Environmental Assessment
Fire Management Program

May 2005

NORTH CASCADES

National Park Service Complex • Washington

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By mail or hand delivery to: *Superintendent*
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Summary

North Cascades National Park Service Complex is revising its Fire Management Plan. The revised plan will replace the 1991 Wildland Fire Management Plan and the 1995 Stehekin Valley Forest Fuel Reduction/Firewood Management Plan. This Environmental Assessment (EA) accompanies the revised plan, as required by the National Environmental Policy Act. Proposed actions in this EA are supported by the 2001 Federal Wildland Fire Management Policy.

The purpose of this proposed federal action is to develop further a fire management program that restores and maintains ecosystem processes while minimizing the impact of fire to the public, firefighters, natural and cultural resources, and private property. This EA analyzes several alternatives that meet the objectives of the revised plan. Three final alternatives were developed using input from public and internal scoping meetings. Two additional alternatives were initially considered, but later rejected because they failed to meet the purpose and need of this EA. Below is a summary of the three alternatives that are analyzed in detail:

Alternative 1 – No Action (no change to current management)

- **Suppression Response Zone:** Fire suppression is required on 47,851 acres (7 percent of the Complex).
- **Wildland Fire Use Zone:** Wildland fire use is an option on 633,250 acres (93 percent of the Complex).
- **Project Work:**
  1) **Stehekin Forest Fuel Reduction Areas:** 822 acres of thinning and prescribed burning conducted on federal lands in the Stehekin valley bottom.

Alternative 2

- **Suppression Response Zone:** The Suppression Zone surrounding Stehekin is expanded. Fire suppression is required on 98,322 acres (14 percent of the Complex).
- **Wildland Fire Use Zone:** Wildland fire use is an option on the remaining 582,779 acres (86 percent of the Complex)
- **Project Work:**
  1) **Stehekin Forest Fuel Reduction Areas:** Project work is expanded to 1,209 acres of thinning and prescribed burning on federal lands in the Stehekin valley bottom.
  2) **Stehekin Road Corridor Thinning:** Thinning within a 150- to 200-foot buffer along the Stehekin Road will be conducted to provide reliable escape routes to designated safety zones.
  3) **Safety Zone Thinning:** Nineteen acres within the Orchard Safety Zone and 5 acres within the Ranch Safety Zone will be thinned and pile-burned to enhance safety zones.
  4) **Wyden Amendment Thinning/Burning:** A portion of the 440 acres of private land in Stehekin could be thinned and pile-burned or prescribe burned for hazard fuel reduction goals, at the landowner’s request.

Alternative 3 – Preferred Alternative (and the Environmentally Preferred Alternative)

- **Suppression Response Zone:** Fire suppression is required on 47,851 acres (7 percent of the Complex).
- **Wildland Fire Use Zone:** Wildland fire use is an option on 633,250 acres (93 percent of the Complex).

- **Project Work:**
    1) **Stehekin Forest Fuel Reduction Areas:** This project description is identical to Alternative 2.
    2) **Stehekin Road Corridor Thinning:** This project description is identical to Alternative 2.
    3) **Safety Zone Thinning:** This project description is identical to Alternative 2.
    4) **Wyden Amendment Thinning/Burning:** This project description is identical to Alternative 2.
    5) **Stehekin Contours:** Eleven burn units totaling 4,848 acres would be prescribe burned along the south-facing valley walls above Stehekin (4,255 acres are located in the Stephen Mather Wilderness).
    6) **Hozomeen Contours:** Two burn units totaling 5,219 acres would be prescribe burned above Hozomeen and Lightning Creek at the north end of Ross Lake (4,603 acres are located in the Stephen Mather Wilderness).
    7) **Re-ignition of Suppressed Fires:** Fires that were previously suppressed could be re-ignited anywhere within the Wildland Fire Use Zone (633,250 acres/72 percent of which is burnable), including within the Stephen Mather Wilderness.

The environmental consequences of implementing each alternative are analyzed in detail in Chapter 4. Primary issues identified during public and internal scoping sessions are addressed under different impact topics. The impact topics included in this analysis are air quality, water resources, topography and soils, fish and wildlife, vegetation and associated fire regimes, research natural areas, wilderness, cultural resources, visitor use, health and safety, and socioeconomics. Cumulative impacts to each topic are quantified when possible, and mitigation measures designed to minimize impacts to the resources are discussed.

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1 Introduction

North Cascades National Park Service Complex (hereafter, the Complex) is located in the heart of the greater North Cascades Ecosystem in northwestern Washington. The Complex is composed of three units that are managed as one: North Cascades National Park (505,000 acres), Ross Lake National Recreation Area (117,000 acres), and Lake Chelan National Recreation Area (62,000 acres) (Appendix A, Figure 1). Both the park and recreation areas were established in 1968 with variation in the enabling legislation (PL 90-544) of each unit type. North Cascades National Park was created "In order to preserve for the benefit, use, and inspiration of present and future generations certain majestic mountain scenery, snowfields, glaciers, alpine meadows, and other unique natural features…" With a greater emphasis on recreation, both recreation areas were created "In order to provide for the public outdoor recreation use and enjoyment… and for the conservation of the scenic, scientific, historic, and other values contributing to public enjoyment of such lands and waters…"

The mission of the North Cascades National Park Service Complex is as follows:

> As a unit of the National Park Service, the North Cascades National Park Service Complex is dedicated to conserving, unimpaired, the natural and cultural resources and values of North Cascades National Park, Ross Lake National Recreation Area and Lake Chelan National Recreation Area for the enjoyment, education, and inspiration of this and future generations. We also share responsibility for advancing a great variety of national and international programs designed to help extend the benefits of natural and cultural resource conservation and outdoor recreation (NPS 2000b).

Special land designations inside the Complex include Research Natural Areas and wilderness. Research Natural Areas were established in the early 1970s to provide examples of undisturbed ecosystems for scientific research. There are five designated and two proposed Research Natural Areas in the Complex. In 1988 over 93 percent (635,000 acres) of the Complex was designated as the Stephen Mather Wilderness (PL 100-668). The NPS is directed to manage the area to protect and perpetuate its wilderness resources and to provide a special wilderness experience "involving outstanding opportunities for solitude or a primitive and unconfined type of recreation."

Fire management in the Complex has evolved over the last century. Prior to 1968, the US Forest Service managed what is now the Complex under a fire policy of total suppression. This policy continued under NPS management until 1973, when the agency recognized that natural fire performed an important role in the ecosystem, and an important role in the preservation of wilderness values. Thus, some lightning ignitions were managed as natural fires between 1973 and 1988. Following the Yellowstone fires of 1988, the Complex returned to full suppression of all fires until the 1991 Wildland Fire Management Plan (hereafter, 1991 FMP) was approved. The 1991 FMP designated suppression and "prescribed natural fire" (now Wildland Fire Use) zones and called for "management ignited prescribed fire" (now prescribed fire). Fires that occurred within the suppression zone would be immediately suppressed, whereas fires that occurred within the prescribed natural fire zone would be allowed to burn if they met all of the requirements outlined in the Decision Criteria Checklist (See Appendix B). In recognition of the need to protect Stehekin from wildfire through prescribed fire, the 1995 Stehekin Forest Fuel Reduction/Firewood Management Plan (hereafter, 1995 Stehekin Plan) was developed.

The 1995 Stehekin Plan was designed to strengthen wildland fire protection and restore the fire-adapted forested ecosystem with the benefit of providing firewood for the Stehekin community. The valley's Douglas fir/ponderosa pine forest shows characteristic signs of being at risk of a stand replacing fire: a dense understory of Douglas fir pole and seedling trees overcrowding a weakening overstory that is succumbing to insects and disease. These conditions are common in forests of this type throughout the area. Historic levels of ponderosa pine have decreased as fire suppression and selective harvesting allowed the more shade tolerant Douglas fir to shade the more fire dependent pine out (Ohlson and Schellhaas 1999).

Both the 1991 FMP and the 1995 Stehekin Plan require revision because it is recognized that Stehekin requires greater protection, that areas with altered ecosystems need restoration, and that areas with unaltered ecosystems need to be maintained. One area of concern is the region that stretches from the US/Canada border near Hozomeen south to Lightning Creek along the Ross Lake Corridor. The proposed plan addresses the protection of Hozomeen and Stehekin as wildland/urban interface communities, along with promoting wildland fire use throughout the majority of the Complex.

1.1 Fire History and Rationale for Proposed Actions

Fire has played a key role in forested landscapes and vegetation in the Pacific Northwest since the end of the last major glaciation 12,000 years ago. An analysis of temporal patterns of areas burned over the past 600 years throughout the Cascade Range shows a synchronous nature of fire in the Pacific Northwest: widespread fires occurring from 1400 to 1650, reduced burning from 1650 to 1800, widespread fires again from 1801 to 1925, potentially related to European settlement, and finally fire suppression beginning to show its influence by 1950, when the number of acres burned drops again (Weisberg and Swanson 2003). This study, which includes the fire history of Desolation Peak within the Complex (Agee et al. 1986), attributes the synchronous response to these fluctuations in the fire regime to interactions between anthropogenic change, climate, and stand/fuel development. It is suspected that all of these factors have played a role in the fire regimes of dry Douglas fir/ponderosa pine forests on the eastside of the Complex, whereas climate alone may have been the primary driver of fire regime dynamics in the subalpine, alpine, and low elevation westside forests throughout the Complex.

Although the fire history of the Complex is not complete, substantial fire research projects have occurred in the Ross Lake area (Agee et al. 1986, Larson 1972) and Stehekin Valley (Oliver and Larson 1981), the two areas where active fire management projects are proposed (prescribed burning in wilderness) or underway (prescribed burning and thinning in non-wilderness), and in the Thunder Creek Basin (Prichard 2003, Miller and Miller 1973), a subalpine site representative of the majority of areas within the proposed Wildland Fire Use Zone. The knowledge gained from these studies is supplemented by recent fire activity in the Complex, small localized surveys and monitoring activities, expert opinion, and interpretation of studies in similar forest types in other locations.

1.1.1 Ross Lake

Tree ring analysis and historical records of the Desolation Peak area were used to calculate a natural fire rotation of 100 years across all forested zones (low elevation to subalpine) for the 1573 – 1985 time period, indicating that over the course of 100 years an area the size of Desolation Peak would have burned (Agee *et al.* 1986). In this study 26 fires were discernable between 1573 and 1945. It was also suggested that smaller, less severe fires probably occurred more frequently than they appeared early in the record, as is a common downfall of fire histories based upon tree-ring records (Agee 1993).

At least one of these fires was also documented in Larson's study of lodgepole pine across what is now Ross Dam, in the Big Beaver Drainage. This fire occurred in 1926, and burned over 40,000 acres after it was initiated by a lightning strike on the north slope of the Tenmile Shelter, burned out to the mouth of Big Beaver, and then swept north up the Skagit Valley. Larson's study also documents a major fire that was reported in the upper Skagit River Valley (Ross lake area) in 1859 (Thompson 1970).

It is not clear how many of the fires documented in the two studies above were human caused. Evidence of anthropogenic burning has not been definitive, although indigenous tribes are known to have inhabited areas in the North Cascades for the past 8,400 years (Mierendorf 1993), and it is suspected that they may have utilized prescribed burning. Henry Custer, one of the earliest white explorers of the Complex, described the "whole forest burned by late fires, ignited by persons recently encamped here", in his report to the US Northwest Boundary Commission regarding his 1857 travels along the Skagit as a topographer. He further stated that "fires are very frequent during the summer season in these Mountain forests, and are often ignited purposely by some of the Indians hunting in these Mountain regions, to clear the woods from under brush and make travel easier."

One of the important findings in the fire history study of the Desolation Peak area pertains to the forest above Lightning Creek, which contains a unique combination of species that is not typically found west of the Cascade Crest (Agee *et al.* 1986). The natural fire rotations for these communities, Douglas fir with ponderosa pine, and Douglas fir with lodgepole pine, were calculated as 52 years and 76 years respectively. Evidently, the forest above Lightning Creek experienced a more frequent fire return interval that is more typical of dry Douglas fir forests on the eastside of the Cascades. Although it is not certain whether this fire rotation was partially due to anthropogenic burning, it is evident that returning low severity fire to this area is required to maintain the unique landscape diversity of this fire-dependent community (Agee personal communication).

1.1.2 Stehekin Valley

Martin Gorman described a similar scenario east of the Cascade Pass in his survey of Lake Chelan and the Stehekin Valley in 1897 for the United States Geological Survey's Nineteenth Annual Report to the Secretary of the Interior:

> "*Of the whole region traversed by our party during the season, a few small spots about the passes and a small tract on Bridge Creek were the only sections that showed no evidence of ever having been visited by fire. Even the moist valleys of Stehekin River, Early Winters Creek, and Railroad Creek gave ample proof of having been burned over seriously more than once.*
>
> *According to the testimony of settlers, some forest fires occur here every summer; for instance, during the present season, in addition to three simultaneous fires in the vicinity of Lake Chelan, there was also one on the Entiatqua divide and two in the Methow Valley. They further allege, apparently on good evidence, that this region had been burned over long before the coming of the first white settlers. This is well borne out by the scarred bases of the mature trees in the yellow pine belt, nearly all of which show traces of more than one forest fire."*

It is assumed that fire suppression and other human activities (e.g., selective harvesting) influence fire regimes in the Stehekin Valley (Hessburg and Agee 2003). Research and analysis of 200 to 400 year long tree-ring records to derive historic forest structure and composition in dry Douglas fir/ponderosa pine forests on the east side of the Cascades confirm that forests of this type have been significantly altered by settler activities, fire suppression, and climate change (Everett *et al.* 2000, Wright and Agee 2004, and Hessl *et al.* 2004). Although stand reconstructions and research of this depth has not been performed in Stehekin to date, similar low elevation Douglas fir/ponderosa pine dominated stands occurring there have been the focus of fire management activities since the mid 1990's when concern over public safety in fire-prone forests led to approval of the 1995 Stehekin Plan.

Stand examinations performed for the development of target conditions for the 1995 Stehekin Plan document the present day stand structure, including "unnatural fuels buildup," insects, and disease (Oliver and Larson 1981, USDI 1995). Oliver and Larson's survey describes the regular occurrence of several small fires throughout the 19th and 20th centuries, and estimates that large stand-replacing fires occur approximately every 90 to 100 years, indicating that the valley is currently overdue for another stand-replacing event.

A stand examination in the Rainbow Creek Drainage within the proposed Stehekin Contours prescribed burn area found similar forest conditions along the valley walls to what Oliver and Larson found in the valley bottom (Harper 2004). The tree distribution consists of a full cohort of young, smaller diameter trees, with fewer widely spaced older legacy trees, a pattern referred to as a "reverse J-shaped diameter distribution" that is commonly found in moderate severity fire regimes (Agee 1990).

In moderate (or mixed) severity fire regimes of the eastside Douglas fir forests, stand replacing events occur infrequently (approximately every 100 years), whereas low severity fires occur within a range of 6 to 38 years (Ohlson and Schellhaus 1999). When these fire regimes are not significantly altered, fires tend to burn in a mosaic of low, medium and high severity patches (Camp *et al.* 1997). More recent fire events in this area, such as the 1994 Boulder Creek Fire, tend to be more of a homogenous high severity, indicating that the regime is altered.

An informal fire history project is underway to determine the average interval between fire events in the Stehekin area before the fire suppression era by counting fire scars on tree cores and on wedges of dead and downed ponderosa pine trees. In the Flick Creek Drainage several ponderosa pines were found to have multiple fire scars, although only one sample was found to show a definitive record of fires in the pre-suppression era. This tree has five distinct fire scars that occur at age 31, 40, 52, 76 and 99 on a 178 year old tree which had recently died. This single point sample yields a 17-year average fire return interval, with intervals ranging from 9 to 24 years. Although a single point sample does not provide sufficient evidence for determining the average fire return interval for the Stehekin area, this preliminary finding does show that frequent fire is within the range of historic variability in at least one Stehekin drainage.

1.1.3 Thunder Creek Basin and other Subalpine Forests

Although fire histories based upon tree-ring records may be most appropriate in dry Douglas fir-dominated forests with frequent low severity fires, they cannot capture the true mean fire return interval in subalpine and alpine forests that experience stand replacing fires and have long fire free intervals (Whitlock *et al.* 2003). Rather, long-term fire histories, such as those based upon lake sediment charcoal, macrofossils and/or pollen records are required to capture the true range of variability (Prichard 2003).

The first fire history research of this type in the Complex was recently completed in a subalpine forest in the Thunder Creek Watershed (Prichard 2003). This important study reconstructs fire events and vegetation for 10,500 years, documenting fire frequency fluctuations between 30 to 400 years throughout this time period. This finding reflects the extreme heterogeneity in fire size and frequency, and encourages managers to reconsider decisions based on estimates of historical range of variability in an environment in which current fire effects may be unprecedented. In subalpine forests, the recent warming trend may beckon the onset of fire regimes outside of the current realm of understanding.

Recognizing that fire ecology dynamics in westside and subalpine forests of the North Cascades reflect complex interactions that are still relatively unknown, and probably cannot be replicated through human means, the approach to managing fire in approximately 90 percent of the Complex (633,000 acres) is through wildland fire use. This is the most ecologically sensible approach to managing natural areas in forests that historically had stand-replacement fires and long fire return intervals (subalpine fir, western hemlock and Pacific silver fir forests), whereas it is not recommended for areas with altered fire regimes (Hessburg and Agee 2003). In order to allow wildland fire use to occur in areas that are adjacent to communities at risk, or that occur within a matrix of continuous fuels near altered ecosystems, prescribed burning and fuels treatments could be undertaken to create effective fuel breaks and to reduce fuel loads.

1.1.4 Modern Fire History

Ignition point and fire perimeter records were kept by the Mount Baker and Chelan Forest Service districts well before the units of the North Cascades National Park Service Complex were established in 1968. An effort to create a detailed fire atlas from these records is in progress as the Ignition Points map (Appendix A, Figure 2) and Fire Perimeters map (Appendix A, Figure 3) illustrate. Figure 2 currently shows fire ignition points from 1973 through 2004. Figure 3 shows fire perimeters dating back to the early 1900s, but this is not a complete fire history coverage (fire perimeters are missing from 1960 through 1989, and some perimeters are circles instead of the true shape of the fire). Completion of the fire history map dating back to the conception of the Complex in 1968 has been identified as a research need in the Fire Management Plan. Until this project is completed the fire records are only reliable as ignition points from 1973 and forward.

The past 31 years of ignition data for the Complex are in Table 1. Every ignition, strategy and outcome was recorded in the Shared Applications Computer System (SACS). These records are used to assess program management needs, budget, qualifications of individuals, risk to cultural and natural resources, and to provide a tool that local managers can use to base sound fire management decisions. They are categorized by management strategy and annual acres burned as a result of each strategy. The management strategies include “Fires Suppressed” in which active suppression was utilized, “Wildland Fire Use” which was previously referred to as “prescribed natural fire”, and “Other” which includes fires that went out on their own or were confined and contained without active suppression.

Table 1. Recent Fire History 1973 – 2003, by Management Strategy

Year	Fires Suppressed			Wildland Fire Use			Other*	
	# fires	acres		# fires	acres		# fires	acres
1973	5	3.0		1	0.1		0	0.0
1974	4	1.3		2	2.0		0	0.0
1975	5	0.5		1	0.1		0	0.0
1976	2	0.2		0	0.0		0	0.0
1977	10	185.9		0	0.0		0	0.0
1978	22	1,854.5		25	56.0		0	0.0
1979	14	3.2		1	0.1		0	0.0
1980	12	7.0		2	20.1		0	0.0
1981	12	6.0		2	0.2		0	0.0
1982	2	0.2		1	1.0		0	0.0
1983	7	1.6		11	27.0		0	0.0
1984	3	2.1		2	132.0		0	0.0
1985	6	0.6		2	1.6		0	0.0
1986	5	6.1		6	0.6		0	0.0
1987	6	0.7		2	0.2		0	0.0
1988	6	4.0		0	0.0		1	0.4
1989	10	2.2		0	0.0		5	0.5
1990	21	27.5		0	0.0		17	289.4
1991	11	2.9		1	0.2		1	0.1
1992	12	1.7		1	0.1		8	12.7
1993	0	0.0		0	0.0		0	0.0
1994	19	4,118.4		0	0.0		4	0.5
1995	1	0.2		1	0.3		0	0.0
1996	3	0.4		0	0.0		0	0.0
1997	7	5.7		2	37.0		4	320.5
1998	4	4.7		0	0.0		2	0.2
1999	12	17.6		1	175.0		2	0.8
2000	4	4.1		0	0.0		0	0.0
2001	3	1.1		2	1.1		3	823.1
2002	10	2.2		1	60.0		0	0.0
2003	15	7.0		9	3,542.8		1	0.1
sum	253	6,272.6		76	4,057.5		48	1,448.3
average	8.2	202.3		2.5	130.9		1.6	46.7

*Includes fires that went out on their own or were confined and contained without active suppression

The recent history of the Complex reveals that there are an average of 12.3 fires per year (8.2 suppressed, 2.5 managed for wildland fire use, and 1.6 with little if any suppression required). Three hundred and seventy-seven fires have been recorded since 1973, burning almost 12,000 acres. Three suppression fires burned 1,000 acres or more during this period (Little Beaver in 1978, and Butte Creek and Little Boulder in 1994). The large number of acres burned in these fires can be attributed to drought conditions in combination with resource shortages and the difficulty of suppressing fires in steep and dangerous terrain. Although wildland fire use has always been an option during this time period, only two wildland fire use fires have burned over 1,000 acres, and these fires both occurred in 2003 (Big Beaver and No Name).

The fire records from 1973 – present also document the cause of the fires that have occurred. Table 2 reveals that 70 percent of the ignitions in the Complex are due to lightning strikes rather than human causes. There are an average of 8.5 natural ignitions and 376.5 acres burned as a result per year.

Table 2. Recent Fire History 1973 – 2003, by Cause

Cause	Human			Lightning	
Year	# fires	acres		# fires	acres
1973	5	2.6		1	0.5
1974	4	1.3		2	2.0
1975	0	0.0		6	0.6
1976	1	0.1		1	0.1
1977	5	0.6		5	185.3
1978	5	5.4		42	1,905.1
1979	1	0.1		14	3.2
1980	11	6.9		3	20.2
1981	4	5.2		10	1.0
1982	3	1.2		0	0.0
1983	5	1.4		13	27.2
1984	2	1.1		3	133.0
1985	6	0.6		2	1.6
1986	5	5.9		6	0.8
1987	6	0.7		2	0.2
1988	6	3.3		1	1.1
1989	3	0.3		12	2.4
1990	1	0.1		37	316.8
1991	7	0.7		6	2.5
1992	3	0.3		18	14.2
1993	0	0.0		0	0.0
1994	5	0.5		18	4,118.4
1995	1	0.2		1	0.3
1996	3	0.4		0	0.0
1997	2	0.2		11	362.9
1998	4	4.7		2	0.2
1999	3	0.3		12	193.1
2000	0	0.0		4	4.1
2001	3	1.1		5	824.2
2002	5	60.4		6	1.8
2003	4	0.6		21	3,549.3
sum	113	106.2		264	11,672.0
average	3.7	3.4		8.5	376.5

1.1.5 Fire Density Assessment

The ignition point density map (Appendix A, Figure 4) displays “hot spots” where the most fires have occurred per square mile from 1973 to 2004. When ignitions from all causes are considered there are several areas that appear to have a higher frequency than others. The most actively managed area is south of Hozomeen on the ridge dominated by Little Jackass Mountain, and extending south towards Desolation Lookout. Stehekin is another area that exhibits a high fire occurrence. These high fire occurrence areas are caused primarily by lightning (see above). Human caused fires do occur, and normally are significant due to their location on the lower portions of the slopes during hot and dry weather. They do not occur very frequently, and therefore are insignificant in number compared to the lightning fire occurrence.

1.2 Purpose and Need for Action

The purpose of this proposed federal action is to develop further a fire management program that restores and maintains ecosystem processes, while minimizing the negative impacts of fire to the public, firefighters, natural and cultural resources, and private property. The current guiding document for fire management decisions in the Complex is the Wildland Fire Management Plan, which was revised and updated in 1991 from the original 1981 Fire Management Plan. In 1995 the Stehekin Forest Fuel Reduction/Firewood Management Plan was developed to further protect structures in Stehekin from wildfire while attempting to restore the fire-adapted forested ecosystem. The revised plan builds off of the 1991 FMP and the 1995 Stehekin Plan.

This action addresses three primary needs:

- the protection of lives, health, and property in the Complex;
- the restoration of fire-dependent ecosystem processes in areas that are outside their historical range of variability; and
- the maintenance of natural fire processes in areas that are not yet outside their historical range of variability

Protection of lives, health and property. The following forest characteristics have been found to significantly increase potential for high severity fires: 1) ladder fuels, which are dead branches, shrubs and seedlings that provide continuity between surface fuels (dead and downed wood, litter and duff) and tree crowns; 2) dense and continuous canopy cover of trees that allows fire to spread from crown to crown; and 3) heavy and continuous fine surface fuel loading (small diameter dead and downed wood, litter, and duff), which increases fire intensity and facilitates fire spread on the surface (Graham *et al.* 2004). These forest conditions are considered to be *hazardous fuels* in the wildland urban interface where potential fire behavior puts lives, health and property at risk. Fuels treatments (thinning and prescribed burning) aimed at reducing hazard fuels are currently performed in the Forest Fuel Reduction Areas (FFRAs) that were designated in the 1995 Stehekin Plan. Additional thinning around structures and along roadsides is also performed in the Stehekin Valley in order to create defensible space.

Monitoring of the thinning and prescribed fire treatments in Stehekin demonstrates that the 1995 plan’s objectives are being met on the 780 acres of dry Douglas fir/ponderosa pine forest where treatments have occurred to date (Kopper and Drake 2002). In 2000, results from the peer review of the 1995 Stehekin Plan included recommending that additional measures are needed to provide greater community protection in areas at risk; for example, larger acreages of fire adapted conifer stands along the valley walls (Stehekin Contours) could be prescribe burned (See Appendix C).

Restoration of fire-dependent ecosystem processes. The historical range of variability is the natural range of conditions occurring in key ecosystem components (species composition, structural stage, stand age, canopy closure, and fuel loadings) in an ecosystem unaffected by human influence. The identification of the historical range is dependent on the fire regime (e.g., low severity fire regimes are shorter and their imprint on the landscape is only perceptible for centuries rather than millennia, whereas high severity fire regimes are longer and occur at the millennial time scale). All of these components show signs of alteration in the Douglas fir/ponderosa pine forests of Stehekin (see Section 3.5.3). Prescribed burning and thinning in non-wilderness areas (Stehekin FFRAs), or prescribed burning only in wilderness (Stehekin Contours) could be used to restore stand structure and composition. Thinning, where it is applied, can efficiently reduce stand density to a desired future condition within the historical range of variability which also meets hazard fuel reduction goals; however, it does not replace the need for prescribed burning to reduce surface fuels, and stimulate regeneration of fire-adapted plant species.

Maintenance of natural fire processes. Managing for wildland fire use in areas that are still within their natural range of variability will help to maintain fire as a natural process in those ecosystems. It is important to note that wildland fire use is not beneficial to areas in which fuel loads have increased beyond their historical range, causing un-naturally severe fire behavior during wildland fire (Graham *et al.* 2004). These areas are targeted for prescribed burning so that wildland fire use can be considered as a management alternative in the future. Additionally, prescribed burning is needed to reduce fuel loads in areas that may be within their historical range of variability, but that are adjacent to resources at risk (Hozomeen, Stehekin). Until these areas have been treated, wildland fire use cannot be safely implemented.

1.3 Goals and Objectives of Fire Management and Planning

This EA analyzes alternatives for how the Complex's fire management program will meet outlined goals and objectives as stated through the National Fire Plan, the National Wildland and Prescribed Fire Management Policy, recommendations resulting from peer review of fuel reduction treatments, and comments from internal and public scoping. The goals of the fire management plan are grounded in the goals of other management plans in the Complex, including the General Management Plan (NPS 1988), the Wilderness Management Plan (NPS 1989), the Lake Chelan General Management Plan (NPS 1995) and the Resource Management Plan (NPS 1999a). More quantitative objectives for all prescribed burning and/or thinning treatments are developed in separate burn plans for each project. The goals, objectives, and strategies of the revised fire management plan are listed below. Each goal has specific objectives developed to meet the intent of the goal, and the strategies that will be used to meet the objectives are listed.

Goal 1: Ensure firefighter and public safety
Protection of both firefighters and the public is the first priority in the Complex's fire management program and in every fire management activity.

Management Objectives:

- Ensure all wildland fire operations, including prescribed fire and community protection fuel break projects, sustain no preventable injuries to anyone
- Contain all unwanted fires, occurring in the suppression zones and adjacent to communities, at less than 10 acres in size

Management Strategies:

- Plan and carry out all activities consistent with and subordinate to safety considerations by complying with OSHA regulations, NPS, and interagency safety policies.
- Maintain a high level of readiness per interagency "red book" standards for fire suppression equipment and personnel to enable an adequate suppression response to unwanted fires.

- Provide the fire management workforce with the training, equipment, operating procedures, safety measures, and information needed to manage risks and carry out their activities safely
- Inform and protect visitors and communities by providing information on fire locations, associated activities, and implementing closures or evacuations as needed
- Implement hazard fuel reduction treatments within the wildland urban interface with prescriptions that minimize impacts to ecological integrity
- Manage wildland and prescribed fires using the most current planning and risk assessment techniques available:
    - Assess the risk of using fire to achieve management objectives using the risk assessment process located in the Wildland and Prescribed Fire Policy Implementation Guide and RM 18, Chapter 10
    - Establish a Wildland Fire Use Zone where wildland fire could be utilized to accomplish resource management goals without compromising firefighter and public safety or threatening property
    - Establish a Suppression Zone where wildland fire use would have a high potential to compromise public safety or private property
    - Utilize prescribed fire to protect communities and to reduce the need for suppression response to naturally ignited fire in Wildland Fire Use Zones near these communities (Stehekin and Hozomeen)
    - Impacts to air quality will be considered during the go/no-go decision making process for both appropriate management response to wildfires and during prescribed fire implementation
    - Smoke mitigation measures will be developed and implemented for all fire use actions

Goal 2: Allow the natural process of fire to prevail in the Complex
It is recognized that natural interactions between fire and the environment influence the vegetation structure and biodiversity within the Complex. The role of fire should be maintained through wildland fire use in order to prevent the eventual impacts of fire exclusion to the ecosystems of the Complex. Furthermore, in areas showing adverse effects from fire suppression, restoration of forest structure and reduction of fuel loads will allow natural processes to resume and reduce the risk of unwanted, high-intensity wildland fires that might cause undesirable changes in forest type and threaten human lives or property.

Management Objective:
Manage 75 % of all natural ignitions in the Wildland Fire Use zones for the benefit of the resource where it can be done safely, and increase the use of natural ignitions adjacent to communities, where possible, following the completion of prescribed fire treatments.

Management Strategies:
- Manage ecosystems to preserve the natural range of variability in processes and structure
- Minimize adverse impacts to threatened, endangered, and sensitive species and their habitat
- Set strategies for fire management activities based on site-specific information or local research findings on departure from natural fire return intervals and fire regime characteristics

- Minimize the impacts of all fire management activities throughout the Complex by using minimum impact techniques (MIT, as outlined in Appendix H), and use the minimum requirement concept for actions in designated wilderness
- Develop a prescribed fire and thinning treatment sequence schedule and stay committed to annual targets

Goal 3: Use the adaptive management process to guide future management actions
The adaptive management process incorporates scientific knowledge, monitoring and evaluation of results to provide a mechanism for feedback. The Complex will continue to use a 5-year peer, academic and public review process. This review includes the presentation of program goals and objectives, monitoring results, and photos and/or site visits, with opportunities for all participants to provide feedback on all elements of the plan. This feedback could be used to recommend future revisions to the fire management plan. A major revision of the plan would require additional environmental analysis.

Management Objective:
Annually review the fire management plan in order to update and revise implementation efforts based on ground results; community, staff, and academic feedback; and updated science specific to the Complex.

Management Strategies:
- Encourage research to improve understanding of natural fire regimes in order to more effectively implement the fire management program and refine fire prescriptions.
- Monitor and evaluate fire management activities to assess their effects on natural and cultural resources
- Update thinning and prescribed fire prescriptions and treatment priorities as data and feedback suggest

Goal 4: Educate, inform, consult, and collaborate with local communities; county, state, federal and Canadian stakeholders
Education and collaboration of fire management activities in fire dependent ecosystems are key to a successful fire management program because fire can span many jurisdictions.

Management Objective:
By 2007, all visitor centers and significant points of public contact will display ecological information about the ecological role of fire in North Cascades ecosystems, and how the goals, objectives, and strategies of the fire management plan meet the needs for the Complex's resources.

Management Strategies:
- Conduct wildfire prevention education and provide fire information to communities within or nearby the Complex
- Collaborate with local communities, county, state, federal, and international agencies with fire management interests
- Develop interpretive displays, educational programs, and publications with Complex staff to foster understanding and acceptance of the fire management program

1.4 Scoping Issues

Public scoping for the revision of the current Fire Management Plan took place from October 9 to November 17, 2003. A scoping letter was sent to agencies, tribes and interested organizations and individuals. The scoping letter encouraged the involvement of the public in identifying issues and concerns related to fire management in the Complex. The Fire Management Plan revision and proposed actions have also been discussed in Stehekin community meetings since 2001. These community meetings are informal and occur several times a year to discuss management issues of particular interest to Stehekin residents and property owners. Eleven comment letters (including email) were received from the public. Internal scoping meetings with park staff have been held to provide a forum for comment during this same period. Comments from all sources have been used to identify key issues, which were then used to determine the scope of analysis in this EA. Key issues are summarized below.

1.4.1 Air Quality and Visibility

Smoke from wildland and prescribed fires can impact public health and welfare. Individuals living in communities in close proximity to the Complex (including Stehekin, Diablo, Newhalem, Marblemount, Hozomeen; and Hope, Princeton, and Manning Park Lodge in British Columbia) could be impacted through the respiration of particulate matter from smoke. Smoke may impact visibility and aesthetics by reducing long range visibility and scenic vistas.

1.4.2 Unnatural Fuel Loadings

Areas within the Complex in which fire has been excluded in low severity fire regimes (Douglas fir/ponderosa pine forests) can have unnaturally heavy surface fuel loads (dead and downed branches, litter and duff) and dense standing live and dead fuel loads (trees and vegetation). This condition can put these ecosystems, humans and infrastructure at risk from the effects of severe wildfires that are uncharacteristic of this fire regime. This condition exists in the Stehekin Valley.

1.4.3 Fire Management Activities in Wilderness

Fire management activities associated with wildland fire and project work, located in designated wilderness, can include intrusive measures such as helicopter use, tree cutting, fire line construction, fire retardant use, etc., that may interfere with a suite of wilderness characteristics and values. Under both fire suppression and wildland fire use, helicopter activities are the most disruptive interference to values mandated by the Wilderness Act and the Complex's Wilderness Management Plan (WMP). The WMP restricts flights to before July 4th and after Labor Day. While emergency fire activities are exempt from this, along with other emergencies such as search and rescue, there is opportunity to reduce the flight hours during this period through an assessment of critical aircraft needs during fire incidents. Other non-emergency fire activities, including proposed project work, could be accomplished within similar restraints of regular aviation project work at the Complex. The proposed projects in wilderness also have the potential to be disruptive to wilderness values by impacting the quality of "wildness," or the perception that wilderness is unhindered and free from intentional modern human control or manipulation.

1.4.4 Rare, Threatened, and Endangered Species

Fire management activities have the potential to impact both listed plant and animal species (state, federal, and species of special management concern within the Complex). These impacts can range from short-term to long-term and negative to positive.

1.4.5 Fire-Adapted Species

The Complex contains various species that are adapted to fire. These adaptations can include germination and/or rapid growth and development following fire, fire resistant foliage or bark, and serotinous cones. These species thrive from wildland fire and may be out-competed by other species through fire exclusion. Fire-adapted species in the Complex include trees such as ponderosa pine and lodgepole pine, shrubs such as snow brush and bear berry, and grasses such as Thurber's needlegrass and Great Basin wildrye.

1.4.6 Invasive Plant Species

Certain routine fire management activities may contribute to the establishment and spread of invasive, non-native plants. Actions that contribute to the disturbance of an area, including line construction (both mechanically and with hand tools), clearing of land for helispots and spike camps, and even routine thinning may contribute to the presence of invasive species. While disturbance resulting from fire or fire management activities may by itself result in available habitat for pioneering invasive species, the primary threat of these activities is due to the vectors introduced into otherwise pristine areas. Equipment (hand tools, trucks, pumps, tracked equipment, tents, etc.) and personal line gear (line packs, nomex, and boots) worn by firefighters may carry seeds and plant parts readily from site to site. Contracted equipment, especially equipment (e.g., helicopters) brought from areas of similar climate with known problematic species, can also hasten the spread of invasives from site to site and into otherwise pristine areas.

1.4.7 Wetlands and Water Resources

Fire and/or fire management activities could have various impacts on wetlands and other water resources within the Complex, including the trampling of sensitive wetland vegetation, disturbance from fire line construction, alteration of the hydrologic regime, and burning of riparian vegetation during very dry summers. The use of certain lakes (especially shallower lakes) as water sources for bucket drops during fire suppression could also impact adjacent wetlands and associated biota by reducing water clarity and dissolved oxygen levels, which can impact plankton and invertebrate communities if water levels drop. Other impacts to water resources include disturbance of riparian zones, runoff and sedimentation, and changes in water quality and temperature.

1.4.8 Research Natural Areas

Five Research Natural Areas (RNAs) within the Complex are set aside permanently and managed exclusively for approved non-manipulative research. Natural disturbances are allowed to prevail in these areas; however, certain fire management activities (especially direct suppression) could impede these processes and consequently compromise the ecologic and scientific values of the RNA. Four of the five RNAs lie within Wildland Fire Use Zones, and would not likely experience impacts from suppression. However, a portion of the Silver Lake RNA lies within the Suppression Response Zone near the US/Canada border, and could experience localized, major adverse impacts from direct fire suppression activities, unless a confinement strategy is utilized.

1.4.9 Cultural Resources

Prehistoric, historic, and ethnographic resources within the Complex could all be impacted by fire management activities, which could result in trampling and/or compaction of cultural resource sites, burning of historic structures, soil erosion, or changing of the cultural landscape.

1.4.10 Protection of Wildland-Urban Interface Communities

The communities of Diablo, Hozomeen, and Stehekin are listed in the Federal Register as "Urban Wildland [sic] Interface Communities within the Vicinity of Federal Lands That Are at High Risk from Wildfire (66 FR 43383)." Wildland-urban interface communities exist where humans and their development meet or intermix with wildland fuel. According to a recent peer review in Stehekin, the fuel treatments that are currently underway are not sufficient to protect the wildland-urban interface. Both Stehekin and Hozomeen are considered *at-risk* because of the potential for a severe wildfire to occur nearby, which, paired with limited means of escape, could threaten the safety and property of community residents and visitors. Defensible space treatments to remove hazard fuels can help to protect structures from fire by removing flammable brush and other vegetation surrounding them, but larger fuel breaks may be required to control large fires that could move into either community.

1.4.11 Fire Suppression Activities

Suppression activities such as the use of retardants and foams; fire line construction, helispot clearing, spike camp locations; and aircraft use can negatively impact Complex resources and visitor experiences. For example, chemicals used to suppress fires can have major impacts on water quality, fish, and wildlife, especially aquatic organisms. Fire line construction, helispot clearing, and spike camps can damage sensitive vegetation and hasten erosion on slopes. Aircraft use can disturb private landholders, visitor experiences, and wildlife.

1.4.12 Park Operations

Fire can impact operations within the Complex in both developed and undeveloped areas when closures are required. These closures could include trails, campsites, visitor facilities, roads and highways, all of which can impact visitor use and experience.

1.5 Scoping Issues Considered but not Further Addressed

One issue was raised that will not be subjected to further analysis because it involves the concern of livestock grazing, which does not occur within Complex boundaries. The issue is:

"Depict where livestock grazing occurs and establish a protocol that will help reduce or eliminate the spread of noxious weeds via this vector in burned areas."

1.6 Compliance and Authority for Action

The Complex complies with NPS policies, director's orders, and plans, as well as federal laws, policies, and plans related to fire management. Compliance with the National Environmental Policy Act (NEPA) is satisfied by this environmental assessment. NEPA requires all federal agencies to study the impacts of proposed actions on the environment of federal lands, to analyze alternatives to the actions, and to inform and seek input from the public on the actions. Environmental consequences of the proposed action and alternatives to the proposed action are analyzed in detail to provide managers and the public adequate information in order to provide input and to make informed decisions. The Complex's enabling legislation, mission statement, and other related laws, policies and plans provide guidance for the development and implementation of a sound fire management program.

Federal Policies and Plans

The 1995 Federal Wildland Fire Management Policy (reviewed and updated in 2001, also called Federal Fire Policy) serves as the basis for managing wildland fires on public lands. It was the first comprehensive fire policy developed for federal land management agencies, ensuring that policies are uniform and programs are cohesive across agency boundaries. It calls for the development of a fire management plan for all areas subject to wildland fire. Federal Fire Policy supports and complements the National Fire Plan, which provides guidance for operational and implementation activities. Revision of the Complex's fire management plan is required in order to comply with the 2001 Federal Fire Policy, which contains the following guiding principles:

1. Fire fighter and public safety is the first priority in every fire management activity.
2. Wildland fire is an essential ecological process that when managed properly creates favorable change in ecosystems.
3. Fire management plans, programs and activities support land and resource management plans.
4. Sound risk management is a foundation for all fire management activities.
5. Fire management programs and activities are economically viable, based on values to be protected, costs, and land and resource management objectives.
6. Fire related plans and activities should be based on the best available science.
7. Fire management plans and activities incorporate public health and environmental quality considerations.
8. Federal, state, tribal, and interagency coordination and cooperation are essential.
9. Standardization of policies and procedures with other agencies is an ongoing objective.

The Department of the Interior Departmental Manual directs bureaus to give priority to wildland fires and declares them emergencies: “Wildland fires, whether on or adjacent to lands administered by the Department, which threaten life, improvements, or are determined to be a threat to natural and cultural resources or improvements under the Department's jurisdiction, will be considered emergencies and their suppression given priority over other Departmental programs (620 DM 1.6B).”

NPS Fire Management Program

In addition to broad federal policies and plans, the Complex follows guidance specific to the National Park Service (NPS). The NPS Wildland Fire Management Strategic Plan, 2003-2008, reflects the mission of the NPS Fire Management Program. The mission is as follows: “The National Park Service Fire Management Program is dedicated to protecting lives, property and resources while restoring and maintaining healthy ecosystems.” The strategic plan outlines seven NPS wildland fire management mission goals:

- Natural and cultural resources and their associated values are protected, restored, and maintained in good condition, managed within their broader ecosystem and cultural context. Management actions will not compromise safety for employees and the public.
- Fire management is integrated with other service wide programs to contribute knowledge about natural and cultural resources and associated values; management decisions about resources and visitors are based on adequate scholarly and scientific information.
- Fire management practices help ensure that visitors safely enjoy and are satisfied with the availability, accessibility, diversity, and quality of park facilities, services, and appropriate recreational opportunities.
- Natural and cultural resources are preserved through formal partnership programs (including interagency fire planning).
- Fire management develops improved management practices, systems, and technologies to accomplish its mission.
- NPS fire management programs are cost effective and efficient.
- Adopt leadership and management practices that promote a competent, motivated, diverse workforce.

Other NPS guidance comes from NPS Management Policies (NPS 2000a), which stipulates that any park with vegetation that is capable of burning will prepare a fire management plan and an environmental assessment in support of the plan. Fire management programs are required to meet resource management objectives while ensuring that firefighter and public safety are not compromised. Director's Order 18: Wildland Fire Management (NPS 2003) outlines NPS policy on fire. The goals of the NPS wildland fire management program are outlined in Reference Manual 18: Wildland Fire Management (NPS 1999c):

1. Conduct a vigorous and safe wildland fire management program with the highest professional and technological standards.
2. Identify the type of wildland fire that is most appropriate to specific situations and areas.
3. Efficiently accomplish resource management objectives through the application and management of prescribed and wildland fires.
4. Continually evaluate the wildland fire program operations and accomplishments to better meet program goals by refining treatment and monitoring methods, and by integrating applicable technical and scientific advancements.

Director's Order 41: Wilderness Preservation and Management (DO 41) states that natural fire is seen as a "fundamental component of the wilderness environment (1999)." National Park Service policies on fire in designated wilderness require parks to integrate wilderness considerations into the decision-making process. All fires burning within wilderness are classified as either prescribed fires or wildland fires. Wildland fires that no longer meet resource management objectives and are being suppressed must use the 'minimum requirement' concept defined in DO 41, as required by NPS Management Policies (2001).

Park-specific guidance comes from the General Management Plan (NPS 1988), the Wilderness Management Plan (NPS 1989), the Lake Chelan General Management Plan (NPS 1995) and the Resource Management Plan (NPS 1999a). The General Management Plan directs the Complex to protect ecological processes, including natural fire. Specifically, it calls for a fuel management and prescribed burning program in Stehekin. One key goal of the Wilderness Management Plan is "to manage the wilderness environment so as to conserve, maintain, enhance or restore the wilderness natural resources and those ecological relationships and processes that would prevail were it not for human influence." It also directs the Complex to "manage indigenous plant and animal communities to sustain natural processes…"

The Lake Chelan General Management Plan has the following management objective: "Use fire suppression, prescribed natural fire, management-ignited prescribed fire, and selective manual fuel reductions to improve wildland fire protection for human life and property; to manage for late-succession stage in Douglas fir/ponderosa pine forests; and to monitor and evaluate manual thinning and prescribed fire effects over time." The Resource Management Plan calls for improvement of the program through completion of the following projects: research fire history/fire cycles, survey forest health in developed areas, monitor prescribed fire program, train firefighters in minimum impact techniques, revise fire management plan, forest fuel reduction, public assessment of forest fuel reduction program, develop fire use information program, forest health roadside exhibits, and reduce Hozomeen hazardous forest fuels.

2 Alternatives

This chapter describes the alternatives developed to achieve the goals of the fire management plan. Each alternative addresses the need to protect lives, health, and property; to restore ecosystems that are outside of their historical range of variability; and to maintain the role of fire in those areas that are still within their historical range of variability. The difference between the alternatives is largely a matter of scale; the number of acres treated increases from Alternative 1 to Alternative 3. The alternatives also differ by the combination of management strategies (defined below) that are used to achieve the objectives. Under all alternatives, a combination of thinning treatments and prescribed fire could be used in the areas *outside* of wilderness, and only under Alternative 3 could prescribed fire be used *within* wilderness.

Suppression Zone and Wildland Fire Use Zone acreages are the same for alternatives 1 and 3, and under Alternative 2, the Suppression Zone surrounding Stehekin is expanded (and the Wildland Fire Use Zone reduced), acknowledging that without prescribed fire treatments along the Stehekin valley walls, wildland fire use could not be allowed without threatening the Stehekin Community. (Note: Because Alternative 1 is the No Action alternative, the Suppression Response Zone is the original size as defined in the 1991 Wildland Fire Management Plan; however, all ignitions that have occurred surrounding Stehekin have been suppressed, and will continue to be suppressed without further reduction of fuels surrounding Stehekin.)

Included in the alternatives is the *No Action* alternative, as required by NEPA. The *No Action* alternative is used as a baseline from which to measure the impacts of the other *Action* alternatives. In other words, the *No Action* alternative is a measure of what would happen if management continued according to the 1991 Wildland Fire Management Plan (hereafter, 1991 FMP) and the 1995 Stehekin Valley Forest Fuel Reduction/Firewood Management Plan (hereafter, 1995 Stehekin Plan).

The *Action* alternatives are alternatives to the current fire management program. They meet the goals and objectives outlined in Section 1.3, and they fulfill the requirements of the National Fire Plan and Federal Fire Policy. All alternatives, including the *No Action* alternative, reflect recent changes in national fire terminology. The environmental impacts of implementing each of the alternatives are analyzed and compared in Chapter 4.

2.1 Strategy Definitions

There are four main strategies used to accomplish the objectives of fire management. These include fire suppression, wildland fire use, prescribed fire, and manual/mechanical thinning. NPS Management Policies (2000a) requires all parks to use a systematic decision-making process to determine the most appropriate management strategies for all unplanned ignitions, and for any prescribed fires that are no longer meeting resource management objectives (i.e., prescribed fires that become wildfires).

Fire Suppression is defined as all the work of extinguishing or containing a fire, beginning with its discovery. Management responses can range from aggressive initial attack to a combination of strategies to achieve confinement. Confinement minimizes risks to firefighters and resources by employing natural boundaries (e.g., rock, snow, or water) beyond which fire won't spread. The suppression strategy is used when a wildland fire does not meet criteria required to manage it for resource benefits, when a wildland fire threatens communities, when a prescribed fire burns outside of its scheduled burn plan, or when a wildland fire threatens to cross outside of the Complex boundary where there is no agreement to accept a fire (where the Complex shares a boundary with Canada and with the Mt. Baker-Snoqualmie National Forest). All non-prescribed, human-caused fires are also suppressed. Suppression techniques that could be used inside the Complex include the construction of fire lines; application of water, foam, retardant, or gel; cutting of vegetation; and application of fire (i.e., back burning). All wildland fire suppression activities provide for firefighter and public safety as the highest consideration while minimizing loss of resource values, economic expenditures, and/or the use of critical firefighting resources.

Wildland Fire Use is defined as the management of naturally ignited wildland fires (by lightning strikes) to accomplish specific pre-stated resource management objectives in predefined geographic zones. Managers choose the appropriate management response based on environmental and fuel conditions, constraints, safety, and ability to accomplish resource objectives. Under the wildland fire use strategy, fires that begin after a lightning strike in designated areas could be allowed to burn if appropriate conditions exist. Wildland fire use is not recommended for areas that typically have low severity fire regimes but have missed one or more fire return intervals because there would be an increase in the amount of higher severity fire effects than would occur naturally (Hessburg and Agee 2003). The term “wildland fire use” replaces “prescribed natural fire” as it was used prior to implementation of the 1998 Wildland and Prescribed Fire Management Policy.

Prescribed Fire is defined as any fire ignited by management actions to meet specific objectives. It takes place under specified environmental conditions (e.g., weather and fuel moisture); is confined to a predetermined area; and is within a range of fire intensity and rate of spread that permits attainment of planned management objectives. Prescribed fire can be used around communities that are near or within undeveloped wildlands (the wildland/urban interface) to reduce the risk of severe wildfires. It can also be used to reintroduce fire into areas that were previously managed under a suppression policy. Prescribed fire typically involves the construction of a fire line, though sometimes existing breaks such as trails or ridgelines are used to prevent the spread of the fire beyond a predetermined line. Drip torches are typically used for ignitions, although in larger burn units, helicopters equipped with sphere-dispensing ignition devices or torches are utilized in combination with drip torches on the ground. The term “prescribed fire” replaces “management ignited prescribed fire” as it was used prior to implementation of the 1998 Wildland and Prescribed Fire Management Policy.

The ***re-ignition*** of suppressed wildfires in the Wildland Fire Use Zone is a type of prescribed fire. Its aim is to allow fire to burn in an area where it had to be extinguished for a variety of reasons, including; 1) lack of fire fighting resources, 2) impacts from smoke deemed unacceptable, 3) fire anticipated to reach resources at risk, or 4) fire would create unfavorable effect on an altered ecosystem. This strategy can be used to meet management objectives when conditions are more favorable to letting a fire burn. The intent of a re-ignition fire is to mimic the mosaic created by a lightning fire.

A summary of prescribed fire treatments is described in Table 3 below.

Table 3. Methods Used in Prescribed Fire Treatments

Treatment	*Description*
Pile burning (non-wilderness only)	Piles are covered with slash paper, allowed to cure and ignited when fuel and weather conditions are favorable for burning with minimum risk of spread.
Understory burning (wilderness or non-wilderness)	Burning occurs under specific conditions (fuel moistures and weather conditions) using a burn plan to achieve fuel reduction and resource objectives. Differing fire intensities can be used to meet specific vegetation mortality objectives. Natural barriers are used as control lines whenever possible and hand line is dug around the remainder of the perimeter. The perimeter may be black-lined (burned) using drip torches, and the interior is burned through aerial ignition or with drip torches.
Re-ignition of suppressed wildfires (wilderness or non-wilderness)	The perimeter of the suppressed fire will be re-ignited using drip torches or through aerial ignition. Natural boundaries and areas that can be defended will be identified during the delineation of the maximum manageable area that is defined and used for wildland fire use fire implementation. This same maximum manageable area will be used as the boundary for the re-ignition, and is not anticipated to burn in its entirety.

Manual/Mechanical Thinning is defined as the use of hand-operated power tools and hand tools to cut, clear, or prune herbaceous and woody species. It is a method of reducing hazardous accumulations of wildland fuels, and is often used to create defensible space near structures or shaded fuel breaks that reduce canopy cover and continuity of vertical fuels. Manual treatment is used to remove excess woody debris from the ground; to remove "ladder" fuels, such as low limbs and brush (which could carry fire from the forest floor into the crowns of trees); and to thin dense stands of trees in order to reduce the horizontal continuity of fuels. Material cut or gathered through manual/mechanical treatment can be disposed of by piling and burning on site, burning at an established burn pit, yarding, or chipping. This strategy is often used in combination with prescribed burning (outside of wilderness). A summary of mechanical fuel treatments is described in Table 4 below.

Table 4. Methods Used in Mechanical Fuel Treatments

Treatment	*Description*
Overstory thinning	Thinning of overstory trees with desired spacing to create a shaded fuel break. Used to break continuous vertical fuels in the canopy.
Understory thinning	Thinning of small diameter trees (generally less than 8 inches in diameter at breast height). Used to reduce trees that serve as ladder fuels and contribute to fuel density.
Lop and scatter	Slash treatment method for understory thinning. Cut material is left on-site and cut to maximize fuel bed contact. Depth of material does not exceed 18 inches. Slash is either left on site to decay or is burned.
Yarding	Used to remove thinned trees over snow using either a tracked vehicle or cable yarding with a pulley suspended from a tree. Bole wood staged in natural openings or landing areas. Used primarily to remove freshly cut trees from Forest Fuel Reduction Areas.
Hand piling	Thinned trees and branches not suitable for use as firewood are manually piled in preparation for pile burning on-site.
Chipping	Vegetation is removed from the site and fed through a chipping machine. The chipper reduces vegetation into smaller pieces that can later be used for resource management projects that require restoration.

2.2 Management Zones

All acres of the Complex fit into either a *Wildland Fire Use Zone* or a *Suppression Response Zone* (Appendix A, Figures 5 and 6). These classifications direct managers on how to respond to fires in areas with different management goals. Zonal boundaries and acreages vary between the alternatives. All alternatives reflect recent changes in terminology: “Prescribed Natural Fire Zones” are renamed “Wildland Fire Use Zones.”

Suppression Response Zones
All wildfires would be immediately suppressed or confined in the Suppression Response Zones, which include areas in the Skagit and Stehekin river drainages where natural ignitions could lead to wildfires that could put lives and property at risk. Thinning and prescribed fire would be used to reduce hazard fuels in some areas within these zones, thus helping to protect high-value areas from wildfires. A buffer along the US/Canada border is also within a suppression zone; this designation exists in order to prevent wildfires from crossing the international boundary. Community and visitor protection is the highest priority in these zones; all fires will be suppressed using strategies that reduce the threat of injury to firefighters and the public while keeping costs as low as possible.

Wildland Fire Use Zones
In the Complex’s Wildland Fire Use Zones, the full range of management options would be considered before deciding on a course of action; however, wildland fire (typically lightning-ignited) would be the primary tool used to manage these areas to the extent conditions allow. The Decision Criteria Checklist (Appendix B) is used to assess whether or not an ignition can be managed as a wildland fire use fire. If deemed appropriate, fire would be allowed to play its natural role in these zones, which encompass the majority of the Complex. In order to allow wildland fire use to occur in areas that are adjacent to communities at risk, or that occur within a matrix of continuous fuels near altered ecosystems, prescribed burning treatments can be undertaken to create effective fuel breaks and reduce fuel loads.

2.3 Alternatives Descriptions

2.3.1 Alternative 1 (No Action)

Continue current management under 1991 Wildland Fire Management Plan (1991 FMP) and 1995 Stehekin Valley Forest Fuel Reduction/Firewood Management Plan (1995 Stehekin Plan)

Under Alternative 1, the existing direction in the 1991 FMP and the 1995 Stehekin Plan would continue. This alternative would continue to utilize all fire management strategies including wildland fire use, suppression, and hazard fuel reduction through the thinning of dense forests and the use of prescribed fire adjacent to populated areas (Appendix A, Figure 7).

The emphasis under this alternative is to continue to treat 822 acres of dry Douglas fir/ponderosa pine stands in Forest Fuel Reduction Areas (FFRAs) defined in the 1995 Stehekin Plan. This will continue to be achieved through hazard fuel reduction treatments that include selective hand cutting (thinning) and prescribed fire. Prescribed fire will also provide a catalyst for fire-adapted vegetative change.

Eighty acres in Hozomeen have been treated with small diameter thinning and pile burning to protect structures and the campground. Sixty acres at the Environmental Learning Center (ELC) near Diablo have been treated with small diameter thinning and pile burning. No further treatments will be applied at Hozomeen or the ELC under this alternative.

The current Suppression Response Zone includes a zone along the US/Canada border (24,533 acres), a zone along the Highway 20 corridor (16,567), and a zone that contains the Stehekin valley bottom (6,750), totaling 47,851 acres, or seven percent of the Complex. Wildland fire use is currently allowed on 633,250 acres, or 93 percent of the Complex. Seventy-five percent of the Suppression Response Zone contains burnable vegetation, and 72 percent of the Wildland Fire Use Zone contains burnable vegetation. See Appendix A, Figure 5.

The current program has succeeded in protecting structures with limited mechanical and prescribed fire treatments. Defensible space treatments on the small scale are anticipated to keep community members and structures safe from the effects of unwanted fires. However, it has not allowed for larger scale treatments aimed at protecting the Stehekin community under severe fire conditions. Nor does it improve the opportunity to increase the number of natural fires burning near communities. Although these treatments are viewed favorably by Stehekin community members, they do not meet the need for restoring and maintaining ecosystem function, and they are conducted at a scale that is too small to effectively protect the Stehekin community from uncontrollable wildfire.

Project Descriptions

1. Stehekin Valley Forest Fuel Reduction Areas (FFRAs)

The primary objective of the 1995 Stehekin Plan is *hazard fuel reduction* in the wildland/urban interface in order to reduce the potential for high intensity and severity fires, including crown fires. The *hazards* that can be mitigated (weather being an uncontrollable factor) include; 1) ladder fuels, 2) heavy and continuous canopy cover, and 3) heavy and continuous fine surface fuel loading. These factors are targeted in the FFRA management objectives and are addressed through the following actions:

- Small diameter trees (< 8 inches diameter) are thinned by the North Cascades Fire Crew throughout the spring and fall. This is primarily performed to reduce ladder fuels and release ponderosa pine from Douglas fir encroachment.
- Thinning of larger diameter trees (> 8 inches diameter) is generally performed via contract and the trees are removed over snow to reduce soil disturbance and compaction. The larger diameter trees are marked by the North Cascades Supervisory Forestry Technician, Fuels Specialist or designee(s) for removal. The majority of these trees are Douglas fir rather than ponderosa pine. Trees infested with mistletoe or weakened by insects and other pathogens are also targeted for removal regardless of their species.
- Prescribed burning is performed in the spring or fall.

The FFRAs consist of six sub-units ranging in size from 52 acres in the Weaver Point subunit to 200 acres in the McGregor subunit (see Table 5). Treatments of these six units, with a total acreage of 822, began following the approval of the 1995 Stehekin Plan. Three additional units with a total of 322 acres (Harlequin, Lower McGregor, and Lower Field) were designated as “Future Units,” but have not been treated yet. The delineation of the sub-units was originally, and continues to be based upon tactical concerns, trails, roads, and stands of trees that could be treated under a uniform prescription. The units were broken into small subunits with the intention to monitor the effects of the treatments, and allow for adaptive management as the plan progressed.

Table 5. Stehekin FFRA Units (Alternative 1)

Stehekin FFRA	1995 Acres (Alternative 1)	Dominant Covertype	Secondary Covertype	Median Fuel Model
Orchard/Rainbow	120	Douglas fir	hardwood	8
Boulder Creek	132	Douglas fir	hardwood	8
Company Creek	138	Douglas fir	hardwood	8
Coon Run	180	Douglas fir	hardwood	8
McGregor	200	Douglas fir	hardwood	8
Weaver Point	52	Douglas fir	hardwood	8
Harlequin	“future unit”	Douglas fir	hardwood	10
Lower McGregor	“future unit”	Douglas fir	hardwood	8
Lower Field (Upper McGregor)	“future unit”	Douglas fir	hardwood	8
Totals	822			8

2.3.2 Alternative 2

Continue current direction under 1991 Wildland Fire Management Plan and 1995 Stehekin Valley Forest Fuel Reduction/Firewood Management Plan, with an increase in acreages of forest fuel reduction areas in Stehekin (outside of wilderness)

Under Alternative 2, the existing direction in the 1991 FMP and the 1995 Stehekin Plan would continue with an increase in prescribed fire and mechanical thinning acres outside of designated wilderness. Its primary emphasis is a net increase in fire protection to the Stehekin community. Through defensible space prescriptions, dry Douglas fir/ponderosa pine forests would be thinned and underburned in the Stehekin FFRAs, escape routes (road corridors) would be made safer through hazard fuel reduction on adjacent Complex lands, historic district buildings and other park infrastructure would undergo defensible space treatments, and privately owned properties would be made safer through defensible space treatments at the property owner’s request. This alternative continues to utilize all fire management strategies including wildland fire use, suppression, and hazard fuel reduction through the thinning of dense forests and the use of prescribed fire adjacent to populated areas (Appendix A, Figure 8).

Thinning and underburning in Stehekin would increase to 1,209 acres of dry Douglas fir/ponderosa pine forest. This increase targets units that are adjacent to structures and road systems with the primary objective of reducing the threat of high intensity crown fire events.

Roadside thinning of conifers and the piling and eventual burning of debris would occur on 124 acres of the Stehekin road corridor. This work would strengthen the road system as a firebreak, and increase its value as an escape route.

Safety Zones would be strengthened through thinning of conifers within the zones (24 acres).

This alternative includes the use of Wyden Authority[1] to spend federal monies on privately owned property in the Stehekin Valley for hazard fuel reduction. Potentially, and through

[1] **Wyden Amendment Authority**. The Wyden Amendment authority was signed in 1997 “for the purpose of entering into cooperative agreements with willing private landowners for restoration and enhancement of fish, wildlife, and other biotic resources on public land, private land, or both, that benefit those resources on public lands within the watershed.” Instruction Memorandum No. 2000-179, dated August 24, 2000, concentrates on the use of the Wyden Amendment authority for the “reduction of risk from

cooperative agreement, up to 440 private acres of dry Douglas fir/ponderosa pine forest may be treated with a combination of thinning, piling of excess and burnable debris, and prescribed fire treatments.

Recognizing that the opportunities for wildland fire use are not viable within the majority of the Lake Chelan National Recreation Area due to smoke concerns, altered fuel loads and fire regimes, and the potential for wildfire to threaten the Stehekin community, the Suppression Zone is expanded from 6,750 to 57,222 acres in the Stehekin area. The increase of the Stehekin Suppression Zone is based on the understanding that ignitions in these areas were invariably suppressed throughout almost the entire NRA. Without a fuel break, the valley is likely to be indefensible from wildland fire due to continuous fuels and steep slopes, and the resulting pattern of fire spread down valleys that lead to Stehekin. (Note: The same situation exists under Alternative 1; however, the Suppression Response Zone cannot be changed in Alternative 1 because it is defined as such in the 1991 FMP.)

Wildland fire use will be allowed on 582,779 acres (86 percent) of the Complex. Suppression will be required on the remaining 98,322 acres (14 percent), including the zone along the US/Canada border, the zone along the Highway 20 corridor, and the zone that contains the Lake Chelan NRA. Seventy-seven percent of the Suppression Zone contains burnable vegetation, and 71 percent of the Wildland Fire Use Zone contains burnable vegetation. See Appendix A, Figure 6.

As in the no action alternative, Alternative 2 targets the protection of the Stehekin community from wildfire by reducing the types of fuels that facilitate fire spread. Although this alternative increases the area treated in Stehekin by 387 acres, it does not attempt to restore altered ecosystems in wilderness adjacent to the Stehekin community, thus leaving the community at a greater risk from wildfires and perpetuating the effects of fire exclusion on stand structure and composition. As a result, wildland fire use near this community would not be an option given the threat of fire spread toward the community due to heavy and continuous fuel loadings.

Project Descriptions

1. Stehekin Valley Forest Fuel Reduction Areas (FFRAs)

The objectives and actions for the FFRAs under this alternative are identical to the objectives and actions described in Alternative 1. The acreages reported in the 1995 Stehekin Plan have been unofficially amended on the maps of the units following the 2000 Stehekin Peer Review when discrepancies between the original acreages and the GIS layer were resolved. These changes, along with additional increases in the acreages of the Boulder Creek and Company Creek unit are proposed at this time. The 387-acre proposed expansion to the units will correct the mapping discrepancies following the five-year review, and incorporate additional acreage to the sub-units that will increase fire management efficiency and ease tactical concerns around structures and private property. Table 6 below compares acreage adjustments between alternatives 1 and 2.

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natural disaster where public safety is threatened that benefits these resources on public land within the watershed." Amendment No. 2002-478 gave further clarification to the US Forest Service and the Department of the Interior to immediately reduce the risk of catastrophic fire. This amendment also gave highest priority to land identified as Condition Class 3 within wildland-urban interface areas.

Table 6. Stehekin FFRA Units (Alternative 2)

Stehekin FFRA	1995 Acres (Alternative 1)	Adjusted Acreage (Alternatives 2 & 3)	Dominant Covertype	Secondary Covertype	Median Fuel Model
Orchard/Rainbow	120	128	Douglas fir	hardwood	8
Boulder Creek	132	147	Douglas fir	hardwood	8
Company Creek	138	157	Douglas fir	hardwood	8
Coon Run	180	201	Douglas fir	hardwood	8
McGregor	200	200	Douglas fir	hardwood	8
Weaver Point	52	54	Douglas fir	hardwood	8
Harlequin	“future unit”	51	Douglas fir	hardwood	10
Lower McGregor	“future unit”	133	Douglas fir	hardwood	8
Lower Field (Upper McGregor)	“future unit”	138	Douglas fir	hardwood	8
Totals	822	1,209			

2. Corridor Thinning
Thinning along the Stehekin Road corridor will provide more dependable escape routes for both residents and firefighters in case of the need for an evacuation. Fire fighters are required to have planned escape routes during any fire management activity. Trees that have a high probability of falling or dropping their tops, trees with large mistletoe brooms near the road, or understory trees creating ladder fuels along the road will be thinned. The trees that are most likely to obstruct the roadway include those with excessive pitch on their boles (that facilitates consumption of the base of the tree during burning), dead or weakened trees that lean towards the road, or trees that have large mistletoe brooms that could fall into the road or more easily ignite and prevent safe passage. Some understory trees (less than 8 inches diameter) will be limbed and left standing, and others will be thinned, piled, and burned on-site. The corridor thinning and limbing will create a buffer that varies in width from 75 to 100 feet on each side of the road depending on the height of the overstory trees (taller trees will have a larger buffer from the road). Thinning within the buffer will occur on a total of 124 acres of federal land stretching from the head of Lake Chelan to High Bridge.

3. Safety Zone Thinning
The Buckner Homestead Historic District (otherwise known as the Orchard) and the Courtney Ranch serve as safety zones where residents and firefighters can take refuge in the event of a fire that overcomes the valley. The Orchard Safety Zone, located 3.5 miles up the Stehekin Road, is 51 acres. The Ranch Safety Zone, located 9 miles up the Stehekin Road, is 38 acres. The majority of both zones are open and treeless, but there are conifers within their perimeters that require thinning, consisting of approximately 19 acres at the Orchard, and 5 acres at the Courtney Ranch. The thinning prescription is the same as that of the FFRAs, with understory and overstory trees being cut or limbed, piled and burned on-site.

4. Wyden Amendment Thinning/Burning
Under the Wyden Amendment, federal land management agencies have the authority to spend federal funds to conduct hazard fuel reduction projects on private land where it would benefit both parties. In Stehekin there are 440 acres of private land, a portion of which, through cooperative agreements, can be treated with a combination of thinning, piling of excess and burnable debris, and prescribed fire treatments at the landowner’s request.

2.3.3 Alternative 3 (Preferred Alternative)

Continue current direction under 1991 Wildland Fire Management Plan and 1995 Stehekin Valley Forest Fuel Reduction/Firewood Management Plan with increases in acreages of forest fuel reduction areas in Stehekin, additional prescribed burning along Stehekin valley walls and at Hozomeen (including wilderness), and re-ignition of previously suppressed fires

Under Alternative 3, the existing direction in the 1991 FMP and the 1995 Stehekin Plan would continue with an increase of prescribed fire and mechanical thinning acres *outside* of designated wilderness, plus the additional use of prescribed fire *within* wilderness. The additional use of prescribed fire in wilderness is aimed at increasing protection for the communities of Stehekin and Hozomeen, restoring altered ecosystems, and increasing opportunities for wildland fire use (Appendix A, Figure 9 for Stehekin projects, and Figure 10 for Hozomeen projects).

This alternative includes the same acreages as Alternative 2 for thinning and underburning in Stehekin FFRAs (1,209 acres), the same roadside thinning acreage (124 acres), the same thinning acreage around community safety zones (24 acres), and the same potential thinning acreage under the Wyden Amendment (440 private acres).

In addition, this alternative outlines plans for underburning 4,848 acres of dry Douglas fir/ponderosa pine forest along the Stehekin Valley walls (called Stehekin Contours), with 4,255 of those acres located in designated wilderness; and 5,219 acres of Douglas fir-dominated forests near Hozomeen (called Hozomeen Contours), with 4,603 of those acres located in designated wilderness. These projects are intended to reintroduce fire under controlled conditions into areas where natural ignitions are usually suppressed. Prescribed fire will help to restore these areas to within their natural range of variability, and will allow wildland fire use to be utilized closer to both Stehekin and Hozomeen without endangering the communities.

The Suppression Response Zone in Stehekin will be returned to its original acreage in the Stehekin valley bottom (as defined in Alternative 1: 47,851 acres, or seven percent of the Complex) and opportunities to utilize wildland fire will become increasingly more viable as the treatment of units progresses (Appendix A, Figure 5). The treatment of the Hozomeen Contours will similarly provide for increased opportunities for wildland fire use (however, the Suppression Response Zone near Hozomeen remains the same as in Alternative 1 and 2, because unlike Stehekin, wildland fire use would still be considered in some limited cases; this area is considered to be less altered than Stehekin (see Section 3.5.2 Condition Classes and Fuel Models) and consequently the potential for wildland fire to burn outside of its historic range of variability is reduced).

Wildland fire use will be allowed on 633,250 acres, or 93 percent of the Complex.

Re-ignition of wildland fires that were suppressed earlier in the season would be an option under this alternative.

Alternative 3 best meets the intent of the National Fire Plan, the Wildland and Prescribed Fire Management Policy and the goals and objectives set forth by Complex staff. The proposed treatments of this size and scope provide the greatest amount of protection to the communities threatened by the potential for high severity wildland fire within the urban interface by reducing hazardous fuels and vertical fuel continuity. Furthermore, this alternative promotes restoration of altered ecosystems (no longer within their historic range of variability) that will increase protection of nearby communities at risk and preserve fire-dependent species habitat. Finally, in the majority of the Complex this alternative facilitates the maintenance of fire regimes within their historic range of variability by increasing opportunities for wildland fire use.

Project Descriptions

1. Stehekin Valley Forest Fuel Reduction Areas (FFRAs)

This project description is identical to the Alternative 2 project description.

2. Corridor Thinning

This project description is identical to the Alternative 2 project description.

3. Safety Zone Thinning

This project description is identical to the Alternative 2 project description.

4. Wyden Amendment Thinning/Burning

This project description is identical to the Alternative 2 project description.

5. Stehekin Contours

The Stehekin Contours project is proposed in order to address protection, restoration and maintenance issues. There are 11 units, ranging in size from 153 to 888 acres, for a total of 4,848 acres (see Table 7). Eighty-eight percent, or 4,255 acres, is located within wilderness. The units are delineated by maximizing natural boundaries and minimizing the need for digging line along a perimeter that is easily defensible. The units will be burned in the fall to reduce smoke concerns, costs of monitoring (which would be required throughout the summer if burned in the spring), and potential conflicts with the nesting of listed wildlife species. Additional spring burning could be used to black line [2] the upper elevation edges of the units in order to strengthen the upper line prior to fall burning. Burning of these units will involve both hand-held drip torches and ignition via helicopters equipped with sphere-dispensing ignition devices or torches. Typically hand-held drip torches will be used along the unit's edge to mark the boundary, whereas helicopters will be used to light the interior of the unit. Lighting of each unit is expected to take one full day of helicopter passes. Each unit will be burned one time only.

Table 7. Stehekin Contour Units (Alternative 3)

Stehekin Contours	Acres	Dominant Covertype	Secondary Covertype	Median Fuel Model
Courtney	375	Douglas fir	Shrubland	1
Coon Lake	564	Douglas fir	Shrubland	8
Lower Field	295	Douglas fir	Hardwood	9
Wilsey	153	Douglas fir	Hardwood	8
Upper Rainbow	604	Douglas fir	Shrubland	8
Upper Boulder	309	Douglas fir	Hardwood	8
Buellers	635	Douglas fir	Shrubland	5
Imus Creek	268	Douglas fir	Shrubland	8
Hazard Creek	888	Douglas fir	Shrubland	8
Maxwell	393	Douglas fir	Hardwood	8
Flick Creek	363	Douglas fir	Shrubland	8
Totals	**4,848**			

[2] Black line: a line created by flames from a drip torch to pre-burn fuels on the edge of a burn unit and to help secure a prescribed burn.

There are three major structural types that are prevalent within the Stehekin Contours units, including 1) Closed Canopy Single-story Douglas fir (PSME) forest, 2) Closed Canopy Multi-story Douglas fir / Ponderosa pine (PSME/PIPO) forest, and 3) Open canopy Douglas fir / Ponderosa pine (PSME/PIPO) forest. Each structural type is expected to respond differently to treatment with prescribed fire, yielding a mosaic of fire effects. Table 8 illustrates objectives that are based upon the desired future condition of each structural type.

Table 8. Structural Objectives for Primary Structural Forest Types – Stehekin Contours

Structural Type	Condition Class	% of area	Variable	Current Stand Condition	Desired Future Condition
Closed-canopy Single-story PSME	3+ (high 3)	15	Trees	80–100% canopy cover, stagnant stand with dead branches on lower 2/3 of ≥ 50% of trees.	≥ 5% reduction in cover (to 60–95%), reduce ladder fuels by ≥10 % of affected trees.
			Ground Fuels	~ 20 tons/acre (from 2-MC-3 in photo series) with largest amount in 3–9" fuel class.	≥ 20% reduction in 3–9" diameter fuel class.
			Understory Vegetation	0–10% cover of forbs and shrubs.	5–20% cover of forbs and shrubs.
Closed-canopy Multi-story PSME / PIPO	3- (low 3)	70	Trees	70–90% canopy cover, large trees (≥20" dbh) comprise ≤ 35% relative cover of all trees.	≥ 15% reduction in cover (to 40–75%), increase relative cover of large trees by ≥ 5%.
			Ground Fuels	~ 11 tons/acre (from 1-MC-3 in photo series) with largest amount in 9-20" fuel class	≥ 20% reduction in 9-20" diameter fuel class.
			Understory Vegetation	5-40% cover of forbs and shrubs.	Maintain, or increase understory cover by 2nd year post-burn.
Open-canopy PSME / PIPO	1	15	Trees	20-60% canopy cover, large trees (≥20" dbh) comprise ≥ 50% relative cover of all trees.	Maintain or reduce cover by ≤10%, maintain ≥ 50% relative cover of large trees.
			Ground Fuels	~ 20 tons/acre (from 1-MC-4 photo series) with largest amount in 9-20" fuel class.	≥ 20% reduction in 9-20" diameter fuel class.
			Understory Vegetation	20-80% cover of forbs and shrubs.	Maintain, or increase understory cover by 2nd year post-burn.

The stand conditions of each structural type described in Table 8 are based upon approximations from ground surveillance, and will be adjusted in the development of the burn plans for each unit. The condition classes in the table refer to the structural types within the overall covertype (Douglas fir/Ponderosa pine is the overall covertype, and has an average Condition Class of 3 (see Table 15, page 63)) and are assigned according to the number of fire entries that are estimated to have been missed within these structural types. The loading of the ground fuels were estimated from a photo series that lists fuel loadings by size class based upon structural stand characteristics (Maxwell and Ward 1980).

6. Hozomeen Contours

Two units are proposed for treatment under the Hozomeen Contours project. The units are Little Jackass Mountain (2,180 acres) and Lightning Creek (3,039 acres) (see Table 9). Over 88 percent, or 4,603 acres, is located in wilderness. The Lightning Creek unit only contains 1,630 acres of the desired treatment area; however, the 1,409 acres north of the Desolation Trail creates a more defensible boundary. The Desolation Trail divides the unit into two community types, Douglas fir/western hemlock to the north, and Douglas fir/lodgepole pine/ponderosa pine (the targeted treatment type) to the south; it is steep and the fuels are continuous across the trail. Thus, an attempt will be made to hold the unit to the area south of the trail; however, the area north of the trail may burn. Lighting techniques for these units would be identical to the techniques used on the Stehekin Contours. The Hozomeen Contours will be burned in the fall to reduce smoke concerns, costs of monitoring (which would be required throughout the summer if burned in the spring), and potential conflicts with the nesting of listed wildlife species. Each unit will be burned one time only.

Table 9. Hozomeen Contour Units (Alternative 3)

Hozomeen Contours	Acres	Dominant Covertype	Secondary Covertype	Median Fuel Model
Little Jackass Mtn.	2,180	Douglas fir	Western hemlock	10
Lightning Creek	3,039	Douglas fir	Western hemlock	8
Totals	**5,219**			

There are three broad forest types within the Hozomeen Contours units, including: 1) Douglas fir / Lodgepole pine / Ponderosa pine (PSME/PICO/PIPO), 2) Douglas fir / Lodgepole pine (PSME/PICO), and 3) Douglas fir-Western Hemlock (PSME-TSME). Table 10 illustrates objectives for the Hozomeen Contour prescribed fires which are intended to open up the canopy to enhance fire dependent forest habitat (PSME/PICO +/- PIPO). Ponderosa pine in the Lightning Creek Unit will benefit from the mortality of less fire resistant species (such as lodgepole pine and western hemlock). Lodgepole pine regeneration will increase in new canopy openings in both units.

Table 10. Structural Objectives for Primary Structural Forest Types – Hozomeen Contours

Structural Type	% of area	Variable	Current Stand Condition	Desired Future Condition
PSME/PICO/PIPO Lightning Creek Prescribed Fire Unit	70	Trees	50–90% canopy cover, relative cover of PIPO at Lightning is ≤ 25% of all trees.	Reduce canopy cover by ≥10% (to 30 – 80%), increase relative cover of PIPO at Lightning to ≥25%.
		Ground Fuels	~ 20 tons/acre (from 1-MC-4 in photo series) with largest amount in 9-20” fuel class	≥20% reduction in 9-20” diameter fuel class immediate post-burn. ≤20% increase in total fuel load by 5 years post-burn.
		Seedlings	Low density of PIPO and PICO seedlings relative to PSME and TSME	Maintain or increase relative density of PIPO and PICO seedlings by ≥10%.
PSME/PICO Little Jack Ass Prescribed Fire Unit		Trees	50–90% canopy cover	Reduce canopy cover by ≥10% (to 30–80%).
		Ground Fuels	~ 20 tons/acre (from 1-MC-4 in photo series) with largest amount in 9-20” fuel class	≥20% reduction in 9-20” diameter fuel class immediate post-burn. ≤20% increase in total fuel load by 5 years post-burn.
		Seedlings	Low density of PIPO and PICO seedlings relative to PSME and TSME	Maintain or increase relative density of PICO seedlings by ≥10%.
PSME - TSME	30	Trees	70-100% canopy cover	Reduce canopy cover by ≥5% (to 30-95%)
		Ground Fuels	~ 55 tons/acre (from 4-DF-4 in photo series)	Maintain or reduce total fuel loading by 5 years post-burn.
		Understory Vegetation	0-40% cover of moss, forbs and shrubs.	Maintain or increase cover of understory vegetation (to 5–50% cover)

The stand conditions of each structural type described in Table 10 are based upon approximations from local knowledge and aerial photographs, and will be adjusted in the development of the burn plans for each unit. The loading of the ground fuels was estimated from a photo series that lists fuel loadings by size class based upon structural stand characteristics (Maxwell and Ward 1980).

7. Re-ignition of Suppressed Fires

The re-ignition of suppressed wildfires in the Wildland Fire Use Zone is another method of reducing the undesirable effects of fire exclusion. This action may be taken in any area within the Wildland Fire Use Zone where fire is suppressed following the creation of this plan (not intended to be used to re-ignite fires that were suppressed historically). The boundaries for the re-ignition unit will be based upon the maximum manageable area defined in a burn plan. The area anticipated to burn will be modeled using FARSITE (a fire growth simulation model that uses spatial information on topography and fuels along with weather and wind) or other models to predict fire behavior and spread before re-ignition. The season of re-ignition will be based upon the following factors:

- If the suppressed fire was burning with fire behavior within its historical range of variability, in an unaltered fire regime, the re-ignition will occur within the fire season, thus allowing for the desirable range of fire effects for that fire regime (see fire season in Covertypes and Associated Fire Regimes, Section 3.5.1).
- If the suppressed fire was burning with fire behavior outside its historical range of variability, in an altered fire regime (see descriptions of the Douglas fir-dominated fire regimes in Section 3.5.1) the re-ignition will occur when conditions are favorable (generally fall) for low severity fire.

The perimeter of the suppressed fire will be re-ignited using drip torches or aerial ignition devices. Natural boundaries to fire movement and areas that can be safely defended by firefighters will be identified during the delineation of the maximum manageable area. This same maximum manageable area will be used as the maximum boundary that the re-ignited fire could reach, and is not anticipated to burn in its entirety.

2.3.4 Actions Common to All Alternatives

Several elements of the Fire Management Program do not vary among the proposed alternatives. All mitigation measures would be the same regardless of the alternative chosen. These include all measures listed by impact topic in Chapter 4, as well as those listed in Section 2.4, including Minimum Impact Techniques (MIT), Minimum Requirement concepts, Wildland Fire Implementation Planning, Burned Area Emergency Rehabilitation, prescribed burn plans, Interdisciplinary Team reviews, and Wilderness and Aviation Committee reviews. Additionally, fire retardant use will require approval by the superintendent regardless of the alternative chosen. Finally, the Fire Management Plan, which describes in detail how the chosen alternative will be implemented, will guide fire management for the next five to 10 years, at which time it will be re-evaluated and refined as necessary based on new environmental information and experience from project implementation.

There are also several unvarying external factors that either influence the fire management program itself, or create cumulative resource impacts. Ninety percent of the Complex is bounded by US Forest Service land, including the Mount Baker-Snoqualmie (MBS), Okanogan, and Wenatchee national forests. The remaining 10 percent of the boundary includes the US/Canada border. Sixty percent of the US Forest Service boundary is designated wilderness. Wildland fire use policies vary by forest; the Okanogan and Wenatchee currently allow for wildland fire use whereas the MBS currently requires suppression of all ignitions on lands bordering the Complex. Suppression is also required along the US/Canada border, as there is no international agreement to allow a wildland fire to cross the boundary. Fire management policies on lands neighboring the Complex can have direct influence on lands within the Complex. For example, fires that ignite on those neighboring lands that require suppression are extinguished or confined, and generally not allowed to cross into the Complex. Additionally, fires that ignite within the Complex near these lands are also extinguished or confined to prevent them from moving onto lands that have suppression policies.

The Complex is currently developing an Environmental Impact Statement (EIS) on a High Lakes Fishery Management Plan. Proposed actions include fish removal and/or the cessation of fish stocking in certain impacted lakes. Many of the lakes approved as sources for bucket drops during fire suppression are also being considered in the EIS. Lakes that are known to be sensitive will not be approved as bucket sources.

2.4 Mitigation

Mitigation measures are used to minimize the impacts of fire management activities on the affected environment. Below are the channels through which mitigation measures will be implemented. Mitigations for resource-specific impacts are listed in Chapter 4, Environmental Consequences. For any action not covered in this EA, additional NEPA compliance would be completed.

All Management Strategies:

- Minimum Impact Techniques (MIT) are guidelines that are used to minimize the impacts associated with all fire management activities, including suppression, wildland fire use, prescribed burning and thinning, and re-ignition. They are adapted from the nationally recognized Minimum Impact Suppression Tactics (MIST), and include guidelines specific to the Complex. They include guidelines for monitoring fires, establishing and setting up camp, helicopter use, helispot construction, fire lining and mop-up, and installations and structures. A list of MIT can be found in Appendix H.
- Minimum Requirement Analysis is conducted for all proposed projects in wilderness, and minimum requirement concepts (as guided by MIT) are followed during all suppression and wildland fire use activities in wilderness, in order to minimize impacts to wilderness character. The Minimum Requirement Analysis conducted for the proposed projects in this EA can be found in Appendix G.

Suppression and Wildland Fire Use:

- A Wildland Fire Implementation Plan (WFIP) is initiated for every wildland fire. The WFIP contains three stages that are developed progressively as fires are managed for resource benefits or where initial attack is not the selected response. Wildland fire implementation planning requires input from an interdisciplinary committee that is formed to address natural and cultural resource objectives and constraints and to develop the Maximum Manageable Area (MMA). The committee typically includes (in addition to fire staff) a cultural resource advisor, a natural resource advisor, and a wilderness advisor, who all help to identify and protect sensitive resources that could be at risk.

Suppression:

- Burned Area Emergency Rehabilitation (BAER) is an extension of emergency actions directly related to managing an unplanned and unwanted wildland fire. Funding is available to allow parks to take immediate actions to prevent unacceptable resource degradation and to minimize threats to life and property resulting from a wildland fire. The NPS will continue to utilize the least intrusive and least resource damaging methods to manage unwanted wildland fire, and the least intrusive BAER actions required to mitigate actual or potential damage caused by the fire. In natural areas, natural recovery of native plant species will continue to be the preferred action, except in rare circumstances.

Prescribed Burning and/or Thinning:

- Specific operational plans are developed and approved for every prescribed burn. At a minimum, plans must include:
    - Description of the prescribed fire area
    - Goals and objectives (stated in measurable terms)
    - Range of acceptable results expected (expressed in quantifiable terms)
    - Project assessment, including the level of complexity and a risk assessment
    - Prescribed fire implementation actions

    - Cooperation provisions (with agencies and the public)
    - Contingency plan
    - Funding source
    - Smoke management and air quality requirements, including modeled outputs
    - Monitoring
    - Post-burn evaluation provisions
- Prescribed burn plans and thinning proposals (outside of wilderness) must go through the Complex's Project Coordination and Review Process, the purpose of which is to review proposed projects by members of an interdisciplinary team. The interdisciplinary team will:
    - Review assessment of potential effects on natural and cultural resources.
    - Solicit comments from appropriate subject-matter experts.
    - Review compliance actions needed and assure coordination between divisions.
    - Make recommendations to mitigate potential impacts or improve proposed projects.
    - Provide findings and recommendations to the superintendent.
    - Track compliance, permit, survey, and other coordinated actions to ensure completion prior to project implementation.
- All proposed projects in wilderness must go through the Wilderness and Aviation Committee, whose role is to review wilderness operations, analyze options and, as appropriate, recommend policies or priorities for action to the superintendent. Prescribed burn plans proposing burning in wilderness are reviewed by the committee through this process. Specific roles and functions of the committee are:
    - To provide representation from all divisions on wilderness related issues and decisions, and to provide a wide base of park representation in wilderness management.
    - To review, and recommend action to the superintendent, on all projects potentially affecting the quality of wilderness.
    - To provide recommendations to the superintendent regarding wilderness related budgeting, goal-setting, policies, standards, and management actions.
    - To review and provide recommendations on all proposed projects involving helicopter flights in wilderness.
    - To provide a forum for generating and discussing issues.

2.5 Summary Tables

Table 11 summarizes the acres under each alternative by management zone or project. Table 12 is a summary of the average or range of acres that would be treated or that would fall into either wildland fire use or suppression response.

Table 11. Summary Matrix of Alternatives

Primary details of plan by alternative	*Alternative 1, No Action (Continue activities under current plan)*	*Alternative 2*	*Alternative 3 (Preferred alternative)*
Wildland Fire Use Zone	Lightning ignitions can be managed on 633,250 acres (93% of Complex), 72% of which is burnable vegetation	Lightning ignitions can be managed on 582,779 acres (86% of Complex), 71% of which is burnable vegetation	Lightning ignitions can be managed on 633,250 acres (93% of Complex), 72% of which is burnable vegetation
Suppression Response Zone	Suppress fires on 47,851 acres (7% of Complex), 75% of which is burnable vegetation	Suppress fires on 98,322 acres (14% of Complex), 77% of which is burnable vegetation	Suppress fires on 47,851 acres (7% of Complex), 75% of which is burnable vegetation
Mechanical thinning and prescribed fire in Stehekin Forest Fuel Reduction Areas (FFRAs) (outside of designated wilderness)	Thin and under burn 822 acres of dry Douglas fir/ponderosa pine forest in the wildland/urban interface	Thin and under burn 1,209 acres of dry Douglas fir/ponderosa pine to specific hazard fuel reduction objectives in the wildland/urban interface	Thin and under burn 1,209 acres of dry Douglas fir/ponderosa pine to specific hazard fuel reduction objectives in the wildland/urban interface
Corridor thinning (mechanical treatment)	None included in current plan	Up to 124 acres of dry Douglas fir/ponderosa pine could be thinned adjacent to the road system	Up to 124 acres of dry Douglas fir/ponderosa pine could be thinned adjacent to the road system
Safety zone thinning	None included in current plan	Up to 24 acres of dry Douglas fir/ponderosa pine could be thinned within designated safety zones	Up to 24 acres of dry Douglas fir/ponderosa pine could be thinned within designated safety zones
Wyden Amendment: mechanical thinning of dry Douglas fir/ponderosa pine on privately owned lands in Stehekin	None included in current plan	Potential community assistance using Wyden Authority on 440 acres of private land in Stehekin	Potential community assistance using Wyden Authority on 440 acres of private land in Stehekin
Stehekin Contours: prescribed fire on Stehekin valley walls (within designated wilderness)	None included in current plan	No prescribed fire treatments proposed	Up to 4,848 acres of dry Douglas fir/ponderosa pine surrounding the Stehekin valley could be underburned – 4,255 acres are located in wilderness
Hozomeen Contours: prescribed fire surrounding Hozomeen (within designated wilderness)	None included in current plan	No prescribed fire treatments proposed	Up to 5,219 acres of dry Douglas fir-dominated forest south of Hozomeen on the east side of Ross lake could be underburned - 4,603 acres are located in wilderness
Re-ignition of suppressed fires	None included in current plan	No re-ignitions proposed	Re-ignite up to 200 acres per year

Table 12. Average Acres per Year

Treatments by Management Strategy	*Alternative 1*	*Alternative 2*	*Alternative 3*
Average number of suppressed fires:	9	9	Decrease over time
Average acreage of suppressed fires:	260	260	Decrease over time
Average acreage of WFU fires:	200	200	200*
Prescribed fire in Stehekin Forest Fuel Reduction Areas (FFRAs) (on federal land but not in wilderness):	10 – 180	10 – 200	10 – 200
Manual/mechanical thinning in Stehekin Forest Fuel Reduction Areas (FFRAs) (on federal land but not in wilderness):	10 – 88	10 – 138	10 – 138
Manual/mechanical thinning along Stehekin road:	0	10 – 15	10 – 15
Manual/mechanical thinning within safety zones:	0	10 – 15	10 – 15
Manual/mechanical thinning in Stehekin (on private land):	0	2 – 10	2 – 10
Prescribed fire on Stehekin valley walls (including wilderness):	0	0	153 – 888
Prescribed fire surrounding Hozomeen (including wilderness):	0	0	1,630 – 3,039
Re-ignition of suppressed fires in WFU Zone:	0	0	200
Total treated acres (average per year)	220 – 468	242 – 578	2,225 – 4,705
***WFU acreage is expected to increase over time**			

2.6 Alternatives Considered but not Further Addressed

Two additional alternatives were initially considered but were later rejected as reasonable alternatives because they do not fulfill the purpose and need, as defined in this EA, of the Fire Management Program.

Suppression of All Fires. This alternative would involve the suppression of all wildland fires, whether they were human-caused or lightning-caused. No prescribed burns, manual thinning, or wildland fire use strategies would be involved. The suppression of all fires as a management strategy fails to meet most of the objectives of the revised Fire Management Plan. Fuel accumulation would be the biggest impact, which would result in an increased risk of uncontrollable crown fires.

No Suppression of Wildland Fires. This alternative would involve allowing all fires to burn without suppression. Although the strategy of allowing some fires to burn can be beneficial for resource objectives, some fires, if allowed to burn, could pose significant risks to private property, administrative facilities, natural and cultural resources, and air quality. This alternative also fails to fulfill the purpose and need of the Fire Management Program.

2.7 Environmentally Preferred Alternative

The environmentally preferred alternative is the alternative that causes the least damage to the biological and physical environment, and that best protects, preserves, and enhances historic, cultural, and natural resources. The NPS is required to identify the environmentally preferred alternative that will promote the national environmental policy expressed in NEPA (Sec. 101 (b)). The alternative must:

1. fulfill the responsibilities of each generation as trustee of the environment for succeeding generations.
2. ensure for all Americans safe, healthful, productive, and esthetically and culturally pleasing surroundings.
3. attain the widest range of beneficial uses of the environment without degradation, risk of health or safety, or other undesirable and unintended consequences.
4. preserve important historic, cultural, and natural aspects of our national heritage and maintain, wherever possible, an environment that supports diversity and variety of individual choice.
5. achieve a balance between population and resource use that will permit high standards of living and a wide sharing of life's amenities.
6. enhance the quality of renewable resources and approach the maximum attainable recycling of depletable resources.

Alternative 1, No Action, represents the current direction of the Complex's Fire Management Program. This alternative concentrates project work on the Stehekin valley bottom, and fails to address the broader impacts of fire suppression and exclusion surrounding Stehekin and Hozomeen. Provisions 1, 3, and 4 of Section 101 are not realized under Alternative 1. Provision 2 is realized by project work intended to provide safe surroundings for residents and visitors. Provisions 5 and 6 are equally realized amongst all alternatives.

Alternative 2 better meets Provision 2 by expanding FFRA treatment acreage, improving safety zones and escape routes, and providing fuel reduction on private land surrounding homes and other structures. Provisions 1, 3, and 4 of Section 101 are still not realized under Alternative 2.

Alternative 3, Preferred Alternative, is also the environmentally preferred alternative. Alternative 3 best meets Provision 2 by treating additional altered acres surrounding Stehekin and Hozomeen that, because of heavy fuel loads, could carry an intense crown fire into either community, and threaten lives and property. Provisions 1, 3, and 4 are realized under this alternative through the restoration of altered fire regimes in wilderness. These treatments will help to restore natural processes and relationships so that they can be maintained indefinitely into the future.

3 Affected Environment

The North Cascades National Park Service Complex was established in 1968. It includes North Cascades National Park, Lake Chelan National Recreation Area, and Ross Lake National Recreation Area, and covers 681,800 acres. The Complex is located in northwest Washington, sharing a boundary with Canada to the north and US Forest Service lands on the remaining sides. The North Cascades are part of a mountain range that stretches from Canada to California along the Pacific Crest. Glaciers have carved the mountain landscape into jagged peaks, deep valleys and long lakes. The Complex is the most heavily glaciated area in the United States outside of Alaska, containing more than 300 glaciers. Thousands of miles of rivers and streams flow from glaciers and over 500 lakes, tarns, and ponds in the Complex. Steep mountains rise to over 9,000 feet from valley floors as low as 400 feet at the west boundary. Variation in elevation, rainfall, and exposure contribute to a diverse population of flora and fauna.

The climate of the Complex is dominated by the rugged topography of the North Cascades Range, the proximity of the area to the Pacific Ocean, and latitude. Strong seasonal, interannual, and interdecadal fluctuations in winter precipitation are also important features of the climate. Precipitation varies seasonally due to the presence of semi-permanent pressure regions over the Pacific Ocean. Most precipitation falls during the fall and winter. During this period the climate of the north Pacific is dominated by the Aleutian Low pressure system. Large-scale circulation associated with the Aleutian Low brings a predominantly southwesterly flow of relatively warm, moist air to the North Cascades.

In the summer the Aleutian Low weakens and moves north, allowing the Subtropical High pressure region to dominate the Pacific. Prevailing westerly winds associated with the subtropical high are from the northwest, bringing relatively cooler, drier air to the Complex, and causing a pronounced seasonal drought in July and August. Analysis of fire records for 1973 through 2003 reveals that the typical fire season coincides with the seasonal drought; the season begins in late June and ends in mid-September. The range of lightning caused fires is from June 2nd to October 30th, with 95% of these fires occurring between June 24th and September 12th. The majority of fires occur in late July (July 26th is the mode), and the fire season peaks by early August (August 3rd is the median).

Winter precipitation varies strongly from year to year, depending on seas surface temperatures in both the tropical and north central Pacific. During warm seas surface temperature anomalies (e.g., El Niño), winter precipitation is typically at or below average. In contrast, cooler ocean temperatures typically result in higher than average winter snowfalls (e.g., La Niña). The interannual El Niño-La Niña climatic variation is superimposed on an interdecadal climatic oscillation known as the Pacific Decadal Oscillation (PDO). The PDO is characterized by 15-20 year periods when winter precipitation in this region is at or below average. During this phase of the PDO, El Niño conditions are often stronger. Separating these periods are 5-10 year long events associated with the opposite phase of the PDO, when winter precipitation is generally above average, but can vary dramatically from year to year.

Since the end of the Little Ice Age in the mid-19th century, the climate of the Complex has been warmer and drier than the preceding century–except for a cold period between 1945 and 1965. The warmer/drier climate in the 20th century has meant glacier retreat and disappearance, rising tree line, and numerous other unmeasured natural system adjustments.

The link between fire regimes and climate variation at long timescales (centuries to millennia) in the Pacific Northwest is complicated and not completely understood. A recent 10,500 year fire history reconstruction created from a montane lake sediment core in the Complex did not find significant differences in mean fire return intervals between the early, mid- and late-Holocene periods (Prichard 2004). Findings from this local study conflict with two other long-term studies; one performed in the Coast Range of Oregon (Long *et al.* 1998), and the other in southwestern British Columbia (Hallet *et al.* 2003). Both of these studies found more frequent fires in the early Holocene that were interpreted to be the result of the warmer and drier summers characteristic of this time period (Thompson 1993).

Recent studies have begun to examine the relationship between fire and interannual (ENSO – El Niño Southern Oscillation) and interdecadal (PDO – Pacific Decadal Oscillation) fluctuations in climate in Pacific Northwest ponderosa pine dominated forests using tree-ring analyses. In the Oregon Cascades Heyerdahl (*et al.* 2002) found large fires to occur primarily during dry years and El Niño years, whereas small fires burned regardless of climatic variation. At the decadal scale Heyerdahl's study indicates that there may be a link between fire extent and the PDO as indicated by the size of fires varying with precipitation. Another study that took place in the nearby Okanogan National Forest (Hessl et al. 2004) supports Heyerdahl's finding that there is a weak link between ENSO years and fire occurrence, although both studies conclude that this link is still ambiguous. On annual time-scales, summer drought during the year of the fire (regardless of ENSO, which primarily influences winter-spring moisture and temperature conditions in the Pacific Northwest) is the clearest climatic factor associated with major fires. Findings from Hessl (*et al.* 2004) indicate a more convincing link between large fire years and dry summers and the positive phase of PDO. Both of these studies have implications for fire management in the future, and warrant further investigation.

3.1 Air Quality

Air quality protection under the Clean Air Act of 1977, as amended, is achieved through implementation of National Ambient Air Quality Standards (NAAQS). Standards are set by the Environmental Protection Agency (EPA) for the following six pollutants considered harmful to public health and the environment: carbon monoxide, lead, nitrogen dioxide, particulate matter, ozone, and sulfur oxides. Particulate matter is the primary indicator of impacts from smoke; NAAQS standards are set for fine particles with a diameter less than or equal to 2.5 micrometers ($PM_{2.5}$) and particles with a diameter less than or equal to 10 micrometers (PM_{10}). $PM_{2.5}$ standards are 65 micrograms per cubic meter of air ($\mu g/m^3$) daily and 15 $\mu g/m^3$ annually. PM_{10} standards are 150 $\mu g/m^3$ daily and 50 $\mu g/m^3$ annually. Primary standards (intended to protect public health) and secondary standards (intended to protect public welfare) are the same for particulate matter.

Under the Clean Air Act, North Cascades National Park is a Class I area, the recreation areas are Class II areas, and much of the Complex is adjacent to other Class I wilderness areas. Class I areas have the most stringent air quality requirements; managers are charged with protecting air quality-related values in these areas from adverse impacts by following State Implementation Plans (SIPs) for attainment of primary and secondary NAAQS, Prevention of Significant Deterioration, and for the protection of visibility. Director's Order #41: Wilderness Preservation and Management, calls for the reduction of impacts of smoke from wildland fires on visibility in Class I wilderness, "while understanding and promoting the need to re-introduce the natural role of fire into wilderness ecosystems (1999)." Final Regional Haze regulations call for the improvement of visibility in national parks and wilderness areas, as well as the development of long-term strategies to reduce emissions that cause visibility impairment in Class I areas.

Managers also must adhere to regulations for prescribed fire contained in the Washington State Department of Natural Resources Smoke Management Plan (SMP). The SMP is the key link between fire management practices and the Clean Air Act. The revisions to the plan in 1998 require approval from the DNR for all burns involving over 100 tons of fuel. Large fire (burn) approval considers a number of factors including the likelihood of intrusion into populated areas and Class I areas, air quality regulations, violation of emission reduction targets, violations of another state's air quality standards, and whether smoke will disperse within given timeframes. Following the SMP, working with the DNR, and obtaining approval from DNR for all burns over 100 tons of fuel assures that the purposes of the SMP are met. These purposes are to:

- Protect human health and safety from the effects of outdoor burning
- Facilitate the enjoyment of the natural attractions of the state
- Provide a limited burning program for the people of this state
- Provide the opportunity for essential forest land burning while minimizing emissions
- Reduce emissions from silvicultural burning (other than for forest health reasons) by 50%
- Foster and encourage the development of alternative methods for disposing of or reducing the amount of organic refuse on forest lands
- Acknowledge the role of fire in forest ecosystems and allow the use of fire under controlled conditions to maintain healthy forests

The potential for deterioration of air quality in the Complex is very high because of prevailing westerly winds from large urban-industrial areas of the Puget Sound lowlands less than 100 miles away. The northern Cascade Range is experiencing significant air pollution from vehicles, industry and other sources from Vancouver, BC, to Portland, Oregon. These impacts include acid precipitation, visibility, smoke, and the effects on biota from air pollution (including mercury pollution). Large-scale farms, industrial operations, cars and other sources contribute to high levels of ozone in the Fraser Valley of British Columbia. The ozone-laden air is transported south down the tributary valleys of the Fraser River into the Complex, where glacial valleys have steep sides that restrict airflow. When winds are too weak to carry pollution over the mountains, they blow it along the valleys.

There is little data regarding air movement in the Pacific Northwest related to transport of pollutants. Studies of heavy metals indicate relatively high concentrations in mountain goat hair and some fish in the North Cascades. Beyond the urban-industrial areas to the west of the Complex, there is growing concern that persistent organic pollutants are being transported into the park from air masses that originate in Asia.

Visibility impairment in the Northwest is often attributed to natural causes, such as fog and low clouds, or to fires, from slash burning or wild or prescribed forest fires. The major internally generated impact on air quality in the Complex is from wildland and prescribed fires. However, impairment from human caused aerosols is also documented.

The Complex monitors air quality at four locations: at the ranger station in Marblemount (404 ft), on the Ross Dam Trail (1,880 ft), at the Visitor Center in Newhalem (525 ft), and at the Stehekin Airstrip (1,230 ft). Beginning in 1984, the Complex began monitoring wet deposition as part of the National Atmospheric Deposition Program (NADP). Rainwater collected is measured for concentrations of sulfate, nitrate, ammonium, calcium, magnesium, sodium, chloride, and potassium, along with pH. In 1996, ozone (O_3), dry deposition (National Dry Deposition

Network) and meteorological parameters were added. In 1999, an IMPROVE (Interagency Monitoring of Protected Visual Environments) station to monitor aerosols was installed in conjunction with a nephelometer provided by the Washington State Department of Ecology (WSDOE) on the Ross Dam Trail. In 2003, a visibility web camera was installed at the North Cascades Visitor Center in Newhalem; images are taken hourly and downloaded to a website. A portable particle monitoring system, E-BAM, was installed in Stehekin in January of 2005 that provides continuous particulate concentration measurements. The E-BAM will be used to monitor particulates created in both wildland and prescribed fire situations. Hourly readings are downloaded to a website.

An analysis of the wet deposition site data indicates wet sulfate concentration and deposition has decreased since 1984. There has been no apparent trend in wet nitrate concentration, wet nitrate deposition, and wet ammonium deposition. Wet ammonium concentration increased through 1993, and then returned to 1984 levels. Given the low elevation of the NADP site, it is likely that the site underestimated wet deposition at higher elevations in the Complex. Dry deposition data indicate dry nitrogen deposition is about ten percent of wet nitrogen deposition, and dry sulfur deposition is about eight percent of wet sulfur deposition. There have been no apparent trends in dry deposition since 1996. Ozone data indicate concentrations have not been high enough to either exceed the human health-based primary NAAQS or to injure ozone-sensitive vegetation, but there is an increasing trend in maximum 1-hour average ozone concentrations. The Marblemount station provides an important measure of background ozone concentrations that may be sensitive to fires located as far away as Siberia (Jaffe 2004).

3.2 Water Resources

The Complex has two major watersheds, the Skagit River and the Stehekin River. Smaller areas are drained by the Chilliwack, Nooksack, and Baker rivers. The Chilliwack is tributary to the Fraser River in British Columbia, the Baker is tributary to the Skagit River, the Nooksack flows directly into Puget Sound, and the Stehekin drains in the Columbia River via Lake Chelan. Annual precipitation ranges from 109 inches at Mount Baker (just west of the Complex) to 33 inches at Stehekin.

Several creeks and rivers within the Complex are listed in the Nationwide Rivers Inventory (NRI), a register of river segments that potentially qualify as national wild, scenic or recreational river areas. Federal agencies are required to avoid or mitigate adverse effects on rivers identified in the NRI. The following creeks or rivers have segments that are listed in the NRI: Agnes Creek, Baker River, Big Beaver Creek, Bridge Creek, Canyon Creek, Chilliwack River, Fisher Creek, Granite Creek, Ruby Creek, Silesia Creek, Skagit River, Stehekin River, and Thunder Creek. The Skagit is designated as a Scenic River below Bacon Creek (outside of NPS boundaries), and one of its tributaries, the Cascade River, is also listed as Scenic.

Floods in the North Cascades can occur three times a year. Summer floods occur during thunderstorms and associated periods of intense rainfall. These floods usually affect areas less than 10 square miles. Also in the summer (typically August) are minor glacial-melt floods that have strong diurnal fluxes. Spring floods occur in May or June because of snowmelt. The magnitude of these floods varies depending upon winter snow pack and spring weather (rain, freezing level, and temperature). Floods can also occur in the late fall to early winter period because of large magnitude precipitation events associated with unusually warm temperatures (high freezing level) and a pre-existing heavy snow pack.

In total, 561 permanent natural water bodies, including lakes, tarns, and ponds, are found in a variety of physical and ecological settings within the Complex. These water bodies range in size from less than an acre to over 160 acres, with approximately 300 that are less than 0.5 acres. Over 300 glaciers exist within the Complex, covering 39 square miles. Glaciers play a significant role in the hydrology and ecosystem function of many of the lakes and streams in the Complex. They provide extremely low temperature water, delay the release of water until several weeks after the spring snowmelt floods have passed, and contribute high-suspended sediment and nutrient loads.

In addition to natural lakes, there are three reservoirs within Ross Lake National Recreation Area that were created in the mid-1900s when Ross Dam, Diablo Dam, and Gorge Dam were built to generate hydroelectric power. Though Lake Chelan is a natural lake, it was also dammed in the 1920s, raising the lake level 21 feet.

It appears that water quality in the Complex is generally very good although it is likely that impacts are occurring from regional air pollution. High elevation lakes may be particularly susceptible to these impacts. Limited monitoring programs are ongoing on some waters. Giardia has been found in some surface waters. Water quality concerns are primarily related to development along Lake Chelan, at concession and NPS visitor facilities on Ross and Diablo lakes, and at the Seattle City Light towns of Newhalem and Diablo. The Clean Water Act provides direction to the Washington State Department of Ecology for water quality standards. The act sets objectives for restoring and maintaining the chemical, physical, and biological integrity of the nation's waters. Also, the act regulates discharge of pollutants and requires federal agencies to avoid adverse impacts from modification or destruction of navigable streams and associated tributaries, wetlands, or other waters.

Outstanding water rights are primarily in the Stehekin Valley. Most of these are for private domestic use, including drinking water. However, Chelan PUD has a permit for diversion from Company Creek for operation of its hydroelectric project.

There are 55 lakes within the Complex identified as eligible for dipping into for helicopter bucket drops during fire suppression. These lakes were selected based on minimum depth and surface area measurements; lakes that are less than or equal to 10 acres in size must be greater than 23 feet deep (maximum depth), and lakes that are greater than 10 acres in size must be greater than 16 feet deep (maximum depth). A list of approved lakes can be found under Appendix D, and a map of these lakes can be found under Appendix A, Figures 5 or 6.

3.3 Topography and Soils

Glaciers and rivers have deeply incised and shaped the North Cascades during its geologically recent uplift. Few areas in the lower 48 states are as rugged as the Complex. Local relief is 8,800 feet, with the lowest point at 400 feet along the Skagit River at the Complex’s west boundary, and high points at several peaks over 9,000 feet. Over 300 small glaciers remain active at the heads of valleys in the Complex. Several times over the past 5,000 years they have advanced a few thousand feet, only to retreat again during warmer/drier periods. The glaciers remain an important factor in the region’s hydrology and landscape evolution as they store vast quantities of water and deliver sediment to the valleys below.

Soil types in the Complex are very diverse because of the variety of topographic settings, parent materials, vegetation, climatic regimes and the age of landforms. Parent materials include alluvium, glacial drift, landslide deposits, volcanic ash deposits and bedrock. The main soil groups in the Complex are andisols, entisols, and spodosols. Soils on steep bedrock slopes and in alpine areas are thin and poorly developed. Soils formed in glacial drift and alluvium on valley bottoms are thickest and best developed. Most are well-drained and highly erodable.

Biological soil crusts (also called cryptogamic, cryptobiotic, microbiotic, and microphytic crusts), formed by living organisms and their by-products, are also found in the Complex. Although the full extent of biological soil crusts within the Complex is unknown, they have been found in alpine, subalpine, and exposed south-aspects of lower elevations. They usually consist of cyanobacteria, green and brown algae, mosses, and lichens, all of which help to bind surface soil particles together. Soil crusts influence soil stability and erosion, N-fixation, nutrient contributions to plants, soil-plant-water relationships, infiltration, seedling germination, and plant growth. Disruption to soil crusts can decrease organism diversity, soil nutrients, stability, and organic matter. Recovery of disrupted soil crusts takes considerable time; quickest are the cyanobacteria and green algae, which can visually recover within 5 years. However, it can take up to 50 years to recover crust thickness, and 250 years to recover mosses and lichens.

Landslides are common in the glacially over-steepened topography of the Complex. Earthquakes and heavy precipitation events are responsible for triggering most landslides in the Complex. The landslides range in area from 0.04 square miles to 0.56 square miles and are described as shallow-seated (100 to 200 feet) debris slides. Channelized mass movements are associated with steep, straight first- and second-order streams. Most of these debris torrent systems in the Complex are dormant, but could become active if vegetation in the upper parts of these watersheds was disturbed.

Two mapping projects are currently underway within the Complex. Surficial geology of every watershed in the Complex is being mapped at the landform scale (1:24,000). Twenty-eight different landforms are being mapped along with development of a landslide inventory database. Seamless map coverage of the Complex will be completed in 2006. A soils mapping project in cooperation with the Natural Resource Conservation Service has begun and is expected to continue through 2007. The majority of the survey will be mapped at 1:24,000, with finer detail in areas of special interest to land managers.

3.4 Fish and Wildlife

The variety of habitats in the Complex supports over 320 vertebrate species. There are approximately 75 mammal species in 20 families and approximately 17 species of reptiles and amphibians representing at least five orders. The avian fauna of the Complex is comprised of roughly 210 species in 38 families. At least 28 species of fish are known to be present in the park and recreation areas. Recent surveys have documented over 500 terrestrial invertebrate taxa and approximately 250 aquatic invertebrate taxa. These findings comprise an unknown, but most likely tiny, fraction of the actual number of invertebrate taxa living within the Complex. Very few quantitative data are available on the population status and distribution of either vertebrates or invertebrates within Complex boundaries.

3.4.1 Rare, Threatened, or Endangered Fish and Wildlife

There are 27 wildlife species listed as threatened, endangered, or candidate species by the State of Washington and/or the federal government. The species listed in Appendix E have been documented within the Complex, or for several species (Keen's myotis, flammulated owl, and Johnson's hairstreak) have core habitat identified within the Complex (Smith *et al.* 1997, Johnson and Cassidy 1997, Pyle 2002).

The Skagit is the only river system in Washington that supports all five species of salmon-the sockeye, pink, coho, chum, and Chinook. Other sensitive animals that are supported by the Skagit include the globally rare Salish sucker, neotropical migrant birds, bald eagles, fishers, grizzly bear, wolves, trumpeter swans, gray-bellied brants, and many raptors and waterfowl. The Skagit River and other watersheds of the North Cascades are habitats that attract one of the largest winter gatherings of bald eagles in the lower 48 states. The eagles travel here to feed on spawned-out salmon carcasses that sustain them through the winter.

The riparian zone of the Stehekin River provides, or could provide important habitat for at least eight federally threatened, endangered, or candidate species, including the bald eagle, northern spotted owl, bull trout, Columbia spotted frog, Pacific fisher, grizzly bear, Canada lynx, and gray wolf. For the past four years, a pair of bald eagles has nested successfully at the head of Lake Chelan near Weaver Point. Harlequin ducks have been observed on the Stehekin River most summers; in 1990, 1991, and 1993, seven to 11 breeding pairs were observed mostly between Rainbow Creek and Harlequin Bridge. Extensive spotted owl surveys were completed in 1993, which found five owl pairs in the valley, four of which were in the vicinity of the Stehekin River. The North Cascades area around Stehekin has had the highest density of fisher records in the state. Under natural forest conditions, the valley would be considered good fisher habitat, particularly the riparian zone. Cascades frogs have been found on the south side of the Stehekin River on Battalion Creek, in riparian areas southeast of the airstrip, and in overflow channels of the river. The Stehekin River and low-gradient tributaries could provide suitable habitat for both westslope cutthroat trout and bull trout.

The North Cascades Ecosystem in Washington was designated in 1991 as one of six grizzly bear recovery zones in the contiguous states. A very small population of grizzly bears occupies North Cascades National Park Service Complex and the adjacent Canadian Province of British Columbia. The grizzly bear is listed as threatened (federal) and endangered (state) in all areas. The North Cascades Grizzly Bear Recovery Zone includes nearly 10,000 square miles roughly defined as federal lands north of Interstate 90 and south of the Canadian border. Approximately 10 percent of the Recovery Zone lies in North Cascades National Park Service Complex.

Listed below are the federal and state listed special status species[3].

MAMMALS

Gray Wolf (*Canus lupus) – FE, SE*
Gray wolves are wide-ranging carnivores that use forested and open habitats with sufficient year-round prey, suitable and somewhat secluded areas for raising pups, and sufficient space with minimal exposure to humans. Rendezvous sites are usually near water, often bordering

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[3] ***FE = Federally Endangered:*** Listed by the U.S. Fish and Wildlife Service as a species that is in danger of extinction throughout all or a significant portion of its range.
FT = Federally Threatened: Listed by the U.S. Fish and Wildlife Service as a species that is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range.
FC = Federal Candidate: A species for which U.S. Fish and Wildlife Service or NOAA Fisheries has on file sufficient information on biological vulnerability and threats to support a proposal to list as endangered or threatened.
SE = Washington State Endangered: Any species native to the state of Washington that is seriously threatened with extinction throughout all or a significant portion of its range within the state without cooperative management or removal of threats.
ST = Washington State Threatened: Any species native to the state of Washington that is likely to become an endangered species within the foreseeable future throughout a significant portion of its range within the state without cooperative management or removal of threats.
SC = Washington State Candidate: Includes species that the department will review for possible listing as state endangered, threatened, of sensitive. A species will be considered for designation as a state candidate if sufficient evidence suggests that its status may meet the listing criteria defined for state endangered, threatened, or sensitive.
SS = Washington State Sensitive: Any species native to the state of Washington that is vulnerable or declining and is likely to become endangered or threatened throughout a significant portion of its range within the state without cooperative management or removal of threats.

meadows. Hunting and other human activities eliminated the gray wolf from Washington by the early 20th century. However, wolves appear to be naturally re-colonizing Washington, especially northern Washington, from Canada. The Complex contains ample habitat for gray wolves and abundant prey. Historically, the gray wolf was found in the Complex. Laufer and Jenkins (1989) cite 119 observations of wolves from Washington during 1946 to 1988, with 83 of these observations coming from the Cascades region. Observations were concentrated near Baker Lake and Ross Lake in the North Cascades region and near Mount Rainier.

There are 30 reported wolf sightings by visitors in the Complex's Wildlife Observation Database, dating back to 1967. Studies conducted by resource management biologists and biologists from the Washington Department of Fish and Wildlife documented wolf presence at Hozomeen in Ross Lake National Recreation Area (photos, NOCA Wildlife Observation Database). However, it is now believed this may have been a released animal. While no systematic surveys for wolves have been conducted in the Complex, several studies have used baited or scented camera stations in an attempt to document the presence of carnivore species. These studies include a vertebrate inventory of the Stehekin Valley in 1991 (Kuntz and Glesne 1993) and a park-wide forest carnivore survey conducted in 2003-2004 (Christophersen and Kuntz, In press). Wolves were not documented on either of these surveys.

Canada Lynx (*Lynx canadensis) – FT, ST*
In Washington, lynx are primarily found in high-elevation forests of the north-central and northeast part of the state (Stinson 2001). In the Cascade Mountains, lynx live in mixed conifer forests, generally above 4,000 feet. Just east of the Complex, in Okanogan County, lynx were often found in lodgepole pine or Engelmann spruce-subalpine fir forests (Koehler 1990). Older, mature forests with downed trees and windfalls provide cover for denning sites, escape, and protection from severe weather. Lynx have large home ranges of fairly contiguous forest habitat. The distribution and abundance of lynx is inextricably tied to that of its primary prey, the snowshoe hare (Stinson 2001). Lynx probably never have been abundant in Washington and their numbers have declined due to over-trapping in the 1980s and from a loss of forest habitat caused by development and urbanization, forest fire suppression, and unsuitable types of forest management. Bobcats and coyotes also have spread into lynx habitats, because packed snow trails were created by recreational activities, and the bobcats and coyotes have out-competed the lynx for food and space.

Although the Complex has suitable habitat for lynx and snowshoe hare in subalpine forests and alpine areas along its eastern border, it is highly fragmented. The Complex's Wildlife Observation Database has only six observation records for lynx. While no systematic surveys specifically for lynx have been conducted in the Complex, a 2003-2004 forest carnivore study using baited camera stations attempted to document the presence of carnivore species (Christophersen and Kuntz, In press). Lynx were not documented in this survey; however, surveys were conducted in late winter / early spring when field conditions did not allow surveyors to access areas best considered lynx habitat. Snowshoe hares have been documented in the Complex, incidentally as part of other projects (photos, resource management files). It is unknown whether hare populations are in sufficient densities to support a viable lynx population.

Adjacent to the Complex there have been reports further suggesting this rare predator may utilize habitat within the Complex boundaries. Remotely triggered camera surveys conducted throughout the North Cascades ecosystem during the summers of 2000-2004 by Northwest Ecosystem Alliance identified the presence of lynx on two occasions adjacent to the Complex's eastern boundary (H. Dodd pers. comm. 2005). In addition, a confirmed lynx record, through

DNA analysis, was documented in 2000 near Crater Mountain along the northeastern border of the Complex (K. Romain, pers. comm. 2005).

Grizzly Bear (*Ursus arctos) – FT, SE*
Grizzly bears are omnivores. However, in the North Cascades, they may be mostly herbivorous. In all areas where grizzlies have been studied, home ranges have been composed of a mosaic of several relatively dissimilar habitat types. Data on actual home range sizes in the North Cascades are lacking.

Historical records compiled by Bjorklund (1980), Sullivan (1983), and Almack *et al.* (1993) indicate grizzly bears occurred throughout the North Cascades Ecosystem, including the Complex. The Wildlife Observation Database documents 15 grizzly bear sightings since establishment of the park in 1968. The last confirmed grizzly bear sighting in the North Cascades Ecosystem was in September 1996. Currently it is believed fewer than 20 grizzlies reside in the North Cascade Ecosystem. Servheen *et al.* (1991) evaluated the North Cascades Ecosystem and confirmed that the area offers sufficient amount of quality habitat to warrant grizzly bear recovery.

Pacific Fisher (*Martes pennanti pacifica) – FC, SE*
Pacific fishers prefer dense forests with extensive, continuous canopies and complex forest floor structure, and they are often associated with wetland forests and riparian areas. Fisher populations have declined throughout much of their range during the last half of the 19th century and the early part of last century. Aubrey and Houston (1992) evaluated 137 records dating from 1894-1991 and determined that fishers occur in the Cascade Range, but are apparently very rare.

The Complex contains suitable habitat for fishers, including large forage areas away from human influences. While no systematic surveys specifically for fisher have been conducted in the Complex, a 2003-2004 forest carnivore study using baited camera stations attempted to document the presence of carnivore species (Christophersen and Kuntz, In press). Fishers were not documented in this survey. Since 1997, nine fisher observations in the Complex have been reported. Several of these observations provide good details, and it is likely at least a few fishers still reside in the Complex.

Western Gray Squirrel (*Sciurus griseus*) – *ST*
The western gray squirrel (*Sciurus griseus*) is the largest native tree squirrel in Washington State. They assist in forage tree propagation by burying single seeds primarily as a food cache, but seeds not retrieved germinate to establish the next generation. The western gray squirrel ranges from north-central Washington south through Oregon to southern California. Historically in Washington the western gray squirrel occurred in mixed conifer and oak communities from southern Puget Sound south to the Columbia River, east along the Columbia River through the Cascades and north along the east slope of the Cascades to Okanogan County (Hall 1981). Today only three geographically isolated populations of this species remain in Washington (Bartels 2000, Linders 2000, Ryan and Carey 1995). Within each of these isolated populations, the numbers of squirrels or squirrel nests are thought to be declining. One population, found in Chelan and Okanogan counties, may be fragmented further into small sub-populations. One of these small sub-populations of squirrels is located within the Stehekin Valley in Lake Chelan National Recreation Area.

Characteristics that make the western gray squirrel vulnerable to extinction include: reliance on increasingly rare large, old mixed oak and conifer forests; dependence on canopy travel for dispersal and escape; high susceptibility to disease; low reproductive rate (one litter per year); and slow recovery time from population reductions; small and isolated populations; and sensitivity to human disturbance. In the Chelan-Okanogan squirrel population, preferred habitat has been described as occurring in the grand fir-Douglas fir zone, typically in a densely vegetated valley with significant amounts of ponderosa pine and near water (WDFW 1993).

Keen's Myotis (*Myotis keenii*) – *SC*
Keen's myotis is restricted to the coastal forests of southeast Alaska, British Columbia and northwest Washington (Harvey et al. 1999). It is believed to roost in tree cavities and rock crevices. This myotis forages high along forest edges and over ponds, streams, and open meadows. A Complex-wide baseline inventory of bats conducted in 1998-2001 did not document this species in the Complex (Christophersen and Kuntz 1993). However, western long-eared myotis (*Myotis evotis*) was documented at a number of sites. Taxonomically, these two species are very similar and it is possible some captures were misidentified and were actually Keen's myotis.

Townsend's Big-eared Bat (*Corynorhinus townsendii*) – *SC*
Townsend's big-eared bats hibernate in caves and use caves, lava tubes, and abandoned buildings for breeding and roosting sites. Nursery colonies are extremely sensitive to human activity, and sites are readily abandoned if disturbed. A Complex-wide baseline inventory of bats conducted in 1998-2001 did not document this species in the Complex (Christophersen and Kuntz 1993). However, this species was confirmed ancillary to this survey using an abandoned cabin within Ross Lake National Recreation Area in 2004 (Christophersen NPS field notes).

California Wolverine (*Gulo gulo luteus*) - *SC*
The California wolverine is a resident of subalpine and alpine areas, including montane grasslands/shrublands and montane coniferous forests. Even in the best habitats wolverines occur in low densities and range over vast areas. Home range sizes for this species range from 38.5 to 348 square miles (Banci 1994) and are tied to the range of their main prey, large ungulates. Historic population declines have been linked to trapping. Current threats include habitat loss and/or alteration, landscape fragmentation due to transportation corridors and associated developments.

Wolverines are believed to be residents of the Complex. There have been 32 unconfirmed, but fairly credible, wolverine observations reported within or adjacent to the Complex (within 0.5 mile) from 1965-1999 (NOCA wildlife observation database). Aerial surveys conducted in 2002 by Washington Department of Fish and Wildlife documented the presence of a wolverine and probable natal den just west of the crest along the eastern border of the Complex (S. Fitkin pers. comm. 2005). Camera surveys conducted throughout the North Cascades ecosystem during the summers of 2000-2004 by Northwest Ecosystem Alliance (H. Dodd pers. comm. 2005) identified the presence of wolverines on one occasion along the Cascade Crest in the Okanogan National Forest.

BIRDS

Bald Eagle *(Haliaeetus leucocephalus) – FT, ST*
Bald eagles are large raptors that primarily forage on fish, but will eat a variety of small mammals, amphibians, crustaceans, and birds (particularly waterfowl). Bald eagles are highly mobile and respond to seasonally fluctuating food supplies by migrating to areas with large dependable concentrations of these resources. In the Pacific Northwest, annual concentrations of spawning salmon and waterfowl populations provide ample food resources for wintering

eagles. One of the largest wintering bald eagle concentrations occurs along the Skagit River, both within and adjacent to the Complex. Over the past 25 years, wintering eagle populations along the Skagit River have been monitored. Eagles typically occur in greatest numbers along the Skagit from mid-December until the end of January. Peak 1-day counts varied from 77 in 1983-84 to 506 in 1991-92. Annual eagle detections increased since first counts were made in 1978. Detections increased most rapidly from 1987-92, but have since averaged about 36 percent below the 1991-92 peak. Besides the Skagit River, wintering bald eagles are also observed in small numbers along reservoirs in the Complex and occasionally along the Stehekin River.

Nesting activity of bald eagles is associated with aquatic habitats (coastal areas, rivers, lakes, and reservoirs) with forested shorelines or cliffs in North America. Throughout their range, they select large, live-topped trees or large snags normally in close proximity to major bodies of water such as lakes and rivers. In Washington, nearly all nests are within 1 mile of a lake, river, or marine shoreline. Bald eagles were not known to nest within the Complex until an active nest was found near the head of Lake Chelan in 2001.

The decline of the bald eagle coincided with the introduction of the pesticide DDT in 1947. Eagles contaminated with DDT failed to lay eggs or produced thin eggshells that broke during incubation. Other causes of decline included shooting, trapping, and poisoning. Since implementation of the Pacific Bald Eagle Recovery Plan, eagle populations have rebounded dramatically. Bald eagles were listed as threatened within the lower 48 states in 1967. In 1999, the US Fish and Wildlife Service proposed to de-list the species. Their decision on de-listing has not been made yet.

Marbled Murrelet (*Brachyramphus marmoratus marmoratus*) – *FT, ST*
The marbled murrelet is a small seabird that feeds on fish in near-shore marine waters. Due to their secretive nature and cryptic coloration, information on the distribution and abundance of marbled murrelets in Washington has been difficult to gather (NPS 1996a). Marbled murrelets nest in forested areas up to 50 miles from their near-shore marine foraging areas. They use primarily old-growth forests (characterized by large trees, a multistoried structure, and moderate to high canopy closure), but will also use mature forests that mimic old-growth characteristics. Nest trees must have large branches or deformities that are used as nesting platforms. Nest trees need to be in forests that are open enough for them to fly through, yet have the canopy cover to hide the nests from predators. Typically such conditions have only been found in old growth or later seral forests; however, some younger forests with a high degree of structural diversity and limb-malforming infestations (e.g., mistletoe) may also be suitable.

The marbled murrelets' threatened status is thought to be principally due to continued loss of nesting habitat and poor reproductive success in the remaining suitable habitat. Principal habitat losses are mainly due to commercial timber harvesting and forest management practices, with additional losses occurring from natural disturbances such as windthrow, both natural and human-caused fire, and development. Forest fragmentation also may be making nests near forest edges vulnerable to predation by other birds, such as jays, crows, ravens, and great horned owls. In addition, increased human activities in forests, such as picnic grounds, can attract corvids and thus increase the chances of predation (USFWS 1991, 1992). Critical habitat for the species has been designated within Whatcom and Skagit Counties, but the designation does not include lands in the Complex.

Potential marbled murrelet habitat is distributed throughout parts of several western drainages in the Complex, including Baker River, Skagit River mainstem (and several third and fourth order streams that empty into the Skagit), Bacon Creek, and possibly the Chilliwack River and several tributaries flowing into the Cascade River. To date, no baseline inventory has been conducted within the Complex. Currently, only two incidental observations document murrelet presence in the Complex (Wildlife Observation Database). However, US Forest Service surveys conducted immediately adjacent to the Complex in the early 1990s documented murrelets using suitable nesting habitat in many of their low elevation drainages. The Forest Service surveys documented two dead young found east of Baker Lake within 1.5 miles of the Complex.

Northern Spotted Owl (*Strix occidentalis caurina*) *– FT, SE*
The northern spotted owl is a medium-sized nocturnal owl that preys primarily on small mammals. The owl is strongly associated with mature or old growth forests that are structurally complex – containing trees of several species, sizes, and ages, standing and down dead trees, with multistoried canopies. Moreover, the birds require large amounts of such habitat. Median home range sizes are typically on the order of 3,000 to 5,000 acres per pair. Spotted owls nest in cavities or platforms in trees, and in good habitat, pairs are typically spaced about 1–2 miles apart. Spotted owls are long-lived, territorial birds, often spending their entire adult life in the same territory. Spotted owl pairs begin to roost in February or March. In late March or early April, the female will lay one to three eggs. Young are fed by both parents until August or September, although fledging may occur in May or June and by October the young disperse from the nest site. Northern spotted owls' nesting and fledging season extends from March 1 through September 30 and in western Washington the late nesting season has been identified as beginning on July 6. Nest trees may include Douglas fir, grand fir, Pacific silver fir and other species, and are usually found in forests up to 4,800 feet in elevation. One identified nesting site on the east side of the Complex is in an old burn.

Habitat degradation and loss threaten this species with extinction. Much of the remaining habitat is highly fragmented. In addition, barred owls *(Strix varia)* have invaded much of the range of the northern spotted owl during the last 30 years and have displaced and hybridized with spotted owls (Dunbar *et al.* 1991; Thomas et al. 1993; Hamer *et al.* 1994). Since listing, Anderson and Burnham (1992) indicate northern spotted owl populations are continuing to decline throughout their range and this decline may be accelerating. Large scale analysis of the northern spotted owl over 23 percent of its range indicated that populations were either relatively stable or were experiencing a decline (3.9 percent annually for female owls) (Franklin et al. 1999). Critical habitat for the species has been designated, but the designation does not include lands within the Complex. The northern spotted owl is an uncommon year-round resident of the Complex (breeding from March and August).

The Complex contains an estimated 329,000 acres of potential suitable habitat. However, this estimate does not take into consideration habitat age or structure and includes forests above 4,000 feet in elevation. Approximately 60 percent of that potential suitable habitat was surveyed from 1993 through 1996 (Kuntz and Christophersen 1996). A total of 11 activity sites were identified during this 4-year survey. Six pairs and five singles were documented at these 11 activity sites. All activity sites were located in closed-canopy coniferous forests dominated by Douglas fir and western hemlock. Activity sites range in elevation from 1,040 feet to 2,880 feet. During the course of this inventory, 42 barred owl activity sites were documented. Since 1996, an additional spotted owl activity site, containing a breeding pair, was documented while conducting spotted owl surveys in conjunction with compliance activities.

American White Pelican (*Pelecanus erythrorynchos) – SE*
American white pelicans are very rare spring and fall migrants to reservoirs in the Complex. Only five observations have been reported for the Complex (Wildlife Observation Database). In

Washington, colonies of American white pelicans have disappeared from historical breeding areas (Johnsgard 1955). Currently, only one breeding colony exists in Washington, occurring in the Columbia River (Walla Walla County). Suitable nesting habitat that is free from human disturbance is rapidly declining (Motschenbacher 1984), thus there are few opportunities for breeding populations of American white pelicans to become reestablished. Additionally, non-breeding and wintering populations occur in Washington throughout the year. Factors limiting success of breeding and non-breeding American white pelican populations include habitat destruction, utilization of wetlands and lakes for other purposes (e.g., irrigation, hydroelectricity, waterfowl production), and intentional or unintentional human disturbance of nesting colonies.

American white pelicans are colonial nesters that breed most often on isolated islands in freshwater lakes and occasionally on isolated islands in rivers. Islands free from human disturbance, mammalian predators, flooding, and erosion are required for successful nesting. American white pelicans require shallow water for foraging. Most feeding occurs between water depths of 0.3-2.5 meters (1-8.3 feet) (Anderson 1991). Feeding mostly takes place along lake or river edges, in open areas within marshes, and occasionally in deep waters of lakes and rivers. American white pelicans feed largely on non-game or "rough" fish, amphibians, and crustaceans.

Ferruginous Hawk (*Buteo regalis) – ST*
Ferruginous hawks nest on cliffs, small rock outcrops, or in trees. They are obligate grassland or desert-shrub habitat nesters, found in Washington only east of the Cascade Range. In the Complex, they are very rare migrants, moving through the alpine and subalpine habitats in late summer. The three records are of lone birds moving along alpine ridges (Wildlife Observation Database).

Western Grebe (*Aechmophorus occidentalis*) – *SC*
This species is a locally common breeder on large freshwater ponds, lakes, and reservoirs in arid areas. In winter, it moves to coastal saltwater lagoons, or stays on large freshwater bodies that remain ice free. In the Complex, western grebes are uncommon winter visitors and rare spring and fall migrants to reservoirs (R. Kuntz pers. field notes).

Northern Goshawk (*Accipiter gentilis*) – *SC*
Goshawks are uncommon residents of the North Cascades. Dense, mature coniferous forests are the preferred nesting habitat of this species. Nests are typically built in the largest trees of the nest stand (Reynolds et al. 1982) and can be in either deciduous or coniferous trees. Smith *et al.* (1997) found that this species is most common along the east-slope of the Cascades. Goshawks have been documented throughout the Complex in suitable habitat, though, based on observational data, they appear to be more common in the Lake Chelan National Recreation Area (NOCA Wildlife Observation Database). However, no systematic surveys of the Complex have been completed for this species.

Golden Eagle *(Aquila chrysaetos*) – *SC*
In the Complex, golden eagles occur as both residents and spring and fall migrants. Resident breeders occur mostly at high elevations in alpine parkland, nesting where large, rocky cliffs occur and where suitable prey (hoary marmots) is available (Smith et al. 1997). A 1987 survey of potential golden eagle habitat identified five nest sites in the Ross Lake drainage, all unoccupied (Bjorklund 1987). From five Septembers in 1984-1988, Bjorklund (1989) documented fall raptor migration at seven sites in the Complex. Golden eagles were observed 37 times over 305 hours of monitoring (X=0.1/hr). This is likely a lower density of this species than actually occurs, as golden eagles tend to move through the Cascades later than most

surveys were conducted (October and November).

Merlin (*Falco columbarius*) – *SC*
The status of merlin in the Complex is uncertain. Smith *et al.* (1997) identifies the subspecies *Falco columbarius columbarius* as a potential rare breeder in high-elevation forests that mimic boreal forest conditions, that is Engelmann spruce and subalpine fir dominated forests. Park biologists have documented this species as a rare visitor in the Complex with all records occurring from late June through December (NOCA Wildlife Observation Database, NPS survey data). No evidence of nesting has been documented within Complex boundaries.

Flammulated Owl (*Otus flammeolus*) – *SC*
Uncommon and local in eastern Washington, flammulated owls occur in mature forests consisting chiefly of ponderosa pine and Douglas fir (Smith *et al.* 1997). Breeding habitat has been described as consisting of well-spaced Douglas firs of varying ages, generally containing thick clumps of young trees with some ponderosa pine. Stand understory is very open and contains grasses and isolated shrubs (Campbell et al. 1990). Smith *et al.* (1997) mapped suitable habitat in Washington. This map identifies low elevation areas within the Stehekin River drainage, including Flat Creek and Bridge Creek as core habitat. Despite efforts over the last 15 years to document vertebrate species within Complex boundaries, flammulated owls remain undocumented (Kuntz and Glesne 1993, Siegel et al. 2005). To date, no surveys specifically targeting flammulated owls have been conducted in the Complex.

Vaux's Swift (*Chaetura vauxi*) – *SC*
Vaux's swift is a fairly common summer visitor to the Complex (NOCA Wildlife Observation Database). This swift prefers to breed in coniferous and mixed coniferous/deciduous forests (Bull and Collins 1993). It is more common in old-growth forests than in younger stands (Manual and Huff 1987). Vaux's nest and roost in hollow trees. It is an aerial forager that spends much of its time in flight just above the forest canopy or over water hawking ants, bugs, flies, moths, spiders, and aphids.

Vaux's swift occurs in the Complex from mid-April through September, though it is more common during the months of June, July, and August (Kuntz et al. 1996). It is found both east and west of the Cascade Crest, though it is more common on the west slope of the Cascades.

Lewis' Woodpecker (*Melanerpes lewis*) – *SC*
Lewis' woodpecker is common in open forests and woody riparian corridors of eastern Washington in the ponderosa pine zone (Smith *et al.* 1997). While it has been documented nesting in both living and dead deciduous and coniferous trees, it shows a preference for ponderosa pine and black cottonwood (Campbell *et al.* 1990). Smith *et al.* (1997) identified core habitat in Washington as including the Stehekin Valley. This woodpecker has been observed three times in the Complex, including a 1971 record at the head of the Stehekin River, and two records from west of the Cascades (Diablo in 1989 and Big Beaver Creek in 1997) that likely were birds wandering outside their normal range (NOCA Wildlife Database).

Black-backed Woodpecker *(Picoides albolarvatus*) – *SC*
Black-backed woodpeckers are uncommon residents in moderate to high elevation, open-canopy east-side coniferous forests. They are locally uncommon in burns at lower elevations and rare in western Washington at high elevations along the Cascade Crest (Smith et al. 1997). In Washington, Kreisel and Stein (1999) found black-backs foraged predominately in western larch and Douglas fir. They feed primarily on larvae of wood-boring beetles, engraver beetles, and mountain pine beetles (Dixon and Saab 2000).

The black-backed woodpecker has been observed in the Complex in late July through mid-August, all east of the Cascade Crest in the Stehekin River drainage (three records, NOCA Wildlife Observation Database).

Pileated Woodpecker (*Dryocopus pileatus*) – *SC*
The pileatd woodpecker is an uncommon resident of Washington in mid-seral and late-seral forests, mostly below 4,000 feet in elevation (Smith et al. 1997). Pileated woodpeckers require large trees. Key habitat includes the presence of large snags for nesting. Pileateds roost in cavities of both live and dead trees. Preferred nest and roost stands are characterized by greater than 60 percent canopy closure and dominated by trees greater than 80 years old. Primary food items include ants, beetles, termites, western spruce budworm, and where available fruit and mast of wild nuts (Bull and Jackson 1995).

In the Complex, pileated woodpeckers are uncommon year-round residents, found on both east and west slopes of the Cascade Crest. Siegel *et al.* (2005) documented this species as occurring in late seral forests at low densities (0.006 birds/ha).

Common Loon (*Gavia immer*) – *SS*
Common loons typically breed on forest lakes with deep inlets and bays (McIntyre and Barr 1997). Lakes often have small islands. During migration, they aggregate on rivers, reservoirs, and lakes. In winter, this species moves to shallow, sheltered marine waters. In all situations, loons require water bodies with ample prey populations (Richardson et al. 2000).

Between 1979 and 1999, a total of 20 confirmed and 12 unconfirmed nest sites were documented in Washington (Richardson et al. 2000). This includes one known site (Hozomeen Lake) in the Complex. Loons are uncommon on reservoirs throughout the Complex from April to October. McIntyre and Barr (1997) cite 10 acres as the minimum lake size needed for a pair of nesting loons. Most water bodies in the Complex are not suitable for nesting loons, as they are either smaller than the 50-acre minimum, fishless, or shoreline water fluctuations (reservoirs) flood the nest or leave the nest site unprotected and too far from water.

Peregrine Falcon (*Falco peregrinus*) – *SS*
Peregrines can be found breeding along the Washington coast (highest density in the San Juan Islands and northern Puget Sound) to the arid canyons of the Columbia River and tributaries in eastern Washington (Hayes and Buchanan 2002). The presence of prominent cliffs is the most common habitat characteristic of peregrine nesting habitat (Hayes and Buchanan 2002). Suitable nest sites require ledges that are inaccessible to mammalian predators and provide protection from inclement weather (Campbell et al. 1990). Usually a lake, river, marsh, or saltwater is in close proximity to the site (Johnsgard 1990). In winter, Puget Sound estuaries and other western Washington coastal estuaries are known to contain high densities of peregrines (Anderson and DeBruyn 1979).

Once globally common, the peregrine falcon experienced a dramatic population decline throughout its range due to the widespread use of the insecticide DDT after World War II (Hayes and Buchanan 2002). Banning of DDT in the early 1970s and an aggressive reintroduction program have led to the recovery of the species. Peregrines were de-listed by the US Fish and Wildlife Service in 1999. In Washington during the period 1980-2001, peregrines increased at an annual rate of over 14 percent (Hayes and Buchanan 2002). Surveys conducted in the early to mid-1980s failed to document any active peregrine eyries in the Complex, though much potential habitat appears to be available (Bjorklund and Drummond 1987). Recently, peregrines have been documented nesting near Newhalem and are thought to breed on cliffs overlooking Big Beaver Valley (P. DeBryun pers. comm.).

AMPHIBIANS

Western Toad (*Bufo boreas*) – *SC*
The Western toad ranges in elevation from sea level to over 7,000 feet. Ovipositon sites and aquatic habitat include lakes, springs, ponds, wetlands, stock ponds and slow-moving parts of streams. Terrestrial habitats are forests, grasslands and along streams. Timing of ovipostion is from January to July with one to eight weeks at a site. Tadpoles metamorphose approximately three months after eggs are laid (Olson and Leonard 1997).

Western toads are most common near marshes and small lakes, but they may wander great distances through dry forests or shrubby thickets. In contrast to the jumping habits of frogs, toads move overland by climbing or crawling. Outside of the breeding season, western toads are nocturnal, spending the day buried in the soil, concealed under woody debris, or in the burrows of other animals. The western toad has been documented in the Stehekin Valley, Big Beaver Valley, Skagit River corridor, Ross Lake and Bridge Creek watershed.

Breeding may occur from February to April at low elevations west of the Cascades and from May to early July at higher elevations in the Cascade Mountains. During daylight, males rest quietly upon logs, moss or grasses along the edge of the breeding pool and at night actively swim in search of the few gravid females visiting the pond. Western toad tadpoles commonly form large schools and swim along the margins of ponds or lakes feeding upon filamentous algae and organic detritus and scavenging carrion. Late in the summer, large concentrations of tiny toadlets may be encountered as they roam about the forest floor or as they cross roads (Leonard, et al, 1993).

Columbia Spotted Frog (*Rana luteiventris*) – *FC, SC*
The Columbia spotted frog is nearly always found in or near a perennial water body (required for breeding) such as a spring, pond, lake or stream backwater. It is most often associated with non-woody wetland plant communities (sedges, rushes and grasses). Breeding occurs in February or March at lower elevations of eastern and western Washington but does not occur until late May or early June at higher elevations. Males are not territorial and may gather in large groups of 25 or more at specific locations in a pond. Females usually lay their eggs adjacent to or mixed with other egg masses. The gelatinous masses are only partially submerged. Eggs are typically deposited in the same locations in successive years. Sometime during their first summer, the tadpoles transform into small froglets about ¾ inch (16-23 mm) in length (Leonard *et al.* 1993). Olson, *et al.* (1997) list dates of oviposition as March – June (laid communally), and metamorphose three to four months after eggs are laid.

In the Complex the Columbia spotted frog has been found throughout the lower Big Beaver Valley (1,600 feet) in appropriate wetland habitat and up middle McMillan Creek beaver ponds (2,500 feet) and lower Luna Creek ponds (2,700 feet). On the east side of the crest they have been documented at Dagger Lake (5,500 feet) and a wetland 0.3 mile downstream; McAlester Lake (5,500 feet), McAlester Pass Pond (6,000 feet), and upper Kettling Lake (5,550 feet) (Holmes and Glesne, 1997,1998,1999).

FISH

Bull Trout (*Salvelinus confluentus*) – *FT, SC*
Bull trout, members of the family Salmonidae, are char native to the Pacific Northwest and western Canada. Bull trout are widespread throughout tributaries of the Columbia River basin in Washington, Oregon, and Idaho, including its headwaters in Montana and Canada. Bull trout also occur in the Klamath River basin of south-central Oregon and in the Jarbidge River in northern Nevada. In the northern part of the Complex, bull trout and/or Dolly Varden inhabit Ross Lake, Diablo Lake, Gorge Lake, the Skagit River and possibly some of the drainages that are accessible including Lightning Creek and Thunder Creek. In the southern part of the Complex bull trout are thought to be extirpated from Lake Chelan but may still be present in the upper portion of the Stehekin River drainage. All natural lakes in the Complex were fish-free but many have been stocked. However, none contain bull trout.

The overall present status of bull trout as a threatened species relates to various factors including general habitat degradation and fragmentation from past and ongoing land management activities, such as timber harvest, mining, road construction and maintenance, hydropower and water diversion/withdrawal activities, agriculture, and grazing. Over-fishing and interspecific competition with introduced non-native fishes, such as brook trout *(Salvelinus fontinalis)* and lake trout *(Salvelinus namaycush)*, are also contributing factors in their decline (Bond 1992; Donald and Alger 1993).

Bull trout have relatively specific habitat requirements compared to other salmonids (Rieman and McIntyre 1993). Habitat components that appear to influence distribution and abundance include water temperature, cover, channel form/stability, valley form, spawning and rearing substrates, and availability of migratory corridors (Rieman and McIntyre 1993).

Bull trout primarily inhabit colder streams, although individual fish are often found in larger river systems (Fraley and Shepard 1989; Rieman and McIntyre 1993, 1995; Rieman et al. 1997). Water temperature above 59° F (15° C) is believed to limit bull trout distribution thereby partially explaining their patchy distribution within a given watershed (Fraley and Shepard 1989; Rieman and McIntyre 1995).

Bull trout exhibit resident and migratory life history strategies through much of their current range (Rieman and McIntyre 1993). Resident bull trout complete their life cycles in the tributary streams in which they spawn and rear. Migratory bull trout spawn in tributary streams where the juvenile fish rear from one to four years before migrating to either a lake (adfluvial), river (fluvial), or in some coastal areas, to saltwater (anadromous) where maturity is reached. Repeat and alternate year spawning has been reported, albeit these frequencies along with post-spawning mortality rates are not well known (Fraley and Shepard 1989; Pratt 1992).

Bull trout typically spawn from October to December during periods of decreasing water temperatures, with most adult migratory bull trout moving upstream in autumn (Brenkman et al. 2001). Bull trout have been documented to travel farther than 150 miles to reach spawning grounds (Fraley and Shepard 1989).

Bull trout are opportunistic feeders with juvenile resident and migratory bull trout preying upon terrestrial and aquatic insects, such as macro-zooplankton, amphipods, mysids, crayfish and small fish (Goetz 1989; Donald and Alger 1993). Adult bull trout are primarily piscivorus, feeding on various salmonids, yellow perch and sculpin species (Fraley and Shepard 1989; Donald and Alger 1993).

Puget-Sound Chinook Salmon (*Oncorhynchus tshawtscha*)
The Puget-Sound Chinook salmon occurs in the Skagit River upstream to Newhalem. Overall, abundance of Chinook salmon has declined substantially from historical levels, and spring Chinook populations are chronically low in abundance. Several anthropogenic factors such as habitat degradation, water diversions, harvest, and artificial supplementation along with various negative natural events (e.g., ocean conditions, weather patterns and environmental variability) have served to adversely impact Chinook salmon populations.

Chinook salmon in the Puget Sound all exhibit an ocean-type life history (Myers et al. 1998). The ocean-type migrate to the sea during their first year of life, usually within three months of emergence, spend most of their life in coastal waters, then return to their natal streams in the fall only a few days to weeks prior to spawning (Healey 1991).

BUTTERFLIES

Johnson's Hairstreak (*Mitoura johnsoni*) - *SC*
The caterpillars of this species feed on dwarf mistletoe (*Arceuthobium campylopodum*) on mature western hemlock and perhaps Douglas-fir in Western Washington, and species of pines and true firs elsewhere. Their long flight period may indicate progressive emergence or two generations. In the foothills of the Olympics, nectaring takes place on Oregon grape, males visit damp earth sites. Adults are on the wing from middle of May to early September with peak numbers in May and August.

This is the only old-growth obligate butterfly, found chiefly in old-growth coniferous forests from sea level to 2,000 feet in elevation. Their range is from central California to southwest British Columbia, southeast Vancouver Island and Lower Fraser Valley east to Hope; Olympic and Mt. Rainier national parks and a very few other Western Washington locales; and sparingly in the Cascades, Coast Range, Siskiyous, Blue and Wallowa Mountains in Oregon. Johnson's hairstreak habitat preference for ancient forests has led to its extirpation in much of its former range. Besides logging, it is also threatened by the spraying of Bacillus thurengensis (Bt) to kill tussock moths and budworms. Soon, the national parks may be the last place to see it (Pyle 2002). Johnson's hairstreak has not been documented in the Complex yet but suitable habitat exists.

3.5 Vegetation

Patterns of vegetation and their associated fire regimes within the Complex are strongly influenced by extreme differences in geomorphology, landforms, topography, physiography, and orographic precipitation gradients across the North Cascades mountain range. These factors create a wide variety of vegetation, including some unique areas in the transitional ecotone between coastal and interior community types (Franklin and Dyrness 1988). The area influenced by the mild, coastal climate to the west of the Cascade Crest in Washington and Oregon is generally referred to as the *westside* subregion, and the area exposed to the harsher, more extreme climate east of the Cascades is referred to as the *eastside* subregion. The vegetation assemblages in the south-eastern portion of the Complex fit the eastside subregion characteristics reasonably well; however, the northern and western portions of the Complex exhibit qualities of both the moist coastal westside assemblages, and an anomalous vegetation complex which is transitional to the maritime and inland climates. This transitional climatic assemblage will hereby be referred to as the *east-west mix*.

The east-west mix assemblages are technically west of the Cascade Crest, but because they are located within such a long stretch of mountains within the range, they are in the rain shadow of mountains even further west of the crest. The east-west mix assemblages have been identified as far west as the Copper River drainage, although they are most well developed within the upper Skagit River – Ross Lake area.

3.5.1 Covertypes and Associated Fire Regimes

This section provides a description of each of the vegetation covertypes and associated fire regimes. Fire has had a profound influence on the age, structure and composition of vegetation in the Pacific Northwest (Agee 1993). The fire environment, described by the *fire regime*, is the interaction of fire and vegetation with respect to the factors influencing them both; including but not limited to climate, topography, soils, and historical land use. The *covertypes* (Table 13) are the dominant species or groups of species that exist in the Complex as identified from one or both previous vegetation mapping efforts: a vegetation and fuels map created by Agee and Pickford in 1985, and a vegetation map created by Pacific Meridian in 1988.

The most detailed description of the vegetation of the Complex, *Vegetation and Fuel Mapping of North Cascades National Park Service Complex*, was written in conjunction with Agee and Pickford's map, and serves as the primary reference for the covertype descriptions and the plant associations in this document. This information is supplemented by regional descriptions of Pacific Northwestern vegetation zones from *Natural Vegetation of Oregon and Washington* (1988 Franklin and Dyrness).

The Pacific Meridian data was chosen to develop the map of the covertypes for this project (Appendix A, Figure 11) because it was developed from a more recent remote sensing image of higher resolution than that used for the development of Agee and Pickford's map. The Pacific Meridian map has been altered for this project in several ways. For example, nearest neighbor classification was used to reassign cells that had previously been lumped into a general "mixed conifer" type to one of the covertypes. Furthermore, several species with very small and scattered distributions were reassigned to more general covertypes (e.g., black cottonwood, quaking aspen, bigleaf maple, and red alder were lumped into "Hardwood Mix").

Table 13. Covertypes of the Complex*

<table>
<tr><th>Covertype</th><th>Acres (% total acres*)</th><th>Mean Elev (ft)</th><th>Dominant Species</th><th>Minor Species</th><th>Plant Associations</th></tr>
<tr><td>Western hemlock</td><td>74,655 (11%)</td><td>3,000</td><td>Western hemlock, Douglas fir, Western redcedar</td><td>Mountain hemlock, Western white pine, Pacific silver fir, Engelmann spruce</td><td rowspan="2">W. hemlock / Salal (Gaultheria shallon), W. hemlock / Mahonia (Berberis nervosa), W. hemlock / Oregon boxwood (Pachistima myrsinites), W. hemlock – W. Redcedar / Oregon boxwood – Mahonia, W. hemlock / Blueberry (Vaccinium sp.), W. hemlock / Vine maple (Acer circinatum), W. hemlock / Sword fern (Polystichum munitum), W. hemlock / Devils club (Oplopanax horridum)</td></tr>
<tr><td>Hardwoods</td><td>5,100 (1%)</td><td>1,515</td><td>Bigleaf maple, Black cottonwood, Red alder</td><td>Paper birch, Pacific dogwood</td></tr>
<tr><td rowspan="3">Douglas fir</td><td rowspan="3">115,514 (17%)</td><td rowspan="3">2,965</td><td>Douglas fir, Western hemlock, Lodgepole pine</td><td>Subalpine fir, Engelmann spruce, Western redcedar</td><td>Douglas fir / Blueberry, Douglas fir / Mahonia – Salal</td></tr>
<tr><td>Douglas fir, Lodgepole pine, +/- Ponderosa pine</td><td rowspan="2">Grand fir, Pacific silver fir</td><td rowspan="2">Douglas fir / Pine grass (Calamagrostis rubescens), Douglas fir / Bearberry (Arctostaphylos uva-ursi), Douglas fir / Oregon boxwood, Grand fir / Oregon boxwood, Douglas fir / Snowberry (Symphoricarpos albus), Douglas fir / Oceanspray (Holodiscus discolor), Ponderosa pine – Douglas fir / Bluebunch wheatgrass (Agropyron spicatum)</td></tr>
<tr><td>Douglas fir, Ponderosa pine, +/- Lodgepole pine</td></tr>
<tr><td>Lodgepole pine</td><td>6,505 (1%)</td><td>2,870</td><td>Lodgepole pine</td><td>Douglas fir</td><td>Douglas fir – Lodgepole pine / Salal, Douglas fir – Lodgepole pine / Mahonia – White spirea (Spiraea betulifolia)</td></tr>
<tr><td>Pacific silver fir</td><td>87,540 (13%)</td><td>4,585</td><td>Pacific silver fir</td><td>Mountain hemlock, Douglas – fir, Western hemlock</td><td>Pacific silver fir / Devil's club, Pacific silver fir / Thin-leaved huckleberry (Vaccinium membranaceum), Pacific silver fir / Oregon boxwood, Pacific silver fir / Alaska huckleberry (V. alaskense), Pacific silver fir / White flowered rhododendron (Rhododendron albiflorum), Pacific silver fir / Fool's huckleberry (Menziesia ferruginea)</td></tr>
<tr><td>Mountain Hemlock</td><td>106,125 (16%)</td><td>5,025</td><td>Mountain hemlock</td><td>Pacific silver fir, Subalpine fir, Alaskan yellow cedar</td><td>Mtn. hemlock / Thin-leaved huckleberry, Mtn. hemlock / Rhododendron albiflorum, Mtn. hemlock / Alaskan huckleberry, Mtn. hemlock / Fool's huckleberry, Mtn. hemlock / Pink mountainheath (Phyllodoce empetriformis) – Blue-leaved huckleberry (V. deliciosum)</td></tr>
<tr><td>Shrubland</td><td>33,785 (5%)</td><td>4,200</td><td colspan="3">Vine maple (A. circinatum), Slide alder (Alnus sinuata), Willow (Salix spp.), Thimbleberry (Rubus parviflorus)</td></tr>
<tr><td rowspan="2">Subalpine fir</td><td rowspan="2">16,400 (2%)</td><td rowspan="2">5,660</td><td>Subalpine fir, Engelmann spruce</td><td rowspan="2">Pacific silver fir, Lodgepole pine, Western white pine, Douglas fir</td><td rowspan="2">Subalpine fir / Oregon boxwood (Pachistima myrsinites), Subalpine fir / Thin-leaved huckleberry, Subalpine fir / Pink mountainheath</td></tr>
<tr><td>Subalpine fir, Whitebark pine, Subalpine larch</td></tr>
<tr><td>Subalpine Meadow</td><td>44,045 (7%)</td><td>5,350</td><td colspan="3">Pink mountainheath, White mountain heather (Cassiope mertensiana), Blue-leaved huckleberry, Partridgefoot (Luetkea pectinata), Sedge (Carex sp.), American bistort (Polygonum bistortoides), Subalpine daisy (Erigeron sp.), Fescue (Festuca sp.)</td></tr>
</table>

*Dominant species and plant associations have been assigned to each vegetation zone and covertype in the Complex from Agee and Pickford (1995). Mean elevation (Elev) in feet, and number and relative cover of acres for each covertype has been assigned using Pacific Meridian data.

**The percentage of total acres includes the rock and snow covertypes, which are not listed here.

The following descriptions of the covertypes refer to the fire regimes according to a classification scheme developed for the interagency Fire Regime Condition Class (FRCC) project (Schmidt et al. 2002). These classifications are based upon historical natural conditions under which fires would typically burn (Table 14).

Table 14. Historical Natural Fire Regimes

I	0 - 35 year frequency and low (surface fires most common) to mixed severity (less than 75% of the dominant overstory vegetation replaced)
II	0 - 35 year frequency and high (stand replacing) severity (greater than 75% of the dominant overstory vegetation replaced)
III	35-100+ year frequency and mixed severity (less than 75% of the dominant overstory vegetation replaced)
IV	35-100+ year frequency and high (stand replacement) severity (greater than 75% of the dominant overstory vegetation replaced)
V	200+ year frequency and high (stand replacement) severity

Western hemlock covertype

The western hemlock covertype thrives in the westside wet, mild and maritime climate for which the Pacific Northwest is noteworthy. These forests are low elevation (averaging 3,000 ft) mixed conifer forests that contain a mix of western hemlock, Douglas fir and western redcedar, and usually include a small component of western white pine, Pacific silver fir and Engelmann spruce. Western hemlock dominated sites are well developed in the moist westside watersheds of the Baker River, Bacon Creek and Newhalem Creek. The western redcedar flats within this covertype have the highest number of large diameter trees per unit area (435 ft^2/acre basal area).

The western hemlock and Douglas fir covertype are interspersed in the east-west mix subregions along Ross Lake. A study conducted at Hozomeen to assist in fire management planning found that the western hemlock covertype occurred at relatively moist sites and less well drained soils compared to adjacent Douglas fir dominated sites that contained western hemlock as a secondary dominant (Kailin 1995). Some of the western hemlock sites are influenced by funnel drainage, potholes, seeps and late season snowfields.

Plant associations that commonly occur on mesic to dry sites include W. hemlock / Salal (*Gaultheria shallon*), W. hemlock / Mahonia (*Berberis nervosa*), W. hemlock / Oregon boxwood (*Pachistima myrsinites*) and W. hemlock – W. Redcedar / Oregon boxwood – Mahonia at warm, low elevation sites, and W. hemlock / Blueberry (*Vaccinium sp.*) at cool, high elevation sites. The W. hemlock / Vine maple (*Acer circinatum*) plant association occurs on well drained slopes, and W. hemlock / Sword fern (*Polystichum munitum*) and W. hemlock / Devils club (*Oplopanax horridum*) associations are prevalent in the moist valley bottoms.

The regional mean fire interval estimate for western hemlock forests in coastal Oregon and Washington is 230 years, although the estimations range from less than 100 years in the driest western hemlock forests of Oregon (Morrison and Swanson 1990), to well above 900 years in some moist coastal forests of the Olympics (Agee 1993). The regional estimate is somewhat unreliable because the fire record is not long enough or regular enough to infer a pattern (Agee 1993). More reliable, however, is that when the conditions for fire spread exist, the fires are usually of high intensity and severity.

Western hemlock dominated forests in the Complex typically have high severity fire events in which more than 75% of the vegetation is replaced at moderate duration intervals of 100 to 400 years. In the east-west mix subregion the average interval is closer to 100 years, whereas on the westside the average interval is closer to 400 years. A 400-year fire history of Desolation Peak calculated a natural fire rotation of 169 years for areas in which western hemlock is the primary dominant in the east-west mix (Agee et al. 1996).

Douglas fir covertype
The Douglas fir covertype is the most prevalent and widely distributed covertype in the Complex. It occupies 17% of the land base, and is represented by westside, eastside and east-west forest associations. It is a low elevation forest type, averaging 2,965 feet, which parallels the western hemlock covertype. In the absence of disturbance it would eventually be replaced by western hemlock on the westside, whereas it is the potential natural vegetation dominant of eastside forests.

The fire regimes of the Douglas fir covertype are distinguishable by the ecological subregion (eastside, westside, or east-west mix) in which they occur, and are identifiable by the species that Douglas fir is associated with. Ranking the Douglas fir covertype fire regimes from moist and cool to hot and dry upon the basis of the secondary dominant tree species, western hemlock is the moistest and coolest, lodgepole pine is intermediate, and ponderosa pine is the hottest and driest.

- **Westside: Douglas fir - Western hemlock - Lodgepole pine**
  In westside forests this covertype occurs alongside the western hemlock covertype, occupying the southern aspects and more mesic sites than the moist western hemlock dominated sites. Of the Douglas fir covertype, this assemblage, comprised of a mix of Douglas fir with substantial amounts of western hemlock and other mixed conifers, is the moistest. The Douglas fir / Blueberry (*Vaccinium sp.*) plant association occurs on cooler sites, whereas the Douglas fir / Mahonia (*Berberis nervosa*) – Salal (*Gaultheria shallon*) plant association occupies warmer sites.

  The westside Douglas fir covertype is classified as a fire regime III, a moderate or mixed severity fire regime. The fire return interval is typically between 100 and 200 years, with less than 75% of the dominant overstory vegetation replaced by fire. Consistent with this classification, a 137-year natural fire rotation was calculated for this covertype at Desolation Peak (Agee *et al.* 1996).

  This fire regime is often referred to as *mixed severity* due to the interaction of low, medium, and high severity fire effects that creates a complex mosaic of patches across the landscape (Agee 1998). These mixed effects ultimately influence the structure and composition in the post-fire stand. If lodgepole pine was present in the pre-fire stand, it may be more likely to dominate regeneration in the most severely burned patches, whereas moderate and low severity patches where the canopy cover is greater, the more shade-tolerant Douglas fir is most competitive (Larson 1972). Finally, without fire, Douglas fir and lodgepole pine lose their dominance in the stand as they are eventually replaced by western hemlock (Agee 1993).

- **East-west mix: Douglas fir - Lodgepole pine +/- Ponderosa pine**
  This covertype represents the dry to mesic east-west mix forest type that occurs at low to mid elevations in the Skagit Fire Management Unit (FMU), most frequently in the Ross Lake area. These forests are dominated by Douglas fir in a mixed conifer assemblage that includes a large component of lodgepole pine amongst other conifers. Grand fir is included in this

covertype because it is a component of the stand; whereas usually Grand fir is prevalent enough to warrant its own covertype, it is not locally abundant.

Lodgepole pine and Douglas fir in the Complex overlap at the xeric end of a moisture gradient scale for Douglas fir (Larson 1972). Douglas fir cover averages 35% and is usually comprised of mature trees. Lodgepole pine cover averages 5% and is represented by younger age classes regenerating post-fire (Agee et al. 1986). At Desolation Peak this forest type occurs mostly on southwesterly exposures and fairly steep slopes (15-85%) that are of low to middle elevations (1,600-4,300 ft). It is also found on very steep south-facing slopes above Lightning Creek.

One of the more unique areas in the Complex occurs in this covertype north of Lightning Creek on the eastside of Ross Lake where there is an unexpected ponderosa pine component west of the Cascade Crest. Ponderosa pine comprises 5% of the stand, mostly consisting of large trees with yellow-bark old-growth characteristics (Agee *et al.* 1986). This dry forest type is restricted to low elevations (1,600 ft to 3,400 ft) on southwesterly aspects within an area that is approximately 1,500 acres. There is a dense understory of shrubs, including many fire-adapted species such as the vigorous post-fire resprouting Snowbush (*Ceanothus velutinus*) (Agee *et al.* 1986). On very rocky sites the shrubs are replaced by drought resistant herbs such as Strawberry (*Fragaria virginiana)*, Yarrow (*Achillea millefolium)*, Pine grass (*Calamogrostis rubescens)* and Hawkweed (*Hieracium)*.

Vegetation associations within the covertype as a whole include Douglas fir / Pine grass (*Calamagrostis rubescens*), Douglas fir / Bearberry (*Arctostaphylos uva-ursi*) and Douglas fir / Oceanspray (*Holodiscus discolor*) on the driest sites, and Douglas fir / Oregon boxwood (*Pachistima myrsinites*), Grand fir / Oregon boxwood and Douglas fir / Snowberry (*Symphoricarpos albus*) on the more mesic sites.

The east-west mixed Douglas fir covertype is classified as a fire regime III, although the fire free interval is shorter than for its coastal counterpart. The natural fire rotation calculated for Douglas fir/lodgepole pine at Desolation Peak is 76 years (Agee *et al.* 1986). This estimate is consistent with Larson's findings of two to three fire scars per 115 years throughout the Ross Lake study area. There are several mixed lodgepole pine/Douglas fir stands with widely varied ages (e.g., 45 year old lodgepole pine and 400 year old Douglas fir) suggesting that successive fire-killed generations of younger lodgepole pine and Douglas fir occurred beneath the older Douglas fir canopy (Larson 1972).

In the unique Douglas fir/ponderosa pine forest type above Lightning Creek the natural fire rotation was 52 years (Agee *et al.* 1986). This was the shortest fire rotation calculated in the 400-year fire history. In areas where ponderosa pine is the primary dominant within this forest type the natural fire rotation was even shorter, calculated at 44 years. Fires in this type were of lower severity, as indicated by the larger density of residual trees.

Although it is not clear whether the high fire frequency above Lightning Creek was partially the result of Native Americans or early settlers burning, it is clear that without low severity fire, the ponderosa pine will eventually be replaced by more shade tolerant species (Agee *et al.* 1986). If fires continue to be suppressed in this area, the increase in fuel loading and development of shade-tolerant conifers in the understory will increase the severity of fire effects if the stand were to ignite. Low severity ground fire favoring the maintenance of the existing ponderosa pine would be replaced by higher severity stand-replacing fire that may favor lodgepole pine regeneration rather than ponderosa pine (Lillybridge et al. 1995).

- **Eastside: Douglas fir - Ponderosa pine +/- Lodgepole pine**
  This eastside vegetation assemblage is the warmest and driest covertype in the Complex. It is found in the Stehekin valley bottom and the valley walls below 3,000 feet. In this covertype Douglas fir is the dominant species, which occurs with ponderosa pine in all layers of the canopy. In the valley bottom the ratio of Douglas fir to ponderosa pine is approximately 8:1 (Kopper and Drake 2002). This covertype also contains some isolated pockets that are dominated by ponderosa pine rather than Douglas fir, although they make up less than 0.2 percent of the total cover. These patches of ponderosa pine dominated forest are found on open rocky slopes above the Stehekin Valley. Throughout the eastside form of the Douglas fir covertype ponderosa pine is much more frequent and evenly distributed than lodgepole pine, although lodgepole pine is present at higher elevations.

  In addition to the vegetation associations that occur in the understory of the Douglas fir - Lodgepole pine +/- Ponderosa pine assemblages of the eastwest mix, Ponderosa pine - Douglas fir / Bluebunch wheatgrass (*Agropyron spicatum*) occurs on the ponderosa pine dominated sites.

  The eastside Douglas fir covertype that occurs throughout the Stehekin Valley is the most xeric type in the Complex, and comparable to the dry Douglas fir mixed conifer of the Rocky Mountains. This fire regime is best characterized by a fire regime I of mixed severity, where stand replacing events occur infrequently (approximately every 100 years) and low severity fires occur more frequently (Agee 1994). A survey of the Stehekin Valley confirmed that large stand replacing events occur at approximately 90- to 100-year intervals (Oliver and Larson 1981). However, a long term fire history study has not been conducted in the Stehekin Valley, thus, by necessity the overall fire frequency for low and high severity fire events is based upon fire history studies in dry Douglas fir forests of the eastern Cascades that have been conducted in forests nearby.

  A recent 433-year fire history reconstruction of the Teenaway River drainage in the Wenatchee National Forest (NF) determined that the median fire interval varied within a range of 7 to 43 years, and that larger fires (9,900 acres or > 4,000 ha) occurred at intervals of 1 to 37 years (Wright and Agee 2004). Another fire history study in the Wenatchee NF compared two 300-year long records in the Nile and Mud Creek watersheds, revealing a mean fire free interval (MFFI) of 7 years at both sites during the pre-settlement period (1700/1750–1860), a MFFI of 7.1 and 10.6 years respectively during the settlement era (1860–1910), and a MFFI of 38.3 and 43.0 years respectively during the suppression era (1910-1996) (Everett *et al.* 2000).

  Mean fire intervals may have been longer (12 + years) in Stehekin because Douglas fir typically dominates the overstory in Stehekin, indicating that fire free intervals were long enough to allow Douglas fir to grow to ample size to survive low severity fire along with the more fire resistant ponderosa pine, whereas ponderosa pine was the dominant in the Wenatchee NF study areas.

  The studies in the Wenatchee NF found fires to historically be variable in size and location (Wright and Agee 2004, Everett *et al.* 2000). Small fires created gaps in the forest canopy that perpetuated a mosaic of fire effects; subsequent fires would burn up to but not within the perimeter of the recently burned areas because the fuels were sparser in those areas (Wright and Agee 2004). Larger fire events occurred in both study areas; however, historically these were not stand-replacing fire events. High severity fires occurred at the stand scale (25 – 250 acres, or 10-100 ha) rather than at the landscape scale (>2500 acres, >1000 ha) (Wright and Agee 2004).

Both studies also found a significant lengthening of fire free intervals in the suppression era (Wright and Agee 2004, Everett *et al.* 2000). Fire suppression and/or other factors have increased ground fuels and understory regeneration beyond historic levels; forests of this type were fairly open, perhaps containing 20 trees/acre (50 trees/ha) and 65ft^2 (15m^2) of basal area that was predominantly ponderosa pine, and having low levels of coarse woody debris (Agee 1994, Wright and Agee 2004).

Given that there are differences between Stehekin and Wenatchee (e.g., the average fire interval in Stehekin is probably closer to the longer end of the range determined in the Wenatchee NF, and Douglas fir was probably always the dominant tree in the overstory), managers are only confident in assuming that one fire return has been missed (Agee, personal communication). This cautious estimate is supported by the survey performed in preparation of the 1995 Stehekin Plan which documents the "unnatural fuels buildup", insects and disease as evidence of fire suppression (Oliver and Larson 1981, USDI 1995), and current fire effects monitoring data (Kopper and Drake 2002).

Lodgepole pine covertype

The lodgepole pine covertype represents the relatively pure lodgepole pine stands. Lodgepole pine achieves its maximum importance in the 1,000 to 3,500 feet elevation range, and may be "permanent" or "climax" in this range along with Douglas fir (Larson 1972). These stands are primarily mature to overmature (usually greater than 80 years in age), and evidence of mountain pine beetle kill is apparent along Ross Lake. Lodgepole pine stands below Ross Dam are predominantly comprised of coastal assemblages of species (westside) whereas a strong interior or eastside floristic element is evident in the Ross Lake Basin, particularly east of the lake (Larson 1972). The Douglas fir – Lodgepole pine / Salal and Douglas fir – Lodgepole pine / Mahonia – White spirea (*Spiraea betulifolia*) plant associations occur in this covertype.

The lodgepole pine fire regime in the Complex is a mixed severity fire regime that fits reasonably well in the fire regime IV category, in which more than 75% of the stand is replaced at approximately 100-year intervals. There is typically a mix of low, moderate and high severity events, and fire frequency is not well documented (Agee 1993). Due to widespread mountain pine beetle (*Dendroctonus ponderosae*) infestations in the lodgepole pine stands throughout the Ross Lake area, the heavy fuel loadings from dead or dying trees create the conditions most conducive to high severity fire events, especially if dry, hot and windy conditions occur.

Lodgepole pine dominated sites in the Complex appear to be perpetuated by high severity fire events; lodgepole pine is the most likely pioneer following stand-replacement events, and its continued dominance on the site is reliant upon these high severity fires reducing competition from more shade tolerant species (Larson 1972). In his thesis on the ecological role of lodgepole pine in the upper Skagit Valley, Larson notes that the ages of many of the lodgepole pine stands coincide with the major fire of 1859 that was reported in the upper Skagit River Valley, or the 1926 fire which originated at Big Beaver Creek and burned over 40,000 acres (Larson 1972, Thompson, 1970). Similarly, the initiation of many lodgepole pine stands below Ross Dam correspond to the years 1890 and 1917 when large fires were reported in that area.

Pacific silver fir covertype

This Pacific silver fir covertype is notable for having the highest basal area (densest stands of large trees) in the Complex. It is comprised primarily of Pacific silver fir with western hemlock and Douglas fir associates on lower elevation sites, and mountain hemlock, Alaska yellow cedar, subalpine fir and lodgepole pine associates on higher elevation sites. Pacific silver fir is the potential natural dominant tree species, although young stands are primarily established by more fire tolerant and less shade dependent species such as Douglas fir.

The Pacific silver fir covertype is in the montane region, with an average elevation of 4,585 feet, which is above the western hemlock and Douglas fir covertypes and below the subalpine forests. It is considerably cooler and wetter in the montane, with a short growing season and a significant winter snowpack. The Pacific silver fir covertype is most commonly associated with westside assemblages, although it is also found on north-facing slopes and moist mid-elevation valley bottoms in more easterly locations. Concentrations occur in the Cascade, Baker, and Chilliwack rivers, and the upper reaches of Newhalem, Big Beaver, Little Beaver, and Thunder creeks.

Plant associations recognized for this covertype include Pacific silver fir / Devil's club (*Oplopanax horridum*), Pacific silver fir / Thin-leaved huckleberry (*Vaccinium membranaceum*), Pacific silver fir / Oregon boxwood (*Pachistima myrsinites*), Pacific silver fir / Alaska huckleberry (*V. alaskense*), Pacific silver fir / *Rhododendron albiflorum* and Pacific silver fir / Fool's huckleberry (*Menziesia ferruginea)*.

Fire return intervals recorded in the Complex for Pacific silver fir forests are comparatively shorter than in other Pacific silver fir forests of western Washington. For example, at Desolation Peak fire return intervals are between 100 and 200 years, whereas at Mt. Rainier there is a 300 to 535 year interval (Agee 1993). This is primarily due to drier conditions exhibited in the surrounding matrix forests of the Complex.

Due to the low resistance to fire of Pacific silver fir and most of the conifers in this covertype other than Douglas fir, the majority of trees within the perimeter of wildland fire will die, and these stand replacing fire events will serve as primary sites for regeneration of fir, hemlock and lodgepole pine. The fire severity was predominantly stand replacing on a Pacific silver fir dominated site at Big Beaver that was managed for wildland fire use in 2003 (Kopper, *personal observation*).

Mountain hemlock covertype
The mountain hemlock covertype is the highest elevation covertype west of the Cascades, with an average elevation of 5,025 feet, and the coolest and wettest conditions in the Complex. The canopy is generally continuous at lower elevations, and grades into open parkland at higher elevations. Mountain hemlock is the dominant tree species, although Pacific silver fir may be the potential natural dominant in the closed forest type where it comprises one-third of the basal area and dominates understory regeneration. Other common associates include Alaska yellow cedar on moist sites and Douglas fir and subalpine fir on drier sites.

The plant associations found in this covertype include Mtn. hemlock / Thin-leaved huckleberry (*Vaccinium membranaceum*), Mtn. hemlock / *Rhododendron albiflorum*, Mtn. hemlock / Alaskan huckleberry (*V. alaskense*), Mtn. hemlock / Fool's huckleberry (Menziesia ferruginea) and Mtn. hemlock / Pink mountainheath (*Phyllodoce empetriformis)* - Blue-leaved huckleberry (*V. deliciosum*).

Subalpine fir covertype
The subalpine fir covertype is the eastside equivalent of the mountain hemlock covertype. Although it is not quite as moist as its coastal counterpart, it is the highest, coolest and wettest

zone east of the Cascades. Like the mountain hemlock covertype, there is a closed forest type and an open parkland community.

Appropriately, subalpine fir is the dominant, seral and potential natural species in this covertype; however, Engelmann spruce is also prominent in these stands, along with Pacific silver fir and mountain hemlock. On dry ridges, the open parklands in the subalpine fir covertype usually contain a considerable amount of whitebark pine and subalpine larch. These species often occur in their stunted Krummholz form on ridgetops and in rocky basins. Whitebark pine is most prevalent on the drier sites, whereas subalpine larch dominates the coldest treeline habitats in the park.

The Subalpine fir / Oregon boxwood (*Pachistima myrsinites*), Subalpine fir / Thin-leaved huckleberry (*Vaccinium membranaceum*), and Subalpine fir / Pink mountainheath (*Phyllodoce empetriformis*) plant associations occur in this covertype.

The fire regimes of the subalpine forest types, mountain hemlock and subalpine fir are both classified as a fire regime V in which fire free intervals are greater than 200 years, and where high fire severity fire creates stand replacement. The longest term fire history study (10,500 years) of a subalpine fire regime in the Complex was recently completed in a subalpine forest in the Thunder Creek Watershed (Prichard 2003). This reconstruction was based on charcoal, macrofossil and pollen records in a lake sediment core that documents fire frequency fluctuations between 30 to 400 years throughout this time period.

Fire intervals in whitebark pine/subalpine larch forests may be slightly shorter, and thus are classified in fire regime IV. Agee summarized whitebark pine research, which has primarily occurred in the Rocky Mountains, noting that fire-return intervals range from long intervals similar to the lower subalpine forests, to intervals as frequent as 30 years (Agee 1993, Morgan and Bunting 1990).

Subalpine meadow covertype
Subalpine meadows are the coldest and highest elevation plant communities. They are located above continuous forest, and form a mosaic alongside scattered patches of trees in the subalpine areas throughout the Complex. These meadows are dominated by heather and huckleberry shrubs that share drier areas with alpine fescues, and the wetter areas that melt out last, with sedges.

The subalpine meadow fire regime is characterized by infrequent fire events of fire regime V. Fire events are infrequent because these meadows are typically moist from snowmelt, and have very sparse ground fuels occurring around pioneer trees. Agee (1993) surmises that variable effects on heather and vaccinium recovery may be dependent upon the type of fire; a post-fire study on a fire at Sourdough Ridge in the North Cascades found vaccinium to replace heather in burned areas (Douglas and Ballard 1971), whereas a study of the Chimney Peak fire in the Olympics found red heather to sprout vigorously (Potash 1989).

Drier, eastside grass and sedge dominated subalpine meadows may burn more frequently, as an abundance of charcoal in the soil of these sites attests to (Kuramoto and Bliss 1970).

Shrubland covertype
Shrubs are the dominant vegetation type on the steep, moist slopes of avalanche chutes. Sitka alder, willows and vine maple dominate these sites. This covertype also occurs in wetlands, drainages, and some sites that have recently burned. The shrubland covertype delineated by

Pacific Meridian did not accurately distinguish between the vaccinium and heather shrublands of subalpine meadows, which occur at the highest elevations in the Complex, and those of avalanche chutes, which occur from base to height of avalanches. Therefore, the average elevation is somewhat skewed for both the subalpine meadow and shrubland covertypes.

Hardwood covertype
Hardwood dominated patches are common along the river valley bottoms and at the bases of avalanche chutes in both the western hemlock and the Douglas fir covertypes. Moist forests along the rivers are primarily dominated by bigleaf maple and black cottonwood, whereas red alder and paper birch are more abundant on slopes. Hardwood stands also occur as an early successional stage following disturbances. For example, bigleaf maple stands commonly regenerate areas following fire, and also fill in root-rot pockets. The hardwood covertype is common along the Baker, Big Beaver, Little Beaver, McMillan, Cascade, and Stehekin drainages.

The hardwood and shrubland covertypes occur in various locations, and within multiple fire regimes in the Complex. Shrublands usually occur in moist areas, such as avalanche chutes. The hardwood covertype habitat can also be moist, such as where bigleaf maple and red alder inhabit valley bottoms and stream banks. When the hardwood or shrubland covertype is in a moist environment it often acts as a barrier to fire spread. However, when conditions are hot and dry, wildland fire is stand-replacing.

3.5.2 Condition Classes and Fuel Models

Condition classes and fuel models aid in setting objectives and prioritizing areas for restoration. Condition classes (Table 15) provide a quantitative measure of the vegetation community characteristics as compared to the historical range of variability of its fire regime. Fuel models provide a quantitative measure of the amount of standing live and dead and dead and downed fuels that can also be compared to reference conditions. A map of the FRCC *condition class* of the covertypes was developed on the basis of the degree of departure from the historical natural fire regimes that vegetation communities in the Complex have experienced. The fire management strategies for restoration have been developed with respect to their current condition classes, such that restorative thinning and prescribed burn treatments are proposed in condition classes 2 and 3, and management of wildland fire opportunities is proposed in condition class 1 areas.

Table 15. Condition Classes

1	Within the natural (historical) range of variability of vegetation characteristics; fuel composition; fire frequency, severity and pattern; and other associated disturbances
2	Moderate departure from the natural (historical) regime of vegetation characteristics; fuel composition; fire frequency, severity and pattern; and other associated disturbances
3	High departure from the natural (historical) regime of vegetation characteristics; fuel composition; fire frequency, severity and pattern; and other associated disturbances

The map of the condition classes of the Complex (Appendix A, Figure 12) shows that most of the Complex is within its historical range of variability. Only the dry Douglas fir forests of the Stehekin Valley have a high degree of departure from historical conditions (Condition Class 3). East-west mixed Douglas fir forests and lodgepole pine forests are moderately altered due to some departure from historic fire frequency, as well as due to the occurrence of insects and disease.

The Northern Forest Fire Laboratory (NFFL) fuel models are also considered during fire management planning efforts and activities. They are used to classify the vegetation assemblages with respect to the amount of dead and downed fuels occurring in the three *time-lag fuel classes*[4] as well as by the density and diameter of living and dead trees in forested vegetation communities (Table 16). The Pacific Meridian data was used to map the NFFL fuel models for the Complex by canopy cover and density of the covertypes (Appendix A, Figure 13). The fuel model assignments and map are used to run RERAP (Rare Event Risk Analysis Program) to predict fire spread according to season, and FOFEM (First Order Fire Effects) to analyze smoke emissions within the Complex.

Table 16. NFFL Fuel Models

Fuel model	Typical fuel complex	1 hour (0 – ¼”) tons/acre	10 hour (1/4 – 1”) tons/acre	100 hour (1 – 3”) tons/acre	Fuel depth (Ft)
1	Short grass (1 foot): *Meadow*	0.74	0.00	0.00	1.0
2	Timber (grass and understory): *Woodland*	2.00	1.00	0.50	1.0
5	Brush (2 feet): *Shrubland*	1.00	0.50	0.00	2.0
8	Closed timber litter: *Timber*	1.50	1.00	2.50	0.2
9	Hardwood litter: *Hardwood*	2.92	0.41	0.15	0.2
10	Timber (litter and understory): *Heavy Timber*	3.01	2.00	5.01	1.0

(Anderson 1982) with names used in the Complex in italics.

Table 17 below shows the condition class, fire regime and fuel model designations for the Complex. It is evident that most of the fire regimes of the Complex are of mixed or high (stand-replacing) severity. Only the eastside Douglas fir/ponderosa pine forests of Stehekin had a majority of frequent low severity fire events.

[4] Time-lag fuel classes are fuel size classes that are separated according to the average amount of time that it takes to gain or lose two-thirds of their moisture content; 1 hour for 0 – ¼ “ diameter fuel, 10 hours for ¼ - 1” diameter fuel, and 100 hours for 1 – 3” diameter fuel.

Table 17. Condition Classes, Fire Regimes and NFFL Fuel models of the Covertypes

Covertype	Dominant Species	Condition Class	Historical Fire Regime	P: primary NFFL S: secondary NFFL
Western hemlock	Western hemlock, Douglas fir, Western Red cedar	1	V	P:8 S:10 (closed canopy, large diameter trees)
Hardwoods	Bigleaf maple, Black cottonwood, Red alder	1	II / III / V	P: 9 (Bigleaf maple, Red alder) S: 8 (Other hardwoods)
Douglas fir	Douglas fir, Western hemlock, Lodgepole pine	1	III	P:8 S:10 (closed canopy, large diameter trees)
	Douglas fir, Lodgepole pine, Ponderosa pine	2	III	P:8 S:10 (closed canopy, large diameter trees)
	Douglas fir, Ponderosa pine, Lodgepole pine	3	I	P:8 S:9 (open canopy, large diameter ponderosa pine) S:2 (open canopy, small diameter ponderosa pine)
Lodgepole pine	Lodgepole pine	2	IV	P:8 S:10 (closed canopy, large diameter trees)
Pacific silver fir	Pacific silver fir	1	V	P:8 S:10 (closed canopy, large diameter trees)
Mountain Hemlock	Mountain hemlock	1	V	P:8 S:10 (closed canopy, large diameter trees)
Shrubland	Vine maple, Slide alder, Willow, Thimbleberry	1	II / III / V	P: 5
Subalpine fir	Subalpine fir, Engelmann spruce	1	V	P: 10
	Subalpine fir, Whitebark Pine, Subalpine larch	1	IV	P: 8 (Subalpine larch and Whitebark pine) S: 10 (Subalpine fir)
Subalpine Meadow	Heather and Vaccinium	1	IV / V	P: 1

The fuel models of the vegetation types are primarily within their expected range of variability. One notable exception to this is the strong presence of the heavy timber fuel model 10 in the Douglas fir / ponderosa pine covertype. Open and closed canopy stands in the Douglas fir covertype are primarily classified as NFFL fuel model 8, although the densest stands of the largest diameter trees are NFFL fuel model 10. Although NFFL fuel model 10 is not an indication of an unnatural fuel buildup in the westside subregions containing western hemlock, it may be indicative of altered forest conditions in the dry eastside Douglas fir forests where fuel loads remain low due to periodic low severity fires (Arno *et al.* 1995, Agee 1993).

Altered fuel loadings and dense stand structure not only increase fire potential, but the greater number of trees per area may also increase competition for soil moisture, thus creating greater susceptibility to defoliation and bark beetle infestation (Camp et al. 1997). A heavy average fuel loading of 31.5 tons per acre total fuel loading (7.4 woody, 24.1 litter and duff), and greater than 250 trees/ha (of overstory trees > 15 cm dbh) are currently found in the Stehekin Valley Forest Fuel Reduction Areas (Kopper 2004). These conditions are likely to create crown fires and high severity fire events (Wright and Agee 2004, Hessburg and Agee 2003). The Douglas fir covertype is classified as a Condition Class 3 due to its altered stand conditions, and the missed fire return interval(s) that contributed to this condition.

Fire regimes in the Douglas fir/lodgepole pine and the lodgepole pine covertypes are classified as Condition Class 2 because without the reintroduction of fire, the lodgepole pine and Douglas fir will be replaced by more shade tolerant species (Agee *et al.* 1986).

3.5.3 Project Descriptions

The condition classes, fuel models, and examination of the vegetation communities and fire regimes above form the basis for the proposed fire management projects in this EA. The following descriptions are intended to provide additional background information and help to synthesize all of the factors that contributed to the proposed action.

Hozomeen Contours
The fire history study of Desolation (Agee *et al.* 1986) aids in fire management planning for natural fires and defines the need for prescribed burning in this area. As mentioned in Section 3.5.1, this study addresses the need to preserve the unique Douglas fir/ponderosa pine/lodgepole pine community above Lightning Creek. Little Jackass Mountain south of Hozomeen is another area containing dry Douglas fir communities that has experienced a high density of lightning strikes and suppressed fires. Heavy and continuous fuels here are of concern because fire in this area moves in a north-easterly direction, thus threatening the residents, visitors, and developments at Hozomeen. It is likely that both Lightning Creek and Little Jackass Mountain have missed one fire rotation (Agee personal communication). Prescribed burning will preserve the unique community above Lightning Creek and restore fire to Little Jackass Mountain for the protection of the community and restoration of altered forest types. In addition, this action will allow wildland fire use and re-ignition to be utilized, whereas currently they are not viable options.

Stehekin Contours
The Stehekin Contours project was developed in response to a recommendation by the Peer Review Committee in 2000 that encouraged the Complex to "Explore the uses of prescribed fire outside of the current planned area to meet forest restoration goals, reduce threat of large scale wildfire events threatening the Stehekin Valley, and to increase the opportunity for Wildland Fire Use for Resource Benefits (WFURB) to renew its role in higher elevation forests" (see Appendix C). It was recognized that although the FFRAs would be effective at protecting the Stehekin Community from a fire originating on the valley floor, the threat of a fire moving into the valley from higher elevation ignitions still exists because there are continuous and heavy fuels between the mid- and high-elevation slopes to carry fire.

Although there has not been a complete fire history study of Stehekin, it is accepted that this area has missed at least one fire return interval (Agee, personal communication). This determination has been made on the basis of the current stand conditions, fire behavior and fire effects in this area, a 48-year record of documented fires in Stehekin, preliminary results from an informal tree-ring record, and fire history studies from nearby forests of the same community type.

The forest stand composition consists of an overstory of Douglas fir and a substantial component of large diameter ponderosa pine. The effects of fire exclusion are apparent in the dense understory, where there is only a small component of the shade intolerant ponderosa pine and a dense and continuous understory canopy of Douglas fir. This stand condition is a typical result of fire exclusion, in which the more shade-tolerant and less fire-tolerant Douglas fir out-competes the ponderosa pine, which becomes weakened and often succumbs to insects and disease (Agee 1993, Gruell *et al.* 1982).

The fire regime in Stehekin is a moderate (or mixed) severity fire regime where stand replacing events occur infrequently (approximately every 100 years (Oliver and Larson 1981), and low severity fires occur more frequently (e.g., 6 to 38 years (Ohlson and Schellhaus 1999) (Agee 1993, Harper 2003)). When these fire regimes are not significantly altered, fires tend to burn in a mosaic of low, medium and high severity patches, whereas more recent fire events in this area, such as the 1994 Boulder Creek Fire, tend to be more of a homogenous high severity indicating that the regime is altered (Camp *et al.* 1997).

Fire history studies for nearby forests with similar stand compositions found median fire intervals before the settlement period to vary within a range of 7 to 43 years (Wright and Agee 2004) or at an average of every 7 years (Everett 2002). Although fire return intervals may be somewhat greater than in these forests, it is anticipated that at least one fire return interval has been missed (Agee personal communication).

Treatment of the Stehekin Contours will not only enhance fire-dependent communities, but will also provide more opportunities for wildland fire use closer to Stehekin. Wildland fire use will help to maintain the natural process of fire in areas in which it is currently extinguished, thus preventing the further alteration of the fire regime and reducing the risk for a fire that would burn outside of its normal range of intensity and severity.

3.5.4 Threatened, Endangered, and Special Status Plant Species

Federally Listed Species
At this time no federally listed species, candidate species or species of concern are known to occur within North Cascades National Park Service Complex.

State Listed Species
Those plants listed by the State of Washington, Natural Heritage Department are found in Appendix F. For each species, elevation range, habitat, blooming time and state status are listed. Specific locations within the Complex are not known or have not been verified for many of the species listed. The list of sensitive plant species will be reviewed and revised as necessary on an annual basis to ensure current information is available for each fire season. Plants on the state list will collectively be referred to as “sensitive plants” in this document.

Park Species of Special Management Concern
In addition to those taxa with Washington State status, managers are developing a list of plant species and habitats of special management concern in the Complex. Some of the species included in this designation may have been officially de-listed by Washington State or by the

Federal government, but due to their limited distribution remain of concern to park management. Species or habitats of special concern include locally rare natives, those that are endemic to the Complex, species at the furthest extent of their range, species of special importance to the Complex (identified in legislation or by park management objectives), species of unusual public interest, and those vulnerable to local population declines. To date the species and plant assemblages that have been identified by staff are whitebark pine, aspen, large diameter old growth conifers, and the ponderosa pine stands on the eastside of Ross Lake.

Sensitive Plant Surveys
Numerous plant surveys have been conducted in Stehekin, including several within hazard fuel reduction project areas and the Stehekin Contours units. Common moonwort (*Botrychium lunaria*), giant hellebore (*Epipactis gigantea), c*ommon blue-cup (*Githopsis specularioides*) and Sierra cliff brake (*Pellea brachyptera)* were found in surveys conducted in the Lake Chelan National Recreation Area. These plants were found either on the valley floor or on the valley walls.

Other sensitive species that have been located or verified within the Complex in the last three years include: Arctic aster (*Aster sibiricus*), moonwort (*Botrychium minganense*), stalked moonwort (*Botrychium pedunculosum*), Buxbaum's sedge (*Carex buxbaumii*), russet sedge (*Carex saxatilis* var. *major*), Salish fleabane (*Erigeron salishii*), bog clubmoss (*Lycopodiella inundata*), Kotzebue's grass-of Parnassus (*Parnassia kotzebuei var. kotzebuei*) and curved woodrush (*Luzula arcuata*)

The Hozomeen burn units have not been surveyed for sensitive plant species to date. The units will be surveyed prior to the ignition of these units.

3.5.5 Invasive Species

The Complex contains at least 231 non-native plant species. While not all of these species are considered invasive, a small percentage of them have the potential to invade both disturbed and undisturbed habitats, forming dense monocultures, and altering ecosystem processes. Most of the invasive plant species in the Complex are found in disturbed zones including both areas of anthropogenic disturbance (rights-of-way, trails, visitor use areas, reservoir edges), and areas of natural disturbance (riparian corridors, avalanche chutes, landslides, burned areas). The most common invasive species in the Complex are listed in Table 18.

Table 18. Common Invasive Species in the Complex

Bull and Canada thistle *(Cirsium vulgare, C. arvense)*	Knapweeds *(Centaurea* spp.*)*
Cheatgrass (*Bromus tectorum*)	Orange and yellow hawkweed *(Hieracium aurantiacum, H. pratense)*
Common crupina *(Crupina vulgaris)*	Orchardgrass (*Dactylis glomerata*)
Common mullein *(Verbascum thapsus)*	Oxeye daisy (*Chrysanthemum leucanthemum)*
Common salsify (*Tragopogon porrifolius*)	Periwinkle *(Vinca major)*
English ivy *(Hedera helix)*	Quackgrass (*Agropyron repens*)
Everlasting peavine *(Lathyrus latifolius)*	Reed canarygrass *(Phalaris arundinacea)*
Herb Robert *(Geranium robertianum)*	Rush skeletonweed *(Chondrilla juncea)*
Himalayan blackberry (*Rubus discolor*)	Scotch broom *(Cytisus scoparius)*
Japanese, Giant, Himalayan and Bohemian knotweed *(Polygonum* spp.*)*	Yellow and dalmation Toadflax *(Linaria* spp.*)*

3.6 Research Natural Areas

Research Natural Areas (RNAs) are administratively designated areas identified for unique natural features with essentially no past human influence. They are part of a national network of sites designed to facilitate research and preserve natural features, and they are usually established in a typical example of an ecological community type, preferably one having been little disturbed in the past and where natural processes are not unduly impeded. The tract is set aside permanently and is managed exclusively for approved non-manipulative research; i.e., research that measures but does not alter existing conditions.

RNAs are special sub-zones within natural zones; as outlined in the 1988 GMP, natural zones are lands and waters that are managed to ensure that natural resources and processes remain largely unaltered by human activity. Developments are generally absent or limited to dispersed recreational and management facilities. RNAs are within these zones and are strictly protected for their scientific values. There are five RNAs within the Complex, totaling 21,631 acres (See Appendix A, Figure 1):

1. *Big Beaver* (3,356 acres) was established in 1989 to exemplify a river valley bottom mosaic of terrestrial, semi-aquatic, and aquatic communities; and an old growth western red cedar forest.
2. *Boston Glacier* (2,839 acres) was established in 1973 to provide an example of an active North Cascade glacier with attendant ponds, streams, and plant communities in its associated cirque basin.
3. *Pyramid Lake* (164 acres) was established in 1972 to protect a small oligotrophic lake and the surrounding habitat of the rough-skinned newt (*Taricha granulosa* var. *granulosa*). The area also includes a small, rapidly flowing stream and both recently disturbed and mature montane forest.
4. *Silver Lake* (1,627 acres) was established in 1974 to exemplify an alpine cirque lake typical of those on the western slopes of the North Cascades in Washington. The area includes twelve glaciers, the summit of Mount Spickard, alpine plant communities, a fast-flowing outlet stream and a lake with an approximate maximum depth of 159 m (525 ft).
5. *Stetattle Creek* (13,645 acres) was established in 1973 and expanded in 1980 to represent a large watershed with significant forest types, glacial features, lakes, and streams.

The Silver Lake RNA is located in the North Unit of the Complex, near the US/Canada border. Half of the RNA falls within the current Suppression Response Zone along the border. Although the majority of the RNA is rock, ice, or water, the northeast section contains continuous fuels that, if ignited by lightning strike, could carry a fire into Canada. If a wildfire occurs within the Silver Lake RNA, the Complex will use a confinement strategy to manage the fire perimeter. This strategy is used to limit the extent of the fire area to preset boundaries such as natural barriers and terrain breaks. No direct suppression activity would take place within the RNA unless absolutely necessary to keep a fire originating in the Complex from crossing into Canada.

3.7 Wilderness

Established by Congress in 1988, the Stephen Mather Wilderness encompasses some of the most rugged terrain in the northern Cascade Range. Ninety three percent, or 634,614 acres, of the Complex is designated as wilderness. An additional 5,226 acres is potential wilderness and is managed in the same manner as designated wilderness (Appendix A, Figure 1). All other areas in the Complex that are designated as *backcountry* are also managed using the same standards established for wilderness (DOI 1989). The backcountry/wilderness contains approximately 386 miles of maintained trails. Approximately 135 camps with over 300 tent sites have been designated along the trails.

Over 88 percent of the area in both the Stehekin (4,255 out of 4,848 acres) and Hozomeen (4,603 out of 5,219 acres) contours is designated wilderness. In Stehekin, the burn units range in size from 153 to 888 acres. The upper elevations of the unit boundaries range from about 2,200 feet at the Wilsey Unit to 5,800 feet at the Courtney Unit, with most upper unit boundaries around 3,000 feet. In Hozomeen the burn units range in size from 2,180 to 3,039 acres. The upper elevations range from 4,400 feet at Little Jackass Mountain to 6,100 feet at Desolation Peak. Both project areas are located in steep, rugged terrain that is difficult to access and for that reason they possess the qualities of being relatively undeveloped (there are several trails that dissect project areas) and having outstanding opportunities for solitude, two qualities that are used to describe and evaluate wilderness character. Additionally, both project areas can be described as lacking in the quality of "naturalness" due to years of fire exclusion and associated impacts, while possessing the quality of "wildness" due to their rugged and untouched nature. The proposed projects aim to enhance naturalness by restoring fire to areas in which it has been excluded; however, these actions will likely diminish the wild nature of these particular places within the Stephen Mather Wilderness. These qualities are explained further below.

According to the National Survey on Recreation and the Environment (USDA 2000), the top five benefits that wilderness areas provide to the American people are protecting air quality (91.7% agree that this is extremely or very important), protecting water quality (91.4%), protecting wildlife habitat (86.8%), knowing that future generations will have wilderness areas (85.0%), and protecting rare and endangered species (82.7%). Seventy-four percent of the public believes that providing scenic beauty is an extremely or very important benefit.

Public attitudes about natural fire policies in wilderness have become more supportive over the last three decades (Cordell 1999). This is especially true in regions where wildland fires occur most frequently and the public is consequently more knowledgeable about fire effects. Attitudes about prescribed fire in wilderness differ, however, and are based largely upon varying interpretations of the Wilderness Act. One view is based on the definition that wilderness be "an area where earth and its community of life are untrammeled by man." This interpretation seeks to preserve the quality of *wildness*, meaning that natural processes in wilderness are left free to function without modern human interference and manipulation. Individuals with this point of view typically find that prescribed burning in wilderness is unacceptable because it requires human manipulation, therefore diminishing the quality of wildness.

Another view is based on the definition that wilderness ecosystems be "preserved in their natural condition." This interpretation recognizes that wilderness areas are affected by outside factors, and are subject to human influence. Because of the pervasiveness of human influence; i.e., fire suppression, air pollution, acid rain, climate change, etc., the quality of *naturalness* is impacted in even the most remote wilderness areas. Individuals with this point of view recognize that wilderness areas have already been influenced by humans (e.g., through fire suppression), and in order to allow natural processes to reestablish, prescribed fire can be used to restore altered fire regimes. Active management of wilderness, from this perspective, is seen as imperative to maintaining (or returning to) its natural state.

There are weaknesses in both of the above perspectives; the first view can be seen as failing to recognize the interconnectedness of wilderness and surrounding lands, and the second view can be seen as failing to keep with the Wilderness Act's mandate to keep wilderness untrammeled. National Park Service policy on prescribed burning in wilderness sits between the two perspectives. Prescribed fire programs are allowed as long as the fire management plan includes the prescriptions and procedures under which the program will be conducted. All fire management activities in wilderness are required to conform to the basic purposes of wilderness; minimum requirement analysis is used to determine if a proposed activity in wilderness is necessary, and to identify the method needed to complete the activity with the least impact. For this EA, minimum requirement analysis (Appendix G) was conducted on proposed projects in wilderness, which include prescribed burning (Stehekin and Hozomeen Contours) and re-ignition. Fire suppression and wildland fire use strategies are unplanned ignitions that must follow the minimum requirement concept. A list of minimum impact tactics (MIT) are found in Appendix H.

3.8 Cultural Resources

The rugged landscape of the North Cascades has been occupied and modified by human populations for thousands of years. Pre-contact indigenous peoples, whose descendants still occupy nearby lands, were followed in the 19th century by Euro-American explorers, miners, adventurers, and settlers, and, finally, in the 20th century, by government bureaucracies and utility companies. All left evidence of their presence in the form of a variety of cultural resources ranging from prehistoric quarries and lithic scatters to modern hydroelectric complexes.

Cultural resources in the Complex include prehistoric and historic archaeological sites, historic sites and structures, cultural landscapes, and traditional cultural properties or ethnographic resources (both natural and cultural resources) that are important to the continuing culture and traditions of park-associated American Indian people. Some of the cultural resources are preserved in museum collections. These resources reflect early settlement, use, and management of the lands by indigenous people; westward expansion of Euro-American people (as well as Asian and other non-European people); resource extraction such as logging, mining, and herding; early tourism; early environmental conservation efforts; development of water resources; and park planning, design, and land management—they are the physical evidence of human presence spanning the majority of the Holocene.

For the purposes of this discussion, these cultural resources are grouped into prehistoric (pre-contact period), historic (historic-period sites and structures), and ethnographic resources. Fire management recommendations for each resource type reflect a consistent approach to managing cultural resources that is based on Section 110 of the National Historic Preservation Act (NHPA), as amended, and related federal laws and regulations; National Park Service Management Policies (Chapter V), and NPS-28: Guidelines for Cultural Resource Management.

Aside from the specific provisions for the protection of historic resources in the enabling legislation, the single most important piece of legislation governing cultural resource management is the NHPA, as amended. Section 110 provides the congressional direction to all agencies, requiring properties under the jurisdiction or control of the agency that are listed on or may be eligible for the National Register to be managed and maintained in a way that considers the preservation of their historic, archeological, architectural, and cultural values in compliance with section 106. Section 110 also gives special consideration to the preservation of such values in the case of properties designated as having national significance. Further, the preservation of properties not under the jurisdiction or control of the agency, but subject to potential impacts by agency actions, is given full consideration in planning.

3.8.1 Prehistoric Resources

The prehistory of the North Cascades region has recently become the subject of increased interest and research. Evidence indicates the region was extensively used by Native American groups, in some places permanently, and others on a seasonal basis. Seven Native American groups occupied or utilized resources of the region: the Upper Skagit, Swinomish, and Sauk-Suiattle, who permanently resided along the Skagit River and its tributaries from the river's mouth upstream to the gorge at Newhalem; the Chilliwack, whose homeland was the entire Chilliwack River watershed; the Nooksack, who occupied the middle and upper Nooksack River; the Lower Thompson (Nlakápamux) of southern British Columbia, who jointly utilized the upper reaches of the Skagit River in the area now covered by Ross Lake with bands of the above-mentioned groups; and the Chelan, who occupied the Stehekin-Chelan watershed. Other more distant groups used the area and its resources. These included the Okanogan, Southern Okanogan, Methow, Entiat, Wenatchee, and Yakima on the northeast, east and southeast; the Stillaguamish on the southwest; and the Stó:lō of southern British Columbia (Smith 1987; Boxberger 1996).

Two hundred and sixty-three (263) prehistoric archeological sites have been recorded within the Complex. These sites are found in all altitudinal zones of the park, including the alpine and subalpine; most have been found within major river valleys and their tributaries. Site types include lithic scatters; stone quarries and collecting areas; hunting, gathering, fishing, and food processing camps; rock shelters, overhangs, and caves; rock features including talus pits, rock walls and alignments, and rock cairns; pictographs; culturally-modified trees; permanent and semi-permanent villages and camps; and prehistoric trails and resource use areas. As a group, these sites reveal that the mountains of the North Cascades were used by Native Americans much more than earlier researchers believed. The oldest archeological remains in the park date to the period between 10,000 and 8,400 years ago, but other dated assemblages reveal that indigenous groups occupied today's park lands more or less continuously from this early period until the time of historic contact, about A.D. 1800.

The archeological record of the Complex is documented in a series of technical and published NPS reports. A park-wide archeological overview predicted that pre-contact age sites are widely distributed across the North Cascades, even though strong empirical evidence in support of this assertion was lacking (Mierendorf 1986). Archeological field investigations by NPS implementing the overview recommendations now document that the Complex contains the largest known chert quarry in western Washington and possibly the entire state (Mierendorf 1993; Mierendorf et al. 1998); this same quarry, at 8,400 years old, is the oldest dated archeological site anywhere in the northern Cascades Range of Washington and British Columbia (Mierendorf 1993). As predicted in the park overview, the subalpine bioclimatic zone has a relatively high site density; test excavation of one of these sites has revealed a 4,500 year record of continuous camp use (Mierendorf 1999). Currently, this is the oldest dated subalpine archeological site in the northern Cascade Range. The rich archeological record of the Complex has extended our knowledge of indigenous use of Northwest mountainous landscapes far beyond what had been indicated based on ethnohistoric records alone, particularly with regard to the extent of indigenous bands' procurement and utilization of a wide variety of tool stones that naturally occur in the North Cascades. Through techniques of chemical fingerprinting, it is now possible to correlate individual artifacts with distant quarries, revealing geographic patterns in the transport, trade, and use of distinctive tool stones, such as Hozomeen chert and Hannegan vitrophyre (a variety of obsidian), across major drainage divides (Mierendorf 2004).

3.8.2 Historic Resources

The North Cascades remained unknown to many people living in the Pacific Northwest until the late 19th century. Early explorers and the Hudson Bay Company were among the first Europeans. Settlement patterns followed 3 major watersheds: the Skagit and Cascade rivers on the west and the Stehekin River on the east. The greatest development occurred on the Skagit and included settlement by homesteaders, trappers, and miners. Recorded history of the Stehekin Valley dates to 1814 when Alexander Ross explored the area searching for an easy pass through the mountains. In 1882, Henry Hubbard Pierce led an army expedition through the area. He was soon followed by miners, homesteaders, and tourists. The Field Hotel and later the Golden West Lodge were built as significant destination resorts.

Thirty-seven (37) historic archeological sites and 87 structures presently identified within the Complex are associated with 19th and early 20th century settlement and mining. Aside from the 1984 Historic Structures Inventory, which identified several structural historic sites for consideration as historic archeological sites, systematic survey for historic archeological sites is routinely conducted concurrent with surveys for prehistoric archeological sites. The lands of the Complex also contain 26 Cultural Landscapes, specific areas of local cultural significance. These landscapes include specific features and vegetation and range in complexity from the virtually intact 1930's High Bridge Ranger Station to the discontinuous features of the Old Mine-to-Market Wagon Road.

The Orchard Safety Zone is located within the orchard, pasture, and field of the Buckner Homestead Historic District (Appendix A, Figure 7). All forest fuel reduction activities within and adjacent to the Historic District are designed and conducted in consultation with the Cultural Resources advisors and the Washington State Historic Preservation office in order to comply with the National Historic Preservation Act.

3.8.3 Ethnographic Resources

The National Park Service defines ethnographic resources as any "site, structure, object, landscape, or natural resource feature assigned traditional, legendary, religious, subsistence, or other significance in the cultural system of a group traditionally associated with it" (NPS 2002). A traditional cultural property is an ethnographic resource that is eligible for listing in the National Register of Historic Places. Ethnographic resources may consist of ceremonial/spiritual locations, resource use areas, rock art, or traditional places and objects that embody values central to a group's history, origin, and cultural identity. These resource types are identified through consultation with representatives of the several park-associated groups. Within the Complex, three rock art sites constitute ethnographic resources and they retain both scientific and traditional cultural values.

Presently, there are no ethnographic resources listed in or determined eligible to the National Register of Historic Places. Ethnographic overviews and assessments prepared for North Cascades National Park Service Complex have identified no contact-period camps, settlements, or traditional cultural properties in or near the area of potential effect (Smith 1987, Boxberger 1996). Using informant data published in the 1930's, Smith (1987:302) noted that there are no ethnographic or ethnohistoric data indicating Chelan tribal settlements or encampments along upper Lake Chelan, the Stehekin Valley, or the adjacent mountains.

3.8.4 Cultural Resources Surveys

Less than 5 percent of the total Complex area has been surveyed at any level for cultural resources. Beginning in the early 1970s, a variety of small, project-driven archeological surveys was conducted in compliance with Section 106 of the NHPA. A reconnaissance-level inventory in the Complex was undertaken in 1977 to determine the potential for archeological resources. In 1986 an archeological overview and assessment predicted that many hundreds of prehistoric and historic sites probably exist within Complex boundaries. Archeological inventories between 1988 and 1993 were focused on Ross Lake Reservoir, as per a Memorandum of Agreement between NPS and Seattle City Light. Since 1992 systematic surveys and site evaluations have been undertaken in compliance with Section 110 of the NHPA through the NPS System-wide Archeological Inventory Program.

Beginning in 1990 and continuing through 1997, intensive and reconnaissance-level cultural resource surveys were conducted in all of the FFRAs. Fourteen (14) archeological sites were inventoried in the FFRAs, with site types ranging from rock shelters with associated rock art and lithic scatters to historic can dumps. Surveys along the Stehekin Road corridor have also been conducted in association with various projects. No archeological sites have been found to date in the road corridor. Two properties listed on the National Register, however, are located along the road: the High Bridge Historic District is located along the Stehekin Valley Road and the Courtney (McComb) Cabin is adjacent to the Company Creek Road.

Prior to the 2004 field surveys, most of the high probability land areas within the Stehekin and Hozomeen contours burn units and the FFRAs, had been surveyed for cultural resources. In the case of the contours burn units, these surveys were driven by needs and projects unrelated to this fire plan. Taking these earlier surveys into consideration, the 2004 survey strategy targeted high probability areas not previously examined.

During the 2004 field season, the proposed Stehekin Contour burn units survey was limited to areas not previously surveyed and to areas safely accessible by foot. Generally, high probability areas are identified by landform type. The most favorable landforms are those that are relatively flat, have access to perennial water, and are in proximity to the junction of a tributary stream with the Stehekin River. Such landforms include bedrock benches, river and alluvial fan terraces, ridges that connect the valley floor to the adjacent high country, and the interface between the valley bottom and the steep valley walls. In most cases, the limiting factor that controls the intensity of the survey coverage is the degree of mineral soil visibility. Trail treads, stream cut banks, residential areas, campgrounds and other developed areas are the most common places where mineral soil is exposed. Lacking such soil exposures, cultural resources preserved in or on the soil are effectively obscured from detection by conventional field observation techniques. All high probability survey tract areas were examined, and as many lower probability areas were surveyed as remaining time and funding allowed.

The primary survey technique employed throughout the project area was walking of judgmental transects (this technique involves meandering transects which focus on high-probability areas). Parallel transects spaced no more than 30 meters apart were also used in areas where topography and vegetation allowed. Intensive examination of mineral soil exposure in trail treads, tree tip-ups and stream cut banks was conducted by surveyors trained to recognize a range of cultural resources.

In 2004, a total of approximately 110 survey hours were spent covering 278 acres within the Stehekin Contours. Three new archeological sites were recorded within the proposed prescribed burn areas and one new isolated find. All three of the newly recorded sites (and the single isolated find) date to the historic time period. Five additional sites were recorded, during earlier surveys, within the Stehekin Contours boundaries. This brings to twenty-two (22) the total number of sites that, without mitigation, could be affected by burning within the FFRAs and the Stehekin Contours.

Also in the 2004 field season, 24 hours were spent surveying 57 selected acres of the Hozomeen Contours, within the Lightning Creek unit only (not the Little Jackass Mountain unit). Although no new archeological sites were found, two new archeological loci were inventoried within the previously recorded site 45WH224, which is listed as a contributing property in the Upper Skagit River Valley Archeological District. This district is formally determined eligible to the National Register of Historic Places based on its importance as a pre-contact site of tool stone quarrying activity. Also within this unit (but outside of the archeological district boundaries) are three other previously recorded archeological sites consisting of locations where tool stone was procured in the pre-contact time period.

The overall results, derived from the compilation of earlier Complex survey records and from the 2004 field surveys, reveal an unequal (non-uniform) distribution of cultural resources within both FFRA and Stehekin and Hozomeen contour units. Because this is a park-wide trend, it is likely that cultural resources are also unequally distributed throughout the Wildland Fire Use zone. Cultural resources tend to be located on low elevation landforms associated with the valley bottom, and particularly on those landforms positioned along the interface of steep valley walls with the valley bottom. Archeological sites here are most common on abandoned river and glacial terraces, on alluvial fan surfaces, and in talus and boulder fields at the base of valley walls. On the valley walls at elevations exceeding several hundred feet above the valley bottom, the frequency, size, and range of cultural resources decreases sharply. This decrease remains more or less constant with increasing elevation until the subalpine is reached, after which the site density increases. Above the subalpine, site density and diversity decreases rapidly.

3.9 Visitor Use

On average, about 400,000 people visit the Complex annually, mostly between the months of June and October. The largest concentration of visitors (90%) is along the State Route 20 corridor in Ross Lake National Recreation Area. The highway has heavy use during the summer, attracting people who stop to enjoy the scenic vistas, picnic, day hike, fish, bicycle, camp, or participate in educational activities. Visitor activities in or near the Skagit and Stehekin rivers include rafting, fishing, sightseeing, hiking, boating, and camping. There are five car campgrounds within the Complex; four of which are along State Route 20, and one at Hozomeen that is accessed via Canada. The Environmental Learning Center, an educational facility operated by North Cascades Institute and located on Diablo Lake, is scheduled to open in the summer of 2005.

In the backcountry, visitor activities include hiking, backpacking, mountaineering, horseback riding, and fishing. There are 386 miles of maintained trails in the Complex, and approximately 135 camps with over 300 tent sites have been designated along the trails. Since 1974, there has been an average of 30,000 backcountry use nights per year (total number of nights spent in the backcountry). Mountain climbing and cross-country use have increased significantly in recent years, and are currently estimated at 6,500 visitor nights annually.

During the winter months, visitation drastically drops. Much of the park becomes inaccessible due to heavy snowfall, avalanche danger, and road closures. State Route 20 is closed between Ross Dam at milepost 134 and Early Winters at Milepost 178 from about mid-November to mid-April. Ferry access to Stehekin also declines to four to five ferry trips per week. Winter recreation in the Complex includes snowshoeing, cross-country skiing, hiking in the lower elevations, and wildlife observations.

3.10 Health and Safety

The first priority in every fire management activity is firefighter and public safety, according to both NPS policy and the 12/95 “Federal Wildland Fire Management Policy and Program Review.” Firefighter and visitor safety should always take precedence over property and resource loss (DOI 1999). There are several areas within the Complex that are of public safety concern, including developments along State Route 20, backcountry trails and campsites, and Stehekin.

Smoke from fires or other fire management activities near Highway 20 may impact travelers along the highway, or either of the two communities of Newhalem and Diablo. Both of these towns have ample (green) defensible space to protect them from wildfire in almost all fire years. There are four drive-in campgrounds and facilities along the highway that could also be affected by nearby fire activities. On the north side of Diablo Lake is the newly constructed Environmental Learning Center. Fuel reduction to establish defensible space was completed prior to construction of this facility.

There are many miles of trails and numerous campsites in the backcountry as well as along the shores of Ross Lake Reservoir, Diablo Lake Reservoir and Lake Chelan. The risk to hikers trapped in a wildland fire situation is minor yet always a threat. Information and closures are posted to minimize this threat.

The remote community of Stehekin is the Complex's largest concern in terms of public safety. It is an isolated community located 55 miles up Lake Chelan. Along with housing 90 residents year-round, Stehekin hosts a summer tourist population of approximately 200 persons per day. The community is located in a narrow valley with limited access. The valley's Douglas fir/ponderosa pine forest shows characteristic signs of being at risk of a stand replacing fire: a dense understory of Douglas fir pole and seedling trees overcrowding a weakening overstory that is succumbing to insects and disease. These conditions are common in forests of this type throughout the area. Historic levels of ponderosa pine have decreased as fire suppression and selective harvesting allowed the more shade-tolerant Douglas fir to shade the more fire-dependent pine out (Ohlson and Schellhaas 1999). There are currently two safety zones that can be utilized in a catastrophic fire event, one at the Buckner Homestead Historic District (also known as the Orchard) and one at the Stehekin Valley Ranch. The escape route to these locations is the Stehekin Valley Road.

There is inherent danger involved in fire fighting. Typical hazards include traveling on rough, steep terrain; falling snags and rolling rocks; helicopter use; using sharp tools on uneven ground; smoke inhalation; exposure to fire retardant chemicals; and being overcome by fire. In addition, environmental stresses such as increases in altitude, heat, humidity, and smoke can increase the risk of fatigue. The biggest health hazards from smoke inhalation come from carbon monoxide (CO), aldehydes, benzene, and fine particulate matter. Health effects among firefighters suffering from smoke inhalation range from acute irritation and shortness of breath to headaches, dizziness, and nausea.

The public can also be exposed to particulate matter during wildland or prescribed fires, although exposure is usually at lower levels with greater distance from fire lines. People with respiratory ailments, the elderly, and young children are most at risk for experiencing impacts from fine particulates. To protect public health and safety, the NPS is required to give full consideration to the protection of clean air and clear visibility during fire management operations. The superintendent is authorized to close areas of the Complex to visitors if a fire is posing a threat to human health or safety. Burn bans are also frequently used as a way of restricting outdoor burning to prevent ignitions during periods of high fire danger.

3.11 Socioeconomics

North Cascades National Park Service Complex is located in parts of Skagit, Whatcom, and Chelan counties. According to the US Census Bureau, the total combined population of these three counties in 2000 was 336,409, which is almost a 30 percent increase since 1990 (USCB 2000). Per capita income ranges from $19,000 in Chelan County to $21,000 in Skagit County. The top industry in all three counties is the educational, health, and social services sector, which employs over 20 percent of the total employed civilian population. Retail trade is the second largest industry (13.3%), followed by manufacturing (11.5%).

The tourism industry also employs a relatively large percentage of the population, ranging from 11 percent in Chelan County to 9.6 percent in Whatcom County. Tourism is particularly significant to the economy of Stehekin. Two concession operations that provide lodging and other services have contracts with the Complex: the North Cascades Stehekin Lodge and Ross Lake Resort. Other small concessions sell outdoor gear and local crafts in the Stehekin Valley. In addition, several private operations in the Stehekin Valley provide rental cabins, bed and breakfast and other accommodations and services on private land. Seattle City Light provides various tourist attractions and services. Several outfitters, under permit from the NPS, provide horse packing, backpacking and other visitor services. Attractions outside the Complex include the Mt. Baker-Snoqualmie National Forest, Okanogan National Forest, Wenatchee National Forest, the Methow Valley, Lake Chelan, Puget Sound and the San Juan Islands, and several metropolitan areas.

Fires have the potential to impact the tourism industry by decreasing visibility, air quality, and access; and discouraging visitation through adverse publicity. Though State Route 20 is closed during the winter, road closures during high-visitation summer months could impact local businesses. Fire program operations that depend on the community for support, such as food, supplies, housing, and contracts for prescribed thinning, can contribute to a healthy local economy. Per-acre costs are listed in Table 19 by management strategy. Costs range from $35 per acre for re-ignition to $3,000 per acre for a suppression fire.

Table 19. Per Acre Costs by Management Strategy

Treatments by Management Strategy	*Per Acre Cost*
Suppression fires:	$3,000
Wildland fire use fires:	$70 - 150
Prescribed fire in Stehekin Forest Fuel Reduction Areas (FFRAs):	$200
Small diameter manual/mechanical thinning in Stehekin FFRAs (performed by NPS fire crew):	$250
Large diameter manual/mechanical thinning, skidding, and hauling in Stehekin FFRAs (performed by local contractor):	$1,000
Manual/mechanical thinning along Stehekin road:	$250
Manual/mechanical thinning within safety zones:	$250
Manual/mechanical thinning in Stehekin (on private land):	$250

Treatments by Management Strategy	***Per Acre Cost***
Prescribed fire on Stehekin valley walls (including wilderness):	$90
Prescribed fire surrounding Hozomeen (including wilderness):	$90
Re-ignition of suppressed fires in WFU Zone:	$35 – 125

4 Environmental Consequences

The impact analysis in this chapter is designed to predict the degree to which the resources listed in Chapter 3 – Affected Environment could be affected upon implementation of each of the alternatives. Each resource described in Chapter 3 has been analyzed for the direct, indirect, and cumulative impacts that might occur as a result of implementing one of the alternatives. Direct impacts are caused immediately by an action and they occur in the same place as the action. Indirect impacts are caused by the action but they occur later in time or farther away in distance from the action. Cumulative impacts have additive effects on a particular resource; they include impacts of actions in the past, present, and the reasonably foreseeable future. NEPA also requires an analysis of the type (beneficial vs. adverse), duration (short-term vs. long-term), and intensity (degree of severity) of impacts to affected resources.

The NPS is required by law to avoid, or to minimize to the greatest degree practicable, adverse impacts on park resources and values. Adverse impacts that constitute impairment are prohibited. Impairment is an impact that would harm the integrity of park resources or values, including the opportunities that otherwise would be present for the enjoyment of those resources. Proposed actions that could lead to impairment must be thoroughly analyzed, and before being approved the impacts of the proposed action must be considered and determined, in writing, that the activity will not lead to impairment to park resources or values. If it is determined that an activity leads to, or might lead to impairment, the action may not be approved. Guidance for determining impacts and the prohibition on impairment was established by the Organic Act of 1916 and reaffirmed by the General Authorities Act of 1970, as amended in 1978.

4.1 Methodology

In this chapter, the impacts of each alternative on each resource are identified, and the context, duration, and intensity of impacts are defined. The duration and intensity of impacts were determined after a review of scientific journals, field investigations, and the best professional judgments of NPS staff and consultants. Impacts are quantified in numbers when possible, and are described qualitatively based on intensity and duration. The qualitative levels of impact include:

1) *Negligible*: the impact is at the lowest level of detection and of very short duration;
2) *Minor*: the impact is slightly detectable and of short duration;
3) *Moderate*: the impact is readily apparent and of some duration;
4) *Major*: the impact is either severely adverse or exceptionally beneficial and/or of long or permanent duration;
5) *Impairment*: the impact harms the integrity of park resources or values (not allowed according to NPS Management Policies)

Quantitative evaluations were made using *First Order Fire Effects Model*, or FOFEM, which is a computer modeling program that assists in predicting and planning for fire effects. FOFEM provides quantitative information on tree mortality, fuel consumption, mineral soil exposure, smoke, and soil heating that is based on geographic region and covertypes. In this EA, FOFEM was used to model fuel consumption and potential smoke from proposed treatments.

For those sections where additional information (such as FOFEM modeling, Minimum Requirement Analysis, and National Historic Preservation Act guidelines) is used to assess impacts, there is a subsection titled “methodology,” which provides further clarification as to how impacts were assessed.

4.2 Air Quality

4.2.1 Methodology

Impacts to air quality were analyzed using results from FOFEM (Appendix I). Outputs from this modeling program include fuel consumption (in tons/acre) and emissions (in pounds/acre). Since it is impossible to model ambient concentrations for any given day in the future (due to unknown meteorological conditions and other regional influences on air quality such as nearby fires), this impact assessment assumes the same air quality conditions for every burn. Under the same air quality conditions and fuel moistures, more tons of fuel consumed would equal greater emissions. This assessment compares estimates of tons of fuel consumed for suppression fires, wildland fire use fires, and each proposed burn unit. See Appendix I for all FOFEM output tables, and Table 20 under Section 4.2.8 for a summary of consumed fuel amounts by alternative).

In addition to FOFEM analysis, particulate emissions data collected from the IMPROVE station at Ross Dam was analyzed. The station was installed during 2000 and data is available through 2003. An increase in particulate matter concentrations was recorded during 2003 that correlates with several fires that were burning in the region. The largest fire within the Complex in 2003 was the Big Beaver Fire, which initiated from a lightning strike on August 5 and was declared out on November 6, 2003, burning a total of 2,301 acres. Twelve other smaller fires also burned in the Complex, as well as numerous other fires of varying sizes on bordering US Forest Service lands. Although the source of emissions cannot be pinpointed, wildfire was definitely the cause of the increased emissions at the monitoring station. In the future as more effective modeling is developed, air quality monitoring data could be used to analyze and compare emissions from different locations and ignitions (i.e., natural vs. prescribed burns).

4.2.2 Impacts Common to all Alternatives

Impacts to air quality from fire largely depend on both the size of the fire and the weather conditions that influence smoke production and dispersion conditions. A large fire could produce a lot of smoke, but weather conditions could be such that it is readily dispersed into the atmosphere. In this case, air quality in neighboring communities or at nearby scenic vistas could be relatively unharmed, but other areas in the region could be impacted by the dispersed smoke. Conversely, stable air masses and temperature inversions could prevent the dispersion of smoke into the atmosphere, directly impacting local air quality and scenic visibility. Local communities that could be impacted by smoke include Stehekin, Marblemount, Newhalem, Diablo, Hozomeen, and Hope, B.C. Regions that could be impacted by drifting smoke include the Upper Skagit, Nooksack, Methow, Okanogan, and Fraser valleys.

Burning vegetation causes emissions of several different chemical compounds, including small particles, nitrogen oxides, carbon monoxide, and organic compounds (US EPA 1998). The types of fuel burned, its moisture content, and the temperature of combustion influence the quantity and combination of emissions. The greatest health hazards from smoke inhalation come from carbon monoxide (CO), aldehydes, benzene, and fine particulate matter. Health effects among firefighters suffering from smoke inhalation range from acute irritation and shortness of breath to headaches, dizziness, and nausea. Smoke impacts to firefighters would be adverse, short-term, and minor to moderate. The impacts of particulate matter exposure on the public would generally be short-term and minor, since exposure would be at lower levels with greater distance from burning vegetation; however people with respiratory ailments, the elderly, and young children could experience long-term, major adverse impacts if respiratory problems are exacerbated.

In addition to the health hazards resulting from smoke inhalation, fine particulates are responsible for impacting visibility along roads and scenic vistas within the Complex. Sulfates, nitrates, organic compounds, soot, and soil dust are the primary particles which scatter and absorb light, and consequently impact visibility. During active fire years it might be difficult for managers to protect mandatory Class I Federal areas (North Cascades National Park, Stephen Mather Wilderness, and surrounding US Forest Service wildernesses) from air quality impacts due to smoke.

4.2.3 Alternative 1 - No Action Alternative

Suppression. The general impacts on air quality from fire suppression would be similar to those found in Section 4.2.2. Impacts would be dependent on the size of the fire, weather conditions, duration, and location. The best estimate for the number of acres burned in suppression fires annually is 260, which would consume a total of 9,247 tons of fuel according to FOFEM. Air quality impacts would range from short-term (several days to weeks) to long-term (the duration of the fire season), and moderate to major, depending on the number of days the fire burns. This is because some fires are extinguished immediately, others take weeks to extinguish, and yet others are managed using a confinement strategy that involves allowing the fire to burn until it reaches a predetermined boundary. Longer-term (years to decades) impacts of fire suppression could be major and adverse if fuels build up from fire exclusion and a stand-replacing fire occurs.

Wildland Fire Use. The general impacts on air quality from wildland fire use fires would be similar to those found in Section 4.2.2. Impacts would be dependent on the size of the fire, weather conditions, duration, and location. The best estimate for the number of acres burned in wildland fire use fires annually is 200, which would consume a total of 7,113 tons of fuel according to FOFEM. Air quality impacts would be similar to those found under suppression: ranging from short-term to long-term, and moderate to major, depending on the number of days the fire burns. Generally, however, the number of days the fire burns is longer than a suppression fire because it is usually extinguished by a season-ending rain event. Data gathered from the IMPROVE monitoring station indicate that during 2003 (an active fire year), particulate matter values were well below NAAQS standards for PM_{10} and $PM_{2.5}$ (8.72 for PM_{10} and 6.4 for $PM_{2.5}$, during the time frame of the Beaver Fire).

Mechanical Thinning and Prescribed Fire (FFRAs). Fumes from power equipment used during mechanical thinning in the Stehekin FFRAs would have localized, short-term, minor impacts on air quality. The total tons of fuel consumed during prescribed burning ranges from 497 to 2,462, based on the acres and fuel model of each burn unit. The total tons of fuel consumed for all units combined is 9,976, which would be spread over several (5 – 10) years. Although fuel moistures would generally be higher during prescribed burning (since they are conducted in the spring or fall), managers can limit emissions by burning on days when smoke dispersion would be quickest.

4.2.4 Alternative 2

Suppression. Impacts to air quality during fire suppression activities under Alternative 2 would be similar to those found in Alternative 1.

Wildland Fire Use. Impacts to air quality during wildland fire use activities under Alternative 2 would be similar to those found in Alternative 1.

Mechanical Thinning and Prescribed Fire (FFRAs, private property). Under Alternative 2, the upper range of acres that could be treated in one year increases from 180 to 200 acres. Though impacts to air quality during treatments would be similar to those found in Alternative 1, larger units could produce greater emission amounts. The total tons of fuel consumed during prescribed burning ranges from 516 to 2,474, based on the adjusted acres and fuel model of each burn unit. The total tons of fuel consumed for all units combined is 14,176, which would be spread over several (5 – 10) years. This is an increase of 4,200 tons of fuel that would be consumed. An additional 2 to 10 acres of thinning and burning on private land annually would have negligible to minor impacts on air quality.

Mechanical Thinning and Pile Burning (road corridor and safety zones). Fumes from power equipment used during mechanical thinning in the Stehekin road corridor and safety zones would have localized, short-term, minor impacts on air quality. Pile burning along the corridor and within the safety zones would be conducted when conditions would allow smoke to quickly disperse, with consequently short-term, minor adverse impacts on air quality.

4.2.5 Alternative 3 - Preferred Alternative

Suppression. Impacts to air quality during fire suppression activities under Alternative 3 would be similar to those found in Alternatives 1 and 2. However, over time, it is expected that fewer fires would have to be suppressed after prescribed burn treatments are conducted near Stehekin and Hozomeen, and thus emissions from fire suppression would decrease.

Wildland Fire Use. Impacts to air quality during wildland fire use activities under Alternative 3 would be similar to those found in Alternatives 1 and 2. However, over time, it is expected that the wildland fire use option will be chosen more often after prescribed burn treatments are conducted near Stehekin and Hozomeen, and thus emissions from wildland fire use fires would increase.

Mechanical Thinning and Prescribed Fire (FFRAs, private property). Impacts to air quality during mechanical thinning and prescribed fire activities under Alternative 3 would be similar to those found in Alternative 2.

Mechanical Thinning and Pile Burning (road corridor and safety zones). Impacts to air quality during mechanical thinning and pile burning activities under Alternative 3 would be similar to those found in Alternative 2.

Prescribed Fire (Stehekin Contours, Hozomeen Contours). Prescribed burning in the Stehekin and Hozomeen contours would likely have less of an impact on regional air quality than would suppression or wildland fire use fires because they would be burned during optimal conditions. Local air quality for Stehekin and Hozomeen residents/visitors, however, would be impacted by the burn projects because of their proximity to the communities. The total tons of fuel consumed during prescribed burning in the Stehekin Contours ranges from 1,236 to 8,489, based on acres and fuel model assigned to each burn unit. The total tons of fuel consumed for all Stehekin units combined is 32,330, which would be spread over several (5 – 10) years. The total tons of fuel consumed during prescribed burning in the Hozomeen Contours ranges from 29,053 to 49,006, based on acres and fuel model assigned to each burn unit. The total tons of fuel consumed for both Hozomeen units combined is 78,059, which would be spread over two or more years.

Re-ignition. The impacts of re-ignition on air quality would be similar to those found for wildland fire use under all alternatives; however, the number of days that the fire would burn would be less than a wildland fire use fire, since it would be re-ignited later in the season.

4.2.6 Cumulative Impacts to Air Quality

Regional air quality is threatened by the large urban-industrial areas of the Puget Sound lowlands, the Fraser Valley in British Columbia, and Portland, Oregon. Pollution from vehicles, industry, and large-scale agricultural operations has various impacts, including acid precipitation, nutrient deposition, decreased visibility, smoke, and high mercury levels in biota. Concentrations of fine particles (those less than or equal to 2.5 micrometers ($PM_{2.5}$)), typically found in urban centers, are known to cause serious human health effects, including exacerbation of chronic disease, altered lung function, aggravated respiratory and cardiovascular disease, and even death. Early studies are showing that persistent organic pollutants are being transported into the Complex, which probably originate in Asia. Naturally-caused visibility impacts include fog, low clouds, and smoke from regional fires.

A wood-fired cogeneration facility is scheduled to be built approximately 24 miles from the Complex in Darrington, Washington. The facility will emit all criteria pollutants listed by the EPA: NO_x (NO_2, CO, SO_2), volatile organic compounds, and PM_{10}, as well as several toxic air pollutants identified by Washington State regulation Chapter 173-460 WAC.

4.2.7 Mitigation for Impacts to Air Quality

The Washington State Department of Natural Resources (DNR) Smoke Management Plan requires approval for all prescribed burns involving over 100 tons of fuel (all proposed prescribed burn units in the Complex contain over 100 tons of fuel). The DNR considers a number of factors including the likelihood of intrusion into populated areas and Class I areas, air quality regulations, violation of emission reduction targets, violations of another state's air quality standards, and whether smoke will disperse within given timeframes. The agency models ambient air quality to ensure that prescribed burns occur only during optimal meteorological conditions that minimize ambient concentrations and assure compliance with NAAQS (National Ambient Air Quality Standards). Same-day burn approval is determined based on real-time data that includes regional fires and other smoke impacts that are happening on that same day.

Local air quality impacts during the fire season will be monitored using the nephelometer located at the Ross Dam trail and the E-BAM located in Stehekin. IMPROVE data will be analyzed to evaluate past fire incidents and to build an understanding of air quality effects from local fires.

4.2.8 Conclusion

Air quality impacts from smoke are difficult to predict because there are several confounding variables that influence smoke creation and dispersion. In general, compared to prescribed burns, wildfires are often larger, burn longer, and may occur when conditions are not optimal resulting in more concentrated smoke and potential smoke impacts on nearby communities. Given the same environmental conditions, there is no noticeable difference between wildland fire use and suppression emissions under any of the alternatives, except for the potential for wildland fire use fires to burn (and produce emissions) for a longer period of time (until a season-ending rain event). Under Alternative 3, there could be a decrease in suppression fires and emissions over time (once prescribed burns are conducted around Stehekin and

Hozomeen), but this decrease would be canceled out by an increase in wildland fire use fires and emissions. The emissions generated from prescribed burning would increase with each alternative, since the burn unit acreages increase under each alternative. Potential impacts from prescribed fire smoke would be mitigated through the approval process of the Washington State DNR, which would not approve a scheduled burn if regional conditions were such that air quality standards would be exceeded. Impairment of air quality would not occur under any alternative.

Table 20. Summary of Tons of Fuel Consumed

Management Strategy/Treatment Type	Alt1 / Alt 2 / Alt 3 Acres	Tons of fuel consumed		
		Alternative 1	Alternative 2	Alternative 3
Suppression	**260 / 260 / 260**	**9,247**	**Same as Alt 1**	**Same as Alt 1**
Wildland Fire Use	**200 / 200 / 200**	**7,113**	**Same as Alt 1**	**Same as Alt 1**
Mechanical Thinning and Prescribed Fire Units (FFRAs)				
Orchard/Rainbow	120 / 128 / 128	1,477	1,576	Same as Alt 2
Boulder Creek	132 / 147 / 147	1,625	1,810	Same as Alt 2
Company Creek	138 / 157 / 157	1,699	1,933	Same as Alt 2
Coon Run	180 / 201 / 201	2,216	2,474	Same as Alt 2
McGregor	200 / 200 / 200	2,462	2,462	Same as Alt 2
Weaver Point	52 / 54 / 54	497	516	Same as Alt 2
Harlequin	0 / 51 / 51	0	815	Same as Alt 2
Lower McGregor	0 / 133 / 133	0	1,272	Same as Alt 2
Lower Field (Upper McGregor)	0 / 138 / 138	0	1,319	Same as Alt 2
Total	**822 / 1,209 / 1,209**	**9,976**	**14,176**	**Same as Alt 2**
Prescribed Fire (Stehekin Contours)				
Courtney	0 / 0 / 375	0	0	1,571
Coon Lake	0 / 0 / 564	0	0	5,392
Lower Field	0 / 0 / 295	0	0	1,236
Wilsey	0 / 0 / 153	0	0	1,463
Upper Rainbow	0 / 0 / 604	0	0	5,774
Upper Boulder	0 / 0 / 309	0	0	2,954
Buellers	0 / 0 / 635	0	0	2,661
Imus Creek	0 / 0 / 268	0	0	2,562
Hazard Creek	0 / 0 / 888	0	0	8,489
Maxwell	0 / 0 / 393	0	0	3,757
Flick Creek	0 / 0 / 363	0	0	3,470
Total	**0 / 0 / 4,848**	**0**	**0**	**39,330**
Prescribed Fire (Hozomeen Contours)				
Little Jackass Mtn	0 / 0 / 2,180	0	0	48,310
Lightning Creek	0 / 0 / 3,039	0	0	29,082
Total	**0 / 0 / 5,219**	**0**	**0**	**77,391**
Re-ignition	**0 / 0 / 200**	**0**	**0**	**9,247**
Grand Total	**1,282 / 1,669 / 11,936**	**26,336**	**30,536**	**156,504**

4.3 Water Resources

4.3.1 Impacts Common to all Alternatives

There are several ways in which fire can impact water resources. These effects vary based on the size and severity of the fire, and include changes in annual water yield, peak flows, sediment yield, organic matter input, and water temperature. Annual water yield is defined as the volume of water runoff that can be expected in a 12-month period; it is the difference between precipitation and evapotranspiration. Peak flow is defined as the maximum flow or maximum rate at which water runs off a site during a storm event. Sediment yield is defined as the amount of sediment passing a particular point in a watershed per unit of time. Sediment can include soil as well as ash from burning vegetation.

All of the above parameters can significantly increase after a fire due to a reduction in vegetation, which plays an integral role in the hydrologic cycle. These changes are normal, although small fires and fires of low intensity would have little effect on water quality compared to larger fires and/or fires with higher intensities where effects could be moderate. These changes can have indirect effects on stream life, especially fish and macroinvertebrates. Further impacts to wildlife include a reduction in cover and forage along riparian zones and a reduction in organic debris in streams. These indirect impacts are discussed further under Fish and Wildlife in Section 4.4.

4.3.2 Alternative 1 - No Action Alternative

Suppression. Fire line construction could result in negligible to minor, adverse impacts to water resources through soil erosion and increased sedimentation, especially when lines are dug along steep slopes. Compaction from fire camps and/or heavy equipment can lead to small, localized increases in overland flow during rain events, associated erosion of hillslopes by gully and sheet wash erosion, and subsequent sedimentation and disturbance of nearby streams. Minor to moderate, adverse impacts to lakes and/or wetlands could occur when lake water that is used to fill helicopter buckets is drawn down, potentially removing native flora and fauna from the lake. Other impacts from lake dipping could include a loss of communities and function of areas within the drawdown zone; possible dissolved oxygen deficit in shallow, nutrient rich waters (such as Willow Lake); possible contamination with buckets that carried retardants from previous missions; direct disturbance to benthic communities from dipping the bucket; and disturbance of sediments, which affects lake water clarity and could impact plankton communities and water temperature. Fuel spills into lakes from aircraft during dipping operations could also impact lakes, and visitors could be impacted by the visibility of a “bathtub ring” around the lake as it gets drawn down.

It is unlikely that wetland vegetation in the Complex would carry a continuous fire except during drought conditions. Fire line construction through a wetland would result in a loss of vegetation that is short-term with minor to moderate impacts that include a loss of cover for biota, and changes in organic matter (large and small) recruitment into the water body.

Research on the impacts of wildland fire retardants on drinking water is lacking; however, Landsberg and Tiedemann (2000) stress that all retardants should stay out of streams that are drinking water sources. Most of the research on retardants focuses on fish and aquatic habitat impacts. Retardants and foams can have short-term major, adverse impacts to water quality and aquatic organisms. Retardants contain ammonia and phosphate or sulfate ions, which can be moderately toxic to fish and other aquatic organisms. Ammonia and phosphate elements also create a fertilizer that affects stream and lake invertebrate communities and nutrient budgets. Certain fire retardants contain sodium ferrocyanide, a chemical that releases cyanide when it is exposed to the ultra-violet radiation in sunlight, and is significantly toxic to fish. In addition to the toxicity of retardant chemicals, the surfactants used in foams can interfere with the ability of fish gills to absorb oxygen, in effect suffocating the fish. With proper mitigation measures, the impacts of retardants and foams on water quality would be minimized; however, in the event of a fire overcoming structures in Stehekin, retardant would likely be used to protect homes.

A foam fire suppressant, Phos-Chek WD881, was used in 1994 in the Boulder Creek watershed to aid in suppressing a wildfire burning near Stehekin. An evaluation on the effects of the application shows that there was probably little impact on stream biota and water quality (Glesne 1997). Runoff of the suppressant was likely limited by the ¼-mile buffer zone that was established around Boulder Creek, as well as seasonally low rainfall after the application.

Wildland Fire Use. Fires allowed to burn under the wildland fire use option would have varying effects based on the size and severity of the fire. Larger or higher severity fires would likely produce noticeable changes in annual water yield, peak flows, sediment yield, organic matter input, and water temperature. Because wildland fire use is not an option in areas with altered fire regimes, the impacts from large fires or higher severity patches would be accepted as being within the historic range of variability for water quality.

Mechanical Thinning and Prescribed Fire (FFRAs). Removal of vegetation along riparian corridors could have moderate impacts on water temperature, stream bank stabilization, the amount of organic debris in streams, and nutrient input. With proper mitigation measures that include a 200-foot riparian buffer within which the removal and burning of vegetation would be minimized, the combined thinning and burning treatments within the Stehekin FFRAs would have negligible impacts on water resources. Fire line construction in the FFRAs would have negligible impacts because the units are on flat ground, reducing the potential for erosion before crews can rehabilitate the line.

4.3.3 Alternative 2

Suppression. Impacts to water resources during fire suppression activities under Alternative 2 would be similar to those found in Alternative 1.

Wildland Fire Use. Impacts to water resources during wildland fire use activities under Alternative 2 would be similar to those found in Alternative 1.

Mechanical Thinning and Prescribed Fire (FFRAs, private property). Under Alternative 2 the upper range of acres treated annually by mechanical thinning increases by 50 acres (from 88 acres in Alternative 1, to 138 acres in Alternative 2). The upper range of acres treated by prescribed fire increases by 20 acres (from 180 acres in Alternative 1, to 200 acres in Alternative 2). Immediate impacts to water resources during mechanical thinning and prescribed burning treatments in the Stehekin FFRAS would be similar to those found in Alternative 1, but would occur over a greater area. Over time, these treatments should have increasing benefits to water resources over a greater area as more acres are treated. An additional 2 to 10 acres of thinning and burning on private land annually would have negligible impacts on water resources as long as a 200-foot riparian buffer, within which the removal of vegetation would be minimized, is used.

Mechanical Thinning and Pile Burning (road corridor and safety zones). Because the Stehekin River is adjacent to the road corridor in several stretches that total approximately 4 miles, the removal of trees close to the river to improve the escape route would have moderate adverse impacts on water resources. Tree removal could result in a decrease in bank stability, an increase in sedimentation, a loss of large woody debris recruitment, and an increase in water temperature. A 200-foot buffer along the river and streams could be used during corridor thinning to minimize impacts to water resources. Pile burning would have negligible impacts because it would not take place near stretches that are close to the river. Safety zone thinning and burning would have negligible impacts to water resources because these treatments would not take place near water.

4.3.4 Alternative 3 - Preferred Alternative

Suppression. Impacts to water resources during fire suppression activities under Alternative 3 would be similar to those found in Alternatives 1 and 2. However, over time, it is expected that fewer fires would have to be suppressed after prescribed burn treatments are conducted near Stehekin and Hozomeen.

Wildland Fire Use. Impacts to water resources during wildland fire use activities under Alternative 3 would be similar to those found in Alternatives 1 and 2. However, over time, it is expected that the wildland fire use option will be chosen more often after prescribed burn treatments are conducted near Stehekin and Hozomeen.

Mechanical Thinning and Prescribed Fire (FFRAs, private property). Impacts to water resources during mechanical thinning and prescribed fire activities under Alternative 3 would be similar to those found in Alternative 2.

Mechanical Thinning and Pile Burning (road corridor and safety zones). Impacts to water resources during mechanical thinning and pile burning activities under Alternative 3 would be similar to those found in Alternative 2.

Prescribed Fire (Stehekin Contours, Hozomeen Contours). Fire line construction could result in minor, adverse impacts to water resources through soil erosion and increased sedimentation where lines are dug along steep slopes. Impacts to creeks surrounding and within the contour burn units would be negligible as long as a 200-foot riparian buffer, within which the burning of vegetation would be minimized, is used. Low intensity burning is the prescription for the contours, although it is normal that some very small areas with high fire intensity may become completely devoid of vegetation, which would consequently hasten soil erosion. This impact, however, is likely to be minor given the small area and the likelihood that eroded soil from the site would be intercepted by surrounding unburned vegetation and it would not be transported to waterways.

Re-ignition. The impacts of re-ignition on water resources would be similar to those found for wildland fire use under all alternatives.

4.3.5 Cumulative Impacts to Water Resources

Although water quality within the Complex is generally very good, air pollution from nearby sources in the region is likely impacting water resources, especially high elevation lakes. Historic and current fish stocking continues to impact high lakes and their output streams. Three dams along the Skagit River and one dam at the southern end of Lake Chelan impact their respective watersheds. Multiple fires burning in one watershed could increase downstream sediment loads.

4.3.6 Mitigation for Impacts to Water Resources

Draw-Down.

- Only approved dip lakes will be used for bucket operations (see Appendix A, Figures 5 or 6 and Appendix D)
- Dip lakes identified as “sensitive” in the pending High Lakes Fishery Management EIS will not be approved for bucket operations
- Limit the quantity of water that can be drawn from any of the approved lakes if it appears that normal water level fluctuations may be exceeded
- Resource Advisors will monitor impacts to lakes during suppression operations and determine whether or not they can continue to be used as a water source

Retardants. The following guidelines should be followed to minimize the likelihood of retardant chemicals entering a stream or other body of water:

- The superintendent of the Complex is the only person who can authorize the use of fire retardant chemicals
- Avoid direct drops of retardant or foam into rivers, streams, lakes, or along shores. Establish ¼ mile buffer zones around all water bodies, within which chemicals cannot be applied unless human lives are at stake
- During training or briefings, inform field personnel of the potential danger of fire chemicals, especially foam concentrates, in streams or lakes
- Locate mixing and loading points where contamination of natural water, especially with the foam concentrate, is extremely unlikely
- Maintain all equipment and use a pump system equipped with check valves where appropriate to prevent release of foam concentrate into any body of water
- Exercise particular caution when using any fire chemical in watersheds where federal- or state-listed species exist
- Dip from a tank rather than directly from a body of water, to avoid releasing any foam into these especially sensitive areas
- Make sure all buckets/containers that have carried chemicals are completely cleaned before resuming use with just water (particularly buckets used for dipping out of lakes and streams)
- Operational monitoring will be done and detailed records will be kept concerning the types of chemicals used, their amounts, dates of application, and areas where applied
- Water chemical analysis of nutrients, surfactants, and other significant chemical components of these products will be monitored shortly after application in the vicinity of any water body
- Notify proper authorities promptly if any fire chemical is used in an area where there is likelihood of negative impacts
- Insist that manufacturers provide pertinent information on the chemical content of their products

Riparian.

- All prescribed burns require a burn plan, in which a riparian buffer distance is established to avoid burning or cutting any riparian vegetation.
- All thinning projects are conducted using approved silvicultural prescriptions
- Both prescribed burn and thinning project proposals require approval by the Complex’s Inter-disciplinary Team (IDT). Mitigation for impacts to water resources could be required prior to approval of the proposal
- Use alternative methods of fire line building in sensitive areas

4.3.7 Conclusion

Impacts to water resources would range from negligible to moderate for most fire management activities in all alternatives (major impacts could occur by improper use of retardants and suppressants). Erosion resulting from digging line or soil compaction would create negligible to minor impacts in all alternatives. Alternative 3 would require the largest amount of fire line among the alternatives. Impacts to riparian zones and associated waterways can be avoided if stream buffers are used to prevent loss of vegetation in all alternatives. Lakes and surrounding wetlands could experience minor impacts if a particular lake is overdrawn during fire suppression bucket drop operations. Should the need for fire retardant chemicals be necessary, water resources could experience major impacts. Only the superintendent of the Complex can authorize fire retardant chemical use. Over time, Alternative 3 would allow the natural process of fire to prevail over the largest area within the Complex, thus minimizing unnatural impacts to water resources. Alternative 1 would allow for the smallest area, and Alternative 2 would be in between alternatives 1 and 3. Impairment of water resources would not occur under any alternative.

4.4 Topography and Soils

4.4.1 Impacts Common to all Alternatives

The impact of fire on soils is of primary concern because of the close relationship between soils and vegetation. Fire can impact soil's physical, chemical, and biological properties in both beneficial and adverse ways. Severe, or adverse, impacts are more likely to occur to soils when there are steep slopes (greater than 30 percent), coarse-textured soils, low soil moisture, or high severity burns. Physical impacts to soils after a fire include a loss of organic matter, a decrease in water infiltration, an increase in water repellency (hydrophobicity), and a decrease in porosity, which can all lead to greater overland flow and greater erosion. Soil temperatures can also be altered through the loss of the overstory canopy, removal of the forest floor, and blackened residual organic matter, which can lead to heightened daytime soil temperatures and often lower nighttime soil temperatures. Significant impacts to the chemical properties of soils can occur after burning, such as the loss of long-term nutrient availability due to the volatilization of elements, especially nitrogen and sulfur.

The impacts of fire on biological soil properties are not fully understood; they can include, but are not limited to, the reduction of mycorrhizal formation and the reduction of competition from rhizomatous plant species. High intensity fires can cause severe damage to biological soil crusts; recovery is possible if they are burned by a low intensity fire that doesn't remove all of the structure of the crust.

Certain fire management activities can also severely impact biological soils crusts. Particularly susceptible areas that are likely to be impacted are the fragile subalpine and alpine zones, as well as bedrock benches, that are used as helispots during suppression and wildland fire use. These areas typically have very thin soils that are held in place and protected by soil crusts. Disruption of the crusts can hasten wind and water erosion, which could bury surrounding crusts, desiccate and destroy them. Large-seeded exotic plants such as cheatgrass (*Bromus tectorum*) require burial for germination, and disrupted soil crusts could provide adequate conditions for successful germination (whereas intact crusts would more likely resist invasion of exotics). Recovery time for disturbed crusts is a very slow process; although a crust might visually look healthy in 1 to 5 years, it can take up to 50 years to recover crust thickness, and 250 years to recover mosses and lichens (USGS 2003).

Beneficial impacts from fire are more likely to occur under a low intensity burn. For example, soil productivity and stability can be enhanced if soil temperature stays low. Plant pathogens can be controlled, and nutrient cycling can be enhanced by the release of essential nutrients into the soil that readily become available for plant use. The high pH of ash can neutralize normally highly acidic forest soils, stimulating microbial activity and resulting in more decomposition that makes more nutrients available to plants.

4.4.2 Alternative 1 - No Action Alternative

Suppression. Fire line construction could result in negligible to minor, adverse impacts to soil by hastening rill and gully erosion, especially when lines are dug along steep slopes. The cutting of trees to create a fire line would eventually have minor, adverse impacts to soils once the root systems decompose (typically 2 to 4 years) and become unable to hold the soil in place to reduce erosion. Fire camps, heavy equipment, and other areas where personnel and equipment are concentrated, can compact soil and consequently lead to reduced water infiltration, reduced porosity, and greater likelihood of sheet erosion (localized, minor to moderate adverse impacts). Localized activity surrounding helispots or camps located in subalpine zones can have major, adverse impacts through compaction and disturbance to soils and soil crusts. Free ammonia from concentrated fire retardant chemicals can be highly toxic in soils that have low cation exchange capacity and low microbial activity (Kalabokidis 2000), a common characteristic of soils in the Complex. Overall fire retardant impacts to soils would be major, localized, and of a short duration.

Wildland Fire Use. Fires allowed to burn under the wildland fire use option would have varying effects based on the size and severity of the fire. Higher severity patches of fire would likely produce changes in soil's physical, chemical, and biological properties, as outlined above under Section 4.4.1. Lower severity patches of fire would have long-term beneficial impacts on soils by providing nutrients and enhancing soil formation. Because wildland fire use is not an option in areas with altered fire regimes, the varying impacts from fire would be accepted as being within the historic range of variability for soils.

Mechanical Thinning and Prescribed Fire (FFRAs). The combination thinning and prescribed burning in Stehekin that would take place under this alternative would have short term, beneficial impacts on soils. Mechanical thinning of small-diameter trees could create minor ground disturbance; however, the low intensity burning that would take place after thinning would have moderate, beneficial impacts by enhancing soil productivity and stability, controlling plant pathogens, and increasing nutrient cycling. Large-diameter thinning would have negligible impacts because it is typically conducted over snow during the winter months to avoid ground disturbance.

4.4.3 Alternative 2

Suppression. Impacts to soils during fire suppression activities under Alternative 2 would be similar to those found in Alternative 1.

Wildland Fire Use. Impacts to soils during wildland fire use activities under Alternative 2 would be similar to those found in Alternative 1.

Mechanical Thinning and Prescribed Fire (FFRAs, private property). Under Alternative 2 the upper range of acres treated annually by mechanical thinning increases by 50 acres, and for prescribed fire the upper range increases by 20 acres. Immediate impacts to soils during mechanical thinning and prescribed burning treatments in the Stehekin FFRAS would be similar to those found in Alternative 1, but would occur over a greater area. Over time, these treatments should have increasing benefits to soils over a greater area as more acres are treated. An additional 2 to 10 acres of thinning and burning on private land annually would have negligible impacts on soils.

Mechanical Thinning and Pile Burning (road corridor and safety zones). Thinning of the road corridor and safety zones will have negligible impacts to soils. Pile burning could have short term, moderate adverse impacts if piles are burned when soil moisture is low, thus creating concentrated areas with very hot soil temperatures. If piles are burned when soil moisture is high (e.g., after fall rains), impacts could be minimized. The removal of trees next to the Stehekin River or other streams could hasten soil erosion and reduce bank stability, thus increasing sedimentation.

4.4.4 Alternative 3 - Preferred Alternative

Suppression. Impacts to soils during fire suppression activities under Alternative 3 would be similar to those found in Alternatives 1 and 2. However, over time, it is expected that fewer fires would have to be suppressed after prescribed burn treatments are conducted near Stehekin and Hozomeen.

Wildland Fire Use. Impacts to soils during wildland fire use activities under Alternative 3 would be similar to those found in Alternatives 1 and 2. However, over time, it is expected that the wildland fire use option will be chosen more often after prescribed burn treatments are conducted near Stehekin and Hozomeen.

Mechanical Thinning and Prescribed Fire (FFRAs, private property). Impacts to soils during mechanical thinning and prescribed fire activities under Alternative 3 would be similar to those found in Alternative 2.

Mechanical Thinning and Pile Burning (road corridor and safety zones). Impacts to soils during mechanical thinning and pile burning activities under Alternative 3 would be similar to those found in Alternative 2.

Prescribed Fire (Stehekin Contours, Hozomeen Contours). Fire line construction could result in minor, adverse impacts to soils by hastening soil erosion where lines are dug along steep slopes. Low intensity burning is the prescription for the contours, although it is normal that some very small areas with high fire intensity may become completely devoid of vegetation, which would consequently hasten soil erosion. This impact, however, is likely to be minor given the small area and the likelihood that eroded soil from the site would be intercepted by surrounding vegetation and duff. The majority of these units would have beneficial impacts to soils since low intensity burning would provide nutrients and enhance soil formation.

Re-ignition. The impacts of re-ignition on soils would be similar to those found for wildland fire use under all alternatives.

4.4.5 Cumulative Impacts to Soils

Past fire suppression is likely the largest factor impacting soils surrounding the Stehekin and Skagit valleys. Continued fire exclusion in these areas will continue to have the largest impact on soils, through fuel build-up and potential for high-severity fires. These two valleys have also been impacted by past logging. Biological soil crusts are affected throughout the Complex by foot traffic along ridgelines and helispots that are used for other park operations, where surprisingly few numbers of people can create large impacts. Traffic in fragile subalpine areas can also impact thin soils due to the short growing season and wet soils. Developments along the Skagit Valley, including Seattle City Light industrial development and towns have impacted soils through compaction and ground disturbance.

4.4.6 Mitigation for Impacts to Soils

- Avoid digging line across, and especially down, steep slopes whenever possible
- Construct water bars along fire line that crosses steep slopes
- Set aside the removed topsoil and organic debris for later restoration
- Rake over fire lines as soon as possible, and/or before fall rains
- Maintain fuel moisture at as high a level as possible to achieve objectives (burning an area while moisture content of large diameter fuels, duff, and soil is high will limit the duration of the fire and the amount of heat penetration into lower soil layers)
- Use aeration and raking to relieve soil compaction and promote re-growth
- Leave woody material when prescribed burning for nutrient cycling and mycorrhizal function
- When prescribed burning, leave unburned strips of vegetation along riparian areas to serve as slope stability buffers and to decrease the potential for stream sedimentation (all prescribed burns require a burn plan, in which a riparian buffer distance is established to avoid burning or cutting any riparian vegetation)
- Avoid any activity in areas covered by biological crusts, including helispot locations, fire line digging, foot traffic, camp locations, thinning and prescribed burning
- Educate firefighters on how to identify soil crusts and how to avoid impacts

4.4.7 Conclusion

Impacts to soils range from negligible to major; most impacts are either negligible or minor. Major impacts to biological soil crusts can be mitigated by avoiding the areas in which they are found. Moderate impacts resulting from concentrating crews and equipment in small areas could be mitigated by using aeration and raking to relieve soil compaction. Moderate, localized impacts from pile burning can be minimized by burning when soil moisture is high. Over time, Alternative 3 would allow the natural process of fire to prevail over the largest area within the Complex, thus minimizing unnatural impacts to soils through fire exclusion, fuel buildup, and high severity wildfires. These unnatural impacts would be more likely to occur in areas surrounding Stehekin and Hozomeen under both alternatives 1 and 2, which reduce the area in which natural fire would be allowed. Impairment of soils would not occur under any alternative.

4.5 Fish and Wildlife

4.5.1 Impacts Common to all Alternatives

Ecological Effects of Fire on Terrestrial Wildlife: Ecosystems in the Complex evolved in response to periodic fire and other disturbance events. As a result, individual species that persist as part of these ecosystems either benefit from fire or are tolerant of it over the long-term, despite possible short-term loss of some individuals and habitat. As such, wildlife populations that currently occur in the Complex existed here in the presence of fire under historic fire regime conditions. There would be a range of both adverse and beneficial impacts to wildlife, depending on the species affected, and the season, timing, intensity of the fire and the rate of fire spread. These impacts would include alteration of habitat, species composition and population levels.

With approximately 489,000 acres of forested and subalpine habitat in the Complex, fires would likely have little consequence on long-term impacts to wildlife species, and if spread over the Complex in a pattern similar to its current mosaic of forest stand age classes, would result in overall beneficial impacts to most species. However, impact on some species, especially those with very small populations (e.g., spotted owl) or habitat specialists (e.g., marbled murrelet) could be adversely impacted. Increased soil temperatures, smoke, erosion, and changes in vegetation also affect wildlife. While some loss or displacement of individual animals would inevitably occur in burned areas there would be long-term benefits to some populations as a result of restoration of fire-created habitat diversity. Wildlife would have a wide variety of reactions to fire, including burrowing, fleeing and flying. Some species, such as terrestrial amphibians, reptiles, insects and small mammals may survive fast-moving, low intensity fires by burrowing or fleeing, while some larger animals would not be able to move out of the fire path in time, becoming disoriented by the fire.

Riparian corridors and wetlands may act as refugia for some animals during fires. While soil surface temperatures remain high during fire, the soil below the surface (as few as 4 inches deep) may insulate against temperatures as high as 1000 degrees F (Lawrence 1966 in Barro and Conard 1991). Studies of pocket gophers in the Sierra Nevada, however, have determined that vapor pressure in burrows appears to be a better indication of survival of small mammals than temperature. Fires often result in a temporary increase in insect-feeding birds. Other species that may increase following fire include scavenger/predators such as ravens. Overall, forage species are often enhanced by an increase in nutrients, resulting in similar increases or benefits to populations dependent on these species. With the nutrient rich post-fire flush of herbaceous vegetation increasing browse for deer and other animals, prey-stalking opportunities also would increase. Such populations often increase where suitable habitat has burned. That habitat may be enhanced or expanded. The minor to major effects of fire on wildlife may be short- or long-term depending on vegetation recovery, fire severity and other factors.

Ecological Effects of Fire on Aquatic Wildlife: Direct effects of fire on water would include changes in water chemistry, soils, water temperature and vegetation associated with water resources. Indirect effects could include changes in fish and amphibian species composition, habitat dynamics, accumulation of woody debris, water yield, hydrologic processes, erosion patterns, and nutrient cycling. These changes may result in either beneficial or adverse impacts, depending on factors related to fire severity, season, location, vegetation type, and magnitude of burns. Increased sediment yield and water temperatures would tend to be short-lived, unless a fire was of extreme severity. Increases in runoff and nutrient flux would be expected to continue for several years (as many as ten years), particularly after large fires. Although such events are part of the natural process, large or severe fires could create negative impacts on fisheries if they caused changes in water quality at a time when the fishery was most vulnerable.

Impacts on Individual Species:
Northern Spotted Owls *FT, SE* – Implementation of the fire management plan has the potential to remove suitable spotted owl habitat each year. This could result in the incidental take of spotted owls through the loss of suitable habitat acreage and/or direct take of owls if the fire(s) burned into a nest stand during the breeding season (March 1 – September 30), as well as noise disturbance, impacts from helicopter use, and possibly smoke effects. Habitat destruction outside the Complex (as a result of urban development, logging and wildland fire suppression, etc.) has resulted in increasing vulnerability of late successional species, such as northern spotted owls, to stand replacing fire effects. Within the Complex habitat modifications have been relatively minor and have not had a significant effect on northern spotted owls.

Generally it is unlikely the natural fire regime has been significantly affected, especially since effective fire suppression in the west began only in the early 1950s. Exceptions may have occurred in specific areas, e.g., the Stehekin Valley, where suppression efforts have been relatively effective for about 100 years. Although adult owls could escape a fire, adverse effects to individual nestlings and eggs from nest tree damage or destruction and to the nestlings from excessive smoke could result.

Suppression activities, fire effects and smoke production would be carefully monitored in the vicinity of known owl nesting areas. Conditions would be put in place to protect spotted owl nest sites. Foraging habitat for northern spotted owls could improve as open areas for voles, mice and other small mammals were created by wildland fire use or prescribed fire. As mentioned above, avoidance (to the degree possible) of known activity sites and habitat for northern spotted owls would mitigate impacts.

Under the application of fire suppression or wildland fire use, impacts to northern spotted owls could range from negligible to major, depending on the fire location, severity and extent. As mentioned above, to the extent practicable, prescribed fire would avoid nesting seasons. Prescribed fire in spotted owl habitat could adversely affect the species. Mechanical fuel reduction would have negligible impacts because these activities would either not occur in suitable habitat or if in suitable habitat would be done outside the breeding season.

Marbled Murrelets *FT, ST* – The potential for impacts to marbled murrelets would be limited to drainages along the western edge of the Complex. Management options in these areas would be limited to wildland fire use or suppression. These management options would likely result in the loss of suitable murrelet nesting habitat. Fires can result in loss of local forest structural diversity and suitable nest trees, both necessary components of murrelet nesting habitat. Along with the potential risk of habitat loss is the direct loss of murrelets that could be nesting (April 1 – September 15) within suitable habitat stands, although this risk would diminish as the fire season progressed into the months of September and October. There is also a risk from noise disturbance and impacts associated with helicopter use. Further, it is unknown how much of an adverse effect smoke may have on nesting murrelets. The marbled murrelet recovery plan (US Fish and Wildlife Service 1997) cites fire and smoke disturbance as possible or likely impacts on marbled murrelets, stating that more information is needed in order to fully protect murrelets within national parks.

It is unlikely that wildland fire use would result in beneficial effects to murrelets, since they are not dependent on surrounding habitat quality for food. In addition to the mitigation measures listed above for northern spotted owls, and, in general, for rare, threatened and endangered species, in potential or documented habitat, air operations would be avoided to the degree possible until two hours after sunrise and curtailed two hours before sunset during fire suppression activities. This would be true especially during the early nesting season.

Under fire suppression or wildland fire use impacts to marbled murrelets could range from negligible to major, depending on the fire location, severity and extent.

Bald Eagles *FT, ST* – Most bald eagle use in the Complex occurs from November to March along the Skagit River from the boundary upstream to Newhalem, a distance of approximately 9 miles. Proposed management action within this area is limited to fire suppression. The only nest in the Complex is along the Stehekin River near Lake Chelan. The major threats to bald eagles from wildland fire use in the Complex would include disturbance to pairs during the nesting periods from low flying aircraft and/or loud machinery. Noise from aircraft for fire suppression activities or monitoring may be disruptive up to one mile away, unless there is a topographic sound and visual barrier. Individual site characteristics would warrant variable buffer distances. Other impacts to bald eagles may include the direct loss of nesting or roosting habitat from fires and smoke. Fire benefits to the bald eagle would be the additional nest and perch trees created from snags.

Northern Goshawks *SC*, Merlin *SC* – Potential impacts to these species would be similar to those described above for northern spotted owls and marbled murrelets. While adult birds rarely suffer direct mortality from fire, stand replacement fires can lower recruitment by destroying nests and foraging trees. Long-term effects can be beneficial by promoting seral stages needed by adult goshawks.

Common Loon *SS* – In the Complex, loons are rare nesters (Hozomeen Lake only) and uncommon spring and fall migrants to park reservoirs. Loons' nests are usually at the edge of water. It is unlikely a fire would destroy an active nest due to its juxtaposition to water. Likely impacts to these aquatic species are those impacts that would decrease the abundance of forage fish that they would consume. Loons are highly susceptible to disturbance on lakes where breeding occurs. Fire suppression activities, such as helicopter dipping water out of a lake, have the potential on small water bodies (e.g. Hozomeen Lake) to cause loons to temporarily leave the lake or at least leave an active nest unattended.

Western Grebe *SC*, American White Pelican *SE* – Both species are rare spring and fall migrants to park reservoirs. Both species forage on fish. Likely impacts to these aquatic species are those impacts that would decrease the abundance of forage fish that they would consume.

Flammulated Owl *SC* – Suitable habitat exists in low elevation areas within the Stehekin River drainage, including Flat Creek and Bridge Creek. Despite efforts over the last 15 years to document vertebrate species within park boundaries, flammulated owls remain undocumented in the Complex. Flammulated owls occur in forests with a substantial ponderosa pine component. It is a goal of the Fire Management Program to aid in increasing ponderosa pine to areas within the Stehekin River drainage. This would likely be beneficial to flammulated owls.

Ferruginous Hawks *ST* – In the Complex, ferruginous hawks are very rare migrants, moving through the alpine and subalpine habitats in late summer. Three records exist in the Wildlife Observation Database that are of lone birds moving along alpine ridges. Ferruginous hawks should be able to respond to fire by simply moving their migration flight patterns to another ridge.

Golden Eagle *SC*, Peregrine Falcon *SS* – Golden eagles and peregrine falcons occur mostly at higher elevations in the Complex. While golden eagles nest in trees, both these species mostly use rock faces or out-crops as nesting habitat. Neither species is likely to suffer direct mortality from periodic fires that occur in the Complex. Numbers of individuals increase during fall, as ridges in the North Cascades provide conditions (updrafts along north/south running ridges) needed for migrating birds.

Vaux's Swift *SC* – Potential impacts to the swift would be similar to those described for spotted owls and marbled murrelets.

Lewis' Woodpecker *SC*, Black-backed Woodpecker *SC* – Fire has played an integral role in maintaining suitable habitat for both these woodpecker species. Despite the vulnerability of nest, roost, and forage trees to removal from fire, it is unlikely these species would be negatively affected by implementation of any of the alternatives.

Pileated Woodpecker *SC* – Potential impacts to this species would be similar to those described above for northern spotted owls and marbled murrelets. While adult birds rarely suffer direct mortality from fire, stand replacement fires can lower recruitment by destroying nests and foraging trees.

Gray Wolves *FE, SE* – Fire suppression, wildland fire use or prescribed fire impacts would likely not cause direct mortality as wolves are highly mobile. Effects on gray wolf habitat are best defined by how fire affects gray wolf prey. Ungulates and other prey are fire-dependent species. Browse for ungulates usually increases with frequent low-intensity fires. Catastrophic fires that sterilize soil and destroy roots of browse plants would decrease prey populations and thus negatively affect wolves.

Canada Lynx *FT, ST*; Pacific Fisher *SE*; and California Wolverine *SC* – Stand replacement fires can impact large areas, rendering them unsuitable for these species for several decades. In addition to habitat loss, openings created by large fires remove travel corridors connecting suitable stands of habitat. Mixed severity and low-intensity fires that create or maintain cover for prey species would likely benefit lynx, fisher, and wolverine.

Grizzly Bear *FT, SE* – Periodic, low intensity fires can promote and maintain many important berry-producing shrubs and forbs. Impacts to grizzlies would be the same as those that would occur to other large mammal species. Under fire suppression and wildland fire use, impacts could range from negligible to moderate depending on the fire location, severity and extent. Prescribed burning would have negligible to moderate impacts.

Western Gray Squirrel *ST* – Most squirrels are capable of escaping fires and it is unlikely direct mortality would affect squirrel populations. A small isolated population of western gray squirrels inhabits the Stehekin Valley. These squirrels depend on fire-dependent mast trees for food. Low intensity prescribed fires are unlikely to impact mature trees. Ponderosa pines are dependent on fire for stand maintenance. Long-term effects of prescribed fire are likely to be beneficial to western gray squirrel populations.

Bats, including the Keen's Myotis (SC) and Townsend's Big-Eared Bat (SC) – Little information is available to address the effects of fire on rare bats. The benefits and/or consequences of fire have not been studied. Direct mortality from fire is unlikely in bats because they are highly mobile. There is evidence that they are even able to move young from a nursery site in response to disturbance.

Though unknown, it is believed the long-term effects to habitat from fire are positive. Fire would increase opening used to for foraging and likely increase prey base. Townsend's big-eared bat has only been documented in and around the Complex in buildings and under bridges. Since buildings and bridges would be protected from fire, Townsend's big-eared bat would likely be unaffected. Keen's myotis roosts mostly in rock crevices and is not likely to be negatively affected. However, avoiding smoke impacts to known roosts is a prudent precaution.

Amphibians, including the Western Toad (SC), Columbia Spotted Frog (FC, SC) –
Fire poses a direct threat to mortality of amphibians. However, there is some evidence that western toads are able to escape fire by burying themselves under wet leaves and soil in small depressions. Western toads and Columbia spotted frogs occupy diverse habitats. Some of

these habitats have evolved with frequent fire, other habitats rarely experience fire. These species are vulnerable to changes in both terrestrial and aquatic environments. Fires that burn logs, stumps, and other down woody debris would immediately remove hiding cover. Fires during early spring could affect egg masses by reducing shade and increasing water temperatures. If changes in riparian habitat occurred or if extensive fires caused major erosion or ash deposits in rivers or streams, it is likely amphibian breeding habitat would be degraded.

Fish, including Chinook Salmon (FT, SC), Bull Trout (FT, SC) – Fish could be affected by fire suppression, wildland fire use or prescribed fire. Although it is unlikely, riparian vegetation could be burned to the extent that stream temperatures would rise and fish would be affected during large, high-intensity wildland fire. If such changes in riparian habitat occurred or if extensive fires caused major erosion or ash deposits in rivers or streams, it is likely that fish would be affected. As with other species, however, fish have evolved in response to periodic disturbance by fire and it is reasonable that they would persist. To the extent possible, these management strategies would avoid impacts during the spawning seasons of these fish – for instance the maximum manageable area of a wildland fire use fire could be contained to areas where such impacts would be limited or would not occur. Overall, fires would likely result in long-term beneficial impacts to fish by increasing the nature and extent of woody debris in streams and rivers.

4.5.2 Alternative 1 - No Action Alternative

Suppression. In addition to the ecological impacts of fire on wildlife, the noise and activity associated with wildland fire suppression would result in a variety of impacts to wildlife that would be similar to the impacts associated with construction projects or visitor use in developed areas. Periodically, there would be moderate impacts associated with wildland fire suppression especially when there was significant fire spread before fires could be suppressed. The mobilization and transport of firefighters could result in the use of helicopters, staging of personnel, supplies and equipment and other actions that in combination would result in a decrease in wildlife presence in the vicinity of the suppression effort. These activities could take place throughout the daylight hours (including dawn and dusk), resulting in disturbance during normally quiet periods. The short-term noise and activity would likely cause alarm, confusion and other behavioral responses in large and small wildlife species.

Ongoing helicopter reconnaissance and monitoring related to fire behavior analysis and suppression could result in the same impacts repeated over the duration of the fire. Once the fire had been suppressed, the above short-term minor to moderate impacts would cease and wildlife behavior would return to pre-suppression conditions. Although there would be no long-term effects of fire suppression related activities (noise and disturbance) on wildlife (dependent on the timing, location, duration and extent of the fire) it could result in short-term impacts on breeding, gestation or other processes associated with bearing young or finding food. These impacts could result from stress. Cutting fire line and removal of snags near fire lines could have direct adverse impacts on wildlife.

Although fire retardant chemicals would rarely be used, they do pose a serious threat to aquatic organisms. Long-term fire retardants are ammonia-based chemicals that are considered to be non-toxic to terrestrial organisms and of low to moderate toxicity to aquatic organisms. Some retardants contain an anti-corrosive agent called sodium ferrocyanide, which releases cyanide when it is exposed to ultraviolet (UV) radiation. Although cyanide exposure is of limited toxicity to terrestrial organisms, research shows that it causes significant toxicity to fish when exposed to sunlight. The persistence of retardant chemicals varies by soil types; the toxicity of chemicals is greatly reduced on soils with high organic content. However, where organic content is low, retardant chemicals could remain toxic for over 21 days. Organic content is low throughout much of the Complex; therefore, the use of retardants with ferrocyanide could pose serious threats to water quality and aquatic organisms. Additionally, fertilizers in retardants can cause nitrate poisoning to animals that have consumed forage that has been sprayed.

Short-term fire retardants, or foams, are commonly sprayed on buildings or power line poles for protection from a nearby fire. Foams are more toxic to aquatic organisms than long-term retardants. The primary toxicant in foams is the surfactant, which interferes with the ability of fish gills to absorb oxygen from the water, causing the fish to suffocate. Surfactants also can alter the permeability of biological membranes, making the organism more susceptible to impacts from the uptake of other pollutants.

The long-term impacts of fire exclusion on fauna are not well understood. In general, however, exclusion in fire-adapted forests can change faunal abundance and community composition. For example, in some lodgepole pine communities the most productive period for bird communities is the first 30 years after a fire. The exclusion of fire may make it difficult to maintain the abundance of bird species in these communities. Aspen stands, which are regenerated by moderate to high severity fire, provide more forage and a greater diversity of understory plants than the conifer communities that replace them when fire is excluded. Heavy fuel loads due to fire exclusion increase the risk of a large, uniformly severe wildfire, which would destroy nesting trees and dense forest structure required by spotted owls.

Wildland Fire Use. In addition to the broad range of adverse and beneficial ecological impacts on wildlife described above, wildland fire use would result in minor to moderate long-term ecological benefits to wildlife. This would primarily be as a result of the restoration of a natural fire regime to an ecosystem that developed in the presence of natural wildland fire. Depending on the location, severity and extent of the wildland fire use fire, there would also be minor to moderate adverse effects on wildlife habitat and wildlife presence. Except in the unlikely event of an extremely large fire that would burn over a major portion of a watershed, wildlife impacts would be minor to moderate. Although fire, smoke inhalation or stress would kill some animals, other animals would escape to unburned refuges (such as riparian or other wetland areas) and would repopulate the burned area within a short time. Immediately after the burn, there would likely be increases in some bird species, some browsers and some predators. Some species would naturally take longer to recover pre-fire population sizes. In the long-term most would benefit from the returning of some areas to an early successional stage, where low-growing shoots and herbaceous vegetation in clearings are available. The utility of these areas adjacent to unburned or lightly burned late successional areas would increase localized wildlife diversity and presence.

Mechanical Thinning and Prescribed Fire (FFRAs). There would be negligible to minor impacts to wildlife associated with the continued implementation of mechanical thinning and prescribed burning in the Stehekin FFRAs. These impacts would primarily be related to short-term habitat change (such as loss of down wood and cover), noise and activity, smoke production, and increased human presence along the edges of developed areas and at the designated areas where such treatment would take place.

A bald eagle nest is located within one of the burn units, and spotted owls are known to be present in another unit (although a nest has not been identified in several years). All project work will be conducted to avoid nesting periods and a buffer around nests and roosting areas will be established, within which no project work will be conducted.

Project work could also impact western gray squirrels. Short-term food sources could be impacted; however long-term habitat enhancement would occur.

4.5.3 Alternative 2

Suppression. Impacts to fish and wildlife during fire suppression activities under Alternative 2 would be similar to those found in Alternative 1.

Wildland Fire Use. Impacts to fish and wildlife during wildland fire use activities under Alternative 2 would be similar to those found in Alternative 1.

Mechanical Thinning and Prescribed Fire (FFRAs, private property). Under Alternative 2 the upper range of acres treated annually by mechanical thinning increases by 50 acres, and for prescribed fire the upper range increases by 20 acres. Immediate impacts to fish and wildlife during mechanical thinning and prescribed burning treatments in the Stehekin FFRAS would be similar to those found in Alternative 1, but would occur over a greater area. Over time, these treatments should have increasing benefits to fish and wildlife over a greater area as more acres are treated. An additional 2 to 10 acres of thinning and burning on private land annually would have negligible impacts on fish and wildlife as long as a riparian buffer, within which the removal of vegetation would be prohibited, is used. There are no known additional nests in the expanded units.

Mechanical Thinning and Pile Burning (road corridor and safety zones). The impacts of mechanical thinning and pile burning along the road corridor and within safety zones would be similar to those found under Alternative 1 for the FFRAs. However, there are additional concerns about the removal of large live trees, snags and downed woody debris, all of which provide habitat for numerous cavity nesters and small mammals.

4.5.4 Alternative 3 - Preferred Alternative

Suppression. Impacts to fish and wildlife during fire suppression activities under Alternative 3 would be similar to those found in Alternatives 1 and 2. However, over time, it is expected that fewer fires would have to be suppressed after prescribed burn treatments are conducted near Stehekin and Hozomeen.

Wildland Fire Use. Impacts to fish and wildlife during wildland fire use activities under Alternative 3 would be similar to those found in Alternatives 1 and 2. However, over time, it is expected that the wildland fire use option will be chosen more often after prescribed burn treatments are conducted near Stehekin and Hozomeen.

Mechanical Thinning and Prescribed Fire (FFRAs, private property). Impacts to fish and wildlife during mechanical thinning and prescribed fire activities under Alternative 3 would be similar to those found in Alternative 2.

Mechanical Thinning and Pile Burning (road corridor and safety zones). Impacts to fish and wildlife during mechanical thinning and pile burning activities under Alternative 3 would be similar to those found in Alternative 2.

Prescribed Fire (Stehekin Contours, Hozomeen Contours). The effects of prescribed fire on fish and wildlife would be similar to wildland fire use as described in Section 4.5.2, and would also include the generalized ecological effects of fire on wildlife as described in Section 4.5.1. However, the timing of the prescribed burn would be controlled to reduce the impacts on wildlife;

most burning would be conducted in the fall, thus eliminating potential impacts to most breeding birds. Additionally, the fire would burn at a more uniform low intensity than it would naturally given its current fuel loadings. Comprehensive surveys have not been conducted in the proposed burn units for most species, and several listed species are likely to exist within the units.

Re-ignition. The impacts of re-ignition on fish and wildlife would be similar to those found for wildland fire use under all alternatives.

4.5.5 Cumulative Impacts to Fish and Wildlife

Cumulative impacts to fish and wildlife are numerous and some are poorly understood. They include habitat loss in surrounding lands, habitat degradation through air pollution and acid rain, the historic removal of large predators, fish stocking and potentially fish removal (pending decision on High Lakes Fishery Management EIS), and global climate change.

4.5.6 Mitigation for Impacts to Fish and Wildlife

- Adhere to a 200-foot riparian buffer for all thinning and/or burning project work
- The removal of trees along the road corridor will be monitored by resource staff
- Use developed areas or areas extensively disturbed by human impacts for staging fire suppression activities
- Limit the types of activities, such as helicopter operations, that would be performed at dawn, dusk or night as appropriate to minimize impacts to threatened and endangered species
- Rely on existing trails to the extent possible to access fires
- Minimize the use of fire retardant or foams in suppression efforts
- Dip lakes identified as “sensitive” in the pending High Lakes Fishery Management EIS will not be approved for bucket operations
- Ensure that firefighting equipment is in good condition and use best management practices to ensure that spills of lubricants, fuels or other chemicals does not occur
- Prescribed fire projects will avoid nesting or spawning seasons or will not be conducted in areas where analysis of rare species and habitat have not been made
- To the degree possible, direct fire-related mortality of rare species, including known habitat or activity sites, would be avoided
- To the degree possible, construction of fire lines would avoid known rare, threatened or endangered species habitat
- To the degree possible, avoid helicopter use during nesting season within northern spotted owl and marbled murrelet nesting habitat.

Eagles

- Maintain as many mature trees as possible to protect forage, perch, alternate nest and roost habitat within a ¼ mile radius of a known nest site
- Avoid construction activities that result in increased pedestrian activity within ½ mile of nest sites, and carefully manage public trails and camping within the distance
- Avoid tree cutting and other noisy activities within ½ mile of an active nest during the breeding season (January 1 to August 31)
- Maintain high tree density and moderate canopy closure to visually buffer bald eagle nests from human activities

Spotted Owls

- Maintain mature trees and large snags within a 0.7-mile radius of a known nest site
- Avoid tree cutting and other noises that are above ambient noise levels within ¼ mile of an active nest during the breeding season (March 1 to September 30)

4.5.7 Conclusion

The impacts on fish and wildlife range from negligible to major and short-term to long-term. Implementation of Alternative 1 would result in long-term negative impacts to fish and wildlife as a result of continued fire suppression and failure to return fire to altered fire regimes within the Complex. The impacts of Alternative 2 would not change significantly from Alternative 1. Alternative 3 would provide the greatest long-term benefits to fish and wildlife through the return of fire to areas in which it has historically been suppressed. Faunal habitat would be enhanced over time as natural processes, including fire, are allowed to play their role in forested ecosystems. Impairment of fish or wildlife resources would not occur under any alternative.

4.6 Vegetation

4.6.1 Impacts Common to all Alternatives

Vegetation Communities (Covertypes): There are several ways in which fire and fire suppression can impact vegetation communities. Fire effects vary according to the size and severity of the fire that occurs, and include changes in vegetative community structure (e.g., density of trees, age classes, and fuel loading) and composition (e.g., species, vegetation type). The assessment of the impact of the fire effect is dependent upon the historical range of variability for the fire regime associated with the vegetative community (see Chapter 3 descriptions of fire regimes) and the influence that the disturbance has on the scale of the matrix area in which it occurs. If the frequency, size and severity of a natural disturbance is within the historical range of variability for the vegetation community, and it perpetuates the balance of historical structural diversity at the larger matrix scale, then the impact would be beneficial, and range from negligible to major depending on its duration. If this same disturbance were suppressed, thus enabling the balance of historical structural diversity to be disrupted, then this impact would be deleterious, and range from negligible to major depending on its duration.

Threatened, Endangered, and Special Status Plant Species: The effect of fire, fire management and fire suppression activities on most sensitive plant species is unknown. Complex specialists assume that many of these native plants have evolved in the presence of fire under historic fire regime conditions. These plants would neither be harmed nor benefit from fire. If non-natural fire intensity occurs as a result of excessive fuel levels, some sensitive plant populations may suffer damage. The Fire Effects Information System (FEIS) lists many of the known effects of fire on plant and animal species, including those of special interest to the Complex staff. However, only one of the sensitive plant species, Russet sedge, (*Carex saxatalis*) in the North Cascades National Park Service Complex list, is found in the FEIS site. No fire effects are known for this specie in FEIS. Findings from other resources are listed below followed by brief descriptions of the effects of fire on the special interest species that are listed FEIS.

Impacts on Individual State Listed Species:

Thompson's clover (*Trifoluim thompsonii*) T – Thompson's clover is a threatened plant species that occurs in open to sparsely wooded sagebrush communities near edges of the ponderosa pine zone. It has been shown to have increased flower heads and plants were significantly taller in areas that had been recently burned when compared to unburned areas

(Scherer *et. al.* 1997). This suggests that Thompson's clover may benefit (show a resource release) as a result of fire.

Clustered lady slipper *(Cypripedium fasciculatum*) S – The clustered lady slipper is a sensitive plant species that occurs in mixed conifer forests on the east and west side of the Cascades. Research findings from the nearby Wenatchee NF suggest that wildland fire of varying intensities had little effect on morphologic attributes or numbers of individual plants; however, plants in burned areas had a significantly lower number of fruits the year following fire, suggesting fire has a negative effect on this plant (Harrod *et. al.* 1997).

Seely's catchfly (*Silene seelyi*) S – Seely's catchfly is a sensitive plant species that is a local endemic to the Wenatchee Mountains of Chelan and Kittitas counties where it is found to occur on cliffs and talus slopes. In research conducted following wildfire in the Wenatchee NF, plants in burned and unburned areas were compared for several attributes. Seely's catchfly showed no positive or negative effects of fire on morphologic attributes or population parameters (Harrod *et. al.* 1997).

Moonwort *(Botrychium sp.) W* – Several moonworts have been assigned a "watch" status, and one is state-listed as sensitive. Although the effects of fire have not been studied on any of the species of moonworts that are known to occur, or may occur in the Complex, like those that have been studied, these plants have an unusual biology that consists of an above-ground leaf and a below-ground portion which is mycorrhizal. It has been found that removal of the above-ground leaf does not negatively affect its emergence in subsequent years, and that removal or damage of the leaf by fire or other means is inconsequential (Johnson-Groh 1997).

Invasives: Certain routine fire management activities may contribute to the establishment and spread of invasive, non-native species. Actions that contribute to the disturbance of an area, including line construction (both mechanically and with hand tools), clearing of land for helispots and spike camps, and thinning may contribute to the presence of invasive species. While disturbance resulting from fire or fire management activities may by itself result in available habitat for pioneering invasive species, the primary threat of these activities is due to the vectors introduced into otherwise pristine areas. Several invasive species within the Complex are of specific concern related to fire management. The following is a discussion of those species and the potential effect of fire and fire management activities on their establishment and spread.

Impacts on Individual Invasive Species:
Cheatgrass – Cheatgrass exists as small populations in several areas of the Complex. It readily invades disturbed sites after a fire if there is an available seed source, and may serve as the fine fuel to carry fire from grasslands and understory into timber. Once established, cheatgrass can promote more frequent and larger fires, which can burn entire portions of a landscape, failing to leave islands of unburned vegetation behind (Whisenant 1990). Increased fire frequency favors the existence of cheatgrass by excluding perennial shrubs, forbs, and grasses which can not tolerate reduced fire intervals (Pellant 1990, Peters and Bunting 1994). By itself, prescribed fire is a poor tool for the management of cheatgrass, as surviving populations often quickly recolonize an area, and post burn seed production may increase by a factor of as much as 100 (J.A. Young 1983).

Diffuse and spotted knapweed – Populations of diffuse and spotted knapweed have historically infested large areas of the Complex**.** While fire is unlikely to serve as a successful control for either of these species, limited, low intensity fires may actually result in an increase in their populations, while damaging desirable native grasses (Sheley and Roche 1982). This is due to a combination of the removal of competition from native grasses, combined with the copious amount of seed produced by these plants. Additionally, vigorous re-growth of spotted knapweed has been reported after fires (Xanthopoulous 1988). Spotted knapweed does not carry fire as well as grasses, and as such, may thrive in an environment where fire is excluded, except for the occasional low-intensity event. Fire may be used to clear dead plant material, increasing herbicide efficacy (Lacey, et al. 1992). Both knapweed species will survive fire if the root crown is not killed.

Reed canarygrass – Burning does not kill reed canarygrass and may stimulate additional stem production. Fire may be used to reduce the biomass of reed canarygrass in non-wetland areas with a high percentage of fire adaptive native species, when followed by a targeted herbicide application. Burning may have to be repeated annually for five to six years (Reinhardt and Galatowitsch 2004).

Rush skeletonweed – Serious infestations of rush skeletonweed exist in Stehekin. Due to its deep and extensive root system this plant is unlikely to be affected by fire, and damage to aboveground rosettes can trigger vigorous re-growth from the communal root system. Additionally, rush skeletonweed produces large quantities of small, windborne seeds that may readily invade newly disturbed areas. Controlled fire may function as part of an integrated strategy for the control of rush skeletonweed if fire use encourages the growth of a stable native grass community.

Scotch Broom – Scotch broom is highly flammable. Fire has been used to eliminate large impenetrable thickets and prepare areas for easier follow-up treatments. Fire stimulates seed germination and large flushes of seedlings may be expected following burning. Soil temperatures must be 300 degrees or higher to kill broom seeds. Fire appears to be more effective in controlling re-sprouts when there are adequate grasses to carry the fire.

Canada thistle – Established populations of Canada thistle have extensive, deep perennial rhizomatous root systems, as well as complex, shallow, horizontal root systems. Fire is not an effective control methodology for Canada thistle. While burning may kill new seedlings, it can also top kill established plants, and at the same time stimulate the root system to spread and vigorously send up new sprouts. Additionally, fire may reduce competition of native species to Canada thistle, especially where seed bank dynamics are unknown (Travnicek, Lym and Prosser 2005). In colonies of Canada thistle where viable seeds are produced, large numbers of small, windborne seeds may blow onto newly disturbed sites. The response of Canada thistle to fire is quite variable, and depends greatly on season, severity, site conditions, and the composition of the Canada thistle population (Donald 1990).

Yellow and Dalmatian toadflax – Both toadflax species are present in limited numbers in the Complex. While likely to be top-killed by fire, these perennial, rhizomatous species can re-establish quickly from vegetative root buds and buried seeds. Burning may increase the presence of toadflax by temporarily removing desirable species (Lajeunesse 1990).

Common Crupina – The only known infestation of common crupina in the state of Washington exists on USFS lands along the north shore of Lake Chelan, near Stehekin. This population, which extends over 500 acres, was discovered in 1984 and it is not known how or when it was introduced. Recent wildfires have created 4,500 additional acres of potential habitat. The USFS is currently using integrated weed management to control the population. No persuasive data is available regarding the effects of fire on crupina populations; however, efforts should be made to avoid spreading this population into the Complex.

4.6.2 Alternative 1 - No Action Alternative

Suppression. The direct effects of fire suppression on vegetation include vegetation cut or trampled during fire suppression activities and the vegetation consumed by or killed by the wildland fire that is suppressed. Both effects cause a temporary reduction in vegetation on the site, which depending on the fire size and severity, can impact sensitive plant species habitat and increase opportunities for invasive species.

Indirectly, fire suppression reduces fire dependent species habitat, increases fuel loadings and reduces age-class and species diversity, eventually resulting in conditions which are outside the natural range of variability for these communities. These indirect effects of fire suppression constitute a major negative impact on vegetation communities with high and mixed severity fire regimes that are still within their historic range of variability and Condition Class 1 (all vegetation covertypes other than Douglas fir / Ponderosa pine, Douglas fir / Lodgepole pine and Lodgepole pine) because it interrupts the natural disturbance cycle of fire. As the time since fire eventually exceeds the historic range of variability (the mean fire return interval for these vegetation types is approximately 250 years (Pritchard 2004, Agee 1993)) the effects of fire suppression perpetuate the need to continue with the fire suppression strategy until fuels are otherwise treated, and yet makes it increasingly more difficult to carry out. This is due to the increasing density and continuity of live and dead fuels that precipitate high severity fires over greater proportions of the landscape.

Vegetation types that are associated with low severity and shorter mixed-severity fire regimes (Douglas fir / Ponderosa pine and Douglas fir / Lodgepole pine) are currently outside of their natural range of variability due to previous fire suppression and/or other impacts. Because these forests are already impaired, the indirect impact of continued fire suppression constitutes a moderate impact which is less than the direct impact of the wildland fire behavior itself which is major.

Fire suppression activities that could affect sensitive plant populations include fire line building, the use of fire retardant, fire camps, bucket drops and back burning. Many of these activities may result in direct or indirect effects to sensitive plant species and sensitive species populations. Major detrimental impacts resulting from direct effects would include physical damage to plants or to plant populations as a result of line building and clearing of camp spots. Major detrimental impacts resulting from indirect effects would include changes in hydrology, hydrophobic soil formation, soil sterilization, and changes in soil chemistry as a result of back burning or the use of fire retardant. Bucket drops would constitute a major detrimental impact to plant populations if large amounts of soil are displaced.

These same fire suppression activities that could affect sensitive plant populations could also increase potential habitat for invasive species encroachment. If the equipment and personal line gear worn by firefighters, as well as support equipment such as engines, crew trucks, helicopters, and earth-moving equipment, is not checked and cleaned in between movement of fire crews to different areas, invasive seeds and plant parts may be introduced to pristine areas, precipitating a major detrimental impact.

Wildland Fire Use. The direct effect of wildland fire use on vegetation is the reduction of vegetation that is consumed or killed by the wildland fire, the impact of which is dependent upon the fire size and severity. Wildland fire use is restricted to high severity and longer frequency mixed severity fire regimes (all covertypes except Douglas fir / Ponderosa pine and Douglas fir / Lodgepole pine – Ponderosa pine) until one entry of low severity prescribed fire has been achieved in altered fire regimes. In high severity and longer frequency mixed severity fire regimes mortality of trees and consumption of fuels is a major beneficial impact of long duration. Wildland fire use in these covertypes has beneficial effects because mortality of trees and consumption of fuels creates fuel breaks in the canopy that perpetuate a mosaic for future fires, and promote structural and compositional diversity across the landscape. These high and mixed severity fire events typically kill 75% of the canopy cover (overstory and understory) within burned areas.

Regeneration on the post-fire site is dependent upon many factors including the size and location of the burned area, species composition in adjacent unburned areas, and the fire effect on soils and nutrients. Lodgepole pine and Douglas fir are common pioneer species in low- to mid-elevation mixed conifer stands in the Skagit FMU (Agee et al. 1986, Larson 1972).

Wildland fire use will not be managed for resource benefit during the fire season in forests that historically maintained low severity fire (Douglas fir / Ponderosa pine) or a mix of low and high severity fire where low severity fire intervals have been missed (Douglas fir / Lodgepole pine – Ponderosa pine). This is due to the current high levels of dead and downed debris, ladder fuels and weakened trees that contribute to a combustion environment that exceeds fire behavior characteristic of low severity fire regimes (Pollet and Omi 2002). High severity wildland fire is likely to kill large diameter old-growth conifers and ponderosa pine that have been identified as species of special concern to Complex staff, constituting a major impact of detrimental consequence.

Mechanical Thinning and Prescribed Fire (FFRAs). Due to the requirement for human and mechanical intervention in order to thin or conduct prescribed burns, these operations have temporary minor adverse impacts on vegetation that are similar but less severe than those of fire suppression. These minor impacts to vegetation include trampling of vegetation during thinning, prescribed burning, and fire effects monitoring and felling of trees and branches on vegetation during thinning operations. The impacts of trampling and thinning are not apparent the following year (large diameter trees are thinned over snow). These minor adverse impacts create a temporary reduction in understory vegetation (forbs, shrubs and grasses) on the site, and can enable invasion of non-native species.

The direct effects of thinning and prescribed burn operations on sensitive plant species constitute a potential minor negative impact. The known location of a special status plant species is avoided during all thinning and prescribed burn operations. Although effort has been made to locate and identify all occurrences of the plant species, if the species occurs in other areas that have not yet been identified, below-ground portions of the plant could be disrupted by soil disturbances caused by thinning or prescribed burning operations. The overall impact to this plant population is considered to be minor because the location of the plant population is avoided and direct effects of burning are likely to be minimal, thus leaving very little opportunity for a small percentage of the population to be overlooked and harmed. Low severity prescribed fire is expected to have a negligible impact on the known special status plant species.

The greater impacts to vegetation include the indirect effects of thinning and prescribed fire on restoring stand structure, composition, and vigor in the Douglas fir / Ponderosa pine vegetation type to a condition more similar to the pre-suppression era. These are major impacts of exceptional benefit and long duration. The direct and indirect effects of each are discussed below.

Mechanical thinning: Mechanical thinning is performed using prescriptions to reduce the number of trees to approximately 80 sq ft basal area, which reduces competition between trees and exposes the remaining vegetation to more light. Increases in the diameters of the remaining trees, and in the cover of understory species are apparent by the second year following thinning (Kopper and Drake 2002). Douglas fir and weakened trees of Douglas fir and ponderosa pine are targeted for removal during thinning operations, thus increasing the proportion of ponderosa pine in the stand to levels more comparable to forest conditions of the pre-suppression era as described by Arno (*et al.* 1995) and Ohlson and Schellhaus (1999).

Branches and debris accumulation from mechanical thinning performed by the fire crew does create a minor impact to the forest floor by increasing the amount of small and large diameter (1" – 3+ ") downed woody debris on the ground that remains until prescribed burning is performed. Prescribed burning is not performed for at least one year following thinning, which allows the downed wood on the site to dry and the remaining trees to release (grow in diameter). The increase in downed woody debris on the ground during the time between thinning and burning increases the risk of more intense fire behavior than would naturally occur in un-altered low severity forests if the forest were exposed to uncontrolled wildland fire.

Prescribed Fire Effects: The application of low-severity prescribed fire in Douglas fir / Ponderosa pine forests of the Stehekin Valley has a major beneficial impact on these fire dependent vegetation communities. Prescribed burning effectively prunes dead branches that serve as ladder fuels; consumes litter, duff and small diameter dead and downed fuels; and reduces the number of small diameter trees in the understory, each of which have increased beyond historic levels in these forests. Thus, conditions are created which could precipitate higher severity fire effects on larger scales (Graham *et. al.* 2004) as addressed in the previous analysis of the impacts of fire suppression.

Through the reduction of small diameter trees and shrubs, prescribed fire creates openings in the understory for less shade-tolerant species, including ponderosa pine and many forbs and grasses. Furthermore, the reduction of litter, duff and fine fuels that serve as conduit for fire spread helps to prevent the spread of unwanted fire in the future. The consumption of fine fuels may even stimulate growth in understory species by creating a nutrient release into the soil.

4.6.3 Alternative 2

Suppression. Impacts to vegetation and vegetation communities during fire suppression activities under Alternative 2 would be similar to those found in Alternative 1.

Wildland Fire Use. Impacts to vegetation and vegetation communities during wildland fire use activities under Alternative 2 would be similar to those found in Alternative 1.

Mechanical Thinning and Prescribed Fire (FFRAs, private property). Under Alternative 2 the upper range of acres treated annually by mechanical thinning increases by 50 acres, and for prescribed fire the upper range increases by 20 acres. Immediate impacts to vegetation and vegetation communities during mechanical thinning and prescribed burning treatments in the Stehekin FFRAS would be similar to those found in Alternative 1, but would occur over a greater area. Over time, these treatments should have increasing benefits to vegetation communities over a greater area as more acres are treated. An additional 2 to 10 acres of thinning and burning on private land annually would have negligible impacts on vegetation and vegetation communities as long as a riparian buffer, within which the removal of vegetation would be prohibited, is used.

Mechanical Thinning and Pile Burning (road corridor and safety zones). Although the impact of mechanical thinning in the safety zone would be similar to that of mechanical thinning in the FFRA, the impacts of mechanical thinning along the road corridor, and of pile burning at either location, have the potential to create more deleterious impacts on species of concern to Complex staff, and to increase the potential for invasive species encroachment.

Invasive species: The road corridor can serve as a conduit for invasive plant species spread. Soil disturbances from mechanical thinning operations and/or pile burning could spread invasive plants from the road shoulder farther into the forest. Pile burning typically causes a greater amount of soil disturbance than prescribed fire because the fuels are concentrated into piles that burn more deeply and with greater intensity. If the roadside provides a seed source, the bare ground and depleted soils from burn piles could enable invasive plant encroachment. The spread of invasives into the forest would constitute a major deleterious impact if the invasion was not monitored and controlled in its early stages. If the invasion was controlled, it would constitute a moderately deleterious impact.

Species of Concern: Large diameter trees with pitch on their boles and large amounts of mistletoe broom that are targeted for removal along the road corridor are often the older, mature trees that are of concern to Complex staff. If the tree of concern has a high degree of mistletoe infection or root rot, and it serves as a source for the spread of mistletoe or root rot, then the moderately deleterious impact of removing it is negated by the moderately beneficial impact to the vegetative community by preventing the spread of the mistletoe or root rot infection. (Although these forest diseases are indigenous to these forests, it has been argued that levels of root rot and mistletoe infection have increased in Douglas fir / Ponderosa pine forests of the Pacific Northwest due to fire suppression (Harrington and Wingfield 2000, Edmonds *et al.* 2000)). However, if the mature tree is not contributing to the spread of infection or disease, but rather, it is removed due to its proximity and lean towards the road, then its removal constitutes a moderately adverse impact to the species of concern.

4.6.4 Alternative 3 - Preferred Alternative

Suppression. Impacts to vegetation and vegetation communities during fire suppression activities under Alternative 3 would be similar to those found in Alternatives 1 and 2. However, over time, it is expected that fewer fires would have to be suppressed after prescribed burn treatments are conducted near Stehekin and Hozomeen.

Wildland Fire Use. Impacts to vegetation and vegetation communities during wildland fire use activities under Alternative 3 would be similar to those found in Alternatives 1 and 2. However, over time, it is expected that the wildland fire use option will be chosen more often after prescribed burn treatments are conducted near Stehekin and Hozomeen.

Mechanical Thinning and Prescribed Fire (FFRAs, private property). Impacts to vegetation and vegetation communities during mechanical thinning and prescribed fire activities under Alternative 3 would be similar to those found in Alternative 2.

Mechanical Thinning and Pile Burning (road corridor and safety zones). Impacts to vegetation and vegetation communities during mechanical thinning and pile burning activities under Alternative 3 would be similar to those found in Alternative 2.

Prescribed Fire (Stehekin Contours, Hozomeen Contours). The impacts of prescribed fire on vegetation and vegetation communities in the Stehekin Contours and Hozomeen Contours are somewhat different than those of the Stehekin Valley FFRAs. The differences between the impacts is partially due differences in the vegetation communities themselves, but primarily due to the fact that the units will not be thinned before they are prescribed burned.

Species of Concern: Without thinning prior to burning there may be a greater likelihood of increased mortality in older, mature conifers, particularly ponderosa pine, that are weakened by disease and by the stress of competition in the fire-suppressed stand (Fiedler et. al. 1998). Increased mortality of old-growth conifers due to burning without thinning would constitute a moderately deleterious impact to species of concern to Complex staff. In the FFRAs that were thinned before burning there was 0% mortality of overstory ponderosa pine and 10% mortality of Douglas fir within one year following burning, compared to a 25% mortality of overstory ponderosa pine and 6% mortality of Douglas fir in areas that were burned without thinning (Kopper 2004). In an investigation which involved some of the units that were burned without prior thinning, the primary cause of mortality of the older trees was determined to be due to insect infestation before burning, rather than due to the prescribed burning (Hadfield 2000).

The potential increase in mortality of old-growth conifers from prescribed burning without thinning in the Stehekin Contours and Hozomeen Contours may be minimized by the fact that prescribed burning, other than black-lining along the perimeter of the units will be restricted to the fall season. In a study of ponderosa pine mortality for ten years following prescribed burning in the southwest, mortality of trees scorched in the spring and summer was 2.5 times greater than that in the autumn for similar crown damage (Harrington 1993). Other investigators have found similar results at Crater Lake National Park (Swezy and Agee 1990).

Sensitive Plant Species: There is at least one known species that could potentially be negatively impacted by prescribed burning under this alternative. The effects of fire on this species are unknown. Due to its habitat requirements, it is unlikely that fire would reach this plant. The location of the known population will be avoided; however, the overall impact to this plant population is considered to be moderately deleterious because if a small percentage of the population is unintentionally overlooked the consequence is unknown and could be harmful to this species.

Vegetation Communities (Covertypes): The vegetation community of the Stehekin Contours is similar to that of the Stehekin Valley, and the impacts to it are comparable. Prescribed burning will help to reduce fuel loading, stimulate understory species, and create stand structure that is within the range of historic variability for this forest type. This impact is a major benefit of long duration.

The vegetation communities in the Hozomeen Contours prescribed burn units will benefit from one entry of prescribed fire during the fall season. Without prescribed fire it is expected that the unique ponderosa pine – lodgepole pine stands in the Lightning Creek area will eventually be lost to more mesic species (Agee *personal communication*). Maintenance of this fire dependent system is a major impact of long-term benefit. The Little Jackass Mountain unit does not include the same unique vegetation type; however it is expected to have missed at least one fire return interval (Agee *personal communication*), as evidenced by the high density of lightning strikes that occur in this area per year (See Appendix A, Figure 4). Reducing fuel loads and creating more structural diversity (patches of medium and low severity fire effects) in this area would also be a major impact of exceptional benefit.

Re-ignition. The impacts of re-ignition on vegetation and vegetation communities would be similar to those found for wildland fire use under all alternatives.

4.6.5 Cumulative Impacts to Vegetation

The largest cumulative impact to vegetation and vegetation communities with respect to fire management is fire suppression. Vegetation communities that have missed one or more fire return intervals will continue to accumulate standing live and dead fuels as well as dead and downed fuels that will eventually contribute to higher severity wildland fire events. The effects of fire suppression can even impact vegetation communities in the Complex that are not yet outside of the historical range of variability of their fire regime if they are adjacent to areas that have. In the cases of the Little Jackass Mountain unit of the Hozomeen Contours, and all of the proposed prescribed burn units in the Stehekin Contours area, it is improbable that wildland fire use would be an acceptable risk due to the continuity of fuels that these areas provide to values at risk unless they are treated with prescribed fire.

4.6.6 Mitigation for Impacts to Vegetation

In order to mitigate the impacts to vegetation communities with respect to invasives, equipment (hand tools, trucks, pumps, tracked equipment, tents, etc.) and personal line gear (line packs, nomex, and boots) worn by firefighters will be checked and cleaned in between movement of fire crews to different areas because they may carry seeds and plant parts readily from site to site. Contracted equipment, especially equipment brought from areas of similar climate with known problematic species must be thoroughly cleaned before arrival by the contractor, and prior to the departure of the equipment to other locations.

Disturbed sites will be monitored, and invasive species will be controlled before they spread (e.g., from the road corridors following thinning and pile burning). Available treatment methodologies may vary widely for non-native, invasive species found in the Complex; however, an integrated management strategy of preventative, cultural, mechanical, biological and chemical treatments is recommended. Treatment selection depends on a variety of factors, including species biology / ecology, location, and site type, as well as other factors, such as the presence / absence of threatened and endangered species, proximity to water and potential impact on the visitor experience. Many perennial weed species cannot be effectively treated without the use of targeted herbicide applications. The use of additional mechanical or prescribed fire treatments may increase the efficacy of herbicide treatments, but can also be contraindicated, depending on the ecology of the species.

The removal of trees along the road corridor will be monitored by Resource staff. Documentation will include a description of each tree, its diameter, height, species, and the reason for its proposed removal.

Known locations of sensitive plant species that are disturbance-intolerant will be avoided during prescribed burning and thinning operations. These populations will be monitored before and following treatment in these areas.

4.6.7 Conclusion

The impacts to vegetation and vegetation communities range from being of major benefit to constituting a major detriment. Alternatives 1 and 2 have the most negative impact on vegetation communities because they promote the continued use of fire suppression. Alternative 3 has the most beneficial impact on vegetation communities because it restores low severity fire-regime characteristics to altered ecosystems, and prevents adjacent land from necessarily being suppressed as well. Most of the potential increases in invasives, and potential negative impacts to individual species of concern that are described in each alternative can be minimized through mitigation. Impairment of vegetation resources would not occur under any alternative.

4.7 Research Natural Areas

4.7.1 Alternative 1 - No Action Alternative

Suppression. Of the five Research Natural Areas (RNAs), Silver Lake RNA could experience major adverse impacts from direct fire suppression activities because the northern half of it is located within the Suppression Response Zone along the US/Canada border. Activities allowed in RNAs are "generally restricted to non-manipulative research, education, and other activities that will not detract from an area's research values (NPS 2000a)." Suppression activities could significantly impact the ecologic and research values of the RNA because they would impede the natural process of fire. To mitigate for this impact, the Complex will choose a confinement strategy whenever possible. The remaining four RNAs could also be impacted by fire suppression activities even though they are located within Wildland Fire Use Zones. Wildland fire use would be the preferred strategy, but if direct suppression actions are taken within any of the four other RNAs, impacts would be similar to those found within the Silver Lake RNA.

Wildland Fire Use. Allowing the natural process of fire to take place in RNAs through wildland fire use would be beneficial to research values and would be consistent with NPS Management Policies (2000a).

Mechanical Thinning and Prescribed Fire (FFRAs). This treatment would not take place in any RNA.

4.7.2 Alternative 2

Suppression. Impacts to RNAs during fire suppression activities under Alternative 2 would be similar to those found in Alternative 1.

Wildland Fire Use. Impacts to RNAs during wildland fire use activities under Alternative 2 would be similar to those found in Alternative 1.

Mechanical Thinning and Prescribed Fire (FFRAs, private property). These treatments would not take place in any RNA.

Mechanical Thinning and Pile Burning (road corridor and safety zones). These treatments would not take place in any RNA.

4.7.3 Alternative 3 - Preferred Alternative

Suppression. Impacts to RNAs during fire suppression activities under Alternative 3 would be similar to those found in Alternatives 1 and 2.

Wildland Fire Use. Impacts to RNAs during wildland fire use activities under Alternative 3 would be similar to those found in Alternatives 1 and 2.

Mechanical Thinning and Prescribed Fire (FFRAs, private property). These treatments would not take place in any RNA.

Mechanical Thinning and Pile Burning (road corridor and safety zones). These treatments would not take place in any RNA.

Prescribed Fire (Stehekin Contours, Hozomeen Contours). These treatments would not take place in any RNA.

Re-ignition. The impacts of re-ignition to RNAs would be similar to those of suppression in terms of human alteration. Research values would be impacted because re-ignition would not be part of a natural process.

4.7.4 Cumulative Impacts to Research Natural Areas

Cumulative impacts to RNAs include fire suppression, visitor use, mining, and fish stocking. Past fire suppression has likely impacted some of the RNAs, though no study has been conducted to determine the extent of impact. Visitor use impacts are most apparent at Boston Glacier and Pyramid Lake, where social trails and vegetation damage are common. The Skagit Queen Mine has also impacted the Boston Glacier RNA, especially the Carex meadow nearby. Pyramid Lake was last stocked with cutthroat trout in 1948; no fish have been reported in the lake since 1966. Both Azure and Jeanita lakes, within the Stetattle Creek RNA, have been stocked in the past. Azure Lake was last stocked in 1961, but fish are now absent from the lake. Jeanita Lake continues to have both stocked and reproducing fish.

4.7.5 Mitigation for Impacts to Research Natural Areas

Manage fire perimeters (both suppression response fires and re-ignitions) using a confinement strategy, which limits the extent of the fire area to preset boundaries such as natural barriers and terrain breaks. If a fire ignites within or moves into the Silver Lake RNA/US Border Suppression Zone, the preferred strategy is confinement, and direct suppression activities (e.g., fire retardant drops, hand line construction, tree felling, and back burning) would be used only when absolutely necessary to prevent a fire from spreading into Canada. The preferred strategy for the other four RNAs is wildland fire use. No fire camps will be located within any of the RNAs.

4.7.6 Conclusion

There is no difference in the impacts to Research Natural Areas between Alternative 1 and Alternative 2. Under Alternative 3, re-ignition of suppressed fires would be allowed. Re-ignition of a suppressed fire would cause additional adverse impacts by further manipulating an RNA. Direct fire suppression activity (e.g., hand line construction, burn outs, retardant use, tree felling, etc.) under any alternative would cause major adverse impacts to the ecologic and research values of any RNA. Confinement strategies would generally benefit the RNAs as long as no direct suppression activity is conducted within or nearby the RNA boundary. Wildland fire use would be beneficial to RNAs because it would provide research opportunities in a relatively un-manipulated environment. Impairment of Research Natural Areas would not occur under any alternative.

4.8 Wilderness

4.8.1 Methodology

Impacts to wilderness were assessed using the following four qualities that are based on wilderness legislation and are linked to wilderness character:

Untrammeled - wilderness is ideally unhindered and free from intentional modern human control or manipulation

Natural - wilderness ecological systems are substantially free from the effects of modern civilization

Undeveloped - wilderness has minimal evidence of modern human occupation or modification

Outstanding opportunities for solitude or a primitive and unconfined type of recreation - wilderness provides opportunities for people to experience natural sights and sounds, solitude, freedom, risk, and the physical and emotional challenges of self-discovery and self-reliance

Proposed project work in wilderness (Alternative 3 only) was analyzed using the Minimum Requirement Analysis, found in Appendix G. This analysis was recommended by the Complex's Wilderness Committee, which includes resource specialists, wilderness rangers and specialists, interpreters, trails maintenance staff, and other staff members with responsibility for management of wilderness resources. Prescribed burning in the Stehekin and Hozomeen contours and re-ignition in the Wildland Fire Use Zone were deemed as the minimum requirements necessary to reestablish natural processes in areas where there are altered fire regimes, and to allow natural processes to continue in areas that are not yet altered. A combination of primitive and modern tools was selected as the minimum tool necessary to minimize impacts to wilderness (see Appendix G for a definition of this combination).

Minimum Requirement Analysis was not conducted on wildland fire use and suppression strategies since they are deemed emergencies. However, emergency actions must follow Minimum Impact Tactics (MIT) to ensure the minimum necessary methods and tools are being utilized to meet the needs of the emergency. See Appendix H for a list of MIT.

4.8.2 Impacts Common to all Alternatives

Almost every component of wilderness ecosystems is impacted by fire. As a disturbance agent, fire changes ecosystem, community, and population structure. Vegetation is the most visible ecosystem component that is impacted from fire. Fire also changes resource availability by increasing minerals, and physical properties by removing the organic layer or by the removal of canopy such that surface temperatures change. These changes can be linked to associated changes in hydrologic and geomorphic processes if impacts occur at the subbasin or watershed scale. The biggest impact of fire on wildlife is habitat loss, though most effects to wildlife are indirect and hence difficult to define. The air quality component includes smoke that can impact human health, as well as animals and plants. Ninety percent of smoke is made up of water vapor and carbon dioxide, the latter of which is a major contributor to global climate change.

4.8.3 Alternative 1 - No Action Alternative

Suppression. The qualities describing wilderness character would greatly diminish both during fire suppression activities and as a result of repeated fire exclusion. Activities such as helicopter use (for water drops and/or monitoring), fire line digging, tree cutting and chainsaw use, and application of fire retardant chemicals (only under extreme circumstances) would constitute direct intentional human control and modification, which is contrary to the notion of being untrammeled. These activities would also impact naturalness and opportunities for solitude, and could potentially impact opportunities for unconfined recreation (if there are closures).

The long-term ecological impacts of fire exclusion due to suppression are widespread and far-reaching. These can include accumulation of fuels, loss of structural diversity, more uniform stand ages and composition, and a loss in diversity of undergrowth species. Insects and disease can cause extensive tree mortality when forests are stressed due to overcrowding. This increase in fuels concurrently increases the likelihood of unusually severe wildfires. Once a severe wildfire occurs, the cycle continues as the large amount of heavy fuels created after the first fire accumulates to support another unusually severe wildfire (Arno 2000). The mosaic of forest stands (multi-aged with a diverse composition) typically created in unaltered regimes becomes even-aged and less diverse, impacting habitat for a wide range of wildlife species.

Wildland Fire Use. Wilderness character would largely benefit from wildland fire use. The impacts to wilderness ecosystems from fire would be the same as those listed under Section 4.8.2, *Impacts Common to All Alternatives*. The activities associated with wildland fire use management can also impact wilderness character. Helicopters used for monitoring and/or holding the fire at a certain location can be disruptive to wilderness users, especially when they are seeking the quality of solitude. Trail or cross-country zone closures could impact those seeking an unconfined type of recreation. Conversely, other wilderness users might enjoy the opportunity to experience a natural process in action, where the qualities of naturalness and being untrammeled are highlighted.

Mechanical Thinning and Prescribed Fire (FFRAs). These treatments would not take place in designated wilderness.

4.8.4 Alternative 2

Suppression. Impacts to wilderness from fire suppression under Alternative 2 would be similar to those found in Alternative 1.

Wildland Fire Use. Impacts to wilderness from wildland fire use under Alternative 2 would be similar to those found in Alternative 1.

Mechanical Thinning and Prescribed Fire (FFRAs, private property). These treatments would not take place in designated wilderness.

Mechanical Thinning and Pile Burning (road corridor and safety zones). These treatments would not take place in designated wilderness.

4.8.5 Alternative 3 - Preferred Alternative

Suppression. Impacts to wilderness from fire suppression under Alternative 3 would be similar to those found in Alternatives 1 and 2. However, over time, it is expected that fewer fires would have to be suppressed after prescribed burn treatments are conducted near Stehekin and Hozomeen. Wilderness character would benefit from an increase of fire on the landscape, as well as a decrease in disruptive suppression activities.

Wildland Fire Use. Impacts to wilderness from wildland fire use under Alternative 3 would be similar to those found in Alternatives 1 and 2. However, over time, it is expected that the wildland fire use option will be chosen more often after prescribed burn treatments are conducted near Stehekin and Hozomeen. Wilderness character would benefit from an increase of fire on the landscape, as well as a decrease in disruptive suppression activities.

Mechanical Thinning and Prescribed Fire (FFRAs, private property). These treatments would not take place in designated wilderness.

Mechanical Thinning and Pile Burning (road corridor and safety zones). These treatments would not take place in designated wilderness.

Prescribed Fire (Stehekin Contours, Hozomeen Contours). The majority of acres that would be treated under this alternative are located in wilderness (88 percent of the Stehekin project area and 88 percent of the Hozomeen project area). Prescribed fire treatments in both Stehekin and Hozomeen would impact wilderness character negatively in the short-term and positively in the long-term. The qualities of being untrammeled, naturalness, and opportunities for solitude and unconfined recreation would have short-term, major adverse impacts due to the disruption associated with conducting the burns and the intentional human control over those sections of wilderness where the treatments are proposed. Helicopter activity will be intense during the burns. Fire line will be dug and trees will be cut using chainsaws in areas along the perimeter that do not have natural fire breaks. Since the fuels and stand structures are outside their historic range of variability, the burns will not simulate naturalness; instead, a low intensity burn will be used to reduce fuels (whereas given the current density of fuels, this area would burn under a more high severity). Trail closures during the burns will impact access and freedom to travel in certain areas in wilderness.

Long-term impacts would be largely beneficial and moderate to major if the treatments are successful. Over time the impacts of fire exclusion would diminish; the quality of naturalness would be enhanced as fuel conditions are reduced and lightning fires are allowed to play a more natural role in the surrounding area. Human intervention would be minimized and the quality of being untrammeled would be enhanced as evidence of the prescribed burns fades. Opportunities for solitude and unconfined recreation would be unhindered.

Re-ignition. The impacts of re-ignition on wilderness character would be negative in the short-term and positive in the long-term. Short-term impacts would be similar to those found under the Stehekin and Hozomeen contours. Helicopter use, fire line digging, and tree cutting would have moderate to major impacts on wilderness character, depending on the size and location of the re-ignited fire. Long-term impacts on wilderness character would be similar to those found under wildland fire use. The restoration of a suppressed fire as soon as conditions permit would allow fire to play some role on the landscape rather than the landscape being controlled by fire exclusion. However, it would be almost impossible to attain the burned area and mosaic that would have occurred had the original ignition been allowed to burn.

4.8.6 Cumulative Impacts to Wilderness

The impacts of humans are so pervasive that there is no wilderness ecosystem on earth that remains unaltered. The impacts range from direct to indirect, and they can threaten ecosystem composition, structure, and function. The character of the Stephen Mather Wilderness is influenced by a myriad of factors, many of which originate outside the boundaries of designated wilderness. Impacts originating within the Complex include continued fire suppression and exclusion, heavy visitor use in some areas, invasive plants, invasive pathogens (e.g., white pine blister rust), fish stocking, and mining. Impacts originating outside of the Complex boundaries include loss of large predators, habitat loss, air pollution, acid rain, and global climate change.

4.8.7 Mitigation for Impacts to Wilderness

Please refer to the Minimum Impact Tactics (MIT) list that is found in Appendix H.

4.8.8 Conclusion

Alternatives 1 and 2 would have identical impacts to wilderness character: fire suppression would have major impacts both through suppression activities and through fire exclusion, and wildland fire use would have largely beneficial impacts by allowing fire to play its natural role in the ecosystem. Alternative 3 would have negative short-term major impacts associated with carrying out the prescribed burn treatments in the Stehekin and Hozomeen contours and re-ignitions. Long-term impacts would be positive and moderate to major, depending on the success of the burns. The difference between the first two alternatives and Alternative 3 is a tradeoff between wildness (found in the first two alternatives) and naturalness (found in Alternative 3). Given that allowing all lightning fires to burn is not an attainable goal (and often not ecologically desirable under current fuel conditions), prescribed burning and re-ignition can be used to mitigate the impacts of fire suppression and exclusion. Impairment of wilderness would not occur under any alternative.

4.9 Cultural Resources

4.9.1 Methodology

Impacts to the three general cultural resource types (prehistoric, historic, and ethnographic) are considered in this analysis. There is a wide variety of archeological site types and a comparable array of potential impacts, ranging in degree from “negligible” to “impairment.” Archeological resource types can be of any time period, and for purposes here, are subdivided into lithic remain, processing feature, rock art, rock structure, rock shelter, and historic remain. At some sites these resource types co-occur. Historic resources consist of historic structures and cultural landscapes. Ethnographic resources consist of rock art and traditional resource use areas.

Fire-related effects to cultural resource types are strongly influenced by elevation and topography. Three broadly-defined categories, “valley bottom,” “steep valley walls,” and “subalpine,” will vary with regard to fire effects to cultural types. Valley bottoms and their interface with the steep valley walls are more sensitive overall, because of the high site densities noted in these areas. Steep valley walls are low in site density and not conducive to good site preservation. Cultural resource types in the subalpine occur in moderate densities and are well-preserved.

4.9.2 Impacts Common to all Alternatives

The impacts of fire and fire management strategies on cultural resources are dependent on the nature of each cultural resource, its significance, and the scale of the fire event and the associated actions employed to manage the fire. Many prehistoric cultural resources are protected from adverse fire effects because they are buried at some depth within the soil matrix; however, those that are concentrated at or near the ground surface are potentially threatened by any number of fire-related actions. Of particular concern is the thermal modification from wildfire to a range of tool stone types that comprise the Complex’s pre-contact age lithic remain sites, which constitutes the single largest type of cultural resource inventoried, and at 8,400 years, the oldest cultural resource type in the Complex. Heating of stone artifacts can cause scorching, oxidation, patination, chemical alteration, and loss of organic residues. Two tool stone types native to the North Cascades, vitrophyre of the Hannegan volcanic rocks and Hozomeen chert, associated with oceanic rocks along Ross Lake, are particularly significant for the number of artifacts made from them, and the number of indigenous quarries where the stone was procured. Most historic cultural resources are adjacent to or above the ground surface and would be adversely affected by burning of structural remains, scorching, melting, collapse, and heat-deterioration of architectural materials. Ethnographic resources are subject to the same impacts as archeological resources, in particular, rock art. Intense heat can alter rock art pigment or cause spalling of the rock substrate beneath the pigment.

Additionally, fire fighting actions could adversely affect historic properties by ground disturbance (e.g., fire line construction) and mechanical and chemical impacts (e.g., retardant drops).

Cultural landscapes often are characterized by vegetation features or built features that could be destroyed. Features such as stone walls or stairs may be adversely impacted by fire (e.g., spalling: *the flaking off of thin layers on the rock surface*). Ground disturbance associated with fire fighting can significantly impact physiographic features resulting in the loss of integrity characteristics required for National Register eligibility.

Cultural Resource Types. Cultural resource sites are non-renewable and at considerable risk to adverse effects induced by fire. Ground-disturbing actions that support fire management activities, such as fire line and helispot construction also pose a risk to these sites. Every category below could be impacted by implementation of any of the alternatives.

Lithic remains. This type is the most ubiquitous and common across park lands. Because they occur at and below the ground surface, they are subject to thermal alteration from ground fire and ground-disturbance. Intense heat can alter the chemical composition, appearance, and physical integrity of indigenous tool stone materials made into artifacts or at quarries and tool stone outcrops. Hozomeen chert and Hannegan vitrophyre are two local tool stone types that are likely to be altered by intense heat. Other culturally significant tool stone types are imported from long distances, such as Oregon, Idaho, and California obsidians, and also are altered by heat alteration. This category spans all elevation zones in the Complex.

Integrity of lithic sites can still be lost through the construction of fire lines, roads, or helispots, and by compaction of the site's soil matrix. Because most lithic sites are buried to some depth within the soil, low intensity burns tend to have negligible effects. However, a high intensity burn can alter the properties of stone artifacts when heat extends to considerable depths during the combustion of tree roots. In this latter case, artifact association and integrity can be lost when topsoil fills in the hollow burned-out root casts in the subsoil. This can result in the loss of important scientific and cultural data.

Processing Feature. This important and common type of significant archeological site reflects the variety of built features used for processing a range of resources, but most are associated with cooking, baking, smoking, and drying of food. Like lithic remains, they are found on the ground surface or buried in the soil, and are highly sensitive to both thermal alteration from fire and ground disturbance associated with fire management actions. This resource type is associated with several significant artifact categories, including charcoal and preserved plant parts, animal bones, lithic remains, and organic residues. Concentrations of cooking hearth rocks, built rock features, and pits dug into the ground are also associated with the artifact categories noted above. The association of such artifacts and features is ubiquitous across the Complex, and has been found in both valley bottom (Stehekin and Skagit valleys) and subalpine lands. This resource type constitutes one of the most significant for contributing new information about the prehistory of park lands.

Rock art. Archeological sites with rock art one of the most sensitive cultural resource types for the purposes of this planning document. Rock art could suffer impacts from the use of wildland fire in several ways. Pigments and organic constituents can be altered or destroyed by intense heat, with an ensuing loss in the ability to radiocarbon date the organic matter or to conduct a residue analysis. Intense heat also causes spalling (cracking or breaking), physical disintegration, and chemical deterioration of the rock art substrate. Construction of fire line and helispots can increase access to rock art and cause physical disruption of artifacts and features in the soils associated with the rock art. In addition to scientific values, this cultural resource category embodies important cultural values to contemporary tribal groups, who view rock art as meeting requirements for consideration as a traditional cultural property. Presently, rock art is only found in valley bottom locations.

Rock structures. This type (representing both pre-contact and post-contact time periods) generally consists of on-the-ground built features, including rock walls and alignments, cairns, and rock pits. Fire line dug through rock structure sites can destroy the integrity of the structure, as can the use of a bulldozer used in support of suppression activities. Intense heat from wildland fires can cause scorching, spalling, and deterioration of rock structures and materials. Mechanical thinning can potentially obscure a rock structure with downed woody debris to the point where access is denied along with the ability to monitor effects to the site. Ground disturbing activities associated with fire line, road, and helispot building can dismantle, disarticulate, or otherwise destroy rock structures. This cultural resource type is found at all elevation zones.

Rock shelters. Rock shelters are usually associated with subsurface archeological remains that could be damaged, destroyed, or otherwise lose their integrity, by the digging of fire line, or the use of bulldozers. Scorching , spalling, or other heat-induced modification of the rock shelter itself can result from wildland fires. Mechanical thinning around a rock shelter could destroy the integrity of the setting. It could also destroy the vegetative screening that obscures the site, making it susceptible to vandalism. Fire line, road, and helispot construction can increase access to rock shelters and cause physical disruption of artifacts and features in the soils around and under them. Rock shelters can embody significant archeological data categories as defined by National Register criteria; they are found in all elevation zones.

Historic remains. Hand line or bulldozer tracks dug through historic remains could damage or destroy artifacts, or cause a loss of integrity of setting, including the surrounding landscape, and integrity of association of artifacts and features. Heat from wildland fires could melt or fracture glass and metal artifacts, and historic wood (and other organic materials) can combust or otherwise become heat-deteriorated. Historic remains can embody significant data categories as defined by National Register criteria; they are found in all elevation zones.

4.9.3 Alternative 1 - No Action Alternative

Suppression. All of the categories listed in Section 4.9.2 can be impacted during fire suppression activities. Most destructive is the building of fire lines through or adjacent to archeological, historic, and ethnographic resources. Ground disturbance associated with construction of helispots, fire camps, and staging areas on or nearby sites can also cause major impacts to cultural resources. Bucket drops can hasten soil erosion. Fire retardants can stain or corrode rock features and historic structures, causing major impacts.

Wildland Fire Use. All of the categories listed in section 4.9.2 can be impacted during wildland fire use activities, especially from fire itself. For example, fire can scorch, melt, or incinerate features and/or artifacts, and intense heat can cause exfoliation of rock art or other rock features. In addition, fire line and helispot construction and fire camps could disturb ground containing sensitive archeological sites. Fire can scorch or incinerate historic structures and artifacts. However, the majority of historic structures are located within a suppression zone, where wildland fire use is not an option. Wildland fire use spans all elevation zones of the Complex, and would most likely affect cultural resources in the valley bottoms and in the subalpine.

Mechanical Thinning and Prescribed Fire (FFRAs). All of the resource categories listed in Section 4.9.2 occur within the FFRAs. There are 11 identified archeological sites within the original FFRAs that could be impacted by thinning and prescribed fire. One of these sites may be considered a traditional cultural property. Mechanical thinning within the FFRAs could result in trampling, ground disturbance, and obstruction of sites by downed vegetation, all of which can negatively impact cultural resource sites. Thinning along streams could also adversely affect bank stabilization by increasing erosion and disturbing surface and subsurface archeological remains. Large-diameter thinning would have less of an impact since it is conducted in the winter when the trees can be removed over snow in order to decrease soil disturbance and compaction. Effects are further minimized if mechanically-thinned wood is fallen and piled away from cultural resources.

Impacts from prescribed burning could be similar to the direct impacts of fire during wildland fire use, although prescribed fire intensity is usually lower. Consultation with the Park Archeologist and other cultural resource advisors can help to minimize impacts from thinning and prescribed burning to known cultural sites.

4.9.4 Alternative 2

Suppression. Impacts to cultural resources during fire suppression activities under Alternative 2 would be similar to those found in Alternative 1.

Wildland Fire Use. Impacts to cultural resources during wildland fire use activities under Alternative 2 would be similar to those found in Alternative 1.

Mechanical Thinning and Prescribed Fire (FFRAs, private property). All of the archeological site categories listed in Section 4.9.2 occur within the FFRAs. There are 14 identified archeological sites within the adjusted FFRAs that could be affected by thinning and prescribed fire. Two of these may be considered traditional cultural properties. Impacts to cultural resources during mechanical thinning and prescribed fire within the FFRAs would be similar to those found under Alternative 1. However, archeological surveys have not been conducted on private lands; therefore, it is not possible to comment regarding potential project impacts to cultural resources on private property.

Mechanical Thinning and Pile Burning (road corridor and safety zones). No archeological sites have been found within the road corridor thinning project. The Old Stehekin School is a historic property within the road corridor thinning project. The Orchard Safety Zone is located within the Buckner Homestead Historical District; consequently, thinning projects within this zone could impact historic structures. A potentially significant archeological site is located within the Orchard Safety Zone; this site would not be impacted as long as all activities are restricted to within the 6-inch plow zone. Cultural resource surveys have not been conducted within the Ranch Safety Zone because it is located on private property; therefore, it is not possible to comment regarding potential project impacts. Mechanical thinning along the road corridor and in safety zones can affect undiscovered cultural resources in the manner described in Section 4.9.2. Intense, localized heat from pile burning can also adversely affect the archeological categories listed in Section 4.9.2.

4.9.5 Alternative 3 - Preferred Alternative

Suppression. Impacts to cultural resources during fire suppression activities under Alternative 3 would be similar to those found in Alternatives 1 and 2. However, over time, it is expected that fewer fires would have to be suppressed after prescribed burn treatments are conducted near Stehekin and Hozomeen.

Wildland Fire Use. Impacts to cultural resources during wildland fire use activities under Alternative 3 would be similar to those found in Alternatives 1 and 2. However, over time, it is expected that the wildland fire use option will be chosen more often after prescribed burn treatments are conducted near Stehekin and Hozomeen.

Mechanical Thinning and Prescribed Fire (FFRAs, private property). Impacts to cultural resources during mechanical thinning and prescribed fire activities under Alternative 3 would be similar to those found in Alternative 2.

Mechanical Thinning and Pile Burning (road corridor and safety zones). Impacts to cultural resources during mechanical thinning and pile burning activities under Alternative 3 would be similar to those found in Alternative 2.

Prescribed Fire (Stehekin Contours, Hozomeen Contours). There are eight archeological sites that fall within the prescribed burn units of the Stehekin Contours. There are five sites that fall within the prescribed burn units of the Hozomeen Contours, four of which are within the Lightning Unit, and one of which is in the Little Jackass Unit. Prescribed fire activities within the Hozomeen Contour units have the potential to adversely impact an archeological site (45WH224), which is listed as a contributing property to the Upper Skagit River Valley Archeological District. The sensitive area spans from the Ross Lake shoreline at the western boundary of the Lightning burn unit, east to the mid-slopes of Desolation Mountain. Here, a series of widely scattered, but locally dense, artifact loci consisting of tool stone quarrying debris can be adversely affected by intense heat generated by ground fires, due to their presence in the topsoil. Because artifact loci are located on a steep slope, they are susceptible to loss of integrity of location and association resulting from surface erosion of native soils.

Although not all of the areas included within the proposed units have been surveyed, it is probable that unidentified archeological resources exist. Impacts to archeological sites within both the Stehekin and Hozomeen contours could include scorching, melting, or incineration of features and/or artifacts, and exfoliation of rock art or other rock features. Other impacts could include trampling of sites by fire personnel, ground disturbance due to digging of fire line, and obstruction of sites by downed vegetation.

Because cultural resources are not distributed uniformly across the Stehekin and Hozomeen Contours, neither are their potential effects uniformly distributed. Generally, the most culturally sensitive areas are those located along the interface between valley bottoms and the base of steep valley walls. In Stehekin Valley, this zone coincides with boundaries between FFRAs and contour units. Digging of fire lines along the burn unit boundaries has the potential to adversely affect cultural resources, as does the intense heat generated by the fires.

No designated historic structures exist within the burn units. Hozomeen Cabin, located a short distance north of the Little Jackass Mountain burn unit, is listed on the National Register of Historic Places.

Re-ignition. The impacts of re-ignition on cultural resources would be similar to those found for wildland fire use under all alternatives if the re-ignition takes place from the air. Additional trampling of cultural resource sites could occur if the re-ignition is implemented by a ground crew.

4.9.6 Cumulative Impacts to Cultural Resources

Cultural resources sustain the cumulative effects of many disturbance processes, which include:

- natural and human-caused fires
- construction of roads, trails, parking areas, heliports, and other developments
- soil erosion and loss of artifacts and features along river courses
- burial of artifacts and features by river flooding, mass wasting and soil creep, water inundation, and intentional placement of fill
- loss of integrity of association, location, and setting of artifacts and features due to natural and induced plant growth, and the by the normal death and decay cycles of plants, particularly large trees
- increased access to cultural resources, which can lead to human destruction, defacement, and removal of artifacts and features from sites

Not all effects are adverse. Natural and cultural processes that remove dense, standing and downed vegetation and woody debris can result in increased visibility of landforms and mineral soil. This in turn, can aid in the discovery and inventory of previously unrecorded cultural resources, and help to manage and protect those that would otherwise remain undetected, and therefore susceptible to many of the threats noted in Section 4.9.2. Fuel reduction also reduces the overall burn severity, thus reducing fire-related effects to cultural resources.

4.9.7 Mitigation for Impacts to Cultural Resources

Fire management activities will be conducted in accordance with the National Historic Preservation Act (NHPA) and its amendments as promulgated in 36CFR Part 800, which guides federal agencies on compliance with cultural resource management and preservation procedures. Active consultation with the Park Archeologist and Cultural Resource Specialist will be initiated early on in the case of planned burns, and as soon as possible in the case of unplanned fire events. Detailed, site-specific information regarding cultural resources at risk is available from the Park Archeologist and the Cultural Resource Specialist. The following is a list of mitigation measures that can be used to avoid or minimize impacts:

- In consultation with the Park Archeologist and Cultural Resource Specialist, identify any threatened cultural resources, define their boundaries, and determine the Area of Potential Effect (APE).
- In consultation with the Park Archeologist and Cultural Resource Specialist, maintain an updated version of the Complex-wide archeological sensitivity map for use as a quick reference by fire management staff to assess the potential effects of new fires.
- In consultation with the Park Archeologist and Cultural Resource Specialist, identify the important qualities of the cultural resources and any potential threats to these qualities.
- Avoid disturbances within the APE, and in particular, avoid effects to any important site qualities that are identified as threatened in consultation with the Park Archeologist and Cultural Resource Specialist.
- Make available to fire crews a brief workshop, conducted by the Park Archeologist and Cultural Resource Specialist, with the goal to train crews in the recognition, management, and preservation of cultural resources.
- Depending on the cultural sensitivity of the undertaking, it may be necessary for a qualified archeologist to monitor on-site during the construction of fire lines and helispots.
- Minimum Impact Tactics (MIT) will be used. Minimize the extent of built fire lines and helispots, and other ground-disturbing actions, as a means of limiting damage to subsurface and surface cultural resources.

- In prescribed burn plans, identify threatened cultural resources, or those within the APE, assess the potential fire effects to the same, and avoid, minimize, or mitigate these effects, as required by according to 36CFR Part 800.

4.9.8 Conclusion

Implementation of any of the alternatives would not significantly impact identified cultural resources as long as mitigation measures are followed. There are 11 identified archeological sites within the project areas (Stehekin FFRAs) under Alternative 1. Alternatives 2 and 3 have an additional three sites that are located in the adjusted FFRAs (totaling 14 sites), and two archeological sites and one historic district located within the Orchard Safety Zone. Additionally, Alternative 3 has eight archeological sites located within the Stehekin Contours, and five sites located within the Hozomeen Contours (which also contains the Upper Skagit River Valley Archeological District). Not all of the areas included within the proposed prescribed burn units have been surveyed, and it is probable that unidentified archeological resources exist.

The impacts from wildland fire use or suppression can be mitigated for known cultural resource sites; however, it is impossible to manage and protect sites that have not yet been discovered. Because exercise of the wildland fire use option potentially affects most of the lands (not under water) in the Complex, it could potentially affect any number of cultural resource types located at all elevation zones. Threats to cultural resources will be avoided or mitigated through consultation with the Park Archeologist and Cultural Resource Specialist in compliance with 36CFR Part 800. Impairment to cultural resources would not occur under any alternative.

4.10 Visitor Use

4.10.1 Impacts Common to all Alternatives

Visitors to the Complex would likely be impacted by fire management activities since the fire season coincides with the peak visitor use months of summer. Some of the impacts would be similar regardless of the fire management strategy used. These might include trail or road closures; camp closures; campfire bans; diminished visibility due to smoke; noise from chainsaws, water pumps, or helicopters; and aesthetic impacts to burned or cut vegetation.

4.10.2 Alternative 1 - No Action Alternative

Suppression. The number of visitors impacted from fire suppression activities depends on the location of the fire. Recent suppression fires near Stehekin have had various impacts, including trail closures (ranging from a few days to entire seasons), upper Stehekin Road closures, and frequent helicopter activity. Fire suppression in locations that are more heavily used will impact more people. For example, a fire in the Bridge Creek drainage could affect many hikers on the Pacific Crest Trail. A fire above the State Route 20 corridor could impact large numbers of travelers if the Highway needs to be closed for safety. Fire suppression within the Suppression Response Zone along the US/Canada border would likely affect very few people because of the remote location; however, visitation at Hozomeen and the adjacent Skagit Valley Provincial Park and Manning Provincial Park in Canada could be impacted by suppression efforts. In addition to closures of trails and roads, visitors could be inconvenienced by campfire bans, smoke, chainsaw and water pump noise, fire crew activity, and exposure to burned or cut vegetation.

Wildland Fire Use. Impacts from wildland fire use could be equally as disruptive as suppression is to visitor use; however, since wildland fire use zones are farther away from concentrated areas of visitor use, it is likely that fewer visitors will be impacted by wildland fire use activities. Depending on the fire location, roads, trails, and/or camps could still be closed to visitors. Helicopter use would still be used to monitor and map the fire. Fire crews could be positioned at nearby camps to monitor the fire. The sight of burned areas could impact visitors both negatively and positively; some visitors might be negatively affected if they do not like to see burned vegetation, while others might be positively affected by being able to see this natural process in action. Opportunities for educating the public about the benefits of fire could increase during active fire seasons.

Mechanical Thinning and Prescribed Fire (FFRAs). Noise associated with thinning treatments in the Stehekin valley bottom could impact visitors near the treatment units. Smoke from prescribed burning could impact visitors through decreased visibility and discomfort from breathing emissions. During the Stehekin treatments, fire staff have many chances to interact with visitors and could use the opportunity to educate visitors on how thinning and prescribed burning are used in wildland/urban interface areas.

4.10.3 Alternative 2

Suppression. Impacts to visitor use during fire suppression activities under Alternative 2 would be similar to those found in Alternative 1.

Wildland Fire Use. Impacts to visitor use during wildland fire use activities under Alternative 2 would be similar to those found in Alternative 1.

Mechanical Thinning and Prescribed Fire (FFRAs, private property). Under Alternative 2 the upper range of acres treated annually by mechanical thinning increases by 50 acres, and for prescribed fire the upper range increases by 20 acres. Impacts to visitor use during mechanical thinning and prescribed burning treatments in the Stehekin FFRAS would be similar to those found in Alternative 1. Impacts may vary somewhat based on the location of different units relative to areas where visitors concentrate. An additional 2 to 10 acres of thinning and burning on private land annually would have negligible impacts on visitor use.

Mechanical Thinning and Pile Burning (road corridor and safety zones). Thinning along the road corridor could have minor impacts to visitors who walk, bike, drive, or take a shuttle bus along the road. Temporary traffic delays would have to be used while cutting trees near the road shoulder in order to ensure that passersby wouldn't be injured by falling trees or brush. Chainsaw noise would also impact visitors along the road corridor, as would smoke from pile burning. Thinning and pile burning in the Ranch Safety Zone (on private property) could impact customers by creating noise and smoke. Thinning and pile burning in the Orchard Safety Zone could impact visitors who frequently explore the orchard and surrounding area.

4.10.4 Alternative 3 - Preferred Alternative

Suppression. Impacts to visitor use during fire suppression activities under Alternative 3 would be similar to those found in Alternatives 1 and 2. However, over time, it is expected that fewer fires would have to be suppressed after prescribed burn treatments are conducted near Stehekin and Hozomeen.

Wildland Fire Use. Impacts to visitor use during wildland fire use activities under Alternative 3 would be similar to those found in Alternatives 1 and 2. However, over time, it is expected that the wildland fire use option will be chosen more often after prescribed burn treatments are conducted near Stehekin and Hozomeen.

Mechanical Thinning and Prescribed Fire (FFRAs, private property). Impacts to visitor use during mechanical thinning and prescribed fire activities under Alternative 3 would be similar to those found in Alternative 2.

Mechanical Thinning and Pile Burning (road corridor and safety zones). Impacts to visitor use during mechanical thinning and pile burning activities under Alternative 3 would be similar to those found in Alternative 2.

Prescribed Fire (Stehekin Contours, Hozomeen Contours). Prescribed fire treatments above Stehekin could cause moderate impacts to visitors through trail closures and smoke. The following trails would be closed (at different times) during prescribed burning: Lakeshore, Purple Pass, Rainbow Loop, Boulder Creek, Rainbow Creek, Coon Lake, and McGregor Mountain. The Hozomeen Contours could also cause moderate impacts to visitors through trail closures and smoke. The following trails would be closed (at different times) during prescribed burning: Lightning Creek, Desolation Peak, Willow Lake, and Trail of the Obelisk (interpretive loop trail near the border). Helicopter use during the igniting and monitoring of the burn units could cause moderate adverse impacts to visitors by creating noise and distraction for one or more days.

Re-ignition. The impacts of re-ignition on visitor use would vary depending on the location of the suppressed fire and the method and time of re-ignition. Road, trail, and/or camp closures could be imposed to protect public safety. Re-ignitions via helicopter would have more impact on visitors than re-ignition using drip torches due to noise and visual distraction. Smoke could impact visitors by impairing visibility and causing discomfort to sensitive individuals.

4.10.5 Cumulative Impacts to Visitor Use

Closures along the Stehekin Road due to recent flood damage have impacted visitor use by limiting accessibility to trailheads along the upper sections of the road. Fire bans are regularly imposed during the summer in order to prevent wildfires. State Route 20 is occasionally closed in the summer due to landslides that cover the roadway.

4.10.6 Mitigation for Impacts to Visitor Use

The timing of prescribed burns (either in the spring or fall) impacts fewer visitors during the shoulder seasons when visitation to the Complex is lower. Visual impacts such as cut stumps or fire line are made to look as natural as possible and are rehabilitated as soon as it is safe to do so.

4.10.7 Conclusion

The impacts of fire suppression and wildland fire use activities on visitor use is difficult to estimate because they largely depend on the location of ignition: the closer the ignition is to concentrated visitor use areas, the greater the impact to visitor use. Prescribed fire and/or thinning treatments are likely to impact visitor use because of the location of the treatment units; however, the number of people that could potentially be impacted would be less since visitation is lower during the shoulder seasons. Alternative 3 would have the most impact because it involves a greater amount of helicopter use to conduct prescribed burning in Stehekin and Hozomeen.

4.11 Health and Safety

4.11.1 Impacts Common to all Alternatives

There are inherent risks associated with most fire management activities. These include smoke inhalation associated with burning vegetation and duff; internal combustion engine exhaust inhalation (from chainsaws or heavy equipment); working on steep, uneven ground; falling trees, limbs, snags, and rocks; helicopter use, and using sharp tools on uneven ground. Smoke inhalation symptoms can range from acute irritation and shortness of breath to headaches, dizziness, asthmatic reactions, nausea, and in extreme cases, death.

The public can also be exposed to particulate matter during wildland or prescribed fires, although exposure is usually at lower levels with greater distance from fire lines. People with respiratory ailments, the elderly, and young children are most at risk for experiencing impacts from fine particulates.

4.11.2 Alternative 1 - No Action Alternative

Suppression. Health and safety risks to firefighters are greatest during fire suppression activities where fire crews are working near the fire perimeter. Firefighters are likely to encounter steep slopes, smoke emissions, and changing fire and environmental conditions. Many fires in the Complex are located in areas too steep to place crews on the ground. In this case, fires are suppressed by water using air operations, including fixed-wing and/or helicopter bucket drops or through a combination of ground crews and aircraft drops. Though less people are involved in this type of suppression, there are safety risks involved in helicopter use.

Fire retardant chemicals also pose safety risks if precautions aren’t taken to avoid exposure. Wildland fire retardant foams are known to dry skin, cause mild to severe chapping, and irritate eyes. Retardants can also have physical impacts on people, which could include footing hazards when personnel are walking through wet retardant (retardants are slippery), or even the risk of injury or death to personnel or the public directly in the path of the drop, resulting in an accidental drench (Kalabokidis 2000). There is currently no evidence supporting a link between wildland fire retardant chemicals and cancer (Labat-Anderson Inc. 2003). Retardants used in fire suppression are not of the same chemical makeup as those used in electronics, furniture, and other household items, which are called brominated flame retardants, and are known to be neurotoxic.

Health and safety risks to the public would be minor for most suppression fires since most of them are small in size and are extinguished in a short amount of time. Smoke from larger fires could cause moderate impacts to the public, especially in valleys when there are temperature inversions that hold the smoke in the valley bottom. Smoke impacts could be major for those with compromised respiratory systems.

Wildland Fire Use. Wildland fire use activities would generally be less hazardous to fire personnel than fire suppression activities because monitoring can be conducted remotely from the air or on land, sharp tools and power equipment aren’t necessary, and smoke exposure would be less (though it still could cause irritation). Monitors could experience moderate impacts if they hike into their monitoring positions over steep terrain via cross country travel. Additional hazards associated with air operations would occur if monitors are flown into position by helicopter, and if monitors are supplied by air.

Smoke from wildland fire use fires could cause irritation to both the public and fire personnel, especially when air currents carry the smoke or inversions hold the smoke at lower elevations near visitor use areas or communities.

Mechanical Thinning and Prescribed Fire (FFRAs). Mechanical thinning in the Stehekin FFRAs involves the use of power saws and hand tools to limb or fall trees. If these tools are used incorrectly or if safety precautions aren't followed, personnel or nearby visitors and residents could be harmed. Prescribed fire conducted after mechanical thinning in these same areas could pose moderate impacts to air quality; however burns are conducted during the shoulder seasons when fewer people are in the valley, and at lower intensities that should minimize the amount of smoke. Fire personnel who are working on the prescribed burn could be impacted by smoke inhalation. Hazard fuel reduction projects such as the Stehekin FFRAs would reduce fuel build-up near residences and other structures in the valley, reducing the risk of escaped fires and impacts related to air quality and safety of residents and visitors in the valley.

4.11.3 Alternative 2

Suppression. Impacts to health and safety during fire suppression activities under Alternative 2 would be similar to those found in Alternative 1.

Wildland Fire Use. Impacts to health and safety during wildland fire use activities under Alternative 2 would be similar to those found in Alternative 1.

Mechanical Thinning and Prescribed Fire (FFRAs, private property). Under Alternative 2 the upper range of acres treated annually by mechanical thinning increases by 50 acres, and for prescribed fire the upper range increases by 20 acres. Impacts to health and safety during mechanical thinning and prescribed burning treatments in the Stehekin FFRAS would be similar to those found in Alternative 1; however, larger units would require more time to treat, and consequently crews would be working on the larger projects for a longer period of time. An additional 2 to 10 acres of thinning and burning on private land annually could impact residents if the project takes place in close proximity to their homes where exposure to smoke could cause irritation.

Mechanical Thinning and Pile Burning (road corridor and safety zones). The impacts to fire personnel during mechanical thinning would be similar to those found under Alternative 1 for mechanical thinning in the FFRAs. Because of the location, thinning along the road corridor could pose a greater threat to residents and visitors who are passing by during the treatment. Thinned trees could fall into the roadway, block traffic, and potentially cause a motor vehicle or bicycle accident. Impacts of smoke from pile burning would be minimal during the shoulder seasons. Thinning in the safety zones, both of which are located in areas that have high visitor use, could impact visitors if precautions aren't taken to make sure visitors are kept at a safe distance during project work.

Thinning along the road corridor and within safety zones would benefit fire fighters, residents, and visitors. If a fire should overcome the valley, corridor thinning will increase the likelihood of being able to reach a safety zone without meeting obstacles in the road. Thinning of the safety zones will ensure a safe place for fire fighters, residents, and visitors.

4.11.4 Alternative 3 - Preferred Alternative

Suppression. Impacts to health and safety during fire suppression activities under Alternative 3 would be similar to those found in Alternatives 1 and 2. However, over time, it is expected that fewer fires would have to be suppressed after prescribed burn treatments are conducted near Stehekin and Hozomeen.

Wildland Fire Use. Impacts to health and safety during wildland fire use activities under Alternative 3 would be similar to those found in Alternatives 1 and 2. However, over time, it is expected that the wildland fire use option will be chosen more often after prescribed burn treatments are conducted near Stehekin and Hozomeen.

Mechanical Thinning and Prescribed Fire (FFRAs, private property). Impacts to health and safety during mechanical thinning and prescribed fire activities under Alternative 3 would be similar to those found in Alternative 2.

Mechanical Thinning and Pile Burning (road corridor and safety zones). Impacts to health and safety during mechanical thinning and pile burning activities under Alternative 3 would be similar to those found in Alternative 2.

Prescribed Fire (Stehekin Contours, Hozomeen Contours). Prescribed fire treatments in both the Stehekin and the Hozomeen Contours could pose threats to fire personnel on the ground and in the air. Most of the contour units are located along the valley walls, which are steep and rugged; for this reason many of the units will be ignited via a helicopter equipped with sphere-dispensing ignition devices. Some of the unit perimeters could be ignited by ground personnel, who would be traveling over very rugged terrain and sometimes thick brush. There are also risks associated with helicopter use; these units will be ignited by a helicopter that dispenses the ignition devices in horizontal swaths across the unit over the course of one day.

The long-term benefit of these treatments would be a decreased risk of a high-intensity, large-scale wildfire reaching either Stehekin or Hozomeen. By reducing the fuels in these units, a wildfire that moves into them or ignites within them will burn at a lower intensity, and would be much easier to control should it threaten either community.

Re-ignition. The impacts of re-ignition on health and safety of fire fighters would be similar to those found for prescribed fire in the Stehekin and Hozomeen contours under Alternative 3. Ground personnel would be working in steep terrain, and helicopter use would pose additional risks to personnel in the air. Public health and safety impacts would be more similar to those impacts found under wildland fire use under all alternatives, which relate to smoke impacts that occur farther away from the fire lines.

4.11.5 Cumulative Impacts to Health and Safety

Regional fires could contribute to decreased air quality in the Complex and on adjacent lands.

4.11.6 Mitigation for Impacts to Health and Safety

The NPS currently has several measures in place that help to ensure the safety of firefighters. These include requiring fire personnel:

- to meet qualifications for incident assignments, including all applicable medical requirements
- to meet qualification standards for the implementation of prescribed fires and for using power equipment such as chainsaws for thinning and bucking

- to be equipped with personal protective equipment
- to comply with fitness and personal protective equipment standards
- to complete a required amount of wildland fire training, including refresher safety training

Interagency Standards for Fire and Aviation Operations, produced by the National Wildfire Coordinating Group, is provided to wildland fire suppression personnel. It contains a chapter on firefighting safety, which includes safety guidelines on qualifications, clothing and protective equipment, training, foot travel, and escape routes and lookouts, among other useful firefighting references.

To protect public health and safety, the NPS is required to give full consideration to the protection of clean air and clear visibility during fire management operations. Smoke impacts could be minimized by assessing the smoke trajectory of potential wildland fire use fires and consulting with the Washington Department of Natural Resources to understand regional smoke conditions. The superintendent is authorized to make closures in areas of the Complex if a fire is posing a threat to human health or safety. Burn bans are also frequently used as a way of restricting outdoor burning to prevent ignitions during periods of high fire danger.

While working at project sites that are located near visitor use areas, roads, or private property, staff will ensure that all people are kept a safe distance from the site while they are working. Road flaggers will be positioned along the road to stop traffic while trees are felled, safety zone project work will be conducted when few people are at the Ranch or the Orchard, and private property owners who have requested hazard fuel reduction will be informed about when the project will take place.

Fire retardant chemicals will only be used in extreme emergencies (to protect human life or property) and only with the superintendent's approval.

4.11.7 Conclusion

Implementation of any of the alternatives would not significantly impact human health and safety if all operational precautions and smoke mitigation measures are followed. Project work in Alternative 3 presents the greatest risk to fire personnel because of the rugged terrain and additional helicopter use that would be required to carry out prescribed burns and re-ignitions. Alternative 3 would also, over time, provide for greater protection of the residents and visitors of Stehekin and Hozomeen by minimizing the potential for a large, high-severity crown fire to reach either of the communities.

4.12 Socioeconomics

4.12.1 Impacts Common to all Alternatives

The fire management program can have both social and economic impacts in local communities as well as the broader region. The fire management program and associated activities can impact local communities in several ways: 1) the size of the fire management payroll will impact spending in local communities as employees on the payroll find housing and purchase goods and services; 2) the purchasing of supplies from local businesses to support personnel and program operations will impact the local economy; 3) private local contractors will be impacted by the availability of contract work; 4) tourism spending would vary relative to fire activities and their impacts, such as trail or road closures and limited visibility, which could lead to shortened or cancelled visits; and 5) visitor experience could benefit from educational opportunities related to fire and exposure to natural processes.

4.12.2 Alternative 1 - No Action Alternative

Suppression. The annual budget for the core Fire Management Program is driven by the costs associated with fire suppression and the needs for planning and monitoring treatments. This core budget, which includes worker payroll, remains constant across all of the alternatives. It helps to provide a stable input to the local economy through the purchasing of goods, services, housing and food. Four crew member positions are currently funded primarily through the core budget (Table 21). Tourism impacts from fire suppression activities could include road or trail closures, visibility impairment, and physical irritation from smoke, all of which could lead to decreased spending in local communities if visits are shortened or cancelled. However, closures that impact tourism could be offset by fire personnel support during suppression operations, when purchases are made from local businesses for food, supplies, and housing.

Wildland Fire Use. The impacts on local businesses from wildland fire use activities would generally be similar to those associated with suppression. Some local businesses would benefit since some number of personnel will need to be supplied (with food, gear, and housing) during the wildland fire use operation. However, other businesses might suffer due to shortened or cancelled tourist plans.

Mechanical Thinning and Prescribed Fire (FFRAs). As project work for the FFRAs is completed, fewer crew members would be needed and contract thinning would be reduced. There are currently four additional crew members that are hired to complete fuel reduction targets. Under this alternative two positions would be dropped after 2007, bringing the total crew member count to six (four under preparedness funding and two under fuel reduction funding). The use of contractors for thinning and hauling under this alternative will stop or be severely reduced in 2009.

4.12.3 Alternative 2

Suppression. Impacts to socioeconomics during fire suppression activities under Alternative 2 would be similar to those found in Alternative 1.

Wildland Fire Use. Impacts to socioeconomics during wildland fire use activities under Alternative 2 would be similar to those found in Alternative 1.

Mechanical Thinning and Prescribed Fire (FFRAs, private property). The additional costs associated with treating more acres under this alternative could benefit local economies through increases in local spending to support fire crews, higher incomes to local contractors, and increased local spending where fire crew members live. An additional 2 to 10 acres of thinning and burning on private land annually would have minor beneficial impacts on socioeconomics. Although the number of crew members hired for fuel reduction projects would decrease by one after 2010, the additional work and income associated with treating more acres would offset the lost potential spending by the eliminated crew member position.

Mechanical Thinning and Pile Burning (road corridor and safety zones). Hazard fuel treatments along the Stehekin Road corridor and within the two safety zones would have negligible impacts to the local economy.

4.12.4 Alternative 3 - Preferred Alternative

Suppression. Impacts to socioeconomics during fire suppression activities under Alternative 3 would be similar to those found in Alternatives 1 and 2. However, over time, it is expected that fewer fires would have to be suppressed after prescribed burn treatments are conducted near Stehekin and Hozomeen.

Wildland Fire Use. Impacts to socioeconomics during wildland fire use activities under Alternative 3 would be similar to those found in Alternatives 1 and 2. However, over time, it is expected that the wildland fire use option will be chosen more often after prescribed burn treatments are conducted near Stehekin and Hozomeen.

Mechanical Thinning and Prescribed Fire (FFRAs, private property). Impacts to socioeconomics during mechanical thinning and prescribed fire activities under Alternative 3 would be similar to those found in Alternative 2. The only difference is there would be no reduction in crew members through the life of the plan (four crew member positions would exist through the life of the plan).

Mechanical Thinning and Pile Burning (road corridor and safety zones). Impacts to socioeconomics during mechanical thinning and pile burning activities under Alternative 3 would be similar to those found in Alternative 2.

Prescribed Fire (Stehekin Contours, Hozomeen Contours). Both of these projects would have negative and positive impacts on local economies: negative impacts could result if visitors change their plans due to smoke, noise, and possible closures; positive impacts would result through the additional income earned by fire staff and helicopter operators, which could be spent at local businesses. No additional crew members would be hired to implement the prescribed burns; rather, interagency resources would be used to assist with the burns, if needed, for short durations when the burn window is open.

Re-ignition. Impacts would be similar to those found under prescribed burns of the Stehekin and Hozomeen contours.

4.12.5 Cumulative Impacts to Socioeconomics

Other factors that impact socioeconomics include regional unemployment and lack of job opportunities, the winter road closure of Highway 20, decreased access to upper Stehekin trailheads due to storm-damaged roads that are closed, and other regional fires that impact visitor experiences.

4.12.6 Mitigation for Impacts to Socioeconomics

Conducting mechanical thinning projects in the off-season would be one way to minimize impacts to tourists in Stehekin.

4.12.7 Conclusion

The impacts from implementing any of the alternatives are generally beneficial, especially if impacts to local businesses due to closures and smoke are offset by expenditures made by the fire program to support personnel. The number of crew member pay periods would stay at current levels under Alternative 3, and decrease from current levels under alternatives 1 and 2.

Table 21. Fire Crew Numbers

Alternative 1		Alternative 2		Alternative 3	
Through 2007	8 crew members 69 pay periods/yr	Through 2010	8 crew members 69 pay periods/yr	Through life of plan	8 crew members 69 pay periods/yr
2008 through life of plan	6 crew members 44 pay periods/yr	2011 through life of plan	7 crew members 56 pay periods/yr		
	490 pay periods of funding through life of plan		625 pay periods of funding through life of plan		690 pay periods of funding through life of plan
	Reduction in contract thinning in 2009		Maintain current level of contract thinning through 2012		Maintain current level of contract thinning; increase use of contract helicopters

5 Consultation and Coordination

5.1 Persons, Organizations, and Agencies Consulted

State Historic Preservation Office. This environmental assessment will be sent to the Washington State Historic Preservation Office (SHPO) for review and comment as part of the on-going Section 106 compliance for the proposed project areas. The SHPO will also be contacted to initiate consultation if an identified historic/cultural resource is at risk from a wildfire or related activities.

Tribes. This environmental assessment will be sent to the Colville Confederated Tribes, the Yakama Nation, Upper Skagit Tribes, Sauk-Suiattle Tribes, Swinomish Tribe, and the Nlaka'pamux Nation. Formal consultation will be sought with the tribes, under a separate letter, accompanied by a map showing the area of potential effect.

US Fish and Wildlife Service. Park staff discussed the proposed list of endangered and threatened species to be considered with the US Fish and Wildlife Service. The agreed upon list appears in the EA. In addition to the discussion in the EA, a biological assessment evaluating the effects of the proposed action on listed and candidate species was submitted to the US Fish and Wildlife Service. A biological opinion from the Service is pending.

US Forest Service. The Okanogan, Wenatchee, and Mount Baker-Snoqualmie national forests were consulted regarding cooperation during wildland fire use activities.

5.2 List of Preparers and Contributors

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Jesse Kennedy, Cultural Resource Specialist

Karen Kopper, Fire Ecologist

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Brooke Larrabee, Museum Technician

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Bob Mierendorf, Archeologist

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Gina Rochefort, Science Advisor

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5.3 List of Recipients

This list includes only agencies, elected officials, tribes, organizations and other public offices. A list of individual recipients of the environmental assessment is on file at the superintendent's office at North Cascades National Park Service Complex.

Agencies

US

Environmental Protection Agency – Region 10
Mount Baker-Snoqualmie National Forest
Mount Rainier National Park
Natural Resource Conservation Service
Okanogan National Forest
Olympic National Park
Wenatchee National Forest

Washington State

Department of Ecology
Department of Fish and Wildlife
Department of Natural Resources
Department of Parks and Recreation
Department of Transportation
Department of Transportation, Aviation Division
Historic Preservation Office
Interagency Committee for Outdoor Recreation

County

Chelan County Fire Safety and Planning
Skagit County Planning
Whatcom County Planning

Legislative

US

Senator Maria Cantwell
Senator Patty Murray
Representative Doc Hastings
Representative Rick Larson
Representative Cathy McMorris

State

Senator Dale Brandland
Senator Evans-Parlette
Senator Val Stevens
Representative Mike Armstrong
Representative Gary Condotta
Representative Doug Ericksen
Representative Dan Kristiansen

Representative Kelli Linville
Representative Kirk Pearsen

County
Chelan County Commissioners
Skagit County Commissioners
Skagit County Upriver Services
Whatcom County Council
Whatcom County Executive

Tribal
Colville Confederated Tribes
Nlaka’pamux Nation
Sauk-Suiattle Tribes
Swinomish Tribe
Upper Skagit Tribes
Yakama Nation

Organizations
Earth Justice Legal Defense Fund
Jackson Foundation
The Mountaineers
National Park and Conservation Association
North Cascades Conservation Council
Northwest Ecosystem Alliance
Sierra Club, Cascades Chapter
Signpost
Washington Wilderness Coalition
Washington’s National Park Fund
Western Land Exchange Project
Wilderness Watch

Media
Bellingham Herald
Everett Herald
Methow Valley News
Skagit Valley Herald
Wenatchee World

Public Libraries
Bellingham Public Library-Main Library
Burlington Public Library
Mount Vernon City Library
North Central Regional Library-Chelan Community Library, -Wenatchee Public Library
Seattle Central Library

Other
North Cascades Stehekin Lodge
Port of Chelan County
PUD No. 1 of Chelan County
Ross Lake Resort
Seattle City Light

References

Agee, James K. 1993. Fire Ecology of Pacific Northwest Forests. Washington, DC: Island Press.

Agee, James K. 1994. Fire and weather disturbances in terrestrial ecosystems of the Eastern Cascades. USDA Forest Service, General Technical Report, Pacific Northwest Research Station, Portland, Oregon PNW-GTR-320.

Agee, James K. 1998. The landscape ecology of western forest fire regimes. Northwest Science, Vol 72, Special Issue 24 – 34.

Agee, James K., Mark Finney, and Roland de Gouvenain 1986. The Fire History of Desolation Peak: A Portion of the Ross Lake National Recreation Area. National Park Service Cooperative Park Studies Unit, College of Forest Resources, University of Washington. Seattle, Washington 98195

Agee, James K., and Mark H. Huff 1987. Fuel succession in a western hemlock / Douglas-fir forest. Canadian Journal of Forest Research 17(**7**): 697-704.

Almack, J. A., W. L. Gaines, R. H. Naney, P. H. Morrison, J. R. Eby, G. F. Wooten, M. C. Snyder, S. H. Fitkin, and E. R. Garcia. 1993. North Cascades grizzly bear ecosystem evaluation: final report. Report to the Interagency Grizzly Bear Committee, Denver, Colorado. 156 pp.

Anderson, Hal E. 1982. Aids to determining fuel models for estimating fire behavior. USDA Forest Service General Technical Report, Intermountain Forest and Range Experiment Station, Ogden, Utah. INT-122 22p.

Anderson, J.G.T. 1991. Foraging behavior of the American white pelican (*Pelecanus erythrorhynchos*) in western Nevada. Colonial Waterbirds 14:166-172.

Arno, Stephen F., David J. Parsons, and Robert E. Keane. 2000. Mixed-severity fire regimes in the northern Rocky Mountains: consequences of fire exclusion and options for the future. USDA, Forest Service Proceedings, Rocky Mountain Research Station, RMRS-P-15-Vol-5.

Arno, Stephen F., Joe H. Scott, and Michael G. Hartwell. 1995. Age-class structure of old growth Ponderosa pine/Douglas-fir stands and its relationship to fire history. USDA, Forest Service, Intermountain Research Station, Research Paper INT-RP-481.

Aubrey, K. B. and D. B. Houston. 1992. Distribution and status of the fisher (*Martes pennanti*) in Washington. Northwestern Naturalist 73:69-79.

Banci, V.A. 1994. Wolverine. Pages 99-127 *in* L.F. Ruggiero, K.B. Aubry, S.W. Buskirk, L.J. Lyon, and W.J. Sielinski, eds. The scientific basis for conserving forest carnivores, American marten, fisher, lynx and wolverine in the western United States. USDA Forest Service Rocky Mountain Forest and Range Experimental Station, General Technical Report RM-254, Fort Collins, Colorado.

Bartels, P. 2000. Western gray squirrel nest survey Chelan and Okanogan Counties, Washington. Unpublished report. Washington Department of Fish and Wildlife, Region 2. Ephrata, Washington. 28p.

Belnap, Jayne, Julie H. Kaltenecker, Roger Rosentreter, John Williams, Steve Leonard, and David Eldridge. 2001. Biological Soil Crusts: Ecology and Management. TR 1730-2. Department of Interior, Bureau of Land Management, Denver, CO. 118 pp.

Bjorklund, J. 1980. Historical and recent grizzly bear sightings in the North Cascades. USDI-NPS, North Cascades National Park, Sedro-Woolley, Washington. 10 pp.

Bjorklund, J. and D. Drummond. 1987. Nesting and habitat survey of endangered, threatened, and sensitive raptor species in the Ross Lake drainage, Washington State, 1987. NPS North Cascades National Park Service, Misc. Research Paper. 17 pp.

Bjorklund, J. and D. Drummond. 1989. Autumn raptor migration in the northern Cascade Range, Washington, 1984-1988. NPS North Cascades National Park Service, Misc. Research Paper NCT-30. 8 pp.

Bockheim, J. G. 1972. Effects of alpine and subalpine vegetation on soil development, Mount Baker, Washington. Ph.D. dissertation, University of Washington, Seattle.

Bond, C.E. 1992. Notes on the nomenclature and distribution of the bull trout and the effects of human activity on the species. Pages 1-4 in Howell, P.J. and D.V. Buchanan, eds. Proceedings of the Gearhart Mountain bull trout workshop. Oregon Chapter of the American Fisheries Society, Corvallis, OR.

Boxberger, Daniel L.1996. An Ethnographic Overview and Assessment for the North Cascades National Park Service Complex. Report Prepared for National Park Service, Pacific Northwest Region, Seattle, by Daniel L. Boxberger, Department of Anthropology, Western Washington University, Bellingham.

Brenkman, S.J., G.L. Larson, and R.E. Gresswell. 2001. Spawning migration of lacustrine-adfluvial bull trout in a Natural Area. Transactions of the American Fisheries Society 130:981-987.

Brooks, Randy. 2001. After the Fires: Hydrophobic Soils. University of Idaho Cooperative Extension System, UI Extension Forestry Information Series.

Bull, E.L. and J.A. Jackson. 1995. Pileated Woodpecker (*Dryocopus pileatus*). *In* The birds of North America, No. 148 (A. Poole and F. Gill, eds.). Philadelphia: The Academy of Natural Sciences: Washington, D.C.: The American Ornithologists' Union.

Bull, E.L. and C.T. Collins. 1993. Vaux's swift (*Chaetura vauxi*). *In* The birds of North America, No. 77 (A. Poole and F. Gill, eds.). Philadelphia: The Academy of Natural Sciences: Washington, D.C.: The American Ornithologists' Union.

Camp, Ann, Chad Oliver, Paul Hessburg, and Richard Everett. 1997. Predicting late-successional fire refugia pre-dating European settlement in the Wenatchee Mountains. Forest Ecology and Management 95:63-77.

Campbell, R.W., N.K. Dawe, I. McTaggart-Cowan, J.M. Cooper, G.W. Kaiser, and M.C.E. McNall. 1990. The birds of British Columbia. University of British Columbia Press, Vancouver, B.C. Canada.

Christophersen, R.G. and R.C. Kuntz II. 2003. A survey of bat species composition, distribution, and relative abundance in North Cascades National Park Service Complex, Washington. Tech. Rpt. NPS/NOCA/NRTR-2003/01, Sedro-Woolley, WA. 56 pp.

Christophersen, R.G. and R.C. Kuntz II. *In prep*. A survey of forest carnivore species composition and distribution in North Cascades National Park Service Complex, Washington. Tech. Rpt. NPS/NOCA/NRTR-2005/01, Sedro-Woolley, WA. XX pp + appendices.

Cole, David N. 1996. Ecological manipulation in wilderness: an emerging management dilemma. International Journal of Wilderness 2(1):15-19.

Cole, David N. 2000. Paradox of the primeval: ecological restoration in wilderness. Ecological Restoration 18(2):77-86.

Cordell, H. Ken, principal investigator. 1999. Outdoor Recreation in American Life: A National Assessment of Demand and Supply Trends. Champaign, IL: Sagamore Publishing.

Dixon, R.D. and V.A. Saab. 2000. Black-backed Woodpecker (*Picoides arcticus*). In The birds of North America, No. 509 (A. Poole and F. Gill, eds.). Philadelphia: The Academy of Natural Sciences: Washington, D.C.: The American Ornithologists' Union.

Donald, D. B. and D. J. Alger. 1993. Geographic distribution, species displacement, and niche overlap for lake trout and bull trout in mountain lakes. Can. J. Zool. 71:238-247.

Donald, W.W. 1990. Management and Control of Canada Thistle (*Cirsium arvense*). Rev. Weed Sci. 6:77-101

Douglas, George W. and T. M. Ballard. 1971. Effects of fire on alpine plant communities in the North Cascades, Washington. Ecology 52(6):1058-1064.

Edmonds, Robert L., James K. Agee, and Robert I. Gara. 2000. Forest Health and Protection. McGraw Hill, Inc.

Everett, Richard L., Richard Schellhaas, Dave Keenum, Don Spurbeck, and Pete Ohlson. 2000. Fire history in the ponderosa pine/Douglas fir forests on the east slope of the Washington Cascades. Forest Ecology and Management 129:207-225.

Fiedler, Carl E., Stephen F. Arno, and Michael G. Harrington. 1998. Reintroducing fire in ponderosa pine-fir forests after a century of fire exclusion. Pages 245-249 *in* Teresa L. Pruden and Leonard A. Brennan (eds.). Fire in ecosystem management: shifting the paradigm from suppression to prescription. Tall Timbers Fire Ecology Conference Proceedings, No. 20. Tall Timbers Research Station, Tallahassee, FL.

Fraley, J.J. and B.B. Shepard. 1989. Life history, ecology and population status of migratory bull trout (Salvelinus confluentus) in the Flathead Lake and river system, Montana. Northwest Science 63(4): 133_143.

Franklin, Jerry F. and C. T. Dyrness. 1988. Natural vegetation of Oregon and Washington. Oregon State University Press.

Glesne, Reed S. 1997. Evaluation of the effects of a foam fire suppressant chemical on the water quality of Boulder Creek, Lake Chelan National Recreation Area, Washington. NPS Technical Report NPS/CCSONOCA/NRTR-97/03, Sedro Woolley, WA, 19 pp.

Goetz, F. 1989. Biology of the bull trout, Salvelinus confluentus, literature review. Willamette National Forest, Eugene, OR.

Gruell, G. E., W. C. Schmidt, S. F. Arno, and W. J. Reich. 1982. Seventy years of vegetative change in a managed ponderosa pine forest in western Montana: Implications for resource management. USDA Forest Service General Technical Report INT-130.

Hall, E.R. 1981. Mammals of North America. John Wiley and Sons, Inc., New York, N.Y. 1181p.

Hamilton, Steve, Diane Larson, Susan Finger, Barry Poulton, Nimish Vyas, and Elwood Hill. Ecological effects of fire retardant chemicals and fire suppressant foams. Jamestown, ND: Northern Prairie Wildlife Research Center Home Page. http://www.npwrc.usgs.gov/resource/othrdata/fireweb/fireweb.htm (Version 02MAR98).

Harrington, M. G. 1993. Predicting Pinus ponderosa mortality from dormant season and growing season fire injury. International Journal of Wildland Fire 3(2): 65-72.

Harrington, Thomas C. and Michael J. Wingfield. 2000. Diseases and the ecology of indigenous and exotic pines. *In* D. M. Richardson (*editor*) Ecology and Biogeography of Pinus. Cambridge University Press, Cambridge.

Harrod, R., D. Knecht, E. Kuhlmann, M. Ellis and R. Davenport. 1995. Effects of the Rat and Hatchery Creek fires on four rare plant species. In proceedings of Fire Effects on Rare Species and Habitats Conference, Coeur d' Alene, Idaho. pp.311-319.

Harvey, M.J., J.S. Altenback, and T.L. Best. 1999. Bats of the United States. Arkansas Game & Fish Commission. Little Rock. 64 pp.

Hayes, G.E. and J.B. Buchanan. 2002. Washington state status report for the peregrine falcon. Washington Department of Fish and Wildlife, Olympia. 77 pp.

Healey, M.C. 1991. Life history of chinook salmon, Oncorhynchus tshawytscha. In Groot, C., and L. Margolis eds.), Pacific salmon life histories, p. 313-393. Univ. B.C. Press, Vancouver, B.C., Canada.

Hendee, John C., and Chad P. Dawson. 2002. Wilderness Management: Stewardship and Protection of Resources and Values. 3rd Ed. Golden: Fulcrum Publishing. 640 p.

Hessburg, Paul and James Agee. 2003. An environmental narrative of Inland Northwest United States forests, 1800-2000. Forest Ecology and Management 178:23-59

Hessl, Amy E., Don McKenzie, and Richard Schellhaas. 2004. Drought and Pacific decadal oscillation linked to fire occurrence in the inland Pacific Northwest. Ecological Applications 14(2):425-442.

Holmes, Ronald E. and R.S. Glesne 1997 NOCA NRPP Amphibian Inventory, Big Beaver Watershed, 1996 – Progress Report NPS Sedro-Woolley, WA

Holmes, Ronald E. and R.S. Glesne 1998 NOCA NRPP Amphibian Inventory, Bridge Creek Watershed, 1997 – Progress Report NPS Sedro-Woolley, WA

Holmes, Ronald E. and R.S. Glesne 1999 NOCA NRPP Amphibian Inventory, North Cascades National Park Service Complex 1998 – Progress Report NPS Sedro-Woolley, WA

Jaffe, Dan, Isaac Bertschi, Lyatt Jaegle, Paul Novelli, Jeffrey S. Reid, Hiroshi Tanimoto, Roxanne Vingarzan, and Douglas L. Westphal. 2004. Long-range transport of Siberian biomass burning emissions and impact on surface ozone in western North America. Geophysical Research Letters, 31(L16106):1-4.

Johnsgard, P.A. 1955. The relation of water level and vegetational change to avian populations, particularly waterfowl. Thesis, Washington State University, Pullman, Washington.

Johnsgard, P.A. 1990. Hawks, eagles, and falcons of North America: biology and natural history. Smithsonian Institution, Washington D.C.

Johnson, R.E. and K. M. Cassidy. 1997. Terrestrial mammals of Washington State: location data and predicted distributions. Volume 3 *in* Washington State Gap Analysis – Final Report (K.M. Cassidy, C.E. Grue, M.R. Smith, and K.M. Dvornich, eds.). Seattle Audubon Society Publications in Zoology No. 1, Seattle. 304 pp.

Johnson-Groh, Cindy 1997. Field surveys for *Botrychium gallicomontanum* and phenology of *Botrychium mormo* in Minnesota. Final Report to the Conservation Biology Research Grants Program Division of Ecological Sciences, Minnesota Department of Natural Resources.

Kailin, Janet. 1995. Hozomeen Fire Management Study: North Cascades National Park Service Complex. *Unpublished Report*. Skagit Environmental Endowment Commission, Project Number 92-3.

Kalabokidis, Kostas. 2000. Effects of wildfire suppression chemicals on people and the environment – a review. Global Nest: the International Journal, 2(2):129-137.

Koehler, G. M. 1990. Population and habitat characteristics of lynx and snowshoe hares in north central Washington. Canadian Journal of Zoology 68:845-851.

Kopper, Karen and Cedar Drake. 2002. North Cascades National Park Service fire effects monitoring report: 2002. Unpublished Report. North Cascades NPS Fire Management Office, Marblemount, WA 98267

Kopper, Karen. 2004. North Pacific / Columbia Basin Fire Effects Monitoring Annual Report 2004. Internal Report to the North Cascades National Park Service, Marblemount, WA

Kreisel, I.J. and S.J. Stein. 1999. Bird use of burned and unburned coniferous forests during winter. Wilson Bulletin 111:243-250.

Kuntz II, R.C., J.R. Douglass, and J. Bjorklund. 1996. Checklist of birds of North Cascades National Park Service Complex. Northwest Interpretive Association, Seattle.

Kuntz II, R.C., and R.G. Christophersen. 1996. A survey of the northern spotted owl in North Cascades National Park Service Complex. NPS Technical Report NPS/CCSONOCA/NRTR-96/05. U.S. Department of the Interior, National Park Service, North Cascades National Park, Sedro Woolley, Washington.

Kuntz, R. C. II and R. S. Glesne. 1993. A terrestrial vertebrate inventory of the Stehekin Valley, Lake Chelan National Recreation Area. NPS Technical Report NPS/PNNOCA/NRTR-93/010, Sedro-Woolley, Washington. 36 pp.

Kuramoto, R. T., and L. C. Bliss. 1970. Ecology of subalpine meadows in the Olympic Mountains, Washington. Ecological Monographs 40:317-47.

Lacey, C.A., J.R. Lacey, P.K. Fay, J. M. Story, and D.L. Zamora. 1992. Controlling knapweed on Montana rangeland. Montana State University, Coop. Ext. Serv. Circ. 311., Bozeman.

Lajeunesse, S. Dalmation and Yellow Toadflax. 1999. *In*: R.L. Sheley and J.K. Petroff (eds.), Biology and Management of Noxious Rangeland Weeds. Oregon State Univ. Press, Corvallis.

Landres, Peter, Mark W. Brunson, and Linda Merigliano. 2000. Naturalness and wildness: the dilemma and irony of ecological restoration in wilderness. Wild Earth, Winter 2000/2001:77-82.

Landsberg, Johanna D, and Arthur R. Tiedemann. 2000. Fire Management. Pages 124-138. in George E. Dissmeyer, (ed.). Drinking water from forests and grasslands: a synthesis of the scientific literature. General Technical Report SRS-39. US Department of Agriculture, Forest Service, Southern Research Station, Asheville, North Carolina.

Larson, James W. 1972. Ecological role of Lodgepole pine in the Upper Skagit River Valley, Washington. Master of Science Thesis, College of Forest Resources, University of Washington. Seattle, Washington 98195.

Laufer, J. R. and P. T. Jenkins. 1989. Historical and present status of the grey wolf in the Cascade Mountains of Washington. The Northwest Environmental Journal 5:313-327.

Leonard, William P., H.A. Brown, L.L.C. Jones, K.R. McAllister, R.M. Storm 1993 Amphibians of Washington and Oregon Seattle Audubon Society, Seattle, WA.

Lillybridge, Terry R., Bernard L. Kovalchik, Clinton K. Williams, and Bradley G. Smith. 1995. Field guide for forested plant associations of the Wenatchee National Forest. USDA Forest Service, Pacific Northwest Research Station, Portland, Oregon. General Technical Report PNW-GTR-359

Linders, M.J. 2000. Spatial ecology of the western gray squirrel, (*Sciurus griseus*) in Washington: the interaction of season, habitat and home range. Thesis, University of Washington. 99p.

Little, Edward E., Robin D. Calfee. 2002. Environmental Implications of Fire-Retardant Chemicals. Columbia Environmental Research Center, US Geological Survey. Columbia, Missouri.

Manual, D.A. and M.H. Huff. 1987. Spring and winter bird populations in a Douglas-fir forest sere. Journal of Wildlife Management 51:586-595.

Maxwell, Wayne G., Franklin R. Ward, 1980. Photo series for quantifiying natural forest residues in common vegetation types of the Pacific Northwest. Gen. Tech. Rep. PNW-105. Portland, OR: USDA Forest Service, Pacific Northwest Forest and Range Experiment Station. 230 p.

McIntyre, J.W. and J.F. Barr. 1997. Common Loon. No. 313 *in* A. Poole and F. Gill, editors. The Birds of North America. Academy of Natural Sciences, Philadelphia, and American Ornithologists' Union, Washington, D.C.

Mierendorf, Robert R. 1986. People of the North Cascades. North Cascades National Park Service Complex, Cultural Resources Division, Pacific Northwest Region, Seattle.

Mierendorf, Robert R. 1993. Chert Procurement in the upper Skagit River Valley of the Northern Cascade Range, Ross Lake National Recreation Area, Washington. Technical Report NPS/PNRNOCA/CRTR-93-001. North Cascades National Park Service Complex, Sedro Woolley, Washington.

Mierendorf, Robert R. 1999. Precontact use of tundra zones of the northern Cascades Range of Washington and British Columbia. Archaeology in Washington Vol. VII:3-23.

Mierendorf, Robert R. 2004. Archeology of the Little Beaver Watershed, North Cascades National Park Service Complex, Whatcom County, Washington. Report submitted to the Skagit Environmental Endowment Commission in fulfillment of Grant 02-01, by North Cascades National Park Service Complex, Sedro Woolley, Washington.

Mierendorf, Robert R., David J. Harry, and Gregg Sullivan. 1998. An archaeological site survey and evaluation in the upper Skagit River Valley, Whatcom County, Washington. Technical Report NPS/CCCNOCA/CRTR-98/01. Submitted to City Of Seattle, City Light Department, by the National Park Service, Columbia-Cascade Support System Office, Seattle.

Miller, Joseph W. and Margaret M. Miller. 1973. Succession studies of three wildfire burn sites in the North Cascades National Park Complex. North Cascades National Park Service, Sedro Woolley, WA

Morgan, P., and S. C. Bunting. 1990. Fire effects in whitebark pine forests. In Schmidt, W. C., and K. J. McDonald (comps.), Proceedings: Symposium on whitebark pine ecosystems: Ecology and management of a high-mountain resource: pp. 166-70. USDA Forest Service Research Note 10. Pacific Northwest Forest Experiment Station

Morrison, P., and F. J. Swanson. 1990. Fire history and pattern in a Cascade Range landscape. USDA For. Serv. Gen. Tech. Rep. PNW-GTR-254.

Motschenbacher, M.D. 1984. The feasibility of restoring a breeding white pelican population in the state of Washington. Thesis, Washington State University, Pullman, Washington.

Myers, J.M., Kope, R. G., Bryant, G. J., Teel, D., Lierheimer, L. J., Wainwright, T. C., Grant, W. S., Waknitz, F. W., Neely, K., Lindley, S. T., and Waples, R. S. (1998). Status review of chinook salmon from Washington, Idaho, Oregon, and California. NOAA Technical Memorandum NMFS-NWFSC-35.

Ohlson, Peter and Richard Schellhaus. 1999. Historical and current stand structure in Douglas fir and ponderosa pine forests. Wenatchee national Forest. Unpublished.

Oliver, Chadwick D. and Bruce C. Larson. 1981. Forest resource survey and related consumptive use of firewood in lower Stehekin Valley, North Cascades National Park Complex. College of Forest Resources, University of Washington, Seattle, Washington 98195.

Olson, Deanna H., W.P. Leonard, R.B. Burry 1997 Sampling Amphibians in Lentic Habitats Northwest Fauna Number 4 Society for Northwestern Vertebrate Biology Olympia, WA.

Pellant, M. 1990. The cheatgrass-wildfire cycle – are there any solutions? *In*: E.D. McArthur, E.M. Romney, S.D. Smith, and P.T. Tuller (eds.) Proc. Symp. on cheatgrass invasion, shrub die-off, and other aspects of shrub biology and management. USDA For. Ser. Gen. Tech. Rep. INT-276, 11-18

Peters, E.F. and S.C. Bunting. 1994. Fire Conditions pre- and postoccurance of annual grasses on the Snkae River Plain. *In*: S.B Monson and S.G. Kitchen (eds.), Proc. Ecology and management of annual rangelands. USDA For. Ser. Gen. Tech. Rep. INT-GTR313, 31-36

Potash, L. L. 1989. Sprouting of red heather (*Phyllodoce empetriformis*) in response to fire. M.S. thesis, University of Washington, Seattle.

Pratt, K.L. (1992). A review of bull trout life history. Pages 5 _ 9 *In* Howell, P.J. and D.V. Buchanan, eds., Proceedings of the Gearhart Mountain bull trout workshop. Oregon Chapter of the American Fisheries Society, Corvallis, OR.

Prichard, Susan Joy. 1993. Spatial and Temporal Dynamics of Fire and Vegetation Change in Thunder Creek Watershed, North Cascades National Park, Washington. Doctoral Dissertation. University of Washington, College of Forest Resources, Seattle, Washington 98195.

Pyle, Robert M. 1998. National Audubon Society Field Guide to North American Butterflies. New York, NY.

Pyle, Robert M. 2002. The Butterflies of Cascadia. Seattle Audubon Society, Seattle, WA.

Reinhardt, C. and S.M. Galatowitsch. 2004. Best management practices for the invasive *Phalaris arundinacea* L. (Reed canary grass) in wetland restorations. Minnesota Dept. of Transportation. St. Paul.

Reynolds, R.T., E.C. Meslow, and H.M. Wight. 1982. Nesting habitat of coexisting Accipiter in

Oregon. Journal of Wildlife Management 46:124-138.

Richardson,S., D. Hays, R. Spencer, and J. Stofel. 2000. Washington state status report for the common loon. Washington Department of Fish and Wildlife, Olympia. 53 pp.

Rieman, B.E. and J.D. McIntyre. 1993. Demographic and habitat requirements for conservation of bull trout. General Technical Report INT_302. U.S. Department of Agriculture, Forest Service, Inter Mountain Research Station. Boise, ID.

Rieman, B.E. and J.D. McIntyre. 1995. Occurrence of bull trout in naturally fragmented habitat patches of varied size. Transactions of the American Fisheries Society. 124 (3):285-296.

Rieman, B. E., Lee, D. C., & Thurow, R. F. 1997. Distribution, status, and likely future trends of bull trout within the Columbia River and Klamath River basins. North American Journal of Fisheries Management 17:1111-1125.

Ryan, L.A. and A.B. Carey. 1995. Distribution and habitat of the western gray squirrel (*Sciurus griseus*) on Fort Lewis, Washington. Northwest Science 69(3):204-216.

Scherer, G, R. Everett and B Zamora. 1997. *Trifolium thompsonii* Stand conditions following a wildfire event in the Entiat Mountains of Central Washington. In proceedings of Fire Effects on Rare Species and Habitats conference, Coeur d' Alene, Idaho. pp.245-252

Schmidt, K.M., Menakis, J.P. Hardy, C.C., Hann, W.J., Bunnell, D.L. 2002. Development of coarse-scale spatial data for wildland fire and fuel management. General Technical Report, RMRS-GTR-87, US Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fort Collins, CO.

Servheen, C. A., A. Hamilton, R. Knight, and B. McLellan. 1991. Evaluation of the Bitterroot and North Cascades to sustain viable grizzly bear populations. Report to the Interagency Grizzly Bear Committee. Boise, Idaho. 8 pp.

Sheley, R.L. and B. F. Roche, Jr. 1982. Rehabilitation of spotted knapweed infested rangeland in northeastern Washington. Abstr. Of papers, W. Soc. Weed Sci., Denver, CO.

Siegel, R.B., R.L. Wilkerson, R.C. Kuntz II, and J. McLaughlin. 2005. Landbird inventory for North Cascades National Park Service Complex (2001-2002) – Final Report. Technical Report NPS/NOCA/NRTR-2005. 56 pp.

Smith, Allan H. 1987. Ethnography of the North Cascades. Center for Northwest Anthropology, Washington State University, *Project Report* No. 7, Pullman (and National Park Service, Pacific Northwest Region, Seattle).

Smith, M.R., P.W. Mattocks, Jr., and K. M. Cassidy. 1997. Breeding birds of Washington State. Volume 4 in Washington State Gap Analysis – Final Report (K.M. Cassidy, C.E. Grue, M.R. Smith, and K.M. Dvornich, eds.). Seattle Audubon Society Publications in Zoology No. 1, Seattle. 538 pp.

Stinson, D. W. 2001. Washington state recovery plan for the lynx. Washington Department of Fish and Wildlife, Olympia. 78 pp. + 5 maps.

Sullivan, P. T. 1983. A preliminary study of historic and recent reports of grizzly bears in the North Cascades area of Washington. Washington Department of Game, Olympia.

Swezy, D. Michael and James K. Agee. 1990. Prescribed-fire effects on fine-root and tree mortality in old-growth ponderosa pine. Canadian Journal of Forest Research 21:626-634.

Thompson, Erwin N. 1970. North Cascades N.P., Ross Lake N.R.A., and Lake Chelan N.R.A. History Basic Data. National Park Service. 301 p.

Travnicek, A.J., Lym, R.G. and C. Prosser. 2005. Effect of a Prescribed Burn and Herbicides on Canada Thistle Control and Species Composition in a Grassland Community. Journal of Range Management. Unpublished.

US Census Bureau: State and County QuickFacts. Data derived from Population Estimates, 2000 Census of Population and Housing, 1990 Census of Population and Housing, Small Area Income and Poverty Estimates, County Business Patterns, 1997 Economic Census, Minority- and Women-Owned Business, Building Permits, Consolidated Federal Funds Report, 1997 Census of Governments.

US Department of Agriculture/U. S. Department of the Interior. 1995. Federal Wildland Fire Management Policy and Program Review, Final Report - December 18, 1995.

US Department of Agriculture, Forest Service. National Survey on Recreation and the Environment (NSRE): 2000-2002. The Interagency National Survey Consortium, Coordinated by the USDA Forest Service, Recreation, Wilderness, and Demographics Trends Research Group, Athens, GA and the Human Dimensions Research Laboratory, University of Tennessee, Knoxville, TN.

US Department of the Interior, National Park Service

1988. General Management Plan: North Cascades National Park Service Complex.

1989. Wilderness Management Plan: North Cascades National Park Service Complex.

1995. Forest fuel reduction / firewood management plan: Stehekin Valley, Lake Chelan National Recreation Area, Washington. Denver Service Station

1999a. Resource Management Plan: North Cascades National Park Service Complex.

1999b. Director's Order #41: Wilderness Preservation and Management.

1999c. Reference Manual # 18: Wildland Fire Management (RM-18).

2000a. Management Policies 2001.

2000b. Strategic Plan for North Cascades National Park Service Complex, Fiscal Year 2001 – 2005. (October 1, 2000 – September 30, 2005).

2002. Director's Order #28: Cultural Resource Management.

2003. Director's Order # 18: Wildland Fire Management (DO-18).

US Department of the Interior, Fish and Wildlife Service. 1992. Endangered and threatened wildlife and plants; determination of threatened status for the Washington, Oregon, and California population of the marbled murrelet. Federal Register Vol. 57. No. 191:45328-45337. October 1, 1992.

US Environmental Protection Agency. 1998. Interim Air Quality Policy on Wildland and Prescribed Fires.

US Geological Survey Canyonlands Research Station, Southwest Biological Science Center (2003, April 11). Biological Soil Crusts. Retrieved November 3, 2004, from http://www.soilcrust.org

Weisberg, Peter J., and Frederick J. Swanson. 2003. Regional Synchroneity in fire regimes of western Oregon and Washington, USA. Forest Ecology and Management 172 17-28.

Whisenant, S.G. 1990. Changing fire requencies on Idaho's Snake River Plains: ecological and management implications. *In*: E.D. McArthur, E.M. Romney, S.D. Smith, and P.T. Tuller (eds.) Proc. Symp. on cheatgrass invasion, shrub die-off, and other aspects of shrub biology and management. USDA For. Ser. Gen. Tech. Rep. INT-276, 4-10.

Whitlock, Cathy, Sarah L. Shafer, and Jennifer Marlon. 2003. The role of climate and vegetation change in shaping past and future fire regimes in the northwestern US and the implications for ecosystem management. Forest Ecology and Management 178:5-21.

Wright, Clinton S. and James K. Agee. 2004. Fire and vegetation history in the Eastern Cascade Mountains, Washington. Ecological Applications 14(2):443-459.

Young, J.A. 1983. Principles of weed control and plant manipulation. *In:* S.B. Monsen and N. Shaw (eds.), Managing intermountain rangelands – Improvement of range and wildlife habitats. USDA For. Ser. Gen. Tech. Rep. INT-157, 6-10.

Xanthopoulos, G. 1988. Guidelines for burning spotted knapweed infestations for fire hazard reduction in western Montana**.** *In*: General technical report - U.S. Department of Agriculture, Forest Service, Intermountain Research Station. Ogden, Utah: The Station. 251: p. 195-198.