name	Common Name	Private ag.	Wetland	Clear-cut	Early	Mid	Late	Riparian
Grass	Agrostis spp.	bent-grass	0	0.05	0	0	0	0	0
	Anthoxanthum odoratum	sweet vernal grass	0.03	0.03	0.02	0	0	0	0
	Dactylis glomerata	orchard grass	0.11	0	0	0	0	0	0
Forbs	*Epilobium angustifolium*	fireweed	0	0	0	0	0.03	0	0.01
	Hypochaeris radicata	hairy cat's ear	0	0	0	0	0	0	0
	Oxalis oregana	redwood sorrel	0	0	0	0	0.04	0.01	0.04
	Tiarella trifoliata	foamflower trefoil	0	0	0	0	0	0	0.01
Shrub	*Gaultheria shallon*	salal	0	0	0	0.06	0.04	0.11	0.03
	Vaccinium spp.	huckleberry	0	0	0.14	0	0.03	0.04	0.01
	Rubus ursinus	trailing blackberry	0.01	0.06	0.1	0.1	0.1	0.15	0.05
	Rubus spectabilis	salmonberry	0	0.04	0	0	0.06	0	0.06
Tree	*Alnus rubra*	red alder	0	0	0	0.01	0	0	0
	Populus trichocarpa	cottonwood	0	0	0	0	0	0	0
	Tsuga heterophylla	western hemlock	0	0	0	0.01	0.01	0	0.02
	Thuja plicata	western red cedar	0	0	0	0	0	0	0
Fern	*Polystichum munitum*	swordfern	0	0.02	0	0.02	0.07	0.15	0.05
	Blechnum spicant	deer fern	0	0	0	0.01	0.01	0	0

Source: Skokomish DNR-Emily Wirtz

Having high quality forage available in the high use habitats may be more important than just having a large amount of forage species present. Higher quality forage species are most important to provide better nutrients to elk and increase reproductive success (Cook 2001). A majority of the forage species found in the vegetation surveys have moderate to low level digestible energy. Figure 12 shows forage species found within the vegetation plots that have reported digestible energy of 60% or more at the highest stage of growth (Schwarz 1945; Jenkins and Starkey 1993; Perez 2006). Plant species are considered of good nutrient quality to elk with 60% or more digestible energy (Jenkins and Starkey 1993; Perez 2006; Puget Sound Energy 2003). Many studies have shown high digestible energy to be an important factor in determining reproductive success for female elk as well as growth and survival rates in calves (Cook et. al. 2004; Cook 2002). Managed forests may produce a poorer quality of forage because of secondary plant compounds called tannins present in many forest species especially shrubs (Happe et. al. 1990; Cook 2002). Appendix D has a list of the high quality forage species present in each habitat type and the availability of each species found within the habitat.



Open-ag.	Wetland	Clear-Cut	Early	Mid	Late	Riparian
47.99%	33.78%	32.22%	25.16%	33.86%	24.61%	23.38%

Figure 12: High Quality Forage Species Percentages for Each Habitat Type
Source: Skokomish DNR-Emily Wirtz

Biomass can directly represent how much vegetation is present and the amount available to herbivores in the area (Bonham 1989; Perez 2006). Biomass calculations showed variations in weight totals with inconsistent patterns within each habitat type, which may have been affected by the time of year they were clipped or the specific spot clipped. Figure 13 shows the highest biomass totals were found in early-seral forests. This may reflect higher biomass in those areas because of increased sun exposure allowing for more growth. However, as discussed above, early-seral forest had the lowest high quality forage and the highest shrub abundance. The high weight totals may have come from the heavier shrub species found in the early-seral plots, such as Salal (*Gaultheria shallon*) that is heavier than grass or forb species but offers very little nutritional benefits for elk. Most of the totals for the other habitats averaged out about the same in relation to each other. Time of year can affect the biomass weight totals because the amount of biomass found for each plant type will vary depending on growth stage. The results from this study show June having the highest weight totals for most habitat types sampled. June in 2010 would have been the height of the growing season in the study area.

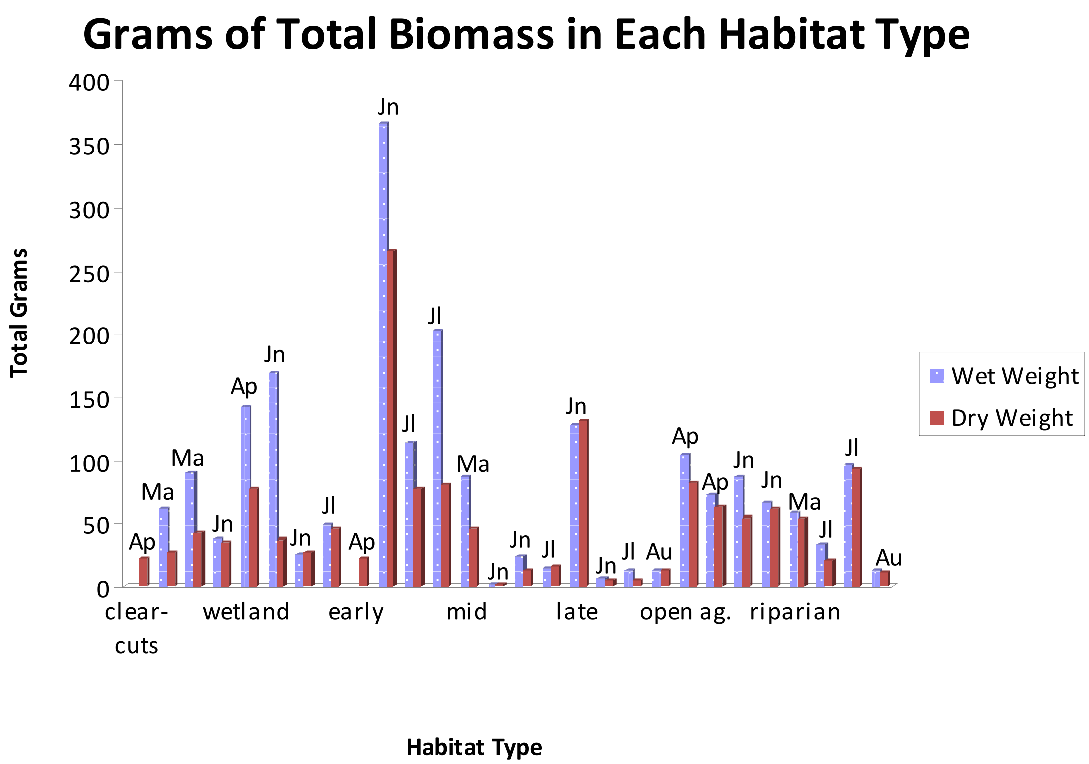


Figure 13: Biomass Totals for Sampled Habitats and the Date Clipped
Source: Skokomish DNR-Emily Wirtz

<u>Discussion of Vegetation Analysis</u>

Understanding habitat and forage availability is critical for managing elk population growth (Nickelson1996; Schirato 1996; WDFW 2005; WDFW 2008). Having higher quality forage available in a range that allows for the least amount of energy use can be a crucial way to improve reproductive health in elk herds (Cook 2002). Overall, the forage abundance seemed relatively high for the sampled areas. However, elk reproductive success will be tied mostly to nutritional value of the diet not just abundance of forage species (Perez 2006; Cook et. al. 2001). The availability of high nutritional value species was closely distributed throughout the habitat types. The species with the highest expected nutritional values were found in private agricultural fields but these values may fluctuate depending on the season.

Clear-cuts are considered desirable elk habitat, because of the ability of grass and forb species to grow in the newly open spaces. More recent forestry practices including clear-cuts in the Skokomish GMU are treated with herbicides, which can reduce the amount and quality of forage, especially winter forage species (Strong and Gates 2006). It is possible the quality of forage species in clear-cuts in the study area is less than desirable, and other habitats could be more beneficial to elk, because quality and nutrition of forage can limit elk more than abundance of forage (Happe et al. 1990; Cook et al. 2004; Perez 2006).

Similar habitat types near utilized areas that are not being used are expected to be limited by human disturbance factors poor quality or low availability of forage. The main human disturbance factors for habitat in the GMU are roads, private fences, and private residences. However, it is unclear from this study how much of a factor these disturbances play in elk habitat selection in the study area.

CHAPTER 3
DISCUSSION AND CONCLUSION

DISCUSSION

Based on the results of the population surveys carried out from October 2009-2010, population size may be slightly increasing in the Skokomish GMU and composition ratios are at an acceptable level to expect growth within the herds. Continued monitoring of the herds for at least 5-10 years will be necessary to find confidence in the growth pattern in the Skokomish herd.

Home range and vegetation analysis was carried out on two residential southeast elk herds in the 636 unit. The Deckerville group and the Wynoochee group were left out of the analysis because not enough data had been recorded on their locations. The Deckerville group shares a similar habitat distribution as the neighboring Beeville group. However, the Wynoochee reservoir herd uses Forest Service land containing late coniferous and riparian forest stands aging over 30 years. GMU 636 has a variety of habitat types supporting the Skokomish Herd, for example a study conducted on the Wynoochee reservoir elk herd showed the group would select mostly riparian or early-seral forest habitats (Perez 2006), while the Beeville herd spends more time in wetlands, riparian areas, and early growth stands, and the South Fork Skokomish herd was mostly divided between private agriculture and riparian areas. Therefore, when planning habitat enhancement projects in GMU 636, it will be important to understand different habitat use between herds.

The study herds' habitat preferences are mostly wetlands, riparian strips, and agricultural lands. Other studies have shown seasonal variations in elk diet preferences. In general, Roosevelt elk will consume mostly forb and grass species, with an increase in eating conifer species during early growth stages of late winter and early spring (Happe et. al. 1993). The vegetation analysis conducted for the study herds found the highest quality forage species were present in private agricultural lands, but that the overall forage availability in each habitat area was relatively similar. Each of the study herds use about 22-25% of their home ranges the majority of the time, mostly wetland and riparian areas were favored by the herds. The high use areas will be important habitat areas to protect within the Skokomish unit.

HABITAT ENHANCEMENT PROJECTS

The USFS in cooperation with the Skokomish Tribe has begun habitat enhancement projects within the Skokomish GMU. These projects work towards improving elk habitat through increased forage availability on Forest Service land and reducing the number of accessible roads. USFS discontinued major logging operations on these lands by the 1980's, so the majority of forests managed by USFS are even aged, late-seral stands. These habitats are believed to be less attractive to elk herds, unless in range of a more open area with a higher quality of forage (Jenkins and Starkey 1991).

The USFS has begun thinning and reseeding forage projects in South Fork Skokomish watershed with intentions of opening up more attractive areas for elk, deer, and other small game. Also, the USFS has begun decommissioning older, unused roads in the area and planting forage species where the roads were before, increasing elk security areas or areas protected from human disturbance. The thinning projects will include native forage seeding and planting with attempts to improve the understory forage available in forested areas (Ward and Fiegener 2007). Once these projects are complete they will be monitored by the USFS and the Skokomish Department of Natural Resources to identify if the areas are successfully attracting elk and other species. If the habitat enhancement projects are successful then these types of projects could be a useful tool for improving elk forage within other Forest Service managed lands. Two of the best known ways to improve elk habitat are through reduction in road densities and increased quality of forage, especially during the spring green-up period (WDFW 2004).

There are multiple areas in the range of the Beeville and South Fork Herd that have gate closures both for purposes of assisting wildlife and to generally limit human use of older logging roads and disturbance to the herds. Appendix B has a map of areas being improved for elk habitat enhancement in the range of the

South Fork of the Skokomish River. The elk symbol indicates areas where projects have already begun and areas that have future projects planned. In fall 2010, forage species were planted in the area north of Browns Creek Campground, future monitoring of the area will indicate the effectiveness of the project. Areas highlighted yellow on the map indicate potential elk security areas.

LAKE CUSHMAN SETTLEMENT

In 2009, Tacoma Power Company made a settlement with the Skokomish Tribe as part of the Lake Cushman Dam No. 2 project completed in 1930. Tacoma Power has agreed to construct, maintain, and monitor up to 200 acres of elk forage fields in the Skokomish River area to make up for the loss of habitat or habitat disturbance due to dam construction on the North Fork of the Skokomish River (Cushman 2009). Currently, the location they would most prefer for the addition of forage fields is undecided. There are five or six parcels within or near GMU 636 that have been considered for the addition of forage fields based on the Wildlife Habitat Enhancement Plan in the Lake Cushman settlement.

Another option for increasing forage quality and availability in the Skokomish GMU would be adding mitigation or forage fields around the herds' high use areas. The addition of forage fields would be especially useful for areas where elk herds use private fields during winter months and cause damage to the landowners' crops. It could be useful to both the herd and the landowner to have a more attractive option away from these private lands. Forage fields have been shown to contain a high quality of forage that can aid in reproductive success and assist in elk population growth (Perez 2006).

Forage fields can be a useful way for herds to obtain necessary amounts of high quality forage during the summer and fall (Perez 2006). Recent studies have shown the importance in elk herds being able to find high quantities of nutritious forage during the summer and fall months (Cook et al. 2004). Spring green-up assists with restocking body fat after the winter, but elk also need enough fat build-up from summer and fall to survive the winter (Cook 2002; Cook et al. 2004). Poor nutrition in the summer and fall home ranges can lead to later birth dates in calves and can affect reproductive success within a herd (Cook et al. 2004).

FUTURE RESEARCH

Important research for future projects in the study area includes: a larger, more in depth study of availability, quality, and preference of forage in habitats both inside and outside the herds' home ranges and in various soil types, canopy covers, and other varying landscape characteristics, and a study investigating barriers or disturbances, other than forage availability, keeping elk herds from selecting nearby, similar habitats. An analysis of available forage in relation to nearest cover and size of nearest cover in relation to patch size would be an important addition to the vegetation analysis in the study area.

Using Resource Selection Function (RSF) could be useful for studying habitat selection when using GPS collared elk in future studies (Friar 2004). RSF measures the value of resource units based on the proportion of the probability that the resource will be used by an organism (McLoughlin et. al. 2010). Understanding the relationship between deer and elk ecology and cougar and elk ecology in the area could be helpful future research. Finally, monitoring the collared herds in the Skokomish unit for at least another 5 to 10 years would allow for a better management of the herd for harvest purposes and a better understanding of the causes for natural and unnatural mortality.

CONCLUSION

This thesis assessed the general status of elk in the Skokomish herd and looked more closely at the habitat availability and use by two elk herds in the Skokomish GMU 636, and considered factors other than habitat that may affect elk herds in the area. The Skokomish GMU has been heavily logged for many decades, which has severely changed the dynamic and complexity of the habitat. More recent forestry management practices in this area have reduced the amount of logging and road activity, which may improve the present and future habitat conditions, but could also leave a large amount of even-aged low quality forage habitats. Also, the use of herbicides to eliminate undergrowth species in fresh clear-cuts could be affecting the forage availability in these habitats.

Increased habitat enhancement projects could be highly beneficial to the elk herds in the Skokomish GMU to offer a more stable habitat that will experience less change and disturbance from logging practices and can allow for high quality forage species growth. The forage projects are more valuable if high quality forage species are added at least a quarter-mile or more from a well-traveled road (Potash 2007). In addition, adding forage fields to the Skokomish GMU could be an important management tool for improving elk herds' populations and decreasing the damage to private agricultural fields.

Monitoring closely the elk harvest numbers and estimated poaching numbers will be necessary in the GMU. Increasing enforcement near the known elk high use areas could possibly assist in regulating elk poaching numbers. Also, increasing public awareness about poaching could greatly benefit the Skokomish elk herds. Wildlife managers may need to consider reducing harvest seasons or tag availability to lessen the burden on the herds. The herds are showing sustainable composition ratios. However, monitoring the mature branch bull numbers in the Skokomish GMU may be important, especially in the South Fork Skokomish Herd.

Monitoring the Skokomish herd and continuing studies in the Skokomish GMU will be important for the future status of elk populations in the Skokomish historical hunting areas. Projects combining efforts of the Skokomish Tribe, Washington Department of Fish and Wildlife, the Green Diamond Resource Company, Tacoma Power, and the US Forest Service could be the best management practice for meeting the needs of all interested parties, while still maintaining sustainable wildlife populations, including Roosevelt elk.

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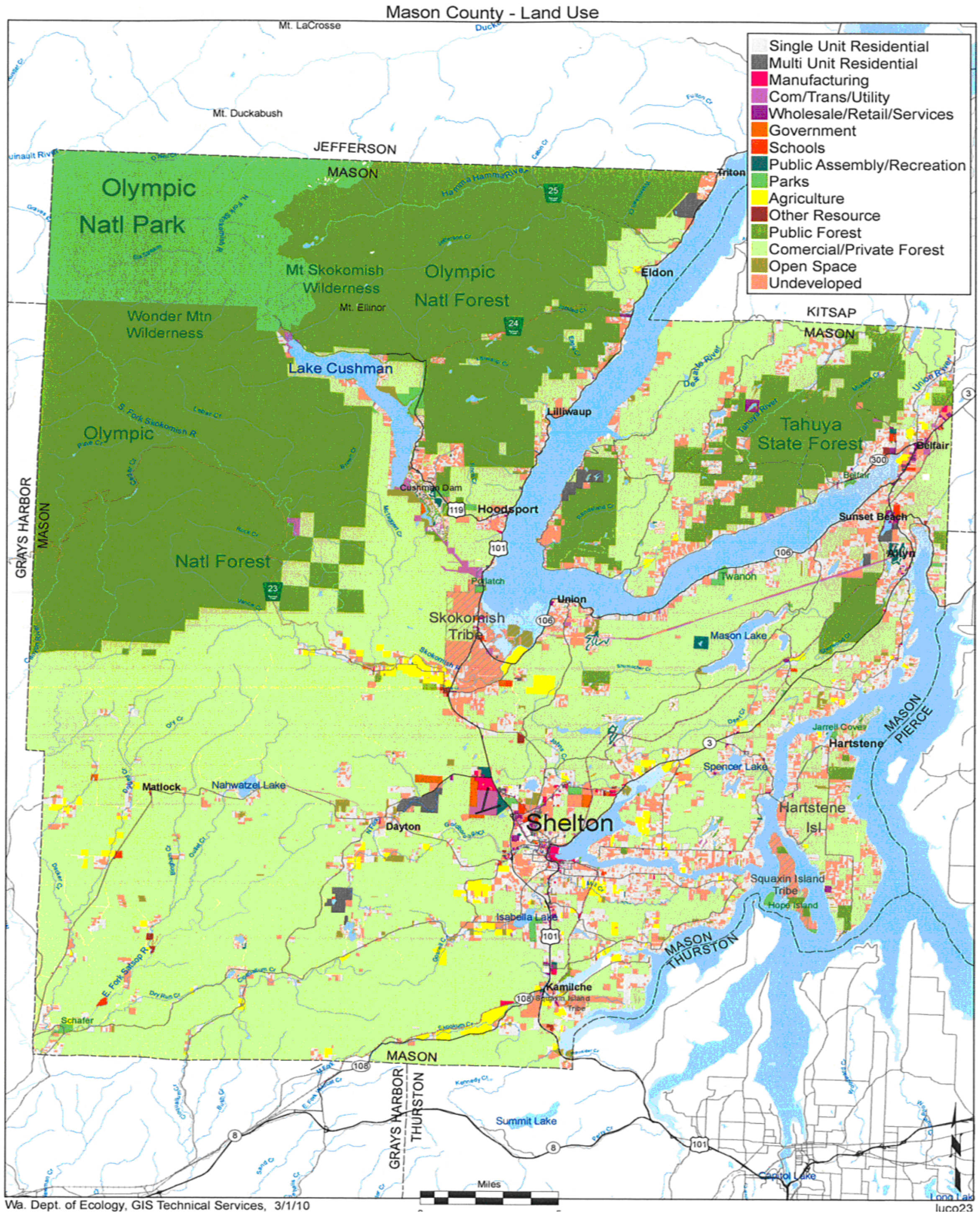
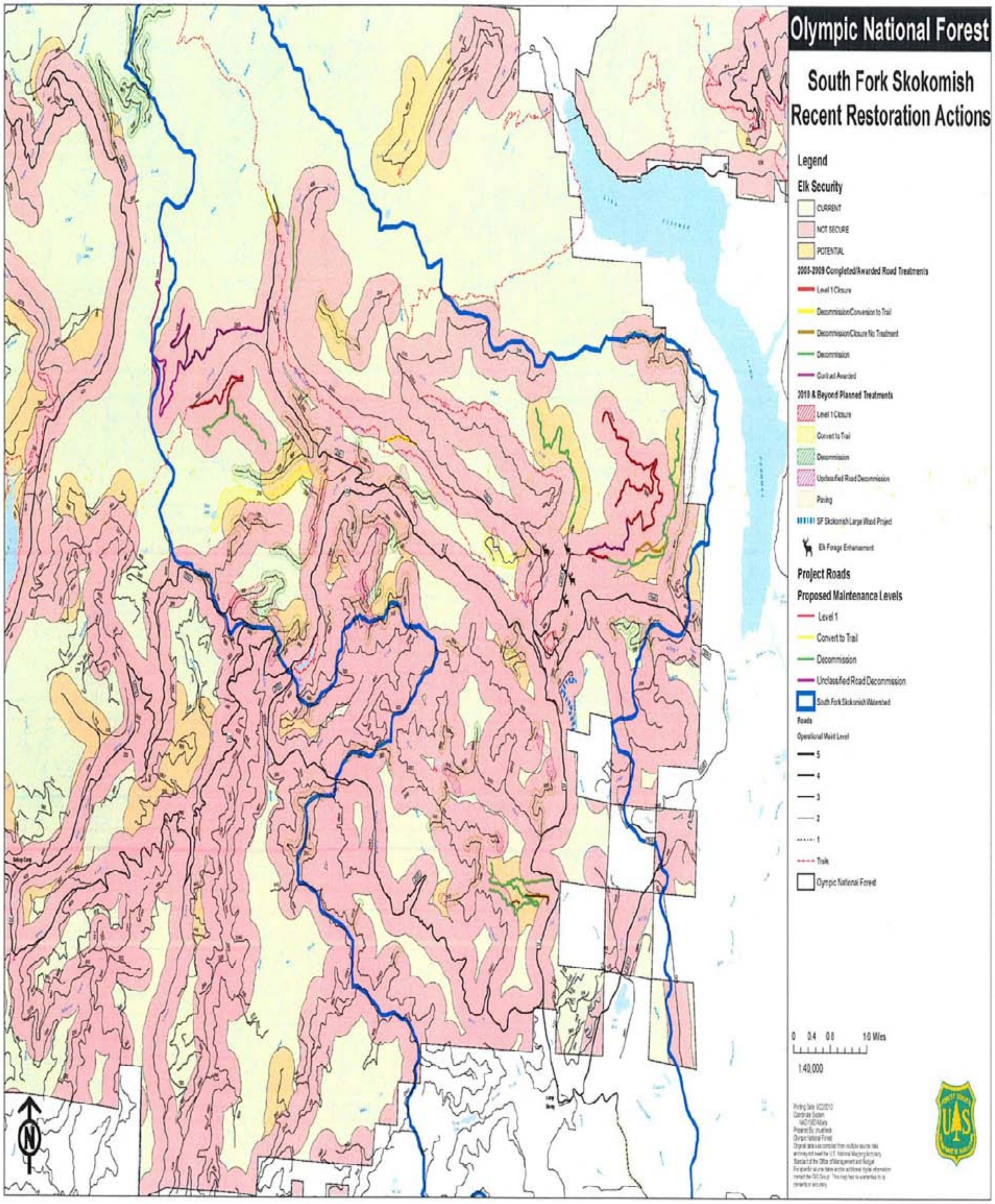
Appendix A: Map of Land Use in Mason County and the Skokomish Reservation



Source: WA Department of Ecology

Appendix B: USFS Map of Habitat Projects in the South Fork Skokomish Area



Source: US Forest Service

Appendix C: Hunting Committee Survey Results

Hunting Committee Survey Results

Number of years hunting GMU 636

30	40	36	20+

	Similar Responses
Main changes noticed in the Skokomish herds	
Diminished population	III
Habitat	II
Poaching	
Moved to lower elevations along the rivers	II
Over harvest	
Less large bulls	
Main causes of the changes in the herds	
Due to logging and development	III
Lack of enforcement	
Overhunting-lack of accurate harvest data	III
Main improvements necessary to increase population	
Better habitat	III
Smaller season	
More enhancement conservation GMU closers	II
Better communication between state and tribal wildlife managers	
Restrictions on hunting permits	
Cooperative management-state/tribes	
More biological studies/forage projects	
Improve mature bull count	
Other thoughts about management practices	
State needs better hunting plans, management practices	
Elk are very important to us (the Skokomish Tribe)	
Need to make quick improvements to ensure the elk don't go extinct	
More restrictive logging practices-control of pesticide spraying	
Preserve habitat and increase forage projects	III
Close GMU	

Source: Skokomish DNR-Emily Wirtz

Appendix D: Occurrences of High Quality Forage Species Found in Each Habitat Type

	Open/Private agricultural fields		
	Scientific name	Common name	Occurrences
Grass	*Poa Pratensis*	Kentucky Bluegrass	78
	Dactylis glomerata	Orchard grass	46
	Holcus lanatus	Common velvet-grass	17
	Phleum pratense	Timothy	8
	Elymus glaucaus	Blue wildrye	3
	Agrostis exarata	Spike bentgrass	2
Forb	*Trifolium repens*	White clover	46
	Plantago lanceolata	English plantain	33
	Trifolium hybridium	alsike clover	12
	Viola sempervirens	Trailing yellow violet	2
	Trifolium dubium	Small hop-clover	1
	Hypochaeris radicata	Hairy cat's-ear	1
	Wetland		
Grass	*Poa Pratensis*	Kentucky Bluegrass	20
	Agrostis exarata	Spike bentgrass	17
	Holcus lanatus	Common velvet-grass	17
	Carex sitchensis	Sitka sedge	8
	Agrostis capillaris	Colonial bentgrass	5
	Agrostis stolonifera	creeping bentgrass	5
	Dactylis glomerata	Orchard grass	5
	Poa palustris	fowl bluegrass	4
	Elymus glaucaus	Blue wildrye	3
	Carex laeviculmis	smooth sedge	3
	Carex arcta	northern clusterd sedge	2
Forb	*Carex athrostachya*	slender-beak sedge	2
	Festuca rubra	Red fescue	1
	Claytonia sibirica	Candy flower	13
	Maianthemum dilitatum	False lily of the valley	10
	Galium aparine	common bedstraw	8
	Veronica officinales	herbal speedwell	7
	Dicentra formosa	Pacific bleeding heart	6
	Oxalis oregana	Redwood sorrel/Oregon oxalis	3
	Stachys cooleyae	Cooley's hedge-nettle	3
	Trifolium dubium	Small hop-clover	3
	Viola sempervirens	Trailing yellow violet	3
	Viola palustris	marsh violet	3
	Oenanthe sarmentosa	Pacific water-parsley	2
Shrub	*Symphoricarpos albus*	common snowberry	4
	Vaccinium parvifolium	Red huckleberry	2
	Mahonia nervosa	Dull Oregon-grape	1
Ferns	*Equisetum arvenase*	Horsetail	17

	Blechnum spicant	Deer fern	1
	Clear-cut		
	Festuca rubra	Red fescue	11
	Poa pratensis	Kentucky bluegrass	6
Forb	*Dactylis glomerata*	Orchard grass	3
	Trifolium repens	White clover	50
	Epilobium angustifolium	Fireweed	21
	Trifolium hybridium	alsike clover	12
	Anaphalis margaritacea	Pearly everlasting	11
	Trifolium dubium	Small hop-clover	4
	Maianthemum dilitatum	False lily of the valley	3
	Viola sempervirens	Trailing yellow violet	3
Shrub	*Veronica officinales*	herbal speedwell	3
	Mahonia nervosa	Dull Oregon-grape	28
	Vaccinium parvifolium	Red huckleberry	4
	Symphoricarpos albus	common snowberry	3
Fern	*Blechnum spicant*	Deer fern	3
	Early-Seral		
Grass	*Poa Pratensis*	Kentucky Bluegrass	14
	Holcus lanatus	Common velvet-grass	14
	Elymus glaucaus	Blue wildrye	9
	Carex sp.		7
	Dactylis glomerata	Orchard grass	6
	Poa palustris	fowl bluegrass	2
Forb	*Epilobium angustifolium*	Fireweed	17
	Viola sempervirens	Trailing yellow violet	15
	Anaphalis margaritacea	Pearly everlasting	11
	Maianthemum dilitatum	False lily of the valley	8
	Oxalis oregana	Redwood sorrel/Oregon oxalis	7
	Veronica officinales	herbal speedwell	7
	Trifolium repens	White clover	3
	Galium aparine	common bedstraw	2
	Hypochaeris radicata	Hairy Cat's-Ear	2
	Dicentra formosa	Pacific bleeding heart	1
		Lily Sp.	1
Shrub	*Vaccinium parvifolium*	Red huckleberry	18
	Symphoricarpos albus	common snowberry	7
	Mahonia nervosa	Dull Oregon-grape	1
Fern	*Blechnum spicant*	Deer fern	7
	Mid-Seral		

Grass	*Carex deweyana*	Dewey's sedge	5
	Holcus lanatus	Common velvet-grass	4
	Poa palustris	fowl bluegrass	4
	Dactylis glomerata	Orchard grass	3
	Poa Pratensis	Kentucky Bluegrass	2
	Festuca rubra	Red fescue	2
	Agrostis stolonifera	creeping bentgrass	2
	Carex sp.		2
	Carex laeviculmis	smooth sedge	1
	Agrostis capillaris	Colonial bentgrass	1
	Elymus glaucaus	Blue wildrye	*2*
Forb	*Oxalis oregana*	Redwood sorrel/Oregon oxalis	20
	Viola sempervirens	Trailing yellow violet	19
	Claytonia sibirica	Candy flower	15
	Epilobium angustifolium	Fireweed	17
	Maianthemum dilitatum	False lily of the valley	12
	Dicentra formosa	Pacific bleeding heart	7
	Galium triflorum	sweet scented bedstraw	5
	Anaphalis margaritacea	Pearly everlasting	5
	Trifolium dubium	Small hop-clover	3
	Trifolium repens	White clover	2
	Plantago lanceolata	English plantain	2
	Galium aparine	common bedstraw	1
	Lupinus nootkatensis	Nootka lupin	1
	Lupinus polyphyllus	Large-leaved lupine	1
	Trifolium hybridium	alsike clover	1
	Veronica officinales	herbal speedwell	1
Shrub	*Vaccinium parvifolium*	Red huckleberry	16
	Mahonia nervosa	Dull Oregon-grape	4
Tree	*Populus trichocarpa*	black cottonwood, balsam poplar	3
Fern	*Blechnum spicant*	Deer fern	7
	Equisetum arvenase	Horsetail	4
	Late-Seral		
Grass	*Agrostis capillaris*	Colonial bentgrass	1
	Carex sp.		1
Forb	*Dicentra formosa*	Pacific bleeding heart	8
	Maianthemum dilitatum	False lily of the valley	5
	Oxalis oregana	Redwood sorrel/Oregon oxalis	5
	Veronica officinales	herbal speedwell	4
	Viola sempervirens	Trailing yellow violet	3
	Galium aparine	common bedstraw	2
	Galium triflorum	sweet scented bedstraw	2
	Claytonia sibirica	Candy flower	2
Shrub	*Mahonia nervosa*	Dull Oregon-grape	33

	Vaccinium parvifolium	Red huckleberry	13
	Riparian		
Grass	*Holcus lanatus*	Common velvet-grass	4
	Carex deweyana	Dewey's sedge	3
	Carex sp.		3
	Poa sp.		3
	Elymus glaucaus	Blue wildrye	1
Forb	*Oxalis oregana*	Redwood sorrel/Oregon oxalis	20
	Dicentra formosa	Pacific bleeding heart	13
	Claytonia sibirica	Candy flower	12
	Epilobium angustifolium	Fireweed	8
	Galium aparine	common bedstraw	8
	Galium triflorum	sweet scented bedstraw	6
	Maianthemum dilitatum	False lily of the valley	4
	Viola sempervirens	Trailing yellow violet	4
	Anaphalis margaritacea	Pearly everlasting	2
	Plantago lanceolata	English plantain	2
	Trifolium repens	White clover	1
	Trifolium dubium	Small hop-clover	1
	Lupinus nootkatensis	Nootka lupin	1
Shrub	*Mahonia nervosa*	Dull Oregon-grape	15
	Vaccinium parvifolium	Red huckleberry	6
Fern	*Equisetum arvenase*	Horsetail	7
	Blechnum spicant	Deer fern	1

Source: Skokomish DNR-Emily Wirtz

Appendix E: All Species Present within Sampled Plots

Scientific Name	Common Name	Forage Species
Abies amabilis	Pacific silver fir	√
Acer circinatum	Vine maple	√
Acer macrophyllum	Bigleaf maple	√
Achillea millefolium	Yarrow	√
Achlys triphylla	Vanilla-leaf	x
Adenocaulon bicolor	Pathfinder	x
Agrostis capillaris	Colonial bentgrass	√
Agrostis exarata	Agrostis exarata	√
Agrostis stolonifera	creeping bentgrass	√
Alnus rubra	Red alder	√
Amelanchier alnoifolia	Saskatoon	√
Anaphalis margaritacea	Pearly everlasting	√
Anthoxanthum odoratum	Sweet vernal grass	√
Arctostaphylos columbiana	hairy manzanita	x
Arrhenatherum elatius	Tall oatgrass	√
Arctostaphylos uva-ursi	Kinnikinnick	√
Asarum caudatum	wild ginger	√
Athyrium filix-femina	common ladyfern	√
Blechnum spicant	Deer fern	√
Bromus hordeaceus	soft brome	√
Bromus sitchensis	Alaska brome	√
Bromus vulgaris	Columbia brome	√
Cardamine angulata	angled bittercress	x
Carex arcta	northern clusterd sedge	√
Carex athrostachya	slender-beak sedge	√
Capsella bursa-pastoris	shepard's purse	√
Carex deweyana	Dewey's sedge	√
Cardamine hirsuta	hairy bittercress	x
Carex laeviculmis	smooth sedge	√
Campanula scouleri	pale bellflower/scouler's harebell	x
Carex sitchensis	Sitka sedge	√
Cerastium arvense	Field chickweed	√
Circaea alpina	enchanter's-nightshade	x
Cirsium arvense	Canadian thistle	√
Cirsium edule	Edible thistle	√
Claytonia sibirica	Candy flower	√
Cornus canadensis	Bunchberry	√
Corylus cornuta	beaked hazelnut	√
Cornus stolonifera	Red-osier dogwood	√
Crepis capillaris	Smooth hawksbeard	x
Cytisus scoparius	Scotch broom	x
Danthonia californica	California oatgrass	√
Dactylis glomerata	Orchard grass	√
Danthonia intermedia	Timber Oat-Grass	√

Deschampsia cespitosa	Tufted hairgrass	√
Dicentra formosa	Pacific bleeding heart	√
Digitalis purpurea	common foxglove	√
Dryopteris expansa	wood fern	√
Draba verna	Common draba	x
Elymus glaucus	Blue wildrye	√
Elymus hirsutus	Hairy wildrye	√
Epilobium angustifolium	Fireweed	√
Epilobium ciliatum	purple-leaved willowherb	√
Equisetum arvenase	Horsetail	√
Festuca occidentalis	western fescue	√
Festuca rubra	Red fescue	√
Festuca subulata	Bearded fescue	√
Fragaria virginiana	Wild strawberry	√
Galium aparine	common bedstraw	√
Galium triflorum	sweet scented bedstraw	√
Gaultheria shallon	Salal	√
Glyceria elata	tall mannagrass	√
Glehoma hederacea	creeping charlie	x
Goodyera oblongifolia	Rattlesnake-plantain	x
Heracleum lanatum	cow-parsnip	√
Heracleum maximum	common cow-parsnip	√
Heuchera micrantha	Small-flowered alumroot	x
Hierchloe occidentalis	California sweetgrass	√
Hieracium albiflorum	white-flowered hawkweed	√
Holcus discolor	Oceanspray	√
Holcus lanatus	Common velvet-grass	√
Hypochaeris radicata	Hairy Cat's-Ear	√
Hydrophyllum tenuipes	Pacific waterleaf	x
Juncus effusus	common rush	√
Lapsana communis	nipplewort	x
Lamiastrum galeobdolon	yellow archangel	x
Linnaea borealis	twinflower	√
Leucanthemum vulgare	Oxeye daisy	x
Lotus pinnatus	meadow bird's-foot trefoil	√
Lupinus nootkatensis	Nootka lupin	√
Lupinus polyphyllus	Large-leaved lupine	√
Lysichiton americanum	skunk cabbage	√
Lycopodium clavatum	Running clubmoss	
Maianthemum dilitatum	False lily of the valley	√
Malus fusca	Pacific crab apple	x
Matricaria discoidea	Pineapple weed	x
Mahonia nervosa	Dull Oregon-grape	√
Medicago lupulina	black medic	√
Melica subulata	alaska oniongrass	√
Myosotis sp.	Forget-me-not	x
Nothochelone nemorosa	woodland penstemon	x
Oemleria cerasiformis	Indian Plum	√

Oenanthe sarmentosa	Pacific water-parsley	√
Oplopanax horridum	Devil's club	√
Oxalis oregana	Redwood sorrel/Oregon oxalis	√
Petasites palmatus	palmate coltsfoot	√
Phalaris arundinacea	Reed canary grass	√
Phleum pratense	Timothy	√
Pinus monticola	western white pine	x
Plantago lanceolata	English plantain	√
Plantago major	common plantain	√
Poa bulbosa	bulbous blue grass	√
Polystichum munitum	Sword fern	√
Poa palustris	fowl bluegrass	√
Poa pratensis	Kentucky bluegrass	√
Populus trichocarpa	black cottonwood, balsam poplar	√
Prunus emarginata	bitter cherry	√
Pseudotsuga menziesii	Douglas fir	√
Pteridium aquilinum	Bracken fern	√
Puccinellia pumila	Dwarf alkali grass	√
Ranunculus occidentalis	Western buttercup	√
Ranunculus repens	Creeping buttercup	√
Ranunculus uncinatus	Little buttercup	√
Rosa gymnocarpa	Baldhip rose/dwarf	√
Rosa nutkana	Nootka rose	√
Rhododendron albiflorum	White-flowered rhododendron	x
Rhamnus purshiana	Cascara	√
Ribes lacustre	prickly current/gooseberry	√
Rumex acetosella	common sheep sorrell	√
Rumex crispus	curly or sour dock	√
Rubus discolor	himalayan blackberry	√
Rubus laciniatus	evergreen blackberry	√
Rubus leucodermis	whitebark/black raspberry	√
Rumex obtusifolius	bitter dock	√
Rubua parviflorus	Thimbleberry	√
Rubus spectabilis	Salmonberry	√
Rubus ursinus	Trailing blackberry	√
Sambucus racemosa ssp. Pubens	Red elderberry	√
Sanguisorba officinalis	official burnet	x
Scirpus microcarpus	small-flowered bulrush	√
Schedonorus pratensis	meadow fescue	√
Senecio jacobaea	tansy ragwort	√
Sisyrinchium idahoense var. macounii	blue-eyed grass	x
Smilacina racemosa	false solomon's seal	√
Smilacina stellata	star-flowered false solomon's-seal	√
Spirea douglasii	hardhack	√
Stellaria borealis	boreal starwort	√
Stellaria calycanha	northern starwort	√

Stachys cooleyae	Cooley's hedge-nettle	√
Stellaria crispa	curled starwort	√
Stachys mexicana	mexican hedge-nettle	√
Symphoricarpos albus	common snowberry	√
Symphoricarpos mollis	trailing snowberry	√
Taraxacum officinale	Common dandelion	√
Thalictrum occidentale	western meadowrue	√
Thuja plicata	Western redcedar	√
Tiarella trifolia	Foamflower	√
Tolmiea menziesii	piggy-back plant	√
Trisetum cernuum	nodding trisetum	√
Trifolium dubium	Small hop-clover	√
Trifolium hybridium	alsike clover	√
Trientalis latifolia	western starflower	√
Trillium ovatum	western trillium	√
Trifolium repens	White clover	√
Tsuga heterophylla	Western hemlock	√
Typha latifolia	cattail	√
Urtica dioica	Stinging nettle	x
Vaccinium ovatum	Evergreen huckleberry	√
Vaccinium parvifolium	Red huckleberry	√
Vancouveria hexandra	Inside-out flower	x
Veronica americana	American-brooklime or speedwell	√
Veronica officinales	herbal speedwell	√
Veratrum viride	green false hellebore	√
Vicia americana	American vetch	x
Viola palustris	marsh violet	√
Vicia sativa	Common vetch	x
Viola sempervirens	Trailing yellow violet	√
Vulpia bromoides	barren fescue	√
Xerophyllum tenax	bear-grass	√
Whipplea modesta	Whipplevine	√

Source: Skokomish DNR-Emily Wirtz