Reader's Guide

Most readers of this document will wish to begin with Chapter 5, which outlines in table form the findings and recommendations for the Middle Fork Snoqualmie River Watershed. Chapter 3 is the main research body of the document, with additional details included in the Appendices. Chapter 4 summarizes future trends for the watershed.

Oversize maps appear at the end of this document, in Appendix E. They are assigned figure numbers sequentially, as references to them appear in the document (e.g., the first reference to Figure 1.4 appears in Chapter 1; the first reference to Figure 3.14 appears in Chapter 3). The clear overlay of Figure 1.4 can be used in conjunction with all of the oversize maps to orient the reader to specific geographical features.

A list of people contributing to the writing and compilation of this document is shown in Appendix A.

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CHAPTER 1 - INTRODUCTION

Purpose of the Analysis

The Middle Fork of the Snoqualmie River Watershed Analysis was conducted in compliance with the watershed analysis requirements established in the Record of Decision for Amendments to the Forest Service and Bureau of Land Management Planning Documents within the Range of the Northern Spotted Owl, April 13, 1994. The Record of Decision (ROD) and the 1990 Mt. Baker-Snoqualmie National Forest (MBS) Land and Resource Management Plan, which was amended by the ROD, are hereafter referred to as the Forest Plan.

Watershed analysis is not a decision-making process. This analysis will be used to provide information for subsequent decision-making analyses as prescribed by the National Environmental Policy Act (NEPA). By characterizing ecosystems, highlighting problem areas, suggesting solutions, and focusing on the watershed scale, the analysis will help decision makers to determine whether proposed projects meet the management objectives contained in the Forest Plan.

A detailed explanation of the watershed analysis process can be found in Ecosystem Analysis at the Watershed Scale: Federal Guide for Watershed Analysis, 1995.

Assumptions and Limitations

This analysis is based on a number of assumptions and has certain limitations which should be noted by the reader:

Future watershed condition trends were based on the assumption that the standards and guidelines in the Forest Plan will be in effect for at least the next several decades.

Future trends were also based on the assumption that private and state-owned land within the watershed will continue to be managed on relatively short rotations and in accordance with current State Forest Practice regulations and applicable habitat conservation plan requirements for the next several decades.

Trends were also limited by knowledge of future projects planned within the watershed. Only those proposals for which sufficient information was available for analysis were considered.

The Middle Fork of the Snoqualmie Watershed analysis area contains four "fifth field" watersheds. Although the Forest Plan recommends that watershed analysis be conducted at the fifth field level, the Forest Supervisor determined that analyzing the entire Middle Fork at one time would produce a better understanding of the conditions and trends within the watershed. It is believed that this will enhance the Forest's ability to manage the federal lands within the watershed as well as to integrate federal management activities with the other landowners and the public. The Middle Fork Snoqualmie River Watershed analysis area is defined as shown in Figure 1.4 Geographic Feature Reference. The analysis area includes all land ownerships as shown in Table 1.1.

The Watershed

Location and Ownership

The Middle Fork is located in central Washington on the west slope of the Cascade Range in King County (Figures 1.1 to 1.4). National Forest lands make up approximately 80% of the 109,549 acre watershed. This includes Weyerhaeuser lands scheduled to be transferred to the National Forest in the Huckleberry Land Exchange (Figure 1.5). Forest Plan allocations provide the basis for the management of National Forest lands within the watershed (Figure 1.6).

Table 1.1 Land Ownership

Land Ownership	Percent of Watershed	Acres
National Forest lands	77	84,713
Lands being acquired by National Forest	5	5,117
State of Washington (DNR) lands	8	8,764
Champion Timber Company lands	6	6,573
Other private lands	3.5	3,834
King County lands	0.5	548

The analysis area is divided into four "fifth field" watersheds: the Upper Middle Fork Snoqualmie River, Lower Middle Fork Snoqualmie River, Taylor River, and Pratt River watersheds. These are further divided into 31 subwatersheds, or "sixth field" watersheds (Figure 1.7). These range in size from just over 1,000 acres to over 5,000 acres, except for one which is over 21,000 acres.

Climate

The climate in this region is generally wet and mild with a period of summer drought. This, combined with the blocking effects of the mountain ranges on westerly winds of maritime air masses and the northeasterly winds of the continental air masses, creates the general climatic conditions of the watershed. Precipitation generally increases with elevation within the watershed. Due to the prevailing winds, the analysis area is in the path of airborne emissions from urban areas in the Puget Sound basin.

Geology and Physiography

The watershed is predominantly underlaid with igneous rocks of the Snoqualmie batholith, with minor intrusions of volcanic and metamorphic rocks. The basin was modified by both continental and alpine glaciers. Many of the unstable soil problems are associated with soils deposited during these glacial periods.

Elevations within the watershed range from 400 feet at the mouth of the Middle Fork to over 6,000 feet on some of the ridge tops.

Vegetation

The natural vegetation in the watershed reflects the area's climate and physiography. Nearly 50% of the watershed is in the higher elevation mountain hemlock and subalpine parkland zones while only about one fourth is in the more productive lower elevation western hemlock zone.

Historically, vegetation patterns in the watershed consisted of large blocks of forest shaped by periodic large fires that burned portions of the watershed approximately every 200 years. Currently the federal portion of the watershed is occupied by large blocks of mid and late seral forests. Only about 1% of these lands are covered by early seral forests. Outside the National Forest boundary the reverse is true. The majority of the land is covered with early to mid seral forests, reflecting ownership patterns and timber harvest activities.

Terrestrial Habitats and Species

There are approximately 290 terrestrial vertebrate species that either have been recorded in the watershed or are expected to occur. Timber harvest, especially west of the National Forest boundary, has fragmented and isolated habitat for low elevation late seral species. Approximately 70% of National Forest lands are capable of providing security habitat for wide ranging species such as bears and wolves.

Three vascular plant species that require protection, candy stick, round-leafed rein-orchid, and boreal bedstraw, have been documented in the watershed. The presence of protected species of fungi, lichens, and bryophytes has not yet been determined.

Hillslope and Hydrologic Processes

Stream flows generally are at their minimum in late summer and at their maximum in the spring as rain and melting snow swell channels. While the highest average flows occur in the spring the largest individual flows often occur in the fall when warm rains follow snows early in the season. This pattern, combined with unstable glacial deposits and the high road concentrations outside the Forest boundary in the western portion of the watershed, often results in scoured channels, debris flows, and flooding.

Aquatic Habitats and Species

Approximately 572 miles of perennial streams within the watershed are known to support fish. The majority of these streams are in the lower elevations of the Upper Middle Fork fifth field watershed. Resident populations of rainbow trout, cutthroat trout, eastern brook trout, mountain whitefish, and sculpin have been documented in the watershed. No native anadromous fish occur within the watershed since there is no fish passage around Snoqualmie Falls.

Human Use

The Middle Fork was the province of the ancestors of the present-day Snoqualmie Indian group. National Forest lands are currently used by members for a variety of activities. Logging has been the primary economic activity since European-American settlement in western Washington. Recreation has been the main use on National Forest lands for at least a generation.

Management Direction

The 1990 Forest Plan, as amended by the 1994 ROD, provides management direction for the National Forest system lands within the analysis area. To date, a plan reconciliation or "merger" of the Forest Plan and ROD has not been produced. Both documents must be considered together to determine Forest management direction in the form of goals, desired future conditions, land allocations, and standards and guidelines.

Land Allocations/Standards and Guidelines

The ROD established seven categories of land allocations which amended the 1990 Forest Plan land allocations and standards and guidelines. One, Managed Late Successional Areas, does not occur on the MBS. There is considerable overlap among the ROD categories because these allocations are not mutually exclusive. Like the 1990 Forest Plan, the ROD also contains some Forest-wide standards and guidelines. Section C of Attachment A to the ROD contains detailed standards and guidelines for the ROD land allocations.

The following ROD land allocations are found in the Middle Fork Snoqualmie River watershed analysis area:

1. Congressionally Reserved Areas: Included are Wilderness and Wild & Scenic Rivers.

2. Late-Successional Reserves: The main objective for these reserves, in combination with other land allocations and standards and guidelines, is to maintain a functional late successional and old growth forest ecosystem as habitat for late successional and old growth-related species.

3. Administratively Withdrawn Areas: These are areas allocated under the 1990 Forest Plan which emphasize recreation, scenery, wildlife, or other resources and do not include timber harvest.

4. Riparian Reserves: This allocation, a major component of the ROD Aquatic Conservation Strategy, includes areas along all streams, wetlands, ponds, lakes and unstable or potentially unstable areas. Riparian Reserves overlay all other management areas, and the Riparian Reserve standards and guidelines apply wherever Riparian Reserves occur (including designated Wilderness and Late-Successional Reserves).

5. Other lands (lumped together as "matrix" in the ROD): These are lands not included above. In the 1990 Forest Plan they were allocated to management areas that included full or partial yield timber harvest (e.g., 14 - Deer and Elk Winter Range).

In addition to the seven ROD land categories, five of which occur in the analysis area, the ROD also designated some lands within the range of the northern spotted owl as Tier 1 or Tier 2 Key Watersheds. The analysis area is designated Tier 2 Key Watershed. This Key Watershed category does not contain anadromous fish stocks, but it is an important source of high quality water for downstream beneficial uses (including fisheries). The Key Watershed allocation has its own set of standards and guidelines that are applied in addition to the underlying land allocation standards and guidelines.

Riparian Reserves are also ROD land allocations with their own set of standards and guidelines (Figure 1.8). Riparian Reserves occur within all management areas, and the Riparian Reserve standards and guidelines apply wherever they occur, in accordance with ROD C-1 and C-30.

Refer to the ROD for complete descriptions of those land allocation objectives and standards and guidelines, and to the MBS 1990 Forest Plan for those standards and guidelines to be followed in those areas not covered by standards and guidelines from the ROD. In those instances, such as in LSR, where a 1990 Forest Plan land allocation is more restrictive than the ROD land allocation, the more restrictive Forest Plan standards and guidelines will be followed (e.g., in the Pratt River where Alpine Lakes Dispersed Recreation overlaps LSR, no thinning would be allowed in stands under 80 years of age).

Summary of the Initial Plan Merger

For the purposes of this watershed analysis, an initial plan merger was completed. The results are included here as the Merged Land Allocations map (Figure 1.6) and as Table 1.2.

Table 1.2 Forest Plan/ROD Merged Land Allocations

Combined Upper and Lower Middle Fork Snoqualmie, Pratt, and Taylor River Watersheds

Allocation (MLA1)	**Acres**	**Description**
Undefined	22,066	Private, State, and King County Lands
1B	353	Semi-Primitive Nonmotorized Dispersed Recreation
2A	168	Scenic Viewshed Foreground
2A/5A	67	Scenic Viewshed Foreground/Recreation River
5A	4	Recreation River
5ALSOG	19	Recreation River/Late-Successional Old Growth
5ALSR	2,653	Recreation River/Late-Successional Reserve
5B	1,666	Scenic River
5BLSOG	541	Scenic River/LSOG
5BLSR	1,301	Scenic River/LSR
10C	50,736	General Trailless Wilderness
12	233	Mature and Old Growth Wildlife Habitat
12LSOG	10	Mature and Old Growth Wildlife Habitat/LSOG
14	1,379	Deer and Elk Winter Range
15LSR	771	Mountain Goat Habitat/LSR
17	1,124	Timber Management Emphasis
DR	4,625	Dispersed Recreation
DR5ALSOG	12	Dispersed Recreation/Recreation River/LSOG
DR5ALSR	84	Dispersed Recreation/Recreation River/LSR
DR5B	1,200	Dispersed Recreation/Scenic River
DRLSOG	664	Dispersed Recreation/LSOG
DRLSR	4,389	Dispersed Recreation/LSR
GF	3,593	General Forest
LSOG	377	LSOG
LSR	7,670	LSR
SF	2,295	Scenic Forest
SF5A	770	Scenic Forest/Recreation River
SF5ALSOG	124	Scenic Forest/Recreation River/LSOG
SF5B	655	Scenic Forest/Scenic River
TOTAL	**109,549**	

The ROD states: "The existing land management plans contain many standards and guidelines that are not amended by this decision. Only those existing plan standards and guidelines in conflict with this decision are replaced. Where existing plans are more restrictive or provide greater benefits to late-successional forest related species than Attachment A, the existing plan standards and guidelines will continue [with] (four exceptions...listed in Attachment A, p. C-3)" (USDA, USDI 1994).

To develop the initial merger of land allocations and standards and guidelines, the main criterion for "more restrictive or greater benefits to late-successional forest related species" was scheduled (programmed) timber harvest. If an existing management area (MA) has no scheduled harvest, this standard and guideline is "more restrictive" than the LSR standard and guideline, which allows thinning in stands under 80 years of age.

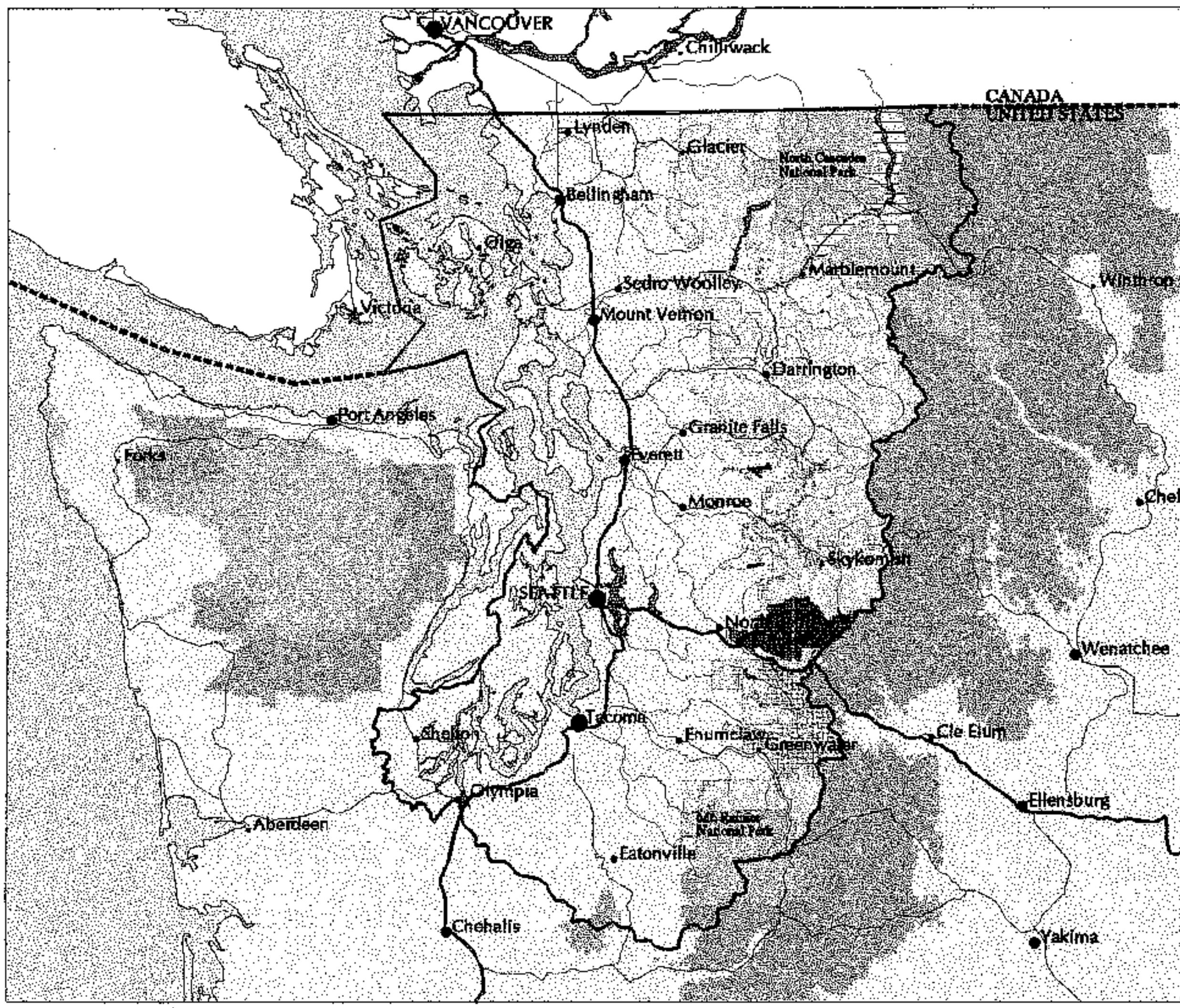
Where those MAs overlap with LSR, both the management area and LSR are mapped (e.g., "DRLSR" or DR5B"--see Figure 1.6).

Roadless Areas

There are no RARE II Inventoried Roadless Area parcels in the analysis area. However, there are unroaded lands in the analysis area that did not meet the 5,000 acre minimum area requirement for the RARE II process (see Figure 3.61 for a map of areas considered unroaded).

Figure 1.1

Western Washington Cascades Province



- United States
- Canada
- Puget Sound / Pacific Ocean
- Mt. Baker - Snoqualmie National Forest
- Private Lands within Forest Service Administrative Boundary
- Lands Proposed for Exchange
- Lands Proposed for Acquistion
- Surrounding National Forests
- National Parks
- Ross Lake National Recreational Area
- Middle Fork Snoqualmie Analysis Area

- US / Canada Border
- Western Washington Cascade Province
- Major Forest River Systems
- Interstate Highway
- Major Highways

Cities / Towns Population

- < 1000
- 1000 - 10,000
- 10,000 - 100,000
- > 100,000

N

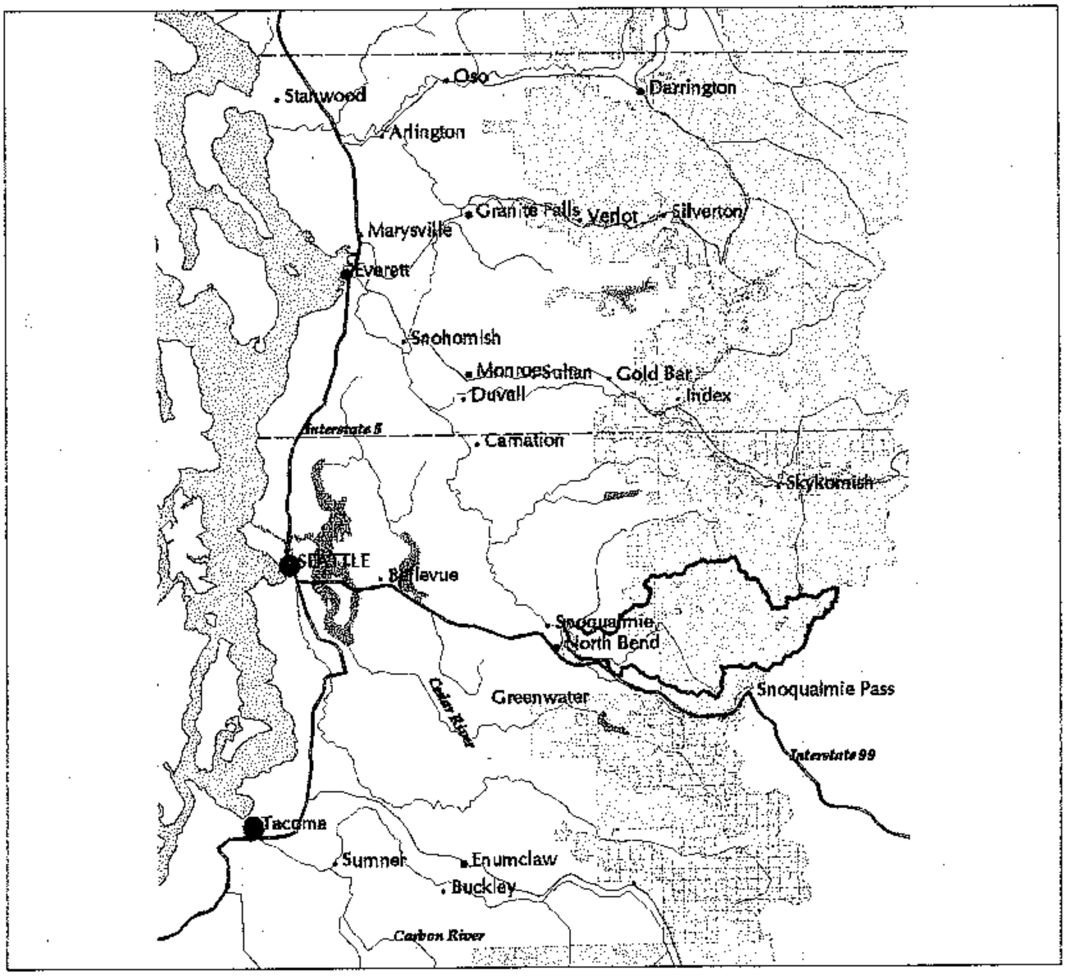
Mapscale = 1:2300000

USDA Forest Service
Mt. Baker-Snoqualmie National Forest
Geographic Information Resource Team

28 May 1997

Figure 1.2

Middle Fork Snoqualmie Watershed Analysis Area



Mt. Baker - Snoqualmie National Forest

Other Ownership Within MBS Boundary

Lakes Major Water Bodies

Middle Fork Snoqualmie Watershed Analysis Area Boundary

Major Forest River Systems

Interstate Highway

Major Highways

Cities / Towns Population

- < 1000
- 1000 - 10,000
- 10,000 - 100,000
- > 100,000

Scale = 1 : 50,000

USDA Forest Service

Mt. Baker-Snoqualmie National Forest

Geographic Information Resource Team

28 May 1997

CHAPTER 2 - ISSUES AND KEY QUESTIONS

Issues and key questions were developed by the watershed analysis team based on Forest Plan objectives, as well as comments from team members, the public, and other agencies. These questions were considered throughout the analysis.

Issue 1: Maintenance of viable populations of plant and animal species.

How does the current distribution of suitable habitat for plant and animal species compare with historic trends?

- What are the historic conditions and the natural range of variability within the watershed?
- What habitats are available within the watershed?
- What is the species composition within the watershed?
- How much habitat diversity exists within the watershed?
- What threatened, endangered, or sensitive species exist within the watershed? What suitable habitat exists for these species within the watershed?
- What is the status of noxious weeds in the watershed?

Issue 2: Effects of natural and human influences on the terrestrial system and organisms over time.

What are the natural factors and ecological processes limiting terrestrial habitats and species?

How, and to what extent, have human influences affected the terrestrial system and species over time?

Issue 3: Future trends for habitats and species of concern.

What are the future trends for habitats and species of concern?

Issue 4: Sustainability of aquatic and riparian ecosystem elements.

What erosion processes are dominant in the watershed, where have they occurred or are likely to occur?

What are the natural and human-caused changes between current and historical erosion processes?

What are the dominant hydrologic characteristics, features, and processes in the watershed?

What are the natural and human-caused changes between the historic and current channel conditions?

What is the relative abundance and distribution of fish species and what is the distribution and character of their habitats?

What is the composition of the amphibian and invertebrate communities in riparian areas?

What, if any, are the natural and human causes of changes between the historic and current species distribution, quality, and quantity?

Are State water quality standards being met?

Issue 5: Ability to meet human needs through time while conserving resources.

What are the historic human uses in the watershed?

What are the current uses, conditions, and trends of human activities within the watershed?

What are the influences and relationships between human uses and other ecosystem processes in the watershed?

What effects will proposals for providing and managing recreation and access being developed by citizen groups have on resources, including the recreation resources, if they are adopted by the Forest Service?

CHAPTER 3 - PAST AND CURRENT CONDITIONS

Vegetation

Vegetation throughout the Middle Fork Watershed has been quite variable since the last glacial maximum. The distribution of plants and the patterns of vegetation zones have changed in response to changing climate. During the Medieval Optimum (about 900 to 1300 AD), when the climate was warmer than today, the Western Hemlock Zone covered more of the watershed, extending to higher elevations. The Silver Fir Zone was smaller and the Mountain Hemlock Zone was probably a little smaller than today. During the Little Ice Age (about 1400 to 1850 AD) the climate was cooler and probably drier than today. The Silver Fir Zone had a much narrower elevation range until about 1750 when it began expanding downward as the climate became wetter.

The ranges of individual species shifted along with the changes in climate. At the beginning of the little ice age, the upper elevation range of Douglas-fir was 500 to 1,000 feet higher and the lower elevation range of silver fir was about 1,000 feet higher than it is now. During the last 600 years Douglas-fir retreated downward and the Silver Fir Zone expanded.

Changes brought about by succession occurred gradually over tens or hundreds of years, as specific plants and plant communities grew and matured. In some of the western hemlock forests at lower elevations, plants and communities progressed rapidly through succession moving from an early seral stage to a mid seral stage in 20-30 years and from a mid seral to a late seral stage in 150 years. In the silver fir and mountain hemlock forests of the higher elevations, this same development took between 40-100 years for the early to mid, and over 300 years for the mid to late. At lower elevations stand structural characteristics typically associated with old growth forests are reached at a younger age than in stands at higher elevations.

A table of approximate ages of each successional stage by vegetation series (Table 3.1) can be constructed from the parameters presented in the Regional Ecological Assessment Project (REAP, Peter 1993).

Table 3.1 Age of Successional Stages by Vegetation Series (REAP, Peter 1993).

	Series Ages (Years)			
	Early	Mid	Late, Single Story	Late, Multi Story
Western Hemlock	0-25	26-174	175-399	400+
Silver Fir	0-40	41-299	300-499	500+
Mountain Hemlock	0-100	101-349	350-499	500+

Vegetation Series

The following discussion is based largely on a classification of the potential vegetation that was completed on the Mt. Baker-Snoqualmie National Forest as a part of the regional ecology program (Henderson, Lesher, Peter, and Shaw 1992; Peter 1993). Acreage is from the Forest's TRI/Oracle vegetation series database.

Henderson, et al. (1992) define ecozones as areas with similar environments, delimited by the lower elevation limit of the Silver Fir zone. The ecozones of the MBS range from Ecozone 5 (wettest) to Ecozone 13 (driest). Ecozones 5, 6, 7, 8, and 9 are represented in the Middle Fork Watershed (Figure 3.1 and Table 3.2) with most of ecozone 9 outside the National Forest boundary in the western portion of the analysis area. The wettest ecozone in the analysis area (ecozone 5) is in the Taylor and Upper Middle Fork Watersheds and receives heavy precipitation.

Table 3.2 Ecozones of the Middle Fork Watershed (acres and percent of lands within the National Forest Boundary; MBS Ecology Program Database).

Ecozone	Acres within National Forest Boundary	% of land within National Forest Boundary
5	13,186	16
6	16,265	19
7	19,784	23
8	33,113	39
9	2,856	3

Approximately 28 percent of the analysis area (29,925 acres) is in the Western Hemlock Zone (projected climax species is western hemlock, *Tsuga heterophylla*)(Figure 3.2). The Western Hemlock Zone occurs primarily along the lower reaches of the Middle Fork and the lower elevations of its tributaries. This series is found from the lowlands up to 2400 feet elevation on the wettest and coldest sites and up to 3000 feet elevation on the driest and warmest sites. The Western Hemlock Zone is generally characterized by less than 100 inches of precipitation, most of which is rain. The summer drought, typical of western Washington, is well expressed in this zone. There is generally little snow accumulation during the winter and when spring arrives, soils begin to warm and plants begin to grow early in the year. The Western Hemlock Zone includes some of the most productive lands on the Forest. The dominant tree species are Douglas-fir and western hemlock. Douglas-fir, a long-lived seral species, is common except in the wettest areas. The bulk of human activity within the analysis area has taken place in the Western Hemlock Zone.

Approximately 24 percent of the analysis area (26,301 acres) is in the Silver Fir Zone (projected climax species is silver fir, *Abies amabilis*). Silver fir and western hemlock are the dominant tree species. The Silver Fir Zone occupies the middle elevations and many mid and upper slopes in the watershed. Within the analysis area this series is found as low as 1000 feet elevation on cool, wet sites and as high as almost 4000 feet on the driest sites. This zone is characterized by cool, moist soils, persistent winter snowpack, a general lack of summer plant moisture stress, and a short, cool growing season.

The Mountain Hemlock Zone is the dominant vegetation series of the analysis area. Almost 37 percent of the analysis area (approximately 40,675 acres) is in this zone (projected climax species is mountain hemlock, *Tsuga mertensiana*), where silver fir and mountain hemlock are the dominant tree species. The Mountain Hemlock Zone occupies the upland areas in the watershed. This zone is found as low as 2400 feet elevation in the coolest, wettest areas and as high as almost 5400 feet elevation on drier sites. This zone is characterized by cool summers, a long lasting, heavy snowpack, and a short growing season. The Mountain Hemlock Zone includes some of the least productive habitat types on the Forest. There has been relatively little human activity centered in the Mountain Hemlock Zone, with the exception of recreation use.

Eleven percent (approximately 12,350 acres) of the analysis area is in the subalpine Parkland Zone. This area has not yet been classified into plant associations by the Area Ecology Program. It is structurally characterized by tree species (including mountain hemlock, Alaska yellow cedar, *Chamaecyparis nootkatensis*, and/or subalpine fir, *Abies lasiocarpa*) growing in clumps or small "islands" of forest surrounded by open meadows, rock, snow, or ice. The Parkland Zone can occur as low as 4400 feet elevation on the wettest sites or as low as 4800 feet on the drier sites. Most of the Parkland Zone occurs in the Upper Middle Fork Watershed.

There are 256 acres of Alpine Zone at Overcoat Peak and Lemah Mountain in the Upper Middle Fork Watershed.

Table 3.3 The Potential Vegetation Zones of the Middle Fork Watershed Analysis Area.

	Entire Analysis Area		National Forest Land Only	
Vegetation Zones	**Acres**	**Percent**	**Acres**	**Percent**
Western Hemlock	29,925	28	14,746	17
Silver Fir	26,301	24	21,469	25
Mountain Hemlock	40,675	37	38,317	44
Parkland	12,350	11	12,267	14
Alpine	256	<1	256	<1

Vegetation Disturbance

Fire History

Forested stands which originated before 1800 (approximately 42,700 acres) were almost entirely a result of the natural fire regime with a small portion a result of other natural disturbance such as avalanches, landslides, and windthrow.

Catastrophic fire events have shaped the vegetation across the landscape of western Washington for at least the last 1,000 years. For the period of the past 1,000 years we can study living trees (both Douglas-fir and western redcedar live to over 1,000 years) and refer to historical records to construct a more detailed picture of fire history.

During the period between 900 and 1300 (Medieval Optimum), the climate was warmer and drier than today; and it is generally assumed that fires burned frequently throughout Northwest forests during this time. The fact that there are very few trees surviving this period suggests that fires were either frequent or large, at least near the end of this period. Very old Douglas-firs are mostly found outside their present natural range, in higher sites (Silver Fir or Mountain Hemlock Zone) where they can no longer regenerate.

Three great burning periods occurred from 1300 to 1750 during the Little Ice Age. The first of these occurred about the year 1308 as a very large fire or series of fires which swept western Washington. During this event, the Upper Middle Fork Watershed and the Quartz Mountain areas burned.

The second great burning episode occurred around the year 1500, with several fires burning during this period. The biggest of these fires occurred about the year 1508 and remnants of this series of fires occur in the southern Pratt, Lower Middle Fork and on private lands in the analysis area. These fires covered much of the low to mid-elevation forests in the analysis area.

The last of the three great burning episodes occurred around the year 1700, with one of the last big fires occurring about the year 1701. These fires covered a smaller portion of the analysis area than the 1500 episode and were generally limited to the Western Hemlock Zone, affecting mostly lands outside the Forest boundary.

These fires were very extensive but not all of the area within the fire boundaries burned and burning may have been patchy. From both the vegetation patterns across the landscape and fire ecology analysis, we know that specific microsites either burned lightly (e.g. underburned) or did not burn at all. The most obvious are the driest sites like rock outcrops or talus slopes that may have had light or patchy burning; moist stream bottoms, north slopes, and riparian areas that show little or no evidence of fire.

A Prescribed Natural Fire Action Plan for the Alpine Lakes Wilderness was approved by the Regional Forester in December 1982. The plan was revised in April of 1992 and provides a methodical procedure for managing prescribed natural fires within the Alpine Lakes Wilderness. The objective is to permit natural fires to exert their effects on the vegetative patterns within the wilderness without endangering public safety or values outside the wilderness. Each prescribed fire will be evaluated daily to ensure the criteria outlined in the action plan are met. Three fires less than 3 acres each have occurred in the Alpine Lakes Wilderness within the analysis area that have met this criteria since the plan was approved in 1982 (Kapral, personal communication 1997).

Historic Timber/Vegetation Management

The initial timber harvest activity on National Forest lands in the analysis area which began before the turn of the century was associated with mining. The harvest associated with mining activity was small scale, normally tied with specific mining claims and the associated access. Much of the first several decades' harvest was primarily railroad logging, where short rail spurs were built into the gentle river/stream bottoms accessing some of the largest diameter, highest volume stands in each drainage.

Approximately 16 percent of the National Forest lands and inholdings of the analysis area (approximately 14,275 acres) are forested with stands that originated after 1920 (Table 3.4). Most of these forest stands can be assumed to have been logged. Though there was some harvesting before 1920 in the watershed there was little large-scale, stand-replacing timber harvest until the 1930's. Data for lands outside the Forest boundary is not available; however, a large percent of this vegetation originated after 1920.

Railroad logging occurred in the Lower Middle Fork Watershed on both sides of the main channel during the 1930's and 1940's. Harvesting in the 1970's occurred more upslope on both sides of the river. Harvesting in the 1980's removed pockets of old growth west of the Taylor River confluence. The Upper Middle Fork was also railroad-logged from the confluence with Taylor River to just upstream from Burnt Boot Creek. The logging occurred on both sides of the drainage and tended to be concentrated along the lower slopes. Private lands bordering Hardscrabble Creek were harvested in the 1970's. Timber harvest occurred in the Pratt Watershed in the 1930's and 1940's from Tuscohatchie Creek to the confluence with the Middle Fork. Harvest along this portion of the Pratt occurred within a half mile of the river. Harvest continued up Thompson Creek to the confluence with Spider Creek. The majority of harvest within the Taylor Watershed occurred during the 1940's and 1950's (Figure 3.62 Historic Timber Harvests).

Table 3.4 Stand Year of Origin

Stand Year of Origin	Acres
1100's	11,329
1300's	21,795
1400's	355
1500's	5,631
1600's	73
1700's	2,312
1800's	1,462
1920's	**1,036**
1930's	**3,549**
1940's	**7,632**
1950's	**388**
1960's	**768**
1970's	**695**
1980's	**208**

Seral Stages

Acreage values for forest zones and seral stages (stages in the process of ecological succession) used in this section of the document are based on a combination of the MBS TRI/Oracle vegetation database and the MBS ecology program fire history database. The seral stages here represent stand age within each forest zone as defined by the REAP (Table 3.1). Data are specific to National Forest land within the analysis area only. Seral stage information for areas outside the National Forest is limited and not directly comparable. The discussion of seral stages applies only to forested sites. Non-forested sites were not included in the calculations due to the absence of reliable fire history and TRI data in those habitats.

Successional stage for this discussion is divided into four main categories: early seral, mid seral, late seral single-story, and late seral multi-story. Late seral was divided into "single-storied" and "multi-storied," reflecting structural differences between the younger and older late seral stands. The age of a successional stage can vary by vegetation series and elevation.

Table 3.5 Acres and Percent of Seral Stages in the Middle Fork Analysis Area. Data derived from MBS fire history and TRI/Oracle vegetation databases for forested National Forest lands only. Percentages of analysis area do not sum to 100 because seral stages outside the USFS boundary are unknown at this time.

	National Forest Lands Only (Forested)		
Seral Stage	**Acres**	**% National Forest, Forested**	**% of Analysis Area**
Early	646	1	<1
Mid	18,083	33	17
Late, single story	6,108	11	6
Late, multi story	30,056	55	27
Total Late	36,164	66	33

The successional stages within each vegetation series are also summarized in Table 3.6 for the analysis area. Within the Western Hemlock Zone, most of the stands are in the mid seral stage of development. Within the Silver Fir and Mountain Hemlock Zones, most of the stands are in the late seral condition. Although development of late seral conditions is relatively fast in the Western Hemlock Zone, there has also been more wildfire and harvest activity within this zone.

Table 3.6 Current Successional Stages within each vegetation series in the Middle Fork Watershed. Data derived from MBS fire history and TRI/Oracle vegetation databases for forested National Forest lands only; seral stage outside the National Forest boundary is unknown at this time. Percentages are the relative proportions.

	Western Hemlock Zone		**Silver Fir Zone**		**Mountain Hemlock Zone**	
Seral Stage	Acres	Percent of Zone	Acres	Percent of Zone	Acres	Percent of Zone
Early Seral	210	2	224	1	213	1
Mid Seral	8,622	73	5,355	33	4,107	15
Late Seral SS	904	8	2,733	17	2,471	9
Late Seral MS	1,975	17	8,091	49	19,990	75
Late Seral Total	2,879	25	10,824	66	22,461	84

Fragmentation

Fragmentation is the degree to which the landscape is broken into distinct patch types. It can be a relatively permanent and natural feature, such as in the subalpine parkland, or a temporary human-caused feature such as a clearcut. As defined in the REAP (Peter 1993), an area in which 50% of the landscape is in patch clearcuts and 50% in old-growth forest is highly fragmented. An area that has been entirely clearcut or burned or conversely, an area of contiguous old growth, is considered unfragmented.

Portions of the analysis area have been fragmented by patch clearcutting or development resulting in more high contrast edge that occurred in the past from fire and other natural disturbances. In general the Upper Middle Fork and the Pratt River watersheds have the least amount of fragmentation, while the Lower Middle Fork and the Taylor River watersheds have the most.

Range of Natural Variability

The idea of the range of natural variability acknowledges that ecosystems are not static and that they vary over time and space. The dynamic nature of ecosystems exemplifies the need for us to consider ranges of conditions under natural disturbance regimes, rather than single points in time. A key assumption of this concept is that when systems are "pushed" outside the range of natural variability there is substantial risk that biological diversity and ecological function may not be maintained. As discussed above, a significant portion of the analysis area was within the boundaries of the 1300 fire; climate has changed since then and there has not been a fire event of anything close to that magnitude in recent centuries. For the purposes of this discussion then, the year 1300 will be considered a starting point and the historical range examined will be from 1300 to present. The stand information has been grouped into 25-year increments so the dates discussed below are approximate. Only the amounts of late seral stands were discussed because this seral stage is most limited and of greatest concern.

Range of Natural Variability for All Series, Entire Analysis Area

After the 1300 fire, there were very few late seral stands in the analysis area until around 1475, when forests in the Western Hemlock Zone made the transition from mid-seral to single story late seral stage. From then on depending on the fire history, the amount of late seral stands in all zones fluctuated from a low of 20% (of the forested National Forest lands) around 1525 (reflecting the influence of the 1501 fire) to a maximum coverage of 85% (of the forested National Forest lands) around 1900. This compares to a current condition of 66% late seral stands. Considering trends in the analysis area, there were only a few periods of time when there was more late seral than currently exists; the majority of the time there was less. The current amount of late seral stands within the analysis area (Table 3.5) is well within the range of natural variability, comparing today's amount to past trends over time (Figure 3.5).

All Series, Within Each Vegetation Zone, Entire Analysis Area

The proportions of late seral stands is quite different in the different vegetation zones. Currently 25% of forested National Forest lands in the Western Hemlock Zone is in the late seral condition (Figure 3.6), compared to 66% in the Silver Fir Zone and 84% in the Mountain Hemlock Zone (Figures 3.7 and 3.8).

The proportions of late seral stands in the Western Hemlock Zone have fluctuated so widely in the past that it is hard to pinpoint a general trend. After recovery from the 1301 fire, the amount of late seral varied from about 5% to 98%. Within the Western Hemlock Zone,

Figure 3.5 Proportion of seral stages over time in the entire analysis area. Data derived from MBS fire history and TRI/Oracle vegetation databases for forested National Forest lands only.

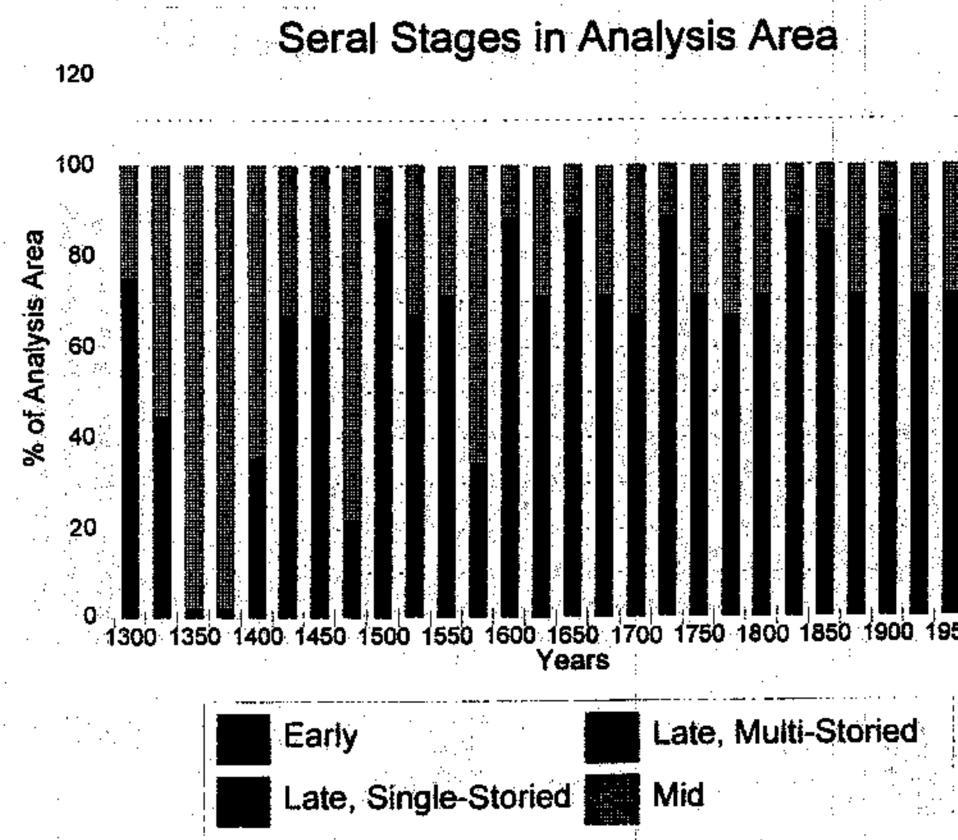


Figure 3.6 Seral Stages over time in the Western Hemlock Zone.

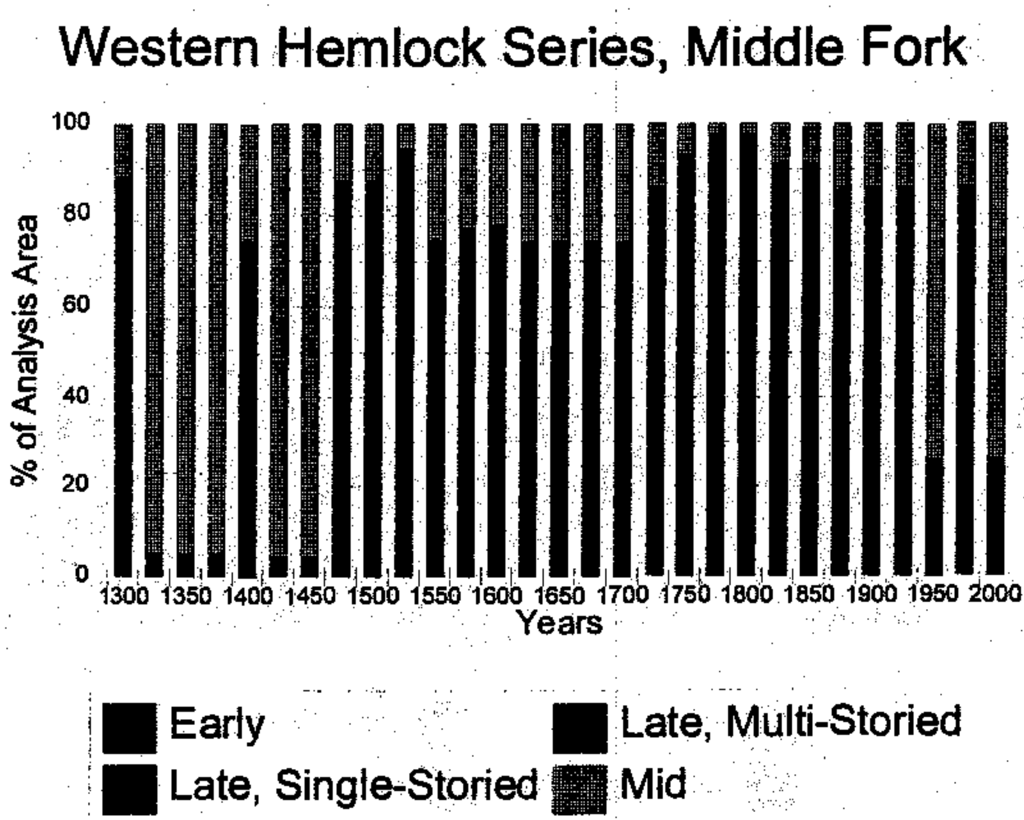


Figure 3.7 Seral Stages over time in the Silver Fir Zone.

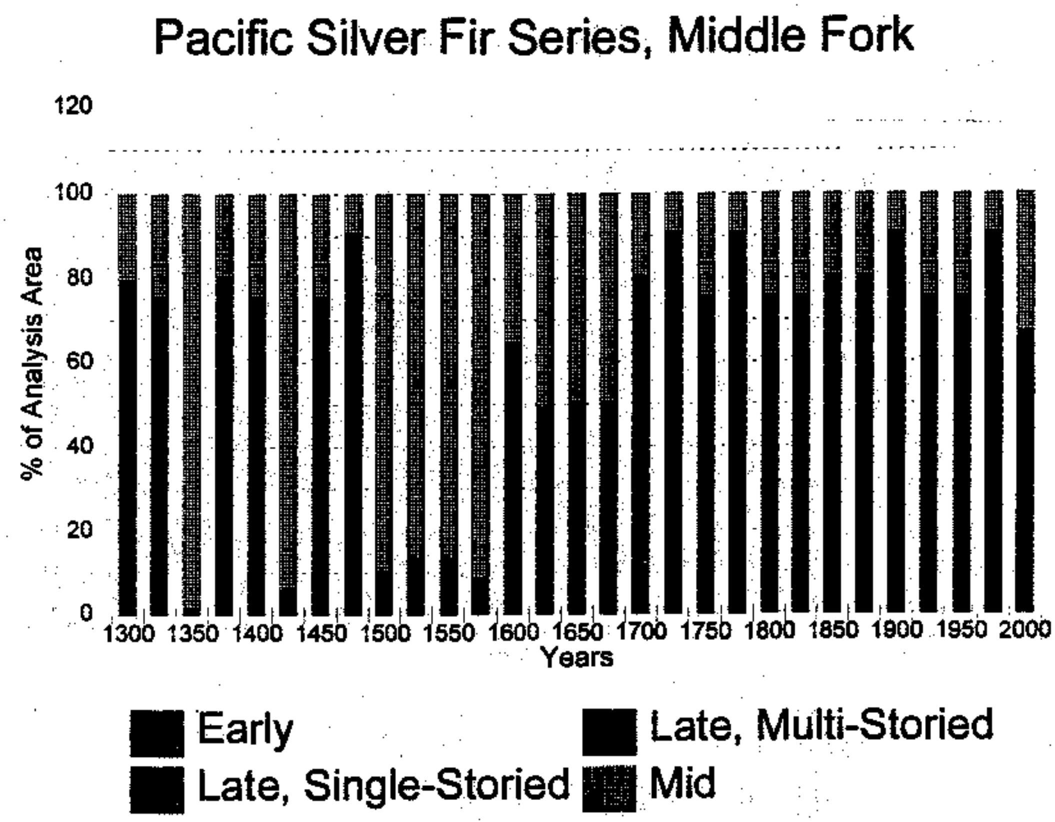
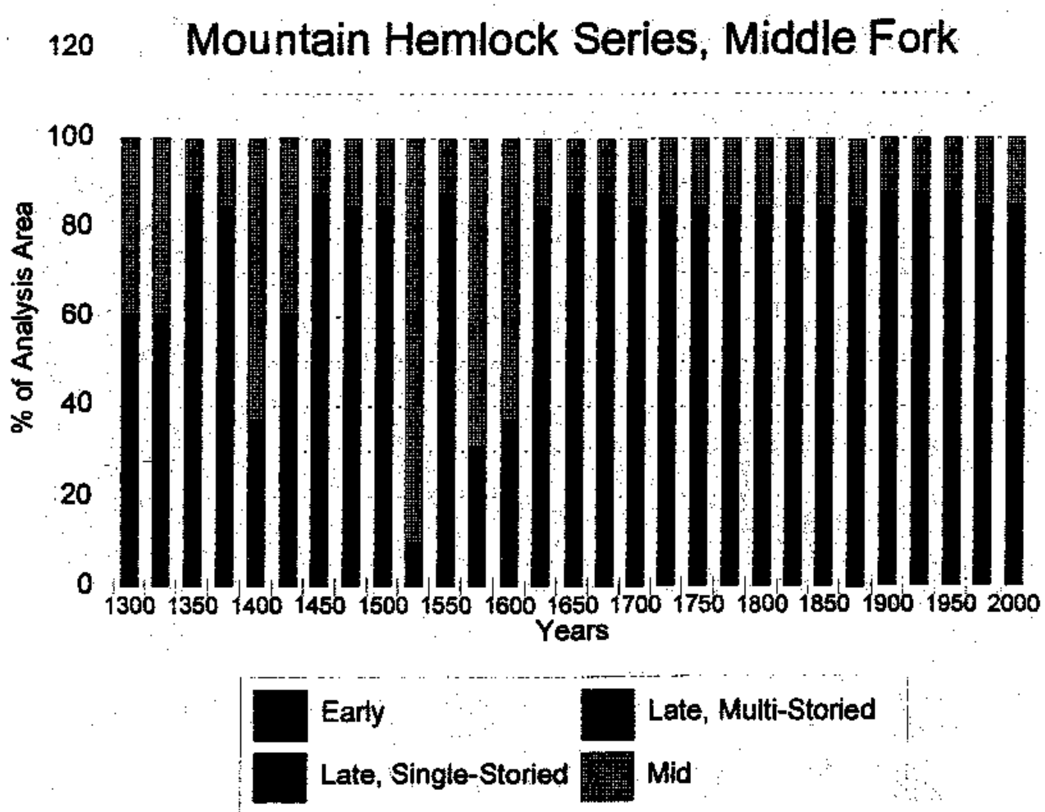


Figure 3.8 Seral Stages over time in the Mountain Hemlock Zone.



National Forest lands are currently at the lower end of the range at 25% because of the timber harvest between 1925 and the 1980's. If lands outside the Forest boundary in the analysis area are considered, the Western Hemlock Zone is probably near the bottom of the range of natural variability, because of disturbance (logging, farming, or development) on private property outside the National Forest boundary.

After the fires of 1300, Pacific Silver Fir forests did not develop into late seral condition until about 1600. From 1600 on it ranged from 49% to 88%; National Forest lands are currently within the historic range at 65%.

Within the Mountain Hemlock Zone, National Forest lands are currently at the upper end of the historic range of late seral stands. Since about 1725 there has been a consistent amount of late seral stands in the Mountain Hemlock Zone.

Range of Natural Variability (RNV) Summary

- All forest series (combined): late seral are within the RNV.
- Western Hemlock Zone: late seral is within the RNV, but at the lower end of the historic range. Actual proportions would probably be well below the historic range if the entire analysis area (including the non-federal lands) could be analyzed but these data were not available.
- Silver Fir Zone: late seral is within the RNV.
- Mountain Hemlock Zone: late seral is within (at the upper end of) the RNV.

Timber/Vegetation Management

There are five management allocations within the National Forest boundary where timber harvest is either a primary objective or a byproduct of meeting other objectives. These are Alpine Lakes General Forest, where timber harvest occurs with visual quality objectives from retention to modification; Alpine Lakes Scenic Forest, where the objective is to retain or enhance viewing and recreation experiences with timber harvest permitted; Management Area 14, where conifer stands are managed to achieve proper forage/cover ratios and distribution for deer and elk winter range over time; Late Successional Reserves (LSR) which are managed to protect and enhance old-growth forest conditions; and Riparian Reserves which are managed to maintain or enhance the Aquatic Conservation objectives.

Management allocations in the analysis area which allow scheduled or nonscheduled timber harvest are as follows:

Scheduled - Full Yield

Alpine Lakes General Forest: 3593 acres

Scheduled - Partial Yield

Alpine Lakes Scenic Forest: 2295 acres

5A - Recommended Recreation Segment, Wild and Scenic River: 4 acres

5B - Recommended Scenic Segment, Wild and Scenic River: 1666 acres

14 - Deer and Elk Winter Range: 1379 acres

Unscheduled - Thinnings Only (must be designed to improve desired habitat character)
Late-Successional Reserve (only in stands under 80 years of age)
Riparian Reserve (See Figure 1.8 Riparian Reserves, for land area affected)

Based on TRI/Oracle vegetation data, aerial photo interpretation, and ground reconnaissance, approximately 1000 acres near Quartz Mountain within the Alpine Lakes General Forest is possibly too rocky to reforest within five years if the area has a regeneration harvest. Reforestation within five years of regeneration harvest is a requirement of the National Forest Management Act.

Of lands currently proposed for acquisition in the Weyerhaeuser land exchange, timber harvest is either a primary objective or a byproduct of meeting other objectives in only three management allocations. These include Management Area 17, where the emphasis is on timber management; Management Area 14; and Management Area 2A: Foreground (areas of visually sensitive landscapes where timber is managed at less than full yield). Stand data for these areas are not available at this time; however, there is a likelihood that commercial thinning or precommercial thinning will be appropriate in the future on portions of these lands.

Plant Association Groups

One way to describe vegetation is through a classification based on potential vegetation, using the plant association as the basic unit (Henderson et al. 1992). Potential vegetation is the projected climax plant community which will occupy a site, given current climate and site conditions. There is no map of plant associations for the Mt. Baker-Snoqualmie National Forest at this time (and may not be for several years). In lieu of a map of plant associations we are using a map of Plant Association Groups (PAG), which was created from a model.

The Plant Association Group (PAG) model groups plant associations which have similar floristic characteristics. The model was developed by the Forest Ecologists mainly from moisture and temperature characteristics associated with climate and topography. In areas where topography is not strongly expressed, the PAG model may be off by one moisture class. The results have been field checked and show a high degree of accuracy. However, care should be used in interpreting any point on the ground because the model interprets broad vegetation patterns across the landscape and may be misleading on the microsite scale. The plant associations grouped in each PAG are described in the Plant Association Guide for the Mt. Baker-Snoqualmie National Forest (Henderson et al. 1992).

Figure 3.9 depicts the PAGs within the analysis area. The most abundant and widespread Plant Association Groups of the Middle Fork watershed include the Moist Mountain Hemlock Alaska Huckleberry PAG (comprising 20% of the watershed), the Moist Pacific Silver Fir Alaska Huckleberry PAG (comprising 16% of the watershed), and the Mesic Mountain Hemlock Big Huckleberry PAG (comprising 13% of the watershed). Other widespread but less common Groups include the Moist Western Hemlock Swordfern PAG (comprising 11% of the watershed) and the Mesic Western Hemlock PAG (comprising 11% of the watershed). Rare Groups with limited extent and distribution (each covering less than 0.1% of the combined watershed) include the Dry Western Hemlock Salal Beargrass PAG, the Mountain Hemlock Wet Shrub PAG, the Non-Forest PAGs, and the Alpine PAG.

It is important to note that while these PAGs are based on a model, they do indicate the potential presence of many rare or unusual plant associations present within the analysis area. These provide an important component of the ecosystem diversity of the watershed and may provide rare plant and animal habitat.

Habitats and Places of Special Concern

One of the goals of the Forest Plan is to "maintain and restore" native species and plant communities. The purpose of this section is to address natural diversity concerns, a key issue for this portion of the analysis. Plant diversity can be measured by the presence of individual species or by the presence of plant communities and their distribution. The analysis area supports a wide diversity of vascular plants. Plant communities of concern are those in the late seral stage of succession (old growth), wetlands and riparian areas, communities that are relatively uncommon for this area, and centers of diversity for rare plants (i.e., where more than one rare species occurs).

An area of special concern is the portion that apparently has not burned since approximately the year 1000 in the north and northeastern portion of the analysis area. This area is located within the Alpine Lakes Wilderness and includes Big Snow Mountain. Another area is an old growth stand of big-leaf maple in section 30 of T24N R10E along the Middle Fork River and the Forest boundary.

Terrestrial Habitats and Species

Wildlife and plant issues are addressed both separately and together in this discussion. This analysis of past and current conditions is based largely on the analysis of vegetative conditions.

This analysis will discuss habitat at the scale of this analysis area as well as at the larger basin scale, the Snoqualmie River basin, in order to more accurately reflect current conditions for all species. Accurate and reliable estimates of both past and current wildlife and plant conditions are unavailable and are difficult to reconstruct. Both the composition and population sizes of species have changed over the past 150 years in response to changes in habitat and increased human presence. Changes in habitat conditions and alteration in predator/prey relationships, and territoriality have occurred on a continuing basis. Consequently, past levels of terrestrial vertebrate and plant populations are inferred from broad changes in habitat.

Habitat Condition Module and Limitations of Data

Historic information on forest conditions was obtained from the REAP report (see Vegetation Patterns section of this document). This information was then used in the Habitat Condition Module (HCM or module) Version 3.0 developed on the Mt. Baker-Snoqualmie National

Forest in 1994 to support watershed analysis and provide a means to monitor habitat conditions over time (Appendix B). The HCM also uses vegetation data from the Forest TRI Oracle database, which has been updated annually to reflect changes in the landscape in the analysis area. This module is incomplete with respect to snags, downed logs, multi-layered canopies, wetland delineation, and unique habitat conditions. A separate analysis was completed for wetlands and unique habitats, and will be discussed under their respective sections. The REAP report includes only National Forest lands within the watershed while the HCM includes both National Forest lands and those under other ownerships. Discussions of habitat conditions are focused on the Middle Fork Snoqualmie River analysis area and center on habitat contributions to vertebrate populations at multiple-landscape scales. For many species, such as wolverine, grizzly bear, and other species with large home ranges, assessment of populations and habitat conditions at the watershed scale is inappropriate, as they might find only a portion of their life requisite needs within any given watershed. Assessing the contribution of a watershed must be done at the basin or even ecoprovince scale to determine the significance of connectivity of patches and subwatersheds, as well as the landscape's ability to allow for dispersal of individuals between and among populations distributed across the landscape.

Species Composition

Wildlife

There are approximately 290 terrestrial vertebrate species that are expected to occur or have been recorded within the analysis area (Appendix B). Conversion of state, private, and Federal lands to early seral conditions has fragmented and isolated habitat geographically, especially on the private lands west of the forest boundary where most logging has occurred. Increasingly, species dependent on low-elevation old growth on National Forest land, and including those dependent on snags, downed logs, riparian, and unique habitats on private land, are becoming isolated from other populations. Of the 290 species, 33 species are of heightened management concern (Table 3.7). See Appendix B for a complete description of habitat requirements of species of concern. In general, habitat requirements by species will not be discussed below. All suitable habitat acres displayed include the entire analysis area, consisting of National Forest lands and all other ownerships. Private and state-owned land data is based on the DNR's vegetation data which was developed using canopy cover. Overestimation of mature habitat on private and state-owned lands is likely due to this methodology of establishing seral stages.

Reliable estimates of historic or current wildlife populations are unavailable. Alterations in composition, population sizes and predator/prey relationships have changed over the years in response to habitat and increasing human presence. Consequently, past and current levels of terrestrial vertebrate populations are inferred from broad changes in habitat over time, and all historical and current sightings are included from all lands. Acreage estimates based on the HCM are displayed for both private and National Forest lands, except where specifically mentioned separately.

Table 3.7 Status, sighting and survey summary for threatened, endangered, sensitive and other species of concern in the Middle Fork Snoqualmie River drainage. Species occur in order of appearance in text.

Common Name	Status *	Year Sighted	Year Surveyed	Survey Results	Suitable Hab Avail
Threatened or Endangered:					
Bald Eagle	T	87, 90, 92-95	no surveys	8 unk. adults 2 unk. juveniles	no anadromous fisheries
Spotted Owl	T	1981-95	1981-1995	activity centers	hi quality & quantity
Marbled Murrelet	T	91,92,95	1991, 92, 95	2 occupied sites	hi quantity & quality
Peregrine Falcon	E	0	no surveys	0	potential cliff habitat
Grizzly Bear	T	0	no surveys	0	hi quantity & quality
Wolf	E	1993	no surveys	1 unk. individual	hi quantity & quality
Candidate or Sensitive:					
Cascades Frog	C2	86, 94-95	1994, 1995	19 sites, 11 repro.	shallow ponds
Tailed Frog	C2	88, 94-95	1994, 1995	10 tadpoles	fast clear streams
Larch Mtn Salamander	S, ROD	0	no surveys	0	some talus slopes
Common Loon	S	0	no surveys	0	no suit. sized lakes
Goshawk	C, C2	1995	no surveys	1 unk. adult	suit hab available
Olive-Sided Flycatcher	C2	0	no surveys	0	patches of suit hab
Wolverine	S, C2	1994	no surveys	1 unknown ind.	hi quality & quantity
Fisher	C2,ROD	0	no surveys	0	Some suitable habitat available
Lynx	S,C2,ROD	0	no surveys	0	limited suit hab avail
Townsends Big-earedBat	S,ROD,C2	0	no surveys	0	patches of suit hab
Fringed Myotis	C2, ROD	0	no surveys	0	patches of suit hab
Long-eared Myotis	C2, ROD	1995	no surveys	1 unk. individual	patches of suit hab
Long-legged Myotis	C2, ROD	0	no surveys	0	patches of suit hab
Yuma Myotis	C2	0	no surveys	0	patches of suit hab
Survey & Manage (ROD)					
Van Dyke's Salamander	ROD	0	no surveys	0	hi quality suit habitat
Hoary bat	ROD	1991	no surveys	1 unk. individual	patches of suit hab
Silver-haired Bat	ROD	0	no surveys	0	patches of suit hab
Great Gray Owl	C,M,ROD	0	no surveys	0	no large meadows
Management Indicator or Concern Sp. (MIS or C)					
Pileated Woodpecker	C, M	85,87,90-91, 93	no surveys	7 unk. individuals	hi quality & quantity
Harlequin Duck	C	1986	no surveys	3 adult females	hi quality str.& rivers
Vaux's Swift	C	83, 86, 94	no surveys	17 unk. individuals	suit. hab available
Marten	C, M	1978, 1986	no surveys	3 unk. individuals	patches of suit hab
Elk	C, M	all years	no surveys	several small groups	winter and spring range, small herd
Mountain Goat	C, M	79-93	no surveys	many small groups on cliffs	several suitable cliff sites
Red-Legged Frog	C	1995	94-95	5 tadpoles, 4 egg masses	hi quality ponds, marshes & slow str.
Spotted Frog	C	0	94-95	0	hi quality mtn str.

* 1 - T = Federal Threatened Species
E = Federal Endangered Species
S = Forest Service Sensitive Species
C2 = Former Federal Candidate Species, now refered to as Federal Species of Concern
C = MBS Concern Species
M = MBS Management Indicator Species
ROD = Species with special mgt requirements specified in the ROD

Plants

The Middle Fork Watershed analysis area supports a wide array of flora. This reflects the diversity of habitats and plant communities present. A total of 249 vascular plants have been documented within the analysis area. Three species are at the edge of their range. Copper bush (*Cladothamnus pyrolaeflorus*) is found in the Middle Fork watershed. This species reaches its southern limit in the Washington Cascades (Hitchcock 1969). *Cassiope* stellariana, also found in the watershed, is near the southern edge of its range. Hitchcock reports that it has been found as far south as Mt. Rainier. *Ledum glandulosum* is considered an eastside species but occurs in several locations in the watershed near Preacher Mountain and Myrtle Lake.

Plant species of heightened management concern are discussed in the lists below. They are grouped by their status as Sensitive, "Survey and Manage," and Noxious Weeds. Data for rare plants are tracked in the Mt. Baker-Snoqualmie Rare Plants Database and the Washington Natural Heritage Program Biological Conservation Database.

Threatened and Endangered Species

Bald Eagle: There have been ten sightings of bald eagles recorded, with three of these occurring during the winter period and the others occurring during the breeding season. The Snoqualmie River basin is not an anadramous fishery, therefore it is expected that bald eagles would only winter in the analysis area. Although there are no documented nest sites in the analysis area, several sightings have occurred during the breeding season in suitable habitat. It is possible that eagles could nest in the analysis area as there may be enough prey in the form of resident trout and waterfowl. Heavy snow has limited access for winter surveys and none have been completed to date. Disturbance is relatively low in this analysis area and approximately 4898 acres of nesting and 4872 roosting acres are available for use. There are enough pockets of old trees in places along the Middle Fork mainstem and other rivers, as well as many lakes in the wilderness, to provide suitable habitat. Generally these lakes are very high in elevation and may not be free of ice during the early spring nesting period. However, two of the sightings occurred during the breeding season on these high elevation lakes. Several small lakes exist on private land, but all potentially suitable nesting trees have likely been removed, as logging has occurred recently in this area.

Spotted Owl: There are eight known spotted owl activity centers with their site centers within the analysis area, all on National Forest land. One additional owl pair has been documented by WDFW on private land near the Granite Lakes/Granite Creek area. Suitable owl habitat within the analysis area includes approximately 7584 acres of nesting/roosting habitat, 11,148 acres of foraging habitat and 14,816 acres of dispersal habitat. Surveys that meet protocol have been conducted in the analysis area from 1981 to 1995. Four of the activity centers are considered to have reproductive pairs. Critical Habitat Unit (CHU) #WA-32 covers the western portion of this analysis area and encompasses 29,480 acres, of which 28,998 acres are on National Forest lands. The CHU is comprised of approximately 5541 acres of nesting and roosting habitat (old growth), 3920 acres of foraging habitat (mature) and

5386 acres of dispersal habitat (closed immature). Historically, nesting habitat was more available than currently as most low elevation old growth has been logged, with only 61 acres of old growth left on private lands. Most existing suitable habitat is located at the upper reaches of the mainstem Middle Fork Snoqualmie River, which is where most of the spotted owl nesting sites are located. Table 3.8 below summarizes the amount of suitable habitat available in each activity center within 1.8 miles of the center of the territory. In some cases, the 1.8 mile distance goes outside the boundary of the analysis area, and may include private land.

Table 3.8 Acres of suitable habitat within 1.8 miles of each spotted owl activity center.

Name of Activity Center	acres of suitable hab	acres of dispersal hab
Taylor	841	498
Rainy	1747	638
Dingford	1158	436
Dingford/Snoqualmie	2024	1442
Kulla	1144	139
Garfield	1048	1060
Pratt	1585	1432
Hardscrabble	733	1

None of these owl territories meet the required number of acres of suitable habitat needed, 2638 acres, to allow for further reduction of suitable habitat without going below "take" guidelines. An area designated as "Mature and Old Growth Forest," as part of the matrix area, has been retained in the Quartz Creek area for species such as the spotted owl. One owl territory exists within this patch of old growth. LSR #122, as well as all LSOG allocations, will also assist in providing long term owl habitat and several of the spotted owl activity centers lie within this LSR.

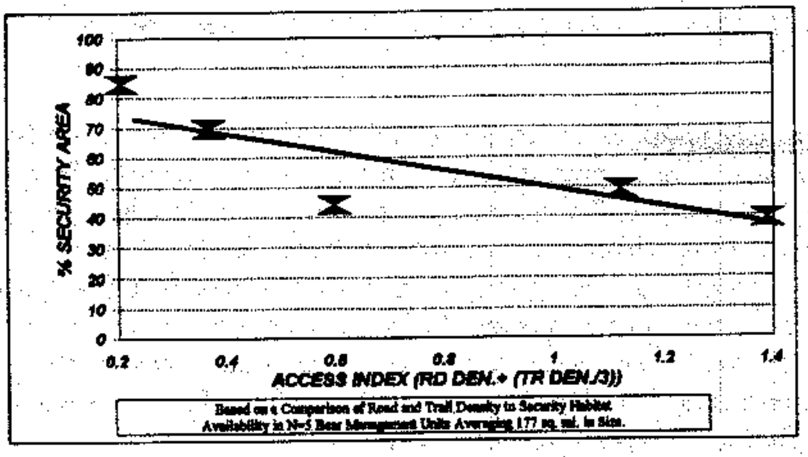
Marbled Murrelet: The upper reaches of the Middle Fork Snoqualmie River analysis area have some of the best marbled murrelet habitat on the North Bend Ranger District. Removal of low elevation old growth in the lower and middle reaches has reduced the available amount of habitat substantially since the advent of European settlement. Presently, there are two known occupied sites in the analysis area with more sites possible in portions of the analysis area that have not been surveyed but have suitable habitat available. In addition, enough large blocks of suitable habitat exist to provide for colonial nesting and it is suspected that this may be occurring. There are approximately 1452 acres of suitable habitat located primarily in the upper reaches of the mainstem Middle Fork Snoqualmie River, Taylor River, Quartz Creek and Pratt River, with 3722 acres of recruitment habitat scattered throughout mostly the private land. LSR #122 encompasses most of the analysis area, making this area also critical habitat for the marbled murrelet, and consists of approximately 25,830 acres of LSR, approximately 1605 acres of which are nesting and 562 acres are recruitment habitat. The western two-thirds of the analysis area lies 30-40 miles from Puget Sound (zone 1), while the remaining eastern third of the analysis area is 40-50 miles from Puget Sound (zone 2), which are designated in the Forest Plan as the primary location for potential nesting habitat for marbled murrelet. The LSR lies within zone 1. Notably, some of the best marbled murrelet habitat, where an occupied site exists along the upper Middle Fork of the Snoqualmie River, is not in LSR, but rather in matrix classified as dispersed recreation. This site will become an "unmapped LSR" as per Forest Plan direction. The occupied site along Quartz Creek is within an LSOG.

Peregrine Falcon: There are several suitable cliff faces that could be considered suitable habitat for peregrines. No sightings have been recorded in the analysis area and no nests have been found. There are approximately 83 acres of potentially suitable nesting habitat and 1665 acres of foraging habitat are available in the analysis area. Most cliff sites that could be suitable for nesting are located in higher elevation areas where snow may still be persistent during the March nest-site selection period, limiting the available nesting sites.

Grizzly Bear: The analysis area is located within the Grizzly Bear Recovery Zone and within Bear Management Unit (BMU) #01. There have been no confirmed sightings of grizzlies in the analysis area, but there are several confirmed sightings, including a sow with cubs, just east of the analysis area within the Alpine Lakes Wilderness on the Cle Elum Ranger District. Portions of this analysis area as well as the surrounding Wilderness act as a refugia to repopulate areas that are currently suitable habitat but may not contain bears. The analysis area contains abundant spring and fall foraging habitat in the form of berry/shrub fields, elk winter range, and avalanche chutes throughout most of the analysis area. Road densities are relatively low, trail densities are moderate, and security habitat contains highly suitable habitat in moderate distribution for this portion of the BMU within the analysis area.

Open road density in the analysis area is .91 miles per square mile. National Forest land in the analysis area has an open road density of .3 mi./sq. mi., while privately owned land has an open road density of 3.35 mi./sq. mi. Trail density for all ownerships in the analysis is .40 miles per square mile, consisting of .49 mi./sq. mi. on National Forest land, and .02 mi./sq. mi. on privately owned land. There are 1.31 miles of open roads and trail per square mile, which provides a human accessibility index (HAI) of 1.04, including private land (Figure 3-11). The HAI on just National Forest lands is 0.47. This indicates that about 70% of the National Forest land within the analysis area is available for security habitat. Approximately 50% of the entire analysis area is available for security habitat. If only National Forest lands are considered, this amount of security habitat indicates that this BMU meets the desired amount necessary according to the Grizzly Bear Recovery Plan. There are 11,397 acres of spring foraging habitat, 3,482 acres on National Forest lands, and 26,872 acres of fall foraging, of which 26,703 are on National Forest lands. There are also three acres of high talus slopes available which bears could utilize for foraging for moths. There are 274 acres of this type in the entire Snoqualmie basin. The amount of denning habitat is unknown, although it is expected that the amount of denning habitat is high due to plentiful high elevation security habitat combined with abundant suitable habitat during the winter months. See Figure 4.3 for a display of BMU #01 and subsequent proposed management situation areas.

Figure 3.11 Relationship of Security Habitat and the Accessibility Index



Gray Wolf: There has been one Class 2 sighting of a gray wolf within the analysis area, with several recorded just outside the analysis area. Suitable habitat can be termed as areas with available prey and large blocks of security habitat, and they are relatively abundant in the analysis area. Open road density in the analysis area is .91 mi./sq. mi., and the trail density is .40 mi./sq. mi., for an existing combined open road and trail density of 1.31 miles per square mile, which is just above the threshold of 1.00, in which disturbance to rendezvous sites is a concern (Thiel 1985, Mech 1988). Because the HAI is 1.04, large expanses of potential denning habitat are available, primarily within the Wilderness. Deer and elk, the major prey of gray wolf, winter along the lower mainstem of the Middle Fork, Pratt and Taylor rivers, although the herd size is considered small compared with other elk herds. There are 6682 acres of potentially suitable denning and rendezvous habitat available in the analysis area, with 12,726 acres available within the entire basin.

Species of Concern (C2) and/or Sensitive Species

Cascades, and Tailed Frogs: Surveys for these species have revealed 19 sites of Cascades populations and 10 Tailed frog tadpoles in various locations. While Cascades frog uses primarily shallow ponds and slow moving streams within the adjacent timber stands, and Tailed frogs use clear fast moving streams, both habitat types are prevalent throughout the analysis area. There are potentially 39,120 acres of suitable habitat for Cascades frog and 18,718 acres of suitable habitat for Tailed frog. See discussion below on Amphibians.

Larch Mtn. Salamander: Old growth stands both with and without adjacent talus slopes, with high litter and soil content are abundant in this analysis area. The stands that meet this criteria have only been impacted by minor mining activities, if at all. No surveys have been completed, though, and there are potentially 43,900 acres of suitable habitat available in this analysis area for this species. Currently, there are no known records of this species in the analysis area. However, one Larch Mtn. Salamander was confirmed on the Cle Elum Ranger

District just five miles southeast of the analysis area in habitat very similar to habitat found in the analysis area. As abundant suitable habitat exists with little past impact, there appear to be few or no limiting factors, and the potential to find this species if surveys were performed is high.

Common Loon: No loons have been found in the analysis area on Forest Service land. However, there was a nesting pair of loons on private land on Lake Calligan from 1990-1993 just outside the analysis area. This pair nested successfully and fledged young. There are potentially 60 acres of suitable habitat on National Forest lands, according to the HCM, and an additional 4 acres on private land. The shorelines around lakes on private land have been logged and the small trees growing along the lake side are not considered suitable habitat. If suitable habitat did exist, disturbance during the nesting season by recreationalists, such as boaters and water-skiers, would be the primary cause of nest failure. There have been no formal surveys for loons on National Forest lands.

Goshawk: One incidental sighting of an adult has been recorded in the analysis area. No formal surveys have been conducted. Suitable nesting and foraging habitat exists throughout the basin in large blocks, totaling approximately 14,231 acres. Goshawks' home ranges are approximately 6000 acres in size with a core nest site area of 430 acres, as described in the draft Regional protocol (USDA Forest Service 1993). The amount of suitable habitat available could potentially support two to three territories within this analysis area. There is additional habitat north and south of the analysis area that also provides suitable habitat and could allow for adequate genetic interchange among territories. Not all of the acres within a home range need to be suitable habitat but there must be enough suitable habitat in the correct configuration and well connected to other blocks of habitat to support these territories.

Olive-Sided Flycatcher: See discussion on Vaux's Swift as these two species have very similar habitat needs. There are no known records of this species in the analysis area, and no surveys have been completed.

Wolverine: There are potentially 26,968 acres of denning habitat, and 23,777 acres of foraging habitat available in this analysis area. There is a recent sighting (1994) of this species in the analysis area, and abundant suitable habitat with sufficient security habitat available to allow for denning and dispersal exists, as well as sufficient refugia both within and adjacent to the analysis area. The wolverine conservation strategy indicates that this analysis area contains secondary habitat surrounded by primary habitat north and east. The HAI for this analysis area is 1.04, and the combined open road and trail density is 1.31mi./sq. mi. (.91 miles of open road per square mile and .40 miles of trail per square mile), indicating that road and trail densities are presently at the upper end of the threshold where existing levels are probably not affecting wolverine dispersal and denning, although any additions may. Low to moderate road and trail densities, abundant security habitat, and presence of high elevation wilderness areas lead to good habitat conditions. The dispersal model indicates that the majority of the analysis area contains high dispersal habitat with the remainder having moderate dispersal (Fig. 3.12). See discussion below under "Connectivity" for a more detailed description.

Fisher: Recent literature has found that the marten out-competes fisher in other states, and therefore martens could be mutually exclusive in their range. Three martens have been found in the analysis area. On the west side of the Cascades fishers are found primarily below 3000 feet in elevation, presumably because travel through the heavy wet snow is avoided (Aubrey personal communication). Unsuitable patches greater than 300 meters are considered barriers to movement (Heinemeyer and Jones 1994). The present open road density of 0.91 miles per square mile is below the recommended level of 1.00 miles per square mile. There are potentially 17,187 acres of suitable denning/foraging habitat available in this analysis area. Potentially suitable habitat is highly fragmented from past clearcutting, especially on private land west of the National Forest boundary. Combined with an average home range size of 6,000 acres, it is possible that two to three pairs of fisher could be supported in this analysis area, although additional suitable habitat exists north and south of the analysis area to allow for possible dispersal of individuals. It is also possible that this analysis area does not provide adequate habitat for any fishers as very little low elevation old growth and mature habitat exist. Where this habitat does exist, at the lower elevations, it is primarily connected through stands in the closed immature stage on private land.

There are 31,638 acres of suitable habitat for fisher within the entire Snoqualmie River basin, which indicates that five to six fisher pairs could potentially use the basin and assumes that fisher will move through these younger stands in order to utilize small patches of old growth and mature forest at slightly higher elevation upslope. These areas have deeper snow depths and may limit the ability of fisher to utilize the area. One historical sighting exists along the mainstem Middle Fork just outside North Bend. No historical or recent sightings exist in the analysis area. Adequate dispersal corridors need to be provided to ensure movement through this basin to other basins (Figure 3.13). The dispersal model indicates the majority of the analysis area provides moderate to high dispersal even through the heavily logged private land, where enough patches of 80-year-old stands exist to offer connections. See discussion below under "Connectivity" for a more detailed description.

Lynx: Habitat for lynx is associated with dense boreal forest, as found in the mountain hemlock zone and parkland types. There are approximately 26,964 acres of suitable denning and 25,131 acres of foraging habitat available in this habitat type in this analysis area. Although there is an historical sighting, and the lynx conservation strategy recommends that this basin is managed as secondary habitat, they are primarily an eastside species and have been found only in the northern part of the North Cascades recently (Ruggiero et al. 1994). The acres of potentially suitable habitat should be maintained in a condition that would allow dispersal of lynx through the analysis area.

Townsend's Big-Eared Bat: No surveys have been conducted in the analysis area and there have not been any incidental sightings of this species. However, several of the old abandoned mine tunnels and some natural caves found in this analysis area could offer suitable roosting and breeding habitat. Surveys conducted on other parts of the Forest found only male and one juvenile hibernacula (Perkins 1989). There are approximately 87 acres of potentially suitable hibernating habitat, 18,633 acres of potential breeding habitat, and 14,318 acres of potential feeding habitat in this analysis area for this species. Refer to the discussion under "Unique Habitats" for a complete description of available habitat.

Fringed Myotis, Long-Eared Myotis, Long-Legged Myotis, Yuma Myotis: These species utilize caves, abandoned mines and buildings extensively, of which the former two are found within this analysis area. Fringed myotis is not found in the North Cascades and is not a concern in this basin. Although there are no incidental sightings, bats usually cannot be identified unless specific surveys and protocol are conducted. Further discussion of these species will occur under the Survey and Manage Species section below, since habitat needs are the same as for those species. There are potentially 2,377 acres of roosting and 35,288 acres of foraging for the long-eared myotis; 2,736 acres of roosting and 14,082 acres of foraging for the Yuma myotis; and 2,493 acres of roosting and 20,191 acres of foraging habitat for the long-legged myotis.

Boreal bedstraw (*Galium kamtschaticum*): This vascular plant has been documented from three locations within the watershed analysis area. This species is typically found in wet areas with seeps or standing water in the Silver Fir Zone and the Mountain Hemlock Zone.

Alaska harebell (*Campanula lasiocarpa*): This vascular plant has been documented in one location within the watershed analysis area. This species is typically found in rock crevices in alpine zones.

Fringed pinesap (*Pleuricospora fimbriolata*): This non-photosynthesizing mycotrophic vascular plant has been documented in one location within the watershed analysis area. This species is typically found in dense conifer forests with closed canopies (generally greater than 80%) and may be associated through fungal mycorrhizae with Douglas-fir (Gamon 1983). The Middle Fork population was found in the Silver Fir Zone in association with Douglas-fir, western redcedar and western hemlock. This species has been recommended for delisting from the Washington Natural Heritage Program sensitive plant list because of the high number of sightings in the state.

Survey & Manage Species

Van Dyke's Salamander: This species is found in moist and seeping areas along talus, cliffs, rocks, and streams. No surveys have been conducted, and no incidental sightings exist. There are potentially 21,725 acres of suitable habitat available for this species in this analysis area. See additional discussion on "Amphibians" below.

Hoary bat, Pallid Bat, Silver-Haired Bat: Suitable roost sites and hibernacula fall within a narrow range of temperature and moisture conditions for bats. Sites commonly used are caves, mines, snags, decadent trees, wooden bridges, and old buildings. This analysis area offers primarily snags and mines as opportunities. See discussion under "Unique Habitats" and "Downed Logs and Snags" for further information. Potentially, there are 43,817 acres of breeding habitat and 5550 acres of foraging habitat for the Hoary bat. There are 19,708 acres of breeding habitat and 25,290 acres of foraging habitat available for the silver-haired bat. It is unlikely pallid bat would occur within this analysis area as they are typically found east of the crest.

Vascular Plants: The survey and manage standards and guidelines list 17 vascular plants to be protected on federal lands. Three of the 17 vascular plants are documented for the Middle Fork watershed: candy stick (*Allotropa virgata*), round-leafed rein-orchid (*Platanthera orbiculata*, also known as *Habenaria orbiculata*) and Boreal bedstraw (*Galium kamtschaticum*).

Fungi, Lichens, and Bryophytes: The survey and manage standards and guidelines also list 235 species of fungi, 81 species of lichens, and 28 species of bryophytes to be protected on federal lands. A discussion of the species' natural history, range, and rationale for inclusion is found in Appendix J2 of the ROD. Two of the 81 lichen species are known to occur in the analysis area: *Pseudocyphellaria rainierensis* and *Hypogymnia duplicata*. *Pseudocyphellaria rainierensis* is considered one of the rarer lichens in this area. It occupies a fairly narrow elevation band in climatically wet areas in moist Pacific silver fir forests that are quite old. The population in the analysis area is sparsely scattered, occurring on just a few trees within the stand in old growth mesic Pacific silver fir over 500 years old, at about 2700' elevation. *Hypogymnia duplicata* is not as rare as *Pseudocyphellaria rainierensis*. The population in the analysis area occurs sporadically on mountain hemlock in an elevation band from approximately 3000'-3800' in moist mountain hemlock/Alaska huckleberry and moist Pacific silver fir/Alaska huckleberry Plant Association Groups. Habitat for *Lobaria linita* is found within the analysis area but has not been documented. It occurs in old forests that are cool, mesic to moist and usually at the base of Pacific silver fir boles. At this time we do not have sufficient information to determine which of the other species is known or suspected in the watershed. Their status will need to be evaluated in the future (Lesher 1995).

Management Indicator Species or Concern Species

Pileated Woodpecker and Vaux's Swift: No surveys for either of these species have occurred, although 7 pileated woodpeckers and 17 Vaux's swift incidental sightings have been recorded. There is an area designated for Mature and Old Growth Dependent Species within matrix that is surrounded by LSOG on the northwest side and matrix, Scenic Forest elsewhere. Since these old growth patches are surrounded by matrix, they may be valuable areas for retention in this category. Due to the high amounts of existing mature and old growth in this analysis area dispersed across the landscape such that cavity-nesting species could utilize them, it appears that adequate snags exist fairly well distributed across the analysis area, with the exception of the valley bottoms. No snags were retained in any harvest units along the valley bottoms, therefore opportunities for snags in openings will be limited to those found in naturally occurring stands. There are potentially 44,389 acres of nesting and foraging habitat for pileated woodpecker and 18,087 acres of roosting with 17,671 acres of foraging habitat available for the Vaux's swift. We do not know if adequate snags of appropriate sizes are available since there is no snag inventory.

Harlequin Duck: Three incidental sightings of Harlequins have been reported, although no formal surveys have been done. Suitable nesting habitat is available along all the major rivers, although very little old growth exists along the rivers to provide nesting habitat in the lower reaches where logging occurred in the 30's or 40's. Potentially, there are 20,183 acres of suitable nesting/foraging habitat available. There are large blocks of deciduous forest alongside the major rivers that could provide suitable nesting habitat where concurrently little recreation use exists.

Marten: Recent literature has found that this species out-competes fisher in other states, and therefore they could be mutually exclusive in their range (Aubrey personal communication). Three martens have been found in the analysis area. One designation in the Forest Plan has retained old growth habitat for dependent species such as marten and spotted owl. This designation is in an important old growth area predominantly surrounded by thinned stands with the potential for future thinnings. There are approximately 38,643 acres of potentially suitable breeding habitat and 6,139 acres of potentially suitable foraging habitat for the marten in this watershed. Assuming 2000 to 4000-acre territories, dispersal corridors to connect them, and locations of observations, there are potentially 12 to 13 territories available for marten in this analysis area. Since there is abundant suitable habitat spread evenly throughout the analysis area, it is likely that the analysis area can sustain a viable marten population.

Elk: This analysis area contains a small elk herd which utilizes the entire analysis area. Elk winter down along the mainstem Middle Fork Snoqualmie River mostly on private land. Summering and calving occur in the Pratt, Taylor, and Quartz Creek drainages with some elk moving to the higher elevations in the Wilderness. There have been relatively few sightings of elk in the Wilderness indicating that the rugged terrain may not be suitable for calving and summer range, which may occur on the lower slopes instead. Land allocated in the Forest Plan for elk and deer winter range is located along the mainstem Middle Fork Snoqualmie River both on the Weyerhaeuser land and National Forest lands. The open road density of 0.91 miles per square mile is lower than the recommended 1 mile per square mile for key summer foraging, calving, and winter range (Fig. 3.14).

Mountain Goat: There are several large cliff groups in the analysis area that provide small clusters of habitat, and several sightings of mountain goat exist in these areas. All of these have adequate old growth for winter range adjacent to them. There is an area identified in the Forest Plan as "mountain goat habitat," alongside Garfield Mountain where suitable winter habitat exists. It appears a healthy population of mountain goats exists in the analysis area as suitable cliff habitat, with old growth along the lower slopes of the cliffs, is available and well-connected across the landscape.

Spotted Frog: The presence of this species has not been confirmed during amphibian surveys in this analysis area. High elevation slow-moving streams and shallow ponds are their preferred habitat. Many such habitats exist in the analysis area and are found primarily in the Wilderness, where no surveys have been conducted to date. Spotted frogs are extremely rare, and difficult to identify, and no verified records exist in the Cascades since 1947.

Approximately 4122 acres of potential breeding habitat and 308 acres of foraging habitat has been identified in this analysis area. See additional discussion on "Amphibians" below.

Red-Legged Frog: Five tadpoles and four egg masses were identified during surveys. As this species uses primarily low-elevation (0-2500 feet) wetlands and streams, it is expected this species will be locally abundant. There are approximately 1,118 acres of potentially suitable habitat for this species in this analysis area. See additional discussion on "Amphibians" below.

Noxious Weeds: Many exotic species are known to be invasive and reduce natural floristic diversity by displacing native plants. The most extreme examples of invasive problematic species are those legally classified by the state of Washington as "noxious weeds." Under Washington State Weed Law RCW 17.10.080, noxious weeds are species that are highly destructive, competitive, and difficult to control by cultural or chemical practice. These populations are increasing along travel corridors and are becoming a threat to native plant diversity.

Noxious weeds are typically found in disturbed areas such as roadsides, gravel pits, and clearcuts. Once these species are established in disturbed sites, they often spread into the surrounding areas such as burns and frequently flooded areas, and the natural succession process is put out of balance. The early seral species can be out-competed by noxious weeds and the site can eventually become a monoculture.

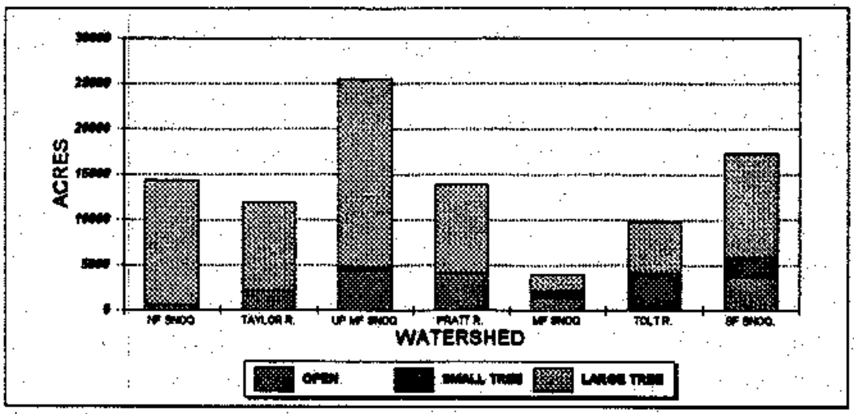
The analysis area has not been surveyed for noxious weeds at this time, so little information is available. The following noxious weeds have been documented in the watershed: field bindweed (*Convolvulus arvensis*), Canada thistle (*Cirsium arvense*), and oxeye daisy (*Chrysanthemum leucanthemum*).

Wildlife Species and Habitat Diversity

Habitat Availability

On private lands, timber harvest conducted on a relatively high frequency and on a large scale has resulted in a landscape dominated by open and small conifer structure classes west of the Forest boundary. Historically, a greater percentage of this area had been in a large conifer structural class. Habitat within the Forest boundary is dominated by a landscape matrix of immature forest stands interspersed with large patches of mature and old growth habitat, which make up the large tree class as displayed in Figure 3.15.

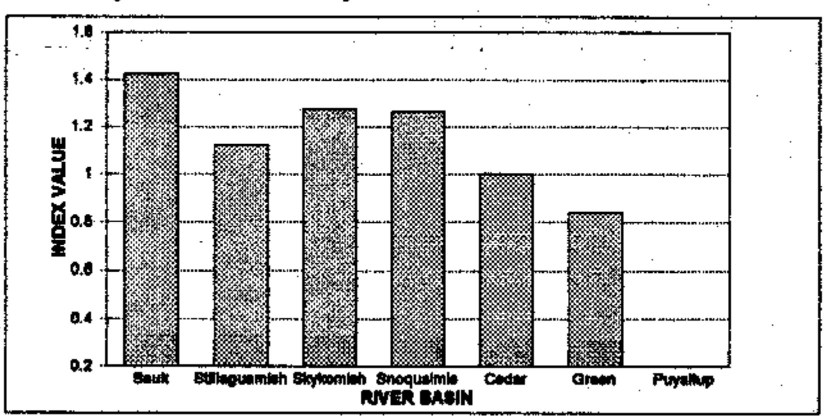
Figure 3.15 Comparison of Watersheds within the Snoqualmie River Basin by Current Forest Structural Class



Biotic Diversity

Indices are used to compare basins for relative diversity. As can be seen in Figure 3.16, the Snoqualmie River basin has a rating of approximately 1.25 which is higher in diversity than all other basins on the Forest with the possible exception of the Sauk and Skykomish basins. Harvest activities in the watershed, particularly those in the early part of this century when the lower elevations were logged, are much less likely to leave diverse connectivity habitat. This leaves small patches of isolated habitat which are often unable to support species dependent on this habitat, particularly those with large home range requirements. Lack of connectivity habitat leads to a failure to disperse and can separate potential breeding pairs, leading to population reductions and local extirpations. All of these factors contribute to a decline in biotic diversity. Since this basin is relatively high in biodiversity, indications are that connectivity is relatively intact, stands are not isolated and dispersal throughout the landscape is relatively high. Three areas of high biodiversity are apparent based on field information. The "old growth" stand of big-leaf maple in section 30 of T24N, R10E; the large hardwood deciduous/wetland complex in section 22 of T24N, R10E; and the large stand of old growth at Goldmeyer Hot Springs which has a good sighting database available due to the year-round naturalists that reside there.

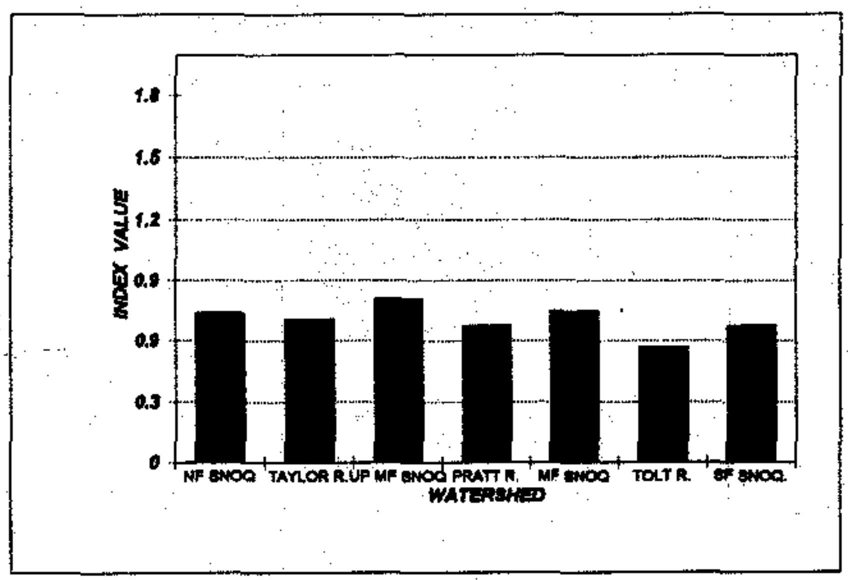
Figure 3.16 Diversity Index Values by River Basin



Habitat types vary in their potential to support species, with some types being able to support more species than others. Habitat types which can support the greatest number of species include wetlands, riparian areas, and old growth stands (Fig. 3.17). Approximately 4061 acres of wetlands are known to exist in the Middle Fork Snoqualmie River analysis area that include wet meadows, shrubby wetlands which are often avalanche chutes, and hardwood wetlands. Most of the known wetlands are shrubby wetlands located within higher elevations usually within the Wilderness. There are 15,869 acres of old growth forest in this analysis area, approximately 15% of the landscape, and this occurs mostly in large well-connected patches, more likely to support a large variety of species. Approximately half of the old growth forest in the analysis area occurs in the riparian reserves.

In the HCM, each habitat type was assigned a biotic richness class based on the number of vertebrate species using that habitat, and a biotic diversity class based on the number of species of concern using that habitat type. The number of acres in the watershed that fall into each species richness and biotic diversity class can be seen in Appendix B. In the Middle Fork Snoqualmie River, 40% of the watershed has a concern species index of 6, meaning it can support 26-30 species; approximately 25% of the watershed has a concern species index of 7, the highest index, meaning it can support 31+ species. This indicates that 65% of the analysis area has a very high diversity rating. The overall index for the watershed is 5.16, which is relatively high and suggests that this watershed provides important habitat for species of concern (Fig. 3.18). When all species are considered, in the richness index, the overall index is 4.25 with most of the analysis area (72%) rating as a 5 or higher, suggesting that this analysis area provides diverse habitat for all species expected to occur there. Diversity indices are displayed between all watersheds in the Snoqualmie basin (Fig. 3.18), indicating that all watersheds in the analysis area have a relatively high diversity rating.

Figure 3.18 Habitat Diversity Index Values by Watershed

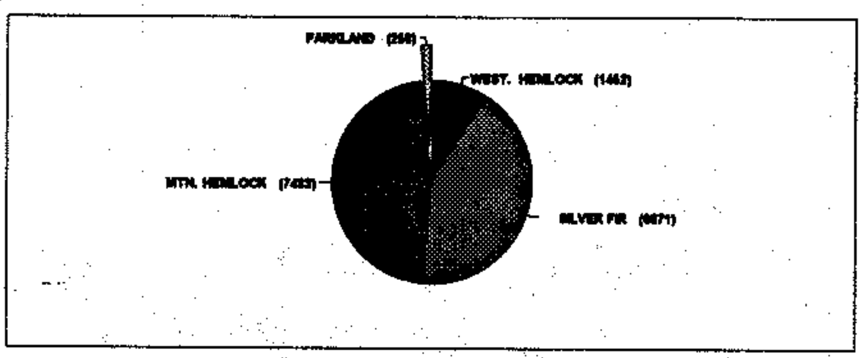


The 290 wildlife species potentially occurring in the analysis area have been grouped into 53 guilds to aid in analysis. Guilds are species grouped together based on similarities in habitat use and anticipated response to changes in landscape conditions. On this Forest, guilds were based on how species use the landscape (patch, mosaic, general, contrast, unique); the primary habitats which are used (forest, non-forest, early seral, mid seral, late seral, etc.); home range requirements (small is less than 60 acres, medium is 60 to 1000 acres, large is greater than 1000 acres); and dispersal capabilities (high--migratory or capable of dispersing across landscapes; moderate--capable of dispersing at the landscape scale; low--disperses only within a patch or between adjacent patches). These terms are further defined in the unpublished document "Wildlife Species - Habitat Relationships Summary, Mount Baker-Snoqualmie National Forest," 1994. These guilds are grouped into two broad categories: terrestrial guilds and riparian guilds. Terrestrial guilds are those containing species which utilize both riparian and upland habitat and they are discussed in this section. Riparian guilds are those which utilize habitat in riparian zones only.

Old-Growth and Late Successional Dependent Species

Comparatively, old growth habitat is less available today than in the past (Figure 3.19). Eby and Snyder (1990) investigated past and current rates of low elevation loss in the Puget Sound basin, and found that less than 10% remained in 1988. As Figure 3.19 shows, the amount of old growth in all vegetation zones, except western hemlock, is comparable to the highest levels of old growth available in these vegetation zones in the past. The amount of old growth available in the western hemlock zone is the lowest it has been since Euroamerican settlement due to the logging of all accessible low elevation old growth in the 30's and 40's. This would coincide with a pattern displayed in all watersheds across the forest. This pattern of logging affects low mobility old growth species predominantly, as shown in the lack of dispersal capabilities in the dispersal model for these species (Fig. 3.20).

Figure 3.19 Acres of Old Growth Habitat by Potential Vegetation Zone



There are presently three large blocks of core old growth and many smaller blocks of core old growth well-distributed across the analysis area and connecting the larger blocks. One of the three large blocks is located in the LSR, with many smaller blocks dispersed around the large block. Although there is an LSR, LSOG and a "Mature and Old Growth" block, and wilderness areas which encompass one of the other old growth blocks, one large block near Goldmeyer Hot Springs is located in matrix, and is scheduled for dispersed recreation emphasis. This particular block has a potential colonial nesting site for murrelets, a spotted owl territory, and is excellent habitat for a variety of other concern species such as the wolverine.

There are eight terrestrial guilds requiring mid, late-successional, or old-growth habitat containing a total of 38 species potentially found in the Middle Fork Snoqualmie River analysis area. Species that use mid seral structure stands also use late successional stands and are therefore lumped for purposes of discussion. The habitat potentially available for these guilds in the watershed can be seen in Appendix B (TVHC). Six species are considered dependent upon late seral habitat and have large home ranges. These are boreal owl (unlikely to occur in the watershed, may occur during winter), white-winged crossbill, marten, fisher, sharp-shinned hawk, and marbled murrelet. These guilds also include five neotropical migrant bird species with declining populations and three guilds contain species of concern, including those previously mentioned as well as the northern spotted owl, northern goshawk, pileated woodpecker, barred owl, and wolverine.

There are approximately 46,696 acres of old growth and mature habitat which make up "Late-Successional Habitat," 43% of the analysis area. This includes private land which has a moderate amount, albeit at the younger end of the mature stage. Fire has played a less dominant role in the distribution of late-successional habitat compared to basins south of the Snoqualmie. Rather, logging that occurred during the 30's and 40's plays the dominant role in the current distribution of late-successional habitat along the lower elevational portions of the valleys. Late successional habitat was at its most abundant level at the turn of the century before harvest began.

Downed Wood and Snag Dependent Species

Habitat components such as snags and down woody material are required for many species. There are 53 vertebrate species on the Forest which use snags and down wood as primary habitat for breeding, feeding, and/or resting, and six terrestrial guilds containing a total of 18 species require snags as an integral part of their habitat. One of the distinguishing characteristics of old growth and mature forest, however, is a large number of both snags and downed logs. An assumption can be made that those portions of the watershed containing these forest types probably have sufficient amount of this habitat. This would mean at least 43% of the analysis area contains adequate levels as required by the Forest Plan. Most of the early seral habitat in the watershed is the result of regeneration following clear cutting, primarily on private land, and these areas are usually devoid of snags (13,965 acres or 13%). Second-growth forests which were not burned are found to have a significant amount of down woody material due to the cull material which was left behind at the time of harvest. These stands do not, however, have the quantity of standing snags, or the potential to recruit down wood and snags, that older forests have. A small portion of this analysis area is in the mid seral stage, much of which is the result of logging in the 30's and 40's (17,632 acres or 16%).

One guild in this group requires snags in conjunction with early seral habitat. This habitat type is not likely to exist, as explained earlier, since no snags were retained during logging. Of the remaining guilds, three contain generalist species which prefer mid to late seral structure habitat but will use the earlier stages if snags are available. The last guild contains contrast species which use edge habitat where snags are present. This guild has probably benefited from past clearcutting practices, which creates edge habitat. Natural processes often create snags along these edges as trees that have grown up in a stand are exposed to wind and often break or blow over.

Unique Features

There are several unique habitat types which are used by wildlife. These include buildings, bridges, caves, cliffs, dry meadow, and talus. All but buildings and dry meadow occur in the analysis area. There are four terrestrial guilds which are dependent upon unique habitat types, specifically buildings, cliff and talus, cliff and talus associated with early seral structure vegetation, and cliff and talus associated with late seral structure vegetation. Other species also utilize these and the remaining unique habitat types to differing extents.

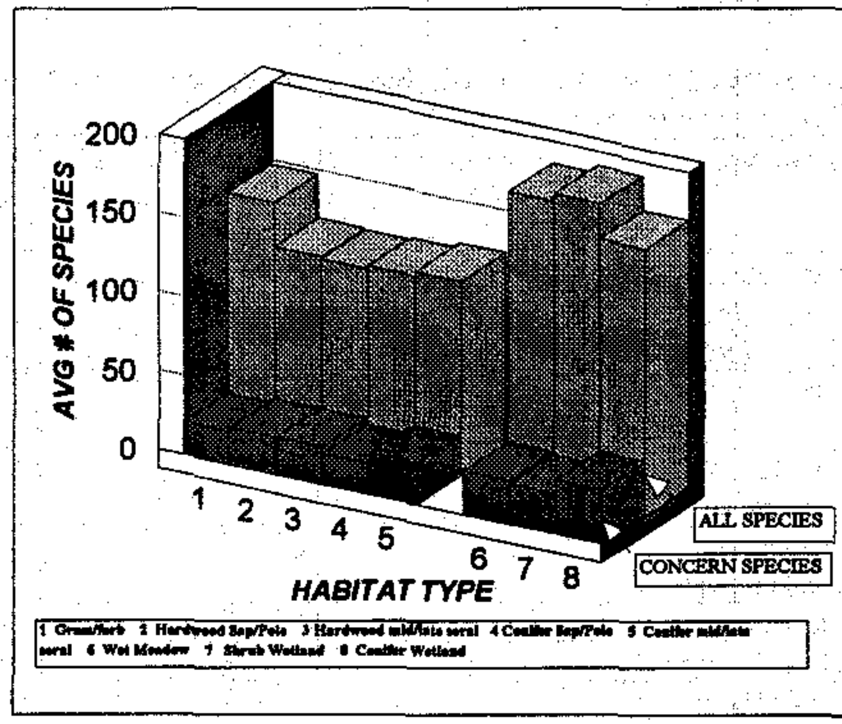
According to the HCM, this watershed contains approximately 87 acres of cliff and talus, although additional unmapped acres probably exist. The sparsely vegetated habitat type includes predominantly wilderness area dominated by rock and alpine vegetation. This type may also contribute habitat, especially for the mountain goat. Among the other species in guilds dependent upon these habitat types are Peregrine falcon, mountain goat, Larch Mountain salamander, and Townsend's big-eared bat. Not much disturbance has occurred for species needing this guild, with the exception of some scattered mining activities.

Riparian Dependent Species

There are 19 guilds dependent upon riparian habitat, containing a total of 84 species. Within the riparian guilds, there are those species requiring early or mid/late seral structure habitat, generalist guilds, contrast guilds, and guilds dependent upon unique habitats. Diversity within riparian areas tends to naturally be high as so many species are dependent on the biotic diversity that exists within these areas, as can be seen in Fig. 3.21.

The availability of snags in the riparian reserves is not known; however, approximately 36% of the area within the riparian reserves is in the late seral structure stage and so can be assumed to contain some snags. This is a fairly large portion of the riparian reserves that are intact, compared to other basins. Riparian reserves in this analysis area can function as dispersal corridors for small and large animals adequately, due to the relatively high proportion of riparian reserves that are in a closed structure class. Approximately 14% of the riparian reserves are in an early seral stage without snags which is a small proportion of the analysis

Figure 3.21 Vertebrate Diversity in Riparian Habitats



area and suggests that lack of snags may be a limiting factor for some species in riparian guilds, although not to a great degree. Most of the riparian species are sensitive to low levels of human activity and moderately sensitive to high levels of human activity, where human activity is defined as presence only and does not connote habitat changes.

Amphibians

Amphibian species have drawn more attention recently due to population declines throughout the world (Wake 1991, Blaustein and Wake 1990, Blaustein et al. 1994, Blaustein and Wake 1995). Some declines may be due to environmental degradation; however, populations have also declined in relatively pristine, undisturbed environments. Ultraviolet radiation, which can damage DNA, has recently been shown to account for losses of fertilized eggs in the Cascades frog, northwestern salamander, and western toad in Oregon (Fellers and Drost 1993). All of these species occur in the analysis area. Some of the species potentially impacted by timber harvesting, road building, and increases in UV radiation, may also be impacted by the introduction of fish into historically fishless lakes. The stocking of high mountain lakes, a common practice in the analysis area since the 1930's, has been a source of concern throughout the west (Bahls 1992). A study in the North Cascades National Park found that the stocking of lakes results in a loss of zooplankton communities and a decline in long-toed salamander populations in lakes with high density fish populations (Liss and Larson 1991). In addition to changes to zooplankton communities, amphibians are at risk from a fungus known to affect hatchery-reared fish. Increasing numbers of amphibians have been sickened by this fungus in Oregon (Blaustein et al. 1994). It is unknown whether these issues have affected this analysis area, and further study is recommended. Table 3.9 summarizes the risks to local amphibian populations.

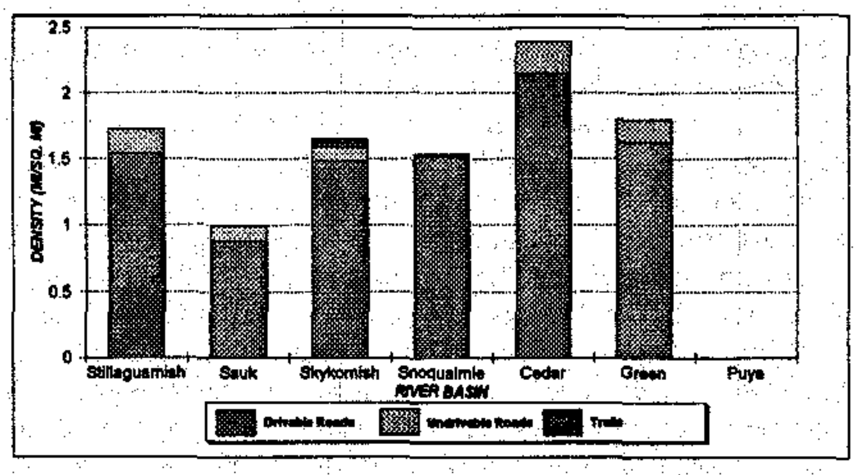
Table 3.9 Summary of Risks to Local Amphibian Populations in the Middle Fork Snoqualmie River Analysis Area

Amphibian	Increased UV Radiation	Fish Stocking Lakes	Loss of Old growth	Loss of Talus/Forest Habitat
Pacific giant salamander (*Dicamptodon tenebrosus*)			X	
Tailed frog (*Ascaphus truei)*			X	
Rough-skinned newt (*Taricha granulosa)*		X	X	
Northwestern salamander (*Ambystoma gracilis)*	X	X	X	
Long-toed salamander (*Ambystoma macrodactylum)*	X	X		
Cascades frog (*Rana cascadae)*	X	X	X	
Western toad (*Bufo boreas)*	X	X		
Pacific tree frog (*Pseudacris regilla)*				
Larch Mountain salamander (*Plethodon larselli)*			X	X

Effects of Recreation, Road and Trail Use on Wildlife

Most species occupying the Forest show some level of sensitivity to human presence. Disturbance from human presence can lead to abandonment of nesting or denning sites, prevention of access to prime foraging areas, or removal of a species from the area, and additionally fragments the area (Christy and West 1993). Examining the road and trail information for a watershed provides indications as to the level of impacts human activities are having in that watershed. Currently there are 161 miles of open road in the Middle Fork Snoqualmie River analysis area (Tables 3.26 and 3.27) and 91.9 miles of trails (Table 3.29). The open road density in the analysis area is 0.91 miles per square mile of land. Open road density on National Forest land is .3 mi./sq. mi., and the open road density on privately owned land in the analysis area is 3.35 mi./sq. mi. Most of these roads are reported as moderate use, meaning they receive some traffic by both the public and Forest Service administration. Use on roads in this analysis area consists of almost entirely recreating public with some Forest Service administration. The trail density of .49 mi./sq. mi. on National Forest land in the analysis area, and .02 mi./sq. mi. on privately owned land, for a combined open road/trail density of .40 miles of trail per square mile, is higher than some watersheds, because of the high backcountry use of the Alpine Lakes Wilderness. Compared with other basins on this forest, however, the Snoqualmie basin has the second lowest combined road/trail density (Fig. 3.22).

Figure 3.22 Road and Trail Densities (All Owners) by River Basin



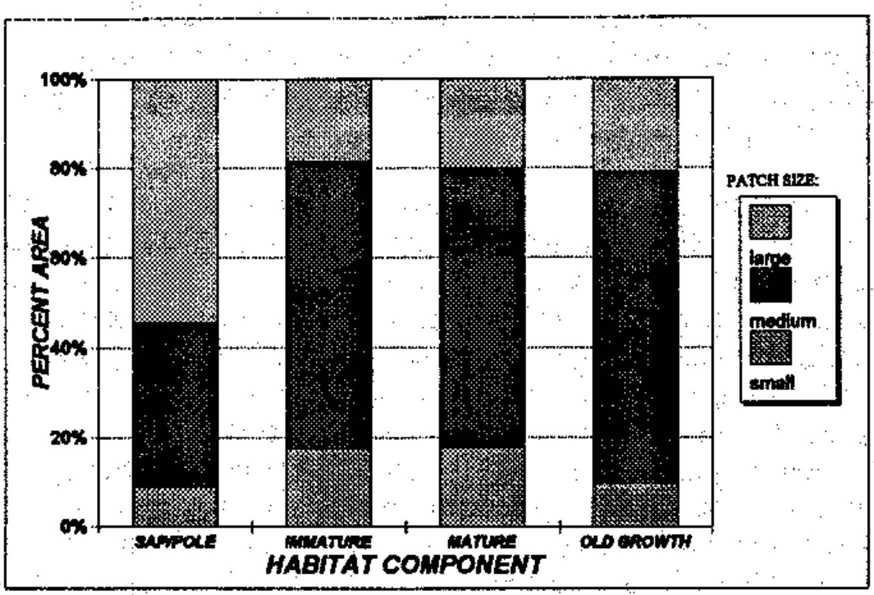
There are 48 species which are moderately or highly sensitive to both low and high levels of human activity. Since most roads are closed in winter and other roads receive low amounts of use, disturbance is low for the 10 species in this group that are winter residents only. Snowmobile use does not occur in this analysis area. Among the 38 summer residents that can expect high levels of disturbance in preferred habitat are bald eagle, marten, fisher, wolverine, wolf, elk, all species of bats, several waterfowl species, and raptors, as well as others, due to high amounts of dispersed recreation use.

The level of human disturbance directly influences the quality and quantity of habitat available to some terrestrial vertebrates. The grizzly bear, wolverine, fisher, marten, and gray wolf are examples of species with large home ranges which require large contiguous areas away from human disturbances. In order to determine how much security habitat is available for these species and where it is located in the watershed, human influence buffers were placed within 0.3 mile on all roads and trails. In the analysis area, security habitat is moderate, as can be seen in Figure 3.23. Relatively large areas of security habitat potentially occur in all areas east of the Forest boundary and above 1500 feet. Due to the low road density in this watershed and the availability of large blocks of security habitat, this analysis area is likely to provide habitat for species with large home ranges which are sensitive to human disturbance. The recommended maximum road density for most of these species is one mile of open road per square mile of land (Ruggerio et al. 1994, Heinemeyer and Jones 1994, Thiel 1985, U. S. Fish and Wildlife Service 1994). The current level in this analysis area is just below this level. With the current high dispersed recreation emphasis in the analysis area and the probable continuation of recreation as the emphasis in this analysis area it is unlikely that road and trail densities will decline over time.

Fragmentation, Connectivity and Dispersal

Fragmented forest (small patches of forest interspersed with young or non-forest patches) offers less effective habitat to forest dependent species than unfragmented forest. Fragmentation of habitat into smaller patch sizes can influence species composition and population demographics either positively or negatively, depending on the species involved. Some species are dependent on large patches of habitat away from patch edges, while others thrive on edges or ecotonal habitat. Many species which occupy edge habitat either compete with or predate on species associated with interior habitat. Forest dwellers in fragmented landscapes are also more susceptible to predation from generalist predators, and encounter more obstacles to dispersal. The level of fragmentation may be indirectly assessed by examining the size distribution of some key habitat components (Figure 3.24), and by noting the amount of ecotone, which is the edge between open habitats (grass/forb, shrub, sparse vegetation, and sapling/pole) and closed or older forested areas. Ecotone data, however, is not available for this analysis, which would help determine fragmentation levels. However, since logging has occurred at very low levels recently, and future logging proposals are limited, it is not expected that ecotone data would provide much meaningful information for this analysis area.

Figure 3.24 Current Patch Size Distribution



The analysis area quickly changes from a low elevation to a predominantly high elevation area, with half of the area falling within the mountain hemlock (38%) and parkland (12%) zones. In the higher elevation mountain hemlock and parkland vegetation zones, natural fragmentation is more likely to occur than in the lower elevation western hemlock and Pacific silver fir zones. Natural meadows and shrubfields are more likely to occur at the higher elevations, and harsher growing conditions lead to a much longer time between stand replacement following events such as fires. Since half of this analysis area is in the higher elevation potential vegetation zones, very high amounts of natural fragmentation are expected. Most natural habitat types on the west slopes of the Cascades are forested, with some exceptions such as wetlands, rock and cliff areas, and other sites unable to support large trees. These areas are generally small on a landscape level, except in wilderness areas, which make up a large portion of this analysis area. As can be seen in Figure 3.24, most of the stands in the old-growth and mature age classes are in the medium patch size category (61-1000 acres), with equal amounts distributed between the large and small patch sizes. There are several patches of either old-growth or mature habitat greater than 1000 acres in size in this watershed. As can be seen in Figure 3.17, these habitats do exist in relatively large, well connected blocks. Figure 3.24 also shows that the majority of the stands in the immature and sapling pole stages occur in large and medium blocks. All of this suggests a low level of fragmentation across the landscape.

Prior to Euroamerican settlement, the free flow of individual animals and populations through various landscapes was likely. Since large scale forest fires did not occur frequently in this analysis area, large blocks of suitable habitat existed to re-colonize those areas that did burn. This buffer allowed for continued re-colonization as suitable habitat was recreated. A low level of fragmentation in the analysis area also means that connectivity habitat is more likely to exist. Habitat connectivity is crucial to species, allowing them to migrate seasonally or as part of their daily foraging activities, allowing dispersal of individuals, and allowing overlap of home ranges of large ranging animals. Many animals native to the western Cascades will use forested riparian areas as travel corridors. At the lower elevations, however, over half of the vegetation is in the late seral stage and all of this may be suitable habitat for travel corridors. At the higher elevations many of these stands are in a natural state and provide even better dispersal habitat.

Some occasional small fires that historically burned in this analysis area caused some habitat fragmentation to occur. The level of fragmentation is not expected to have changed much due to these small fires. Very little patch clearcutting has occurred, as most past logging occurred during the 30's and 40's and entire drainages were logged at once. After logging, dispersal and connectivity were severely compromised, but adjacent source areas allowed for re-colonization of species over time. The logging probably had a much greater effect on the connectivity within the analysis area than fires because fires generally left riparian areas and some upland areas unburned. These unburned areas provided dispersal habitat for many animals. However, since the logged stands are now several decades old, many animals can disperse through them, as long as source areas of suitable habitat are on either side. Dispersal and connectivity currently should not be affected by any past logging. Rather, the roads and trails and the increased human disturbance they bring, are a bigger issue in this analysis area, as demonstrated by the interest in this analysis area by the public in the last few years.

The dispersal models indicate:

1. Connectivity for wolverine is high throughout the majority of the analysis area.

2. Dispersal for spotted owls is high up and down the major river corridors, and the potential for additional pairs to occupy unsurveyed sites is high.

3. Fisher should be able to disperse at moderate levels through most of the lower elevations primarily on National Forest lands, although since the snow pack stays along the valley bottom throughout the winter, there may be limitations that the model cannot reflect.

4. Low mobility, old growth obligate species such as the shrew-mole, will have difficulty dispersing, especially in the lower elevations where little old growth exists, and in the moderate to high elevations due to the high level of natural fragmentation. Localized populations may be able to persist due to a relatively high number and size of moderate to large old growth patches.

Hillslope Processes

Geology

The analysis area is predominantly underlaid with igneous rocks of the Snoqualmie batholith with minor volcanic and metamorphic rocks (Figure 3.25 Geology--refer to page 3-37 for geologic unit definitions). The Middle Fork valleys have experienced multiple advances and retreats of alpine glaciers. The alpine glaciers on the west flank of the Cascade Range were not in phase with the Puget Lobe of the Cordilleran ice sheet during the last (Fraser) glaciation of the Puget Lowland. Alpine glaciers seem to have reached a maximum and receded before the arrival of the Puget Lobe at the latitude of Seattle. The analysis area has been subjected to the influence of both alpine glaciers and the Puget Lobe. The Puget Lobe advancing from the lowland penetrated the drainage forming long proglacial lakes that extended close to the termini of alpine glaciers. In the lake sediments (lacustrine) are preserved a record of fluctuation of both the alpine glaciers and the Puget Lobe. With the exception of the alluvium along the Middle Fork and Taylor Rivers, all the surficial deposits are the result of glaciation. There are major deposits of lacustrine bedded silt and clay with sand lenses. Many of the slope stability problems (landslides) in this drainage are associated with the lacustrine deposits.

The Straight Creek fault zone is located east of the Cascade Crest; however, it has a major influence on the geology of Washington State. It extends from central Washington into Canada with 90 to 180 km (56 to 112 miles) of right-lateral, strike-slip offset.

The fault forms a boundary between fundamentally different geologic terranes, a difference expressed in both the crystalline rocks to the north and the Tertiary rocks to the south. In general, the fault separates unmetamorphosed and low-grade metamorphic rocks on the west from medium to high grade metamorphic rocks on the east.

Table 3.10 Percent of Watershed Occupied by Geologic Material

Geologic Material	049	050	051	052	Total % of Analysis Area
Ked			1		0.4
Qa	12	13	6	3	8.4
Qag	7	1	7	11	1.9
Qgp			1		0.4
Qvgl	19	5	2	1	3.9
Qvr		10			3.7
TKev		1	1		0.8
TKwa	17	13			5.8
TKwg		4			1.5
Tn			3		1.2
Tnbg			2		0.8
Tng			2		0.8
Tns			1		0.4
Tsb			1	6	1.5
Tsg	27	6	23	9	14.6
Tsgs		38			13.9
Tsm		2		9	2.3
Tss			1		0.4
Tst	1	5		2	2.2
Tstn			44	45	25.5
Tv			3	12	3.3
gb	17	1			1.4

Virtually all the higher elevation peaks, ridges, and sideslopes within the Middle Fork Snoqualmie River watershed are composed of hard, intrusive igneous bedrock material (Table 3.10). Quartz diorite and granodiorite (Tst/Tstn) are most prevalent in these locations within the Upper Middle Fork (051) and Taylor River (052) watersheds. Granodiorite and granite (Tsg/Tsgs) are most common within these upper slope, higher elevation locations in the Lower Middle Fork (049) and Pratt River (050) watersheds. An extensive outcrop of gabbro (gb) also exists within the Lower Middle Fork. Relatively large areas of sedimentary bedrock exist within the lower reaches of the Lower Middle Fork and Pratt River watersheds. These deposits are primarily composed of argillite (TKwa) and graywacke (TKwa).

Surficial deposits exist, to varying degrees, throughout the watershed. Alpine glacial deposits (Qag) are relatively extensive within the Upper Middle Fork and Taylor River watersheds. These deposits vary in composition from boulder till in the uplands and upvalley to gravel or sand outwash on broad valley floors. Alluvium (Qa), which is composed of moderately sorted cobble gravel, exists within the floodplain along the lower reaches of the watershed.

Recessional outwash (Qvr) and glaciolacustrine deposits (Qvgl) exist immediately adjacent and upslope from the floodplain alluvium along the lower reaches. River migration across the floodplain continues to erode the toeslopes of these unstable glacial deposits which results in a persistent contribution of fine sediment to the Middle Fork Snoqualmie River system.

Land Areas and Soils

The majority of dominant landscape features within the analysis area have developed as the result of glacial action. The hard granitic bedrock that exists through the higher elevations was scoured by glacial ice, and very steep rugged slopes currently exist throughout the upper slope regions. A broad U-shaped valley floor was sculpted by the glaciers and later partially filled with glacial lake deposits.

Table 3.11 shows the acreage comprising eight dominant land areas on National Forest lands in the Middle Fork Snoqualmie River Watershed. Refer to Figure 1.7 for locations of subwatersheds.

Table 3.11 Eight dominant land areas are identified on National Forest lands within the watershed (SRI-1972). Four land areas occupy more than 65% of the watershed area (A,B,F, &G).

Sub-watersheds	Land Areas % of Sub-watershed									Total Acres
	A	A/B	B	D	F	G	J	K	L	
1049A	3	4	28		7	18	5		35	4187
1049B		15	41		14	30				742
1050A	7		22		18	34	11		8	8068
1050B	27		20	5	9	25	8			3207
1050C	20		31		18	15		16		1563
1050D	35		12	8	15	22	8			1396
1050E	34		26		14	16	10			1634
1050F	100									360
1050G	68				32					1166
1051A	18		31		23	13		7	8	1527
1051B	3	19	28		7	14	12		17	5330
1051C			46		27	13		14		837
1051D	65		18		6	12				2318
1051E	9		31		44	6	10			3007
1051F	27		43		11		7	12		2107
1051G	12		44		24		7	13		1902
1051H	26		34		9	20	11			8870
1051I	65		35							1512
1051J	70		21			9				1683
1051K	67		17		3	6				5752
1051L	85		5		7			3		5649
1051M	100									1157
1051N	100									1094
1052A	15		29		14	23	14		5	6335
1052B			18		20	32	12			3301
1052C	100									1099
1052D	53		39		8					1459
1052E	58		29		13					1217
1052F	33		35		32					1868
1052G	20		29		27			18		3577

Land areas-A & B dominate the landscape within the Upper Middle Fork and Taylor River watersheds (Figure 3.26). Land area-A consists of rugged & rocky, high elevation ridges and mountains. Slopes are extremely variable, ranging from nearly vertical to essentially level within meadows and ridges. The majority of land area-A occurs above 6,000 feet. Soils are shallow, gravelly and stony sandy loams or loams. Volcanic ash is frequently incorporated in the surface 2 to 4 inches. Infertile soils, low soil temperatures, and insufficient moisture during optimum growth periods produce a very harsh environment and severely limit vegetative establishment and growth. Land area-B is similar to (A) but occurs at lower elevations (3,500-5,600 feet). Land area-B is also frequently dissected with rock outcrop, narrow talus slopes, avalanche tracks and/or debris slide tracks.

Land areas-F & G exist throughout approximately half of the Pratt River watershed with Land areas-A & B occupying the other half. Land areas-A & B occupy the more rugged higher elevation locations. Land area-F is characterized by steep, upper-elevation sideslopes with slopes ranging from 50 to 100%. Slopes are frequently rugged and contain scattered rock outcrop. The majority of land area-F occurs at elevations ranging from 2,800 to 4,500 feet. Soils are shallow to moderately deep, gravelly, and stony sandy loams and loams. Drainage is usually good. Land area-G is very similar to land area-F with the major difference being that (G) occurs at lower elevations (generally below 3,000 feet).

The majority of the Lower Middle Fork watershed exists at relatively lower elevations and occupies a lower position in the watershed. More of its area has been influenced by depositional actions of glaciers. While steep rugged topography exists within the upper slope positions (land area-B), land areas-G & L are very well represented within this watershed. Land area-L occurs throughout approximately 24% of the watershed. This land area consists of valley bottoms and toeslopes in glacial valleys. Slopes range from 0 across portions of the valley bottom to approximately 60% on the toeslopes. The topography is frequently uneven and hummocky. Elevations range between 600 and 2,200 feet. Soils are very deep, mixed glacial and glaciolacustrine deposits. These materials are heterogeneous and occur as interlayered beds of gravelly sandy soils and silty clay soils. Soils are generally wet and frequently imperfectly drained. The glacial lacustrine deposits associated with land area-L are frequently unstable. Natural slope failures are prevalent and persistent throughout these areas and contribute large quantities of fine sediment to the Middle Fork Snoqualmie River system. Land area-G occupies a slope position immediately upslope from the low elevation valley bottoms and toeslopes (land areas-J & L). Glacial till, particularly along the steeper lower slopes of land area-G, can be highly unstable with high sediment delivery potential to perennial streams.

Erosion Processes

Surface Soil Erosion

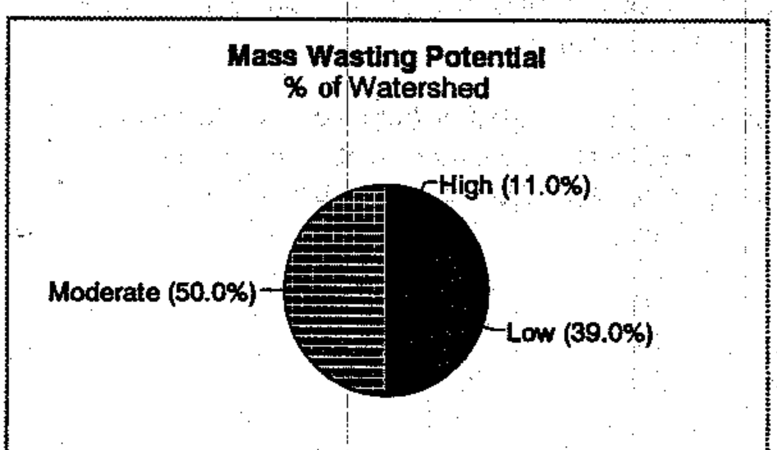
A comprehensive inventory of sediment sources originating from surface erosion processes has not been completed for the analysis area. The majority of soil types within the watershed are highly erodable when the surface cover (i.e., litter layer, vegetation, stones, etc.) is removed (SRI 1977). Surface erosion was undoubtedly very active immediately following the wildfires that occurred within the watershed. Mass wasting events frequently result in the creation of erodable surface areas. Several large slope failures associated with the lacustrine deposits in the lower valley continue to produce sediment from surface erosion processes. Avalanche chutes (primarily in land areas-A & B) are frequently disturbed which results in persistent surface soil erosion from these sites.

Mass Wasting

No comprehensive landslide inventory has been completed for the Middle Fork Snoqualmie River watershed. The Mt. Baker-Snoqualmie National Forest Slope Stability Model was used in order to identify the locations which would be expected to represent the highest probability of experiencing slope failures (mass wasting) under natural or undisturbed conditions. The MBS model integrates six interrelated physical characteristics, using a GIS (Arc/Info), for the evaluation and interpretation. The six characteristics used include: bedrock geology, slope morphology, soil parent material, soil infiltration characteristics, precipitation zones, and previously identified highly unstable soils. (See Appendix C for a detailed description of model assumptions and processes).

From a total watershed perspective, the analysis area is relatively stable in terms of mass wasting activity. According to the model, only approximately 11% of the total watershed area is considered to have a high potential for mass wasting. Approximately half of the area has a moderate potential and 39% is interpreted as having a low potential for naturally occurring slope failure (Figure 3.28 Mass Wasting Potential).

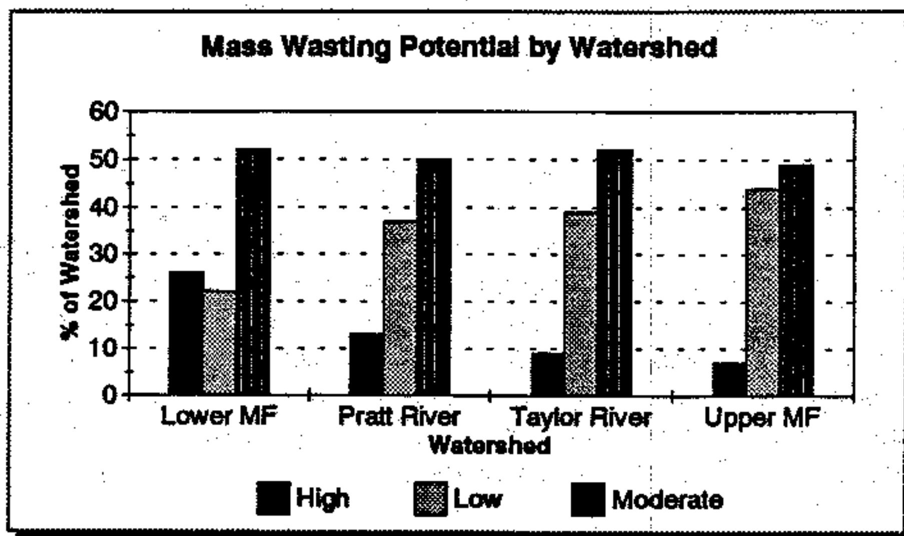
Figure 3.27 Mass Wasting Potential: Percent of Watershed



Potential slope failure is not distributed equally throughout the watershed however. Seventy-six percent of the high risk acreage is located within the Upper Middle Fork and Pratt River watersheds. The Lower Middle Fork only contains approximately 6% of the total high risk acreage for mass wasting.

While the Lower Middle Fork contains less total acreage of high risk, it actually contains the highest percent of high risk acreage. Approximately 26% of the Lower Middle Fork watershed is considered, according to the MBS model, to have a high potential of experiencing naturally occurring mass wasting events. The Pratt, Upper Middle Fork, and Taylor River have 13%, 7%, and 9% of their areas rated as high risk respectively.

Figure 3.29 Mass Wasting Potential by Watershed



The most influential characteristics in determining relative slope stability within the Middle Fork appear to be surficial geology, soil parent material, and soil hydrologic group. While it is difficult to interpret all the various interactions of physical slope characteristics, it appears that the glaciolacustrine deposits and glacial tills which exist along the valley bottoms and toeslopes of the Middle Fork, in conjunction with the relatively poor infiltration characteristics associated with these deposits, are the principal characteristics which influence mass wasting frequency and distribution within this watershed.

Table 3.12 Percent of watersheds rated as high mass wasting potential for each of the evaluation characteristics

	Lower MF	Pratt River	Upper MF	Taylor River
Geology	19	15	2	1
Parent Material	24	2	3	2
Precipitation	26	22	17	22
Hydrologic Group	18	2	3	1
Slope Morphology	29	23	35	31
S-8	1.1	0.2	0.2	1.6

Table 3.13 Mass Wasting Potential by Sub-watershed

Sub-Watershed	High (acres)	High %	Moderate (acres)	Moderate %	Low (acres)	Low %	Total Acres
1049A	1530	28	2969	52	1160	20	5659
1049B	155	19	422	51	252	30	829
1050A	1459	19	4734	59	1791	22	7985
1050B	143	5	1692	53	1339	42	3174
1050C	41	2	759	49	765	49	1564
1050D	7	1	756	52	680	47	1442
1050E	37	2	861	53	722	45	1620
1050F	7	1	243	41	347	58	597
1050G	0	0	422	31	927	69	1349
1050X	3244	15	10575	49	7781	36	21600
1051A	240	15	856	54	500	31	1596
1051B	1149	22	3043	58	1071	20	5262
1051C	24	3	416	49	402	48	842
1051D	28	1	932	40	1367	59	2327
1051E	64	2	1548	52	1393	48	3005
1051F			724	34	1375	66	2099
1051G			703	37	1197	63	1900
1051H	1230	14	5577	63	2069	23	8876
1051I	17	1	884	50	865	49	1766
1051J	66	4	900	47	935	49	1901
1051K	225	4	2614	46	2869	50	5708
1051L			2171	39	3454	61	5626
1051M			372	32	784	68	1156
1051N			279	25	815	75	1094
1052A	1220	19	3661	59	1374	22	6255
1052B	288	8	1664	50	1382	42	3334
1052C	87	5	683	51	592	44	1342
1052D	55	4	600	53	656	43	1511
1052E	24	2	728	58	509	40	1260
1052F	21	1	756	40	1099	59	1876
1052G	59	1	1719	48	1840	51	3618

Management Influenced Erosion Processes

Surface Erosion

Roads can be a source of sediment due to erosion of the running surface. Heavy commercial use during periods of high precipitation can result in relatively high rates of erosion. Vehicular traffic associated with timber harvest activities and road construction and maintenance has probably resulted in periodic erosion.

Surface soil erosion also occurs within timber harvest areas. Activities which result in the removal of surface cover and disturbance of soil material can result in soil erosion. Yarding systems with inadequate suspension of logs and broadcast burning are activities which present high potential for soil erosion.

No inventory of existing surface soil erosion sites (management or otherwise) has been completed for the Middle Fork.

Mass Wasting

Management activities have the potential of influencing naturally occurring slope stability characteristics (Figure 3.30 Management Influenced Mass Wasting Potential). Road construction and clearcut timber harvest are particularly prone to altering the frequency and distribution of mass wasting activity. These activities have the potential of altering hillslope hydrology, soil strength, and other hillslope processes that determine site specific slope stability characteristics. The relationship of roads, streams, age of vegetation and naturally occurring slope stability potential was evaluated through a GIS model in order to assess the influence of management activities on slope stability characteristics. (See Appendix C for a detailed description of the modeling assumptions and processes.)

Table 3.14 Management Influenced Mass Wasting Potential
Percent of Watershed

Sub-Watershed	High	Moderate	Low
Lower Middle Fork	-	11	89
Pratt River	1	-	99
Upper Middle Fork	2	32	68
Taylor River	-	9	89

Management activities have had a relatively low influence on the frequency and distribution of mass wasting activity within the Middle Fork. The highest influence probably occurred as a result of the railroad logging that occurred in the 1930's and 1940's. Since that period, very low levels of timber harvest and road building have occurred.

According to the GIS model, the Upper Middle Fork watershed has the highest percentage of high risk area associated with management influence. The existence of the mainline FS road along the lower slopes of much of this watershed is primarily responsible for this modeling interpretation. If evaluated at the subwatershed rather than the watershed scale, the Quartz Creek subwatershed (within the Taylor River watershed) actually contains the highest percentage of high risk area associated with management activities. Quartz Creek contains a higher concentration of young stands (recent clearcut harvest) and frequency of road/stream intersections in conjunction with a moderately high percentage of naturally occurring high mass wasting potential.

Hydrologic Processes

There is relatively little meteorologic, hydrologic, or water quality data available in the Middle Fork Snoqualmie watershed compared to many of the other watersheds on the Forest. Neighboring drainages such as the South Fork Snoqualmie and Green River have much more information available from active or discontinued discharge or water quality monitoring stations, and various project studies. The only active stream discharge gauge in the analysis area is located near Tanner, Washington at river mile (RM) 55.6, about 6.4 miles east of North Bend. This station has been in operation continuously since 1961 by the U.S. Geological Survey (USGS station #12141300). The only other flow gauge which has ever been located in the watershed operated from 1907-26, and 1930-32 (USGS station #12141500) near the city of North Bend.

Hourly rainfall data is available from National Oceanic and Atmospheric Administration (NOAA) sites at Snoqualmie Falls and Snoqualmie Pass. Some other climate data is available seasonally at several sites near the analysis area, but not within it. These sites are maintained mostly by the Washington State Department of Natural Resources (DNR) and the Forest Service and are operated as part of a network of fire weather forecasting stations. The nearest snowpack data is available at a SNOTEL site maintained by the Natural Resources Conservation Service (NRCS) at Ollalie Meadow, about 6 miles west of Snoqualmie Pass on the South Fork of the Snoqualmie River. Very little surface water quality data has been collected, and there have been no long-term monitoring sites. The largest single source of water quality data known to be available comes from monthly grab samples collected from an ambient monitoring station located near the mouth of the mainstem of the Middle Fork Snoqualmie. Samples were collected between June 17 and September 16, 1991 by the Washington State Department of Ecology (Ecology).

The Middle Fork Snoqualmie watershed lies between the South and North Forks of the Snoqualmie River. The mainstems of these rivers join near North Bend, and together become the Snoqualmie River. The Snoqualmie River enters the Snohomish River system near Monroe. These two systems make up the Snohomish River basin, one of the seven major river basins that drain the west slopes of the Cascade Mountains on the Forest. The mainstem of the Snoqualmie River continues upstream as the Middle Fork Snoqualmie (RM 44.5) above the confluence with the North Fork. There are about 40 miles of the mainstem of the Middle Fork, and over 60 perennial and intermittent tributaries totalling about 1800 stream miles.

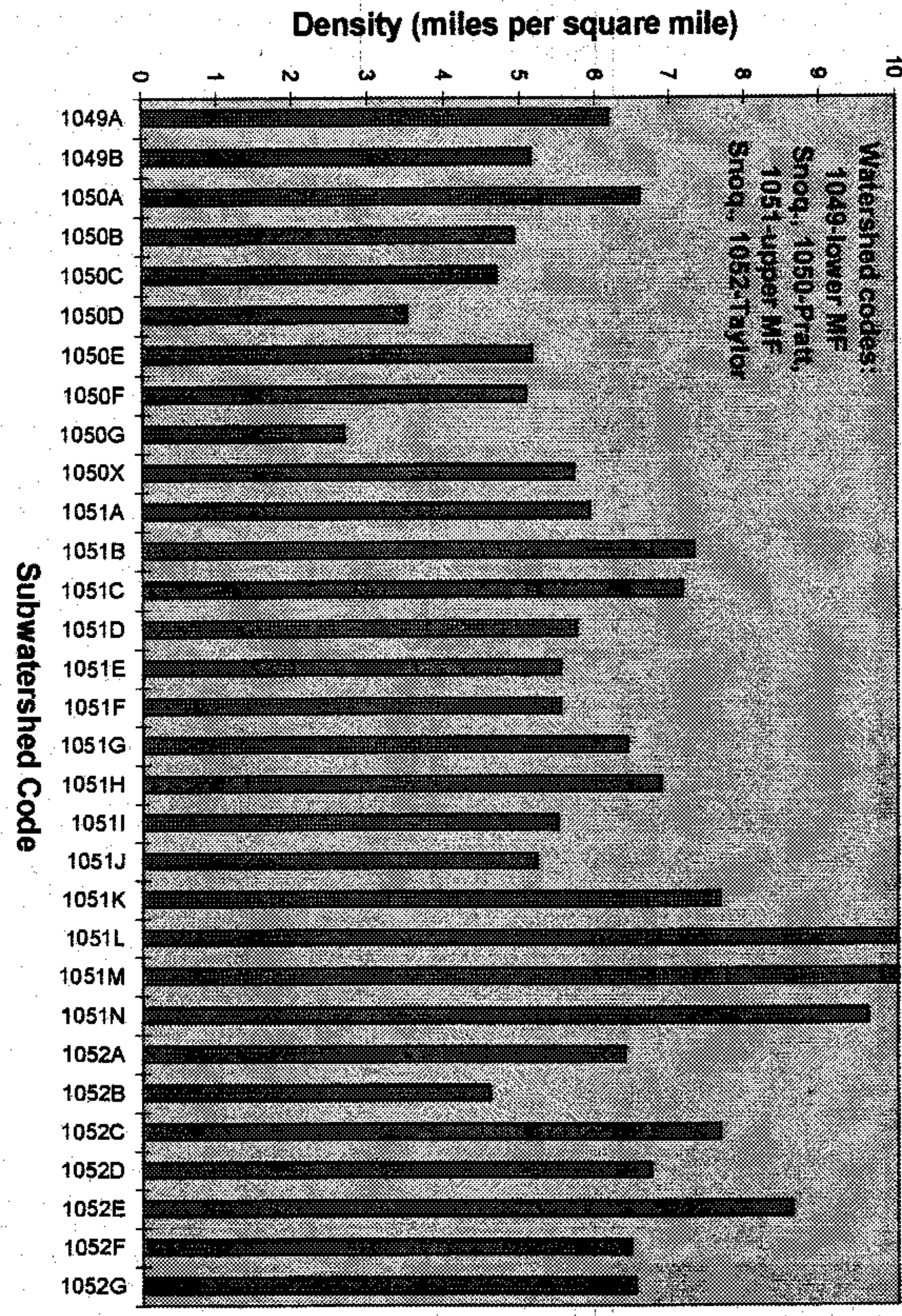
The head of the watershed is located in the Chain Lakes region (RM 82) near Crawford Lake, which is several miles east of Snoqualmie Lake, one of the largest in the watershed. The three main tributaries of this fourth-order watershed are Dingford Creek (entering the mainstem of the Middle Fork RM 70.3), the Taylor River (RM 65), and the Pratt River (RM 61.1). River elevations on the mainstem of the Middle Fork vary from 4600 at the source outlet at Williams Lake at the head of the watershed, to about 400 feet at the mouth near North Bend. Stream gradients vary from 10% to 20% in step-pool or cascade dominated, narrowly confined reaches over the first ten miles of the mainstem. Gradients shallow to approximately 1% over the lower four miles of the 30 to 75-foot wide active channel which meanders or braids over the 1 to 3-mile wide valley floor.

The average stream density in the fifth-field watersheds, including both perennial and intermittent streams, varies from 5.56 and 6.05 stream miles per square mile in the Pratt and lower Middle Fork Snoqualmie watersheds, respectively, to means of 6.36 and 7.18 in the Taylor and upper Middle Fork Snoqualmie watersheds, respectively. These stream density values are relatively average for the watersheds on the Mount Baker-Snoqualmie National Forest, which as a whole has very high stream densities compared to most other forested areas of the country. Figure 3.31 shows all perennial and most intermittent streams within the analysis area, along with all lakes, and known ponds and wetlands. Figure 3.32 displays the stream densities for each of the subwatersheds in the analysis area. Levels vary from about 2.5 stream miles per square mile in the Tuscohatchie subwatershed (1050G) of the Pratt, up to about 10.0 in the upper subwatersheds of the Middle Fork Snoqualmie watershed (1051L and 1051M). All but a few of the subwatersheds in the analysis area have stream densities over 5 miles per square mile, hence most areas are highly dissected with stream channels.

Climate

Elevations in the analysis area vary from 400 feet at the confluence of the Middle, North , and South Forks of the Snoqualmie River, to just over 6000 feet on some of the ridgetops surrounding the headwaters of the Middle Fork Snoqualmie and Taylor Rivers. In addition to the effects of this varied local relief, the overlying impacts of the Cascade and Olympic Mountain Ranges also greatly influence climate. The Cascades shield the watershed from some of the cold air masses that travel south across Canada in the winters, while the Olympics protect the area from most of the intense winter storms heading inland from the Pacific. Winters are wet and usually mild, while summers are usually cool and dry. Average temperatures range from the 60's in the summer at the higher altitudes to the upper 70's in the foothills in the lower portions of the Middle Fork Snoqualmie watershed. Average high

Figure 3.32 Stream Densities by Subwatershed



temperatures during the coldest months of the winter range from the 30's to 40's in the lowest areas, to seldom above freezing at the highest elevations. Occasional periods of warm winds combined with rainfall at relatively high elevations have a great impact on snowmelt rates and consequently the timing and magnitude of stream discharges; these rain-on-snow events are discussed later.

Estimates of the annual average and individual storm event totals vary greatly between the subwatersheds in the area. Figure 3.33 shows an isohyetal map of rainfall equivalents over the analysis area. These estimates were built by transferring data digitized from 1:2,000,000 National Oceanic and Atmospheric Administration (NOAA) maps (Miller et al. 1973) onto 1:24,000 USGS Quadrangle maps by the Washington Department of Natural Resources (WSDNR 1994). The original isohyetal lines drawn by NOAA were estimates constructed from interpolations between known data points; the interpolations were based on models which largely depend on variations in elevation and exposure.

The annual (unweighted) average for the entire Snoqualmie basin, including the North, South, and Middle Forks of the Snoqualmie, and the Tolt River, is about 113 inches. The greatest precipitation levels in the basin occur in the Taylor River watershed, where the annual average is estimated to be up to about 180 inches in one of its subwatersheds (52E, Big Creek). The minimum annual average occurs in the lower reaches of the Tolt watershed, far downstream of the analysis area, where as little as 46 inches fall. The average deviation from the mean is about 15 inches. The Taylor River also has the largest estimated 10-year, 24-hour storm precipitation amounts (up to 7.5 inches), compared to as little as only 2.7 inches in the Tolt River. The average deviation from the mean is about 0.5 inches.

Figure 3.34 shows the annual area weighted precipitation for the subwatersheds in the analysis area. Figure 3.35 shows the area weighted 10-year, 24-hour storm precipitation amounts across the analysis area. These figures display the range of estimated rainfall throughout the subwatersheds. The lowest overall annual, and 10-year, 24-hour storm averages both occur in the lower Pratt watershed (subwatershed 50X, all below off Forest Service boundaries in watershed), where estimates are 85.6 and 5.0 inches of rainfall, respectively. The highest levels occur in the Taylor watershed in the Big Creek subwatershed (52E), which has some of the highest elevations in the analysis area; an estimated 179.4 inches fall annually on average, and the mean 10-year, 24-hour storm drops 7.5 inches of precipitation. The annual average precipitation varies from mean values 112 and 115 inches in the lower Middle Fork Snoqualmie and Pratt watersheds, respectively, up to a mean of 139 inches in the upper Middle Fork Snoqualmie watershed, and about 155 inches in the Taylor River watershed.

Flow Regime

Stream discharges throughout the analysis area generally follow a bimodal annual hydrograph. Baseflows generally reach a minimum in late summer and may continue low into October. Flows increase in the fall, decrease greatly during the coldest winter months, then increase again in the spring as the combined effects of rains and melting snowpacks swell channels. The greatest mean monthly flows occur in the spring, but the largest individual peak flows often occur in late fall and early winter when warm fronts follow periods of heavy snows, resulting in large amounts of snowmelt at relatively high elevations.

Figure 3.34 Annual Average Precipitation by Subwatershed.

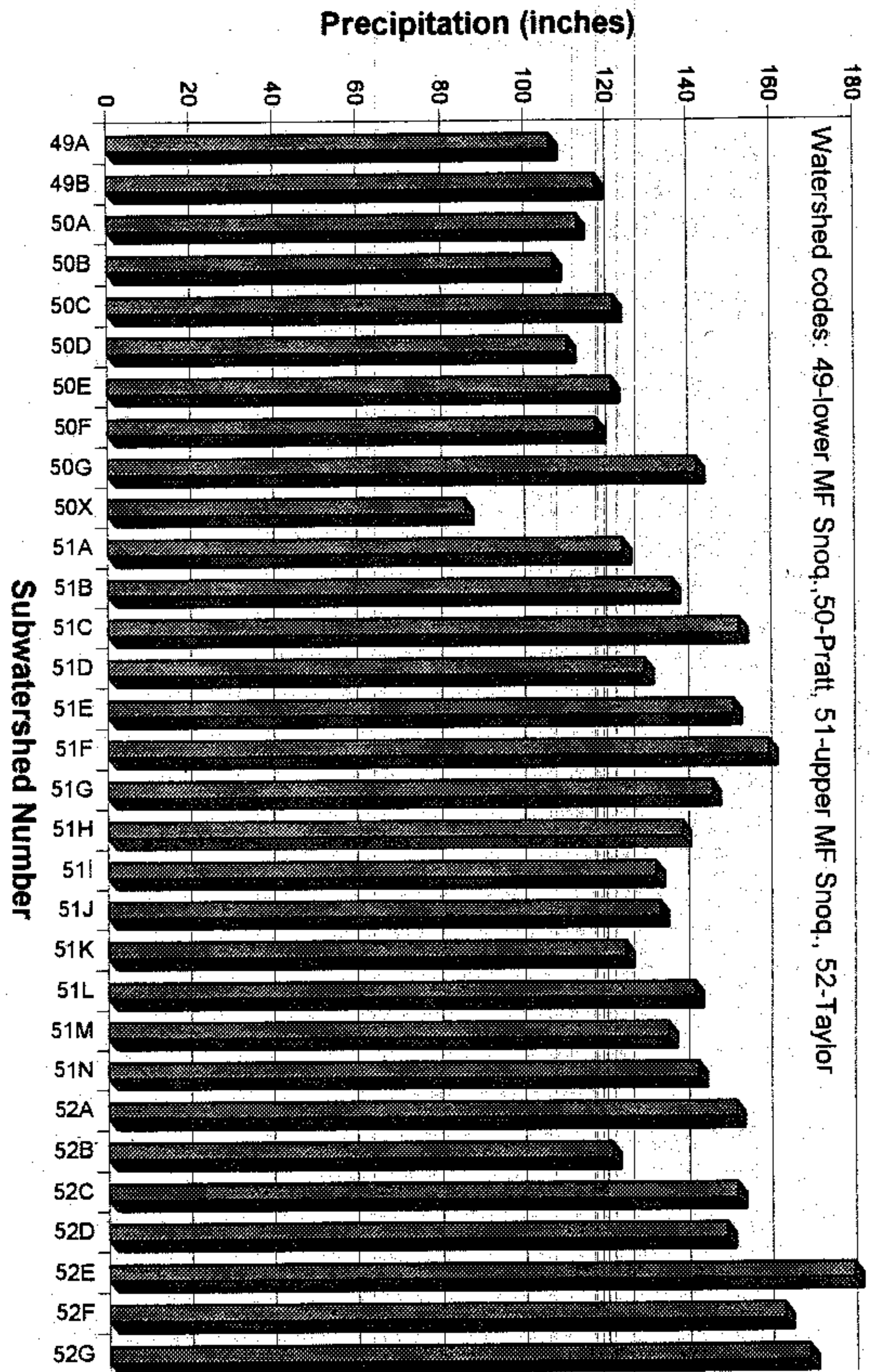


Figure 3.35 Plots of 10-Year, 24-Hour Average Storm Precipitation by Subwatershed.

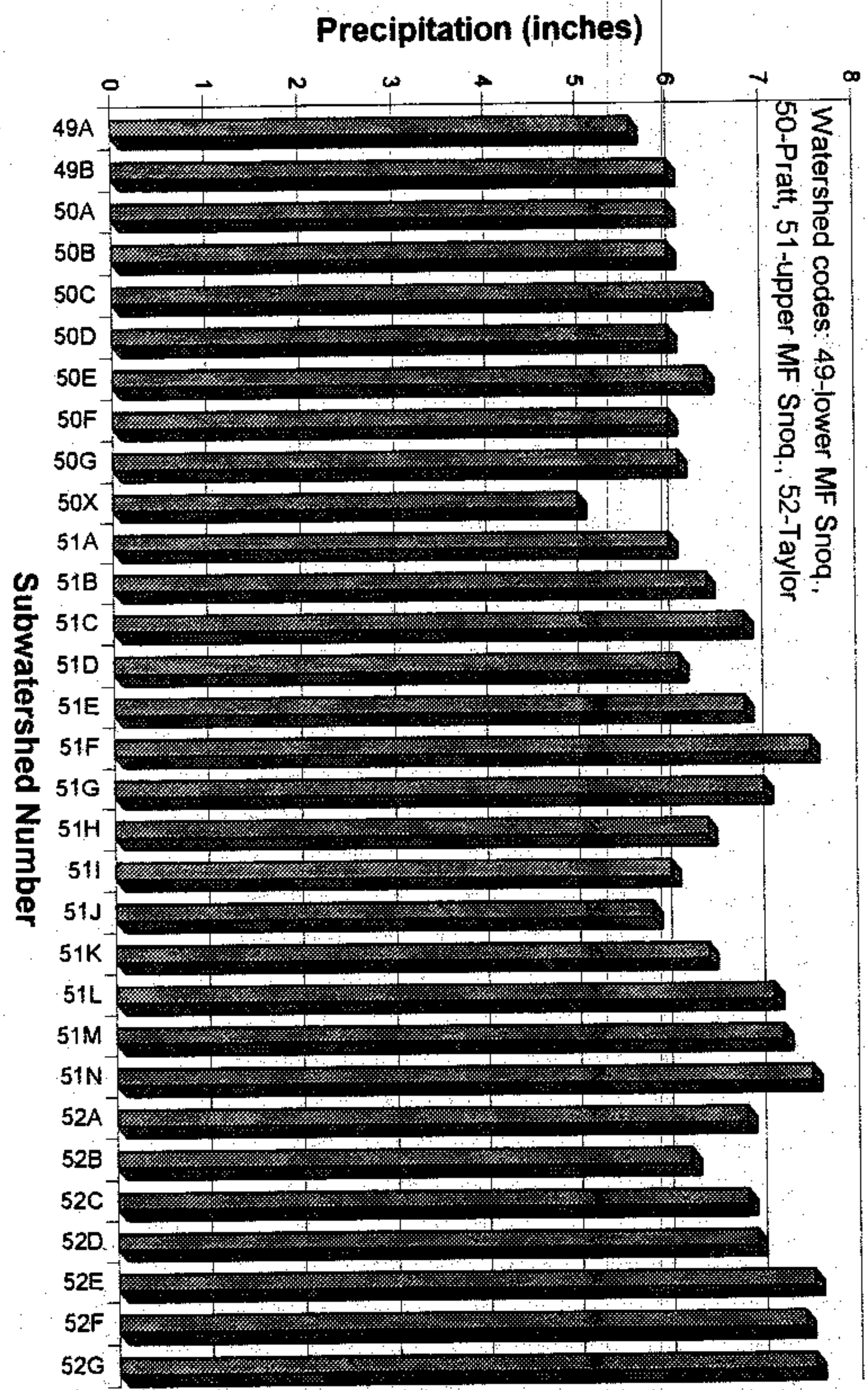


Figure 3.36 shows the mean monthly discharge for the mainstem of the Middle Fork Snoqualmie River near Tanner, Washington (RM 55.6) gauge over the period of 1961-1992; this is the only gauge currently operating in the watershed. The annual peak flows at the same site are shown in Figure 3.37. Since the gauge site at Tanner was established in 1961, the largest flow on record was observed in 1977 when maximum discharge was estimated at 30,200 cfs on December 2. This peak was equaled 13 years later on November 24, 1990 when discharge was estimated to be 30,100 cfs, and nearly matched again on November 29, 1996 when flow was measured at 27,400 cfs. Hence, the three largest peak flows on record all occurred in late November or early December, and all were related to rain-on-snow events.

Table 3.15 ranks the annual peak flows from 1961-1996 in order from largest to smallest. It shows that four of the largest eight annual peaks occurred within the last ten years (among 37 years of record). On its own this does not conclusively indicate a trend in flood magnitudes, but it does indicate that further investigation is merited. Only four of the peak annual floods occurred in spring, while one occurred in September and one in October. All of the remaining peak flows occurred between November and February. Estimations of the associated discharges for various return intervals in the mainstem of the Middle Fork Snoqualmie were made using a log-Pearson Type III distribution and the annual peak flow data at the Tanner gauge site between 1961 and 1992. This data is displayed in Table 3.16 which shows that the largest flows on record (i.e., the discharges of about 30,000 cfs recorded in 1977 and 1990) are estimated to be about 20-year flood events. Table 3.16 also shows relatively small differences between the magnitudes of the larger, rarer flood events.

Estimation of flow characteristics in the tributaries of the watershed was not attempted in the time frame of this analysis. Except for the two gauge sites (one active, one abandoned) on the mainstem of the Middle Fork, no other flow data is known to exist for any other location. Various models are available to estimate discharge in ungauged streams. They range in assumptions, requirements, and accuracy from relatively simple basin-characteristic models (e.g., regional models such as Cummans 1975), to empirical statistical models relating discharge to net annual precipitation (e.g., Pentec 1996), to relatively rigorous conceptual or physically-based models. These models, however, could be neither calibrated nor validated without at least a minimal set of miscellaneous flow measurements. In addition, the more accurate models require a great deal of hydrologic data, some of which is currently unavailable.

Several past attempts to model the impacts of timber harvest and road construction on peak flows, and to assess trends in stream discharge associated with changing land use in or near the analysis area were reviewed, however, and are presented in a following section. In addition, a model was run for this analysis which estimates the level of vegetation disturbance in each subwatershed. The removal of forest canopy causes changes in the amount of precipitation that reaches the ground and also changes in rates and timing of snowmelt. These factors can cause changes in the magnitude and timing of peak flows. The results of this vegetation disturbance model are presented below.

Figure 3.36 Mean, Maximum, and Minimum Average Monthly Flows for the Middle Fork Snoqualmie River over the Period of 1961-1995 at Tanner, Washington (USGS Gage Station 12141300).

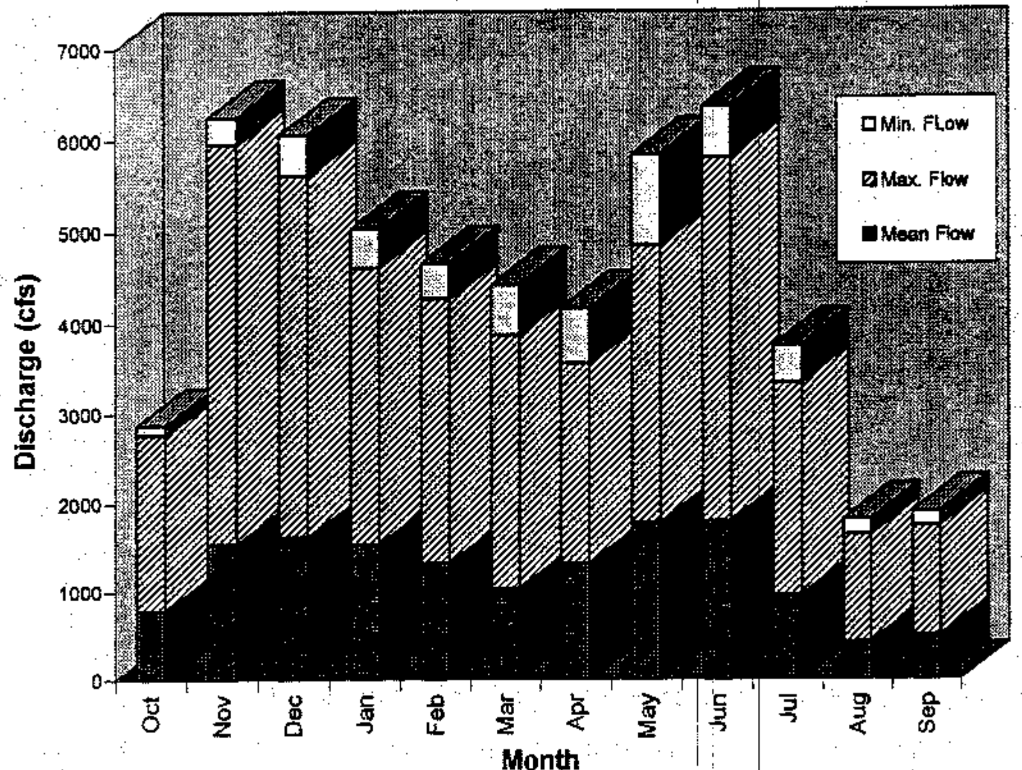


Figure 3.37 Peak Annual Discharge in the Middle Fork Snoqualmie River at Tanner, Washington (USGS Gage Station 12141300) from 1961-1996.

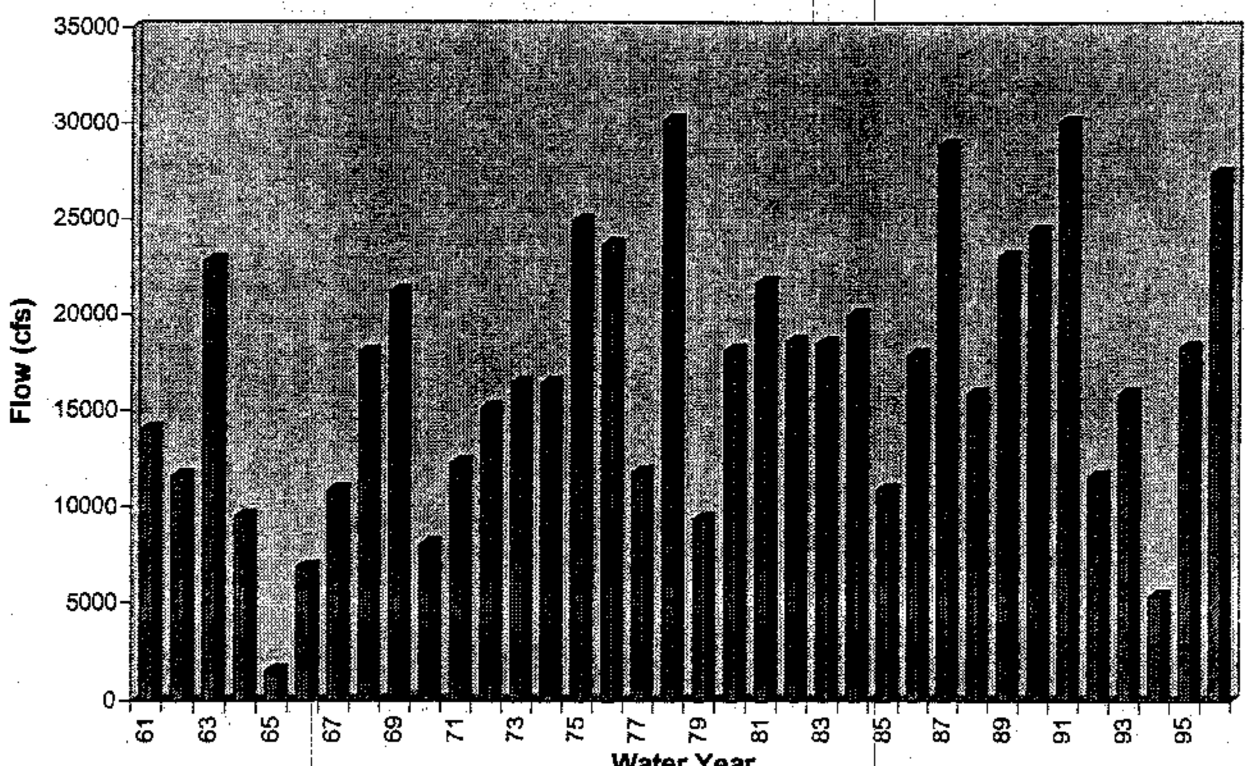


Table 3.15 Ranking of annual peak flood events at the Tanner gauge site (RM 55.6) on the Middle Fork Snoqualmie River for the period of record (1961-1996). Drainage area above site is 154 square miles (drainage area for entire watershed is 171 square miles).

FLOW RANK	MO	DAY	YEAR	FLOW (cfs)	RANK	MO	DAY	YEAR	(cfs)
1	12	2	77	30200	21	1	21	93	15900
2	11	24	90	30100	22	12	9	87	15900
3	11	23	86	28900	23	1	29	65	15800
4	1	24	95	27400	24	2	28	72	15100
5	1	18	75	24900	25	2	21	61	14000
6	11	9	89	24400	26	1	19	71	12300
7	12	3	75	23700	27	9	25	91	11900
8	10	16	88	23100	28	1	18	77	11800
9	11	19	62	22800	29	12	5	92	11600
10	12	26	80	21700	30	11	3	62	11600
11	1	5	69	21200	31	6	7	85	10900
12	1	24	84	20000	32	12	1	66	10900
13	1	24	82	18600	33	11	26	63	9520
14	12	3	82	18500	34	11	8	78	9360
15	2	19	95	18300	35	4	9	70	8070
16	12	15	79	18100	36	5	6	66	6860
17	1	20	68	18000	37	6	14	94	5370
18	11	1	85	17900					
19	1	15	74	16400					
20	12	26	72	16400					

Summer baseflows in the Middle Fork Snoqualmie are a small fraction of the winter flows (about 3% of the 1-year storm flow, and about 0.5% of the estimated 100-year storm flow). At the Tanner gauge site discharge drops to about 130-200 cfs for periods of days to weeks each year. It is unknown whether baseflows are significantly limiting the quantity or quality of instream habitat in some reaches of the mainstem without conducting water quality sampling and cross-sectional surveys.

The Washington Department of Ecology (Ecology) has established minimum instream flow targets at four gauge sites within the Snohomish Basin (Pacific Groundwater Group 1995). The nearest site to the Middle Fork is on the Snoqualmie River at Snoqualmie; the other three are the Snoqualmie River at Carnation, the South Fork Skykomish near Index, and the Snohomish near Monroe. In all four cases Ecology's August in-stream flow requirement is more than the average and median 7-day low flows. This means that in more than half of all years, the 7-day low discharge is less than the in-stream flow required. Additionally, there is almost no water withdrawal upstream of either the South Fork Skykomish at Index or the

Table 3.16 Estimated recurrence intervals for flood flows based on a log-Pearson Type III distribution using discharge data at the Tanner site gauge station (RM 55.6) based on 32 annual events from 1961-1992.

		Confidence Limits of Estimate	
Computed Flow (cfs)	Recurrence Interval (Years)	.05 level	.95 level
45300	500	60900	36900
41100	200	54100	34000
37900	100	48900	31700
34600	50	43800	29300
30100	20	37000	26000
26500	10	31700	23200
22700	5	26300	20100
16500	2	18500	14700
11800	1.25	13300	10200
9850	1.11	11300	8210
8440	1.05	9850	6810
6260	1.01	7600	4720

(source- King County Surface Water Management 1992)

Snoqualmie River at Snoqualmie sites (Pentec 1996), meaning that the low flows cannot be explained by consumptive water use. It is very possible, therefore, that some summer baseflows in the Middle Fork Snoqualmie would also be judged by Ecology to not meet in-stream flow requirements. Low summer precipitation levels and little groundwater flow into stream channels result in low discharges which do not provide enough water to fill streams that have a channel capacity large enough to pass winter storm flows, hence shallow summer baseflows limit aquatic habitat and fish populations.

Summer baseflows may also be limiting in some other streams besides the mainstem of the Middle Fork Snoqualmie, especially in reaches where flows go subsurface in areas of heavy alluvial deposits, such as near the mouths of some tributaries. The mean 2-week low flow from 1962-79 was about 244 cfs, while the minimum was 144 cfs and the standard deviation was about 72 cfs. Table 3.17 below shows the low flow discharges for 1-day, 7-day, 14-day, 30-day, and 90-day periods for a range of recurrence intervals.

Table 3.17 Low flow discharge levels in the mainstem of the Middle Fork Snoqualmie River at Tanner (RM 55.6) for varying durations and recurrence intervals based on flows from 1962-1979.

		Mean flow (cfs) over a period of consecutive days				
Recurrence Interval [(YEARS)/ (exceedance probability)]		1-day	7-days	14-days	30-days	90-days
1.01	[.99]	456	493	596	768	1095
1.11	[.90]	276	301	355	452	758
1.25	[.80]	233	254	296	371	653
2	[.50]	179	195	221	266	459
5	[.20]	148	160	176	201	381
10	[.10]	138	148	160	177	334
20	[.05]	132	141	149	161	300
50	[.02]	126	134	140	149	267
100	[.01]	123	131	135	138	247

[source: U.S. Geological Survey 1985]

Rain-on-Snow Influence

Many of the peak flood flows in the analysis area occur during rain-on-snow periods when warm fronts bring warm winds and heavy rainfall to relatively high, snow-covered elevations. The resulting snowmelt rates swell stream and river channels and may cause flooding. On November 24, 1990 the freezing level quickly rose from about 1000 feet to 8000-10,000 feet. This resulted in combined rainfall and snowmelt runoffs that caused the second largest annual peak flow on record for the mainstem of the Middle Fork Snoqualmie River. Exactly five years later a similar warm front entered the area from the southern Pacific and caused the fourth largest annual peak flow on record.

Figure 3.38 shows distribution of the five rain-on-snow zones throughout the analysis area. The zones shown were obtained from the DNR and were developed for Washington State Watershed Analysis (Washington State Practices Board). They were defined on the basis of the amount of snow that was likely to be on the ground relative to the amount that could be melted during a storm. The five zones (ranging from highest to lowest elevations) are: highland (HL), snow dominated (SD), rain-on-snow (RS), rain dominated(RD), and lowland (LL).

Some short-term increases in snow melt rates occur in the highland and rain dominated zones, but the majority happen in the snow dominated and rain-on-snow zones. Peak conditions for these events are considered to occur in the rain-on-snow zone according to the DNR model. Although there is no quantitative data to support it, it is thought that large rain-on-snow events also occur fairly frequently at higher elevations in the analysis area, in what the model calls the snow-dominated zone. The actual definitions for each DNR zone are summarized in Appendix C. These zones covary largely by elevation, but it is not the sole variable in the model. The rain-on-snow zone was originally defined for the western Cascades as a band between 1500 and 3000 feet elevation (Coffin and Harr 1992).

Figures 3.39 and 3.40 display the relative areal percents for each of the rain-on-snow zones for each subwatershed in each fifth-field watershed. Distributions vary widely among each of the watersheds, with the exception of the lower Middle Fork Snoqualmie which has only two subwatersheds. Table 3.18 below lists the range of area within each fifth-field that lies within each zone, in each of its subwatersheds. The greatest probability of rain-on-snow induced high stream flows in the upper Middle Fork Snoqualmie fifth-field watersheds appears to exist in its Rainy Creek (1051A), Middle Fork below Dingford Creek (1051B), Lower Dingford Creek (1051E), and Middle Fork above Dingford Creek (1051H) subwatersheds. Over 50 percent of these four subwatersheds (among 14 subwatersheds in this fifth-field watershed) lie in the rain-on-snow or snow dominated zones. Risks increase somewhat in the Pratt watershed, where half of the subwatersheds occur in one of these zones. The Taylor River watershed appears to have a far greater area of rain-on-snow influence; all but two of its seven subwatersheds lie in the rain-on-snow or snow dominated zones. Similarly, both of the subwatersheds that comprise the lower Middle Fork Snoqualmie fifth field have about 50 percent or more of their area in one of these two zones. This means that the lower reaches of the Middle Fork Snoqualmie are susceptible to rain-on-snow caused increases in flow from both the surface runoff and return flow from the surrounding hillsides, and from similarly increased instream flows originating upstream in the Pratt and Taylor Rivers.

Figure 3.39 The relative areal percents for each of the rain-on-snow zones for each subwatershed within the upper and lower Middle Fork Snoqualmie Watersheds.

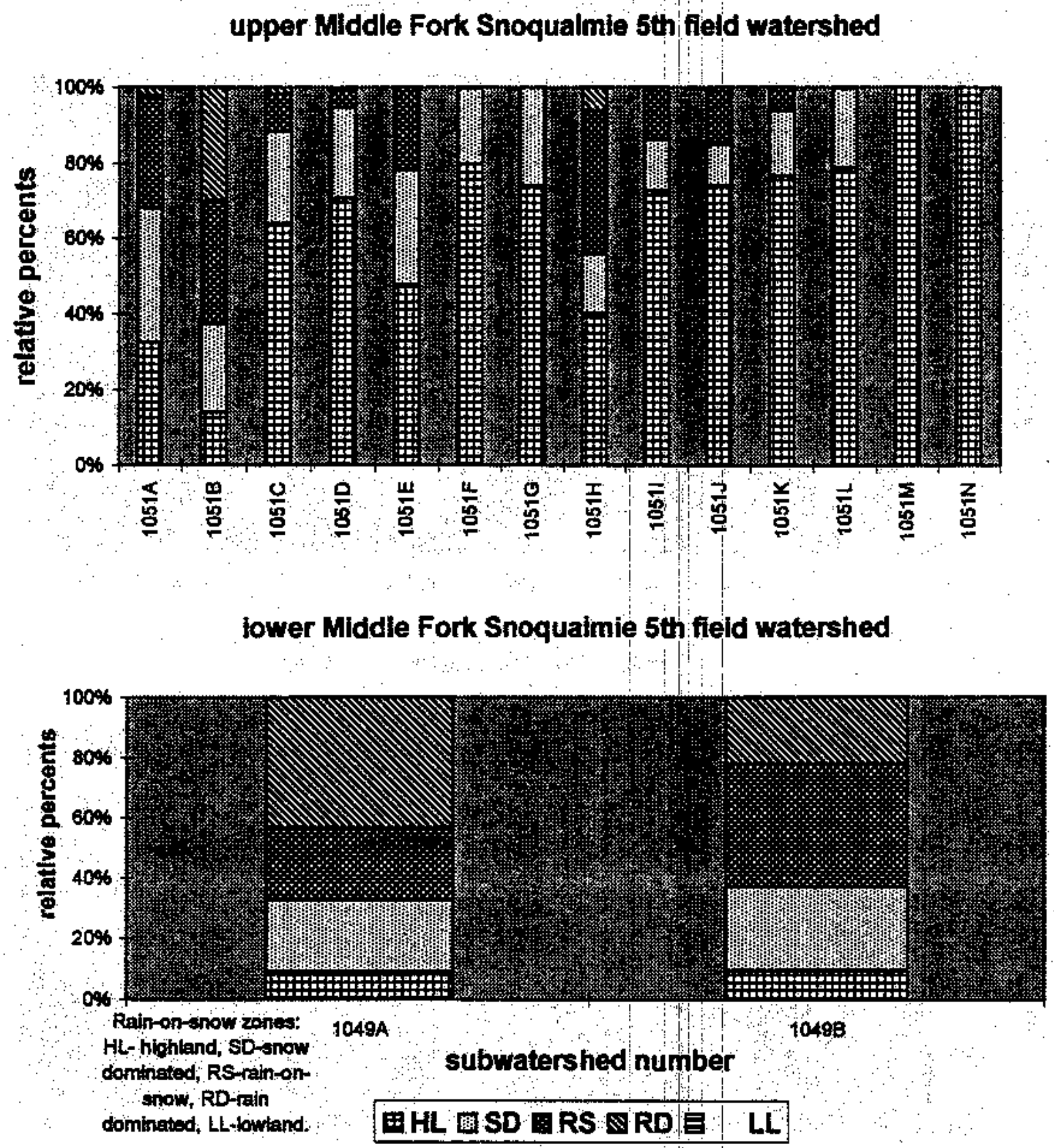


Figure 3.40 The relative areal percents for each of the rain-on-snow zones for each subwatershed within the Pratt and Taylor Watersheds.