Washington State Elk Herd Plan

NORTH RAINIER ELK HERD

Washington Department of Fish and Wildlife
Wildlife Program
600 Capitol Way North
Olympia, WA 98501-1091

Prepared by

Michelle Tirhi, Wildlife Biologist, Washington Department of Fish and Wildlife

David Vales, Wildlife Biologist, Muckleshoot Indian Tribe

Mike Smith, Wildlife Biologist, Washington Department of Fish and Wildlife

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Director, Washington Department of Fish and Wildlife

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Preliminary Data

A considerable amount of data for this report was provided by the Muckleshoot Indian Tribe collected during their studies beginning in 1998. The studies are ongoing and the data analysis is preliminary. Results presented herein identified as Muckleshoot Indian Tribe (or MIT) unpubl. data must not be cited or used without expressed written permission from the Muckleshoot Indian Tribe's Wildlife Program Director.

This plan should be cited as:

Washington Department of Fish and Wildlife. 2019. North Rainier Elk Herd Plan. Wildlife Program, Wash. Dept. Fish and Wildl., Olympia. 103 pp.

NORTH RAINIER ELK HERD PLAN

EXECUTIVE SUMMARY

The North Rainier Elk Herd is one of ten elk herds, as defined by the WDFW for management purposes, residing in Washington State. This elk herd's range encompasses portions of Pierce, King, Snohomish and Kittitas counties. These elk are distributed along the western slopes of the Cascade Mountain Range, however, some elk that winter on the east side of the Cascades spend time on the west side during summer. Small satellite groups occur in the foothills and pockets of habitat near urban and suburban developments. This herd is an important resource that provides significant recreational, subsistence, cultural, aesthetic and economic benefits to Washington citizens and is a valued cultural, subsistence, and ceremonial resource to the Native American people of the area.

This plan's purpose is to provide direction for managing the North Rainier elk resource into the future as well as provide a historical perspective on the herd. This plan is subject to amendment as needed, and will be in effect until revised. It will be a valuable reference document and guideline for the Washington Department of Fish and Wildlife, tribes, agency cooperators, landowners, land planners and the general public. Priority management and research activities will be implemented as funding and resources become available.

Four primary goals guide the North Rainier Elk Herd Plan:

1. Preserve, protect, perpetuate, manage and enhance elk habitats to ensure healthy, productive populations
2. Manage the North Rainier elk herd for a sustained annual harvest
3. Manage elk for a variety of recreational, educational, and aesthetic purposes including hunting, scientific study, cultural and ceremonial uses by Native Americans, wildlife viewing and photography
4. Minimize property damage and public safety risks associated with elk

Specific elk herd and habitat management objectives, problems, and strategies are identified in this plan. Priority objectives address specific problems in managing this elk herd, and a variety of strategies have been developed to solve these problems.

The following herd management objectives have been identified:

- Develop and implement standardized and statistically valid survey protocols that will generate reliable estimates of population size or indices of population trend for the North Rainier elk herd by 2025.
- Maintain the NREH at 4,850 elk (+ or – 10%), as determined by post-season population estimates, using the accepted protocols identified in Objective 1.
- Manage the elk herd to maintain minimum post-season bull to cow ratios of 12 to 20 bulls per 100 cows.

- While attempting to achieve the population objective, reduce the number of elk-caused damage complaints on private lands in the NREH area.
- By 2025 initiate at least two projects that focus on reducing elk vehicle collisions in high collision areas.
- By 2025 complete at least two projects that enhance the public's ability to observe and appreciate elk in their natural habitat or increase public understanding of elk biology and their habitat requirements.
- Meet as necessary, but at least annually to cooperate and collaborate with the Tribes to implement the NREH Plan.

The Spending Priorities section shows the additional funding needed to complete priority tasks in this plan. Most of the strategies listed in the plan do not require additional funding, but only a change to WDFW staff work-plan assignments. This is called base funding. In addition, many priority tasks are already being performed each year, sometimes by outside partners such as the MIT. Only Objective 1 requires spending above base funding.

SPENDING PRIORITIES	CURRENT EXPENDITURE	1ST YEAR	Additional years
FORMAL ESTIMATES OF HERD DEMOGRAPHICS	**$00.00**	**$7,000**	**$7,000**

Abbreviations used in this plan:

BY	Biological Year – A biological year begins on June 1 and ends May 31 of the following year. For example, spring 2015 survey data represent biological year 1 June 2014-31 May 2015.
BLM	United States Bureau of Land Management
BPA	Bonneville Power Administration
DNR	Washington State Department of Natural Resources
DOD	United States Department of Defense (primarily Joint Base Lewis McChord)
DOS	Double observer sightability model
GMU	Game Management Unit
Hancock	Hancock Timber Resource Group
HCP	Habitat Conservation Plan
HUA	Herd Use Area
LSR	Late Successional Reserve
MIT	Muckleshoot Indian Tribe
MREF	Mount Rainier Elk Foundation
MP	Mile Post
MRNP	Mount Rainier National Park
NPS	National Park Service
NWIFC	Northwest Indian Fisheries Commission
NREH	North Rainier Elk Herd
PTI	Puyallup Tribes of Indians
RMEF	Rocky Mountain Elk Foundation
SPU	Seattle Public Utilities
SR	State Route
TW	Tacoma Water (a division within Tacoma Public Utilities)
USFS	United States Forest Service
USACE	U.S. Army Corps of Engineers
USVEMG	Upper Snoqualmie Valley Elk Management Group
WDFW	Washington State Department of Fish and Wildlife
WSDOT	Washington Department of Transportation

Abbreviations used in the Appendix only

Green River transplant elk capture sites:

ChR	South Bank Road Chehalis River between Porter to Oakville
CStP	Centralia Steam Plant
MoxC	Mox Chehalis Creek
Kam	Kamilche Valley

NORTH RAINIER ELK HERD PLAN

INTRODUCTION

The Plan

This revised North Rainier Elk Herd Plan (Plan) provides the historical background, current conditions, and trends for this important natural resource. The Plan is an assessment document that identifies management problems, develops solutions to overcome these problems, and sets direction. The purpose of this Plan is to identify objectives and strategies to provide direction and establish elk management priorities within the North Rainier elk herd (NREH) area.

This Plan is one of ten elk herd plans under the umbrella of the Game Management Plan 2015-2021 (WDFW 2014). This plan is subject to amendment as needed, and will be in effect until revised. The Point Elliott, Medicine Creek and Yakama Treaty tribes are federally recognized with sovereign status and the right to implement their own hunting regulations. The Washington Department of Fish and Wildlife (WDFW) recognizes its responsibility to cooperate and collaborate with Federally recognized treaty tribes. It also recognizes the pivotal role that private landowners, municipal and county land planners, and public land management agencies play in the management and sustainability of this elk herd.

The Herd

For management and administrative purposes the state has been divided into game management units (GMUs), which the WDFW uses primarily to manage recreational harvest. The NREH area is comprised of eight GMUs: Issaquah (GMU 454), Snoqualmie (GMU 460), Stampede (GMU 466), Green River (GMU 485), Cedar River (GMU 490), Puyallup (GMU 652), White River (GMU 653), and Mashel (GMU 654). The western portions of GMUs 454 and 652 are devoid of elk and are not part of the herd use area, and a large part of the Mount Rainier National Park (MRNP) is used by this herd and is considered part of the use area. Some GMUs in the NREH area contain Elk Areas (EA) which are primarily used to address specific management issues, such as human-elk conflict.

It should be noted that some of the elk that summer in GMUs 466, 485, 490, and 653, winter in the Manastash (GMU 340) and Umtanum (GMU 342) units (Bradley 1982, MIT unpubl, data in prep, WDFW file data). The Muckleshoot Indian Tribe (MIT) studies tracked calves collared in the White and Green Rivers to Robinson, Watt, Wenas, Umtanum River, Yakima River, and Cleman Mountain. Some of the elk that spend their summer on the west side are likely harvested in westside units prior to their return trip to their wintering areas in Eastern Washington.

Management updates (North Rainier Elk Herd Plan, 2002)

The 2002 plan identified several areas of concern, set objectives, and identified spending priorities. Some of these were met, others were not. The following is a summary of the herd status since the last plan.

Accomplishments

- Harvest reporting compliance has improved. WDFW implemented a mandatory harvest reporting system in 2001. Tribal harvest reports have improved under the guidance of the Northwest Indian Fisheries Commission.
- Scientific studies conducted by the MIT using radio-collared animals have contributed data to better manage portions of the herd.
- Elk in GMUs 485, 653, 490, and Elk Area 4601 are surveyed using mark-resight of radio-collared elk to estimate population size.
- Elk numbers in GMUs 485, 653, and 460 have increased.
- Cow harvest in GMUs 485, 653, and 466, has remained closed to help increase elk numbers and ensure mortality does not exceed recruitment (485 reopened for limited antlerless permits in 2015).
- Post-season bull to cow ratios are meeting objectives.
- Post-season calf to cow ratios are consistent with a stable to increasing population (WDFW 2017).
- Elk forage enhancement fields have been developed on summer and winter/spring ranges receiving high elk use.
- Eighty two elk were transplanted into GMU 485 in 2002.
- The White River Elk Herd Interagency Technical Committee (WREHITC) was formed to identify elk management issues in GMU 653 and propose solutions with representatives from WDFW, MIT, Washington Department of Natural Resources (DNR), Washington Department of Transportation (WSDOT), United States Forest Service (USFS), MRNP, and Hancock. WREHITC has met 5 times in 2003, 2006, 2011, 2014 and 2017 to discuss technical issues for GMU 653 elk.
- Summer and winter range maps have been created for WDFW's Priority Habitats and Species program.
- The Upper Snoqualmie Valley Elk Management Group (USVEMG) was formed, a citizen's group whose mission is to assist with the management of elk in the Upper Snoqualmie Valley.
- The Mount Rainier Elk Foundation (MREF) was formed, a citizen's group whose mission is to assist with the management of elk in the Enumclaw Plateau.
- Remote cameras were installed by the DNR, the WSDOT, and Conservation Northwest to determine elk use under the North Bend overpass.
- The co-management agreement between WDFW and the Point Elliot Treaty tribe was implemented and updated.
- The study *"Elk Collection and Collaring Plan for the Upper Snoqualmie Valley Sub-Herd"* was approved and implemented.
- WDFW Westside GIS and Data Support Analyst Andrew Duff developed and presented "*Incorporating Community-Based Collaboration and Urban Corridor Suitability Models*" (Duff et al 2010).

- WDFW, MIT, Puyallup Tribes of Indians (PTI), US. Geological Survey (USGS), and the National Park Service (NPS) completed an 8 year research study to develop *A Hybrid Double-Observer Sightability Model for Aerial Surveys (Griffin et al.*, 2013). MRNP implemented this new survey in 2009 and both annual and multi-year analysis reports are being published on the National Park Service (NPS) website. https://science.nature.nps.gov/im/units/nccn/publications.cfm
- WDFW and USFS implemented a Cooperative Road Closure Agreement for lands in Pierce and Thurston County on the Mt Baker Snoqualmie elk winter range to reduce elk disturbance, reduce poaching, and increase elk escapement.
- WDFW created a new Conflict Section and hired staff to focus directly on human-wildlife conflicts. Staff have focused on the Enumclaw/Buckley plateau portions of GMUs 652 and 454 addressing elk caused damage to agricultural properties.
- USVEMG has coordinated volunteers to repair/rebuild much of the elk fence bordering Interstate 90 near North Bend, reducing the number of vehicle/elk collisions in the area.
- Elk body condition relationships were analyzed using MIT study data collected in GMU's 653 and 485 that was published as a Wildlife Monograph (Cook et al. 2013).
- The USFS developed a Westside elk habitat use model using MIT study data from GMU's 653, 485, and 490 was published as a Wildlife Monograph (Rowland et al, 2018).
- MIT has developed an Elk Forage Index and applied it to managed timberlands in the White River to guide timber harvest strategies and approximate elk habitat capacity (Vales et al. 2017).
- MIT partnered with WSDOT to install elk signage along Highway 410 near the town of Greenwater to reduce vehicle-elk collisions.

Emerging issues

- Elk numbers in urban areas of North Bend, Duvall, Enumclaw, Buckley, Lake Tapps, Selleck, and Landsburg are increasing and causing increased human-elk conflicts.
- Changes in elk distribution as USFS lands mature and provide less suitable forage habitat while industrial timberlands continue to generate early successional pockets of abundant forage. Elk may be less abundant on public land where easy access can lead to overharvest, higher recreational hunter densities, and dissatisfied hunters.
- Consistent monitoring of population trends in some portions of the herd area is challenging. A clear and accepted strategy to monitor changes is needed.
- Treponeme-associated hoof disease has been found and surveillance will be continuing.
- Wolves are expected to eventually recolonize areas within the NREH area.

HERD AREA DESCRIPTION

Location

The NREH area encompasses approximately 3,850 square miles (9,970 square kilometers) primarily in King and Pierce counties and small portions of Snohomish, Yakima and Kittitas counties. The westernmost portions of the NREH area contain Seattle, Tacoma and other smaller cities, which taken together form the densest human population area in Washington State. This area does not support elk. Suitable elk habitat in the NREH area is defined in this Plan as the Herd Use Area (HUA) (shown in Figure 1), which excludes more than 1,150 square miles in GMUs 454 and 652. The areas where elk are most common are located in the eastern half of the herd use area and include most of the Snoqualmie, Cedar, and Green River watersheds; the upper White and Clearwater river watersheds extending into the northern portion of MRNP; and the Puyallup River drainage in the western portion of the park.

Ownership and Land Use

The HUA is a patchwork of private, state, and federal ownerships (Figure 1). Most of the HUA is in private ownership (Table 1), although large portions in the eastern half are public lands. The largest single landowner is the USFS with 769 square miles (1,991 square kilometers). The DNR manages 230 square miles (596 square kilometers). Industrial timber companies have large land holdings in the area as well.

Most of the private, state and federal lands are managed primarily to produce timber. However, USFS lands are managed for multiple uses, including wildlife, with an emphasis on managing for old growth forest and recreation. Approximately 85% of USFS land allocations limit what forestry activities can take place. Most industrial timberlands limit access to only those recreational users who purchase access permits.

The cities of Tacoma and Seattle each operate municipal watersheds in King County that supply the drinking water for their cities. The Green River watershed lands comprise about 147,290 acres in GMUs 485 and 466. Tacoma Water currently owns approximately 10 percent of the watershed area, primarily land adjacent to the Green River and its main tributaries. Public agencies and private companies own the remainder. Tacoma Water has executed written agreements with public agencies and private landowners to control access and activities within the Green River watershed (Tacoma Water, 2008). An agreement with WDFW allows limited public hunting in GMU 485.

The city of Seattle water supply originates from two watersheds in the Cascade Mountains: the Cedar River watershed (90,546 acres) and the South Fork Tolt River watershed (12,107 acres). The Cedar River Municipal Watershed covers nearly all of GMU 490, and the South Fork Tolt River Municipal Watershed is within GMU 460. The Seattle Public Utility (SPU) owns all of the land in the Cedar River Municipal Watershed and 70 percent of the land in the South Fork Tolt Municipal Watershed upstream of the South Fork Tolt Dam. The USFS owns and manages the eastern 30 percent of the basin. Unsupervised public access is prohibited by SPU in all of the City-owned portions of the two watersheds in order to protect water quality and infrastructure in these supply systems (City of Seattle, 2000).

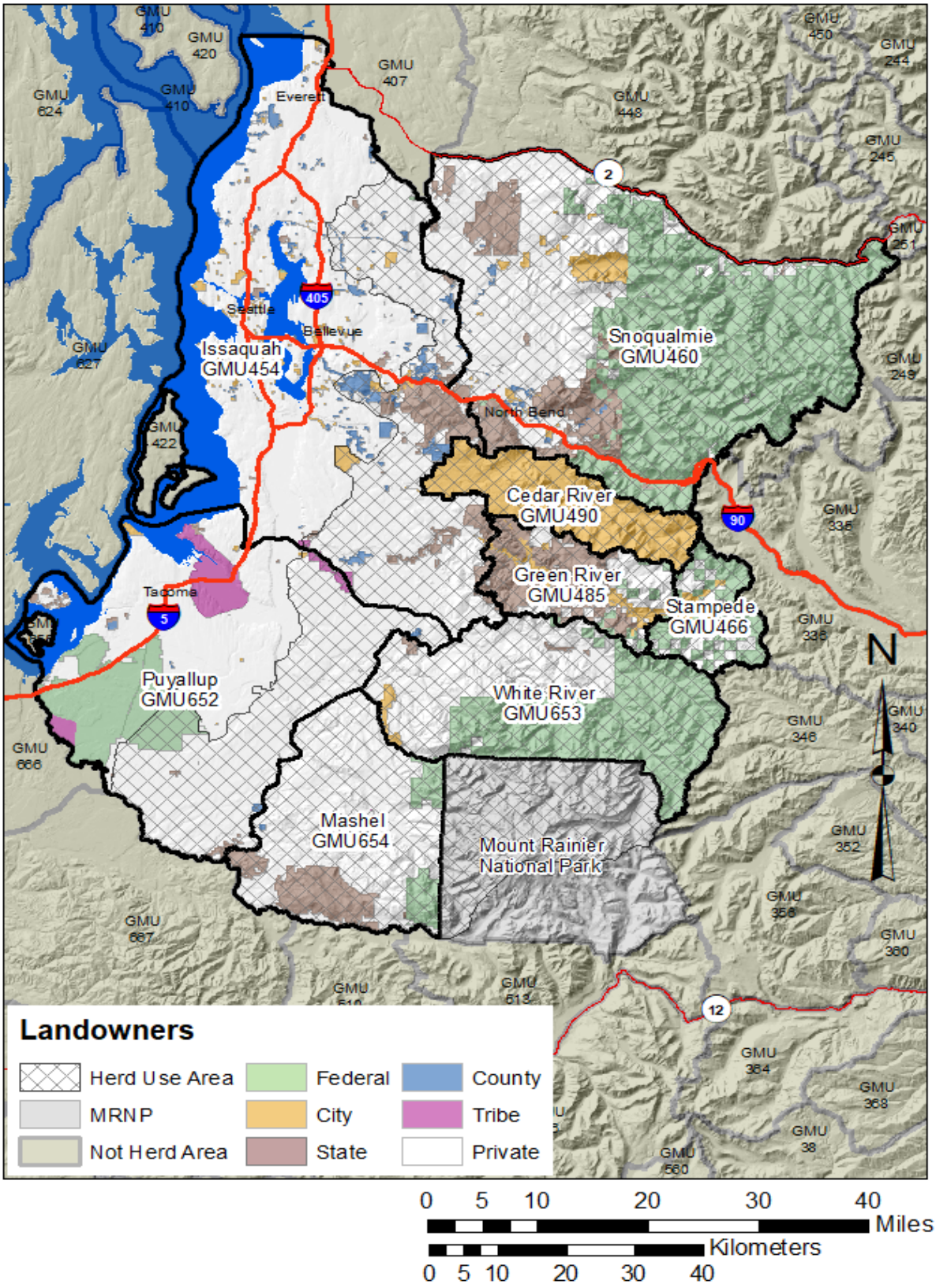


Figure 1. Ownership within the North Rainier Elk Herd Area, 2017.

Table 1. Ownership by GMU for the herd use area (excluding Mount Rainier National Park), 2017. Values are in acres[a].

		Game Management Unit								
Owner	Manager	454	460	466	485	490	652	653	654	Total
Federal	USFS	28	306,198	33,378	5,811	150		130,189	16,687	492,441
	DOD						13,146			13,146
	NPS							223	529	752
	BLM	83	245							328
	Total	111	306,443	33,378	5,811	150	13,146	130,412	17,216	506,667
DNR		27,326	54,710		41,145	15	452	349	23,409	147,406
City		4,756	12,378	4,101	10,734	90,478	135	3,066	11	125,659
Tribe		1,076	65				2,342		22	3,505
County		11,371	2,461			1	866	274	246	15,219
State	State Park	3,877	3,138			18	1,104	577	11	8,725
(Non-DNR)	University						2		4,406	4,408
	WDFW	456	377							833
	Other						1	1,125		1,126
	Total	4,333	3,515			18	1,107	1,702	4,417	15,092
Total		48,973	379,572	37,479	57,690	90,662	18,048	135,803	45,321	813,548
Private Ownership		199,373	215,282	19,725	31,281	3	178,074	115,716	162,939	922,393
Herd Use Area Total		248,346	592,703	56,880	89,007	90,665	196,122	248,067	208,155	1,729,945

[a] Derived from GIS data provided to the Washington Department of Fish and Wildlife by the Department of Natural Resources (DNR), and may differ slightly from actual acreages due to geo-processing error. DNR is surface ownership only.

The primary land use in the HUA is forest, composing more than 70% of the total area (Table 2). These lands occur in the eastern portion of the HUA and dominate the landscape in GMUs 460, 466, 485, 490, 653 and 654 (Figure 2). Developed lands make up more than 14%. Undeveloped non-forestry lands, which include designated open space, exceed 9%, but are largely intermingled with developed land. Likewise, most of the area classified as "unknown" in Table 2 is intermingled with developed lands and would likely fall under the developed classification with further inspection. Much of it appears to be public road right of way. Combined unknown, developed, and undeveloped classifications equal more than 25% of the total HUA. This combination of classes dominates GMUs 454 and 652. A relatively small amount of agricultural land is found scattered in the eastern parts of GMUs 454 and 652 (Figure 2).

Table 2. Land use by GMU for the herd use area (excluding Mount Rainier National Park), 2017. Values are in acres[a].

	Game Management Unit								
LandUse	GMU 454	GMU 460	GMU 466	GMU 485	GMU 490	GMU 652	GMU 653	GMU 654	Total
Forest	56,698	504,693	56,346	87,718	87,263	28,818	232,781	184,724	1,239,041
Developed	104,457	38,560	473	778	571	90,362	4,564	8,513	248,278
Undeveloped	59,584	31,931		201	1,138	46,650	9,078	11,111	159,693
Agriculture	14,188	3,940				22,725	296	1,618	42,768
Unknown	10,607	8,170	33	50	84	7,315	1,265	2,191	29,715
Water	2,805	5,411	29	256	1,609	253	83		10,445
Herd Use Area Total	248,339	592,705	56,881	89,003	90,665	196,122	248,068	208,158	1,729,940

[a] Derived from GIS data provided to the Washington Department of Fish and Wildlife by the Department of Natural Resources, and may differ slightly from actual acreages due to geo-processing error.

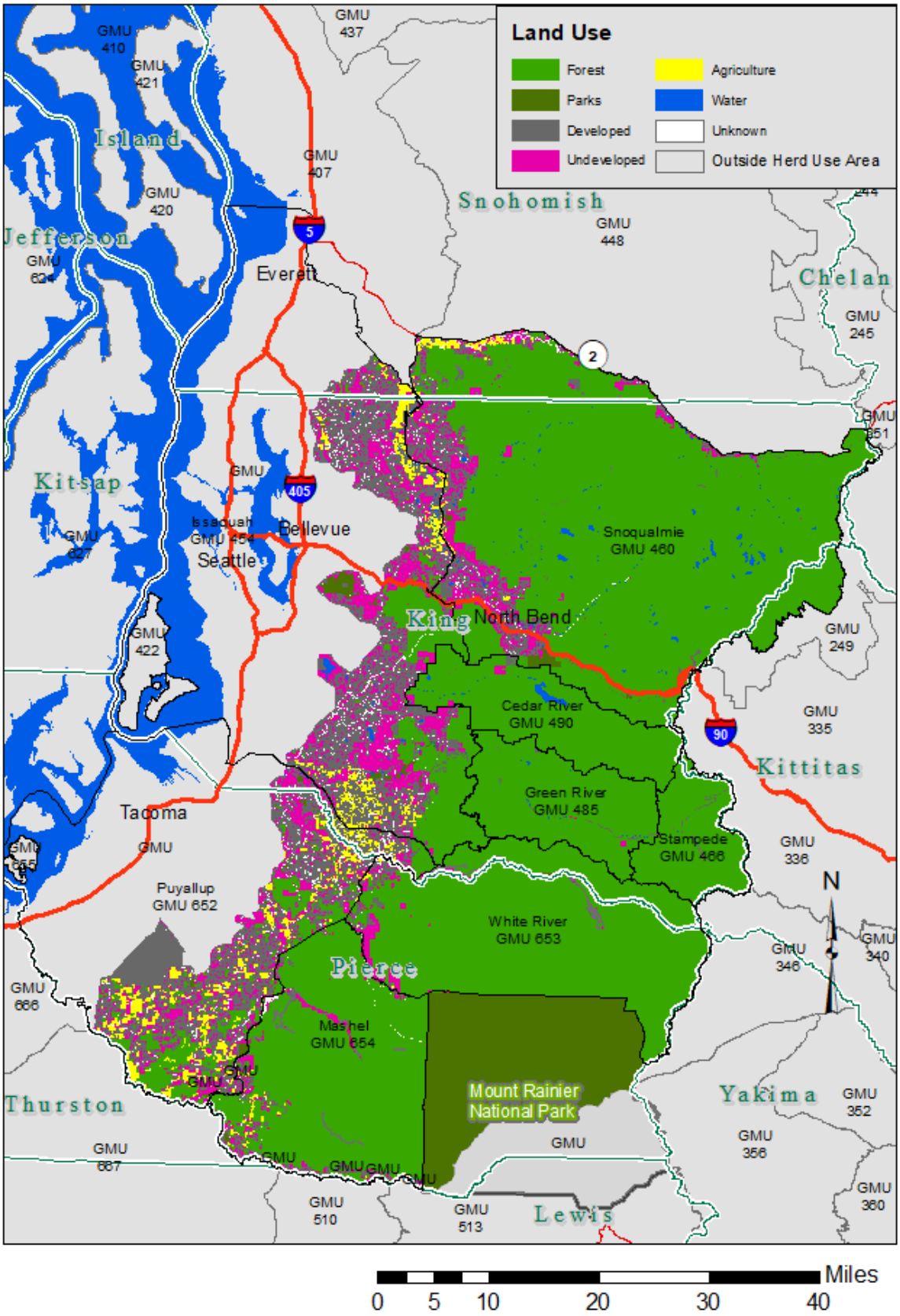


Figure 2. Land use within the North Rainier Elk Herd Use Area, 2017.

Topography

The North Rainier herd area extends into three physiographic provinces: the Puget Lowland, Northern Cascade and Southern Cascade (Franklin and Dyrness, 1973). Most of the elk inhabit the Northern and Southern Cascade provinces characterized by mountainous ridge crests separated by steep, deeply dissected valleys. Elevations in the HUA range from sea level to nearly 7,500 feet (2,300 meters) at the Cascade Crest. In the southeast portion of the HUA Mount Rainier rises to over 14,000 feet (4,265 meters) at its summit. Elk occupy the majority of this elevation gradient from the sub-alpine and alpine meadows of the MRNP to the high alpine areas during the summer and fall months (MIT unpubl. data). Typically the western portion of the herd area consists of low to mid-elevation mountainous terrain and valley floors.

Native Vegetation

Franklin and Dyrness (1973) described the natural vegetation of Washington. Eight of these vegetation zones occur within the HUA (Figure 3). Three major forest zones together make up 90% of the potential natural vegetation (Table 3). These zones arranged along elevation and moisture gradients are named after the climax coniferous tree species, and are in order of increasing elevation: the western hemlock (*Tsuga heterophylla*), Pacific silver fir (*Abies amabilis*), and mountain hemlock (*Tsuga mertensiana*) zones. Differences in soil type, moisture, elevation, aspect, and slope account for considerable habitat diversity even within the major forested zones. This is reflected in different aged forest timber stands with co-dominant tree species and various understory plant communities. Potential natural vegetation influences elk forage quality with the western hemlock zone having lower dietary digestible energy (DDE) than the Pacific silver fir and mountain hemlock zones (Cook et al. 2016). The Western Hemlock Zone is the most important for producing timber. In the southern Cascades it generally reaches its upper limit at about 3,300 feet (1000 meters). Major tree species here are Douglas fir (*Pseudotsuga menziesii*), western hemlock and, on moist sites, western red cedar (*Thuja plicata*). Dominant hardwood species include red alder (*Alnus rubra*) and big-leaf maple (*Acer macrophyllus*), occurring mainly as pioneers growing on recently disturbed sites or along stream sides. Species composition under the tree canopy varies, depending on moisture and soil. Moist sites with better soils tend to be dominated by sword fern (*Polystichum miniatum*) communities while poorer, dry soils often support salal (*Gaultheria shallon*) understories. Most of this herd's winter ranges are located within the western hemlock zone.

The Pacific Silver Fir Zone occurs from about 2,000-4,300 feet (600 to 1,300 meters). Wetter and cooler than the lower western hemlock zone, it has significantly more winter snow and hence a shorter growing season. This zone is often important summer range for elk and is used for seasonal migration.

The Mountain Hemlock Zone is the highest elevation forest zone in the herd area. This zone occurs between 4,300-5,600 feet (1,300-1,700 meters), where heavy winter snow pack can persist for six to eight months. Here, closed canopy forests at lower elevations gradually give way to open parklands of a distinct subalpine character near its upper limit. These open parklands and subalpine open meadows are often intermixed with lakes, wetlands, and timber stands, combining to form a habitat mosaic that is important to elk for summer food and calving areas. These habitats are most abundant in MRNP and provide summer and fall ranges for elk.

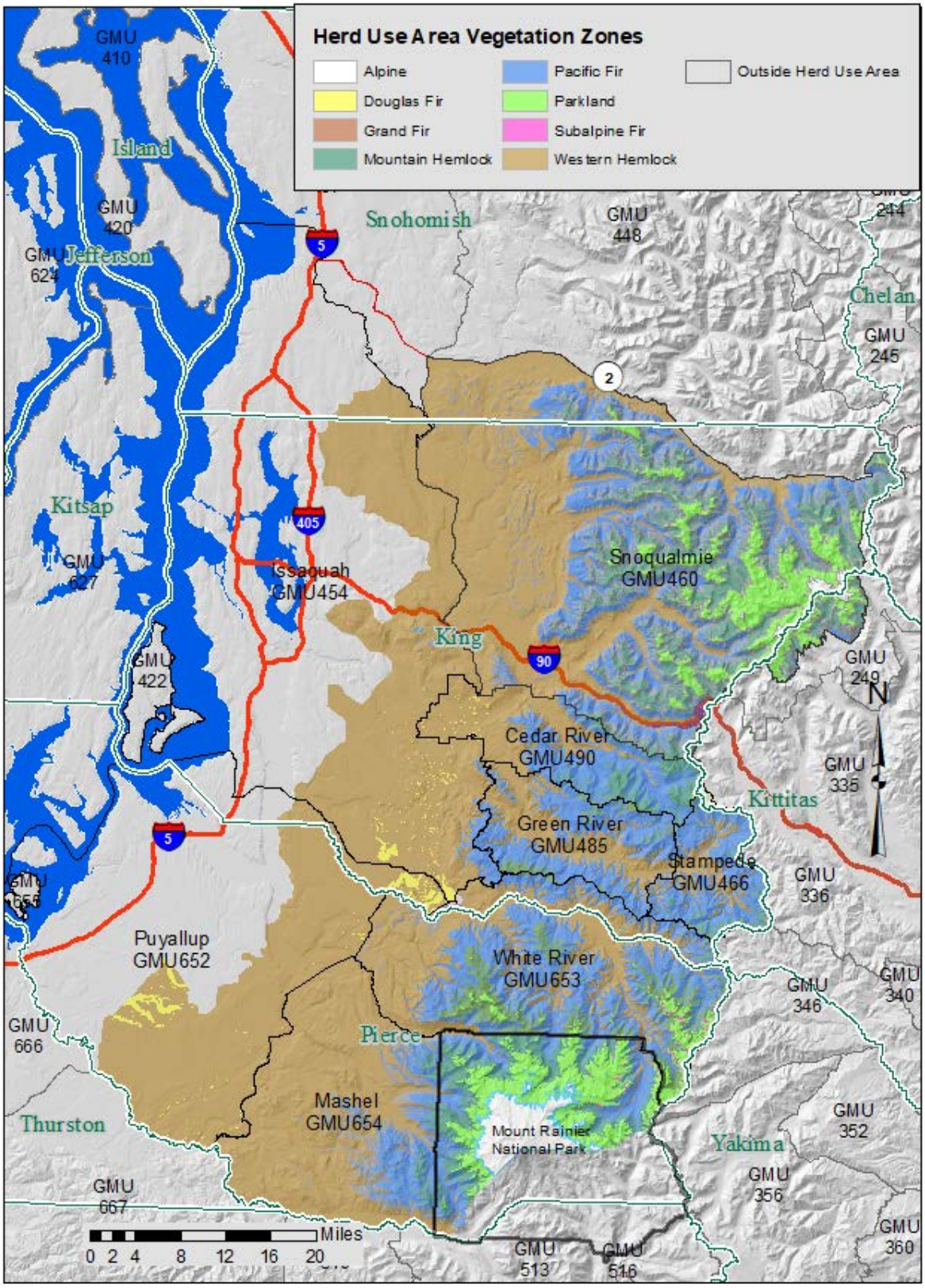


Figure 3. Modeled potential natural vegetation zones within the North Rainier Elk Herd Use Area (USFS Henderson 2009).

Table 3. Potential natural vegetation within the North Rainier Elk Herd Use Area[a]. Values are in acres.

Vegetation Zone	GMU 454	GMU 460	GMU 466	GMU 485	GMU 490	GMU 652	GMU 653	GMU 654	Total	MRNP
Western Hemlock	237,471	243,516	13,702	38,257	42,694	187,515	101,538	167,876	1,032,569	5,488
Pacific Fir	6,938	149,617	34,953	45,620	33,904	0	98,270	35,250	404,552	27,914
Mountain Hemlock	45	118,468	8,173	5,133	13,276	0	33,560	5,037	183,692	35,588
Parkland	0	73,673	55	0	97	0	11,242	0	85,067	46,482
Douglas Fir	3,753	1,424	0	0	681	8,627	2,183	22	16,690	10
Alpine	0	4,974	0	0	0	0	0	0	4,974	25,829
Subalpine Fir	0	692	0	0	0	0	1,298	0	1,990	636
Grand Fir	110	243	0	0	0	0	0	0	353	0
Unclassified	0	96	0	0	12	0	0	0	108	1
Total	248,317	592,703	56,883	89,010	90,664	196,142	248,091	208,185	1,729,995	141,948

[a] Derived from PNV data provided to the Department by the USFS (Henderson 2009), and may differ slightly from actual acreages due to geo-processing error.

Human Influences

Elk in the North Rainier Herd have been affected by human influence to varying degrees throughout the herd's history. Elk were hunted by Native Americans for food, clothing, and other essential needs. Herds throughout Washington were depleted in the late 1800's due to market hunting by European settlers. Elk were transplanted to the region from Yellowstone in the early 1900's to augment the native herd (Pautzke et al. 1939). As numbers increased, hunting seasons were opened and elk were hunted by state and tribal hunters.

The landscape has been extensively modified by humans. Timber harvesting operations, virtually all by clear cutting, have greatly changed the character and structure of most forests outside MRNP. Originally, this HUA was mainly unbroken mature forest with scattered sparse openings, with a large-scale fire history occurring about every 434 years (Hemstrom and Franklin 1982). Native Americans are known to have maintained some of the higher elevation huckleberry fields using fire; this practice enhanced the food sources elk used in these areas leading to better hunting, and possibly greater elk abundance. Douglas fir plantations have now replaced much of the native forest composition on commercial forest lands across the lower elevation eastern half of the HUA. Most of these areas are a patchwork of recently clear-cut and relatively young forests, the exception being some notable old growth acreage on USFS land.

Roads have substantially influenced elk use of the landscape (Lyon 1979, McCorquodale 2013). Roads result in direct elk mortality, increased use and access by hunters leading to increased elk vulnerability to harvest, and as barriers to elk movement. For example, in and around Elk Area 4601 (Figures 4 and 5), 20 elk mortalities caused by vehicle collisions were confirmed in 2017, an important cause of mortality for the elk in this locality. Roads may provide habitat corridors through forests with closed canopies and little understory vegetation, however the risk to human-related mortality and disturbance increases. Disturbance by recreationists utilizing roads may affect elk use of the landscape.

Ongoing residential and commercial developments and agriculture in GMUs 454 and 652 and in portions of GMUs 654, 460 and 653, continue to negatively impact elk distribution. However, expanding elk numbers demonstrates the adaptability of elk in these areas. Development removes habitat, creates barriers to elk migration, and increases vehicle-elk and human-elk conflict situations.

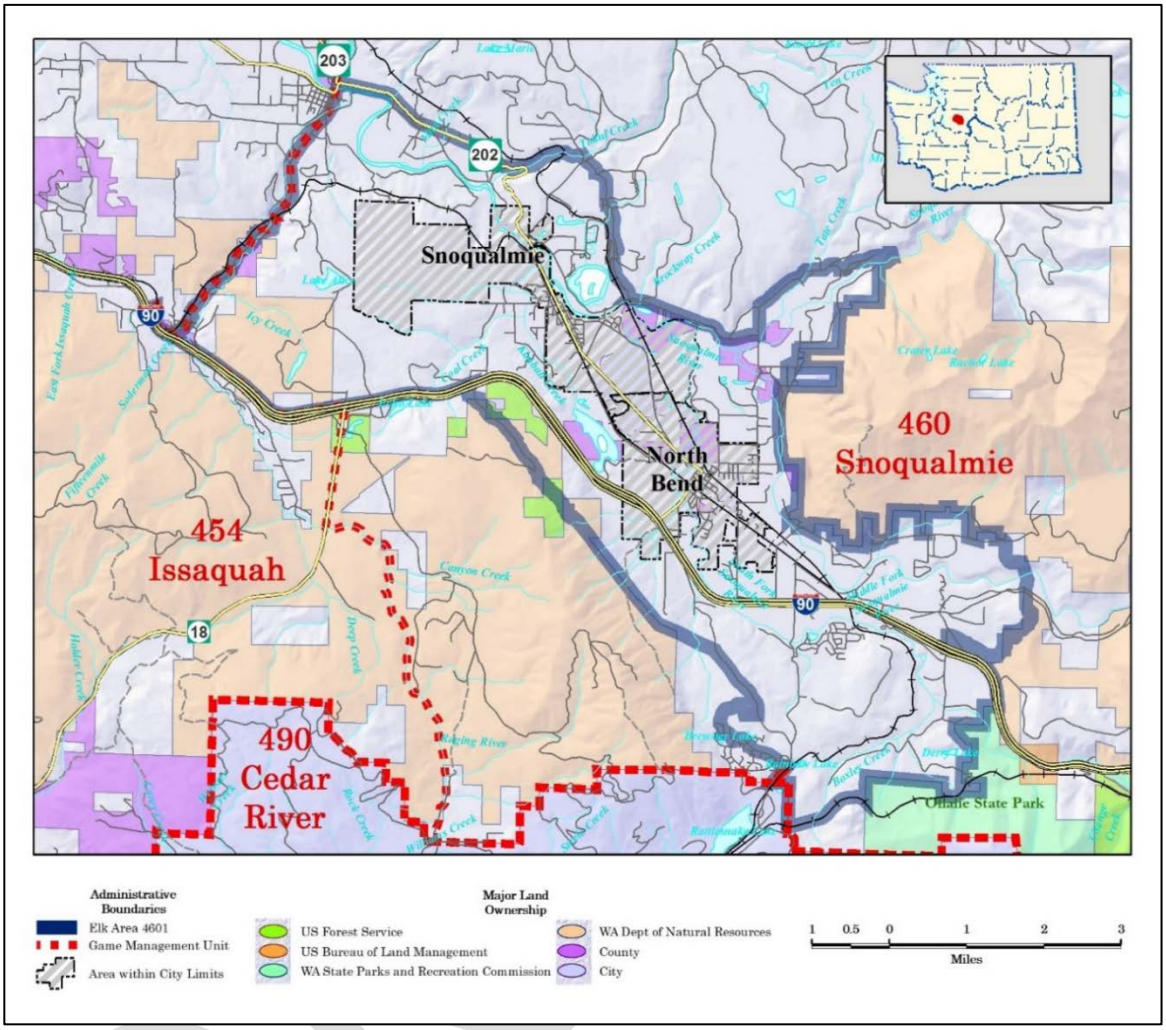


Figure 4. Elk Area 4601, 2017.

Other Prominent Wildlife Species

The range of the North Rainier elk herd is also home to black-tailed deer *(Odocoileus hemionus columbianus).* Mountain goats *(Oreamnos americanus)* occupy high-elevation rugged terrain mainly found along the crest of the Cascade Range. Mountain goats and elk segregate most of the year, due to the mountain goat's preference for steep, rocky terrain. During summer, however, both species occupy high elevation meadows. Cougar (*Puma concolor),* black bear (*Ursus americanus*), bobcat (*Lynx rufus*), and coyote (*Canis latrans*) also inhabit the NREH range. Gray wolves (*Canis lupus*) have returned to Washington State and have been documented close to the eastern border of the NREH area. As Washington's wolf population continues to grow, WDFW has expanded monitoring efforts to help understand the effect of wolf predation on the state's herds.

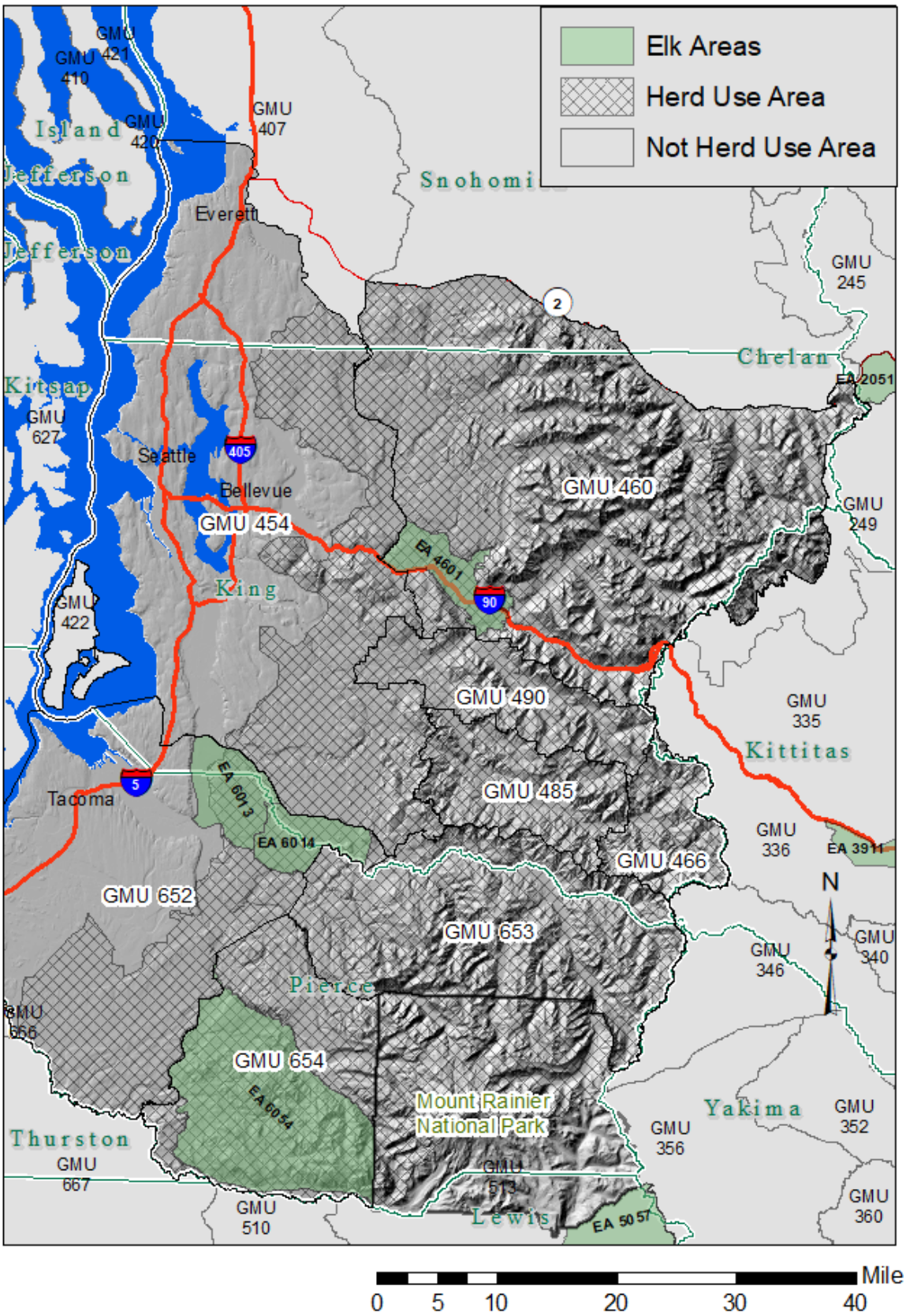


Figure 5. Elk Areas in the North Rainier Elk Herd area, 2017.

HERD DISTRIBUTION

Historical Distribution

The entire NREH area is within the original range of the native Roosevelt elk (*Cervus canadensis roosevelti*) (Schwartz and Mitchell 1945). Although elk historically occurred in this area, they certainly were more limited in numbers and sporadically distributed than they are today. By the time MRNP was established in 1899, elk were not one of the resident animals (Bradley 1982).

Factors contributing to their decline include: 1) the over-harvesting of elk by European settlers using firearms; 2) a sparsely distributed population, concentrating in naturally burned sites, alpine meadows, and stream sides where food would have been more plentiful; and 3) a largely unbroken old growth forest that produced relatively little food (WDFW 2002). Whatever the actual status of the indigenous Roosevelt elk may have been, it is almost certain that the release of Rocky Mountain elk (*Cervus canadensis nelsoni*) near Enumclaw was a significant catalyst responsible for subsequent increases in elk numbers (Bradley 1982, WDFW 1996). This coupled with changes on the land, such as clearing trees for agriculture and pastures, and harvesting timber, improved habitats and increased elk numbers.

Parsons (1967) gives an account of an early elk transplant to the North Rainier herd area. He reported that in 1912 Henry Reif, a County Game Warden, obtained approximately 80 elk from Yellowstone National Park. One died in transit, but the others were held until March of the next year in two corrals, one at the White River Lumber Company near Enumclaw and one at Meadowbrook Farm at Snoqualmie. In March 1913, 36 were released from each of the corrals.

Those at Meadowbrook Farm had become semi-domesticated and caused damage “everywhere they went”. By 1923 farmers and poachers had reduced their number until only 6 remained on Snoqualmie Island. Four Roosevelt elk from the Hoh River were added that year to increase the size of the band, but problems continued and in 1946, nine elk were trapped and transplanted to Whatcom County. The last three remaining were shot by Game Protectors a short time after. The Enumclaw release was more successful, and elk numbers gradually increased under protection from 1913 to 1929. King County began either-sex seasons in 1929, and State controlled seasons began in 1947. Parson reported that the elk population estimate for the “Enumclaw herd” was 1,500 in 1967.

The transplanted elk increased under legal protection from harvest, eventually expanding their distribution into adjacent areas. There were also fifty elk from Montana released on January 20, 1913 near the Naches River in Yakima County (Pautzke et al. 1939). It is speculated that some of these elk moved onto MRNP based on early sightings on the eastern borders of the park (MRNP, chronological record of elk from observation card files).

Current Distribution

Issaquah unit (GMU 454)

Elk occurring in GMU 454 are generally restricted to the eastern portions, adjacent to the areas of greatest elk density and away from the suburban growth and sprawl. However, small satellite groups habituated to humans do occur in suburban and rural areas of GMU 454.

Snoqualmie unit (GMU 460)

Elk in this unit are scattered in small, somewhat isolated groups that normally range in size from 8-12, but occasionally approach >50 elk. Occurrence varies on the extremes, with elk found from isolated wilderness areas and managed timberlands to suburban locations. Elk may have colonized this area by dispersing from GMU 490. This is a growing elk population, occurring in small groups mainly in the north, south and middle fork of the Snoqualmie River and less abundantly in the Skykomish River valley.

Possibly half the elk in the Snoqualmie unit occur in Elk Area 4601 (Figures 4 and 5) which was created in 2009, with the remainder scattered throughout the rest of GMU 460. Recent clearcut timber harvest in the area immediately to the north of Elk Area 4601 has created new forage areas, and there is evidence that elk from Elk Area 4601 are utilizing these areas (Erland, pers.com).

Stampede (GMU 466)

This unit is the smallest in the herd area and supports a small elk population. Many of the radio-collared elk tracked by the MIT which spent summers in the southern half of GMU 466, spent winters mainly on the eastside of the Cascade Crest. Studies indicate that elk in the rest of GMU 466 spend most of winter in or on the boundary of GMU 485 near Lester (MIT and WDFW, unpubl. data).

Green River unit (GMU 485)

Most of the elk in GMU 485 reside year round entirely within the unit, although a small percentage spend a portion of the summer in GMU 466 or GMU 490. As some of these elk cross the GMU 466/485 boundary readily and include both GMUs in their home range, elk in these units are considered one sub-herd.

Puyallup unit (GMU 652)

The western half of GMU 652 is heavily urbanized, while the eastern half contains agricultural land and livestock production. Elk management in this GMU often involves balancing the needs of elk with a growing human population. Elk may be found along the Lower White River from Buckley to areas north of Lake Tapps. Higher numbers of elk are found east of State Route (SR) 167 and SR 161 but scattered groups may also be found in other parts of the unit.

White River unit (GMU 653)

More elk reside in this unit than any other in the North Rainier herd area. Elk can be found throughout the unit, however migratory patterns or origins may vary between local groups. There are a lot of complex movement patterns of elk in this unit that affect seasonal distribution. The following information is based primarily on work conducted by MIT. Elk that summer in the upper Greenwater drainage and its tributaries, and elk that summer in the Dalles Ridge to the Pacific Crest area are mostly comprised of elk that winter east of the Cascade Crest. Elk found at Crystal Mountain in summer are mostly elk that winter on the east side, however, some also winter on the westside in the Buck Creek area. Elk that winter in the lower Greenwater River, Huckleberry Creek, Buck Creek and West Fork River areas tend to migrate to MRNP in summer. Clearwater River elk tend to migrate during summer to higher elevation ridges not far from

winter range, although some migrate into MRNP. Most elk north of Highway 410 from the western GMU 653 boundary to Slippery Creek tend to be resident or make small movements to higher ridges on the north boundary of the unit. Elk west of the Three Sisters make small seasonal movements or are non-migratory.

Some elk that winter east of the Cascades spend summer in the bordering GMUs 653, 466, and 490. Calves radio-collared in the Green and White River drainages have migrated to winter areas as far east as the Watt Canyon, Robinson Canyon, and Wenas feeding grounds on the Oak Creek and L.T. Murray State Wildlife Areas. These migrations may expose these elk to hunters on both sides of the Pacific Crest Trail, which is part of the boundary between Eastern and Western Washington elk units.

Mashel unit (GMU 654)

The elk occupying GMU 654 are primarily located in the Elbe Hills State Forest, Pack Experimental Forest and in private commercial timberlands to the west of the MRNP boundary. Elk migrating out of MRNP in late fall follow the Puyallup and Mashel rivers westwards and spend the majority of time in the southern portions of the GMU.

Potential Future Distribution

Little change is anticipated in the overall distribution of the NREH. Elk distribution in the most urban units (GMU 454 and GMU 652 and portions of GMUs 654, 460 and 653) will continue to be negatively impacted by ongoing residential and commercial developments and agriculture. This will further reduce usable elk habitat and increase human-elk conflicts leading to increases in property damage concerns and control of elk numbers. Localized elk concerns have been and will continue to be managed in specially-designated Elk Areas using a variety of permit options. There are four Elk Areas in the NREH, 4601, 6013, 6014, and 6054 (Figure 4).

Cows and calves in the North Rainier Elk Herd area, 2010. (Photo: M. Tirhi)

Muckleshoot Indian Tribe Elk Population Studies

From 1996 through 2017 the MIT has invested a tremendous amount of effort and spent over 1.5 million dollars developing monitoring programs, conducting numerous research projects and surveys of elk in portions of the NREH area. This has provided invaluable information and contributed considerably to development of this Plan. Their research efforts have also made valuable contributions to development of the USFS Western Oregon and Washington Elk Nutrition and Habitat Models (Rowland et al. 2018), the revision of predictive equations used to index the nutritional condition of cow elk (Cook et al. 2010), a sightability model used in Mount Rainier National Park (Griffin et al. 2013), and to research that evaluated regional and seasonal differences in the nutritional condition and reproductive fitness of cow elk (Cook et al. 2013). Primary objectives associated with MIT's monitoring and research efforts have included: 1) generating estimates of elk abundance using mark-resight; 2) generating estimates of age (calf:cow) and sex (bull:cow) ratios in autumn and spring; 3) determining pregnancy rates; 4) obtaining body condition measurements; 5) determining mortality rates and causes of mortality; 6) documenting movements, migrations, and range fidelity; 7) documenting habitat use; and 8) estimating home range sizes. Some of their research efforts are ongoing and the data presented here are preliminary, have not received peer review, and only represent a coarse summation of their findings. The results are presented with permission of the MIT and herein identified as MIT unpubl. data.

Study Areas

The MIT initiated research efforts in 1998, with assistance from WDFW, KBH Archers, and the National Council for Air and Stream Improvement, that included marking cow elk in GMUs 485 and 653 and elk calves in GMUs 485 and 466. They also independently began marking cow elk on the Muckleshoot Reservation (GMU 652) in 1999, elk calves in GMUs 485 and 653 in 2001, cow elk in GMU 490 in 2006, and elk calves in GMU 490 in 2008. In addition, they monitored 82 elk from 2002–2014 that were translocated from GMU 660 to augment the GMU 485 population (Appendix A). The MIT is currently monitoring cows marked in 5 GMUs [466, 485, 490, 652 (only in Elk Area 6013, see Figure 4), and 653] and marks calves in GMUs 485 and/or 653 when calf to cow ratios fall below 25:100 and funding is available. The study area (Figure 6) totals over 750 square miles.

Methods

Capture and Marking

Adult elk were captured November through mid-April by darting them with carfentanil citrate and xylazine hydrochloride from a helicopter or ground. Elk were blindfolded and fitted with radio collars that only had a very high frequency (VHF) transmitter and mortality sensor or with global positioning system (GPS) radio collars that also included a VHF transmitter and mortality sensor. Elk were given prophylactic injections of penicillin, vitamins B and E, selenium, and a clostridial vaccine to reduce risks of dart-wound infections and capture stress. A vestigial upper canine tooth was taken from the adults for estimation of age via cementum annuli. Blood was drawn for pregnancy testing and fecal samples collected from some animals for parasite analyses. Adult elk body condition estimates using ultrasound and subjective scoring were

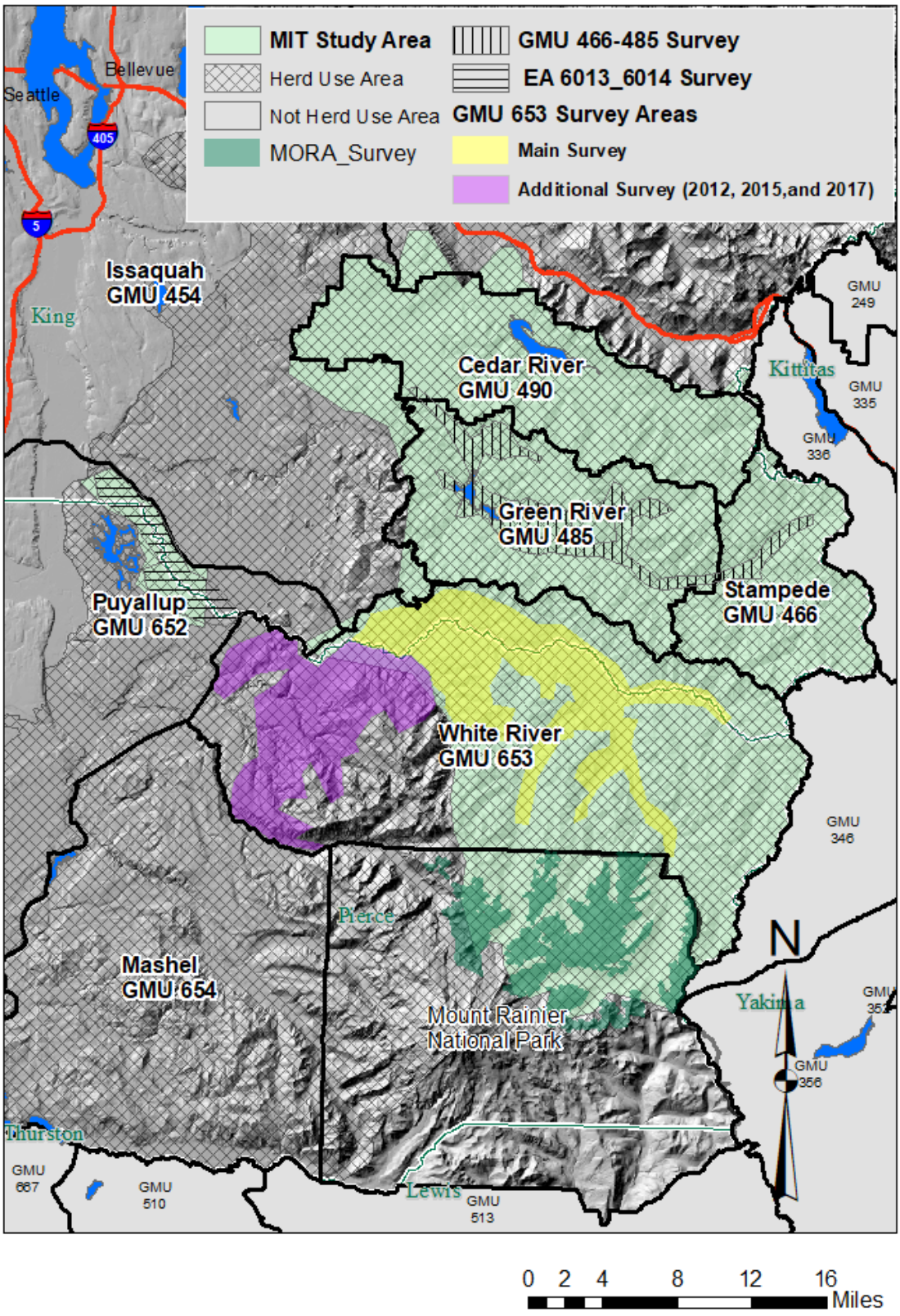


Figure 6. Muckleshoot Indian Tribe elk study area, showing important survey areas, 2018.

collected 1998 to 2007 following the procedures of Cook et al. 2010. Elk sedation was reversed with naltrexone and yohimbine. Adult elk were recaptured and radio-collars replaced before battery power was depleted so most individual animals carried a transmitter until death.

Calves were visually located in May and June each year using a helicopter, and a crew was dropped off nearby to pursue the calf on foot, or used a net-gun from the helicopter if it ran. Calves were blindfolded, ear tagged with VHF transmitters that included a mortality sensor with 4 hour delay, weighed, sexed, and released.

Cause of Mortality and Survival

Elk were monitored from ground, a fixed-wing aircraft, or helicopter, with adult elk monitored at least once a week, often twice weekly, and calves monitored at least twice, often three times, a week until 4 months old and 1 or 2 times a week thereafter. Mortality signals were investigated and an attempt was made to attribute the proximate cause and date of death. The mortality site was thoroughly investigated looking for evidence of human-related cause (i.e. road proximity or bullet wounds), struggle, burial cache, tracks, hair, bite-mark, or fecal material of predator and/or scavenger. Predation was suspected when there were contusions associated with bite or claw marks that would not occur after death, and often blood coming out of mouth. If there was only scavenging with little carcass remaining the cause was listed as unknown, unless there were obvious other identifiers such as broken or shot bones, poor marrow fat, severe infection, highway or train, or accident. When mostly or wholly intact, carcasses were skinned and a field necropsy conducted to determine the presence of bruising, punctures, bite marks, broken bones, lesions, abnormalities, and evidence of factors contributing to death. Tissues and other samples were collected when necessary and sent to a laboratory for disease testing and histological examination. When nothing was apparent, often in situations when the investigation occurred some days after death and scavengers had consumed the carcass, the mortality was labeled as unknown. Femur or other large bones of adult elk were collected for marrow fat analysis (Neiland 1970, Hunt 1979, Ratcliffe 1980) to assess body condition at time of death.

Causes of mortality for adult cow elk were classified as: 1) cougar predation, 2) malnutrition/cougar when an elk was killed by a cougar but bone marrow content indicated the elk was malnourished (<30% femur marrow fat) and may have eventually died even if the cougar had not killed it (i.e., compensatory mortality), 3) malnutrition or starvation, 4) killed by vehicle or train, 5) legal hunting, 6) wound/cougar when an animal was wounded by a hunter and later killed by a cougar, 7) hunter wounding loss, 8) poaching, 9) natural/disease such as accident or pneumonia, 10) unknown, and 11) capture-related. Causes of mortality for elk calves were classified as: 1) cougar predation, 2) bear predation, 3) unknown predator, 4) legal hunting, 5) poaching, 6) accident (drowning, falling, or trapped in slash or talus), and 7) natural death and disease. Some poaching, wounding loss, and legal hunting occurred in GMUs that differed from the GMU where an elk was originally marked. These were normal movements, and not emigrations so these mortalities were recorded as occurring in association with the GMU where the elk was originally captured.

Annual survival rates were estimated using the Kaplan-Meier estimator, modified for staggered-entry of individuals (Kaplan and Meier 1958, Pollock et al. 1989). Off-air and missing animals were right-censored after the last day they were known alive.

Monitoring and Movements

Surveys were done in spring during evenings using a Bell Jet Ranger helicopter with 3 observers and a pilot. Flights were non-systematic covering most habitat where elk were known to occur and where forest conditions were open enough to see elk. Elk were counted and classified as cow, calf, or bull, with the number of collars seen recorded. The MIT also used the marked cow elk in GMUs 653, 485, and 490 to estimate elk abundance using a modification of the Lincoln-Peterson mark-recapture method (Chapman 1951).

Fall surveys on summer range in MRNP were conducted by helicopter during evenings in cooperation with WDFW and MRNP following the approach used by Bradley (1982) through 2006. Starting in 2007 more intensive late-summer surveys were conducted following the protocol described in Griffin et al. (2012). These late summer surveys are described in more detail in the GMU 653 part of the Herd Management section.

In addition, the large sample of radio-marked elk allowed MIT to study elk movements and improve our knowledge of elk distribution and habitat use patterns. Within GMUs there are many localized groups spread throughout, and within each group there may be different migratory patterns among individuals. MIT tried to capture and collar individuals from all geographically distributed groups to collect information on representative patterns. Generalized movement patterns are presented here.

Results

Capture and Marking

The MIT have marked 335 adult cows and 581 calves in GMUs 485, 653, and 490 from 1998–2017, with most marked elk consistently occurring in GMUs 485 and 653 (Table 4). They marked an additional 12 adult cow elk along the lower White River on or near the Muckleshoot Reservation in GMU 652 between 1999 and 2016. Fewer elk have been monitored in GMU 490 because there are very few elk in this GMU and the densely forested habitat makes captures difficult. Ninety-two cow elk were fitted with GPS collars and the remaining 217 were fitted with VHF only collars. Through 2016, 8 of the collared cow elk were unable to be recaptured and went off air, and an additional 9 cow elk dropped their GPS collar without being re-collared.

Body Condition and Pregnancy

Estimates of mean percent ingesta-free body fat in fall in GMUs 485 (1998-2006) and 653 (1998-2007) ranged ~10-12% for elk that were lactating and ~13-16% for elk that were not lactating, while observed pregnancy rates were ≥90% in both GMUs (Cook et al. 2013). More recently (2008-2016, n = 171), pregnancy rates of animals aged 2 through 17 have averaged 91%, although annual samples sizes (n=6 to 46), and consequently inferences, have been more limited. The pregnancy rate in 2015 was 72%, the lowest observed so far and likely due to severe drought conditions in 2015. The average pregnancy rate excluding 2015 was 94% (n=153).

Survival and Cause of Mortality

Estimated annual survival rates for adult cow elk have averaged 0.88 in GMU 485 and 0.87 in GMU 653, 1998-2016, and 0.85 in GMU 490 for 2006-2016, but have varied annually and among GMUs (range = 0.68 to 0.97). The lowest estimates of annual survival rates for adult

cows occurred 1998–2003 averaging 0.82. Most recently (2014–2016), estimates of annual survival rates for adult cow elk have averaged 0.94 in GMU 485, 0.91 in GMU 653, and 0.90 in GMU 490.

Table 4. Summary of radio-collared elk monitored by the Muckleshoot Indian Tribe 1998-2016 in GMUs 485, 653, and 490. Number of radio-collared cows alive at the beginning of each biological year (BY: June 1 of Year t–May 31 of Year t+1) and number of calves captured and radio-marked within each BY. The Total represents the total number of unique cow elk and calves marked in each GMU.

	GMU 485		GMU 653		GMU 490	
BY	Cows	Calves	Cows	Calves	Cows	Calves
1998	30	23	34			
1999	28	31	35			
2000	33	38	38			
2001	30	27	35	44		
2002	32	31	35	37		
2003	27	11	37	44		
2004	22	17	45	46		
2005	25		42	25		
2006	23		51	18	9	
2007	22		46		21	
2008	30		40		26	15
2009	32		44		23	8
2010	38	26	43		19	8
2011	34	31	44		19	2
2012	34		45	20	15	
2013	38		54	31	12	
2014	36		53	48	10	
2015	37		50		11	
2016	39		58		12	
2017	41		62		10	
Total	**114**	**235**	**173**	**313**	**48**	**33**

The MIT has documented 61, 29, and 93 mortality events for adult cow elk in GMUs 485, 490, and 653, respectively, 1998-2016. Cougar predation was responsible for approximately 0.50 of the mortality events in GMUs 485 and 490, but only 0.23 in GMU 653 (Table 5). However, the proportion of mortalities attributed to cougar predation has varied annually (range = 0.00–1.00). For example, the 1998-2003 average in GMU 485 was 0.67 but declined to 0.35 during 2004-2016, and was 0.14 during 2014–2016. The proportion of mortalities associated with hunting (legal, wounding loss, and poaching combined), was 0.20 in GMU 653 compared to only 0.10 in GMUs 485 and 490. Malnutrition-related mortality (includes malnutrition/cougar) accounted for 0.15 of mortalities in GMU 485 and 0.21 in GMU 653. Age however, was a factor in the malnutrition category. In GMU 485, 3 of the 9 elk that died from malnutrition-related causes were <15 years old and 6 were >15 years old while in GMU 653, 9 of the 20 elk that died from malnutrition-related causes were <15 while 11 were >15 years old. Cook et al. (2013) defined "old aged" elk as those ≥15 years. Vehicle collisions accounted for 17% of adult cow elk mortality in GMU 653.

Estimated annual survival rates for elk calves averaged 0.45, 1998–2016, but have also varied annually and among GMUs (range = 0.09 to 0.82). The lowest estimates of annual survival rates for calves occurred 1998-2003 in GMU 485 and averaged 0.27, while the most recent efforts to estimate calf survival rates occurred 2012–2014 in GMU 653 and averaged 0.63. Calves marked in GMU 490 during 2008-2010 had an average annual survival rate of 0.31.

Table 5. Proportion of mortalities by cause for cow elk radio-collared and monitored by Muckleshoot Indian Tribe in GMUs 485, 490, and 653, 1998-2016.

Cause of Mortality	Game Management Unit		
	485	490	653
Years of study	1998-2016 (ongoing)	2006-2016 (ongoing)	1998-2016 (ongoing)
Cougar predation	0.51	0.52	0.23
Malnutrition / Cougar	0.02	0.10	0.09
Malnutrition / Starvation	0.13	0.00	0.13
Vehicle Collisions	0.07	0.07	0.17
Legal Hunting	0.07	0.07	0.09
Wound / Cougar	0.00	0.00	0.01
Wounding	0.02	0.03	0.01
Poaching	0.02	0.00	0.11
Natural / Disease	0.03	0.07	0.04
Unknown	0.11	0.14	0.10
Capture-related	0.03	0.00	0.03

[a]Includes collisions with trains in GMU 485

The MIT has documented 155, 22, and 123 mortality events for elk calves marked in GMUs 485, 490, and 653, respectively, 1998–2014. Predation (cougar, bear, unknown predation combined) was the leading cause of mortality (485 = 0.82, 490 = 0.64, and 653 = 0.68) and cougars were the primary predator in all 3 GMUs. Cougars have been responsible for a higher proportion of predation events in GMUs 485 and 653 than in GMU 490, whereas bears accounted for a higher proportion of predation events in GMU 490 (Table 6). However, the annual calf mortality rate attributed to cougar predation have varied (range = 0.12–0.72) and were greatest in the late 1990s and early 2000s (average 0.47).

Monitoring and Movements

Resulting estimates of bull:cow ratios, calf:cow ratios, and estimates of abundance, along with data collected from other sources, are summarized in the Herd Management section. The MIT studies found that about half of the collared elk in GMU 653 summer in MRNP. The MIT sample was much larger than previous studies, but still was not representative of the entire GMU. The elk in the MIT study tended to fall into 3 migration categories (Figure 7): horizontal + vertical migrators (57%), vertical migrators (23%), and non-migrators (20%). Horizontal + vertical migrators had longer migrations and moved to MRNP (51%) and Crystal Mountain (6%) in summer. Vertical migrators move to higher elevation summer range that is adjacent to their winter range, but also may use their winter range in summer. Non-migrators use the same range

Table 6. Proportion of mortalities by cause for elk calves radio-collared and monitored by Muckleshoot Indian Tribe in GMUs 485, 490, and 653, 1998-2014.

Cause of Mortality	Game Management Unit		
	485	490	653
Cougar predation	0.67	0.45	0.62
Bear predation	0.09	0.14	0.04
Unknown predation	0.06	0.05	0.02
Hunting	0.01	0.00	0.01
Poach	0.01	0.00	0.06
Vehicle or train	0.02	0.00	0.02
Accident	0.03	0.09	0.03
Natural / Disease	0.03	0.14	0.03
Unknown	0.06	0.05	0.12
Capture-related	0.02	0.09	0.05

year-round. The diversity of elevations and habitats used by elk in GMU 653 makes generalizations difficult. Some elk migrate out of MRNP prior to any snowfall, some at the first snowfall, and some remain until there is deep snow, with the majority migrating when there is less than a foot of snow on the ground (MIT unpubl data). Two adult elk that were captured in GMU 653 spent summer in the Crystal Mountain area then shifted their winter range east of the Cascade Crest into GMU 342.

Ninety-five percent of the collared elk in GMU 485 resided year round entirely within GMU's 485 and 466, although about 5% spent a portion of the summer in GMUs 490 or 653. About 50% of the elk from the upper portion of GMU 485 and 10% of the elk from the middle part of GMU 485 spent some time in GMU 466 during summer. Two adult elk that were captured in GMU 485 spent summer in GMU 466 and several winters in 485 then shifted their winter range east of the Cascade Crest in GMU 340. Forage fields created in 2005 by Tacoma Water within GMU 485 as mitigation areas drew elk to those fields, resulting in fewer elk migrating to ridges during summer than had been documented in the early years of the collared-elk studies (MIT unpubl. data).

Collared elk in GMU 490 consisted of residents that spent the entire year within the watershed, and part-time elk that also spent time in GMUs 454, 460, and 485. Two adult elk captured in GMU 490, and one elk translocated to GMU 485 who then moved to GMU 490 (elk 64 Appendix A) spent time on elk feed sites during winter located east of the Cascade Crest in GMU 340, and part of their summer in GMUs 490, 460 and 336.

Since 1999, the MIT has tracked a total of 9 radio-collared elk in the lower White River on or near the Muckleshoot Reservation in Elk Area 6013 within GMU 652. These are non-migratory elk that spend their time on the White River floodplain and on the Lake Tapps/Auburn plateaus.

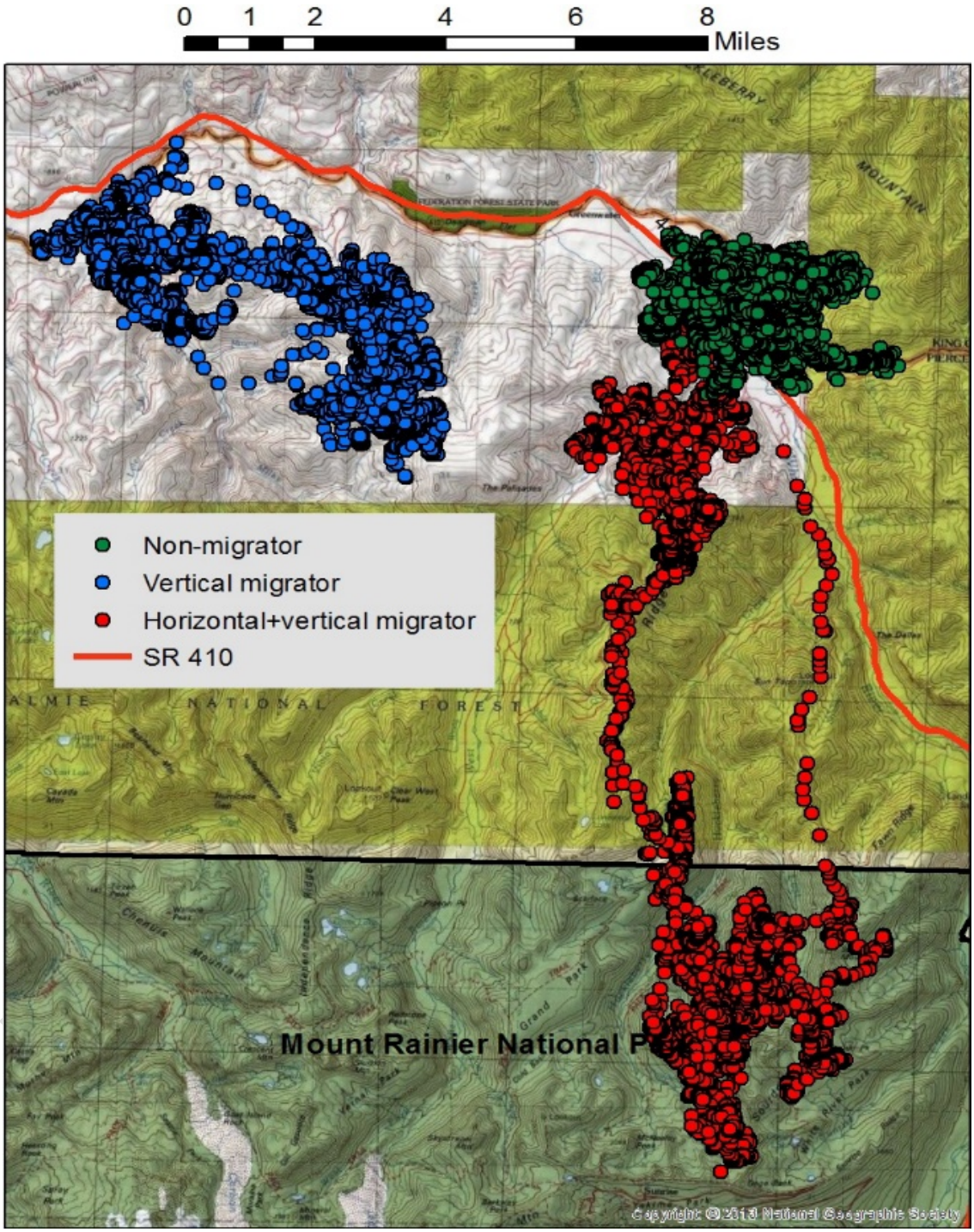


Figure 7. Examples of elk migration for 3 GPS-marked elk in GMU 653, showing non-migrator, vertical migrator, and horizontal+vertical migrator. The horizontal+vertical migrator moves to Mount Rainier National Park in summer. The vertical migrator moves to higher elevation in summer that is adjacent to winter range, but also may use its winter range in summer. The non-migrator uses the same range year-round.

Discussion

Initial research and monitoring efforts in the late 1990s and early 2000s indicated depressed survival rates for elk calves, and for adult cow elk in some years, were the primary factors limiting elk numbers in GMUs 485 and 653, with cougars being the leading cause of mortality. In response to those findings, MIT implemented a cougar reduction program from 2001 through 2007 with the goal of improving elk survival to the degree necessary for promoting population growth. Estimates of annual survival rates for cows and calves, and subsequently estimates of elk abundance, increased during that same period, which suggests cougar predation was a primary factor negatively affecting elk survival in these GMUs. Although the cougar reduction program seemingly benefited local elk numbers, it also occurred simultaneously with the implementation of more conservative hunting seasons and various habitat improvement projects, which also likely benefited elk. Consequently, the degree to which improved survival rates can be attributed to each of these management actions is pending future analyses that considers the full suite of factors that interacted concurrently to influence elk survival (e.g., see Zager et al. 2007, White et al. 2010, Griffin et al. 2011, Brodie et al. 2013, Johnson et al. 2013, Proffitt et al. 2014).

Elk continue to occur at low numbers in GMU 490 and inferences from monitoring and research efforts are limited as a result of small sample sizes. The most recent estimate of annual survival rates for adult cow elk (74%) are believed to be an artifact of a small sample size and may not be representative. The most recent findings associated with MIT's and NPS monitoring and research efforts indicate elk abundance in GMUs 653 and 485 has remained relatively stable the last 5-7 years. Recent estimates of annual survival rates for adult cows and calves, in addition to observed calf:cow ratios, indicate stable and robust elk populations in both GMUs.

Body condition indices and observed pregnancy rates collected 1998-2007, and more recently although sample sizes and inferences are limited, were indicative of a population that was experiencing minimal nutritional limitations during summer and autumn (Cook et al. 2004, 2013). Body condition indices also indicated that migrating elk were in better condition than non-migrators (MIT, unpublished data), which suggests they were getting better nutrition by enlarging their home ranges. However, most of the elk in the NREH area do not migrate, and habitat improvements made within the HUA would likely have a benefit and may be key to increasing elk numbers.

Although body condition indices have indicated minimal nutritional limitations in NREH, approximately 15% and 21% of the mortalities MIT has documented in GMUs 485 and 653, respectively were attributed to malnutrition. However, these estimates are probably biased high because 0.67 (6 of 9) and 0.55 (11of 20) of elk that died of malnutrition-related causes in GMU 485 and 653, respectively, were >15 years old, which likely contributed to their physiological state. Further in-depth analyses of the data are necessary to better understand the habitat effect on malnutrition mortality.

Elk have consistently been more vulnerable to hunting-related sources of mortality in GMU 653 because of greater public access, which is not likely to change in the foreseeable future. For example, hunting-related mortalities only occurred in GMUs 485 and 490 when elk moved out of those GMUs into adjacent GMUs 466, 454, or 460 where public access was not restricted.

Approximately 0.17 of the mortalities MIT has documented in GMU 653 have been associated with collisions between elk and vehicles or trains, with most of those mortalities associated with vehicle-elk collisions on Hwy 410. Managers continue to work with WSDOT to identify strategies for minimizing these events.

Elk within the Muckleshoot Indian Tribe study area. (Photo: Michael P. Middleton, Muckleshoot Indian Tribe)

HERD MANAGEMENT

Estimated Population Size and Objective

Population estimation in the forested habitats of western Washington is a challenge. For that reason, population numbers for parts of the NREH remain elusive. WDFW and MIT surveys and research have focused on the two largest sub-herds residing in GMUs 485/466 and 653. GMU 490 was surveyed in the late 1970's to mid-80's and again starting in 2007. The area of GMU 460 around North Bend and Snoqualmie is now surveyed by the USVEMG. Prior to 1993 the only reliable information about the NREH population came from spring (March/April) survey counts which provided population trend but not an estimate of total numbers. In 1993, 1995, and 2000 paintball marking of elk was tried in GMU 485 and 653 as an affordable way to use mark-resight to estimate numbers (Gove 1994, Spencer 1997). In 1998, cooperative studies provided a means to estimate population size for GMUs 485/466 and 653. Hancock also conducted driving surveys in 2016 and 2017 in portions of GMU 654. Unfortunately, the remainder of the HUA still relies on less precise surveys or in some cases field observations of minimum elk numbers. WDFW currently conducts helicopter surveys in western GMU 653 and Elk Area 6014 (Figure 4), and citizen science driving surveys in Elk Area 6014. Since the degree of precision varies between GMUs this Plan treats each one individually to maximize precision where it exists, and highlight areas needing improvement.

The 2002 herd plan listed population objectives for each GMU (Table 7). At this time, GMU 490 is still below its 2002 objective, however most of the other GMU's reached their 2002 objectives by 2014. The 2002 herd population objective of 2,800 elk was reached by 2010, and the current population estimate of 4,480 is within the + or – 10% margin for the 2018 population objective of 4,850 elk.

To achieve the population target for GMU 460 (Table 7), this plan calls for a reduction of elk numbers in Elk Area 4601 (Figure 4), and an increase in elk numbers in the rest of GMU 460. Additionally, the plan calls for a reduction in elk numbers in Elk Area 6014 while retaining a population of 250 elk in GMU 652 in areas outside EAs 6013 and 6014.

Elk in GMUs 466 and 485 are considered one sub-herd. Therefore, it is not appropriate to derive an elk population target for GMU 466 or GMU 485 individually. The spring estimate of 600 elk (Table 7) for the two GMUs combined does not include elk present in parts of GMU 466 during summer and fall; nor does it include elk that later return to winter ranges east of the Cascades.

Population History and Status by Unit

Issaquah Unit (GMU 454)

No population surveys are conducted in this unit. The population numbers in Table 7 for GMU 454 are based on staff field reports and anecdotal information. Due to damage and public safety issues along the urban interface, the population target is meant to limit population size to 400 elk, which is thought to be near landowner tolerance levels.

Table 7. Minimum spring (March/April) population estimates and targets for the North Rainier Elk Herd.

Game Management Unit (GMU)	2000 population estimate	2002 Herd Plan population objective[@]	2018 population estimate	Herd Plan population target
Issaquah (GMU 454)	200	200	400	400
Snoqualmie (GMU 460) not including elk area 4601	175	500	300	500
Green River & Stampede (GMUs 485, 466)	195	525	600	600
Cedar River (GMU 490)	100	100	80	200
Puyallup (GMU 652)) not including elk areas 6013 and 6014	200	200	250	250
White River (GMU 653)	600	900	1,500	1,800
Mashel (GMU 654)	375	375	400	500
Elk Area 4601	NA	NA	450	200*
Elk Area 6013	NA	NA	50	50*
Elk Area 6054	NA	NA	250	250*
Elk Area 6014	NA	NA	200	100*
Total Number of Elk	**1,845**	**2,800**	**4,480**	**4,850**

[a] **WDFW (2002).** GMU 485 and 466 were combined in the same unit until 1984 when GMU 485 was separated as its own unit. Elk area 4601 was created in 2008. The current target for GMU 460 excludes area 4601. Elk Area 6013 was created in 2010 and then modified in 2015 to create Elk Area 6014. The 2000 population estimate and 2002 population objectives for GMU 460 included 4601, and GMU 652 included 6013 and 6014. * Targets for elk areas are considered to be upper limits based upon landowner tolerance.

Snoqualmie Unit (GMU 460)

At present there is good information on elk in Elk Area 4601 but little information is available on elk numbers in the remainder of the Snoqualmie unit. Anecdotal information from the late 1990's until present suggests rapid growth of the elk herd in the upper Snoqualmie Valley, which includes Elk Area 4601 (Figures 4 and 5). Frequent sightings, ground surveys, increasing frequency of elk damage reports and road kill reports, provide evidence of an increase.

Volunteers of the USVEMG conducted a ground survey in 2008 and estimated there were approximately 350 elk in the upper Snoqualmie Valley. The USVEMG began radio-collaring elk in March 2009 to assess elk movements and estimate numbers. A total of 72 elk have been radio collared since the study began. The USVEMG has conducted repeated ground counts since spring 2011 using the collared elk to estimate total numbers. Annually, each survey route is repeated 12 times to derive a statistical estimate of population size using program NOREMARK (White 1996; Table 8). Outlier surveys are removed using Chauvenet's criterion (Chauvenet 1960).

The WDFW estimates that at least half the elk in GMU 460 likely occur in Elk Area 4601, with the remainder scattered throughout the rest of the GMU. Separate population targets are recommended for Elk Area 4601 and the remainder of GMU 460 outside of 4601 (see Table 7).

Table 8. Results of elk surveys conducted by the Upper Snoqualmie Valley Elk Management Group in the Upper Snoqualmie Valley, 2010-2017.

BY	n collared elk[1]	n surveys[2]	Estimated elk population[3]	95% CI
2010	31	12	428	377-494
2011	34-36	10	412	366-472
2012	33-35	11	485	423-554
2013	36-40	11	427	386-477
2014	32-37	11	511	449-591
2015	24-31	11	456	393-542
2016	23	11	444	392-511
2017	29-31	12	661	573-776

[1]Range in number of collared indicates losses or additions of collared elk between sample periods.
[2]Outlier survey periods removed using Chauvenet's criteria.
[3]Estimates calculated using NOREMARK (White 1996).

Green River and Stampede Units (GMUs 485 & 466)

This area was one unit until 1984 when GMU 485 was created to follow the Tacoma Water administrative boundary of the Green River Watershed to limit public access to protect the water supply. The eastern boundary of GMU 485 is not based on elk behavior and does not limit elk movement as do the ridgetops on the southern and northern portions of the watershed. Elk in the Lester area are known to readily move across the GMU 485 and GMU 466 boundary (MIT unpubl. data).

The elk using these two units should be considered one sub-herd. The spring (March/April) survey counts represent a mix of these elk; some may spend the summer in GMU 485 and some in 466. However some elk wintering east of the Cascade Crest also move into GMU 466 during summer and fall, and contribute to hunter harvest there but may not be among those counted in spring (March/April) surveys (Figure 6).

Raw count data from helicopter surveys shows a declining trend from biological years 1991 through 2000 and then increasing to present (Figure 8). Mark-resight estimates based on the MIT collared elk provide corrections for the raw counts from biological year 1998 onward and show a statistically significant positive growth trend of 10% per year starting in 2001 (Figure 8). The City of Tacoma collaborates with the MIT by providing some funding for studies and projects to benefit the management of deer and elk in the upper Green River Watershed. Elk surveys are conducted cooperatively with MIT, TW, and WDFW using these funds.

In spring 1994, WDFW conducted a paintball mark-recapture study in GMU 485 to determine elk numbers. The landscape was divided in separate identifiable watershed drainages which were randomly selected for marking elk. The 1994 estimated population was 612 elk (± 68 at

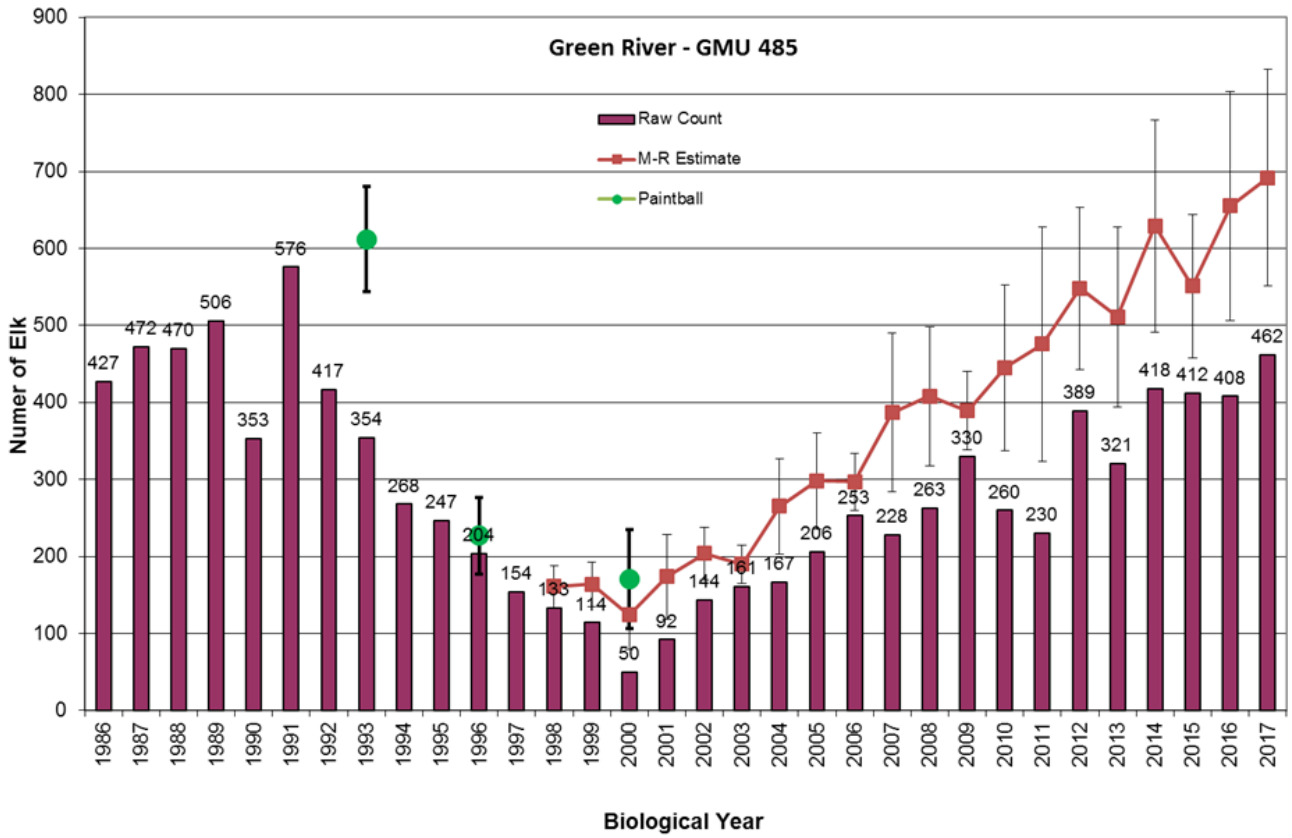


Figure 8. Counts and estimates of elk numbers in the Green River unit (GMU 485) 1986-2017. Number of elk counted during spring helicopter surveys in the Green River unit shown in vertical bars. Mark-recapture estimates derived using Muckleshoot Indian Tribe radio-collared elk shown with 95% confidence intervals. Green dots show Washington Department of Fish and Wildlife paintball estimates and 95% confidence intervals for 3 years.

95% CI) (Gove 1994, Spencer 1997). In March and April 1997 a second paintball mark-recapture estimate concluded that there were only 227 elk (± 50 at 95% CI), a decline of more than half (Spencer 1997). In spring 2001, the WDFW conducted a third paintball mark-recapture survey and estimated 171 elk (± 64 at 90% CI), a decline of an additional 25% since 1997 (Spencer, WDFW, unpubl. data). The 2001 paintball estimate (biological year 2000) compared favorably with the mark-recapture estimate using radio collared elk. Confidence intervals overlapped between biological year 1998 and 2001 but there is no doubt numbers were high in the early 1990's, declined dramatically until around 2000, and have increased since. The high count of 576 elk in biological year 1991 likely represented a herd size of almost 800 or more assuming a 70% average detection rate of collared elk (MIT unpubl. data).

In an effort to bolster the elk population, WDFW and MIT collaborated in 2002 to translocate 82 elk from GMU's 651, 660, 663, and 667 into GMU 485 (Appendix A). The desired result was not realized because many of the translocated elk either died or emigrated out of GMU 485 within a year of being released. Only 15 of the translocated elk were known alive inside the Green River one year after the translocation. Appendix A provides more information on the details of the augmentation including source sites, release sites, animal histories, survival, and other available data.

Annual survival rates of radio-collared adult cows in GMU 485 between 1998 and 2015 ranged from a low of 0.72 in 1998 to 0.97 in 2013. Average annual survival rate during 1998-2002 was 0.82 compared to an average of 0.90 for 2003 through 2015 in the absence of antlerless hunting (MIT unpubl. data). The higher survival rates in later years combined with improved calf survival after 2003 yielding higher calf ratios have helped increase elk numbers in GMU 485.

Habitat improvements (described later in this document) in GMU 485 may have contributed to improved nutrition and helped to increase the population, although large-scale projects were not implemented until 2005 and did not achieve full productivity until a year later. The elk population in this unit now exceeds the 2002 objective of 500. Muckleshoot study data on pregnancy and survival rates indicate that this herd is not nutritionally stressed at 600 elk leading to the proposed target to balance elk numbers with habitat. Muckleshoot radio tracking data has recently identified a few elk moving west outside of the watershed into GMU 454. An increase in the population might result in more animals emigrating into GMU 454.

Cedar River Unit (GMU 490)

Elk numbers in GMU 490 have declined substantially since the 1980's. Schoen (1977) estimated the total number of elk at 300 in 1975. In fall 1986, Raedeke and Paige (1987) estimated between 112 and 151 elk within the lower watershed based on an aerial count. Using ground-based surveys and a mark-resight estimate derived from collared animals, Paige reported that elk in the upper watershed during summer peaked at 644 in 1982 and declined to 528 by 1986 possibly due to density-dependent factors (Paige 1988). Total numbers in the entire watershed thus likely approached approximately 700 during summer from 1982 to 1986. No formal surveys were conducted until 1999 when WDFW attempted a paintball mark-resight study to estimate numbers. The effort was abandoned when too few elk were found to mark (Rocky Spencer, WDFW, pers. comm.; Dwayne Paige, SPU, pers. comm.).

City of Seattle Cedar River watershed staff observed a decline in elk numbers that began in the 1980's. The MIT began radio-collared studies on elk in GMU 490 in fall 2006, using a mark-resight technique described above, to sample the entire GMU. Spring 2008 and 2010 surveys estimated that 80 elk spent most of their time in the unit each year. Additionally, small groups of roughly 30 elk spent some time in GMU 454 (including the Selleck and Landsburg areas) in each of the two years.

The City of Seattle has developed a Habitat Conservation Plan (City of Seattle 2001) that severely limits timber harvest and forest clearing. With the emphasis on old forests, elk in this GMU will be negatively affected due to fewer openings and less food in this GMU. The previously large numbers observed in the watershed will not be possible in the future without habitat creation, thus the proposed target is 200 elk, far less than what the watershed historically supported with logging. The MIT is working with SPU staff to implement habitat improvements, and also assessing what methods may successfully grow elk numbers within the watershed.

Puyallup Unit (GMU 652)

Minimal population surveys are conducted in most of GMU 652. However, a citizen science based driving survey of Elk Area 6014 (Figure 4) began in 2015. The highest one day count according to that survey results was 180. Population trends in 652 can be ascertained using harvest data and are discussed under Harvest to follow.

In response to the MIT's desire to maintain elk along the Lower White River corridor, WDFW created Elk Area 6013 (Figure 4) in 2010. In response to increasing landowner complaints, WDFW created Elk Area 6014 in 2015. A population target has been established for each of these elk areas independent from that of the rest of GMU 652 (Table 7). Since 1999, the MIT has tracked 12 radio-collared elk in the lower White River between Highway 410 and Auburn in GMU 652. These radio-collared elk are non-migratory, with most of their home ranges contained within Elk Area 6013 indicating these elk are resident year round. The tribe surveys elk along the corridor in spring (March/April) and has estimated up to 100 elk using an area that can best be described as all of Elk Area 6013 and the northwestern 60% of Elk Area 6014. WDFW and MIT conducted helicopter surveys of Elk Areas 6013 and 6014 combined in 2013 and again in 2017 with a total count of 126 and 192, respectively.

WDFW conflict staff has documented as many as 75 elk in a group near Enumclaw during 2015-2016. Other smaller groups have been documented in neighboring areas as well. Some of these elk may be migratory and others non-migratory. Landowner complaints have increased as the herd has grown.

White River Unit (GMU 653)

GMU 653 contains the largest elk sub-herd in the North Rainier elk herd area. It borders MRNP and both have been subject to extensive survey efforts to track numbers and composition (Figure 6). GMU 653 is large and has many localized groups of elk throughout the area that have distinct movement patterns, so what occurs in one part of the unit may not represent what occurs in another. Surveys began in 1978 and continue to the present, but changes have occurred in survey technique along the way. Each survey type discussed here sampled only a portion of the entire GMU. Only spring (March/April) flights in 2012, 2015 and 2017 have covered a large enough area to be considered complete.

Mount Rainier National Park Fall Elk Surveys

In 1978, Bradley (1982) established a systematic fixed-wing aircraft survey to assess elk numbers in MRNP. The flights flew over open portions of the northern part of the Park in designated survey units between Governors Ridge and Crystal Mountain. The counts of three replicated survey flights were summed to calculate an "E4" value and doubled to represent an approximate number of elk not seen during the surveys using Bradley's protocol (Bradley 1982).

The Park discontinued the fixed-wing late summer (August- September) surveys in 1988 and the WDFW then followed these same survey routes, using a helicopter to classify elk. From 1996 to 2015, the MIT and MRNP have also cooperated in these flights. Late summer (August-September) trend data collected in MRNP from 1985 to 2006 indicate that the number of elk using the Park's alpine and subalpine open habitats peaked at 1,356 elk in 1991, and then declined thru 2004 to less than 300. From 2004 to the end of the survey in 2011 numbers had risen to nearly 700 elk (WDFW 2002; Jenkins et al. 2015; Figure 9).

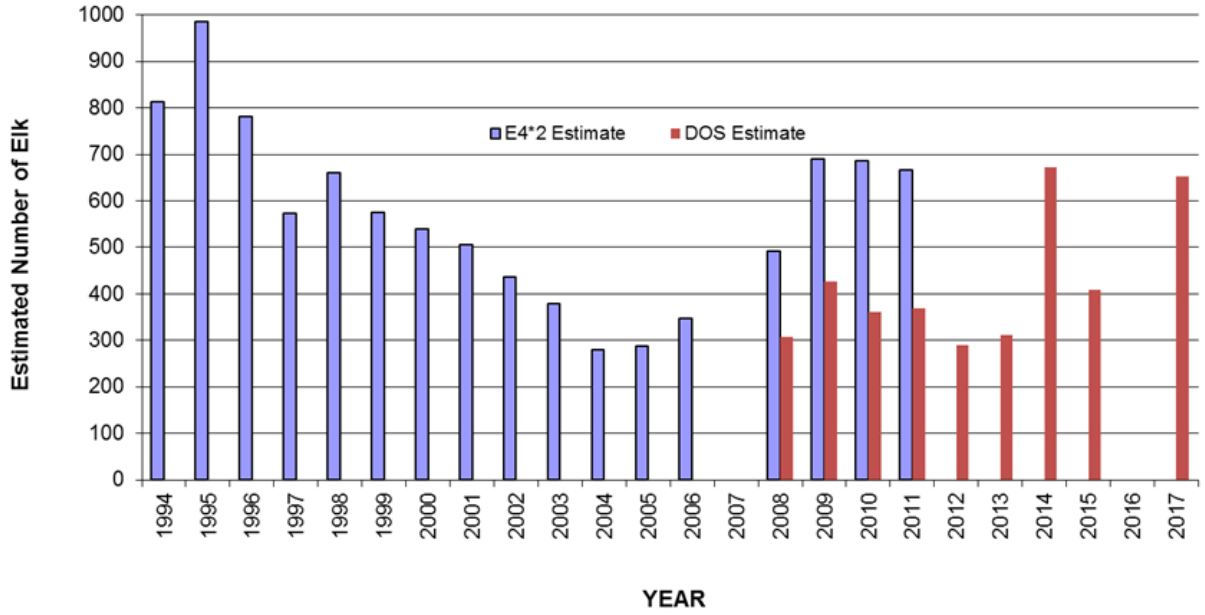


Figure 9. Mount Rainier National Park fall elk trend estimates from aerial surveys using the E4*2 (Bradley 1982) and Double-Observer Sightability (Griffin et al. 2013) methods.

In 1998, MIT began research using radio-marked elk to study elk in GMU 653, which provided an opportunity to improve population data. Between 1998 and 2003, the proportion of collared elk seen during fall survey flights in the Park ranged from 33 - 55%. After 2003 the number dropped to 16 - 25%. By 2007, based on the proportion of radio-collared animals seen compared to those in the Park, and a disparity with spring (March/April) population estimates, it was apparent that the fall MRNP elk surveys were not tracking herd trends. Elk were spending more time in the forest during surveys and were less visible than in previous years.

In 2007 a new fall survey (August 15 to September 15) approach was tested thru the cooperation of MRNP, USGS, WDFW, MIT, and PTI (Griffin et al. 2012, Griffin et al 2013, Griffin et al. 2015). This ran concurrently with the older protocol until it was ended in 2011. The primary changes to the survey were: 1) survey areas (Figure 6) were redefined to allow greater repeatability of survey effort, 2) survey units were redefined to better reflect habitat used by elk, 3) surveys estimated detection biases (i.e. elk present but not seen by aerial survey crews), and 4) survey results replaced old E4 estimation with a model that provides a statistically sound elk index within MRNP. Double-observer sightability (DOS) models have been developed to estimate the probability of detection of each elk group sighted, which varies as a function of group size, the amount of concealing vegetation, and other factors (Griffin et al. 2013). Survey protocols and annual survey results have been reported and multi-year analyses have been conducted and are available from the National Park Service Inventory and Monitoring North Coast and Cascades Network reports and publications web site (https://science.nature.nps.gov/im/units/nccn/publications.cfm accessed March 22, 2018).

As this survey progressed, the WDFW recognized that the MRNP survey did not adequately describe the rest of the elk use in GMU 653. The WDFW then decided that surveys in sub-alpine habitat, in a national park, directed toward a portion of one sub-herd during the summer, was not the optimal use of limited resources, and in 2017 it stopped participating. In the future, the WDFW will seek collaborations that use a more pragmatic approach to timing and landscape scale.

GMU 653 Spring Surveys

Beginning in 1987, while the MRNP survey was continuing, the WDFW began systematic spring helicopter composition and population index surveys for a portion of GMU 653. In 1998 MIT took over the survey responsibility in GMU 653 and have continued to the present. Figure 10 shows the survey data from 1997 to 2016.

In spring 1995 and 2000, the WDFW conducted paintball mark-recapture surveys of elk in GMU 653. The landscape was divided in separate identifiable watershed drainages which were randomly selected for marking elk. The biological year 1994 population estimate was 829 elk (range 693 to 966), and the biological year 1999 estimate was 434 elk (range 363 to 504), a 48% decline (R. Spencer, WDFW, unpubl. data). The 2000 paintball estimate did correlate with the mark-recapture estimate from the MIT radio-collared elk (Figure 10).

Beginning in 1999, spring (March/April) population numbers for the survey area (Figure 6) in GMU 653 have been calculated using MIT-collared elk to produce a mark-recapture estimate. Initially, the results of the spring surveys correlated with the fall population estimates in MRNP (Figure 9), and showed a decline in elk numbers from 1990-91 to 2002. Since spring 2002, the GMU 653 elk population estimates have been increasing (Figure 10, MIT, unpubl. data).

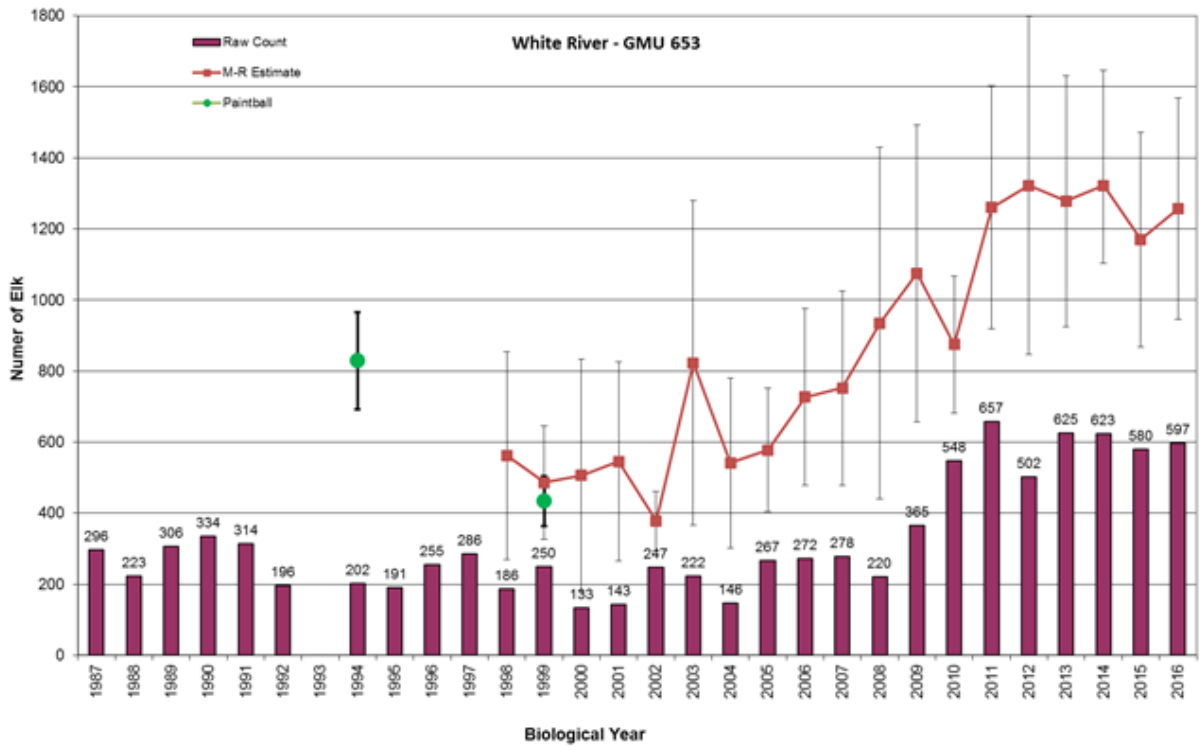


Figure 10. GMU 653 survey results; The raw counts are spring helicopter surveys done by the Washington Department of Fish and Wildlife until 1998 and continued by the Muckleshoot Indian Tribe (MIT) to the present. The chart does not include data from the Clearwater River to Carbon River area. Mark-resight (M-R) estimates are based on MIT collared animals with 95% confidence intervals, and paintball are two WDFW mark-resight estimates with 95% confidence intervals.

During the MIT elk study 50 % of the radio-marked elk wintering in GMU 653 moved into MRNP during summer (MIT unpubl data). However, the collared elk represent only a portion of the elk in the entire unit, and the number of elk that move into the MRNP from areas outside the study area is not known. The MIT study area (Figure 6), covers about 65% of the entire unit. Most years the spring (March/April) surveys occur only within the study area, but in 2012, 2015 and 2017 the survey area was expanded (Figure 6). Only 10 to 15% of the elk observed during the expanded survey occurred outside the study area. The entire GMU 653 survey data indicates that elk density is higher in the study area than in the additional survey area (about 85% of the elk in 65% of the study area compared to about 15% of elk in 35% of the additional survey area). The results of the surveys presented below represent trends for the areas and periods surveyed. They do not represent a complete enumeration of elk in the GMU, except for the spring (March/April) results for 2012 (biological year 2011), 2015 (biological year 2014), and 2017 (biological year 2016).

Figure 10 shows a population increase starting in 2003. Changes in cow and calf survival may help to explain the increase. The average adult cow survival rate which was 0.80 during 1998-2002, improved to a high of 0.95 in 2005, and averaged 0.90 from 2003-2015. There was also a

similar increase in calf survival (MIT, unpubl. data). It should be noted that the MIT increased harvest of cougar in GMU 653 starting in 2001, which may be a factor in the increased cow and calf survival.

The area from the Clearwater River west and south to the Carbon River was not included in past or current surveys because part of it is the Kapowsin Tree Farm; previously a Private Land Wildlife Management Area (PLWMA) that was managed separately from the remainder of GMU 653. PLWMAs no longer exist, and the area is now under GMU 653 regulations. Access is managed by Hancock, and is restricted during elk season. Hancock has conducted elk surveys; however, those data are not available. This area was surveyed in biological years 2011, 2014 and 2016 but these data are excluded from the results in Figure 10 for consistency. The MIT does not have radio-collared animals in this area so only raw counts and a correction factor based on the collared animal observability in the other part of this unit are available. WDFW, MIT, and Hancock cooperatively surveyed the western half of GMU 653 in springs of 2015 and 2017, with total counts of 81 and 68 elk respectively, supporting the conclusion that few elk are found in this area of the GMU.

For GMU 653 in 2011, the main survey area estimate was 1,260 elk, with another 146 elk seen in the additional survey area (Figure 6). Using the proportion of marked animals in the main survey area sample, a correction factor was calculated each year, and used to estimate the population in the additional survey area. The correction factor in 2011 was 2x, resulting in 292 elk estimated in the additional survey area, and an estimated total for GMU 653 of approximately 1,550 elk. The biological year 2014 flight estimated 1,322 elk in the main survey area with another 81 seen in the additional survey area. The correction factor for that year was 2.4x, resulting in 184 elk in the additional survey area, and a total GMU estimate of approximately 1,500 elk. The proposed population target of 1,800 is for all of GMU 653 and is based on spring (March/April) survey numbers. Radio-collared elk in the MIT study area are not showing nutrition-stress-related habitat effects such as lower pregnancy rates or malnutrition mortality for elk aged 16 or less.

Mashel Unit (GMU 654)

No formal population surveys are conducted in GMU 654, and population information is based primarily upon harvest data and anecdotal reports. Hancock conducted nighttime spotlight driving surveys on Kapowsin and Eatonville tree farms in 2016 and 2017 and located 178 and 165 elk, respectively (Table 9).

Table 9. Spotlight survey results for elk located within Kapowsin and Eatonville tree farms; 2016- 2017 (Hancock Timber Resource Group, 2017). Surveys were done mid to late August of each year.

Survey Year	Sampling Time (Hours)	Total Elk	Total Bulls	Total Cows	Total Calves	Calf/Cow Ratio	Bull/Cow Ratio
2016	19.98	178	14	88	48	0.55	0.16
2017	21.45	165	39	67	28	0.42	0.58

Herd Composition

Western Washington elk surveys in the past were either flown in the late summer or spring. Late summer surveys are designed to locate elk gathered in large breeding groups prior to the rut, including older bulls that normally only associate with groups at this time. Spring (March/April) surveys are flown to collect age ratios and annual calf recruitment since they are conducted after winter mortality. The WDFW 2015-2021 Game Management Plan (WDFW 2014) provides herd composition parameter guidelines as a means to guide management decisions.

These guidelines recommend managing for a pre-hunt bull cow ratio range of 15 to 35 bulls:100 cows, or a post-hunt ratio of 12 to 20 bulls:100 cows. The number of calves per 100 cows (calf:cow ratio) is often used as an index to herd productivity, but can also have a broad spectrum of applications including tracking herd trends, intensity of harvest, and as an indication of herd health and nutrition levels. However, an accurate calf:cow ratio is difficult to obtain since most of the variables are hard to control, including accurately identifying calves from cows on winter range. Regardless, calf:cow ratio can be used with caution as another parameter in herd management.

Issaquah (GMU 454), Snoqualmie (GMU 460), Cedar River (GMU 490), Puyallup (GMU 652) and Mashel (GMU 654) Units

No formal composition surveys are conducted within GMUs 454, 460, 490, 652 and 654. The USVEMG conducts spring elk surveys in EA 4601 by ground but composition data has not been formally recorded. Composition data had been collected in GMU 490 by Paige (1988). More recently, the MIT conducted surveys in April 2008 (n=33 classified) and March 2010 (n=32 classified) and found calf ratios in the low 30's and bull ratios of roughly 20, but these ratios were based on the classification of very few elk.

Green River Unit (GMU 485)

Starting in 1986 the WDFW used standardized helicopter surveys in GMU 485 supplemented with ground surveys to gather composition data in GMU 485 (WDFW 2002). The MIT and TW entered into an access and funding agreement in 1995 that stated "TPU [Tacoma Public Utilities] will cooperate with WDFW and MIT to fund any mutually agreed upon biological study relating to herd composition and composition counts." In 1996 the MIT, WDFW, and TW began cooperative helicopter survey flights. Bull to cow and calf to cow ratios were collected in September and March but the September flights were dropped starting in 1998 due to low elk numbers (WDFW 2002). Figure 6 shows the current survey area for GMU 485.

The spring bull:cow ratios shown in Table 10 are conservative and yet generally high, showing the result of permit only bull harvest management. The bull:cow ratio averaged 21 bulls per 100 cows over the past 5 years, well within the parameter guidelines. Calf:cow ratios declined dramatically through the late 1990's but rebounded starting in 2001. By 2005 spring ratios had rebounded and peaked at 54 calves per 100 cows and have averaged 30 over the past 5 years.

White River Unit (GMU 653)

Late summer surveys in MRNP and spring (March/April) surveys on winter-spring range done by the MIT and WDFW provide composition data for a portion of GMU 653 (Happe et al. 2013, 2014, 2015, 2016 and Jenkins et al. 2015). Historical data starting in 1989 through 2000 are available in the 2002 herd plan (WDFW 2002). Table 11 shows the results of the surveys in a portion of GMU 653 (Figure 6) from biological year 2000 to 2017. Pre-season bull to cow ratios averaged 47 over the past 5 years while post-season averaged 13, both well within parameter guidelines with pre-season being quite high. These ratios are believed to be an unbiased estimate for GMU 653 elk using MRNP in summer. Spring calf:cow ratios were low in 2000 and 2001 but improved rapidly since, averaging 44 pre-season and 38 post-season over the last 5 years.

Table 10. Spring composition ratios for elk in GMU 485 of the North Rainier Elk Herd[a].

Biological Year	Sample size	Bulls per 100 cows	Calves per 100 cows
2000	114.0	17.2	19.0
2001	92.0	16.1	32.3
2002	144.0	30.3	15.2
2003	161.0	22.9	26.7
2004	167.0	27.2	54.3
2005	206.0	36.6	47.3
2006	253.0	25.3	43.3
2007	228.0	19.0	41.5
2008	263.0	26.0	29.6
2009	330.0	19.7	31.7
2010	260.0	16.9	29.9
2011	230.0	13.8	24.0
2012	389.0	18.4	24.3
2013	321.0	20.8	38.1
2014	418.0	16.0	36.0
2015	412.0	20.4	35.1
2016	408.0	17.8	16.8
2017	462.0	33.6	16.3

[a] Data from Washington Department of Fish and Wildlife, Muckleshoot Indian Tribe and Tacoma Water.

Harvest

The state hunting regulations for most of the NREH area have been designed to provide maximum recreational opportunity (Appendix B). The exceptions are GMU 490, which is closed and GMU 485, which has strictly controlled access and has been managed since 1984 to provide unique hunting opportunity with limited entry permit-only hunting. A permit-only bull season was initiated in GMU 653 in 2006 in an effort to prevent overharvest of bulls, and offer a less competitive hunting experience with higher success rate. In GMUs 454 and 652, liberal elk hunting seasons and regulations have been used to limit elk damage. The elk areas in the NREH area are shown in Figures 4 and 5. Elk Area 6014 was created in 2015 in a portion of GMU 652 with an emphasis on decreasing the elk population to further control increasing damage to private property. Similarly, permits are issued for Elk Area 6054 in GMU 654. In 2008, the WDFW established Elk Area 4601 inside GMU 460 to help address elk/vehicle collisions and limit elk-related damage in that area. Special permits allow an extended hunting period in Elk Area 4601.

Table 11. Elk composition survey results (bull:cow and calf:cow ratios) for northern Mount Rainier National Park (late summer) and for winter range of GMU 653 (spring).

Biological Year	Bulls per 100 cows		Calves per 100 cows	
	MRNP (Late Summer)	GMU 653 (Spring)	MRNP (Late Summer)	GMU 653 (Spring)
2000	28.4	19.7	29.0	13.6
2001	21.3	11.8	25.0	18.2
2002	23.5	4.7	42.3	39.8
2003	33.0	9.8	48.1	40.2
2004	42.0	11.5	46.0	56.3
2005	38.0	13.3	60.0	48.5
2006	36.0	16.5	46.0	48.8
2007	--	11.6	--	57.9
2008	41.0	7.5	45.0	29.2
2009	31.0	7.4	38.0	43.4
2010	47.0	11.9	50.0	35.8
2011	53.9	14.5	36.1	34.2
2012	48.7	15.1	49.4	30.8
2013	43.2	10.7	42.7	41.0
2014	40.3	11.5	49.6	40.0
2015	51.0	14.5	44.0	45.5
2016	35.0	17.0	34.0	29.7
2017	39.0	--	39.0	--

Prior to 2001 the WDFW used a harvest questionnaire survey (10% sample) each year to determine the number of animals harvested, number of hunters who participated, and number of days hunted. For the NREH the average harvest for state hunters from 1985 to 2000 was 316 elk per year, 215 antlered elk and 101 antlerless (WDFW 2002). In 2001 mandatory reporting was implemented, and since then all hunters must submit a report of their harvest, which has improved harvest statistics. In GMU 485, all hunters (State and Tribal) must check in and out of the area through controlled gates, thus providing an opportunity to accurately tally the harvest. In 2008 data were collected in such a way that permits and general season hunters could be properly accounted for. Table 12 gives the total harvest and hunter numbers for the NREH for state and tribal permit hunts and seasons from 2008 to 2017. The average harvest by state hunters was 376 elk per year, 243 antlered and 133 antlerless.

Tribal elk harvest information is collected by each tribe under their own specific rules. Since 1997, the Northwest Indian Fisheries Commission (NWIFC) has summarized tribal harvest data for the 20 western Washington Treaty tribes (NWIFC 1997-2017). While these documents indicate how many tribes report, they do not provide the specific information each tribe submitted. All NWIFC tribes have reported since 2005, and between 1998-2004 most tribes reported their elk harvest data. Table 12 gives the reported tribal harvest for the NREH from 2008 to 2017 as reported by the NWIFC. The average harvest by tribal hunters was 97 elk per year, 85 antlered and 12 antlerless.

Table 12. State and tribal general season and permit elk harvest and hunter numbers for the North Rainer Elk Herd, 2008-2017 (GMU's 454, 460, 466, 485, 490, 652, 653 and 654).

Year	State Hunters[a]					Tribal Hunters[b]		
	Antlered Elk	Anterless Elk	Total Kill	Total Hunters	Total Days	Antlered Elk	Antlerless Elk	Total Kill
2008	183	84	267	2,513	14,459	69	3	72
2009	226	114	340	2,871	16,448	73	10	83
2010	152	92	244	2,654	14,903	76	4	80
2011	218	91	309	2,538	15,889	81	0	81
2012	239	135	374	2,663	15,079	86	14	100
2013	282	167	449	3,103	17,133	70	12	82
2014	235	179	414	3,101	18,097	81	8	89
2015	255	149	404	3,340	19,345	102	13	115
2016	337	158	495	3,041	17,470	110	35	145
2017	299	162	461	3,013	18,054	101	21	122
Total	2,426	1,331	3,757	28,837	166,877	849	120	969
Mean	243	133	376	2,884	16,688	85	12	97

[a]State harvest numbers include projected estimates. Note: The table begins with 2008 because projected state hunter numbers for years prior to 2008 are not comparable to 2008-2017. [b]Tribal numbers are directly from NW Indian Fisheries Commission hunter reports.

Issaquah unit (GMU 454)

GMU 454 has liberal seasons set for all weapon types; currently modern firearm hunters may take any bull and others may harvest any elk (Appendix B). This is designed to keep vehicle-elk collisions to a minimum and provide landowners with a means to address damage issues. State and tribal harvest in GMU 454 for years 2001-2017 is presented in Table 13. An average of 42 antlered and 31 antlerless elk were taken each year, with nearly all of the harvest taken during state seasons. Figures 11 and 12 show the relative contribution of different weapon types to the overall harvest total for state seasons. General season muzzleloader hunters harvested most of the elk taken in this unit.

Table 13. State and tribal elk harvest from GMU 454, 2001-2017 (All state seasons and weapon types combined)[a].

Year	State General Season and Permit Harvest		Tribal Harvest		State and Tribal Harvest
	Antlered	Antlerless	Antlered	Antlerless	Total Harvest
2001	24	26	0	0	50
2002	36	31	0	0	67
2003	30	24	0	1	55
2004	30	27	3	1	61
2005	41	24	1	0	66
2006	27	31	2	0	60
2007	28	35	3	0	66
2008	39	33	0	2	74
2009	50	23	5	0	78
2010	30	27	1	1	59
2011	46	25	0	0	71
2012	38	29	13	5	85
2013	59	53	2	0	114
2014	39	33	1	3	76
2015	47	22	4	2	75
2016	60	24	6	5	95
2017	46	30	6	3	85
Mean	39	29	3	1	73

[a]State harvest numbers include projected estimates. Tribal numbers are directly from NW Indian Fisheries Commission hunter reports.

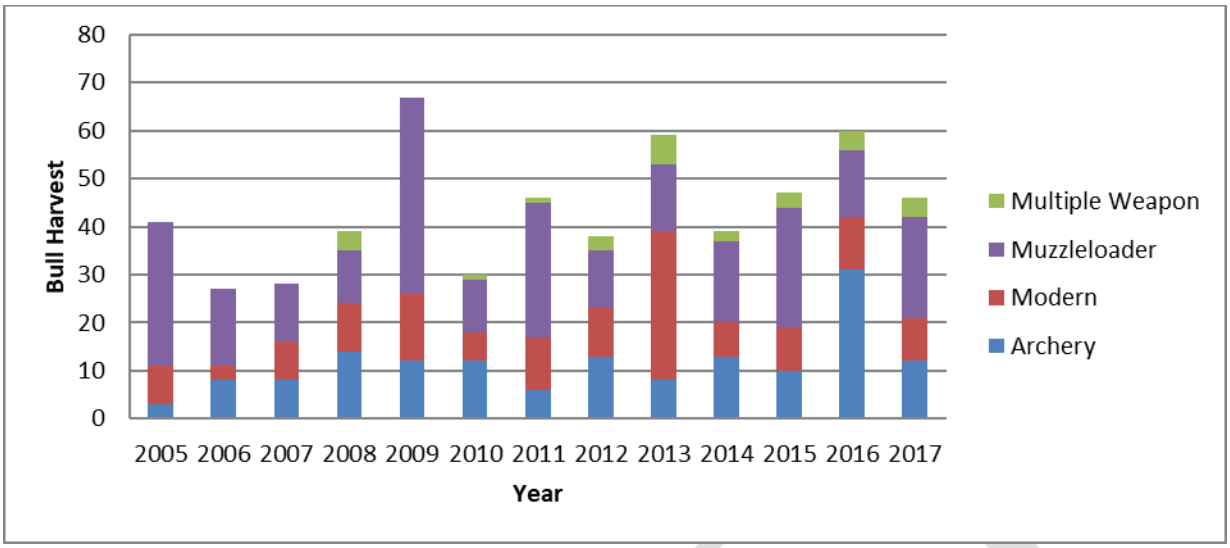


Figure 11. Antlered elk harvest by weapon type for state hunters in the Issaquah unit (GMU 454) from 2005 to 2017.

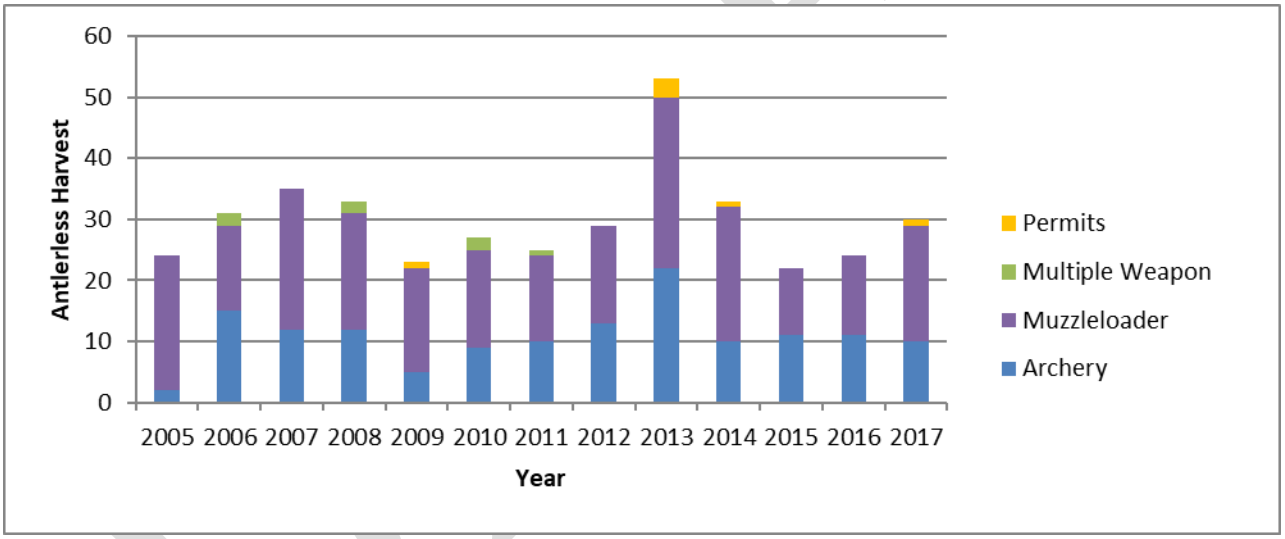


Figure 12. Antlerless elk harvest by weapon type for state hunters in the Issaquah unit (GMU 454) from 2005 to 2017.

Snoqualmie Unit (GMU 460)

State and tribal harvest for years 2001 to 2017 is presented in Table 14. General hunting seasons in GMU 460 since 2000 restricted all hunters to a 3-point minimum or better bull harvest for all weapon types. Between 2001 and 2017 hunters harvested an average of 25 antlered elk each year. Antlerless harvest was eliminated beginning with the 2000 season to enhance population growth. In 2009, Elk Area 4601 (Figures 4 and 5) was formed and antlerless opportunity was added during permit seasons to reduce the elk population in and around North Bend and Snoqualmie. Since 2014, general season archery and muzzleloader hunts in Elk Area 4601 have included opportunity for antlerless harvest as well. All the antlerless harvest for state hunters shown in Table 14 is from Elk Area 4601, and averaged 21 antlerless elk per year since 2009.

Table 14. State and tribal elk harvest from GMU 460, 2001-2017 (All state seasons and weapon types are combined; state antlerless harvest from 2009 to 2017 taken from Elk Area 4601 permit hunt only)[a].

Year	State General Season and Permits Harvest		Tribal General Season Harvest		State and Tribal Harvest
	Antlered	Antlerless	Antlered	Antlerless	Total
2001	10	0	2	5	17
2002	12	0	1	0	13
2003	14	0	0	2	16
2004	16	1	0	0	17
2005	14	0	1	1	16
2006	20	0	0	0	20
2007	22	0	1	2	25
2008	23	0	0	0	23
2009	36	23	1	3	63
2010	21	17	0	2	40
2011	25	17	4	0	46
2012	30	19	0	2	51
2013	55	16	0	1	72
2014	24	36	2	0	62
2015	23	21	2	3	49
2016	44	27	1	3	75
2017	39	12	5	0	56
Mean	25	11	1	1	39

[a]State harvest numbers include projected estimates, Tribal numbers are directly from NW Indian Fisheries Commission hunter reports

Figures 13 and 14 show the relative contribution of different weapon types during general seasons. During the permit hunts shown in Figure 14, master hunters harvested 73% of the antlerless animals taken, modern firearm hunters and archers each harvested 9%, and 7% were harvested by 65 and older, youth and disabled combined.

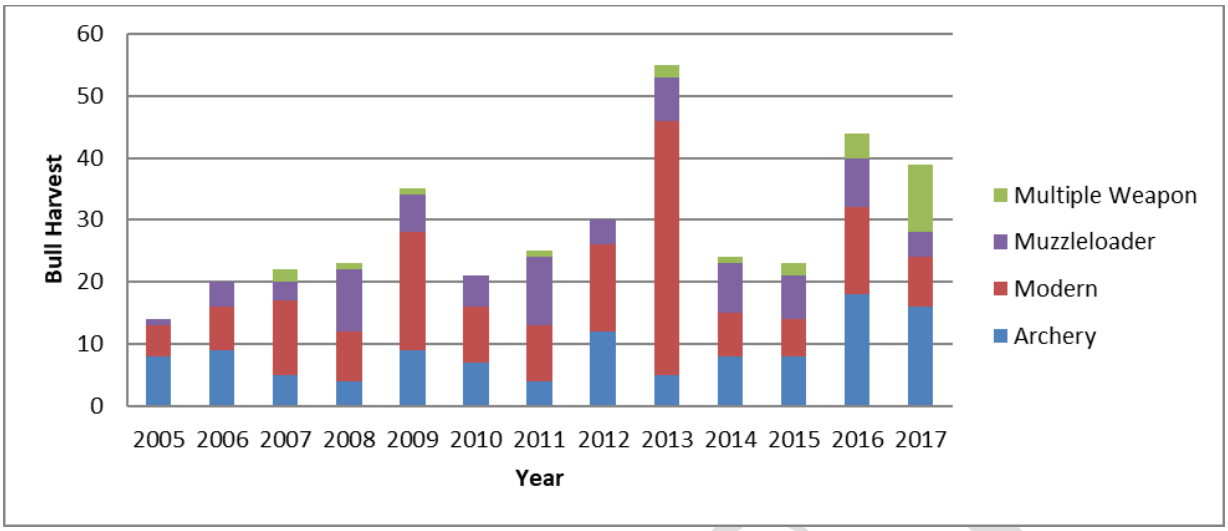


Figure 13. Antlered elk harvest by weapon type for state hunters in the Snoqualmie unit (GMU 460) from 2005 to 2017.

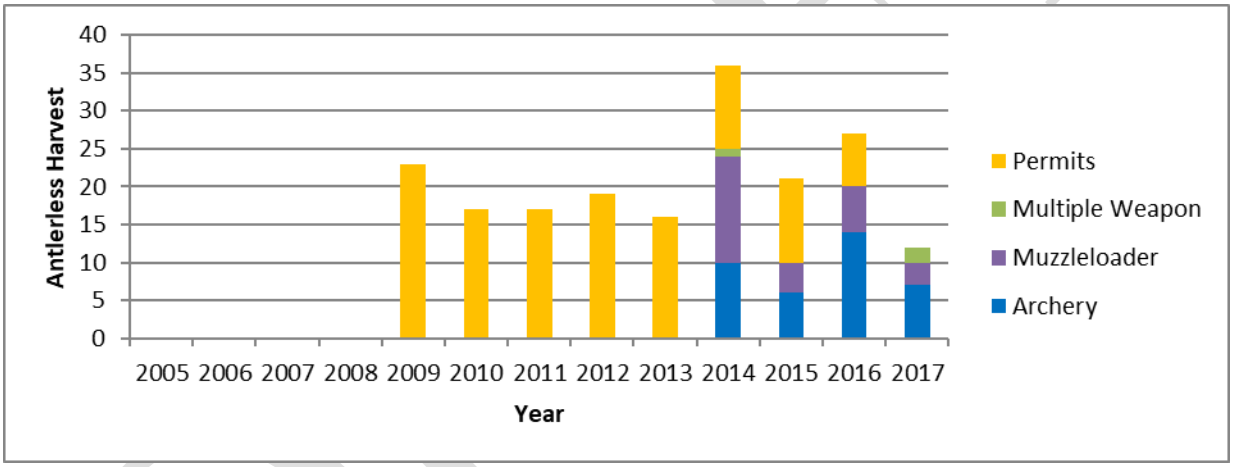


Figure 14. Antlerless elk harvest by weapon type including those taken by permit-only for state hunters in Elk Area 4601 from 2005 to 2017. Permit totals are for all weapon types.

Green River and Stampede Units (GMUs 485 and 466)

Prior to 1984, Stampede 466 was a large GMU encompassing all of the area that has since become Stampede 466, Green River 485 and Cedar River 490. In 1984 when GMU 485 was created, it was opened to state permit hunting only and access was controlled by the City of Tacoma through an agreement between the WDFW and the City of Tacoma. The unit was enlarged in 1987 and enlarged again in 1989 to the approximate size it is today. MIT hunting in GMU 485 began in 1992 (WDFW 2002). It remains a permit only unit and the WDFW, TW, and MIT meet annually to agree upon the number and kinds of permit hunts, distribution of permits, and season dates for GMU 485. When established in 1984, the unit was to provide a quality opportunity to hunt mature bulls and yet maintain high success rates for spike bull and antlerless elk hunting. Despite its small size, GMU 485 gained a reputation for quality hunting

and was one of the most popular permit hunts in Washington State. The demand for hunting permits far exceeded the supply. By 1996 elk numbers were declining, as was hunter success, and this hunt unit was closed to all elk hunters in 1997.

From 1984 to1991, total elk harvest numbers and composition remained consistent, averaging 46 elk, 17 bulls and 29 cows per year (WDFW 2002). Total elk harvest increased in 1992 when Tribal hunting began, adding to both antlered and antlerless elk harvest. With no change in state permit allocation, average total harvest increased to 54 elk per year, then in 1996 dropped to 25 (WDFW 2002). State total antlerless harvest for the 1992-1996 period was 101 and tribal antlerless harvest was 53. Antlered elk harvest for the same period was 48 for state hunters and 41 for tribal hunters (WDFW 2002).

By 2004 the area had been closed to state and MIT hunters for seven years, and with calf:cow ratios (Table 10) and elk numbers had increased (Figure 8), and with elk numbers increasing, GMU 485 was reopened for bull only harvest. Since then permit numbers have been slowly increased as the population has grown, and a few bulls have been harvested each year (Table 15). In 2014 very limited antlerless hunting was allowed to slow the growth of elk numbers in this unit. Tribal harvest in Table 15 includes both the MIT permit-only hunt, and harvest reported by other tribes who did not participate in the permit hunt, but may have hunted elk in that portion of GMU 485 outside the Tacoma Water administrative boundary.

Table 15. State and tribal permit elk harvest in GMU 485 from 1984 to 2017[a].

	State Harvest			Tribal Harvest			
Year	**Antlered**	**Antlerless**	**Total**	**Antlered**	**Antlerless**	**Total**	**Total Harvest**
1984	39	10	49				49
1985	17	30	47				47
1986	20	30	50				50
1987	10	33	43				43
1988	7	31	38				38
1989	13	32	45				45
1990	12	34	46				46
1991	15	30	45	Tribal hunting began in 1992			45
1992	14	28	42	7	6	13	55
1993	10	28	38	4	10	14	52
1994	9	23	32	7	18	25	57
1995	10	13	23	2	15	17	40
1996	5	10	15	3	4	7	22
1997	Closed 1997 through 2003			0	0	0	0
1998				0	0	0	0
1999				2	3	5	5
2000				0	1	1	1
2001				1	0	1	1
2002				1	0	1	1
2003				0	0	0	0
2004	1	0	1	1	0	1	2
2005	1	0	1	2	0	2	3

Table 15. State and tribal permit elk harvest in GMU 485 from 1984 to 2017[a].

	State Harvest			Tribal Harvest			
Year	Antlered	Antlerless	Total	Antlered	Antlerless	Total	Total Harvest
2006	3	0	3	3	0	3	6
2007	3	0	3	8	0	8	11
2008	3	0	3	5	0	5	8
2009	3	0	3	6	0	6	9
2010	6	0	6	6	0	6	13
2011	6	0	6	8	0	8	14
2012	6	0	4	6	0	6	10
2013	5	0	4	7	0	7	11
2014	4	0	3	4	1	5	8
2015	5	2	7	6	2	8	12
2016	7	3	10	12	0	12	20
2017	7	4	11	10	0	10	21

[a]State harvest numbers include projected estimates, Tribal numbers are directly from the NW Indian Fisheries Commission hunter reports.

As mentioned above, the elk in GMU 485 and 466 are not distinct from one another, and harvest in one area likely affects the other (WDFW 2002). General season regulations for GMU 466 restrict all weapon types to 3-point minimum bulls. In 2015 a muzzleloader season was added to this unit (Appendix B). Table 16 shows the state and tribal harvest for GMU 466 from 2001-2017. Combined state and tribal antlered elk harvest averaged 23 for the period shown and antlerless harvest was one animal per year. Figure 15 shows the relative contribution of each weapon type to the state harvest in GMU 466. The cumulative annual average from 2001 to 2017 for the two GMUs combined was 30 antlered and two antlerless elk per year.

Table 16. State and tribal elk harvest from GMU 466, 2001-2017. All state seasons and weapon types are combined[a].

	State Harvest		Tribal Harvest		
Year	Antlered	Antlerless	Antlered	Antlerless	Total Harvest
2001	5	0	6	3	14
2002	5	0	1	2	8
2003	5	0	15	0	20
2004	1	0	10	0	11
2005	6	0	11	1	18
2006	6	0	4	1	11
2007	8	0	13	2	23
2008	10	0	16	0	26
2009	7	0	16	0	23
2010	8	0	21	1	30
2011	7	0	13	0	20
2012	13	0	23	0	36

Table 16. State and tribal elk harvest from GMU 466, 2001-2017. All state seasons and weapon types are combined[a].

Year	State Harvest		Tribal Harvest		Total Harvest
	Antlered	Antlerless	Antlered	Antlerless	
2013	13	0	17	1	31
2014	8	0	20	0	27
2015	10	0	12	0	23
2016	27	0	13	3	43
2017	8	0	12	0	20
Mean	9	0	13	1	23

[a]State harvest numbers include projected estimates, Tribal numbers are directly from the NW Indian Fisheries Commission hunter reports.

Cedar River Unit (GMU 490)

As stated above, this GMU was created out of GMU 466 in 1987, and it was enlarged in 1989 and then again in 2003. The GMU 490 boundary is also the administrative boundary for the SPU Cedar River Watershed (CRW) and is closed to public access. Prior to the transfer of USFS lands within the watershed to SPU, some hunters would trespass to access the public lands, others would charter aircraft. Despite limited access and trespass issues, WDFW had seasons open for elk hunting in the watershed through 1999, and some elk were harvested in the watershed. In 2000, when it seemed that elk numbers were too low to support a hunt, elk hunting was closed. In 2006 the City of Seattle and the MIT entered into an agreement which allows the tribe to exercise its traditional right to hunt in the watershed. Tribal hunting resumed, allowing very limited permits and harvest of a few bulls per year since 2010.

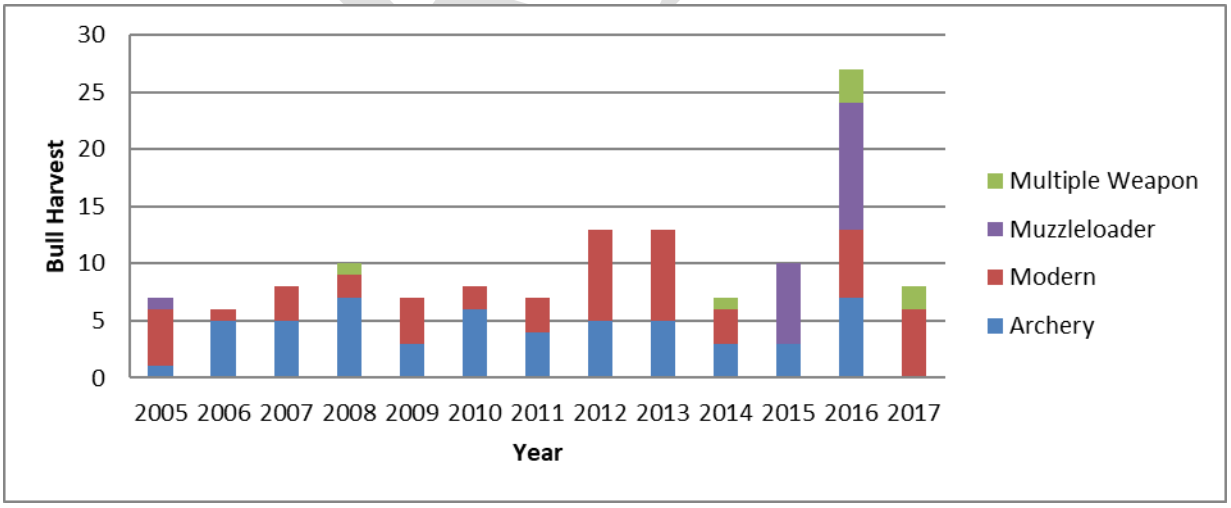


Figure 15. Antlered elk harvest by weapon type for state hunters in the Stampede unit (GMU 466) from 2005 to 2017.

Puyallup Unit (GMU 652)

Since 1998 GMU 652 has had a 3-point minimum general season for modern firearm hunters. Since 2003 archers could take any elk, and muzzleloaders 3-point minimum bulls or antlerless elk. Total state harvest in GMU 652 averaged 42 elk annually from 1985 to 1999 (WDFW 2002). From 2001 to 2017, the annual total state and tribal harvest combined averaged 102 with a low of 35 in 2001 and a high of 170 in 2016 (Table 17). Over the last 5 years antlered harvest averaged 87 per year and antlerless harvest averaged 66 per year for all seasons and weapons combined. Figures 16 and 17 show the relative contribution to the harvest total of different weapon types during general season hunts for state seasons. Bull harvest was dispersed throughout the weapons groups, but muzzleloaders harvested most of the antlerless elk taken. Permit harvest shown in Figure 17 was by modern firearm in 2015-2017, and by any weapon in 2013 and 2014.

Table 17. State and tribal elk harvest from GMU 652, 2001-2017. All state seasons and weapon types are combined[a]. The table does not include animals taken during damage hunts.

Year	State General Harvest		Tribal Harvest		Total Harvest
	Antlered	Antlerless	Antlered	Antlerless	
2001	27	4	4	0	35
2002	27	37	2	0	66
2003	21	37	2	0	60
2004	37	38	0	0	75
2005	26	30	1	0	57
2006	49	32	0	0	81
2007	31	30	1	2	64
2008	44	21	4	0	69
2009	66	37	2	0	105
2010	56	47	1	0	104
2011	61	31	0	0	92
2012	79	45	4	1	129
2013	63	50	0	0	113
2014	87	73	1	0	161
2015	81	78	0	0	159
2016	94	73	1	2	170
2017	112	76	2	0	190
Mean	57	44	1	0	102

[a]State harvest numbers include projected estimates, Tribal numbers are directly from the NW Indian Fisheries Commission hunter reports.

Most hunting occurs on private land and is targeted toward localized resident herds. Elk Area 6013 (Figure 4) was created in 2010 to protect the small resident herd using the Lower White River on the Muckleshoot Indian Reservation. Antlerless muzzleloader harvest was closed starting in 2010 to protect that herd. In 2015, Elk Area 6013 was reduced in size and the new Elk Area 6014 was created to address increasing elk damage complaints. In 2015 and 2016, elk seasons for Elk Area 6014 were liberal, using modern firearm 3 point minimum bull or antlerless seasons and additional antlerless permits to reduce elk numbers.

White River Unit (GMU 653)

Since 1998 GMU 653 has had a 3-point minimum general season for modern firearm hunters. A liberal antlerless harvest prior to 1998 had increased the cow mortality rate and may have been one of several factors contributing to this unit's population decline. Either-sex archery seasons which were initiated in 1985 were ended in 1997 to improve cow survival and slow the decline of the population. Likewise the MIT, along with most other tribes, ended antlerless elk harvest in GMU 653 in 1998. Between 1998 and 2005 state harvest was restricted to 3-point minimum bulls for archers and modern firearm hunters. A muzzleloader season was provided in 2003 and 2004 only with no elk harvested. In 2006 a bull-only permit season was introduced for all weapons and this season structure continued thru 2017.

Total harvest and hunter success have remained fairly stable since the 2006 permit season was initiated with a slight increase in both in 2015. Total state harvest in GMU 653 averaged 45 elk annually from 1988 to 2000, tribal harvest averaged 24, state antlerless harvest averaged 9 while tribal antlerless harvest averaged 37 per year (WDFW 2002). From 2001 to 2017, the annual total state and tribal harvest combined averaged 63 with a low of 40 in 2012 and a high of 107 in 2015 (Table 18). Over the last 5 years antlered harvest averaged 74 per year and antlerless harvest averaged 8 per year for all seasons and weapons combined.

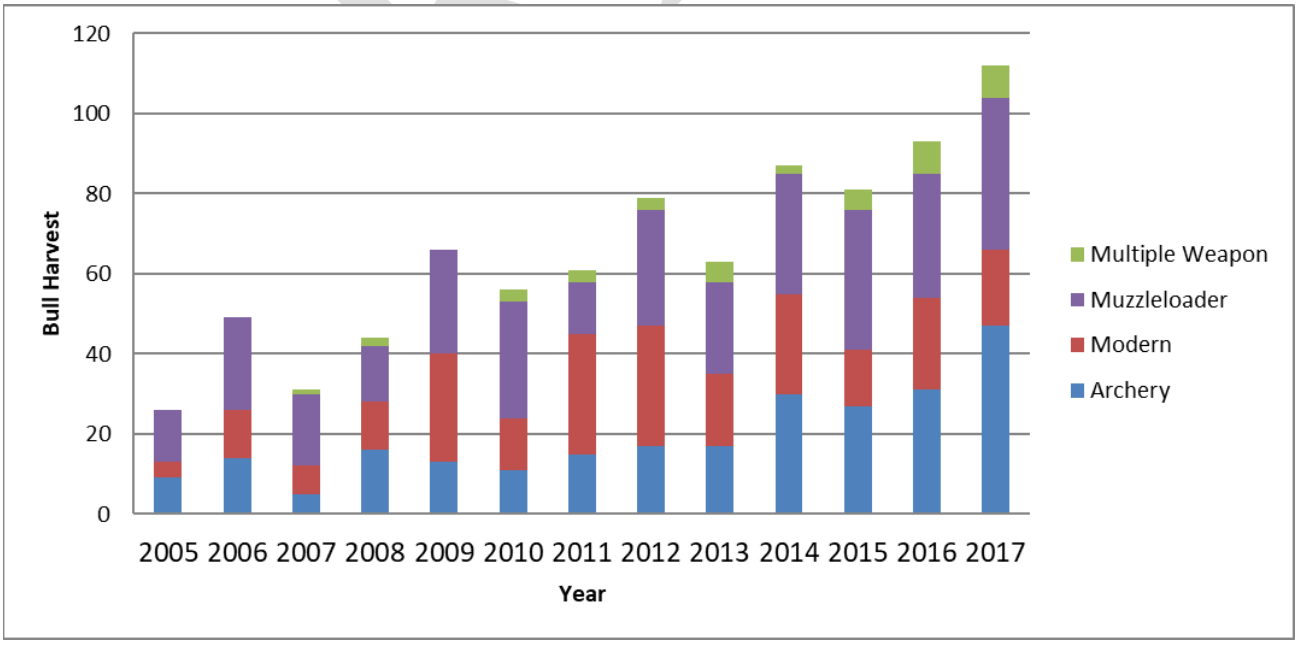


Figure 16. Antlered elk harvest by weapon type for state hunters in the Puyallup unit (GMU 652) from 2005 to 2017.

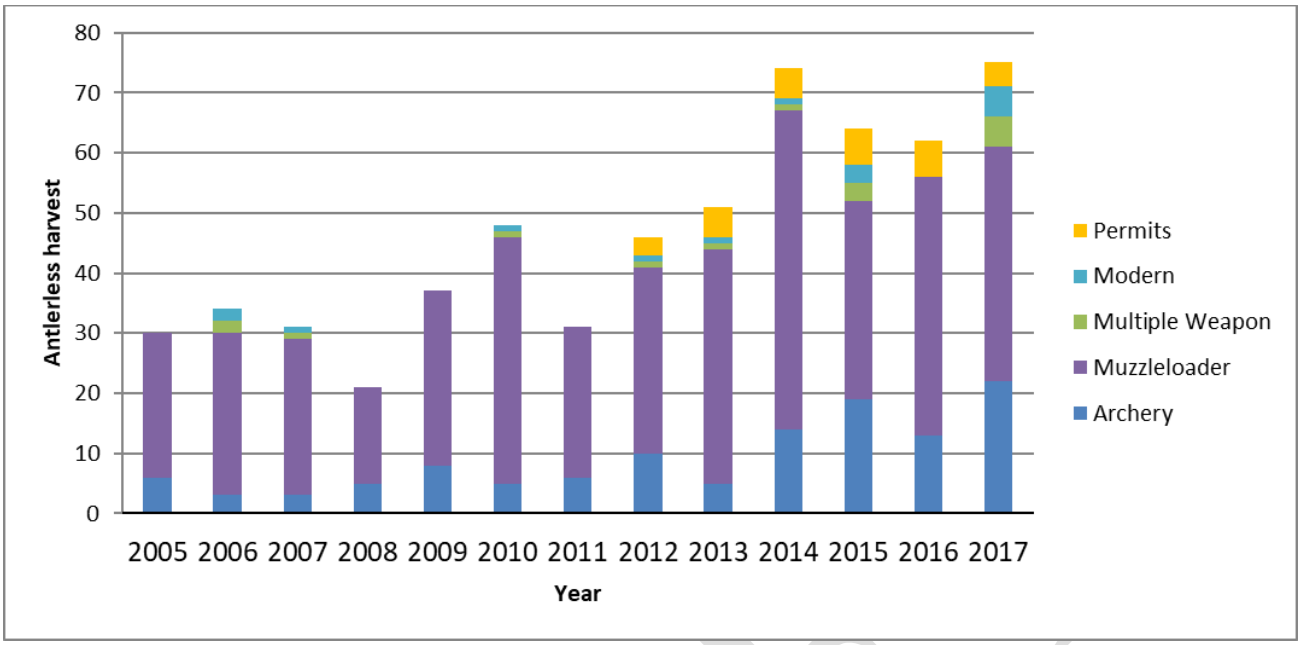


Figure 17. Antlerless elk harvest by weapon type including those taken by permit only for state hunters in the Puyallup unit (GMU 652) from 2005 to 2017. Permit harvest is by modern firearm in 2015-2017, and by any weapon in years before 2015.

Table 18. State and tribal elk harvest from GMU 653, 2001-2017. All state seasons and weapon types are combined[a].

Year	State Harvest		Tribal Harvest		Total Harvest
	Antlered	Antlerless	Antlered	Antlerless	
2001	21	0	23	1	45
2002	19	0	30	4	53
2003	13	0	35	4	52
2004	18	0	25	1	44
2005	23	0	35	3	61
2006[b]	5	0	36	6	47
2007	12	0	48	1	61
2008	10	0	43	1	54
2009	30	0	35	1	66
2010	20	0	46	0	66
2011	14	0	50	0	64
2012	13	0	37	3	40
2013	16	0	38	6	60
2014	13	0	48	1	62
2015	28	0	75	4	107
2016	22	1	60	15	98
2017	10	0	59	15	84
Mean	17	0	43	4	63

[a]State harvest numbers include projected estimates, Tribal numbers are directly from the NW Indian Fisheries Commission hunter reports.

Mashel unit (GMU 654)

Since 1998 GMU 654 has had a 3-point minimum general season for modern firearm hunters. There was no general season for muzzleloaders that year but it was added the next year as 3-point minimum bull only. In the 2000 archery season was changed to 3-point minimum or antlerless, which has continued to the present. In 2007 muzzleloader seasons also went to 3-point minimum or antlerless which remains in place today, while modern firearm seasons since 1998 have remained 3-point minimum bull only. The Kapowsin Tree Farm lies within GMU 654 and is managed as a restricted access area. It covers a large area within the GMU and offers a small number of elk permits each year.

Both antlered and antlerless elk harvest increased in GMU 654 from 2001-2017. Total state harvest in GMU 654 averaged 40 bull elk and 21 antlerless elk annually from 1985 to 2000 (WDFW 2002). From 2001 to 2017, state and tribal harvest combined averaged 54 bull elk and 28 antlerless elk annually for all hunters combined (Table 19). Figures 18 and 19 show the relative contribution of different weapon types and permit hunts to the overall harvest total for state seasons from 2005 to 2017.

Table 19. State and tribal elk harvest from the Mashel unit (GMU 654), 2001-2017. All state seasons and weapon types are combined[a].

Year	State Harvest		Tribal Harvest		Total Harvest
	Antlered	Antlerless	Antlered	Antlerless	
2001	26	20	1	1	48
2002	33	20	0	1	54
2003	41	5	0	5	51
2004	33	3	0	2	38
2005	38	6	2	2	48
2006	29	11	3	4	47
2007	52	27	2	1	82
2008	54	30	1	0	85
2009	34	33	2	0	69
2010	38	31	0	0	69
2011	60	16	2	0	78
2012	64	45	2	3	114
2013	72	50	2	4	128
2014	61	40	2	3	106
2015	63	30	2	2	97
2016	85	30	12	7	134
2017	106	33	3	3	145
Mean	52	25	2	2	82

[a]State harvest numbers include projected estimates, Tribal numbers are directly from the NW Indian Fisheries Commission hunter reports.

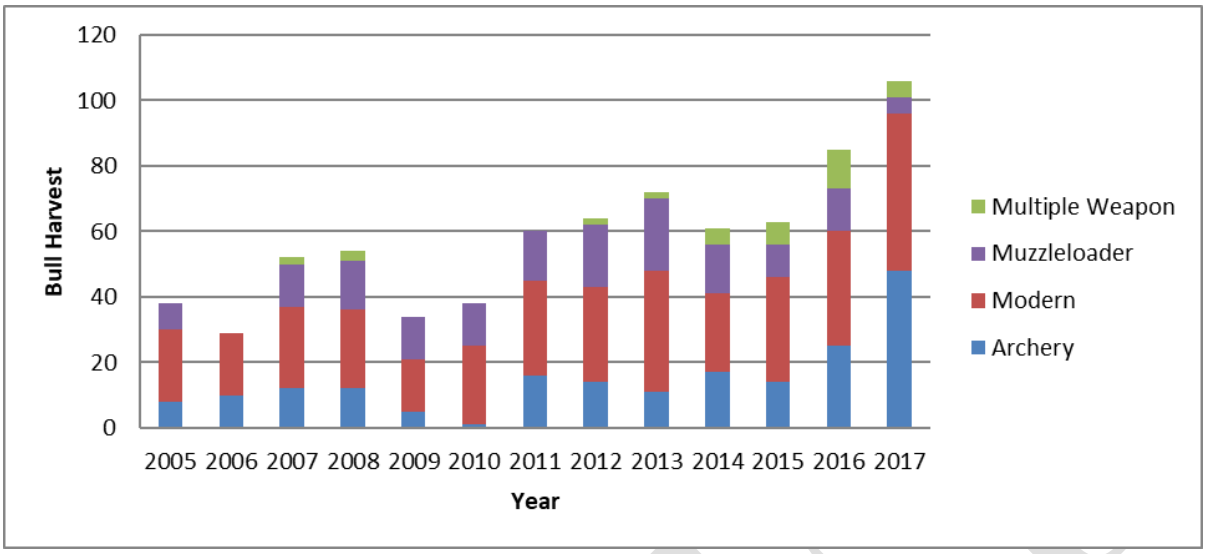


Figure 18. Antlered elk harvest by weapon type for state hunters in the Mashel unit (GMU 654) from 2005 to 2017.

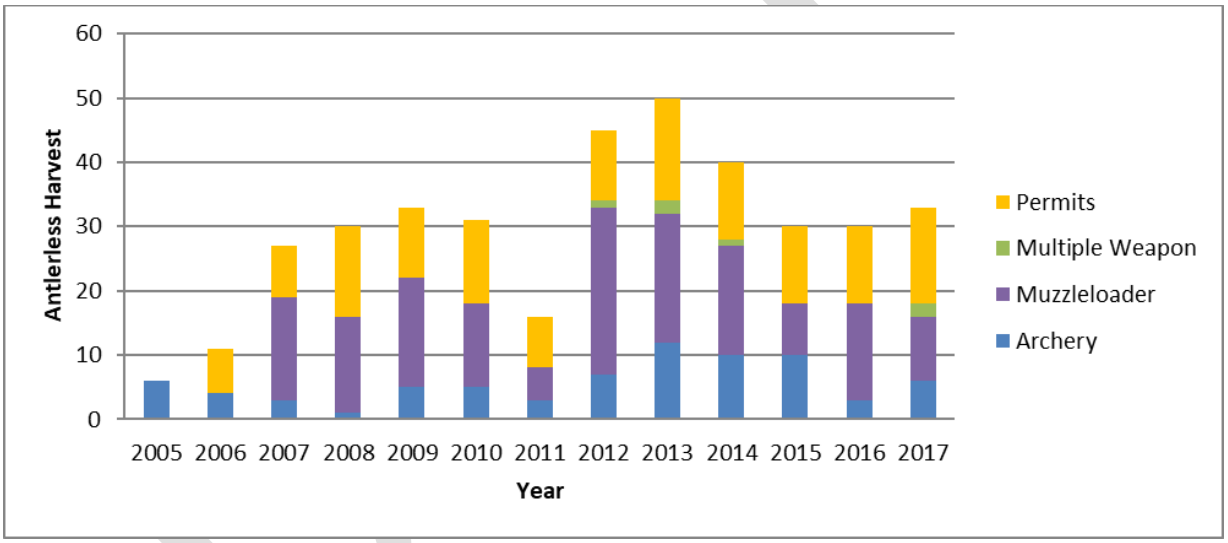


Figure 19. Antlerless elk harvest by weapon type for state hunters in the Mashel unit (GMU 654) from 2005 to 2017. Permit harvest was by muzzleloader.

Illegal elk harvest

WDFW enforcement program has provided information on documented illegal elk harvest in the HUA for the years 2011 to 2016. Their records showed only 20 verifiable illegal kills, about three per year. Seven of these were antlerless, nine were mature bulls and three were spikes (one of these was classed as a small bull). This likely underestimates the actual illegal harvest since every reported case of poaching cannot be verified, and some go unsolved. At least nine cases involving poached elk were investigated from 2015-2016 alone in southeast King County. MIT reported that poaching was responsible for 11% of the adult cow mortalities in their study animals in GMU 653 over 18 years (Table 5). Mortality studies by Smith et al. (1994) indicated

poaching statewide accounted for about 15% of all mortality. There was no significant difference in the poaching rate of cows and bulls among GMUs with either branch antler or branch antler by permit hunting strategies.

Predators

Cougar, black bear, and bobcat prey on elk of the NREH. Cougars kill both adults and calves, while black bear and bobcat take calves almost exclusively (Smith et al. 1994). In addition, black bear scavenging the buried remains of cougar kills may force cougars to kill more elk to make up for this loss. This in turn may increase the cougar predation rate (Murphy et al. 1998). Although the WDFW does not conduct population surveys of cougar and black bear in this area currently, it does monitor damage complaints and annual harvest reported by state hunters.

All indications are that Washington State has an abundant and healthy black bear population (WDFW 2016[a]). The MIT conducted a DNA population assessment of black bears in portions of GMU 485 and 466 and estimated bear density at 16.1 (95% CI 11.7-22.1) bears /100 km^2 in a 588 km^2 study area (MIT unpubl. report). Welfelt (2018) estimated the average black bear density for the west side of the cascades to be 23.20 (19.40-27.74) bears /100 km^2, with a modeled range of 14.19 to 34.37 bears /100 km^2. Welfelt's estimate included cubs, while the MIT estimate did not, which may account for the difference.

Recent research also suggests that cougar populations appear to be stable throughout most of Washington. The MIT study results showed cougar to be the leading cause of mortality of all collared elk in GMUs 485, 490, and 653 (Table 5). During the 18 years of the study, cougar accounted for 23% of the adult cow mortality in GMU 653, and 52% in GMU 485 (MIT unpubl. data). During 10 years of study in GMU 490, cougar caused 52% of the adult cow mortality (MIT unpubl. data). Cougar accounted for 63% of all calf mortality in all three GMUs combined, while predators combined accounted for 75% of the calf deaths (Table 5). Calf mortality rates due to cougar ranged 0.12 to 0.71 while adult cow mortality rates due to cougar ranged 0.00 to 0.21.

Vehicle-Elk Collisions

Elk are vulnerable year round to highway-caused mortality, and to harassment from activities associated with motorized vehicles. A number of studies have shown that elk shy away from areas near roads (Forman et al. 2003, Thomas and Toweill, 1982.). Myers et al. (2008) reported that 85 elk carcasses are removed from Washington highways annually but that figure is likely lower than actual road kill due to under-reporting or injured animals moving away from the highway and later dying.

Vehicle-elk collisions are more common in certain areas and may limit elk numbers locally. Studies being conducted by the USVEMG documented at least 38 elk (35% of all elk mortalities) were killed by collisions with vehicles in 2009 and 164 elk killed by vehicles since that time in Elk Area 4601 (Figures 4 and 5). This rate of collision is a threat to public safety and is additive mortality to this local elk group. By comparison hunters accounted for the highest mortality rate at 54%, predation was 3%, and 8% died of other causes. In 2013 and 2014 vehicle collisions

were lower after repairs made to a fence along the freeway between mile post 27 and 31 on I-90. Severe wind storms in 2015 damaged the fence and a change in habits led to a number of elk killed outside of the fenced part of the freeway (USVEMG, unpub data). The USVEMG is working with the WSDOT on changes to this fence. An extension of the fence to exit 38 or 42 is being examined to help reduce elk mortality.

Winter recreation in particular may disturb elk and could increase winter mortalities. GMU 653 has a high traffic capacity state route, SR410, running through winter range. In MIT studies, of 93 elk that died in GMU 653, 16 (17%) were road related deaths (Table 5). The Crystal Mountain ski resort expansion (USFS 2004) has brought more skiers to the resort leading to more potential highway elk mortalities along SR410. The ski area has a capacity for roughly 7,000 skiers. Winter traffic on weekends in the Greenwater area was documented at roughly 4,000 vehicle trips per day in 1999 (TDA 1999 cited in USFS 2004) and may be higher since the ski resort was expanded. The Crystal Mountain expansion analysis used MIT study data to project a 23% increase in elk mortality caused by vehicle collisions (USFS 2004: page 4-179). The MIT studies found radio-collared elk that were hit but wandered off and died away from the road, so their death would likely go unreported. As this elk herd grows, there will likely be more vehicle-elk collisions on SR 410.

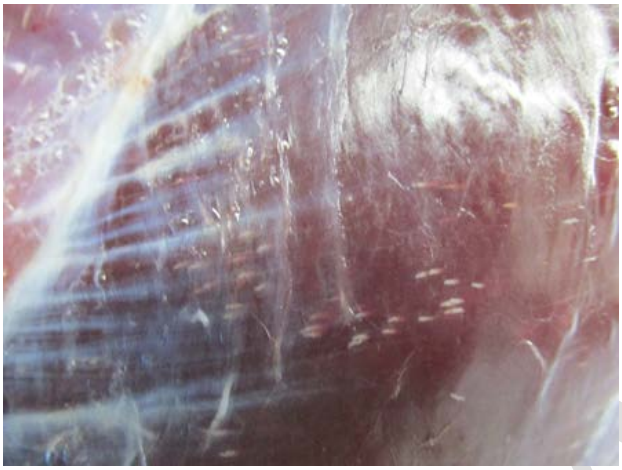
WSDOT regularly removes dead elk from the roadways of state highways and has recorded location information since 2006, although the quality of the data is not uniformly consistent. In some areas it can be used to identify where vehicle-elk collisions regularly occur. In Pierce County along SR 7 from Mile Post (MP) 20 to MP 23, 24 dead elk were removed from 2006-2015, and in the 10 mile stretch between MP 30 and MP 40, 13 carcasses were removed in the same time period. WSDOT also removed 25 elk carcasses during that time from SR 161 in Pierce County from MP 1 to MP 15, with nearly half removed from between MP 12 and MP13. Along SR 410 between MP 44 and MP 52 six carcasses were removed in 2010 and 2011 combined, the only years reported. The highest reported number of carcass removals for the reporting period 2006 – 2015 was on SR 706, with 41removals between its beginning point and MP 11. Fifteen of those were between MP 2 and MP 3 and 17 between MP 6 and MP 11.

More elk are expected to be killed on highways as the elk herd continues to grow and concentrate along the valley bottoms on winter range. In response to concerns about vehicle-elk accidents, the MIT has worked cooperatively with the WSDOT to purchase and install signs warning drivers to watch for elk along SR410. Clearing trees away from the highway is another way to improve sight distance but it also attracts animals to road corridors to feed where they are vulnerable to being hit.

Parasites, Disease and Illness

Elk in western Washington naturally host several parasites. *Taenia krabbei* tapeworm cysts are frequently observed in muscle tissue. *Sarcocystis* sp. are common in wild ungulates throughout Washington and are sometimes visible in muscle tissue. *Dictyocaulus* sp. lungworms are present in cervids throughout western Washington and occasionally contribute to the development of clinical pneumonia, especially in younger animals. The MIT found lungworm larvae in 41 of 230 fecal samples (18%) collected from elk in their study area (Figure 6).

Giant liver flukes (Fascioloides magna) are focally distributed in western Washington and occur in the NREH. Adult flukes are occasionally observed in elk livers. During the MIT study, positive samples came from three transplants relocated from SW Washington (Appendix A) and one resident animal out of 236 samples (1.7%) from GMU 653, 485, 490, and Snoqualmie Valley in North Bend. The MIT also collected 80 fecal samples from non-study elk in two main areas of GMU 485 and six tested positive for flukes (2.5%). None of the parasites described above are likely to have much of an impact on NREH population numbers.



Meat from an elk with sarcocystosis harvested in western Washington, 2013. (Photo: R. Milner)

Liver flukes within the liver of an elk harvested within the North Rainier Elk Herd area, 2010. (Photo: M. Tirhi)

Treponeme Associated Hoof Disease

Since 2008, reports of elk with deformed, broken, or missing hooves have increased dramatically in southwest Washington, with sporadic observations in other areas west of the Cascade Range, including within the NREH area (WDFW 2018, Hoenes et. al, 2018). While elk are susceptible to many conditions which result in limping or hoof deformities, the prevalence and severity of this new affliction suggested something altogether different. WDFW diagnostic research (2009 – 2014), in conjunction with a panel of scientific advisors, found that these hoof abnormalities were strongly associated with treponeme bacteria (Han and Mansfield 2014), known to cause a hoof disease of cattle, sheep, and goats called digital dermatitis. Although digital dermatitis has affected the livestock industry for decades, TAHD is the first known instance of digital dermatitis in a wild ungulate. The disease is currently concentrated in southwestern Washington where prevalence is highest in Cowlitz, Wahkiakum and western Lewis County. The disease is also present at lower prevalence in elk herds that are distant and discrete from the core area. In the NREH area, WDFW has confirmed TAHD in GMUs 454 and 652, and the disease is suspected in GMU 654. WDFW is working with scientists, veterinarians, outdoor organizations, tribal governments and others to better understand and manage TAHD.

The disease appears to be highly infectious among elk, to progress rapidly in individual elk, and there is little evidence of recovery once infected. Similar to domestic livestock digital dermatitis, scientists believe that infected elk carry the causative bacteria to new areas on their hooves,

where bacteria persist in soils until infecting the hooves of other elk sharing the same habitat. In 2015, WDFW initiated research on the Mount St. Helens elk herd to understand the impacts of TAHD on elk survival and productivity. This research is scheduled to be complete in 2019.

Unfortunately, no realistic treatments or vaccines are available for TAHD. However, WDFW is committed to developing and testing viable management strategies for TAHD. For instance, other wildlife diseases are commonly managed through selective removal of infected individuals to reduce disease transmission, particularly where a disease is at low prevalence. This strategy has theoretical support for an infectious disease like TAHD, but is currently unproven. In areas where TAHD is present, WDFW currently encourages the preferential targeting of limping/lame elk during agriculture-damage abatement hunts. WDFW will continue to explore and evaluate this, and other, strategies for their utility in TAHD management. For additional information about TAHD visit WDFW's website at https://wdfw.wa.gov/conservation/health/hoof_disease/.

Social and Economic Values

Number of Elk Hunters, Elk Hunter Days and Added Economic Value

From 1984 to 2000 the average number of hunters reported for the NREH area was 5,678 per year, and those hunters spent on average 25,031 days per year hunting North Rainier elk (WDFW 2002). The trend in state hunter effort in the NREH area declined between 1995 and 2000. The reported effort in 2000 was the lowest since 1985. In 2001 the Department began to require a mandatory harvest report from each hunter, which improved harvest data collection statewide.

From 2001 to 2017, the average number of hunters reported for the NREH was 2,577 per year, and those hunters spent on average 14,968 days per year hunting North Rainier elk (Figure 20). Despite an increasing trend in both hunters and days spent hunting after 2006, elk hunter effort in the HUA remains considerably lower than seen in the 1980's and early 1990's.

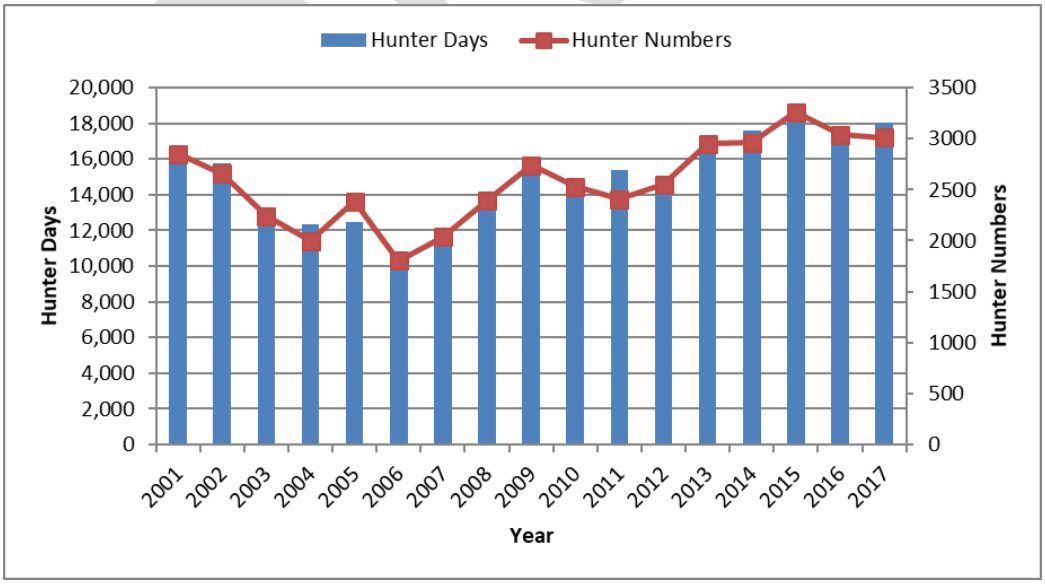


Figure 20. State hunter days and hunter numbers for the North Rainier Elk Herd from the beginning of mandatory hunter reports in 2001 to 2017.

The 2011 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation reported that trip and equipment expenditures for big game hunting in 2006 averaged $973 per hunter (U. S. Department of Interior, et al. 2014). Using the 3,013 elk hunters who reported hunting the NREH in 2017 (Table12, Figure 20), and the $973 average expenditure per hunter from the National Survey, hunters that hunt the NREH area are projected to have added approximately $2.93 million to the local and state economy in 2017.

Tribal Values and Tribal Hunting

Elk have provided food, clothing, tools, and other uses for Native American people for thousands of years. Native Americans managed landscapes using fire to create habitat for wildlife including elk for hunting purposes. Although modern technology has improved access and harvest success, elk are still considered extremely important. The tradition of passing stories and hunting skills on to younger generations is still practiced by Native Americans.

Native American tribes that retain treaty rights to hunt within the NREH's range include signatories to the Medicine Creek Treaty and Point Elliot Treaty. The Muckleshoot, Nisqually, Puyallup and Squaxin Island tribes are included in the Medicine Creek Treaty and the Lummi, Nooksack, Muckleshoot, Upper Skagit, Sauk-Suiattle, Stillaguamish, Swinomish, Suquamish, and Tulalip tribes are signatories to the Point Elliot Treaty. These federally recognized Tribes have a right to promulgate their own hunting regulations; without coordination there may be up to 12 different sets of tribal hunting regulations plus state regulations affecting elk in the HUA. Thus, coordinating management between the state and these tribes regarding elk population levels, habitat, and harvest is the best way to maintain hunting opportunity for both the public and the tribes.

The ground breaking co-management hunting agreement, titled the "Washington Department of Fish and Wildlife and Point Elliot Treaty Tribes Hunting Co-management Agreement" acknowledges that there is a need for the state and the tribes to cooperate in the discharge of their respective authorities in order to insure that healthy populations of wildlife continue to be available to state and treaty hunters (WDFW et al. 2014). The purpose of this agreement is to:

- Provide a cooperative and coordinated science-based approach to resource management and management of harvest opportunity for both parties.
- Promote joint efforts to increase access to private industrial timberlands.
- Promote communication between the parties on policy, enforcement, and technical issues.
- Provide a process to resolve and /or avoid conflicts.

Hunting Seasons

Hunting season recommendations are made every three years as a part of the current Washington Fish and Wildlife Commission's policy of adopting hunting seasons for a three-year period. Minor season adjustments are also made annually to manage elk numbers or control damage. The three-year hunting season package is the state's harvest plan. The WDFW's regional staff receives input on hunting regulation changes and permit levels from tribes and the public for consideration as part of the 3-year package.

Historically, regulations have varied by individual game management unit (WDFW 2002, Appendix B). Seasons have been used to maximize recreational opportunity and at the same time control or manage the number and type of elk removed. The following approaches have all been used at some time: (1) general seasons with legal animal descriptions ranging from either-sex (any elk) to any bull to spike-only to 3-5 point antler minimums, (2) general seasons in combination with permit-only opportunities, and (3) permit-only seasons that provide quality hunting opportunities.

More liberal season structures may be applied in units where elk damage is a concern and where hunter access is limited. Conversely, more conservative seasons may be applied in units where an elk population has declined, shows poor survival to adulthood, or where bull to cow ratios are below management objectives. Season length and timing have also been used to regulate harvest. Resource allocation among user groups, initiated in 1984, requires state hunters to choose their hunting weapon (modern firearm, muzzleloader or archery).

Other Recreational Uses

Hiking is one of the most popular outdoor activities in the United States (Outdoor Foundation 2013). While exercise was given as the primary motivation for participating in outdoor activities, enjoying nature was close behind. A 2013 survey estimated that in the previous year 36.4% of all Washington residents over the age of 18 participated in hiking mountain and forest trails (Washington State Recreation and Conservation Office, 2013). Twenty-nine percent of the participants who reported hiking spent time in a national forest and 13% spent time in a state forest. The survey also reported that 8% of the state's residents rode bicycles on mountain and forest trails, 2.7% rode horses and 1.8% rode motorcycles.

Enjoying nature for many includes watching wildlife, and the 2013 survey estimated that 40% of Washington residents participated in viewing/photographing animals in the previous year (Washington State Recreation and Conservation Office, 2013). Seeing an elk is always a highlight for those who enjoy nature, and the NREH provides substantial viewing opportunities, especially in Elk Area 4601 (North Bend), Elk Area 6014, and GMU 653 in particular MRNP. The Park and adjacent areas provide one of the state's most accessible opportunities to watch elk, particularly during the calving and rutting seasons.

Elk-Related Agricultural Conflicts

Mitigation of elk damage has been a concern for the WDFW for decades, wherever elk may range onto private land. WDFW is the primary source for property owners seeking to determine legal and effective remedies for addressing wildlife interactions (WDFW 2016[b]). Problems associated with elk include damage to tree farms and conifer plantations, hay and alfalfa fields, landscaping, orchards, and other agricultural crops.

Methods to control elk damage in the NREH area include general seasons, permit seasons, Master Hunters, landowner permits, hazing, and fencing. Hazing or harassing elk with cracker shells and other noisy devices can be an effective tool when administered with high frequency and intensity, but it just moves elk from one landowner to another. Elk-proof fencing has successfully been used to protect highly valuable crops, orchards, and golf courses, but fencing unfortunately can also prevent elk from accessing needed habitat. Temporary electric fencing has been used successfully to deter elk from damaging seasonal crops and can then be removed to allow elk to pass.

Varied public perception concerning the role and place of elk in the ecosystem often complicates the damage issue. Farmers, Christmas tree growers, and homeowners often have differing attitudes towards elk. For instance, where elk have habituated to humans such as near Crystal Village and the community of Greenwater, residents often feed the elk during winter and spring, and the WDFW receives few complaints about damage. Conversely, elk damage is a continuing concern near the towns of Buckley and Enumclaw, where permit seasons, Master Hunters and landowner elk removal permits are being used to control elk numbers and reduce damage. In 2015 Elk Area 6013 was divided into two Elk Areas (EA 6013 and 6014, see Figure 4) to assist with damage concerns in the main agricultural areas near Buckley and Enumclaw. General season regulations were liberalized in Elk Area 6014 to include 3-point minimum or antlerless harvest for all weapon types. In addition, antlerless special permits are available for use within Elk Area 6014 between late December and late February. Also, a portion of the available antlerless Master Hunter permits may be dedicated to the Buckley-Enumclaw area as needed. Damage complaint levels in the Buckley and Enumclaw areas have remained consistent since 2013.

Elk damage complaints in and around the city of North Bend in GMU 460 increased during the early 2000s. Here, elk damage generally involves commercial agricultural and horticultural crops, golf courses, residential gardens and landscaping, pastures, or fencing. Elk conflict here also includes elk and vehicle collisions along Interstate 90 and SR 202. Elk Damage complaints in the area have been greatly reduced in recent years as a result of cooperative efforts by the USVEMG, WDFW, concerned citizens and others. As mentioned above a portion of the available antlerless Master Hunter permits may be dedicated to the area as needed. Master Hunters who draw these permits are deployed directly by a Hunt Coordinator. In addition, a variety of antlerless special permit hunts are available for use within Elk Area 4601 (Figure 4) currently. USVEMG and Master Hunters also participate in fence construction/repair on private properties as needed. Elk and vehicle collisions have also been reduced (see section Vehicle-Elk Collisions).

Citizen Groups

In June 2008, the WDFW met with local community leaders in North Bend and Snoqualmie to discuss concerns about the rapidly growing elk population and associated damage they cause. This led to a community forum involving the public, government officials, and stakeholders to address issues associated with the growing elk population in an urban setting.

In June 2009, a non-profit corporation, the Upper Snoqualmie Valley Elk Management Group (USVEMG) was incorporated. Their mission is to work collaboratively to minimize property

damage and public safety risks associated with the Snoqualmie Valley elk sub-herds of the NREH. Furthermore, they work to manage these elk for a variety of recreational, educational and aesthetic purposes including hunting, scientific study, cultural and ceremonial uses by Native Americans, wildlife viewing and photography.

Collaborating agencies and stakeholders include: WDFW, DNR, WSDOT, USFS, King County Water and Land Resources, King County Sheriff's Office, King County Parks, City of North Bend, City of Snoqualmie, MIT, Tulalip Indian Tribe, Snoqualmie Indian Tribe, industrial timber companies, RMEF, Mountains to Sound Greenway, Meadowbrook Farm Preservation Association, hunters, property owners, local businesses, and concerned citizens.

Between 2010 and 2017, the USVEMG has used $113,000 in donations to fund elk research, habitat improvement projects, highway safety projects, public education, and damage mitigation. As part of their work, the USVEMG has collared 79 elk since 2010 to monitor movements, conflict and survival. The group currently strives to maintain about 35 active collars in the area. USVEMG volunteers also planted 70 acres of DNR land with grasses to increase available elk forage outside of Elk Area 4601 and 25 acres of private land within Elk Area 4601 to help draw elk from developed areas (http://snoqualmievalleyelk.org).

Another local organization/citizen group the MREF, a non-profit 501(c)(3) organization founded July 2014, was formed in the Enumclaw area to "Work together to protect, manage and restore the elk populations in eastern King County and the forest land surrounding Mt. Rainier." Its guiding principles state:

- Promote relationships with local farmers and land owners to analyze/reduce property damage or risk to public safety resulting from local elk activity.
- Elk Habitat Stewardship / Restoration for Mt. Rainier region.
- Study effects of human interaction and urban development.
- Identify opportunities to mitigate impact through development offset & wise management.

The MREF has worked to construct and maintain both permanent and temporary elk fencing to exclude elk from agricultural properties and participated in hazing elk from private properties.

Nutrition

Habitat quality and quantity determines potential herd size by affecting animal nutritional condition and reproductive performance (Hobbs et al. 1982). The amount and quality of food are both important. Western Cascade forests appear to have abundant forage but much of it is of low quality (Cook et al. 2016). The number of elk has an effect on habitat quality and quantity in a density-dependent effect (Houston 1982). As elk numbers increase and consume resources less browse becomes available and animal health can decline or lead to emigration. Animals in low condition are more susceptible to predation, disease, reduced pregnancy rates, and death by starvation. Adult cows have increased nutritional needs while raising a calf due to lactation, and additionally require adequate habitat to accumulate enough body fat to become pregnant and survive winter (Cook et al. 2004). Lower quality habitat leads to reproductive pauses and an

overall lower herd pregnancy rate (Cook et al. 2013). Calves may also be born lighter and experience higher mortality rates (Cook 2004).

Elk west of the Cascades live in a nutritionally-deprived landscape, but elk do find small pockets of high-quality forage they can exploit. Elk captured in the MIT initiated studies, provided Cook et al. (2010, 2013) the opportunity to include these elk in their studies of elk body condition and fat levels. These assessments suggested animals of the North Rainier herd had chronically low fat reserves compared to penned animal studies, but the fat level indices measured for elk in GMUs 485 and 653 were equal to or above the average for Westside elk herds.

Pregnancy rates can be an indicator of nutritional condition (Cook et al. 2002). Pregnancy rates of elk captured in the NREH since 1998 have been high. Early in the MIT studies the pregnancy rate was above 90% (Cook et al. 2013), however during this time calf survival was low and cows may have had improved condition in the absence of lactation. The most recent large sample size from GMU 653 was 29 cow elk that had an 86% pregnancy rate in 2014 (MIT unpubl. data). The most recent large sample size from GMU 485 was 14 cow elk in 2013 and all were pregnant. In GMU 490, 100% of the elk captured in 2006-07 were pregnant. With increasing elk numbers in the NREH, reproductive pauses and lower pregnancy rates are predicted as food becomes more limiting as discussed in Cook et al. (2004).

Elk in GMU 653 that migrate to MRNP had significantly higher [11.8% (n=21) vs 9.5% (n=14), $P<0.05$] measured body fat levels in fall than elk that do not migrate to MRNP (MIT unpubl. data). Elk in GMU 485 and 490 that migrate to higher elevation ridges also had higher fat levels compared to non-migratory elk remaining at lower elevation winter range (MIT unpubl. data). Migration to sub-alpine and alpine areas is advantageous, permitting elk to access higher quality food resources. Dietary digestible energy is higher, meaning better quality, at higher elevation habitats (Cook et al. 2016).

Based on femur marrow fat content (Ratcliffe 1980) of dead elk younger than 16 years old in the MIT studies, only 12 % (15 of 113) of the animals died from nutrition-related mortalities. If habitat effects were contributing to poor survival in GMU's 653, 485, or 490 then higher malnutrition mortality might be expected. The low number of malnutrition mortalities in GMU 653, 485, and 490 combined with good pregnancy rates gives managers information on animal-habitat relationships to help understand where elk numbers might be relative to what the habitat can support. Where data are available, the proposed GMU targets reflect study results of expected animal-habitat relationships (Table 7).

Habitat Management

Ultimately, the population size of an elk herd is regulated by the quantity and quality of available habitat. The population objective in this Plan takes into account habitat limitations and the limit of public tolerance for elk damage in rural and urban landscapes. Forage quality and quantity on USFS lands in the herd area is declining as management emphasizes mature forest, however the proposed Snoquera Landscape Project may result in additional thinning in GMU 653 and 466. Recent models have been developed by the USFS to predict the probability of elk use based on quality of forage, open roads, cover-forage edge, and topography (Rowland et al. 2018). An approach has also been developed to guide forest management for elk production (Vales et al. 2017).

Elk Summer and Winter Range

Cook et al. (2004, 2013) identified summer nutrition as a key factor supporting a healthy, productive elk herd. Based upon animals sampled in the MIT studies, the NREH's summer range appears to be in fair to good condition relative to other elk herds based on body fat levels of elk in fall (Cook et al. 2013). However, considerable diversity exists among summer ranges within the NREH area. Fall body fat data from lactating cows ranged from 8% to 12% depending on which range area they summered in (MIT unpubl. data). Elk summering in the mountain hemlock and Pacific silver fir zones of GMUs 490, 485, and 653 have higher fall fat levels than those that summer at lower elevations within those units. Cook et al. (2004) predicted that pregnant elk with 7% to 8% body fat in fall would have a low probability of surviving winter if winter forage availability were low. There is a complex interaction between summer and winter habitat. A good winter range with low snow may offset poor summer range conditions. A good summer range may offset poor winter range and/or harsh winter. A diversity of stand ages, forage, and canopy cover distributed throughout the landscape ensure that elk will be able to find what they need to survive a variety of environmental conditions.

Elk in the NREH area that summer at high elevations descend to winter range after the first significant snowfall accumulation, generally in mid to late October. Upper elevation limits used to delineate winter range are 2,400 feet (WDFW 2002). On south facing slopes it is a little higher, 2,800 feet.

GMU 485 has a mix of ownership and consequently the landscape is very diverse, reflecting each landowner's management goals, although commercial timber production with a 40 year rotation is most common. Habitat managed by Tacoma Water is guided by an HCP (Tacoma Water 2001) that will result in retention of older forest at lower elevation and provide a diversity of stand ages and canopy cover on the winter range landscape. A Bonneville Power Administration power line corridor transects the unit and provides open habitat that is an important foraging area for elk. Habitat enhancements under this and other power line corridors, and in other areas of the watershed, have been developed to mitigate for the Howard Hanson Additional Water Storage project (U.S. Army Corps of Engineers 1998). Mitigation area creation began in 2005 and took time to become fully productive. In the adjacent GMU 466, the USFS has conducted thinning projects on summer range lands designated as matrix under the Northwest Forest Plan. Forest management in these areas allows more flexibility in timber harvest and provides more forage than LSR-designated lands found in neighboring GMUs such as GMU 653. DNR lands in GMU 485 are managed as working forests under the DNR's HCP and provide summer and winter forage and cover.

During the winters of 2007-08 and 2008-09, the most severe since the MIT studies started, radio-tagged elk wintering in GMUs 485, 653, and 490 showed very little winter mortality. Excluding human-caused mortality, the only mortalities recorded during those two harsh winters were elk aged at least 17 years old. This may indicate that winter forage and cover was adequate to support adult elk present on these winter ranges even in the harshest of winters. The subsequent calf recruitment in GMUs 653 and 485, based on spring (March/April) surveys in 2009, indicated a modest decline, so the winter effects may have had an impact on calf recruitment.

In 1984, MRNP contracted with the University of Washington to determine the long-range winter carrying capacity of forested lands outside the park boundaries in GMU 653. A computer simulation model was developed to predict how elk numbers would respond to changes in the forest and forest management, based on historical and projected forest management (Raedeke and Lemkuhl 1984). Assuming 1980 forest management practices as the baseline, the computer model indicated a decline in carrying capacity of about 15 % by the year 2030 on all lands in GMU 653 (Raedake and Lemkuhl 1984). On USFS lands, the decline was projected to be even more dramatic, nearly 40 % less carrying capacity for elk by the year 2030. Interestingly, elk numbers have actually been increasing in most GMUs of the NREH and have met or exceeded 2002 population objectives.

In another study, Jenkins and Starkey (1990) assessed elk winter range use and projected future habitat trends on forested lands north of the park. Their model was similar to that of Raedeke and Lemkuhl (1984) and their results supported the earlier conclusions, predicting similar elk population declines in response to forest management, in particular lack of intensive timber management. Jenkins and Starkey (1990) also predicted that food availability on elk winter ranges would decline steadily well into the future. This decline reflects a loss of created openings and clearcuts, where the majority of the elk's preferred food plants grow. Another consideration recognized by Jenkins and Starkey (1990) is the important role that mature forests play in sustaining elk populations during severe winters. They concluded that a mosaic of immature and old age forest is optimal habitat for elk.

Logging has removed the majority of mature forest vegetation on elk winter and spring ranges in the NREH area. For example in GMU 653, between 1950 and 1969, 90% of elk winter range was logged, leaving only 10 % of original old growth forest (Jenkins and Starkey 1990). The carrying capacity of elk occupying GMU 653 winter range on corporate lands has fluctuated due to the pattern of forest opening thru cutting and regeneration on the landscape. Openings provide forage in the years just after logging, whereas dense timber stands limit understory development.

The Northwest Forest Plan (1993) has limited logging on USFS lands to primarily commercial thinning, and elk numbers that mainly use USFS lands seemed to have declined as less forage is available. The USFS acquired more than 9,000 acres of Weyerhaeuser owned commercial forest in the White River drainage in the 2001 Huckleberry Land Exchange and put these lands into LSR or Greenwater Special Management Area (USFS 2001). The upper Greenwater River area of GMU 653 had a USFS checkerboard ownership that was proposed to become LSR designation. The MIT challenged the USFS over a number of issues, one being the lack of elk forage under future LSR management and its negative impact on the GMU 653 elk population. As a result of negotiations, the USFS agreed to a two phase plan to create up to 500 acres of permanent openings, to provide winter forage for elk within the Greenwater River basin of the Mount Baker Snoqualmie National Forest (USFS 2001). They also agreed to create additional summer forage openings up to 130 acres.

In 2017, the Norse Peak Fire burned approximately 23,253 acres in GMU 653 on the Mt Baker-Snoqualmie Forest, primarily in summer range and the Norse Peak Wilderness. Post-fire vegetative conditions were assessed using the Rapid Assessment of Vegetation Condition after Wildfire (RAVG 2017). Out of this total, approximately 9,756 acres that burned within GMU 653 were estimated to have experienced greater than or equal to 50 percent canopy cover mortality. Depending on effects of the burn severity on soil productivity and residual seedbank, this reduction in canopy cover could lead to positive forage response in the near future for elk in GMU 653 in the NREH area.

As of 2015, Phase I forage area creation has been completed resulting in 150 acres of openings. Unfortunately, some of these are being used intensively for target shooting and neighbor complaints are increasing. Phase II is still being planned, but the total area of winter range openings created may be less than 500 acres due to environmental restrictions, such as riparian reserves or distance to spotted owl sites. In addition to the completion of Phase II, the USFS Snoquera Landscape Analysis Environmental Assessment proposes to commercially thin up to approximately 12,000 acres, spread over 15 or more years, on USFS lands in GMU 653, and to a lesser extent in GMU 466 in the NREH area. The project also proposes to pre-commercially thin up to about 1,883 acres of young stands, most of which occur at higher elevations and in GMU 466. This may add additional elk forage, including in areas where seasonal gate closures and other access management should minimize disturbance and human impacts.

A previous USFS project authorized the commercial thinning of some stands within summer and winter range areas of the upper White River of GMU 653 (USFS 2012) and it is still underway as of this writing. This, along with the forage creation should improve forage conditions. The amount of acreage treated is small compared to similar managed areas of timber elsewhere in the NREH area under a more intensive harvest program.

Elk occurrence in GMU 460 varies on the extremes, with elk found from isolated wilderness areas and managed timberlands to suburban locations. Possibly half the elk in the GMU occur in Elk Area 4601 (Figures 4 and 5) utilizing private agricultural and public open space as habitat throughout the year.

USFS lands total over 300,000 acres in GMU 460, mostly managed as LSR with minimal tree cutting. The USFS is embarking on the Hansen Creek Vegetation Project (within the Mt. Baker-Snoqualmie National Forest Snoqualmie Ranger District) to improve stand structure on 1,347 acres of forest land. One result of this project will be improved forage to cover ratios, however benefits may be limited by I-90, which is a barrier to elk movement.

Roads and Gate Closure

The WDFW, Weyerhaeuser Company, and the USFS entered into agreements in 1987 in GMU 653 that closed some roads to protect elk on their winter ranges on the White and Greenwater river lowlands, Dalles Ridge, and Buck Creek between December 15 and May 1. Road closures were also implemented during state established hunting seasons to protect elk migrating out of MRNP. Previously hunters had formed what was essentially a "firing line" that restricted elk movement to winter range. WDFW supports road and gate closures for the following reasons:

- Minimizing disturbance on critical elk winter range.
- Minimizing human impacts that might negatively affect herd stability or growth.
- Reducing the potential for poaching elk when elk are most vulnerable.
- Reducing road maintenance and hunting enforcement needs.
- Establishing a precedent for state and tribal co-managers on closing gates on public lands. for the benefit of elk winter range conservation in combination with other conservation measures (e.g. permit hunts).
- Allowing walk-in access for general recreationists, hunters, and tribal members.

Thru a Cooperative Road Management Agreement between WDFW and USFS, USFS roads 7010 (which also includes the 7012 and 7020 systems) , 72, and 7013 off Highway 410 in GMU 653, continued to be gated from Dec 15 to May 1 to provide elk winter range protection. Areas behind these locked gates are open to walk-in (boot) hunters and other recreationists. While most believe the gate closure program is providing benefits to elk in the NREH, there have been some unintended consequences such as periodic gate vandalism and vehicular trespass, along with associated target shooting and trash dumping at elk forage openings behind those gates. Although the local public in the town of Greenwater are supportive of elk protection, they are expressing concerns about the increased noise, associated trash and debris, and safety implications (stray rounds) of the target shooting in areas close to their community. This needs to be managed if the local public is to continue supporting elk winter range protections and elk forage enhancements.

The Snoquera Landscape Analysis Project also proposes to address recreational shooting issues by closing shooting in the area adjacent to the road 7013 seasonal closure, and approximately 30 acres of existing elk forage units, while providing designated shooting areas in non-habitat areas elsewhere in the watershed.

WDFW partners with private landowners, USFS and the WDNR to provide drivable access behind many locked gates for hunters with disabilities under the Road Access Entry Program. The Elbe Hills State Forest in GMU 654 is a location in this disabled hunter program.

Residential and Commercial Development

The State has several options for managing wildlife habitat and development. The WDFW's Priority Habitat and Species Program (PHS) is the backbone of the WDFW's proactive approach to the conservation of fish and wildlife. PHS is the principal means by which the WDFW provides important fish, wildlife, and habitat information to local governments, state and federal agencies, private landowners and consultants, and tribal biologists for land use planning purposes. PHS is comprised of a listing of the highest priority species and habitats in Washington and expert recommendations on how to manage the habitat for those species for longevity. Most cities and counties have adopted the WDFW's complete PHS list and species recommendations into their land use regulations.

Within WDFW's PHS Program, elk are a Criterion 3 species, defined as:

"Native and non-native fish and wildlife species of recreational or commercial importance, and recognized species used for tribal ceremonial and subsistence purposes, whose biological or ecological characteristics make them vulnerable to decline in Washington or that are dependent on habitats that are highly vulnerable or are in limited availability."

Figure 21 shows important elk use areas in the NREH area that are recorded in the PHS program.

The following elk use areas are protected under Criterion 3:

- Calving areas
- Migration corridors
- Regular concentrations in winter and in foraging areas along coastal waters (http://wdfw.wa.gov/conservation/phs/list)

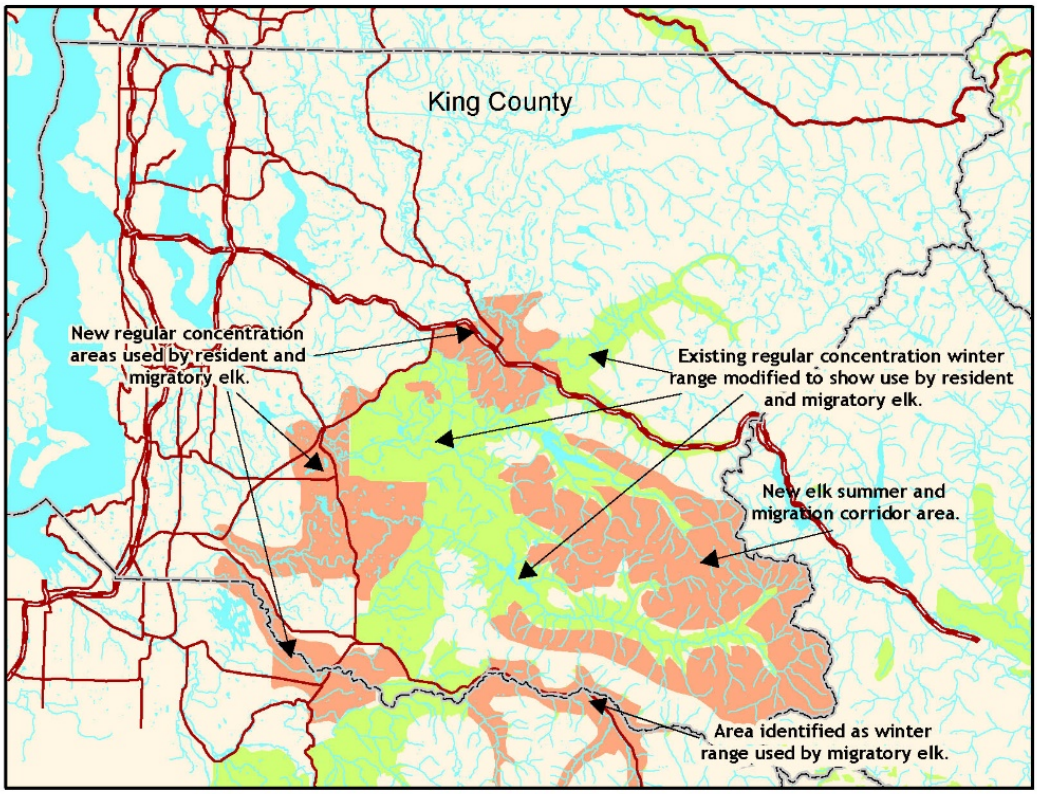


Figure 21. WDFW's Priority Habitat and Species map showing elk regular concentration areas and migration corridors.

A large percentage of crucial elk winter habitat is located on private property. Residential and commercial development continues to degrade habitat and fragment the landscape through which elk have traditionally migrated. For this reason, the WDFW works with the various jurisdictions to mitigate negative impacts that result from development within elk winter range. For example, Pierce County has regulated development on winter range since 1992 as a "Habitat of Local Importance" within Title 18E.40. Within areas mapped as winter habitat, the county applies WDFW PHS habitat recommendations to meet the management goals identified in Table 20. From 2008 to 2017, Pierce County reviewed 114 private property parcels that were submitted to the county for a land use building or grading permit review. Seventy five of those that contained elk habitat were approved and went on to completion, while the remaining either had no impacts to elk habitat or the permit did not progress. Pierce County used the goals and strategies in Table 20 as guidelines to assess whether the parcels adequately met their habitat retention requirements for elk.

WDFW in conjunction with USVEMG assembled several low-cost geospatial datasets for King County along I-90, to better understand and evaluate elk habitat use and travel corridors in the region. They used community-based data derived from radio-telemetry, collision and mortality GPS locations, parcel use mapping, a public spotting hotline, and a K-12 outreach project to support GIS habitat suitability and corridor modeling in land use planning.

Table 20. Pierce County Planning and Land Services goals and strategies within elk winter range (Title 18E.40).

Goal	Strategy	Specifics
Minimize human activity that disrupts normal elk ecology	Regulate land use permits	
Maximize retention of undisturbed vegetation	Retain ≥ 40% vegetative cover consisting of a 50:50 ratio of hiding cover to thermal cover	Hiding cover is defined as vegetation capable of hiding 90% of a standing elk at 200 feet Thermal cover is defined as forest cover at least 40% tall with 70% canopy closure
Avoid constructing features that disrupt or prevent elk from moving through traditional travel corridors	Regulate the construction of fences and roads in elk winter range	Require all perimeter fencing to include sections that are less than 45" in height[a] located in places that facilitates elk travel through the property Review all road construction within mapped elk winter range with the objectives of avoiding or minimizing road construction by directing it elsewhere

[a] Elk can jump higher than 45 inches but, often cause damage to fencing when doing so. This height has been found to be a reasonable compromise between providing the security desired of a fence, allowing elk passage, and minimizing elk damage to the fence.

Enhancement and Improvement Projects/Ideas

Since 1990, many projects have been initiated to enhance elk habitat, perform research, and educate the public about elk, particularly in the Green and White River units. The RMEF has helped fund many projects (Table 21). Past and present work in GMU 485 has included cooperative projects with the U.S. Army Corp of Engineers, TW, and the MIT to create open meadow grass-forb habitat plots for elk. These mitigation measures were enacted to compensate for the anticipated loss of habitat from raising the Howard Hansen Dam and subsequent loss of habitat due to additional water storage. Within GMU 485 there has been a considerable effort to control Scotch broom using funding from the RMEF, TW, MIT, and WDFW.

Table 21. Rocky Mt. Elk Foundation funded projects in the North Rainier Elk Herd area.

Year	Enhancement project	Foundation Contribution	Cooperator	Cooperator Contribution
1990	Kapowsin winter range enhancement (seeding)	$4,000.00	Champion Timber Company	$26,977
1991	Pack Forest habitat improvement	$3,427.00	University of Washington	$5,930
1992	Greenwater drainage road Rehabilitation	$3,750.00	Mt. Baker/ Snoqualmie National Forest	$3,800

Table 21. Rocky Mt. Elk Foundation funded projects in the North Rainier Elk Herd area.

Year	Enhancement project	Foundation Contribution	Cooperator	Cooperator Contribution
1994	White River elk viewing Signs	$2,700.00	Mt. Baker/ Snoqualmie National Forest	$4,200
1997	Kapowsin population estimate Study	$3,500.00	WDFW Champion Timber Company	$2,230 $4,000
1997	Green River elk calf mortality Study	$4,500.00	Army Corps of Engineers, WDFW, Muckleshoot Tribe	$56,382
1999	Green River elk population Study	$7,500.00	WDFW MIT Tacoma Public Utilities Weyerhauser Company Plum Creek Timber Company US Army Corps of Engineers	$35,000 $7,500 $16,000 $5,000 $5,000 $20,000
2000	Pierce County Biodiversity Planning	$4,000.00	Pierce County Planning USGS Gap Analysis Program	$19,128 $20,000
2001	Green River Power Line Scotch Broom Treatment #1	$15,000.00	WDFW BPA US Army Corps of Engineers Tacoma Public Utility	$5,000 $10,000 $10,000 $10,000
2002	Green River Power Line Scotch Broom Treatment #2	$17,000.00	WDFW	$24,000
2003	Upper White River Access Management	$1,250.00	Mt. Baker/ Snoqualmie National Forest	$2,500
2003	Upper Nisqually Elk Forage Enhancement #1	$4,666	Tacoma Public Utility City of Tacoma Public Works	$23,000 $7,500
2003	Green River Power Line Scotch Broom Treatment #3	$19,000	WDFW Tacoma Public Utility BPA MIT	$2,000 $14,000 $5,000 $5,000
2005	Green River Power Line Scotch Broom Treatment #4	$15,000	WDFW	$24,000
2006	Lamb property gift to RMEF	$5,356		
2009	McCullough Tree Orchard Fence	$4,744	Mt. Baker/ Snoqualmie National Forest	$8,200
2010	Hoh Clearwater / White River Access Management	$5,500	WDFW	$5,500
2013	EA4601 Research/Management	$5,400	USVEMG WDFW	$13,900 $500
	CCC Flats	$5,000	USVEMG DNR Tulalip Tribe	$20,000 $720 $2,000
2015	EA4601 Research/Management	$8,525	USVEMG	$10,601
2015	CCC Flats/Boy Scouts Field/Cadman Pit	$5,000	USVEMG	$12,413

Table 21. Rocky Mt. Elk Foundation funded projects in the North Rainier Elk Herd area.

Year	Enhancement project	Foundation Contribution	Cooperator	Cooperator Contribution
2017	GMU460/454 Research	$8,800	USVEMG	$16,694
2016	Greenwater Elk Forage Area Enhancement	$3,553	Mt Baker-Snoqualmie National Forest MIT Tulalip Tribes MREF	$14,728 $21,360 $17,255 $672 (in-kind)
2017	CCC Flats/Fire Training Center/Cadman Pit	$5,000	USVEMG	$10,300
Total		**$162,171**		**$527,990**

Non Rocky Mountain Elk Foundation habitat enhancement projects include:

White River Unit (GMU 653):

- Seeding skid trails with grass-forb mixture (Hancock & MIT)
- Scotch broom cutting on DNR land (MIT) and on the White River Tree Farm (Muckleshoot Federal Corporation)
- USFS elk forage creation areas (USFS) and maintenance (USFS, MIT, Tulalip Tribes)
- USFS Upper White River Vegetation and Restoration Project (USFS)
- Realignment of the Huckleberry seed orchard fence (USFS, MREF)
- Emergency winter feeding during February-March 2008 (MIT with additional funding from Hancock, Upper Skagit Indian Tribe, Swinomish Indian Tribe, Tulalip Tribes)
- 2017 elk emergency winter feeding in Greenwater area (MIT)
- 2019 elk feeding Greenwater area (MIT)

Green River Unit (GMU485):

- Mitigation fields created to offset the Howard Hanson Additional Water Storage Project (89 acres, TW, USACE)
- Scotch broom mowing under BPA and PSE power lines (BPA, PSE, MIT, TPU)
- Scotch broom spraying (TW, MIT)
- GMU 466 Upper Green River PCT thinning (USFS)

Cedar River Unit (GMU 490):

- Managed pasture forage fields created under BPA power line corridor (MIT)
- Native grass seeding in conjunction with Scotch broom mowing under power lines and along roadsides (MIT, BPA, SPU)
- Restoration and ecological thinning throughout the Cedar River Watershed and recent improvements in application of variable density with skips and gaps (SPU, MIT)
- Slash disposal (SPU, MIT)

Snoqualmie Unit (GMU 460):

- Clear out slash and prune on DNR land along the Middle Fork of the Snoqualmie River (USVEMG, DNR)

Research and Management Needs

In addition to population surveys, harvest data collection, radio-collared elk studies, and habitat improvement projects, the following research would aid NREH management:

1. Re-measure body condition of elk in GMU's 485 and 653 and compare to earlier results when herds were smaller. The Green River elk have increased at least three-fold and White River elk twofold since the past work was completed. New data would shed light on the relationship between elk condition and habitat and provide a more informed target population objective in these two units. Alternatively, cow elk could be tested for pregnancy to see if pregnancy rates have declined significantly in these areas as the herds have grown.

2. Validate the predictions of the landscape nutrition model (Cook et al. 2018). Equations to predict nutritional value of forage were developed in other areas and the applicability to the NREH is unknown. The Westside habitat model (Rowland et al. 2018) and elk density index projections (Vales et al. 2017) rely on these equations. Relative predictions among scenarios or areas within a specific analysis area, however, may not require accurate predictive equations. If analysis tools that rely on these predictive equations are being used across areas then testing the predictions may be warranted.

3. Estimate herd size and distribution and local migration patterns of the GMU 460 elk herd outside of Elk Area 4601. Investigate approaches to meeting elk herd size goals outside of Elk Area 4601.

4. Monitor elk response and use of habitat improvement sites.

HERD MANAGEMENT GOALS

The goals of the NREH Plan are to:

1) Preserve, protect, perpetuate, manage and enhance elk habitats to ensure healthy, productive populations.
2) Manage the NREH for a sustained annual harvest.
3) Manage elk for a variety of recreational, educational and aesthetic purposes including hunting, scientific study, cultural and ceremonial uses by Native Americans, wildlife viewing and photography.
4) Minimize property damage and public safety risks associated with elk.

MANAGEMENT OBJECTIVES and STRATEGIES

Herd Management

Background for Objective 1

Formal estimates of herd demographics (i.e. population size, age and sex ratios, and survival rates) are useful in elk management. However, developing survey protocols that generate reliable estimates for the entire NREH remains a considerable challenge. Past efforts to monitor the NREH have focused on several key management units. There is a need to review and select survey protocols that will generate reliable estimates for the entire herd.

Objective 1

Develop and implement standardized and statistically valid survey protocols that will generate reliable estimates of population size or indices of population trend for the NREH by 2025.

Strategies:

a. WDFW will collaborate with tribal biologists and statisticians to assess population estimation techniques currently being used to estimate population size and evaluate the suitability of these approaches for the NREH.
b. In areas not surveyed by the MIT, initiate surveys to complement their population estimation if funding is available.
c. Cooperate with partners who are maintaining a radio-collared sample of elk to facilitate population estimates in selected GMUs.
d. When resources allow WDFW and MIT will conduct surveys that complement each other's effort.

Background for Objective 2

A key aspect of the herd management goals identified for the NREH includes managing for stable to increasing elk numbers to provide for sustainable harvest without compromising ecosystem integrity and biodiversity, or increasing elk damage conflicts. Although population estimates are lacking in some units, ancillary data from harvest reports and surveys provide at least some indication of the status of the NREH. Local knowledge can serve to provide insight into elk population size for GMUs which have no formal survey. Using available data and local knowledge, the current NREH elk population is determined to be 4,850 elk (Table 7), which has surpassed the population objective set in the 2002 herd plan (WDFW 2002). This Plan aims to keep the NREH at approximately its current size, and retain current recreational harvest opportunities. Management will continue to strive to increase elk in some areas while limiting elk numbers in areas of conflict.

Objective 2

Maintain the NREH at 4,850 elk (+ or – 10%), as determined by post-season population estimates, using the accepted protocols identified in Objective 1.

Strategies:

a. Maintain elk numbers in GMUs 454, 466, 485, 652 (not including 6014) and Elk Areas 6013 and 6054 reflecting the targets in Table 7.
b. Increase elk numbers in GMUs 460 (not including 4601), 490, 653, and 654 (not including 6054) reflecting the targets in Table 7.
c. Decrease elk numbers in Elk Areas 6014 and 4601 reflecting the targets in Table 7.
d. Work cooperatively with groups such as the USVEMG and MREF on elk management issues.
e. Manage harvest to achieve the Table 7 population targets, and where data are available use population modeling estimates to set harvest limits.
f. Attempt to increase hunter access to privately owned lands that will assist with maintaining an appropriate harvest distribution.
g. In GMUs that are below the targets in Table 7, and where data are available indicating poor calf recruitment (calf:cow ratios less than 30:100 for three consecutive years), consider a study to determine the rates and causes of calf mortality.
h. Where elk survival is low and elk numbers are below management objective, management of predators to benefit elk will be considered when there is evidence that predation is a significant factor inhibiting the ability of an elk population to attain population management objectives (see WDFW 2014).
i. Establish cooperative harvest strategies with tribes.
j. When necessary, establish conservation closures, permit-only hunts or other measures to meet the population targets of this Plan.
k. Maintain current levels of enforcement emphasis to minimize poaching.
l. Assess and maintain effective road closures and work cooperatively with land managers to identify additional road closures where needed to limit harvest, improve habitat effectiveness, and reduce poaching.

m. Assist city and county jurisdictions with achieving the Planning Goal (RCW 36.70A.020) of Washington's Growth Management Act to conserve fish and wildlife habitat. Provide advice during development and adoption of comprehensive plans and development regulations for those counties and cities that meet this requirement.
n. Together with landowners, identify key elk use areas currently managed primarily for timber that could benefit elk by modifying timber harvest to improve elk forage.
o. Look for opportunities to acquire or otherwise protect important elk habitat, to help mitigate declines in elk habitat availability and reduce conflicts with private owners.
p. Identify mitigation measures for the loss of elk habitat.
q. Work cooperatively to manage habitat to achieve elk population targets.
r. Identify ways to reduce highway mortality where it is an important source of elk mortality.
s. Where possible, monitor elk pregnancy, calf ratios, survival, causes of mortality, and animal age to assess if habitat effects are limiting population productivity relative to population objective. Use adaptive management and animal performance data to get feedback on elk-habitat relationships, and adjust population target appropriately.

Background for Objective 3

Elk management guidelines provided in the WDFW Game Management Plan 2015-2021 (WDFW 2014) were established by the WDFW with the intent of promoting healthy and productive elk herds, while also maintaining herd demographics that promote high hunter satisfaction (e.g., the number of bulls maintained in the population). This Plan will manage harvest rates in accordance with those guidelines.

Objective 3

Manage the elk herd to maintain minimum post-season bull to cow ratios of 12 to 20 bulls per 100 cows.

Strategies:

a. Adjust harvest to maintain adequate bull escapement. Use adaptive management techniques such as reducing hunting season length, applying antler restrictions, and permit only hunting.
b. Track post-season bull ratio trends over 3-year increments to assess the results of harvest management strategies.

Background for Objective 4

Human-elk conflicts in the NREH area are primarily associated with damage to tree farms, hay and alfalfa fields, orchards, pastures, and other agricultural crops. In addition, the Department responds to calls for complaints about impacts to other private property including landscaping and pastures. When frightened, elk may also damage fences and other structures by running through them. Negative human-elk interactions can occur in any GMU in the herd area, but

landowners in portions of GMUs 654, 454, 460, 652, the western edge of 653, and Elk Area 4601 most commonly report elk damage. The Department has worked diligently with landowners to minimize elk damage and has, in some areas, been successful in alleviating damage complaints.

Objective 4

While attempting to achieve the population objective, reduce the number of elk-caused damage complaints on private lands in the NREH area.

Strategies:

a. Develop a program to track the number of elk-conflict complaints requiring WDFW response.
b. Use adaptive damage mitigation techniques to reduce elk damage.
c. Continue to advocate for hunter access on private properties in chronic high damage areas.
d. Use harvest and other methods to reduce elk populations in chronic high damage areas including those with management targets listed in Table 7.
e. Recruit and deploy volunteers to assist landowners with reducing and mitigating elk related agricultural damage.
f. Attempt to sign Damage Prevention Cooperative Agreements with all commercial crop owners that report new or recurring elk damage.
g. Work with local conservation districts to develop programs and materials to educate small and large landowners on how to avoid conflicts with elk.
h. Continue to support local jurisdictional regulation for proposed land uses and fencing in elk migration corridors and winter habitat that may ultimately become conflict sites.

Background for Objective 5

In portions of the North Rainier herd area that are developed, elk colliding with vehicles while crossing roads is a continuing problem. Not only do these collisions reduce elk numbers, but they also threaten human safety. Since 1998 there is increasing public concern regarding vehicle-elk collisions on Interstate 90 and SR 202 and 410.

Objective 5

By 2025 initiate at least two projects that focus on reducing elk vehicle collisions in high collision areas.

Strategies:

a. Identify locations of high vehicle-elk collision and track the number of collisions by location.
b. Support the USVEMG in their effort to repair and improve fencing along I-90.
c. Work with the WSDOT, Crystal Mountain Ski Resort, and MRNP, to reduce elk vehicle collisions on SR410.

d. Decrease the elk population in Elk Area 4601.
e. Work with WSDOT to improve vehicle-animal collision reporting to assist with identification of areas to implement mitigation actions.
f. Work with WSDOT to install signage and other innovative tools to warn people when in elk hazard areas.
g. Use WDFW's roadkill salvage permitting system to monitor for problem areas and changes in elk/vehicle collisions.

Background for Objective 6

A goal of this Plan is to manage the NREH for a variety of recreational, educational, cultural, and aesthetic purposes, including wildlife viewing and photography. Elk viewing opportunities in this part of the state are less predictable than those found in areas east of the Cascades where elk congregate on winter ranges. However elk viewing and photographic opportunities do exist and enhanced public participation could be promoted.

Objective 6

By 2025 complete at least two projects that enhance the public's ability to observe and appreciate elk in their natural habitat or increase public understanding of elk biology and their habitat requirements.

Strategies

a. Create an online or paper document highlighting opportunities where NREH elk can be observed in their natural habitat. Include information on biology, ecology and management.
b. Work with state and local jurisdictions to provide information on the NREH in onsite interpretive displays.
c. Use social media to bring attention to newsworthy events related to the NREH.
d. Work with local citizen organizations such as the USVEMG and MREF to help create local "ownership" of the resident herd.

Background for Objective 7

The Medicine Creek, Point Elliot and Yakama Nation tribes retained the right to hunt on open and unclaimed land within the boundary of their respective ceded areas. These ceded areas taken together cover the entire NREH area. The WDFW respects all governing laws and agreements in treaty areas. It is beneficial to state and tribal co-managers to develop common management goals and objectives.

Objective 7

Meet as necessary, but at least annually to cooperate and collaborate with the Tribes to implement the NREH Plan.

Strategies

a. Work to build bridges of trust and cooperation between the Department and treaty tribes.
b. Form partnerships for funding joint projects to enhance elk populations, improve habitat or advance research and conduct surveys.
c. Invite cooperating agencies, federally recognized Treaty Tribes, and major landowners to meet periodically to discuss NREH management.

SPENDING PRIORITIES

This Spending Priorities section shows the additional funding needed to complete priority tasks in this plan. Most of the strategies listed above in the plan do not require additional funding, but only a change to WDFW staff work-plan assignments. This is called base funding. In addition, many priority tasks are already being performed each year, sometimes by outside partners such as the MIT, TW, MREF and USVEMG. Only Objective 1 requires spending above base funding: Objective 1, Strategies b, c, and d.

Formal Estimates of Herd Demographics

Objective1
Develop and implement standardized and statistically valid survey protocols that will generate reliable estimates of population size or indices of population trend for the NREH by 2025.

Cost summary:
$7,000/year

PLAN REVIEW AND MAINTENANCE

The Plan is a document subject to review and amendment. As new information is gathered and conditions change, it will be necessary to track strategies and their impact on the Plan's goals and objectives in order to re-evaluate and modify this Plan as needed. A free exchange of information and open communication between the WDFW, tribes, cooperators, and the public will be key to this Plan's success. An annual review meeting with delegates from the Point Elliot and Medicine Creek Treaty tribes will be arranged through the Department's Region 4 and 6 Wildlife Programs. Emergent issues can be addressed, as needed, either at the technical or policy level.

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APPENDICES

Appendix A: Green River GMU 485 Elk Augmentation – 2002 Final Report

Green River GMU 485 Elk Augmentation – 2002 Final Report

David J. Vales
Muckleshoot Indian Tribe Wildlife Program
June 2016

Abstract

A substantial effort among many cooperators resulted in 82 elk being transported from southwest Washington to the Green River Watershed, Game Management Unit 485, in south King County during March 2002. By November 2002 only 15 elk remained in the watershed; the others either had moved into other surrounding GMUs or had died. It doubtful that the effort made much of a contribution toward increasing elk numbers in GMU 485. All animals were radio marked and tracked by the Muckleshoot Indian Tribe. Ages of transplanted elk were substantially lower than marked elk in the Green River and should have improved the old age structure of resident animals. Pregnancy rate of transplants aged 2 years and older was 86%, not significantly lower than the 91% for resident marked elk. By then end of May 2002, 2 months after the transplant, 17 had died, 2 were off air, 26 had moved outside the watershed, and only 37 of the transplants were known to be alive within the Green River. Eventually 47 elk moved out of the watershed and 15 remained. Survival after the first year of transplanting was 0.63 including 7 suspected capture-related post-release mortalities. Second year survival was 0.75 and third year survival was 0.94. Comparable survival of marked resident animals was 0.89, 0.79, and 0.94 during the same time periods. The last known surviving translocated elk in the Green River died on 4/6/2014 at the age of 15, and the last one outside died 2/21/2015 at the age of 19.

Introduction

The 2002 North Rainier Elk Herd Plan (NREHP, WDFW 2002) listed elk augmentation in to the Green River, Game Management Unit (GMU) 485, as a high priority management objective. The GMU 485 elk herd had declined to approximately 25% of its high and hunting had been closed. The augmentation plan (Appendix D in WDFW 2002) was intended to bolster the depressed Green River elk herd, by translocating 75-100 female elk from areas where populations had increased above management objectives, and decrease the age structure of the existing population in GMU 485 to improve reproductive rates and the overall viability of the herd. Since historical elk in GMU 485 were thought to be Roosevelt elk, source areas were chosen to add those genes to the existing Rocky Mountain elk genes already in the watershed (Warheit et al. 2014). Translocations occurred in March with the hope that steep terrain and

snow at higher elevations would limit the movements of translocated elk. If the translocated elk stayed in the watershed and produced calves that survived, it was thought that translocated elk would promote an increase of GMU 485 elk.

Study Areas

Captures occurred in 4 areas: Chehalis River along the South Bank Road between Porter and Oakville (41 cows, 2 male calves, and 3 female calves), Centralia Steam Plant (22 cows), Mox Chehalis Creek (10 cows), and Kamilche Valley (4 cows, Fig. 1). There were 4 release sites in the GMU 485 (Green River): McDonald (16 cows, 1 female calf), Maywood (53 cows, 2 male calves, and 2 female calves), Green Canyon (5 cows), and Lester (5 cows, Fig. 2). The City of Tacoma administrative boundary for the Green River Watershed is closed to public access to protect the water supply, and aligns with GMU 485. The Green River, however, extends east of GMU 485 into GMU 466 to the Cascade Crest. Green River as used in this report is meant to be synonymous with GMU 485. Elk experience less human influence in GMU 485 because it is closed to the public. A harvest moratorium was in effect 1997–2003, but was lifted in 2004 when 2 bull permits were issued. Harvest opportunities continue to be limited to permit-only hunts.

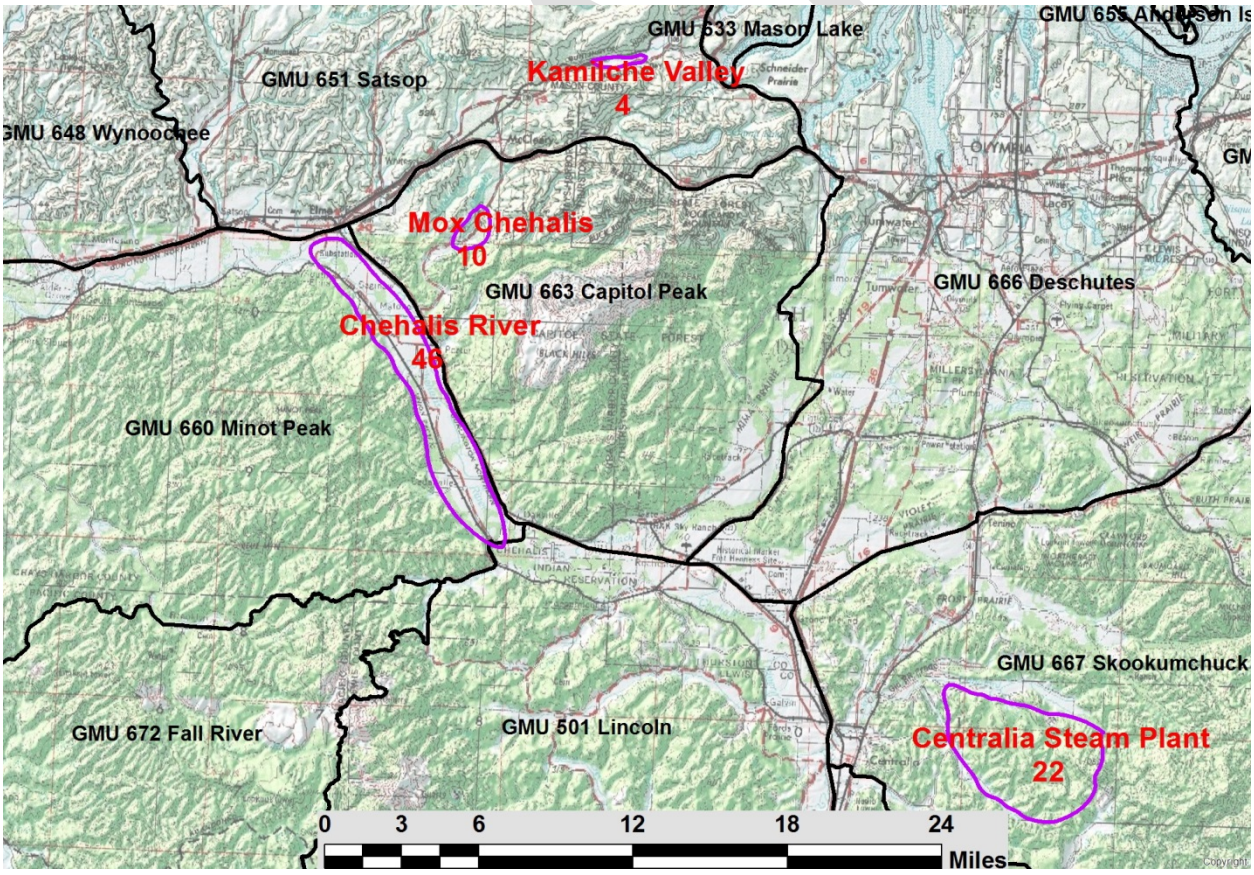

Figure 1. Four capture areas outlined in purple in southwest Washington and associated number of elk captured and transported from the area.

Methods

Elk were darted from a helicopter and immobilized using a carfentanil-xylazine drug combination. Once immobilized, elk were blindfolded and hobbled, and the dart was removed. A ground crew hiked, drove, or was flown to each capture site, and then secured immobilized elk to a pallet for helicopter transport back to the processing area. At the processing area biologists and volunteers fitted elk with a VHF radio-collar, marked each elk with a color and number coded ear tag, removed an upper canine tooth for age determination, collected a fecal sample for examination of parasites, collected blood samples for disease and pregnancy testing, and administered Vitamin B, MuSe, clostridium, and penicillin to assist with capture recovery. Body condition scores (Cook et al. 2001) were collected on 24 animals captured on the first day, but none thereafter. Elk were moved into a horse trailer where biologists antagonized immobilants using naltrexone and yohimbine. The elk were driven to the release site, up to 130 miles away, in the Green River on the same day they were captured (Fig. 2).

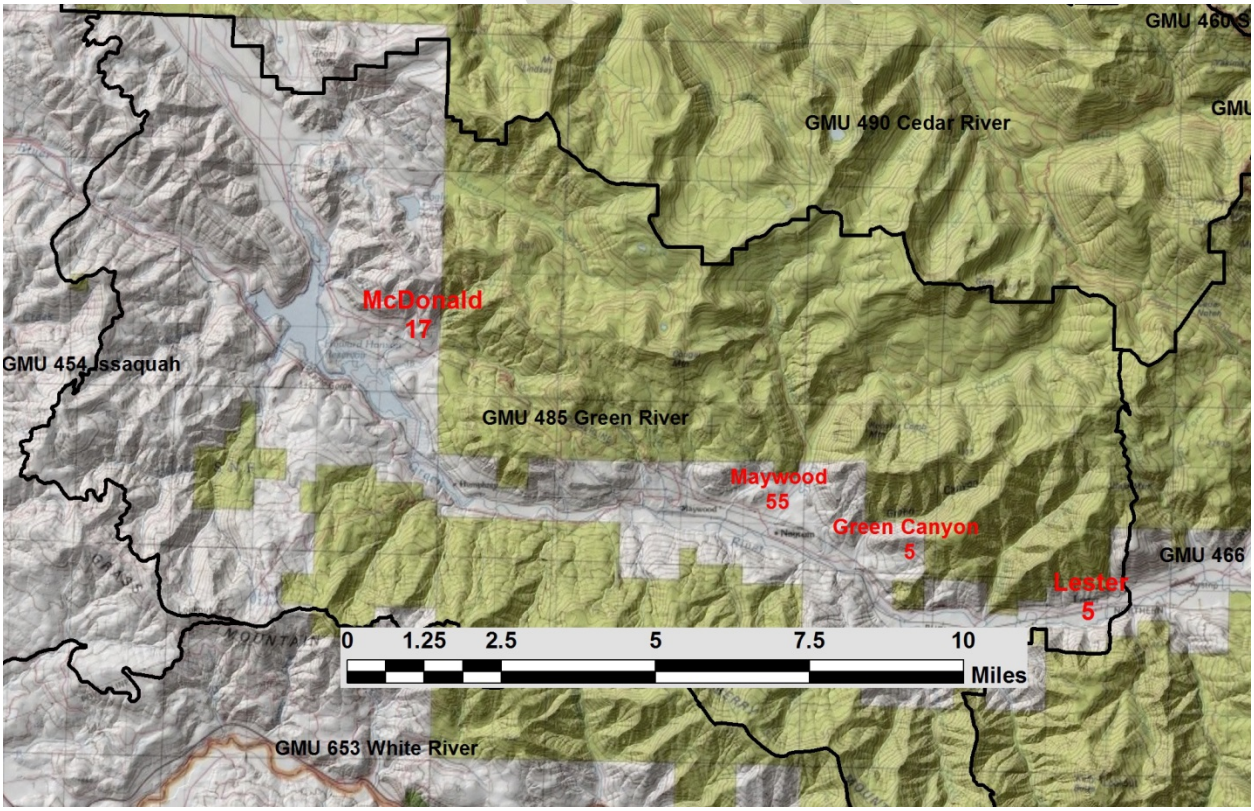

Figure 2. Four release sites in the Green River, GMU 485, and the associated number of elk released in each area.

We used radio-telemetry to monitor translocated elk in the Green River at least once a week, and often twice a week. General location was noted for elk outside the watershed. We also located missing elk by helicopter and recorded specific location coordinates.

Elk that remained within the Green River were re-collared as necessary to replace aging collars until the elk died. One elk that moved to the adjacent White River was re-collared and tracked until her death in March 2014, 12 years after capture.

Mortality investigations were conducted by MIT and WDFW staff. During elk mortality investigations we visually assessed bone marrow fat content based on color and texture to assess the condition of elk at time of death (Cheatum 1949, Mech and DelGuidice. 1985). We also collected a femur when available, for more specific quantitative analysis (Neiland 1970). Elk were skinned when necessary to identify perimortem trauma from tooth or claw puncture marks. We assessed if the animal had been buried, and searched for evidence of cougar fecal material. We also assessed if there were indications of other injuries or abnormalities that might have been a precursor for predation. Non-predation mortalities such as road kills were thoroughly investigated. Survival was estimated using the Kaplan-Meier approach (Pollock 1989).

Costs and Funding

The major project expenses were for the helicopter capture and radio-telemetry collars. Other less expensive items included capture drugs and reversals, capture supplies such as darts, needles, syringes, biologicals, and blood tubes. Additional post-capture expenses included tooth aging, disease, parasite, and pregnancy testing. The Muckleshoot Indian Tribe Charity Fund granted $40,000 to WDFW for the capture effort. The Rocky Mountain Elk Foundation provided a $5,000 grant to WDFW for capture costs. The Muckleshoot Wildlife Program provided radio collars and ear tags to mark all elk (about $20,000 for 82 transmitters), and spent many days ground tracking and flying to search for missing animals and investigating mortalities. MIT paid for tooth aging, parasite testing, pregnancy tests, and follow-up liver fluke analyses, spending another $6,000. Volunteers contributed many hours during the capture, and those who provided their vehicles and trailers absorbed the cost of fuel to transport the elk. An estimate of the total cost of the relocation was approximately $71,000 not including volunteer time.

Results

Elk were captured and transported during 6 days of capture in March 2002. Six elk who were in poor condition died from overheating, or capture related stress. We transported 82 elk from the source areas and released them at 4 sites in the Green River. Five calves, 2 males and 3 females, were captured and translocated, all other elk were adult females ≥1 year old. Table 1 lists attributes, mortality, and historical information for each of the animals that were captured and translocated. The table data include information on capture and release locations, age at capture, sex, pregnancy status at capture, chest girth, whether the elk emigrated from GMU 485, date died, and cause of mortality. Malnutrition/cougar caused mortality are cases where there was evidence of the elk being in poor condition, while the cougar caused mortality indicates

where the animal had been in adequate condition based on femur marrow fat and other characteristics. Some mortality reported as unknown also lists a suspected cause. The status is listed as off-air when collar life had expired, and is shown as missing when it was unknown if a failed collar or other factors may have resulted in the animal going missing.

Table 1. Recorded data for elk captured and translocated to the Green River.

Ear	Date Collared	Capt loc	Rel site	Age	Sex	Preg	Chest Girth (cm)	In/Out	Date died or last heard	Days after capture	Died in GR?	Status	Mortality cause
12	3/9/02	ChR	McDonald	3	F	Y	163	Mort	3/12/02	3	Y		Capture-related
18	3/9/02	ChR	Maywood	0.5	F	**N**	116	Mort	3/18/02	9	Y		Cougar
56	3/14/02	MoxC	Lester	10	F	Y	162	Mort	3/19/02	5	Y		Capture-related
48	3/24/02	CStP	Maywood	18	F	**N**	164	Mort	3/26/02	2	Y		Capture-related
51	3/14/02	MoxC	Lester	1	F	**N**	137	Mort	3/26/02	12	Y		Capture-related
54	3/14/02	MoxC	Lester	4	F	**N**	140	Mort	3/30/02	16	Y		Capture-related
65	3/14/02	ChR	Maywood	0.5	M	**N/A**	130	Mort	3/30/02	16	Y		Cougar
74	3/15/02	MoxC	GrnCyn	3	F	Y	154	Mort	4/1/02	17	Y		Cougar
68	3/14/02	ChR	Maywood	1	F	Y	151	GR Shed	4/2/02	19	**Unk**	Shed	
71	3/15/02	MoxC	GrnCyn	3	F	Y	158	Mort	4/8/02	24	Y		Malnutrition/Cougar
21	3/9/02	ChR	Maywood	0.5	F	**N**	119	Mort	4/12/02	34	Y		Capture-related
47	3/24/02	CStP	Maywood	4	F	Y	160	Mort	4/15/02	22	Y		Capture-related
13	3/9/02	ChR	McDonald	5	F	Y	163	Mort	4/18/02	40	Y		Malnutrition/Cougar
53	3/14/02	MoxC	Lester	3	F	Y	160	Mort	4/19/02	36	Y		Unk-Cougar?
35	3/22/02	ChR	Maywood	3	F	**N**	159	Mort	4/23/02	32	Y		Cougar
62	3/14/02	ChR	Maywood	2	F	Y	148	Mort	5/1/02	48	Y		Malnutrition/Cougar
40	3/23/02	CStP	Maywood	1	F	**N**	155	Mort	5/4/02	42	Y		Cougar
49	3/24/02	CStP	Maywood	6	F	Y	160	Mort	5/12/02	49	Y		Cougar
11	3/9/02	ChR	McDonald	0.5	F	**N**	N/D	GR off air	5/16/02	68	**Unk**	Off air	
4	3/9/02	ChR	McDonald	1	F	Y	157	Mort	6/17/02	100	N		Malnutrition
41	3/23/02	CStP	Maywood	10	F	Y	160	GR off air	8/2/02	132	**Unk**	Off air	
60	3/14/02	Kam	Maywood	12	F	Y	168	Out	9/16/02	186	N		Poach
80	3/24/02	CStP	Maywood	5	F	Y	162	GR	10/1/02	191	Y		Road
75	3/15/02	MoxC	GrnCyn	7	F	Y	158	Out	10/2/02	201	N		Road
82	3/24/02	CStP	Maywood	4	F	Y	152	Out	10/22/02	212	**Out**	Missing	
76	3/24/02	CStP	Maywood	13	F	**N**	162	Out	10/31/02	221	**Out**	Missing	
20	3/9/02	ChR	Maywood	17	F	Y	163	Out	11/20/02	256	N		Hunting
9	3/9/02	ChR	McDonald	3	F	Y	153	Out	11/28/02	264	N		Hunting
39	3/23/02	CStP	Maywood	1	F	Y	157	Out	12/8/02	260	N		Hunting
72	3/15/02	MoxC	GrnCyn	3	F	**N**	155	Out	12/25/02	285	N		Unk-Wound?
63	3/14/02	ChR	Maywood	3	F	Y	156	Out	1/1/03	293	N		Unk-Wound?
23	3/9/02	ChR	Maywood	2	F	Y	159	Out	2/21/03	349	N		Cougar
31	3/22/02	ChR	Maywood	4	F	Y	162	Out	2/26/03	341	N		Road
69	3/14/02	ChR	Maywood	5	F	Y	160	Out	4/21/03	403	N		Cougar
2	3/9/02	ChR	McDonald	3	F	Y	147	Out	5/15/03	432	N		Unk-Cougar?
83	3/24/02	CStP	Maywood	4	F	Y	156	GR	5/23/03	425	Y		Cougar
70	3/14/02	ChR	Maywood	0.5	M	**N/A**	122	GR	7/10/03	483	Y		Unknown
43	3/23/02	CStP	Maywood	2	F	Y	158	Out	7/10/03	474	**Out**	Missing	

5	3/9/02	ChR	McDonald	5	F	Y	154	Out	11/30/03	631	N		Hunting
17	3/9/02	ChR	McDonald	17	F	**N**	156	Out	11/30/03	631	N		Hunting
22	3/9/02	ChR	Maywood	8	F	Y	157	Out	11/30/03	631	N		Hunting
25	3/9/02	ChR	Maywood	3	F	Y	162	Out	11/30/03	631	N		Hunting
7	3/9/02	ChR	McDonald	8	F	Y	155	Out	12/1/03	632	N		Hunting
34	3/22/02	ChR	Maywood	1	F	Y	150	Out	12/15/03	633	N		Hunting
61	3/14/02	ChR	Maywood	3	F	**N**	155	Out	12/15/03	641	N		Hunting
78	3/24/02	CStP	Maywood	2	F	Y	160	GR	3/28/04	735	Y		Cougar
26	3/9/02	ChR	Maywood	2	F	Y	164	Out	9/14/04	920	**Out**	Missing	
6	3/9/02	ChR	McDonald	3	F	Y	163	Out	9/30/04	936	N		Hunting
28	3/22/02	ChR	Maywood	4	F	**N**	157	Out	10/29/04	952	**Out**	Missing	
73	3/15/02	MoxC	GrnCyn	7	F	Y	157	Out	12/15/04	1006	N		Hunting
45	3/24/02	CStP	Maywood	3	F	Y	161	Out	10/5/05	1291	N		Road
79	3/24/02	CStP	Maywood	11	F	Y	160	Out	12/13/05	1360	N		Hunting
55	3/14/02	MoxC	Lester	4	F	Y	160	Out	12/13/05	1370	N		Wounding loss
33	3/22/02	ChR	Maywood	3	F	Y	160	Out	1/29/06	1409	N-WR		Cougar
32	3/22/02	ChR	Maywood	1	F	Y	156	GR	3/7/06	1446	Y		Cougar
3	3/9/02	ChR	McDonald	1	F	**N**	153	Out	8/8/2006	1613	**Out**	Off Air	
24	3/9/02	ChR	Maywood	4	F	Y	159	Out	11/30/06	1727	N		Hunting
67	3/14/02	ChR	Maywood	7	F	Y	154	Out	12/15/06	1737	N		Hunting
29	3/22/02	ChR	Maywood	2	F	Y	156	Out	12/27/06	1741	**Out**	Off Air	
10	3/9/02	ChR	McDonald	2	F	Y	148	Out	2/22/07	1811	**Out**	Off air	
27	3/9/02	ChR	Maywood	4	F	Y	160	Out	3/31/07	1848	N		Accident
66	3/14/02	ChR	Maywood	1	F	Y	151	Out	4/12/07	1855	**Out**	Off air	
50	3/24/02	CStP	Maywood	5	F	Y	159	GR	4/28/07	1861	Y		Cougar
42	3/23/02	CStP	Maywood	16	F	Y	164	GR	5/16/07	1880	Y		Cougar
64	3/14/02	ChR	Maywood	2	F	**N**	154	Out	5/30/07	1903	N		Cougar
37	3/23/02	CStP	Maywood	2	F	Y	160	Out	3/20/08	2189	N		Road
44	3/24/02	CStP	Maywood	3	F	Y	159	GR	4/6/09	2570	Y		Malnutrition
38	3/23/02	CStP	Maywood	2	F	Y	160	GR	5/16/09	2611	Y		Cougar
15	3/9/02	ChR	McDonald	2	F	Y	163	Out	1/13/10	2867	**Out**	Shed	
14	3/9/02	ChR	McDonald	4	F	Y	161	GR	4/14/10	2958	Y		Malnutrition
1	3/9/02	ChR	McDonald	1	F	Y	153	Out	8/5/10	3071	**Out**	Off air	
81	3/24/02	CStP	Maywood	6	F	Y	162	Out	10/30/10	3142	**Out**	Off air	
46	3/24/02	CStP	Maywood	6	F	Y	161	GR	12/4/10	3177	Y		Hunting
8	3/9/02	ChR	McDonald	3	F	Y	160	Out	1/26/11	3245	**Out**	Off air	
59	3/14/02	Kam	Maywood	1	F	Y	157	GR	2/29/12	3639	Y		Cougar
77	3/24/02	CStP	Maywood	1	F	Y	150	GR	5/9/12	3699	Y		Cougar
30	3/22/02	ChR	Maywood	2	F	Y	154	Out	3/1/13	3997	N		Accident
19	3/9/02	ChR	Maywood	9	F	Y	158	Out	10/9/13	4232	N		Hunting
16	3/9/02	ChR	McDonald	1	F	Y	153	GR	2/6/14	4352	Y		Cougar
57	3/14/02	Kam	Maywood	3	F	Y	158	Out	3/23/14	4392	N		Cougar
58	3/14/02	Kam	Maywood	3	F	Y	162	GR	4/6/14	4406	Y		Malnutrition/Old
36	3/22/02	ChR	Maywood	6	F	Y	167	Out	2/21/15	4719	N		Malnutrition/Old

The age structure of translocated elk was younger than previously-marked Green River animals used for other Muckleshoot studies (Fig. 3). The median age of animals ≥1 year was 11.5 for Green River animals and 3.0 for transplants; the average was 11.3 and 4.5 respectively.

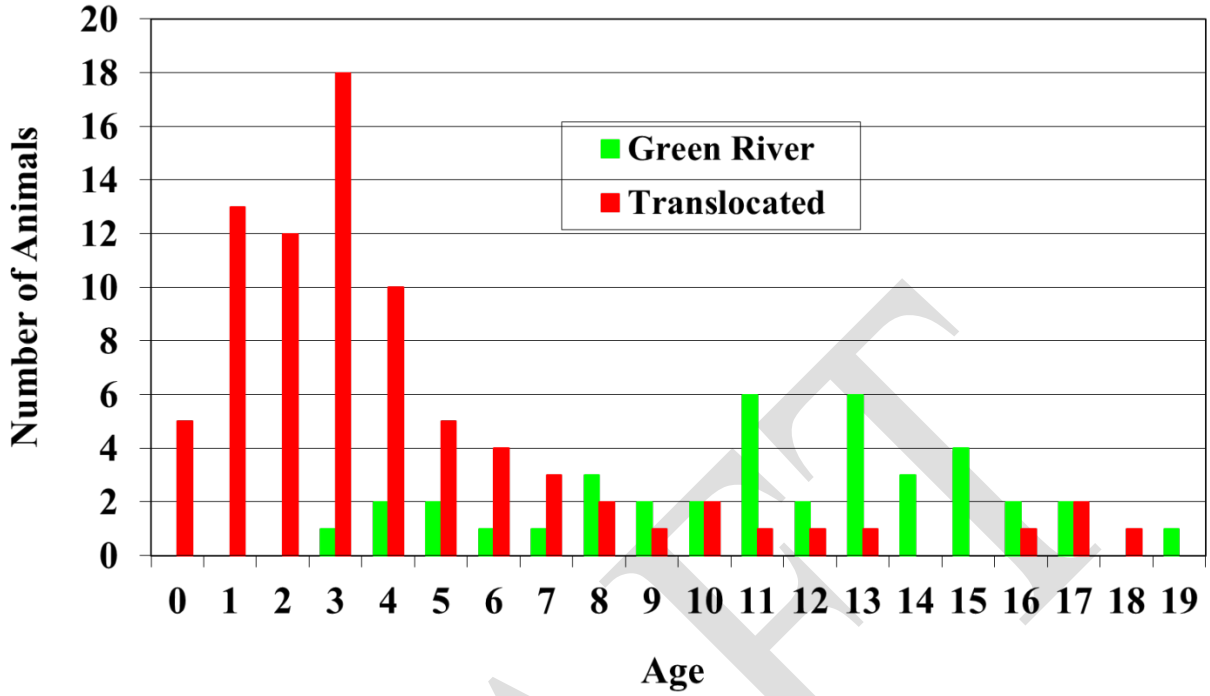

Figure 3. Age distribution of translocated elk compared to radio-marked resident Green River elk.

We found that 10 of 13 yearlings were pregnant (77%), suggesting high nutrition and early puberty for the transplant animals (Cook et al. 2004). Animals 2 years and older had an 86% pregnancy rate (56 of 65). The adult pregnancy rate of translocated elk was lower than the 91% of resident marked animals, but not significantly different.

We subsampled and tested 32 fecal samples for *Giardia*, *Cryptosporidium*, *E. coli*, and *Salmonella*. Four samples were positive for crypto, 3 from the Chehalis River area and 1 from Mox Chehalis, and 3 were positive for *Giardia*, 2 from the Chehalis River area and 1 from Mox Chehalis. None were positive for *E. coli* or *Salmonella*. No samples from the Centralia Steam Plant or Kamilche Valley areas were analyzed for parasites due to cost concerns. Follow-up fecal samples that tested for liver flukes in spring and fall 2003 and spring 2004 found 3 of 23 transplant elk sampled were positive for liver fluke while 1 of 36 resident animals was positive.

Disease testing for brucellosis, blue tongue, anaplasmosis, EHD, johnes disease, *Leptospira serovars pomona*, *hardjo*, *grippotyphosa*, *icterohemorrhagiae*, and *canicola* was done on 30 animals. Seven animals from the Chehalis valley had low titers for L. *grippotyphosa*. Titers this low usually mean that the animals immune system has recognized the infectious organism but are not indicative of a serious illness and was not of significant concern.

Body condition was measured using ultrasound on 24 elk during the first day of capture from the southwest side of the Chehalis River. Ingesta-free body fat estimates (Cook et al. 2001)

of 19 elk ≥2 years old averaged 8.6% and was significantly higher than the average of 3.3% for 22 resident Green River elk that were captured 17 days later. The much higher body fat levels were indicative of better food at the source area, or milder winter, than in the release area.

Despite the desire to transplant Roosevelt elk, no genetic testing was done on individual translocated animals. WDFW has tested genetics in herds throughout the state and found that elk in the source areas are Roosevelt elk (Warheit et al. 2014). The 2002 NREHP objective of bringing in Roosevelt elk genes probably was met.

Transplant elk mortality was high soon after release with 17 of the 82 elk dying in the first 50 days. Seven elk that died within 2 to 33 days after release were attributed to capture-related issues (Table 1). There were another 10 cougar related mortalities within 9 to 49 days after release. Three of these elk were in poor condition based on femur marrow fat at time of death which may have made these elk susceptible to predation. Also, relocated elk were likely more susceptible to predation since the landscape was new to them. Three of the 5 calves, 1 male and 2 females, were part of the 17 early mortalities. The average age of the 17 elk that died early was 3.9. Of the 17 early mortalities, elk from Mox Chehalis died at a higher rate (0.60) than elk from Chehalis River (0.15) or Centralia Steam Plant (0.18, Table 2). First year survival after transplanting excluding calves was 0.63 (n=77) and included the 14 adult cow early post-release mortalities. Second year survival was 0.75 (n=49) and third year survival was 0.94 (n=36). These survival rates are for all transplants ≥1 year of age including those inside and outside the Green River. Survival of radio-marked resident Green River elk during the same periods was 0.89 (n=26), 0.79 (n=28), and 0.94 (n=34) (MIT unpubl. data in prep).

Table 2. Known number of elk that remained in the Green River and number that moved out for the 4 capture areas. In and out exclude 17 early mortalities and 3 unknown status. Table includes number of mortalities during first 50 days by source area and release site.

Capture Site	In	Out	Early 17 Mortalities
Chehalis River	4	33	7 of 46
Centralia Steam Plant	9	8	4 of 22
Mox Chehalis	0	4	6 of 10
Kamilche	2	2	0 of 4
Total	15	47	17

We do not have much information on the fate of calves born to translocated elk. In summer 2002 we captured a male calf with a transplant but the pair moved outside of the watershed. The calf was alive when its transmitter battery expired. Survival of 31 calves radio marked in 2002 in the Green River was 0.13 (MIT unpubl. data in prep) and the transplants may have had even lower survival. It is likely that the transplants did not contribute much to calf recruitment in 2002. In summer 2004 we caught one female calf with a transplant and it survived through its first year of life. Calf survival in 2004 was 0.51 (MIT unpubl. data in prep),

so calves born to the 12 transplants alive in the watershed at that time should have been fair if they had a similar survival rate.

The elk that moved out of the watershed did so soon after release. As of May 17, 2002, 10 weeks or less after release, only 37 elk were known to be alive inside GMU 485, of which 32 were pregnant. By June 22, only 20 elk remained in the watershed on the air while another 42 were outside the Green River and on the air. Mortalities and additional movements outside the watershed resulted in only 15 elk being in the watershed by November 2002, and only 12 by June 2004.

The average age of 15 elk that stayed in the Green River was 3.6 which was not significantly different than the 4.7 average of the 47 elk that moved out. Elk from the Chehalis River were more likely to move out, and elk from the Centralia Steam Plant were more likely to remain in the Green River (Table 2). All of the Centralia Steam Plant animals were released at Maywood and half stayed, whereas only 2 of the 23 Chehalis River animals released at Maywood stayed in the Green River.

In summary:

- 17 elk died by May 12, 2002 inside the Green River, 7 were capture related and 10 were killed by cougar
- 3 elk went off air inside Green River with fate unknown
- We tracked 15 elk that stayed in the Green River until their deaths with the last on 4/6/2014
- We documented 33 mortalities of transplants that moved outside the Green River, 15 of those were hunter kills. The last known elk death occurred on 2/21/2015 near Buckley of an elk at the age of 19
- We last heard 13 additional elk outside the Green River, fate unknown

Elk that moved out were tracked to many different areas: 2 moved to North Bend, 1 to Rattlesnake Mtn., 3 to Hobart, 1 to Lake Sammamish , 1 to Auburn , 1 to Bonney Lake , and several to Enumclaw, and many south of Enumclaw (Fig. 4). Two elk spent winter on the Watt feed ground near Ellensburg with one returning to the Green River and the other to the Cedar River in summer.

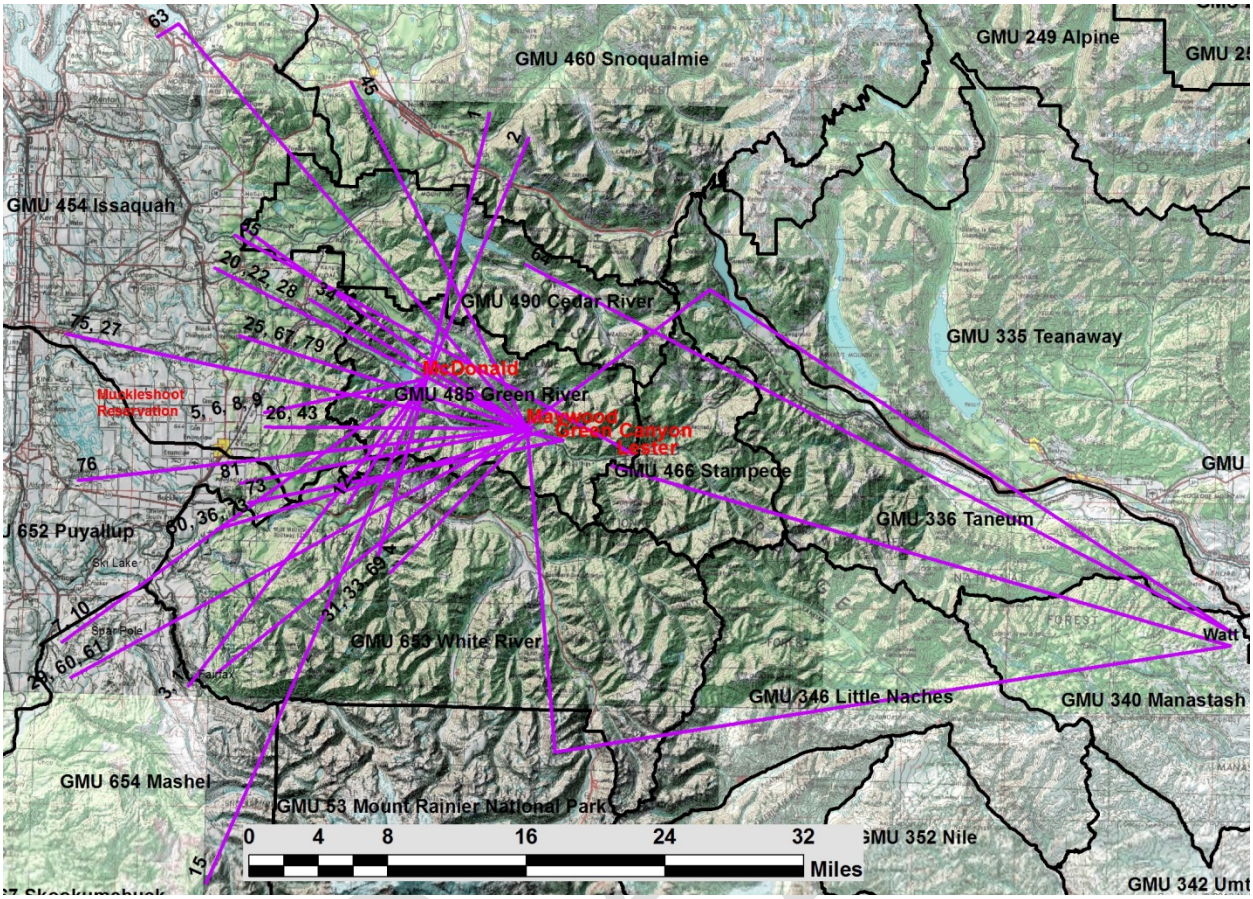

Figure 4. Straight-line movements from release sites to known extreme distances for radio-marked transplants that moved out. Numbers represent ear tag ID numbers.

Discussion

Several factors affected the success of this relocation effort. Prior to the transplant cougar numbers were high in the Green River since this watershed had been closed to cougar hunting with resident marked adult and calf elk being subject to substantial mortality due to cougar (Tables 5 and 6 in the plan above). The translocation occurred in spring when snow was melting at higher elevation and no snow was on the ground at lower elevation. Snow on ridges bordering the watershed did not limit elk movement out of the watershed in the first two months after release as had been hoped. Had elk been held in the watershed by snow more animals might have remained, although survival would still have been a question.

The Army Corps of Engineers and Tacoma Public Utilities had planned a test pool rise in 2002 for the Howard Hanson Additional Water Storage Project (USACoE 1998). Water levels rose 20 feet above what had previously been high water mark of 1147 feet and inundated substantial high quality elk pasture in the McDonald area. These levels remained higher than normal from 4/11-7/22 and affected the availability of high quality habitat and the potential to

hold elk. Mitigation fields intended to offset the forage loss had not yet been planted and elk were left scrambling to find adequate spring-summer forage during the critical late pregnancy and lactation period. While only 17 of the 82 elk were released at McDonald, elk moved from other release sites downriver toward the McDonald site. They did not find what they were looking for and continued on out of the watershed.

Spring population survey data in the Green River indicated that elk herd numbers did begin to grow after the augmentation, however the Muckleshoot Tribe, began intensively harvesting cougars in 2001, potentially confounding the interpretation of the success of the augmentation (MIT unpubl. data in prep). The transplanted elk that remained in the Green River Watershed likely had a small positive effect on the herd, but cougar removals probably had a greater effect on population increases because annual calf survival rate improved from 0.11 to 0.56.

Considering how many elk initially died, and how many moved out, the augmentation cannot be considered to have been a success. It likely did little to bolster the elk population in the Green River. However some things have been learned and suggestions for future transplants would include:

- Insure predator numbers are low to reduce mortality on naïve, vulnerable animals.
- Time the release to ensure that deep snow on watershed ridge borders might limit movements out.
- Choose source animals that have similar or worse habitat so they will not emigrate to seek high quality forage similar to what they had at the source area. Avoid translocating animals from agricultural areas to natural habitats.
- Consider feeding elk near the release sites to encourage them to stay, especially if they were moved from a snow-free area to one with snow, or from one of higher quality forage to lower quality forage.
- Mark every individual to know their fate.
- Do not translocate calves.
- Avoid surprises like what occurred with the reservoir water level increase.

Acknowledgments

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Special appreciation goes to the many volunteers who provided transport vehicles and trailers and who drove long distances late into the evening to transport elk to release sites. This effort was greatly improved by the efforts of the Muckleshoot Wildlife Program staff and Wildlife Committee who exhibited a strong commitment to manage elk in the Green River Watershed.

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Appendix B: Elk Hunting Seasons in the North Rainier Elk Herd Area 2002-2017[a]

YEAR	GMU # & (Number of permits)	Dates	Days	Legal Animal	Hunt Description and Tag Type
2017	454, 652 (except Elk Area 6013) 654 460, 466	09/09- 09/21 09/09- 09/21 09/09- 09/21	13 13 13	Any elk Antlerless or 3 pt. min. 3 Pt. minimum	Early Archery General (WA)
	454 652 (except Elk Area 6013)	11/22-12/15 11/22-12/15	24 24	Any elk Antlerless or 3 pt. min.	Late Archery General (WA)
	454 460, 466 652 (except Elk Area 6013 closed to antlerless), 654	10/07-10/13 10/07-10/13 10/07-10/13	7 7 7	Any elk 3 Pt. minimum Antlerless or 3 pt. min.	Early Muzzleloader General (WM)
	454 652 (except Elk Area 6013 closed to antlerless)	11/22-12/15 11/22-12/08	24 17	Any elk Antlerless or 3 pt. min	Late Muzzleloader General (WM)
	454 460, 466, 652 (except for Elk Area 6014), 654 Elk Area 6014	11/04-11/15 11/04-11/15 11/04-11/15	12 12 12	Any bull 3 Pt. minimum Antlerless or 3 pt. min.	Modern Firearm General (WF)
	485 Green River 2031 (8) 653 White River 2050 (2) 653 White River 2822 (35) 653 White River 2844 (7) 4601 North Bend 2241 (5) 485 Green River 2242 (4) 653 White River 2074 (24) 4601 North Bend 2706 (15) 6054 Mashel 2323 (25) 6014 Puyallup 2261 (10) 6014 Puyallup 2262 (10) 6014 Puyallup 2263 (10) 4601 North Bend 2425 (5) 4601 North Bend 2511 (5) 4601 North Bend 2615 (5)	11/04-11/10 09/25-09/29 11/04-11/15 10/07-10/13 11/04-11/15 11/04-11/10 09/09-09/21 07/01/17-03/31/18 12/29/17-01/12/18 12/29/17-01/17/18 01/18/18-02/07/18 02/08/18-02/25/18 11/04-11/15 11/04-11/15 11/04-11/15	7 5 12 7 12 7 13 289 15 20 21 18 12 12 12	Any bull Any bull Any bull Any bull Antlerless Antlerless Any bull Antlerless Antlerless Antlerless Antlerless Antlerless Antlerless Antlerless Antlerless	Modern Firearm Bull Permit (WF) Modern Firearm Bull Permit (WF) Modern Firearm Bull Permit (WF) Muzzleloader Permit (WM) Modern Firearm (WF) Modern Firearm (WF) Archery Permit (WA) Master Hunter, (Any Elk Tag) Muzzleloader Permit (WM) Modern Firearm (WF) Modern Firearm (WF) Modern Firearm (WF) Youth, (WF, WA, WM) 65 and older, (WF, WA, WM) Disabled, (WF, WA, WM)
2016	454, 652 (except Elk Area 6013) 654 460, 466	09/010- 09/22 09/010- 09/22 09/010- 09/22	13 13 13	Any elk Antlerless or 3 pt. min. 3 Pt. minimum	Early Archery General (WA)
	454 652 (except Elk Area 6013)	11/23-12/15 11/23-12/15	23 23	Any elk Antlerless or 3 pt. min.	Late Archery General (WA)
	454 460 654	10/1-10/07 10/1-10/07 10/1-10/07	7 7 7	Any elk 3 Pt. minimum Antlerless or 3 pt. min.	Early Muzzleloader General (WM)
	454 652 (except Elk Area 6013 closed to antlerless)	11/23-12/15 11/26-12/08	23 13	Any elk Antlerless or 3 pt. min	Late Muzzleloader General (WM)
	454 460, 466, 652 (except for Elk Area 6014), 654 Elk Area 6014	11/05-11/16 11/05-11/16 11/05-11/16	12 12 12	Any bull 3 Pt. minimum Antlerless or 3 pt. min.	Modern Firearm General (WF)
	485 Green River 2031 (8) 653 White River 2050 (2) 653 White River 2822 (34) 653 White River 2844 (7) 4601 North Bend 2240 (5) 485 Green River 2241 (4) 653 White River 2074 (24) 4601 North Bend 2706 (15) 6054 Mashel 2323 (25) 6014 Puyallup 2260 (10) 6014 Puyallup 2261 (10) 6014 Puyallup 2262 (10) 4601 North Bend 2425 (5) 4601 North Bend 2511 (5)	10/22-10/28 09/26-09/30 11/05-11/16 10/01-10/07 11/6-11/17 10/22-10/28 09/10-09/22 07/01/16-03/31/17 12/30/16-01/13/17 12/30/16-01/18/17 01/19/17-02/08/17 02/09/17-02/26/17 11/06-11/17 11/06-11/17	7 5 12 7 12 7 13 289 15 20 21 18 12 12	Any bull Any bull Any bull Any bull Antlerless Antlerless Any bull Antlerless Antlerless Antlerless Antlerless Antlerless Antlerless Antlerless	Modern Firearm Bull Permit (WF) Modern Firearm Bull Permit (WF) Modern Firearm Bull Permit (WF) Muzzleloader Permit (WM) Modern Firearm (WF) Modern Firearm (WF) Archery Permit (WA) Master Hunter, (Any Elk Tag) Muzzleloader Permit (WM) Modern Firearm (WF) Modern Firearm (WF) Modern Firearm (WF) Youth, (WF, WA, WM) 65 and older, (WF, WA, WM)

YEAR	GMU # & (Number of permits)	Dates	Days	Legal Animal	Hunt Description and Tag Type
	4601 North Bend 2615 (5)	11/06-11/17	12	Antlerless	Disabled, (WF, WA, WM)
2015	454, 652 654 460, 466	09/012- 09/24 09/012- 09/24 09/012- 09/24	13 13 13	Any elk Antlerless or 3 pt. min. 3 Pt. minimum	Early Archery General (WA)
	454 652 (except Elk Area 6013)	11/25-12/15 11/25-12/15	21 21	Any elk Antlerless or 3 pt. min.	Late Archery General (WA)
	454 460 654	10/3-10/09 10/3-10/09 10/3-10/09	7 7 7	Any elk 3 Pt. minimum Antlerless or 3 pt. min.	Early Muzzleloader General (WM)
	454 652 (except Elk Area 6013 closed to antlerless)	11/26-12/15 11/26-12/08	20 13	Any elk Antlerless or 3 pt. min	Late Muzzleloader General (WM)
	454 460, 466, 652 (except for Elk Area 6014), 654 Elk Area 6014	11/07-11/18 11/07-11/18 11/07-11/18	12 12 12	Any bull 3 Pt. minimum Antlerless or 3 pt. min.	Modern Firearm General (WF)
	485 Green River 2031 (6) 653 White River 2050 (2) 653 White River 2822 (33) 653 White River 2846 (8) 4601 North Bend 2239 (5) 485 Green River 2240 (2) 653 White River 2073 (31) 4601 North Bend 2706 (15) 6054 Mashel 2325 (25) 6014 Puyallup 2260 (10) 6014 Puyallup 2261 (10) 6014 Puyallup 2262 (10) 4601 North Bend 2423 (5) 4601 North Bend 2510 (5) 4601 North Bend 2616 (5)	11/07-11/13 09/28-10/02 11/07-11/18 10/03-10/09 11/01-11/12 11/07-11/13 09/12-09/24 08/01/15-03/31/16 01/01/15-01/15/16 01/01/16-01/20/16 01/21/16-02/10/16 02/11/16-20/28/16 11/01-11/12 11/01-11/12 11/01-11/12	7 5 12 7 12 12 13 258 15 20 21 18 12 12 12	Any bull Any bull Any bull Any bull Antlerless Antlerless Any bull Antlerless Antlerless Antlerless Antlerless Antlerless Antlerless Antlerless Antlerless	Modern Firearm Bull Permit (WF) Modern Firearm Bull Permit (WF) Modern Firearm Bull Permit (WF) Muzzleloader Permit (WM) Modern Firearm (WF) Modern Firearm (WF) Archery Permit (WA) Master Hunter, (Any Elk Tag) Muzzleloader Permit (WM) Modern Firearm (WF) Modern Firearm (WF) Modern Firearm (WF) Youth, (WF, WA, WM) 65 and older, (WF, WA, WM) Disabled, (WF, WA, WM)
2014	454, 652 654 460, 466	09/02- 09/14 09/02- 09/14 09/02- 09/14	13 13 13	Any elk Antlerless or 3 pt. min. 3 Pt. minimum	Early Archery General (WA)
	454	11/26-12/15	20	Any elk	Late Archery General (WA)
	454 460 652(except Elk Area 6013 closed to antlerless), 654	10/4-10/10 10/4-10/10 10/4-10/10	7 7 7	Any elk 3 Pt. minimum Antlerless or 3 pt. min.	Early Muzzleloader General (WM)
	454 652 (except Elk Area 6013 closed to antlerless)	11/26-12/15 11/26-12/08	20 13	Any elk Antlerless or 3 pt. min	Late Muzzleloader General (WM)
	454 460, 466, 652, 654	11/01-11/12 11/01-11/12	12 12	Any bull 3 Pt. minimum	Modern Firearm General (WF)
	485 Green River 2030 (6) 653 White River 2047 (1) 653 White River 2822 (21) 653 White River 2845 (6) 4601 North Bend 2235 (5) 653 White River 2070 (13) 4601 North Bend 2706 (25HM) 6054 Mashel 2329 (25) 6013 Puyallup 2260 (10) 4601 North Bend 2402 (5) 4601 North Bend 2511 (5) 4601 North Bend 2607 (5)	10/25-10/31 09/22-09/26 11/01-11/10 10/04-10/10 11/1-11/12 09/03-09/15 08/01/14-03/31/15 01/01/15-01/15/15 01/01/15-01/20/15 11/01-11/12 11/01-11/12 11/01-11/12	7 5 10 7 12 13 258 15 20 12 12 12	Any bull Any bull Any bull Any bull Antlerless Any bull Antlerless Antlerless Antlerless Antlerless Antlerless Antlerless	Modern Firearm Bull Permit (WF) Modern Firearm Bull Permit (WF) Modern Firearm Bull Permit (WF) Muzzleloader Permit (WM) Modern Firearm (WF) Archery Permit (WA) Master Hunter, (Any Elk Tag) Muzzleloader Permit (WM) Any Weapon (WF, WA, WM) Youth, (WF, WA, WM) 65 and older, (WF, WA, WM) Disabled, (WF, WA, WM)
2013	454, 652 654 460, 466	09/03 - 09/15 09/03 - 09/15 09/03 - 09/15	13 13 13	Any elk Antlerless or 3 pt. min. 3 Pt. minimum	Early Archery General (WA)
	454	11/27-12/15	19	Any elk	Late Archery General (WA)

YEAR	GMU # & (Number of permits)	Dates	Days	Legal Animal	Hunt Description and Tag Type
	454 460 652(except Elk Area 6013 closed to antlerless), 654	10/5-10/11 10/5-10/11 10/5-10/11	7 7 7	Any elk 3 Pt. minimum Antlerless or 3 pt. min.	Early Muzzleloader General (WM)
	454 652	11/27-12/15 11/27-12/08	19 12	Any elk Antlerless or 3 pt. min	Late Muzzleloader General (WM)
	454 460, 466, 652, 654	11/02-11/13 11/02-11/13	12 12	Any bull 3 Pt. minimum	Modern Firearm General (WF)
	485 Green River 2029 (6) 653 White River 2046 (1) 653 White River 2820 (21) 653 White River 2841 (4) 4601 North Bend 2234 (7) 4601 North Bend 2305 (5) 4601 North Bend 2270 (10) 653 White River 2068 (14) 4601 North Bend 2708 (25HM) 6054 Mashel 2330 (25) 6013 Puyallup 2259 (10) 4601 North Bend 2402 (5)	11/09-11/15 09/23-09/27 11/03-11-14 10/06-10/12 11/2-11/13 10/05-10/11 09/04-09/16 09/04-09/16 08/15/13-03/31/14 01/01/14-01/15/14 01/01/14-01/20/14 11/03-11/09	7 5 11 7 12 7 13 13 244 15 20 7	Any bull Any bull Any bull Any bull Antlerless Antlerless Antlerless Any bull Antlerless Antlerless Antlerless Antlerless	Modern Firearm Bull Permit (WF) Modern Firearm Bull Permit (WF) Modern Firearm Bull Permit (WF) Muzzleloader Permit (WM) Modern Firearm (WF) Muzzleloader Permit (WM) Archery Permit (WA) Archery Permit (WA) Master Hunter, (Any Elk Tag) Muzzleloader Permit (WM) Any Weapon (WF, WA, WM) Youth, (WF, WA, WM)
2012	454, 652 654 460, 466	09/04 - 09/16 09/04 - 09/16 09/04 - 09/16	13 13 13	Any elk Antlerless or 3 pt. min. 3 Pt. minimum	Early Archery General (WA)
	454	11/21-12/15	25	Any elk	Late Archery General (WA)
	454 460 652(except Elk Area 6013 closed to antlerless), 654	10/6-10/12 10/6-10/12 10/6-10/12	7 7 7	Any elk 3 Pt. minimum Antlerless or 3 pt. min.	Early Muzzleloader General (WM)
	454 652 (except Elk Area 6013 closed to antlerless)	11/21-12/15 11/21-12/08	25 18	Any elk Antlerless or 3 pt. min	Late Muzzleloader General (WM)
	454 460, 466, 652, 654	11/03-11/14 11/03-11/14	12 12	Any bull 3 Pt. minimum	Modern Firearm General (WF)
	485 Green River 2029 (6) 653 White River 2049 (1) 653 White River 2818 (24) 653 White River 2836 (3) 4601 North Bend 2235 (7) 4601 North Bend 2308 (5) 4601 North Bend 2273 (10) 653 White River 2074 (13) 4601 North Bend 2710 (25HM) 6054 Mashel 2332 (25) 4601 North Bend 2400 (5)	11/ 12-11/18 09/24-09/28 11/03-11/14 10/06-10/12 11/3-11/14 10/06-10/12 09/04-09/16 09/04-09/16 08/15/12-03/31/13 01/01/13-01/15/13 11/03-11/09	7 5 11 7 12 7 13 13 244 15 7	Any bull Any bull Any bull Any bull Antlerless Antlerless Antlerless Any bull Antlerless Antlerless Antlerless	Modern Firearm Bull Permit (WF) Modern Firearm Bull Permit (WF) Modern Firearm Bull Permit (WF) Muzzleloader Permit (WM) Modern Firearm (WF) Muzzleloader Permit (WM) Archery Permit (WA) Archery Permit (WA) Master Hunter, (Any Elk Tag) Muzzleloader Permit (WM) Youth, (WF, WA, WM)
2011	454, 652 654 460, 466	09/06 - 09/18 09/06 - 09/18 09/06 - 09/18	13 13 13	Any elk Antlerless or 3 pt. min. 3 Pt. minimum	Early Archery General (WA)
	454	11/23-12/15	23	Any elk	Late Archery General (WA)
	454 460 652(except Elk Area 6013 closed to antlerless), 654	10/1-10/7 10/1-10/7 10/1-10/7	7 7 7	Any elk 3 Pt. minimum Antlerless or 3 pt. min.	Early Muzzleloader General (WM)
	454 652	11/23-12/15 11/23-12/08	23 16	Any elk Antlerless or 3 pt. min	Late Muzzleloader General (WM)
	454 460, 466, 652, 654	11/05-11/15 11/05-11/15	11 11	Any bull 3 Pt. minimum	Modern Firearm General (WF)

YEAR	GMU # & (Number of permits)	Dates	Days	Legal Animal	Hunt Description and Tag Type
	485 Green River 2030 (6)	11/12-11/18	7	Any bull	Modern Firearm Bull Permit (WF)
	653 White River 2050 (1)	09/19-09/23	5	Any bull	Modern Firearm Bull Permit (WF)
	653 White River 2818 (30)	11/05-11/15	11	Any bull	Modern Firearm Bull Permit (WF)
	653 White River 2836 (3)	10/01-10/07	7	Any bull	Muzzleloader Permit (WM)
	4601 North Bend 2230 (5)	11/5-11/15	11	Antlerless	Modern Firearm (WF)
	4601 North Bend 2296 (5)	10/02-10/08	5	Antlerless	Muzzleloader Permit (WM)
	4601 North Bend 2265 (10)	09/06-09/23	18	Antlerless	Archery Permit (WA)
	653 White River 2075 (13)	09/06-09/18	13	Any bull	Archery Permit (WA)
	4601 North Bend 2711 (25HM)	08/15/11-03/31/12	244	Antlerless	Master Hunter, (Any Elk Tag)
	6054 Mashel 2321 (25)	01/01/12-01/15/12	15	Antlerless	Muzzleloader Permit (WM)
	4601 North Bend 2400 (5)	10/15-10/21	7	Antlerless	Youth, (WF, WA, WM)
2010	454, 652	09/07 - 09/19	13	Any elk	Early Archery General (WA)
	654	09/07 - 09/19	13	Antlerless or 3 pt. min.	
	460, 466	09/07 - 09/19	13	3 Pt. minimum	
	454	11/24-12/15	22	Any elk	Late Archery General (WA)
	454	10/2-10/8	7	Any elk	Early Muzzleloader General (WM)
	460	10/2-10/8	7	3 Pt. minimum	
	652,654	10/2-10/8	7	Antlerless or 3 pt. min.	
	454	11/25-12/15	21	Any elk	Late Muzzleloader General (WM)
	652	11/25-12/08	14	Antlerless or 3 pt. min	
	454	11/06-11/16	11	Any bull	Modern Firearm General (WF)
	460, 466, 652, 654	11/06-11/16	11	3 Pt. minimum	
	485 Green River 2113 (6)	10/30-11/05	7	Any bull	Modern Firearm Bull Permit (WF)
	653 White River 2047 (1)	09/20-09/24	5	Any bull	Modern Firearm Bull Permit (WF)
	653 White River 2118 (30)	11/06-11/16	11	Any bull	Modern Firearm Bull Permit (WF)
	653 White River 2133 (4)	10/02-10/08	7	Any bull	Muzzleloader Permit (WM)
	4601 North Bend 2231 (5)	11/6-11/16	11	Antlerless	Modern Firearm (WF)
	4601 North Bend 2301 (5)	10/02-10/08	5	Antlerless	Muzzleloader Permit (WM)
	4601 North Bend 2267 (7)	09/07-09/19	13	Antlerless	Archery Permit (WA)
	653 White River 2073 (13)	09/07-09/19	13	Any bull	Archery Permit (WA)
	6054 Mashel 2329 (25)	01/01/11-01/15/11	15	Antlerless	Muzzleloader Permit (WM)
	4601 North Bend 2712 (25HM)	08/15/10-03/31/11	244	Antlerless	Master Hunter, (Any Elk Tag)
2009	454, 652	09/08 - 09/20	13	Any elk	Early Archery General (WA)
	654	09/08 - 09/20	13	Antlerless or 3 pt. min.	
	460, 466	09/08 - 09/20	13	3 Pt. minimum	
	454	11/25-12/15	21	Any elk	Late Archery General (WA)
	454	10/3-10/9	7	Any elk	Early Muzzleloader General (WM)
	460	10/3-10/9	7	3 Pt. minimum	
	652,654	10/3-10/9	7	Antlerless or 3 pt. min.	
	454	11/25-12/15	21	Any elk	Late Muzzleloader General (WM)
	652	11/25-12/08	14	Antlerless or 3 pt. min	
	454	11/07-11/17	11	Any bull	Modern Firearm General (WF)
	460, 466, 652, 654	11/07-11/17	11	3 Pt. minimum	
	485 Green River **(3)**	10/17-10/23	7	Any bull	Modern Firearm Bull Permit (WF)
	653 White River A (48)	11/07-11-17	11	Any bull	Modern Firearm Bull Permit (WF)
	653 White River B (1)	09/21-09/25	5	Any bull	Modern Firearm Bull Permit (WF)
	4601 North Bend A (5)	11/7-11/17	11	Antlerless	Modern Firearm (WF)
	4601 North Bend B (5)	10/03-10/09	7	Antlerless	Muzzleloader Permit (WM)
	4601 North Bend C	09/08-09/20	13	Antlerless	Archery Permit (WA)

YEAR	GMU # & (Number of permits)	Dates	Days	Legal Animal	Hunt Description and Tag Type
	653 White River D (20)	09/08-09/20	13	Any bull	Archery Permit (WA)
	4601 North Bend D (25HM)	08/14/09-03/31/10	243	Antlerless	Master Hunter, Second Hunt (Any Elk Tag)
	6054 Mashel A (25)	01/01/10-01/15/10	15	Antlerless	Muzzleloader Permit (WM)
2008	454, 652	09/08-09/21	14	Any elk	Early Archery General (WA)
	654	09/08-09/21	14	Antlerless or 3 pt. min.	
	460, 466	09/08-09/21	14	3 Pt. minimum	
	454	11/19-12/15	27	Any elk	Late Archery General (WA)
	454	10/04-10/10	7	Any elk	Early Muzzleloader General (WM)
	460	10/04-10/10	7	3 Pt. minimum	
	652,654	10/04-10/10	7	Antlerless or 3 pt. min.	
	454	11/19 - 12/15	27	Any elk	Late Muzzleloader General (WM)
	652	11/19 - 12/08	20	Antlerless or 3 pt. min	
	454	11/01-11/10	9	Any bull	Modern Firearm General (WF)
	460, 466, 652, 654	11/01-11/10	9	3 Pt. minimum	
	485 Green River (3)	11/01-11/07	7	Any bull	Modern Firearm Bull (WF)
	653 White River A (40)	11/01-11/10	10	Any bull	Modern Firearm Bull (WF)
	653 White River B (3)	10/01-10/10	10	Any bull	Muzzleloader Bull (WM)
	653 White River C (15)	09/08-09/21	14	Any bull	Archery Permit (WA)
	6054 Mashel A (25)	01/01/09-01/15/09	15	Antlerless	Muzzleloader Bull (WM)
2007	454, 652	09/08-09/21	14	Any elk	Early Archery General (WA)
	654	09/08-09/21	14	Antlerless or 3 pt. min.	
	460, 466	09/08-09/21	14	3 pt. min	
	454	11/21 - 12/15	25	Any elk	Late Archery General (WA)
	454	10/06 - 10/12	7	Any elk	Early Muzzleloader General (WM)
	460	10/06 - 10/12	7	3 Pt. minimum	
	654	10/06 - 10/12	7	Antlerless or 3 pt. min	
	454	11/21 - 12/15	25	Any elk	Late Muzzleloader General (WM)
	454	11/03-11/12	10	Any bull	Modern Firearm General (WF)
	460, 466, 652, 654	11/03-11/12	10	3 Pt. minimum	
	485 Green River (3)	10/27-11/02	7	Any bull	Modern Firearm Bull (WF)
	653 White River A (40)	11/03-11/12	10	Any bull	Modern Firearm Bull (WF)
	653 White River B (3)	10/01-10/10	10	Any bull	Muzzleloader Bull (WM)
	653 White River C (11)	09/08-09/21	14	Any bull	Archery Bull (WA)
	6054 Mashel A (25)	01/01/08-01/15/08	15	Antlerless	Muzzleloader Bull (WM)
2006	454, 652	09/08 - 09/21	14	Any elk	Early Archery General (WA)
	654	09/08 - 09/21	14	Antlerless or 3 pt. min.	
	460, 466	09/08 - 09/21	14	3 Pt. minimum	

YEAR	GMU # & (Number of permits)	Dates	Days	Legal Animal	Hunt Description and Tag Type
	454	11/22 - 12/15	24	Any elk	Late Archery General (WA)
	454	10/07 -10/13	7	Any elk	Early Muzzleloader General (WM)
	460	10/07 -10/13	7	3 Pt. minimum	
	652	10/07 -10/13	7	Antlerless or 3 pt. min.	
	454	11/22 -12/15	24	Any elk	Late Muzzleloader General (WM)
	652	11/22 -12/08	17	Antlerless or 3 pt. min.	
	454	11/04- 11/13	10	Any bull	Modern Firearm General (WF)
	460, 466, 652, 654	11/04- 11/13	10	3 Pt. minimum	
	485 Green River (3)	10/28-11/03	7	Any bull	Modern Firearm Bull (WF)
	653 White River A (23)	11/04-11/12	9	Any bull	Modern Firearm Bull (WF)
	653 White River B (3)	10/01-10/10	10	Any bull	Muzzleloader Bull (WM)
	653 White River C (19)	09/08-09/21	14	Any bull	Archery Bull (WA)
	654 Mashel (1)	Included with permit		Any elk	Hunter Ed Instructor Incentive
	6054 Mashel A (25)	01/01/07-01/15/07	15	Antlerless	Muzzleloader Bull (WM)
2005	454, 652	09/08 - 09/21	14	Any elk	Early Archery General (WA)
	654	09/08 - 09/21	14	Antlerless or 3 pt. min.	
	460,466, 653	09/08 - 09/21	14	3 Pt. minimum	
	454	11/23 - 12/15	23	Any elk	Late Archery General (WA)
	454	10/01 - 10/07	7	Any elk	Early Muzzleloader General (WM)
	460, 654 except for PLWMA 401	10/01 - 10/07	7	3 Pt. minimum	
	652	10/01 - 10/07	7	Antlerless or 3 pt. min.	
	454	11/23 - 12/15	23	Any elk	Late Muzzleloader General (WM)
	652	11/23 - 12/08	16	Antlerless or 3 pt. min.	
	454	11/05 - 11/13	9	Any bull	Modern Firearm General (WF)
	460, 466, 652, 653, 654	11/05 - 11/13	9	3 Pt. minimum	
	485			Permit only	
	485 Green River (1)	10/29-11/04	7	Any bull	Modern Firearm Bull (WF)
	6054 Mashel A (25)	01/01/06-01/15/06	15	Antlerless	Archery (WA)
	654 Kapowsin Bull North (1) 654 Kapowsin BullCentral(4) 654 Kapowsin Bull South (4)	09/16 - 10/02	17	Any bull	PLWMA Auction/Raffle Hunt (Any Tag
2004	454, 652	09/08 - 09/21	14	Any elk	Early Archery General (WA)
	654	09/08 - 09/21	14	Antlerless or 3 pt. min.	
	460, 466, 653	09/08 - 09/21	14	3 Pt. minimum	
	454	11/24 - 12/15	22	Any elk	Late Archery General (WA)
	454	10/02 – 10/08	7	Any elk	Early Muzzleloader General (WM)
	460, 654 except for PLWMA 401	10/02 – 10/08	7	3 Pt. minimum	
	652	10/02 – 10/08	7	Antlerless or 3 pt. min.	
	454	11/24 - 12/15	22	Any elk	Late Muzzleloader General (WM)

YEAR	GMU # & (Number of permits)	Dates	Days	Legal Animal	Hunt Description and Tag Type
	652	11/24 - 12/08	15	Antlerless or 3 pt. min	
	454	11/06 - 11/14	9	Any bull	Modern Firearm General (WF)
	460, 466, 652, 653, 654	11/06 - 11/14	9	3 Pt. minimum	
	485 Green River (1)	10/30 – 11 /05	7	Any bull	Modern Firearm Bull (WF)
	6054 Mashel A (40)	01/01/04-01/15/04	15	Antlerless	Archery (WA)
	654 Kapowsin Bull North (1) 654 Kapowsin BullCentral(4) 654 Kapowsin Bull South (4)	09/17– 11 /03	17	Any bull	PLWMA Auction/Raffle Hunt (Any Tag
2003	454, 652	09/08 - 09/21	14	Any elk	Early Archery General (WA)
	654	09/08 - 09/21	14	Antlerless or 3 pt. min.	
	460, 466, 653	09/08 - 09/21	14	3 Pt. minimum	
	454	11/19 - 12/15	27	Any elk	Late Archery General (WA)
	454	10/04 - 10/10	7	Any elk	Early Muzzleloader General (WM)
	460, 654	10/04 - 10/10	7	3 Pt. minimum	
	652	10/04 - 10/10	7	Antlerless or 3 pt. min.	
	454	11/19 - 12/15	27	Any elk	Late Muzzleloader General (WM)
	652	11/19 - 12/08	20	Antlerless or 3 pt. min.	
	454	11/01 - 11/09	9	Any bull	Modern Firearm General (WF)
	460, 466, 652, 653, 654	11/01 - 11/09	9	3 Pt. minimum	
	6054 Mashel A (40)	01/01/04-01/15/04	15	Antlerless	Archery (WA)
2002	454	09/01 - 09/14	14	Any elk	Early Archery General (WA)
	652, 654	09/01 - 09/14	14	Antlerless or 3 pt. min.	
	460, 466, 653	09/01 - 09/14	14	3 Pt. minimum	
	454	11/20 - 12/15	26	Any elk	Late Archery General (WA)
	652	11/20 - 12/15	26	Antlerless or 3 pt. min.	
	454	10/05 - 10/11	7	Any elk	Early Muzzleloader General (WM)
	460, 652, 654	10/05 - 10/11	7	3 Pt. minimum	
	652 (where bounded by Hwys 167,410, & 164 not legal for antlerless)	10/05 - 10/11	7	Antlerless or 3 pt. min.	
	454	11/20 - 12/15	26	Any elk	Late Muzzleloader General (WM)
	652 (where bounded by Hwys 167,410, & 164 not legal for antlerless)	11/20 - 12/08	19	Antlerless or 3 pt. min.	
	454	11/02 - 11/10	9	Any bull	Modern Firearm General (WF)
	460, 466, 652, 653, 654	11/02 - 11/10	9	3 Pt. minimum	
	654 Mashel A - primarily private property (50)	12/15 – 12/23	9	Antlerless	Modern Firearm Damage Hunt (WF or WM)
	654 Mashel B - that part S of Puyallup Rv. (100)	1/12/03- 01/21/2003	10	Antlerless	Modern Firearm (WF) or WM)

YEAR	GMU # & (Number of permits)	Dates	Days	Legal Animal	Hunt Description and Tag Type
	654 Mashel B - that part S of Puyallup Rv. (40)	1/12/03- 01/21/2003	10	Antlerless	Archery Permit Hunt (WA)
	654 Kapowsin Bull North (2) 654 Kapowsin Bull Central(2) 654 Kapowsin Bull South (2) 654 Kapowsin All (2)	09/13– 29	17	Any bull	PLWMA Auction/Raffle Hunt (Any Tag

[a]Seasons from 1970-2001 may be found in WDFW 2002