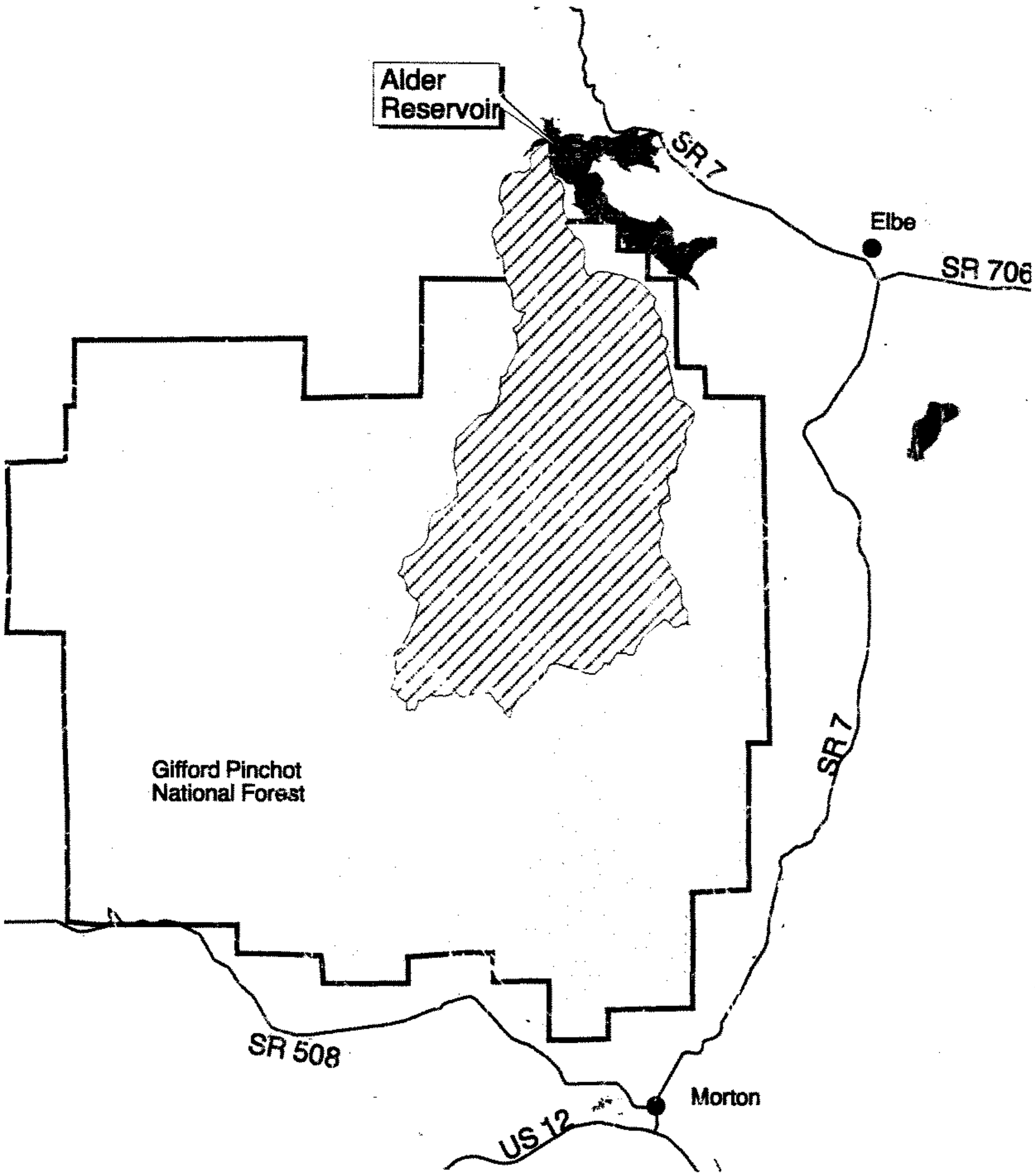
Little Nisqually Watershed Analysis



Gifford Pinchot National Forest
Cowlitz Valley Ranger District
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Chapter 1 - Overview

Introduction

Watershed analysis is an analytical tool designed to describe the biophysical processes and interactions that operate on a landscape at the watershed scale. The purpose of the analysis is to provide a scientific understanding of ecological processes that can be used to guide future management activities within the watershed. Management direction pertinent to conducting watershed analysis is found within the *Record of Decision for Amendments to Forest Service and Bureau of Land Management Planning Documents Within the Range of the Northern Spotted Owl* (USDA, USDI 1994).

Analysis Process

The process used to conduct the Little Nisqually Watershed Analysis is a synthesis of previous efforts that have been utilized on the Cowlitz Valley Ranger District. The key tasks involve, 1) identifying issues and questions that are relevant to key management objectives, 2) characterizing the historic and current condition of the watershed's physical, biological, and human elements, 3) determining trends based upon historic and current conditions, and 4) interpreting the results in the form of recommendations that are responsive to the key watershed processes identified.

Based upon the time frame given to complete the analysis, limited field data collection was gathered during the process. Data used in the analysis was collected during these limited field visits or extracted from existing sources. Data in the following chapters are presented for National Forest lands, unless otherwise noted. Although it is important to characterize the entire analysis area regardless of land ownership, in many cases only data for the National Forest portion was available. Data sources, data gaps, and any associated assumptions are noted at the beginning of each respective resource section in Chapter 3.

The information presented in this document may need periodic updating to reflect changing conditions and newly discovered information. An analysis file to track document edits will be on file in the planning department at the Cowlitz Valley Ranger District. A process for tracking and disseminating edits of these documents needs to be developed.

Watershed Overview

The Little Nisqually watershed encompasses 17,873 acres situated in and around the Little Nisqually River near Alder Reservoir and the town of Elbe, Washington (Map 1, Regional Vicinity). The northern portion of the watershed is bounded by Alder Reservoir while the southern boundary is defined by the boundary between the Tilton and Nisqually River Watersheds (Map 2, Local Vicinity and Ownership).

Because of the relatively small size of the Little Nisqually watershed, the descriptions, conclusions, and recommendations generally apply to the entire watershed, unless otherwise noted. Data for the watershed was collected and displayed for the entire watershed, land ownership or forest zones. The three sixth-field watersheds in the analysis area were named according to the primary aquatic feature they encompass and/or general location. Table 1-1 lists the three sixth-fields and associated aquatic features within the Little Nisqually watershed. See Map 3, Sixth-field Watershed Boundaries, for a display of their locations.

Table 1-1 : General Location of Sixth-field Watersheds

Sixth-field	Name	Other Aquatic Features
20Q	Little Nisqually River	Spencer Creek, Wildcat Creek
20R	West Fork Little Nisqually	Winston Creek, Lake Creek
20S	Hiawatha Creek	Trap Creek, Scatter Creek

The watershed consists of 15,879 acres of National Forest land, and 1,994 acres of private or other ownership lands (Table 1-2). Federal land holdings within the Little Nisqually watershed are part of the Mount Baker-Snoqualmie National Forest but are administered by the Gifford Pinchot National forest (Map 2, Local Vicinity and Ownership).

Table 1-2: Summary of Land Ownership Within Sixth-field Watersheds

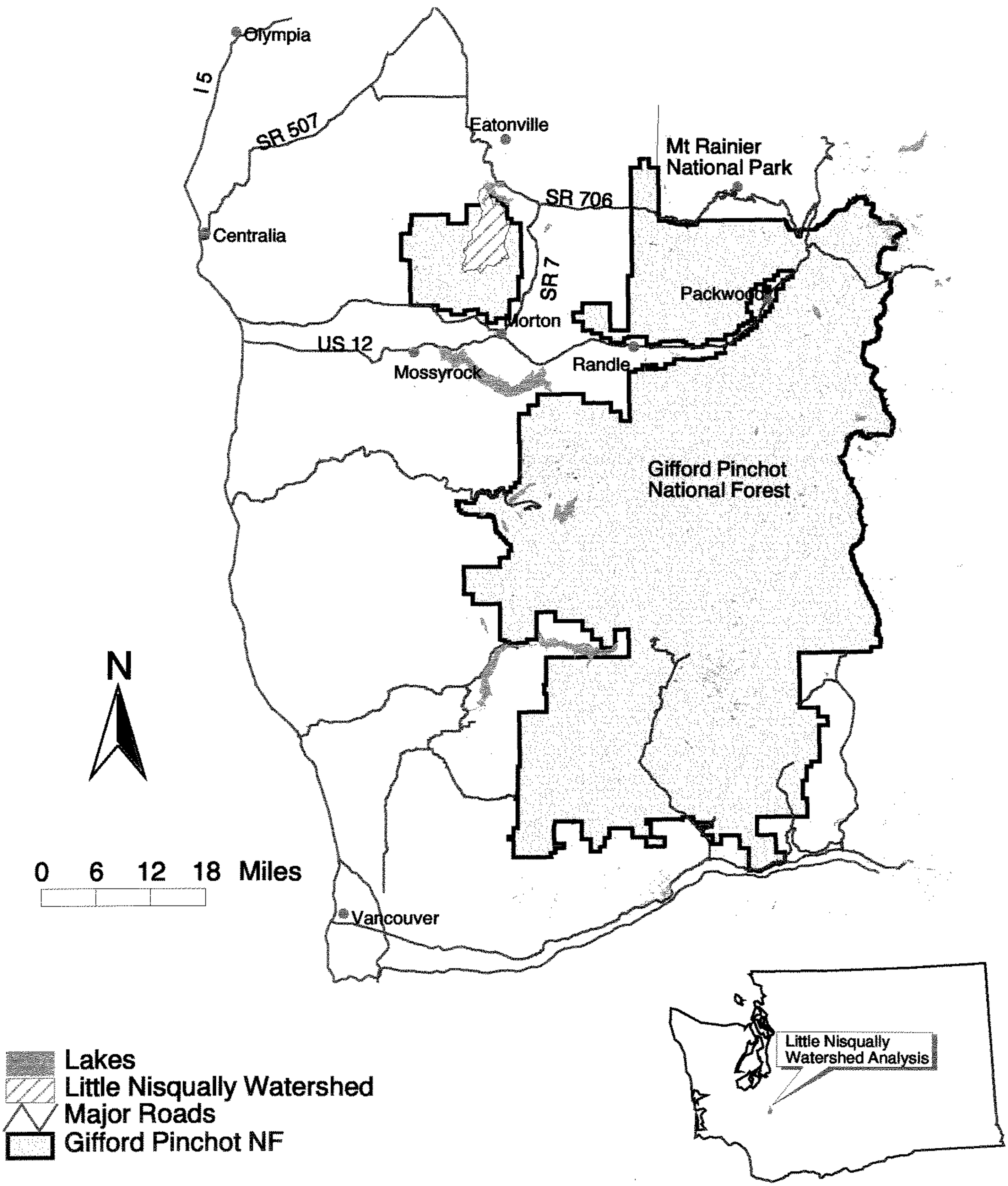
Sixth-field	Total Acres	Private Acres	% Private	USFS Acres	% USFS
20Q	7,232	1,562	22	5,670	88
20R	5,794	432	7	5,362	93
20S	4,847	0	0	4,847	100
Total	17,873	1,994	11	15,879	89

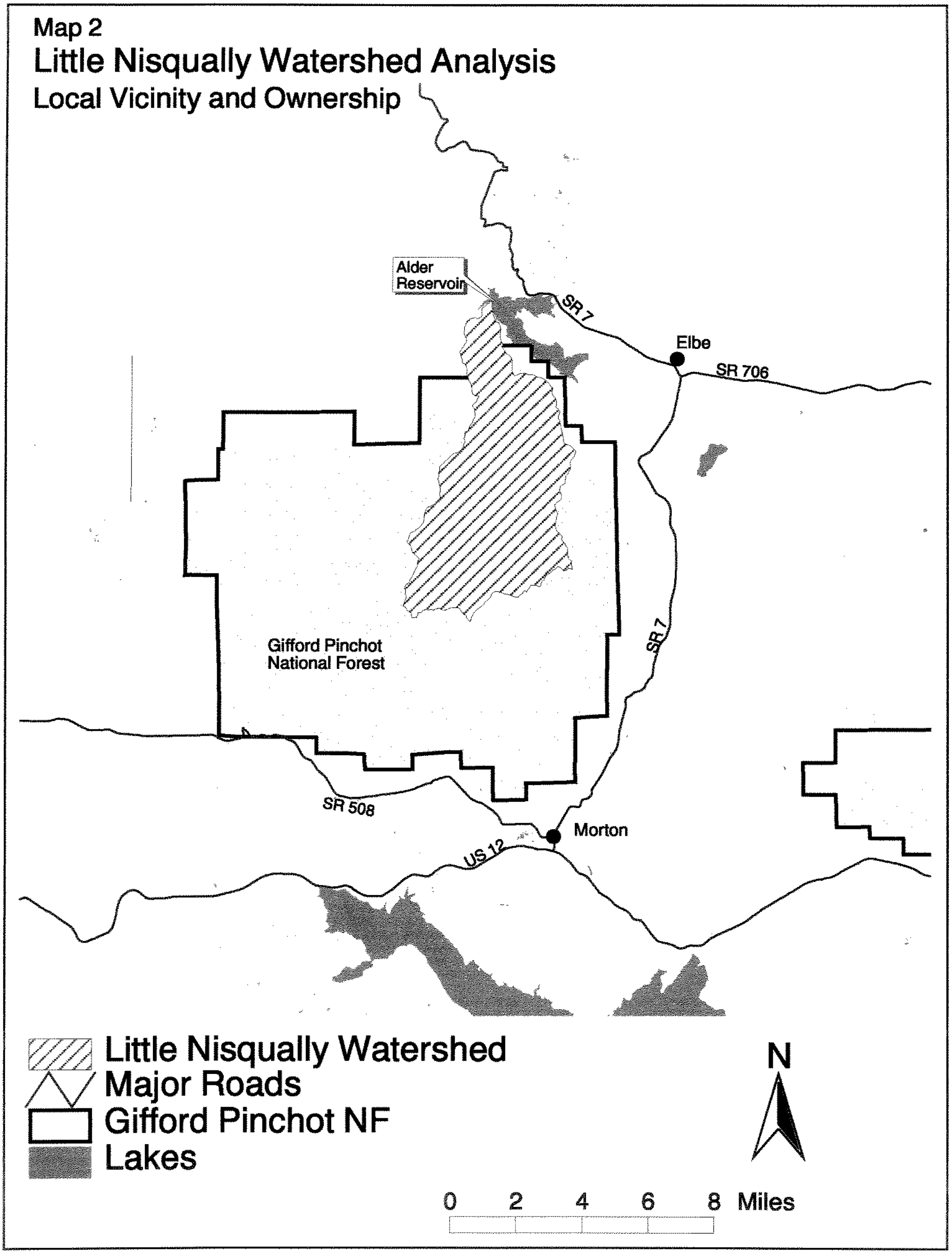
The major road through the watershed is Forest Road 74 (see Appendix A, Access and Travel Management (ATM) Plan for other roads within the Little Nisqually Watershed). Road 74

Map 1

Little Nisqually Watershed Analysis

Regional Vicinity

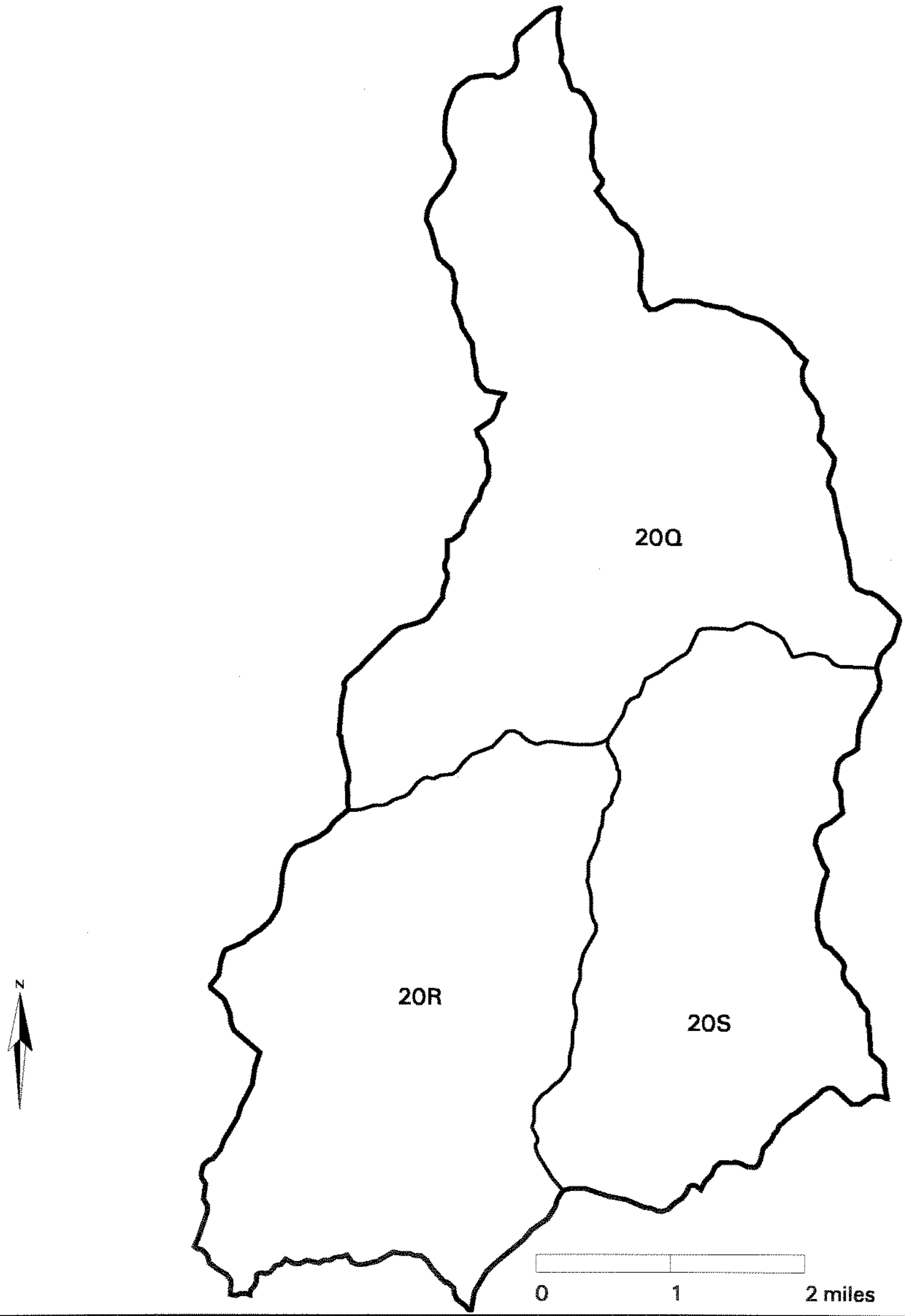



Map 2
Little Nisqually Watershed Analysis
Local Vicinity and Ownership
Alder
Reservoir
SR 7
Elbe
SR 706
SR 7
Gifford Pinchot
National Forest
SR 508
Morton
US 12
Little Nisqually Watershed
Major Roads
Gifford Pinchot NF
Lakes
N
0
2
4
6
8
Miles

Map 3

LITTLE NISQUALLY WATERSHED ANALYSIS

Sixth-Field Watershed Boundaries



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provides access to a few dispersed recreational sites and other destinations within the watershed. Other roads leading off of Road 74 connect to private road systems to the south and west of the watershed. Complete descriptions of the historic and current conditions for the major terrestrial, aquatic, and social elements found within the watershed are presented in Chapter 3 of this document.

Management Direction

Lands within the National Forest portion of the Little Nisqually watershed are managed according to direction provided by *Gifford Pinchot National Forest, Land and Resource Management Plan, Amendment 11* herein referred to as Amendment 11. This document combines direction from the *Gifford Pinchot National Forest Land and Resource Management Plan* (USDA 1990) and the *Record of Decision (*ROD*) for Amendments to Forest Service and Bureau of Land Management Planning Documents Within the Range of the Spotted Owl* (USDA, USDI 1994), herein referred to as the Northwest Forest Plan.

Management direction is applied to specific lands using the overlying direction from the 1994 Northwest Forest Plan and the underlying Management Area Category (MAC) direction of the 1990 GP Forest Plan. Amendment 11 documents the combination of these two levels of management direction.

Northwest Forest Plan

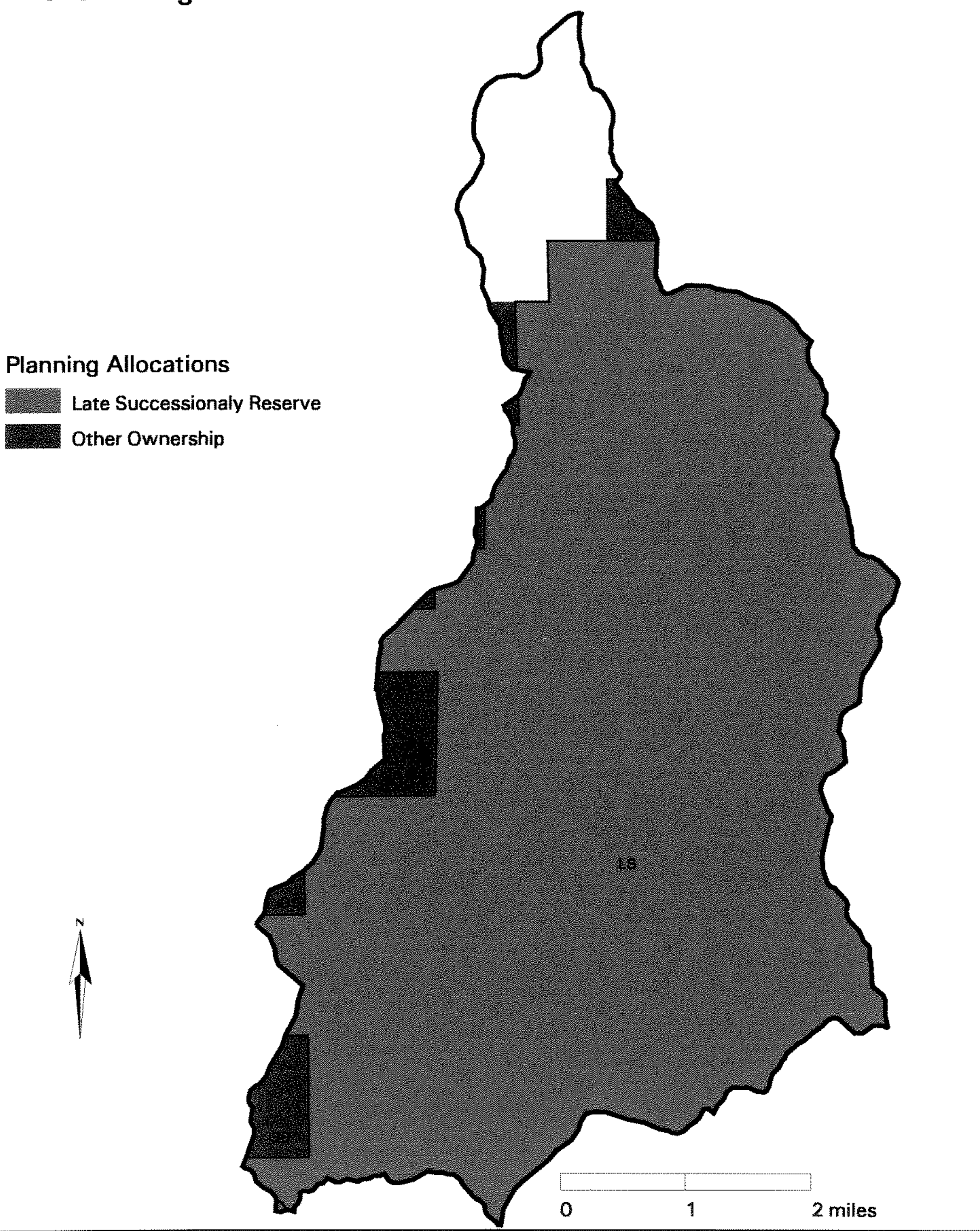
The Northwest Forest Plan designated all federally owned lands within the Little Nisqually watershed (Map 4, Land Management Allocations) as *Late-Successional Reserves* - lands where the objective is to protect and enhance conditions of late-successional and old-growth forest ecosystems. This corresponds to the *LS* Management Area Category described in Amendment 11, pages 5-31 and 5-32. For further information, see Amendment 11, Chapter 5.

Also included within the Late-Successional Reserves are *Riparian Reserves* - this allocation includes areas along streams, wetlands, ponds, lakes, and unstable and potentially unstable areas. Riparian Reserves are mapped overlaying all other allocations. Riparian dependent resources receive primary emphasis and special standards and guidelines apply (see Amendment 11, pages 2-4 to 2-10). Map 5, Riparian Reserves, displays the Riparian Reserves within the Little Nisqually watershed.

Map 4

LITTLE NISQUALLY WATERSHED ANALYSIS

Land Management Allocations



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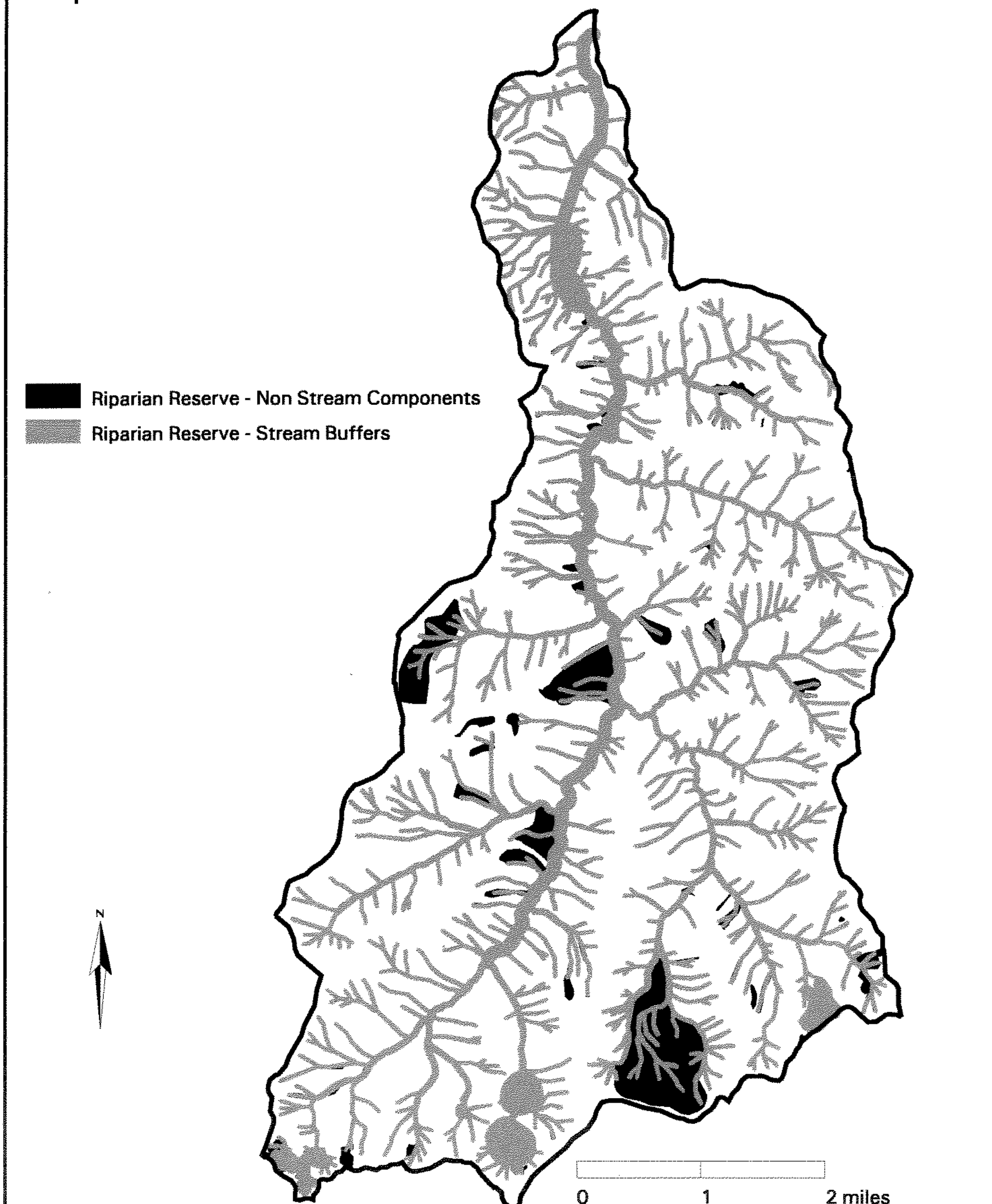
Map 5
LITTLE NISQUALLY WATERSHED ANALYSIS
Riparian Reserves



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Chapter 2 - Issues and Key Questions

Within any given area there are many issues that must be considered prior to the implementation of management activities. The following list of issues and associated questions focuses this analysis on issues that were deemed most pertinent to management within the Little Nisqually watershed. The issues and key management questions were developed by the interdisciplinary team in association with the line officer on the Cowlitz Valley Ranger District. The analysis questions represent the fundamental information necessary to answer the key management questions. This document does not contain enumerated answers to all the questions listed below. Rather, answers are provided throughout chapters 3-6 in the form of narratives, tables, and ratings.

Issue 1 - Water Quality and Quantity

The water quality/quantity issue being addressed is whether changes to vegetation, soils, and aquatic features in the Little Nisqually watershed are having notable or cumulative effects on water quality and quantity. Resources and processes relevant to evaluating these conditions include channel migration and widening, presence of amphibians, condition of fish habitat, amount and frequency of soil disturbance, rates of human-caused sediment input as compared to natural rates, and continuity of late-structural forest in riparian areas.

Water Quality and Quantity - Key Management Questions

- Do existing conditions (including natural or human-caused cumulative effects) meet USFWS and ACS objectives in the watershed?
- Which roads, sideslopes, stream crossings, and riparian areas have restoration needs?
- Where is restoration of streams and aquatic refugia needed to improve aquatic habitat?

Water Quality and Quantity - Analysis Questions

- What is the extent of past road construction and use of stream crossings, campsites, diking, channelization, and floodplain isolation in Riparian Reserves?
- Are road crossings affecting the distribution and populations of aquatic species?
- Have road densities within the watershed affected peak flows or sediment delivery? What were historical peak flows?

- What is the history of flooding and measured changes in peak flows, and what is the influence of land use on water available for runoff?

- Have management activities caused or contributed to increased peak flows at the watershed level?

- What type of stream channels exist in the watershed?

- Does upslope delivery to stream channels exceed the ability of the stream channel to route the sediment through the system?

- How have stream channels or lakes changed from historic/reference (ca. 1900) conditions?

- Have management activities caused or contributed to mass wasting or surface erosion? Where are there opportunities to correct these occurrences?

- How does natural sediment delivered to streams compare to increased sedimentation caused by management activities?

- What are the dominant stream channel types that exist within the watershed and habitat-forming processes that occur in the channel network?

- Are there any known water quality problems such as temperature or turbidity?

- Has the function and condition of floodplains in the watershed been altered by management activities? If so, how?

Issue 2 - Economic Outputs (Recreation, Mining, Fish and Wildlife, etc.)

The issue of economic outputs from the Little Nisqually watershed is analyzed in the context of the sensitivity of resources that support economic demands. Water quality conditions, existence of TES species, amount and distribution of forest vegetation structural stages, and the ability of the ecosystem to function normally will be evaluated with respect to their effects on economic outputs (potential vegetation management, recreational activities, mining activities, fishing, hunting, wildlife viewing etc.)

Economic Outputs - Key Management Questions

- Where and under what circumstances is stocking manipulation, precommercial and commercial thinning appropriate?
- Are there sensitive habitats within the watershed which may be adversely affected by vegetation management or other activities? Where are they?
- What standards should be developed for human uses in Riparian Reserves?
- What human uses and/or dispersed sites are preventing attainment of ACS objectives?
- Is the lack of developed, managed recreation facilities in this area appropriate? Is development warranted?
- Is additional management attention warranted for ongoing activities?
- What role does the area play in meeting overall District recreation management objectives?
- What is the current Road Plan (Access and Travel Management Plan) for the area and how does it apply to project proposals?
- Are there any opportunities to improve habitat conditions for fish and wildlife?

Economic Outputs - Analysis Questions

- What is the current distribution and amount of forest vegetation structural stages?
- How has the distribution and amount of forest structural stages changed over time?
- What changes have occurred to forest structural stages and their spatial and temporal distribution as a result of past management activities?
- What is the distribution and amount of non-forest vegetation and non-vegetated areas?
- What is the distribution and size of the forest vegetation zones?

- What is the contribution of recreation activities to the local and regional economy?

- How much and what kinds of human use is occurring in the watershed and what are the trends?

- What special forest products occur within the watershed? What is the current use of these products? How will management activities affect special forest products or use of them?

- What are the kinds of recreation use and numbers of users in the area?

- What social and resource impacts are occurring as a result of unmanaged and illegal uses?

- What is the cost of mitigating impacts of unmanaged and illegal uses or activities?

- What are the alternatives for addressing impacts of recreation and illegal uses with increased management attention?

- What is the contribution of recreation activities to the local and regional economy?

Issue 3 - TES and S&M Plant and Animal Species

The issue to be addressed by this analysis is to determine whether changes to vegetation, soils, and aquatic features in the Little Nisqually watershed are having cumulative impacts on habitat for TES and S&M species. Resources and processes relevant to evaluating these conditions include population levels, habitat distribution and use, vegetative diversity and continuity, and riparian conditions.

TES and S&M Plant and Animal Species - Key Management Question

- Are habitats for TES and S&M species adequately protected under GP Forest Plan and *Northwest Forest Plan* standards and guidelines?

TES and S&M Plant and Animal Species - Analysis Questions

- What are the known and suspected TES and S&M species within the watershed?

- Where are suitable habitats present for TES and S&M species in the watershed?

- How does the current condition of these habitats affect species viability?
- How much nesting, roosting, foraging, and dispersal habitat exists for northern spotted owls, and what is its condition?
- How well are late-structural habitats linked within the watershed?
- What are the road densities within the watershed and how do they affect big game, TES and S&M species?
- What is the current level of coarse woody debris and snags in the uplands?
- How much spawning and rearing habitat exists for TES fish species?
- Are there current or anticipated human activities that may affect TES and S&M plant and animal species?

Issue 4 - Ecosystem Function

One of the primary issues affecting forest land managers is the necessity of maintaining a properly functioning, self-sustaining ecosystem. This includes ensuring that all native plant and animal species are retained, distribution of the species is adequate, and suitable habitat is abundant enough to maintain populations across the landscape. The issue to be addressed by this analysis is to determine the role of this watershed as it fits into the larger landscape and whether impacts to vegetation, soils, and aquatic features in the Little Nisqually watershed are having notable or cumulative effects on overall ecosystem functions. Resources and processes relevant to evaluating these conditions include changes in aquatic condition, loss of populations, presence of riparian and overland migration corridors, amount and frequency of soil disturbance, continuity of late-structural forest in riparian areas, and rates of human-caused sediment input.

Ecosystem Function - Key Management Questions

- What are the unique ecological functions of National Forest lands in the context of the Southwest Washington Province?

- Which riparian corridors may be adversely affected by human use such as road construction and recreational activities?

- What are the necessary riparian reserve widths needed to maintain or restore ecosystem function?

Ecosystem Function - Analysis Questions

- How does the existing landscape pattern compare to the historic/reference (ca. 1900) landscape pattern with regard to forest vegetation patch size, shape, spatial arrangement and connectivity?

- Have any plant or animal species been lost from this watershed? If so, what was the cause?

- Have any non-native or exotic plant or animal species become established within the watershed? If so, what is the cause?

- What proportion of the watershed falls within the various riparian reserve types (wetlands, streams, and unstable areas)?

- What are the natural limiting factors and processes related to attainment and maintenance of healthy riparian areas throughout time?

- Where are areas of key aquatic habitat in need of protection?

- Has channel widening occurred and if so, what are the contributing factors?

- What past natural conditions would suggest a need for standards and guidelines beyond current direction?

- Where is there evidence of dam-break floods and debris flows within the watershed?

- Are changes in the sediment regime apparent in this watershed, and if so what effect does this have on ecosystem function?

- What are the landscape conditions on adjacent private lands?

- How are existing conditions on private lands affecting resources within the National Forest portion of the watershed? How could future management of these adjacent lands affect resources within the National Forest portion of the watershed?

- Within the riparian corridors, what is the degree of canopy closure, large woody debris recruitment, shading, and stream bank stability? How do these factors relate to attainment and maintenance of healthy riparian areas through time?

- What is the current distribution of structural stages within riparian corridors, and how does this compare to historic or reference conditions?

- Currently, how well are riparian corridors functioning with regard to connectivity of late-successional refugia and Late Successional Reserves?

- Are there any vegetative health concerns within the watershed?

- Are there current or anticipated human activities that may affect ecosystem function?

Chapter 3 - Historic and Current Conditions

Introduction

The purpose of this chapter is to describe what we currently know about the historic and current conditions of the various physical, biological, and social components of the watershed. In previous watershed analyses, the difference between historic and current conditions has been used synonymously with the concept of a "range of natural variability". In most cases, we do not have sufficient data to accurately describe a "historic" condition for the entire watershed. Thus, it would be erroneous to conclude that these differences constitute the "range of natural variability". Landres, et al. (1997) states that "natural variability is a complex temporal and spatial property of all ecosystems that is best described with several metrics, not just range."

What we do have, and present in this document, are scattered historic data for small areas, small pieces of the puzzle or discreet snapshots in time, that are better described as "reference" conditions. The historic or reference data are compared to the current condition to determine trends within the watershed. Our understanding of these trends allows us to prescribe appropriate management activities within the watershed that are designed to lead us toward desired future conditions.

Reference (historic) and current conditions are presented for the major terrestrial, aquatic, and social elements of the Little Nisqually watershed in the following narratives. Each topic begins with a statement of the data sources used, data gaps, and any major assumptions that are important to the interpretation of the data.

SOCIAL ELEMENTS

Past Human Uses

Data Sources

Information on past human use of the analysis area was obtained from reference material on file with the Heritage Program, Gifford Pinchot National Forest. Descriptions of prehistoric human use are based on the interpretation of archaeological data from sites within the Little Nisqually River study area, but necessarily draw upon studies developed for other sites in the adjacent watersheds. The summary of prehistoric land use is based on the recent regional model developed by Greg Burtchard (1998) as a part of his study for Mount Rainier National Park.

Data on historic non-native use comes from a variety of archival source material also on file with the Heritage Program, including historical records, maps, and atlases summarizing Forest Service management activities.

Prehistoric Land Use Patterns

Early Prehistoric Period: ca. 7,000 to 3,500 years ago

Archaeological evidence from sites in the southern Washington Cascade mountains suggests that initial human use of the area began around 7,000 years ago. Early residents of the area likely employed foraging subsistence strategies that required frequent shifts in residence and a broad-based economy. During the initial period of human occupation, hunting and gathering would have involved daily forays from camp to obtain food on an ``encounter basis'." Little use was made of storage technology. As resources close to camps were exhausted, camp locations were moved. Some subsistence activities were probably planned around locally abundant resources. Archaeological data from the local area have provided little information regarding social or political organization, beliefs, cultural affiliation, or the structure of the settlement system.

Faunal remains from Early Period occupations indicate that deer and salmonids were probably the most important sources of food to early peoples. Anadromous fish runs within the Nisqually watershed were impeded by falls lower on the river. Elk, mountain sheep, snowshoe hare, mountain beaver, and grouse were also hunted or caught during this time period. Archaeobotanical remains from two sites suggest that elderberries and hazelnuts were gathered locally, and huckleberries were also collected by Early Period people. Samples from Layser Cave, in the Cowlitz River watershed, suggest higher frequencies of xeric flora, such as oak, existed during this period, a trend also apparent in the results of local pollen studies (Barnosky 1981).

Early period people engaged in trade with groups from outside the area. Exotic materials found within the area include clamshell and Olivella beads, indicating a trade network with coastal groups. Obsidian stone from Oregon sources suggests a southern network of exchange that may have involved contact with lower Cowlitz River, Columbia River, or Portland Basin groups. The distribution of toolstone materials in local archaeological sites indicates that local bands - groups living within the analysis area - ranged as far east as the crest of the Cascade Range during annual subsistence forays.

Middle Prehistoric Period: ca. 3,500 to 1,500 years ago

With the onset of Mount St. Helens' Smith Creek Eruptive Phase 3,900 to 3,500 years ago, some areas of the southern Washington Cascades may have been temporarily abandoned. The sequence of radiocarbon dates for archaeological sites in the upper Cowlitz basin shows a hiatus in occupation that lasted for nearly 2,000 years. Studies by Mullineaux (1996) and others demonstrate that the thickest tephra deposition was directly downwind from the eruption in northeast direction from Mount St. Helens. Archaeological sites within the Little Nisqually River watershed, however, lack the deposits of the Smith Creek (set Y) pumice so common in soil profiles within the upper Cowlitz Valley. One of the sites within the analysis area produced a radiocarbon date of 2,240 years BP (300 BC), suggesting that areas peripheral to the zone of heavy tephra deposition were reoccupied somewhat earlier than those in the area of greatest impact.

A regional shift toward increased sedentism occurred between 5,000 and 2,500 years ago. Groups that used the analysis area during this time period are thought to have used a strategy incorporating logistically-organized collection, processing, and storage of key resources. These developments may have given rise to the development of semi-permanent winter villages not unlike those used by native groups in the historic period.

Late Prehistoric Period: ca. 1,500 to 150 years ago

Throughout the Northwest, prehistoric populations peaked during this time period. Some researchers have suggested that the density of human populations was reaching environmental carrying capacity. Possible responses were greater emphasis on the collection of more ``marginal" resources - those requiring greater energy expenditure for return. Late Period people appear to have exploited a greater variety of environments than had the earlier culture. People continued to use sites frequented during the Early and Middle Periods, also establishing camps and settlements in new locations.

Historic Native Americans

No specific ethnographic or ethnohistoric references to traditional use of the Little Nisqually watershed were found during the research for this analysis document. Ethnographic and historic source data indicate that during the middle of the 19th century the Little Nisqually River area was considered within the territory of the Nisqually, Southern Coast Salish speakers of the Southern Lushootseed language. The Medicine Creek Treaty of 1854 describes the area as part of the lands ceded to the Federal government by the Nisqually. More specifically, the area is also described as part of the homeland of the Meshal or Mishalpam, an autonomous band centered at the village of Meshal, approximately 6-7 km north of the Little Nisqually River. According to Smith (1940:13), this group was bilingual, including Sahaptin as well as Lushootseed speakers.

The area to the immediate south of the Little Nisqually River headwaters was traditional territory of the Taidnapam, or Upper Cowlitz, people. Their closest village was Wa-sa, located near the city of Morton, approximately 10-12 km southeast of the analysis area. The Taidnapam were Sahaptin speakers living along the Cowlitz River and larger tributaries east of Mossyrock. Several references indicate their familiarity with mountain areas, including the high country north of the Tilton River. Because they considered watershed boundaries as joint use areas, it is likely that the peaks and ridgelines at the headwaters of the Little Nisqually were visited by Taidnapam as well as Meshal people.

General information on Nisqually/Puyallup resource use of mountain areas was examined to determine possible Meshal relationships with the watershed analysis area. A review of traditional subsistence practices suggests that huckleberries (Vaccinium sp.) ranked high among resources gathered for storage. Smith (1940:248) reports that ``Long trips were made by inland groups. . . to obtain the mountain huckleberry which grew in the foothills and on up into the mountains." Huckleberries were dried on racks covered with a plaited screen of cedar bark strips. A fire was built beneath the rack. Dried berries were transferred to baskets for transport and storage in the home. To ensure a continuous food supply, Nisqually groups sometimes burned over berry fields (1940:273).

Data pertaining to Taidnapam use of the mountains is more extensive. Mountain areas were clearly destination points in the seasonal round, and family camps were established in late summer specifically for berry picking. Three species of huckleberries, Vaccinium deliciosum, V. membranaceum, and V. ovalifolium, which occur most abundantly between 915 m and 1,520 m in elevation, were preferred (Smith 1964). Huckleberry gathering was usually done by the women and children. Berries were pressed into cakes or dried to a raisin-like form on mats laid atop wooden racks or directly on the ground. The Taidnapam purposefully set fires to promote productivity of huckleberries in mountain locations (Kiona 1964, 1965).

The Taidnapam also hunted game in the mountains. Deer, elk, bear, and mountain goats were hunted by the men when family groups were camped in the mountains for berry picking. The bow and arrow was the principal hunting weapon for larger game. The use of dogs in fall/winter elk hunting is indicated by Curtis (1913). Deer, elk, and mountain goat meat was dried in the sun on wooden racks, sometimes over smoky fires, as a means of preservation. Smaller game obtained by the Taidnapam include mountain beaver, marmot, and grouse (Kiona 1964; Smith 1964). Grouse were probably obtained during the late summer when they congregate in huckleberry patches.

Traditional use of mountain areas declined following the effects of non-native settlement in the region. Epidemics of malaria in the 1830's measles in 1848, and smallpox in 1853 contributed to substantial population loss. In 1856, during the Northwest Indian Wars, Mashel villagers were massacred by a battalion of Washington Volunteers under the command of Major H. J. Maxon (Emmons 1965). These factors, along with the influx of new settlers and the establishment of Indian Reservations, led to relocation for many remaining Native people. By the 1880's only a few Taidnapam families continued to live in the Morton area. People with Mashel affiliation had moved to the Nisqually or Yakama Indian Reservations.

Historic Period Land Use Patterns

A significant shift in human land use occurred between 1880 and 1890. It was during this decade that the cultural composition of the upper Nisqually area changed from an indigenous population to one of English -speaking immigrants. These new settlers brought with them the traditions of agricultural subsistence, property ownership, and the desire to become part of a regional market economy.

Administration of Federal Forest Lands

Federal lands in the analysis area were part of a 1906 addition to Rainier National Forest. Known as the Ashford, or Mineral Addition, the area was initially administered as a part of the Nisqually District. William A. McCullough was District Ranger at the time, and his home near Ashford served as his district headquarters. From 1913 to 1922 the Ashford Addition was administered separately as the Tilton District. For several years, the small district was administered from an office in Morton, later moving to Mineral. From 1922 until 1934, when a ranger station was built by Civilian Conservation Corps construction crews, the Mineral Ranger District was administered from the home of the District Ranger.

When Rainier National Forest was dissolved in 1933, Mineral District became part of Snoqualmie National Forest. In 1969, Mineral District was disbanded, and administration of the area transferred to Gifford Pinchot National Forest.

Land management activities during the early period of Forest Service administration were oriented toward the protection of forest resources. Historians characterize this as a period of ``custodial" resource management. It was during this period that trails were constructed within the Little Nisqually River watershed to access the interior of the Mineral Block from the north. Fire patrols and lookout stations were established for fire detection. The first fire lookout within the Mineral District was also built during this early period of administration. Rockies Lookout was built in 1922 on The Rockies, highest point within the analysis area. Stahl Mountain Lookout was built later.

Heritage Resources

Evidence of past human use in the study area exists in the form of prehistoric and historic archaeological sites and features, and historic landscapes. Heritage resources are documented through the process of cultural resource inventory by field surveys for specific land management activities. Since 1975, 18 survey projects covering over 6000 acres over have been conducted within the analysis area, most in conjunction with the timber sale program for the Randle Ranger District. A total of 6 cultural resource sites have been identified within the analysis area as a result of these surveys.

Portions of several historic trails have been identified during cultural resource surveys, including the Cougar Mountain Way Trail. Part of the Stahl Mountain Trail (#288) is still maintained.

Three prehistoric archaeological sites have been recorded on National Forest lands within the analysis area . The sites represent occupation by Native American peoples from ca. 4000 B.C. to the historic period. All of the sites are subsurface lithic scatters located at higher elevations within the study area. Additional, as yet undocumented sites likely exist throughout the analysis area.

Human Ecology and Ecosystems Management

Comparing the reference (historic) and current conditions, the most obvious changes in human land use relate to the differences between traditional Native American resource orientation and that of 20th century Euroamerican culture. The subsistence economy of 200 years ago limited human populations to sustainable levels within the overall upper Nisqually River watershed ecosystem. As the ethnic composition of the area changed in the late 19th century, the structure of the economy shifted toward greater reliance on a regional market economy. As different resources were exploited by non-native residents, the entire relationship to the local ecosystem changed radically, both in terms of land use patterns and the types of resources extracted from the environment.

Historic shifts in local land use practices and the resource demands of an increasing regional population probably resulted in changes to the distributions of specific plant communities in the analysis area. After 1906, the occurrence and spread of natural fire (lightning strikes) was almost completely eliminated through the protective efforts of the Forest Service. Native American burning to promote huckleberry productivity also ceased. By comparing 1930's panoramic photographs taken from the summits of Stahl Mountain and The Rockies with modern views, we can infer an overall reduction in fire sere communities. The change is apparent in the growth of trees along the ridges in the watershed.

The historic landscape included ridges that were undoubtedly more open, supporting plant communities that were dominated by big huckleberry (Vaccinium membranaceum) or Alaska huckleberry (V. alaskense) and beargrass (Xerophyllum tenax). Existing older timber harvest openings within the analysis area frequently contain abundant huckleberry growth. The degree to which harvest openings have replaced burned over ground as ideal habitat for huckleberry growth is not known. Distribution, however, is more discontinuous than under historic conditions.

Recreational Uses

The watershed is a part of the Mineral Block, once a part of the Snoqualmie National Forest, now administered by the Gifford Pinchot National Forest. There are no developed recreation facilities or trails within the watershed and management presence is almost non-existent. Despite a fairly well-developed road system, much of the area is steep and inaccessible.

The area is relatively remote, a remoteness made more distinct by its separation from the rest of the Forest by 10-20 miles. Remoteness is further exaggerated by a road system in poor condition that limits access. Access roads are generally one-lane with turnouts, and frequently potholed, rutted, or damaged, or blocked by blowdown or slides. Brush is encroaching on most roads to the point that damage to vehicles is possible. They are not suitable for most recreation/tourist-oriented traffic, being more destination or activity oriented.

The area is moderately to highly roaded but relatively lightly harvested. Upper elevations and ridge tops provide spectacular views of the region. Recreation activities occurring in the area include specialized sight-seeing (high clearance vehicles highly recommended), dispersed fishing in streams and at Goose and Duck Lakes, hunting, and dispersed camping. Other known and suspected activities include garbage dumping, poaching, and other possible illegal activities that occur primarily because of remoteness, poor access, and lack of management presence.

Although we have little data on actual use of the area, we estimate that use is relatively low in comparison to the rest of the District, being limited by lack of facilities and poor access. Therefore, the area is not a high priority for investing the limited funds and staffing available for recreation management on the District. This situation is unlikely to change in the foreseeable future. Recreation management of this area is largely by reaction to significant problem situations when they are discovered. In general, the most significant problem situations that we are aware of are garbage dumping and littering in dispersed sites. Poaching is also considered to be a problem but is not addressed by recreation management.

Special Forest Products

Data Sources/Data Gaps

Information on the number of special forest product permits issued and the value of these products is summarized from information contained in the Cowlitz Valley Ranger District permit database. Only generalized information is known about where harvest is occurring on the district. This information is primarily from knowledge of where products grow, administration of Special Forest Product permits, law enforcement personnel and other forest users. The number of permits issued and amount of harvest specific to the Little Nisqually watershed is not known.

Assumptions

A permit is required to remove any product from National Forest lands. For purposes of this analysis, it is assumed that no illegal harvest is taking place. Estimates of the amounts of harvest are based on permit sales.

Reference (Historic) and Current Conditions

Special forest products have been gathered throughout the Cowlitz Valley Ranger District and the watershed for at least the last 6,000 years. There are a wide variety of special forest products which may be harvested. Many of the products collected are not site-specific (i.e., they are harvested over wide-ranging areas within the Gifford Pinchot National Forest).

In the past decade, demand for traditional and non-traditional products has increased substantially. Many native plants, including trees, shrubs, forbs and mosses are currently harvested. Plants such as salal, sword-fern, evergreen huckleberry and beargrass have increased in popularity as floral greens. Noble fir is popular for Christmas greens and boughs. Huckleberries, mushrooms and fiddlehead fern are collected for consumption. Medicinals and herbs harvested on the district include Pacific yew, cascara, devil's club, prince's pine and stinging nettle. Oregon grape, red alder and Western red cedar are commonly used for dyes. Unusual burls, conks, stumps, cones and twigs are gathered for decoratives.

There are four types of collection "allowed" on the forest:

1. Tribal Use: Traditional noncommercial gathering by Native Americans affiliated with a federally recognized tribe.

2. Incidental Use: On-site product consumption/use, usually associated with recreation activities.

3. Personal Use: Collection of materials for personal use/consumption, not for sale or resale after any intermediate processing.

4. Commercial Use: Collection of materials for the primary purpose of sale, resale, or use in a manufacturing process resulting in a finished product that will be sold.

A permit is required to remove all forest products other than edible berries from the Gifford Pinchot National Forest. Nearly 5,000 permits were issued in 1998 on the Cowlitz Valley Ranger District, yielding approximately $400,000 in revenues. In addition, nearly 1,000 free-use permits were issued with an estimated value of $10,000. A total of almost $500,000 worth of products were removed from the Cowlitz Valley Ranger District in 1998.

Tables 3-8 through 3-10 list the primary special forest products commonly harvested on the Cowlitz Valley Ranger District. Currently there are few special forest products offered for harvest within the Little Nisqually watershed due to the checkerboard ownership in the Mineral area and lack of funds to administer permits. Currently, due to the location of this watershed to urban areas, there is a high rate of theft of special forest products as well as a number of other illegal activities. In response to the high theft rate and private ownership, special forest products will be offered by contract for commercial use only in 1999. Estimates of the amounts of harvest are based on permit sales. Most permits are sold on a per-day basis. Markets and weather conditions dictate the demand for permits to harvest these products.

Table 3-1: Commercial Use Special Forest Products - Primary Products Harvested on the Cowlitz Valley Ranger District

Product	Permits Issued (1998)	Year Permits First Issued	$ Value	Elevation Typically Found
Mushrooms	640	1991	$26,699	< 3,000 ft
Beargrass	841	1989*	$41,672	> 3,000 ft
Salal	680	1989*	$35,180	< 2,500 ft
Stewardship/ Boughs	16	1989*	$179,403	> 3,000 ft
Ferns	112	1989*	$2,250	< 1,500 ft

Table 3-1: Commercial Use Special Forest Products - Primary Products Harvested on the Cowlitz Valley Ranger District				
Product	**Permits Issued (1998)**	**Year Permits First Issued**	**$ Value**	**Elevation Typically Found**
Moss	20	1989*	$480	Restricted to Timber sale areas

** First year data was recorded*

Table 3-2: Personal Use Special Forest Products - Primary Products Harvested on the Cowlitz Valley Ranger District				
Product	**Permits Issued (1998)**	**Year Permits First Issued**	**$ Value**	**Elevation Typically Found**
Christmas Trees	1,560	1989*	$7,800	2,000 - 4,000 ft
Firewood	762	1989*	$9,340	1,000 - 4,500 ft

** First year data was recorded*

Table 3-3: Free-Use* Special Forest Products - Primary Products Harvested on the Cowlitz Valley Ranger District			
Product	**Permits Issued (1998)**	**Year Permits First Issued**	**$ Value**
Mushrooms	700	1991	$7,000
Transplants	67	1989**	$1,340
Cuttings	31	1989**	$140

** Free-Use means no fee for the permit*
*** First year data was recorded*

Forest management activities affect availability and distribution of special forest products. The effects of management activities depend on site treatment. For example, Chantrelle mushrooms often take 20 to 30 years to return in abundance following stand treatments such as regeneration harvest or burning. Special forest product harvest can also benefit forest management goals. For example, the fungus that produces Chantrelles forms mycorrhizal relationships with trees that benefit the growth of trees by providing nutrients for the trees in forms that are easy to utilize. In addition, pruning white pine boughs may significantly reduce mortality form white pine blister rust.

Road access is a key factor in determining where forest products are harvested. Gatherers will walk to harvest products, but prefer not to carry forest products to a road. Harvesters often have to carry products a couple of miles out of the forest to a road. All Terrain Vehicles (ATV's) are used where roads are not passable to standard passenger vehicles or pickups.

Lands, Minerals and Special Uses

Mining Activities Assessment

Data Sources/Data Gaps

Locatable Minerals - The primary data source for mining activities for locatable minerals (those minerals subject to the U.S. Mining Laws of 1872 and all related subsequent legislation) is the current (9/96) USDI, Bureau of Land Management, Geographic Claims Listing for unpatented mining claims recorded with the BLM's mining claims office in Portland, OR. Although BLM's listings can sometimes be up to 6 months old, the current claims listing for the WA area is typical for activities in the WA area during the last several years; i.e. public records of active claims indicate little if any current mining activities. While the Forest Service also deals with owners of claims not filed with BLM, few reports of such claims have been received by the Cowlitz Valley District.

Leasable Minerals - The primary data source for leasable minerals is District, Forest and BLM files. Exploration for and development of these minerals on National Forest lands are subject to issuance and administration of leases by the U.S. Department of the Interior, pursuant to the Mineral Leasing Acts of 1920 and 1947. Under the 1920 Act, the Forest Service has no statutory responsibility for issuance or administration of such permits or leases. The Forest Service is, however, authorized to make such rules and regulations as are needed to govern the occupancy and use of National Forest lands. By agreement with the Department of the Interior, the Forest Service does review permit and lease applications, and does make recommendations for the protection of National Forest surface resources, and for prevention of conflicts with other activities, plans and programs of the Service and other users. Although not required by statute, the Department of Interior normally accepts Forest Service recommendations regarding public domain leasable materials. Where leasable minerals are part of a mineral estate acquired by the Government (through land exchange, purchase, etc.), the 1947 Act requires that there be Forest Service consent to such leases and permits, and the Forest Service may specify the terms and conditions under which such leases may be issued, in order to protect surface resources and prevent conflict with agency programs and uses by others.

Reference and Current Conditions - Mining, Locatable Minerals

The areas encompassed by the Cowlitz Valley Ranger District, which include the WA area, have been open to mineral exploration for better than a century. Where areas with mineral deposits of commercial potential were found long ago, interest in same on the part of mineral prospectors has continued unabated to the present. Based upon a review of District and BLM records, the WA area is not an area where there has historically been, nor would there likely be, extensive interest in mineral prospecting and development for locatable minerals. Within this WA area we might expect to see an occasional filing of a mining claim for a minor amount of exploration at the pick, shovel, panning and maybe suction dredging levels. Add to the latter activities very minor amounts of recreational gold panning and suction dredging not associated with formal mining claims.

Reference and Current Conditions - Mining, Leasable Minerals

In February 1997, ten-year leases for oil and gas exploration on three sections 1/ of National Forest lands within the WA, were issued to a private firm by the U.S. Department of Interior, Bureau of Land Management. Due to potential resource concerns, and a lack of Forest funding at that time to complete the evaluation of such concerns vis-a-vis proposed exploratory drilling for gas, it was the recommendation of the Forest that such leases be issued with a stipulation that there be no surface occupancy of National Forest lands. Initial drilling by the firm mentioned above began on private lands just north of the Town of Morton in late 1996. In January of 1997, these drilling operations were curtailed. There has been no further exploration activity.

1/ Sections 24 and 36 of T.14N., R.3E., and Section 26 of T.14N., R.4E.

Interpretations/Areas of Concern - Mining

While the apparent level of mining activities in this WA area is minimal, mining is a legitimate activity on National Forest lands, as recognized by a century and-a-quarter of Federal mining laws. Proposed mining activities are not discretionary; i.e. the Forest Service cannot choose to defer consideration of a mining proposal, as it could an application for a Special Use Permit. As they occur, mining proposals are matters that the Forest Service must deal with. The Forest Service's function is to evaluate a mining proposal pursuant to all pertinent Federal laws and regulations, and to help shape resulting on-the-ground operations pursuant to same.

Special Uses Assessment

Data Sources/Data Gaps

All private uses of National Forest lands, except for common recreational uses such as camping, hiking, fishing, etc., timber harvest, grazing and mining, require prior authorization through a Special Use Permit. The primary data sources for special use authorizations within the WA area are the Cowlitz Valley District's special use files.

Reference and Current Conditions - Special Uses

A review of District files indicates only one type of special use authorizations of relevance to watershed analysis; i.e. private uses of National Forest roads. There are some special one-of-a-kind permitted activities as well.

Private Uses of National Forest Roads

Existing National Forest roads within the WA area provide owner access to privately and State-owned lands located within or adjacent to the National Forest. These are primarily industrial forest holdings. By various Federal laws, the Forest Service must grant access across National Forest lands to an owner of such private lands, when the most reasonable access route to the owner's land is across the National Forest and/or along National Forest roads. Some access authorizations in the WA area have been granted through permits. Numerous roads within the WA area are jointly owned by the U.S. Government and the Weyerhaeuser Company pursuant to long-standing, formal, road right-of-way construction and use (cost share) agreements. Through such cooperative road construction and ownership, both the Government and the Weyerhaeuser Company have exchanged easements so that a road system that serves their intermixed ownerships could be developed and (currently) maintained. For some years now, activities under these cost-share agreements have been primarily maintenance and repair-related.

Miscellaneous other Special Uses - Holders of Special Use Permits for outfitter/guide and apiary (bee keeping) activities have also, in the past, used various roads in the WA area for access to trailhead and hive placement sites. Occasionally, permits are granted for the use of National Forest trees as tailholds or guyline anchors for logging operations on adjacent private lands.

Interpretations/Areas of Concern - Special Uses

Private Use of National Forest Roads - The Forest Service, by law, must allow access across National Forest lands for the benefit of adjacent private lands, when such access across the National Forest is reasonable.

Road Maintenance and Repair Activities - The activities as described above could be on-going.

Lands Assessment

Data Sources/Data Gaps - Land Use Adjustments

The primary data source for land use adjustments are the Cowlitz Valley District's and Forest Headquarters' files for such activities.

Assumptions - Land Use Adjustments

Given the extensive interface of the Forest boundary with privately-owned and other-agency-managed lands, land use adjustment activities of all types will be ongoing.

Management of Adjacent Private Lands Assessment

Data Sources/Data Gaps - Management of Adjacent Private Lands

The primary data source for this subject area comes from the Cowlitz Valley District lands and special uses files pertaining to dealings with adjacent private landowners in the areas of road right-of-way, road cost-share, cooperative maintenance, land exchange and special use permits.

Reference and Current Conditions - Management of Adjacent Private Lands

Corporate and State landholdings within, and adjacent to, the WA area are managed for the maximization of income from timber harvest. Investments continue to be made in replanting and pre-commercial thinnings in anticipation of future commercial harvests. Investments in construction and maintenance of transportation facilities have been commensurate with management of these private and State lands primarily for current and future timber production.

TERRESTRIAL ELEMENTS

Disturbance Regimes

The Role of Fire

Data Sources/Data Gaps

Only high severity fires (stand replacement) can be mapped. Low to moderate severity fires cannot be traced through stand-age analysis or other methods for this fire regime. Age-class analysis also needs to compensate for the "lag time," that is, the additional amount of time for a stand to become established after a stand-replacing fire. These recruitment periods may range from 50-75+ years at higher elevations and harsher environments. Fire history must be placed in a 500+ year context in order to account for the majority of fire events. Data or research in this context is minimal, and the analysis, by necessity, is highly extrapolative. Although little is known about fire frequencies, live successional pathways, and the amounts of dead fuel loadings over time in the western hemlock zone, even less is known about these characteristics in the Pacific silver fir zone.

Fire history analysis for the Little Nisqually watershed is based on stand age analysis. Stand age was determined by use of the Gifford Pinchot GIS vegetation database (GPVEG), which is based on stand exam information, professional judgement, personal on-the-ground knowledge, and aerial photo interpretation.

Assumptions

- Catastrophic disturbances permit the establishment of an identifiable, more or less even-aged class of early seral species. Historic large-scale disturbances (fires) are not desired today, and their effects can only be replicated on a small scale. The effects most easily created through human activities include the maintenance of certain stand structure characteristics, such as large down woody debris, snags, and a diversity of stand age classes.

- The designation of a land allocation (e.g. Late-Successional Reserve), is a management issue and/or decision. The resultant desired future condition in most cases does not reflect historic natural fire conditions. The scale needed to more accurately draw conclusions about past fire history and its effects is quite large. All fire events mapped in the Little Nisqually watershed analysis area extend beyond the boundaries of the analysis area. No assumptions, interpretations, or recommendations can or should be made about historic fire disturbance at this watershed scale. Potential natural vegetation can only be reached in the absence of fire or other disturbances. In most cases, the frequency and extent of natural fires precludes the attainment of this potential.

Reference (Historic) and Current Conditions

Historically, fire has been a very significant ecosystem disturbance mechanism in this watershed. Fires were low in frequency but high in severity, and had the potential to be quite large. Suppression activities since the 1930's have virtually eliminated natural wildfire effects in this watershed.

Historic fire events tend to be either very small (less than 5 acres) or very large (greater than 1000 acres). Prior to suppression, whether natural or human-caused, traceable fire events were very large. Large events probably mask scores of smaller events. More recent events mask older events or parts of older events.

Riparian areas, especially in the western hemlock zone, tend to have microclimates which somewhat protect them from many wildfire events. These areas tend to be associated with older or large tree stands. This effect is pronounced in steeper drainages.

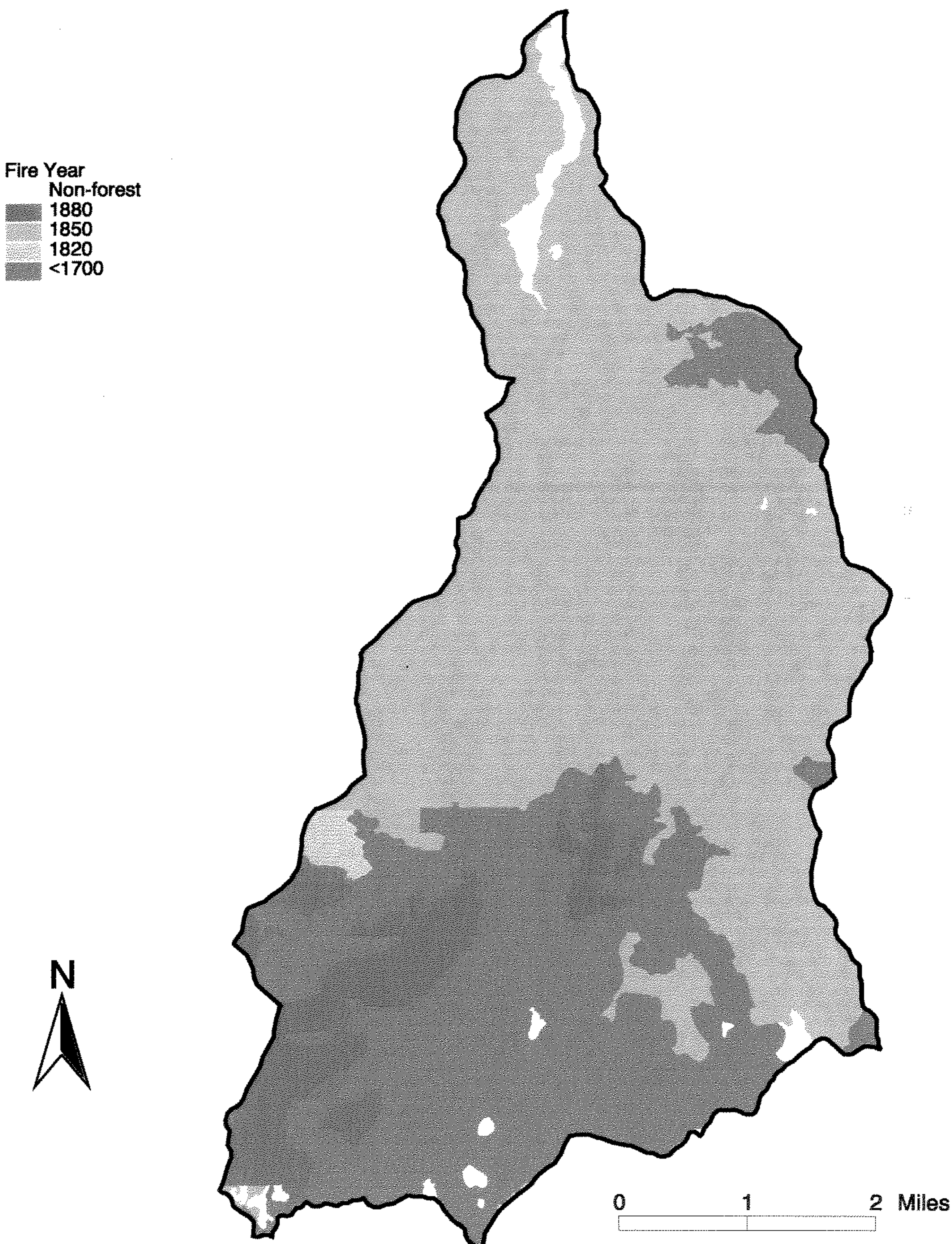
The Little Nisqually watershed, in general, is subject to greater marine climatic conditions than watersheds east of the Cascade crest, which are influenced by more continental (colder and drier) conditions. Average yearly rainfall in the analysis area ranges from sixty to ninety inches.

Based on stand age analysis, three large fires burned within, and to an unknown extent, beyond the boundary of the Little Nisqually watershed analysis area between 1700 and 1900. (Map 6, Fire History as Determined by Stand Age). Approximately 1700, or possibly earlier, one or more large fires burned in the Little Nisqually analysis area. Stand age analysis indicates older stands resulting from these fires (origin prior to 1729, estimated 300 years old , some of which have been logged) in the mid to upper Mona Creek drainage, upper Scatter Creek drainage, and portions of the Winston, West Fork, Lake, Hiawatha, and Trap Creek drainages. It is impossible to determine the exact acreage or perimeter because later fire events mapped during the 1800's may have reburned some of the original fire area and the fire areas go beyond the analysis area boundary. It appears that this/these fires burned at least 5,700 acres or more of the analysis area.

During the time period from 1800 to 1900, three large fires burned portions of the analysis area.
It appears that a small part (128 acres) of the Winston Creek drainage was burned in about 1820. This event probably burned beyond the analysis area boundary to the west, but how much is unknown.

In about 1850, a large portion (10,171 acres) of the analysis area was burned. This included all or most of the Little Nisqually River, Wildcat Creek, Spencer Creek, and Scatter Creek drainages, and portions of the Winston Creek, Hiawatha Creek, and Trap Creek drainages. Several smaller 1,000 to 2,000-acre fires were noted in the planning area. This fire also extended beyond the analysis area boundary to the east, west, and north.

Map 6
LITTLE NISQUALLY WATERSHED ANALYSIS
Fire History



In about 1880, fire burned parts of the Winston Creek, West Fork, and Hiawatha Creek drainages. The burned area includes about 1455 acres of the analysis area and appears to have burned to the west and south beyond the analysis area boundary.

Between 1700 and 1900, an average of about 3,000 acres of the analysis area burned every 50 years. After 1900, there are no recorded stand-replacing fires. This is at least partially due to aggressive fire suppression that was started in the 1930's.

Based on stand age analysis, approximately two thirds of the Little Nisqually watershed analysis area was burned by stand-replacing fires during the 200-year period from 1700 to 1900.

Approximately 7% of today's stands originated before 1700, and none of the area had stand-replacing fires after 1900.

Fire Ecology Groups

The vegetation communities found within the Little Nisqually analysis area can be classified into two general fire ecology groups within which fire follows certain characteristics. These groups and characteristics are described below:

FireGroup 0: Miscellaneous Special Habitats

This fire group is made up of scree, forested rock, dry meadow, wet meadow, recent volcanic deposits, alder glades, and deciduous riparian communities. This group does not stand alone as a large mappable area, but is dispersed as small areas within the other fire ecology groups.

Scree, or talus, refers to slopes covered with loose rock fragments, usually at or near the maximum angle of repose. Scree slopes rarely burn.

Forested rock consists of very steep canyon walls or mountain sides composed of rock outcrops or cliffs with occasional clumps of trees clinging to ledges and crevices. Surface fires usually spread slowly due to vertical and horizontal discontinuity of ground fuels. Crown fire probability depends on the density and arrangement of trees on the rock.

Grasses and bare soil characterize the dry meadows. Fire exclusion has allowed tree invasion into many high elevation meadows and into deeper pockets of soil in low elevation meadows.

Herbaceous vegetation and abundant water characterize wet meadows. Such sites may contain a fire-maintained grassland bordering the wet meadow. Fire exclusion has allowed conifers to invade the drier edges of meadows.

Extensive areas of rock, sand, or ash with varying amounts of vegetation characterize recent volcanic deposits. These sites may support a crown fire under extreme conditions, but would not support a surface fire that spreads beyond the point of origin.

Alder glades, openings dominated by various alder species, appear primarily in the lower Mountain Hemlock Zone and upper Pacific Silver Fir Zone. Alder glades remain moist throughout the summer and do not burn readily.

Deciduous riparian communities consist of sites dominated by deciduous trees and shrubs adjacent to perennial streams, seeps, and open bodies of water. Moist conditions and generally rapid decay of leaf litter and downed woody material generally reduce the potential of fire spread.

Fire Group 8: Western Hemlock/Pacific Silver Fir

Fire ecology group eight includes most of the western hemlock and Pacific silver fir plant associations found in the Little Nisqually watershed analysis area. As such, it includes a wide range of topographic positions, moisture regimes and temperature regimes.

Three conifer species, Douglas-fir, western hemlock and western redcedar, tend to dominate the overstory in the Western Hemlock Zone. The Pacific Silver Fir Zone includes a wider variety of overstory species, including Pacific silver fir, western hemlock, noble fir, western white pine and mountain hemlock.

This group generally lacks fine fuels through most of its stand history. "Classic" old-growth stand conditions (closed canopy overstory of large diameter trees and a lush understory) are common in undisturbed areas. Disturbances are infrequent. Fuel loadings build rapidly once the overstory begins to die from disease or insect attack and the canopy breaks up. Conditions become drier in these canopy gaps and can provide a suitable fuel bed for fire starts.

Western hemlock and Pacific silver fir are extremely fire sensitive due to thin bark, shallow roots, and highly flammable foliage. Western redcedar exhibits moderate fire resistance compared to western hemlock, but due to its thin bark, shallow roots, a low, dense branching habit, and highly flammable foliage, redcedar is vulnerable to even low intensity fire. Douglas-fir resists fire damage well. Fire frequency tends to be low because of the cool, moist habitats that western hemlock and Pacific silver fir generally occupy. Fire frequency varies from 150 to 400 years or more.

Insects and Disease

Data Sources/Data Gaps

- The primary data sources for information on insects and disease were U.S. Forest Service Region 6 Forest Pest Management (FPM) aerial insect survey maps and the Gifford Pinchot National Forest Total Resource Inventory (TRI) Pest Management Subsystem.

- The earliest data available from the aerial insect surveys for this watershed is from 1974 surveys, the latest is 1994. Survey maps are not available for every year from 1974 to 1994.

- Only a very small portion of the watershed has been surveyed and mapped for disease occurrence. Funding and priority to gather information concerning insects and disease has been low; consequently the amount of data available is limited and incomplete.

- There is no insect and disease data available for the private lands in the watershed. Data from the FPM aerial insect survey maps did cover this part of the Mineral Area during the years 1974, 1977, 1979, 1989, and 1994.

Assumptions

- A quick review of available data on disease and insect occurrences is sufficient to draw some conclusions about insect and disease activity in this watershed.

- Insect and disease activity on private lands is similar to that found on National Forest land.

Reference (Historic) and Current Conditions

We have no knowledge or data about historic insect and disease occurrence in this watershed prior to 1974. The only thing we can say with any certainty, is that most of the insects and disease present today were very probably here hundreds, if not thousands, of years ago. The only exceptions are the balsam woolley adelgid (an insect) and white pine blister rust (a disease). Both are introduced pests not present in the Pacific Northwest until the early part of this century.

Insects and disease are a natural part of the ecosystem and serve as agents of disturbance across the landscape. For the most part, native insects and diseases occur at endemic, or normal, levels and only occasionally appear as spectacular or seriously damaging epidemic outbreaks. However, even at endemic levels, damage to forests from some insects and diseases can, over time, be quite serious. The amount of disturbance caused by them can vary greatly from large conspicuous outbreaks to small, almost imperceptible outbreaks, with damage to trees being anywhere from light to severe. These agents of disturbance are essentially always present in the ecosystem at some level, their presence waxing and waning as the ecological conditions that affect them change over time.

Disease infections and insect infestations are an integral part of this forested ecosystem. Through their presence and actions they affect and participate in a wide range of ecosystem components and relationships. They foster diversity in the ecosystem by altering stand structure, and they can change the species composition of a stand over time. Through the killing or damaging of trees they: 1) create snags and down wood that provide habitat for a variety of wildlife species and serve as an important link in the cycling of nutrients, and 2) cause changes in the amount of sunlight that enters the canopy and reaches the forest floor, thus causing changes in the types, sizes, and amounts of vegetation. Insects and disease are also an important link in the ecosystem's food chain (e.g., wildlife feed on insects and the fruiting bodies of fungi that cause tree disease and decay).

Insects

Currently, based on FPM aerial surveys, the insects that have been observed causing the most damage to trees in the watershed over the past 25 years is the Douglas-fir beetle (in Douglas-fir), with most of the beetle activity having occurred in 1974. There are other insects at work in this watershed (e.g., fir engraver beetle [in all true fir tree species], balsam woolley adelgid (in Pacific silver fir), but the level of their presence and activity is relatively small, very sporadic and scattered.

Douglas-fir Beetle (Dendroctonus pseudotsugae)

The Douglas-fir beetle is a native insect that occurs throughout the range of Douglas-fir. It is considered the most important bark beetle which causes mortality in Douglas-fir. Douglas-fir bark beetles attack a tree by boring a tunnel through the bark, where they live and mine between the bark and the wood. A tree is killed when a large number of beetles attack it and effectively girdle it.

The greater portion of tree mortality is a result of endemic infestations, continually present in mature forests, where the beetle inhabits diseased (especially root-diseased trees), felled, or damaged trees. This normal mortality can be large in number, but is usually widely scattered. Epidemic outbreaks generally develop when conditions are adverse for the host tree, as in drought periods or defoliation by other agents, or when an abundance of favorable breeding material is available to the beetles, as in extensive windthrow or large wildfires. Epidemic outbreaks can spread over large areas and kill vast numbers of apparently healthy trees. In the coastal Douglas-fir region of western Washington, outbreaks are sporadic and of short duration, but can kill large numbers of trees. These outbreaks are usually connected to windthrow or wildfire events, although relatively small outbreaks can be a result of localized root disease infections. Host tree resistance usually keeps the Douglas-fir beetle under control most of the time. But even when outbreaks occur, following stand disturbance by fire, wind, or disease, they abruptly subside because the beetles do not thrive in normal, vigorous trees (Furness, et al. 1977).

The occurrences of Douglas-fir beetle are generally scattered across the watershed where Douglas-fir is dominant. They have been documented by FPM aerial surveys in the Spencer Creek drainage. They have also been noted near areas of windthrow in the Winston Creek, Trap Creek, Scatter Creek and Wildcat Creek drainages.

The majority of the documented occurrences can be characterized as having caused light mortality. Most of the Douglas-fir beetle activity has occurred from 1974 through 1994. Besides windthrow, this activity is sometimes linked directly to laminated root rot infections.

Generally, the patches of Douglas-fir beetle mortality range from less than a quarter acre to 1 acre in size (rough estimates based on FPM aerial survey sketch maps and local experience), with most being less than one-quarter acre. Not every tree in these patches dies.

Disease

Currently, based on the TRI Pest Management Subsystem and Forest Pest Management Pest Evaluations, no major diseases have been observed, however, based on local experience, the disease causing the most notable damage to trees in the watershed over the last 20 years is laminated root rot (caused by Phellinus weirii). There are, without doubt, other disease agents (e.g., Armillaria root disease, dwarf mistletoe, annosus root disease, white pine blister rust, and various butt/stem rots) present and working in the watershed, but there was not sufficient time and/or data to determine the level of their presence and activity.

Laminated Root Rot (Phellinus weirii)

This native disease is one of the most damaging and difficult diseases to control in Pacific Northwest conifer forests. Hundreds of thousands of acres are affected and it is estimated to cause an annual loss of 32 million cubic feet of tree volume. At least 5 percent, possibly as much as 10 percent, of the forested area of Oregon and Washington are thought to be infected (Hadfield 1985). Trees of all ages and sizes are susceptible to infection, but damage is most obvious in stands 20 to 150 years of age.

Laminated root rot is capable of infecting a wide range of conifer species, but in this watershed its most susceptible hosts are Douglas-fir, Pacific silver fir, and mountain hemlock. Laminated root rot can be considered a disease of the site. Because of its persistence and spread from one generation to the next, the fungus has the potential to greatly reduce site productivity.

Laminated root rot centers often appear as roughly circular patches of dead and dying trees, but in some stands may have a diffuse distribution that is difficult to detect. Infected trees may be windthrown or broken at the base, but usually die standing. Infection centers west of the crest of the Cascade Range are usually smaller than one acre, but it is not uncommon for them to be 5 to 10 acres in size, and sometimes even larger. The fungus survives for long periods (50 years or more) in infected stumps and snags. It spreads from tree to tree and to the next generation via root grafts and contacts.

The exact locations and extent of this disease in the watershed is not well known. It is most common in the areas dominated by Douglas-fir below about 3000 feet in elevation, although it is also found occasionally in Pacific silver fir at the higher elevations in the watershed. There is no data on disease occurrence on the private lands in the watershed, but the amount of private land is very minor.

Windthrow

Data Sources/Data Gaps

- The primary data source for information on windthrow is aerial photo sets from 1963, 1979, 1985, 1989, and 1993. Those photos, covering discrete points-in-time, do not easily allow the discovery of windthrow that occurred between those points-in-time.
- The 1963 aerial photos were the earliest data available for this watershed. There is no reliable information (photographic or otherwise) concerning windthrow in the watershed prior to 1963.

Assumptions

- A quick review of past and current aerial photos is sufficient to draw some conclusions about windthrow activity in the watershed.

Reference (Historic) and Current Conditions

We have no knowledge or data about historic windthrow events in this watershed prior to the early-1960's. The only thing we can say is that windthrow events have very likely occurred in this watershed for as long as it has been forested.

Wind is a natural, but elusive, part of the forest ecosystem. It serves as an agent of disturbance across the landscape when it becomes strong enough to topple trees. In this manner, wind becomes a part of the natural recycling of forest stands; playing an important role in maintaining and renewing the forest ecosystem. Wind is always present in the ecosystem, usually at levels low enough not to cause the windthrow of trees. The amount of windthrow caused by the wind can vary greatly from a few, scattered individual trees to large, contiguous patches of several hundred acres.

The actions of the wind, manifested as windthrow, affect and participate in a wide array of ecosystem relationships. Windthrow fosters diversity in the ecosystem by altering stand structure. Windthrow can affect forest succession, soil, wildlife, fish, and the safety of people and structures.

Windthrow Events (location and size)

A quick review of the aerial photos revealed many separate windthrow patches in the watershed over the past 30 years. Windthrow patch size was less than 5 acres most of the time, with a few being 5 to 10 acres in size.

In addition to identifiable patches of windthrow on the aerial photos, there have been a large number of single trees or very small groups of trees that have blown down in the watershed over the years (events not usually identifiable on the photos).

No attempt was made to determine patterns or concentrations (related to locations in the watershed) of windthrow to try and deduce where future windthrow is most likely to occur, but based on a quick review, it seemed to occur most often where east/west regeneration harvest cutting lines occurred and near ridgetop areas or areas exposed to southwesterly winds.

Windthrow Events (weather and timing)

Storms associated with windthrow events in this watershed probably involved gale-force and storm-force winds during the fall and winter months (November through February), very often associated with heavy rainfall. There are several categories of gale-force winds and one category of storm winds. The wind speed associated with these categories ranges from 32 miles per hour to 72 miles per hour.

Information from Harris (1989) and Savill (1983) indicates that windthrow events generally begin to occur when wind speeds reach gale-force or higher. In addition to windspeed, wet, saturated soils from heavy or prolonged rainfall (preceding and during a storm) can be an important contributing factor to windthrow. Rain saturated soils can contribute to windthrow occurring at lower windspeeds, which under drier conditions probably wouldn't produce windthrow.

The occurrence of windthrow events is tied directly to storm events in the watershed. Determining the exact timing, intensity, and scope of storm events in the watershed is difficult at best because no local records have been kept documenting them, especially in relation to any windthrow that might have been associated with them. While many windthrow events west of the Cascade Range are usually linked to strong storms that blow in from the south or southwest, it is very possible that some of the windthrow events that have occurred in this watershed were a result of strong east winds.

Windthrow and Management Activities

The principal management activities that have occurred in the watershed are timber harvest (mostly regeneration harvest by clearcutting and some partial cut salvage), road construction and precommercial thinning. No windthrow was identified as being associated with precommercial thinning.

Based on local experience, a substantial amount of individual-tree and small-group-tree windthrow is probably associated with road edges. It is not known exactly how much of this type of road-related windthrow occurs, due to the lack of data. Harris (1989) indicates that other studies have shown that greater concentrations of windthrow are associated with roads. In a dense, 90-year-old spruce-hemlock stand at Cascade Head Experimental Forest in Oregon, McComb and Munger found in a 1940 study that over four times as much windfall occurred within 100 feet of roads as in the zone 100 to 200 feet from the roads.

The majority of the windthrow observed on the aerial photos (approximately 90%) was directly related to the edges of clearcuts. Only about 10% of the windthrow events occurred away from clearcut edges and most of this was associated with newly constructed roads.

Forest Vegetation

Forest Zones

Data Sources/Data Gaps

For Forest Service land, the data sources for production of the forest zones map was the Gifford Pinchot National Forest Vegetation (GPVEG) database. For forest zone coverage of private lands the data sources included aerial photo interpretation, on-the-ground knowledge of Forest Service personnel, and knowing which forest zones are located on Forest Service lands immediately adjacent to private lands.

Assumptions

For the purposes of this large-scale analysis, the forest zones are reasonably accurate given the time allowed and method used to determine their boundaries. It is assumed that the boundaries and acreages of the forest zones have not changed over the last several hundred years.

Reference (Historic) and Current Conditions

Terrestrial ecosystems develop and are affected by the influences of geology, landform, climate, and soils. Natural plant communities reflect these influences on the ecosystem. As a way of classifying these plant communities, forested ecosystems are divided into smaller systems (called forest series or forest zones) based on the climax tree species (i.e., potential natural vegetation) on a site. The two forest zones found in the Little Nisqually River fifth-field watershed are typical of those found in the southern Cascades of Washington State. The two zones are:

Western Hemlock Zone -- *Tsuga heterophylla* (TSHE)
Pacific Silver Fir Zone -- *Abies amabalis* (ABAM)

Table 3-4 below displays the number of acres (forest and non-forest) comprising each of the forest zones across the watershed. For a visual display of each zone's distribution across the watershed, see Map 7, Forest Zones.

Table 3-4: Forest Zones by Forest and Non-Forest Acres				
Zone	Forest		Non-Forest	
	Acres	(%)	Acres	(%)

Table 3-4: Forest Zones by Forest and Non-Forest Acres				
Zone	Forest		Non-Forest	
Western Hemlock	13,745	77.0	291	1.6
Pacific Silver Fir	3,762	21.0	75	0.4
Totals	17,507	98.0	366	2.0

Western Hemlock Zone

This forest zone includes the lower elevation, warm and moist forests. It is the most environmentally moderate zone of the two forested zones found in this watershed. Its upper elevation occurs at about 3,000 feet where it begins to transition into the Pacific Silver Fir Zone. The Western Hemlock Zone covers the largest portion of the watershed. The only portion of the watershed that it doesn't cover is the area around Stahl Mountain, Cougar Mountain, the Rockies and the Duck and Goose Lake area. It covers 14,036 acres (78.6%) of the watershed, with 13,745 of those acres being productive forest land, and 291 acres being non-forest land.

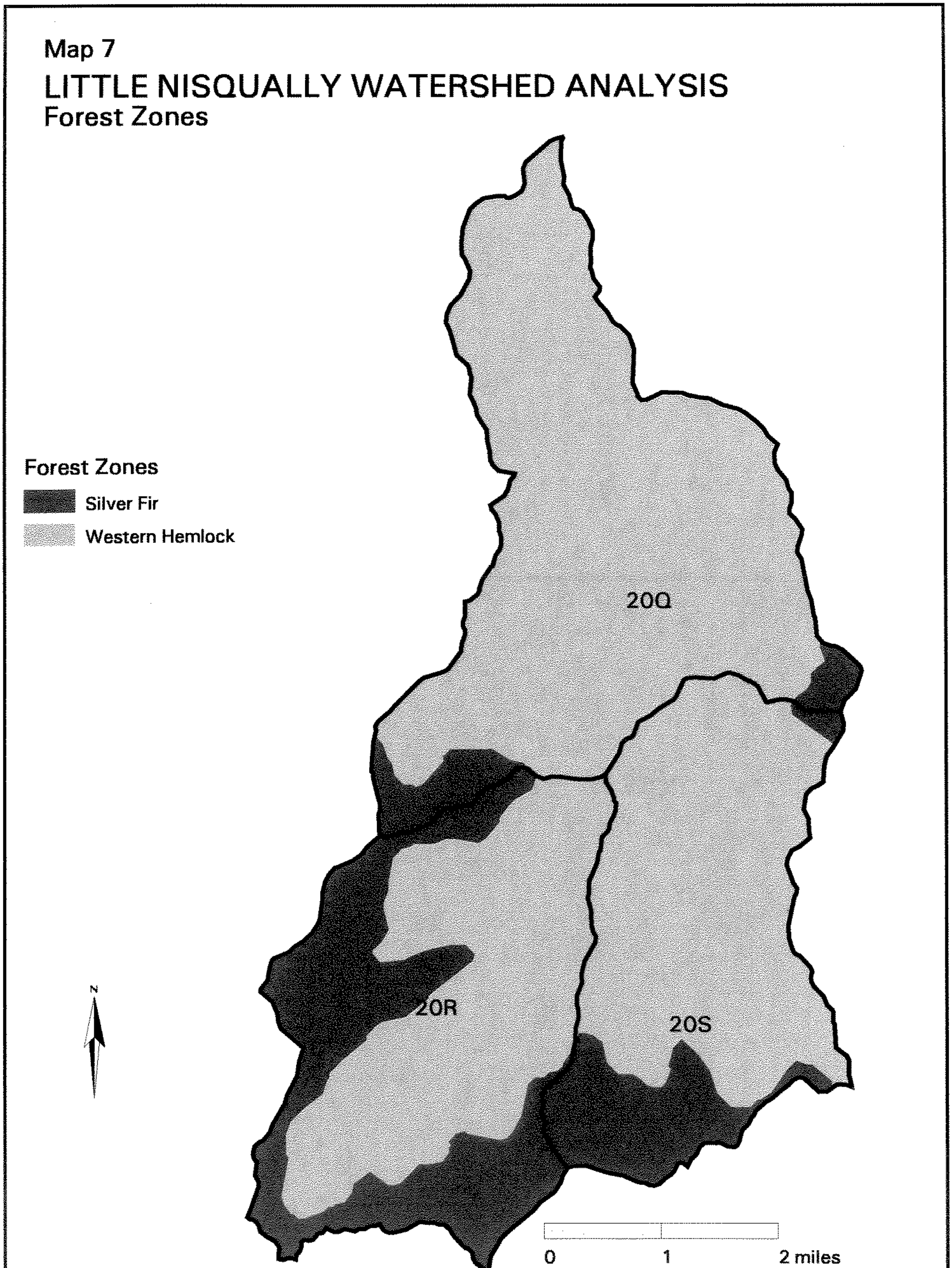
Pacific Silver Fir Zone

This forest zone includes the mid to upper elevation, cool and moist forests. It occupies sites of upper elevation between approximately 3000 to 4500 feet. The Pacific Silver Fir Zone covers the smaller portion of the watershed and occurs mostly along the southern and western edge of the watershed with a minor portion along the eastern edge near Stahl Mountain. It covers 3,837 acres (21.4%) of the watershed, with 3,762 of those acres being productive forest land, and 75 acres being non-forest land.

Vegetation Structural Stages

Data Sources/Data Gaps

- The primary source for current vegetation descriptions on Forest Service land is the Gifford Pinchot National Forest GPVEG (Gifford Pinchot Vegetation) database. The GPVEG database was initially installed in 1993-94 and is updated annually. The GPVEG data is based on a mixture of stand exam data (of various ages), aerial photo interpretation , and on-the-ground knowledge of Forest Service personnel. The GPVEG database is reasonably accurate, but it is highly probable that some of the data is not accurate (due to such things as poor aerial photo interpretation, outdated stand exam data, input errors, etc.).



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- The primary source for current vegetation descriptions on private lands is the Washington State Department of Natural Resources (DNR) GIS vegetation map classified by Pacific Meridian Resources. The DNR data is based on remote sensing using 1988 satellite photography that, because of its age, does not reflect changes in vegetation that have occurred since 1988. In addition, the classification of the vegetation is suspect in many cases.

- Reconstruction of historic vegetation conditions relied on known current stand information (e.g., stand year-of-origin), observation of aerial photos, and on-the-ground knowledge of Forest Service personnel. There are very few sources of historic stand information available for this watershed, and what is available is of very limited usefulness.

Assumptions

- The GPVEG database (and the resultant vegetation classification based on that database) is reasonably accurate, while the DNR database is passably accurate; both providing a general description of current vegetation structure that is accurate enough for this large-scale analysis.

- Riparian vegetation is often different than upland vegetation in size, structure, and species composition; but for the purposes of this analysis it will be considered the same.

- Before 1930, fire (natural and man-caused) was the most significant disturbance that caused stands to revert to a grass/pole (early) structural stage in this watershed.

- The classification of historic vegetation structure is reasonably accurate for this large-scale analysis. There are undoubtedly errors in the classification due to the lack of historic vegetation information.

Reference (Historic) and Current Conditions

In this watershed analysis, we are describing forest vegetation structural stages at two points in time to illustrate and compare historic and current situations across the watershed. The year 1900 was chosen as the historic point in time, with 1999 being the current point in time. The historic forest vegetation structural stages were reconstructed by reclassifying the structural stages of the current vegetation polygons based on their current age, aerial photos, and on-the-ground knowledge of Forest Service personnel. The year 1900 serves as a "snapshot" of the vegetation in the watershed when the landscape had not yet been significantly altered by Euro-American settlers. The year 1900 was also chosen because a large portion of the watershed was burned around 1880.

The range of vegetation characteristics and conditions in the watershed results from succession and disturbance (both natural and human-induced). Structural stages describe and define this range of vegetation characteristics and conditions. Four broad structural stages were defined for this watershed: grass/pole, small tree, large tree, and non-forest. The four stages are defined somewhat differently for Forest Service land and private lands. The definitions for both situations are described below.

Forest Service Land - The four structural stage categories on National Forest land are defined as follows:

> *Grass/pole forest* - One-storied forest stands whose trees range in size from seedlings (less than 4.5 feet tall) to poles less than 9.0" dbh.
>
> *Small tree forest* - One- or two-storied forest stands of 9.0" dbh up to 18.0" dbh (for the Pacific Silver Fir Zone) or 20.9" dbh (for the Western Hemlock Zone).
>
> *Large tree forest* - One-, two-, or more-storied forest stands greater than 18.0" dbh, or equal to or greater than 21.0" dbh (depending on the forest zone).
>
> *Non-forest* - Rock, water, avalanche chutes, meadows, grasslands, forblands, and shrublands.

Private Lands - The four structural stage categories on private lands are defined as follows:

> *Grass/pole forest* - Forested stands with >10% crown closure of conifers, but <70% crown closure of conifers and <75% hardwood shrub cover, or other lands in forested areas with <10% crown closure of conifers or >75% hardwood crown closure.
>
> *Small tree forest* - Forested stands with >70% crown closure of conifers, with <10% crown closure in trees greater than 21" dbh and <75% hardwood shrub cover.
>
> *Large tree forest* - Forested stands with >70% crown closure of conifers, with >10% crown closure in trees greater than 21" dbh and <75% hardwood shrub cover.
>
> *Non-forest* - Urban land, agricultural land, rangeland, barren, and glaciers.

Historic Vegetation

Amount, Distribution, and Location

The amount of historic (1900) grass/pole, small tree, and large tree forest vegetation (and areas of non-forest) in the watershed is shown by ownership in Table 3-5 below and in Map 8, Vegetation Structure (1900). In 1900, the acres of forest land in this watershed were dominated by small tree and large tree structural stages.

Table 3-5: Historic (1900) Vegetation by Structural Stage and Ownership (USFS and Private)

Structural Stage	USFS Acres (%)	Private Acres (%)	Total Acres (%)
Grass/Pole	1,165 (7)	291 (15)	1,456 (8)
Small Tree	8,851 (56)	1,448 (72)	10,299 (58)
Large Tree	5,716 (36)	26 (1)	5,742 (32)
Non-Forest	147 (1)	231 (12)	378 (2)
Totals	15,879 (100)	1,996 (100)	17,875 (100)

The amount of historic grass/pole, small tree, and large tree forest vegetation on productive forest land in the watershed is displayed by forest zone and ownership in Table 3-6 below. See Map 8, Historic (1900) Vegetation Structure, for a visual display of the historic vegetation structure.

Table 3-6: Historic (1900) Vegetation by Structural Stage and Forest Zone (USFS and Private)

Forest Zone	Grass/Pole Acres (%)	Small Tree Acres (%)	Large Tree Acres (%)	Total Acres (%)
W. Hem (FS) (P)	674 (46) 110 (8)	8,083 (79) 1,223 (12)	3,653 (64) 1 (0)	13,744 (79)
P SilvFir (FS) (P)	491 (34) 181 (12)	768 (7) 225 (2)	2063 (36) 25 (<1)	3,753 (21)
Totals	1,456 (100)	10,299 (100)	5,742 (100)	17,497*(100)

* This represents the number of historic productive forest land acres in the watershed.
Total watershed acres = 17,875 Non-forest watershed acres = 368

(FS) = USFS land (P) = Private land

Grass/Pole

At 1,456 acres, the grass/pole forest had the smallest number of acres of the three forested structural stages (8% of the watershed's productive forest land). The grass/pole forest (46% or 672 acres) was distributed fairly equally between the Pacific Silver Fir Zone and the Western Hemlock Zone (54% or 784 acres). Most of the grass/pole forest was located in the upper reaches of the West Fork of the Little Nisqually River and around the Little Rockies.

Small Tree

At 10,299 acres, the small tree forest had the largest number of acres of the three forested structural stages (59% of the watershed's productive forest land). Most of the small tree forest (91% or 9,306 acres) was located in the Western Hemlock Zone. The majority of the small tree forest is located in the northern and central portion of the watershed with an arm running up near the head of Trap Creek. The exception is a small piece of large tree forest located near Stahl Mountain.

Large Tree

At 5,742 acres, the large tree forest covered 33% of the watershed's productive forest land; the largest patch being located in the southern part of the watershed around Fly Creek, Hiawatha Creek, Trap Creek and Duck and Goose Lakes. Most of the large tree forest (64% or 3,653 acres) was located in the Western Hemlock Zone.

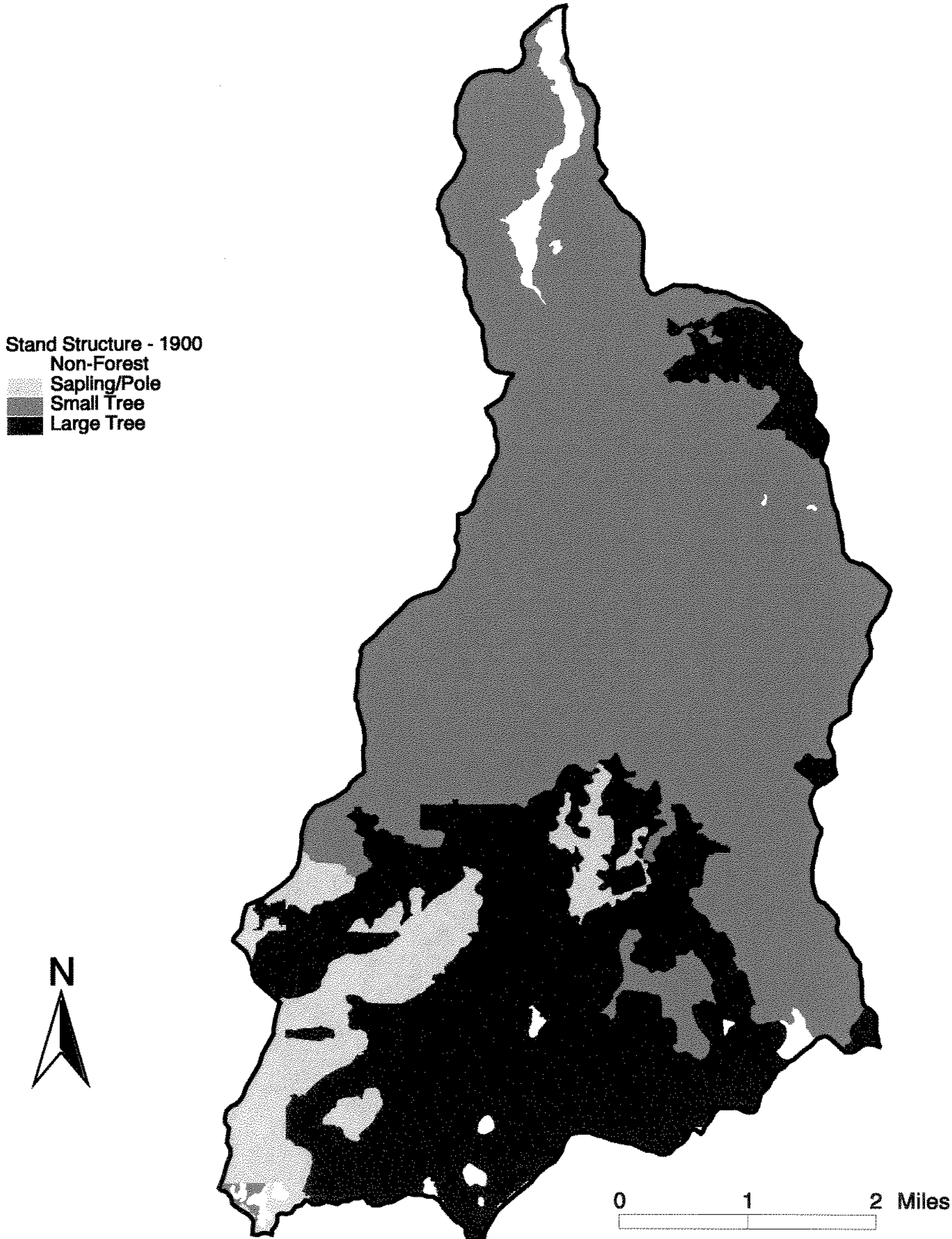
Historic Landscape Patterns: Patch Size, Shape, Spatial Arrangement and Connectivity

No detailed analysis was performed to calculate statistics concerning historic vegetation landscape patterns. Therefore, a basically qualitative description is provided here, based on Map 8, Vegetation Structure (1900) .

In 1900, small tree forest and large tree forest structural stages were the most dominant forest vegetation across the watershed.

Most of the small tree forest was located in the north and central portion of the watershed in the lower reaches of the Little Nisqually, Spencer Creek, Mona Creek, Wildcat Creek,

Map 8
LITTLE NISQUALLY WATERSHED ANALYSIS
Vegetation Structure (1900)



Scatter Creek and much of Trap Creek. It was concentrated in one very large, contiguous matrix approximately 10,000 acres in size.

Almost all of the large tree (late-successional) forest was located in the southern one-third of the watershed as a relatively contiguous block somewhat broken up by grass/pole in the upper reaches of the West Fork Little Nisqually. Some smaller patches exist near the east boundary of the watershed around Stahl Mountain and other high elevation areas along the east boundary. The large tree patches ranged widely in size (from a few hundred acres to several thousand acres).

Most of the grass/pole forest was contained in one large, somewhat linear patch (approximately 1000 acres in size) located along the upper reaches of the West Fork of the Little Nisqually. This large patch of grass/pole forest was the result of a wildfire in the 1880's. The remainder of the grass/pole forest was located in small patches nearby (less than 200 acres in size).

The forest patches in 1900 were generally large with irregular shapes and irregular, sinuous edges. They tended to be somewhat linear in shape (but not in all cases) and mostly well-connected. The larger forest patches ranged in size from about 1,000 acres to 10,000 acres. The smaller forest patches ranged in size from less than 50 acres to 200 acres.

In 1900, the southern one-third of the watershed was moderately diverse in terms of forest patch size, structural stages (mix of grass/pole, small tree, large tree, and non-forest), and patch shape. The northern two-thirds of the watershed had much less diversity of patch size, structural stages, and patch shape and was dominated by one very large patch, one of small tree forest.

Current Vegetation

Amount, Distribution, and Location

The amount of current (1999) grass/pole, small tree, and large tree forest vegetation (and areas of non-forest) in the watershed is shown by ownership in Table 3-7. Currently, the acres of forest land in this watershed are dominated by stands with grass/pole structure.

Table 3-7: Current (1999) Vegetation by Structural Stage and Ownership (USFS and Private)

Structural Stage	USFS Acres (%)	Private Acres (%)	Total Acres (%)
Grass/Pole	7,337 (46)	1509 (76)	8,846 (50)

Table 3-7: Current (1999) Vegetation by Structural Stage and Ownership (USFS and Private)			
Structural Stage	**USFS Acres (%)**	**Private Acres (%)**	**Total Acres (%)**
Small Tree	4,643 (29)	181 (9)	4,824 (27)
Large Tree	3,746 (24)	73 (4)	3,819 (21)
Non-Forest	137 (<1)	229 (11)	366 (2)
Totals	15,863 (100)	1,992 (100)	17,855 (100)

The amount of current grass/pole, small tree, and large tree forest vegetation on productive forest land in the watershed is shown by forest zone and ownership in Table 3-8. See Map 9, Current (1999) Vegetation Structure, for a visual display of the current vegetation structure. Note that many of the large tree and small tree structural stages are the same age class.

Table 3-8: Current (1999) Vegetation by Structural Stage and Forest Zone (USFS and Private)				
Forest Zone	**Grass/Pole Acres (%)**	**Small Tree Acres (%)**	**Large Tree Acres (%)**	**Total Acres (%)**
W. Hem (FS) (P)	5,325 (60) 1,124 (13)	3,977 (82) 136 (3)	3,093 (81) 73 (2)	13,738 (79)
P SilvFir (FS) (P)	2,012 (23) 385 (4)	666 (14) 45 (1)	653 (17) 0 (0)	3,761 (21)
Totals	8,846 (100)	4,824 (100)	3,819 (100)	17,489*(100)

* This represents the number of current productive forest land acres in the watershed. There are about 20 acres within the watershed which have no data and do not show up in the above table.

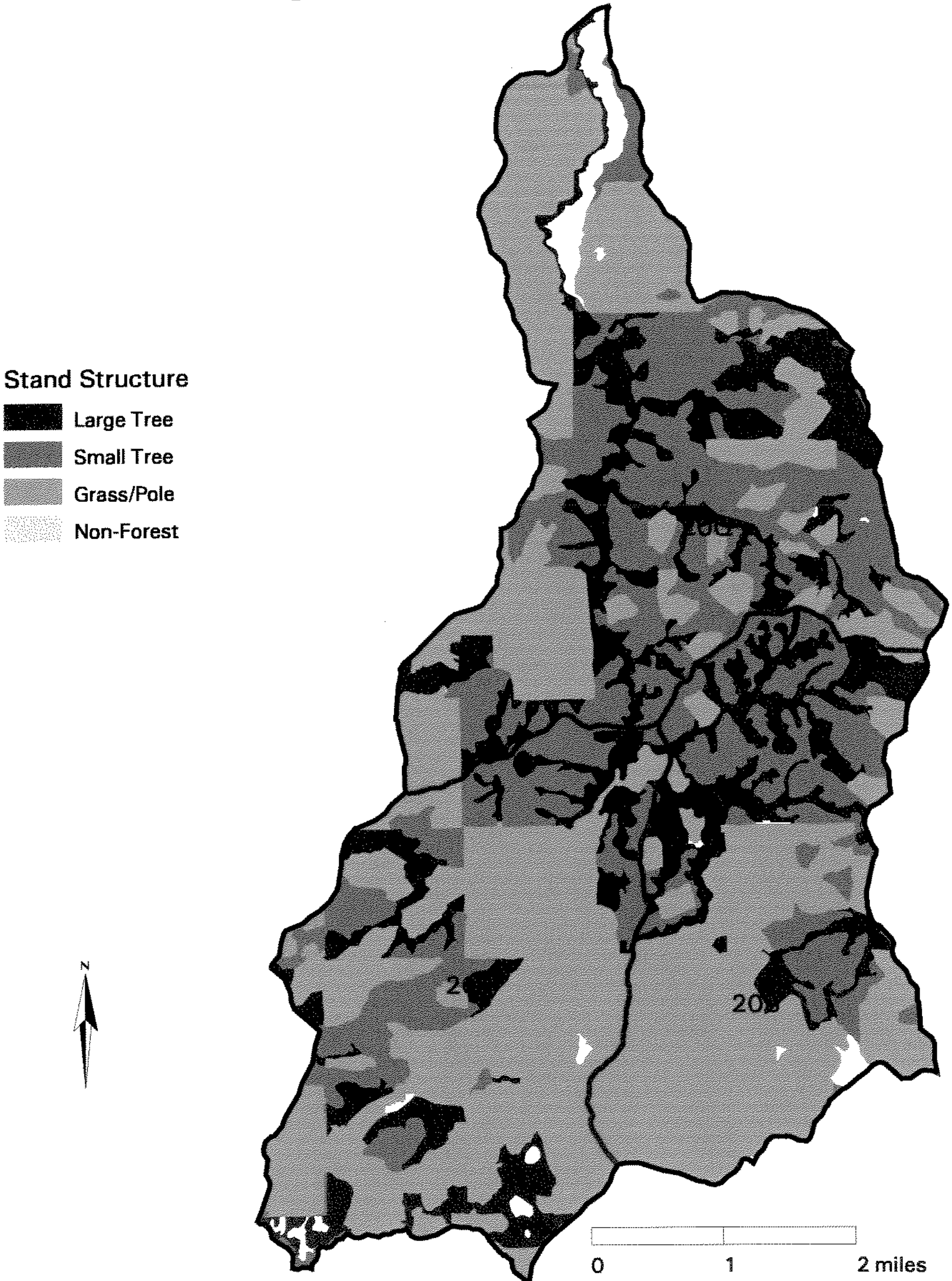
Total watershed acres = 17,875 Non-forest watershed acres = 366
(FS) = USFS land (P) = Private/State

Grass/Pole

Map 9

LITTLE NISQUALLY WATERSHED ANALYSIS

Current (1999) Vegetation Structure



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At 8,846 acres, the grass/pole forest has the largest number of acres of the three forested structural stages (50% of the watershed's productive forest land). Grass/pole forest is mainly concentrated on U.S. Forest Service land in the southern portion of the watershed and on private parcels of ground along the east boundary of the watershed and the far northern portion of the watershed. There is also a moderate amount of grass/pole forest scattered throughout the watershed resulting from old regeneration harvest cuts. The grass/pole forest is divided between the Pacific Silver Fir Zone (2,397 acres or 27%) and Western Hemlock Zone (6,449 acres or 73%).

Small Tree

At 4,824 acres, the small tree forest covers 28% of this fifth-field watershed's productive forest land. Most of the small tree stands are scattered through the central half of the watershed, with some located near the southeast and southwest corner of the watershed. No large (>1000 acres), contiguous patches of small tree forest exist in the watershed. Most of the small tree forest is located in the Western Hemlock Zone (4,113 acres or 85%), with a minor portion located in the higher elevation Pacific Silver Fir Zone (711 acres or 15%).

Large Tree

At 3,819 acres, the large tree (late-successional) forest has the smallest number of acres of the three forested structural stages (22% of the watershed's productive forest land). The large tree stands are a result of wildfires that occurred prior to 1850. Much of the large tree forest (3,166 acres or 83%) is located in the Western Hemlock Zone, with a minor amount (653 acres or 17%) located in the Pacific Silver Fir Zone.

Large tree forest is well dispersed in the central portion of the watershed, mainly within creeks, draws and the more protected aspects. Little difference exists in some drainages between the small tree forest adjacent to the large tree forest except for the diameters of the trees. A good example of this is in the Wildcat and Scatter Creek drainages. There is also scattered parcels of large tree forest occurring in the southeast portion of the watershed.

Non-Forest

At 368 acres, the areas of non-forest structure (rock, water, avalanche chutes, meadows, grasslands, forblands, shrublands) cover 2% of the total watershed acreage. Most of the non-forest acreage is classified as water and is located at the north and south end of the waters-hed. The Little Nisqually arm of the Alder Lake reservoir is located at the north end and Duck, Goose and another un-named lake are located at the south end of the watershed.

Other non-forest acreage occurs in the southern end as avalanche chutes and a rock quarry. Much of the non-forest structure is located on private land in the form of water.

Current Landscape Patterns: Patch Size, Shape, Spatial Arrangement and Connectivity

No detailed analysis was performed to calculate statistics concerning current vegetation landscape patterns. Therefore, a basically qualitative description is provided here, based on Map 9, Current (1999) Vegetation Structure.

The current size, shape, spatial arrangement, connectivity, and structural stages of vegetation patches in the watershed have been heavily influenced by U.S. Forest Service and private management policies concerning fire suppression (suppress most fires immediately) and timber harvest activities). Since the 1930's, when fire suppression activities began in earnest, the role of fire as a significant, large-scale disturbance agent in the watershed has been reduced dramatically. With the advent of timber harvest in the Forest Service portion of the watershed in the 1960's, it became the disturbance agent largely responsible for moving forest stands into the grass/pole structural stage, instead of fire. There have been two types of timber harvest activity in the watershed: regeneration harvest (mainly by clearcut) and partial-cut salvage.

The grass/pole structural stage that currently exists in the watershed was largely created by regeneration harvest using the clearcut method. Regeneration harvest on Forest Service land in this watershed totals approximately 7266 acres since it began in the 1960's. Of the productive parcels of private land in the watershed (1763 acres total), most of the acres were probably regenerated by the clearcut method starting in the 1940's and continuing through the 1990's, however, information about private lands in the watershed is poor.

The estimated amount of regeneration harvest on Forest Service land, stratified by decade, is shown below in Table 3-9. The acreage is primarily based on year of origin of the plantation. On Map 9, Current (1999) Vegetation Structure, the regeneration harvest areas are depicted as those with a Grass/Pole structural stage.

Table 3-9: Regeneration Harvest Acres by Decade (National Forest Ownership Only)

6th-	1950's	1960's	1970's	1980's	1990's	Total	%
Q,R,S	0	2439	2094	2080	653	7266	42

The amount of partial cut salvage harvest that has occurred in the watershed is unknown, but it has been a common practice since the 1960's. It has been linked primarily with the salvage of down or damaged trees related to windthrow/storm events. The number of partial cut salvage sites has been relatively moderate over the years; usually relatively small in size, and usually located along the edges of existing clearcuts or road prisms where windthrow has most often occurred. Changes in stand structure due to partial cut salvage is usually slight, compared to regeneration harvest, but it does have an influence.

Today (1999), the grass/pole structural stage is the most dominant forest vegetation in the watershed, especially in the northern and southern portions of the watershed. The small tree forest and large tree forest structural stages are similar in abundance 28% and 22%, respectively, and are generally located in the central portion of the watershed with a fair amount located in the southeast corner. Non-forest areas are a relatively insignificant feature in the landscape.

Many of the grass/pole forest patches tend to be small in size (less than 50 acres) and regular in shape (having been created by clearcut, they are often square or rectangular with straight edges of high contrast). There are several larger patches of grass/pole forest where regeneration harvest patches have resulted from a whole section and/or sections have been harvested at in the same time period. The larger grass/pole forest patches that currently exist vary from 300 to several thousand acres in size, with the largest one approaching 4000 acres in size. Most of today's grass/pole forest is structurally simple and homogenous; stands with a single tree layer, possessing few (if any) snags or large, live remnant trees, or pieces of large down wood.

The current small tree forest is largely comprised of natural fire-origin stands (generally irregular in shape and form) at middle to high elevations, with nearly all of it being located in areas on Forest Service land. Small tree forest patches have a wide range of sizes (varying widely from 10 acres to several hundred acres) and shapes with irregular, sinuous edges. The small tree forest has been fragmented to some degree by management activities.

Much of the current large tree forest is located within Forest Service land. It provides some patches of generally unfragmented and well-connected late-successional habitat in the watershed. These large tree forest patches have irregular, sinuous edges. Much of the large tree forest has some large patches (greater than 500 acres) of small tree forest located around them which will be progressing to large tree forest within one to three decades. Most of the large tree forest has been fragmented to some degree by management activities.

Currently, there are very few areas across the watershed that have not been impacted by human management activities. In the areas of high management use, today's landscape is a relatively unstable, fine-grained landscape with a high amount of edge and contrast, and with a much reduced connectivity when compared to the 1900 landscape.

Botanical Species of Concern

Data Sources/Data Gaps

The primary data source used in determining historic and extant populations of threatened, endangered, and sensitive (TES) plant species for this project is the Biological and Conservation Database (BCD) managed by the Washington Department of Natural Resources Natural Heritage Program. No such comprehensive databases exist for survey and manage and noxious weed species, although interim databases have been developed that catalogue some location information on these species groups. Habitat information used in this report comes from maps and data produced and stored in Geographic Information Systems (GIS) and National Wetland Inventory maps.

Assumptions

In most cases, the data stored in the BCD was originally recorded as points on US Geological Survey Quadrangles and thus is only as accurate as the original mapper was. Since these data have been collected by a variety of individuals over a large time span, it is expected that precision of individual locations will vary. It also must be understood that in some cases, individual locations were not reported as the result of a rare plant survey of that area, but were reported by an individual that came across the rare plant while in the course of some other activity. Thus, this data should only be interpreted as the status of our current knowledge, and in no way infers that intensive surveys have been completed within the analysis area unless otherwise stated. Likewise no specific surveys have been conducted within the analysis area for survey and manage and noxious weed species. It is assumed that many undocumented sites exist for these three species groups within the analysis area.

The use of GIS layers for predicting special habitat areas is limited by the accuracy of the methods and data used in creating those layers. The GIS vegetation layer is based heavily on photo-interpretation and since small areas of special habitats are easily overlooked on aerial photographs they may not be well represented in GIS. While the methods used are considered to generate a good approximation of habitat areas, there is no substitute for actual field work to verify these locations.

Proposed, Endangered, Threatened and Senstive Plant Species

No information on the historic condition of this species group was available for this report. It is assumed that viable populations existed within some areas of suitable habitat. There are currently 51 species of Threatened, Endangered, and Sensitive (TES) plants on the Regional Forester's list for the Gifford Pinchot National Forest. Of these species, 31 are potentially found on the Cowlitz Valley Ranger District and thus possibly within the analysis area. Those species that have been documented on the Cowlitz Valley Ranger District and those species that may occur there based on their published distributions, are listed in Table 3-10 At this time there are no federally listed (proposed, endangered, threatened) plant species known to occur on the Forest, however, one federally threatened species (Howellia aquatilis) is suspected.

Table 3-10: TES Plant Species Documented or Suspected on the Cowlitz Valley Ranger District

STATUS	SCIENTIFIC NAME	COMMON NAME	F/S;G/S*
STATUS	**SCIENTIFIC NAME**	**COMMON NAME**	**F/S;G/S***
Suspected	*Agoseris elata*	tall agoseris	-/s; 4/2
Suspected	*Carex densa*	dense sedge	-/s; 5/1
Suspected	*Carex heteroneura (=atrata var. erecta)*	different nerve sedge	-/s; 5/2
Suspected	*Carex stenophylla (=C. eleocharis)*	narrow leaved sedge	-/s; 5/1
Suspected	*Chrysolepis chrysophylla*	golden chinquapin	-/s; 5/2
Suspected	*Cicuta bulbifera*	bulb-bearing water-hemlock	-/s; 5/2
Known	*Cimicifuga elata*	tall bugbane	SC/T; 2/2
Suspected	*Corydalis aquae-gelidae*	cold water corydalis	SC/T; 3/2
Suspected	*Cypripedium fasciculatum*	clustered lady slipper	SC/T; 4/2
Suspected	*Euonymus occidentalis*	western wahoo	-/s; 5/1
Suspected	*Fritillaria camschatcensis*	Black lily	-/s; 5/2
Suspected	*Heuchera grossulariifolia var. tenuifolia*	gooseberry leaved alumroot	-/s; 4T3/3
Suspected	*Howellia aquatilis*	howellia	T/T; 2/2
Suspected	*Lomatium suksdorfii*	Suksdorf's desert parsley	SC/s; 3/3
Suspected	*Luzula arcuata*	curved woodrush	-/s; 5/1
Suspected	*Meconella oregana*	white meconella	SC/T; 2/1
Known	*Microseris borealis*	northern microseris	-/s; 3?/2
Suspected	*Montia diffusa*	branching montia	-/s; 4/1-2
Suspected	*Ophioglossum pusillum (=O. vul-gatum)*	Adder's tongue	-/T; 5/1-2
Suspected	*Parnassia fimbriata var. hoodiana*	fringed-grass-of-parnassus	-/s; 4T3/1
Suspected	*Pedicularis rainierensis*	Rainier's lousewort	-/s; 2-3/2-3
Suspected	*Pityopus californica*	pine foot	-/s; 4-5/1
Suspected	*Platanthera sparsiflora*	canyon bog orchid	-/s; 4-5/1
Suspected	*Polemonium carneum*	salmon polemonium	-/T; 4/1-2
Known	*Ranunculus populago*	mountain buttercup	-/s; 4/1?
Suspected	*Rorippa columbiae*	persistent sepal yellowcress	SC/T; 3/2
Suspected	*Scribneria bolanderi*	Scribner grass	-/s; 3-4/1
Known	*Sidalcea hirtipes*	bristly stemmed checker mallow	-/E, 2/1
Known	*Sisyrinchium sarmentosum*	pale blue-eyed grass	SC/T; 2/2
Suspected	*Utricularia intermedia*	flat-leaved bladderwort	-/s; 5/2

*F/S; G/S refer to federal/state status and global/state rank respectively.
E = endangered; T = threatened; SC = species of concern; s= sensitive
#'s refer to standard ranking after the Nature Conservancy

A search of the Biological Conservation Database yielded no known sites of TES plant species within the analysis area. However, sites for many of these species are suspected within the analysis area within suitable habitats.

Because many of these TES plant species are not confined to one specific habitat type, it is difficult to accurately delineate areas of suitable habitat for them within the analysis area. This was attempted at a broad scale by querying the existing vegetation layer GIS database for all ecoclass codes that represent unique plant habitats (i.e. meadows, red alder wetlands, rocky areas, etc.). Acres of each of these habitat types within the analysis area are summarized below in Table 3-11.

TABLE 3-11: Acres of Special Plant Habitats Within the Little Nisqually Analysis Area

Habitat Type	Total Acres	Percent of Total Area
Rocky Areas	35	0.002%
Riparian Features	31	0.002%
Shrublands	72	0.004%

National Wetland Inventory (NWI) maps are another useful source of information regarding special habitats. Methods and criteria used in compiling data for the GIS vegetation layer and the NWI maps are different, thus, to avoid "double counting" of acres, the NWI data is provided here separately from the GIS data shown above. These two tables represent two different approximations of special habitats and are not additive. Table 3-12 is a summary of the NWI data.

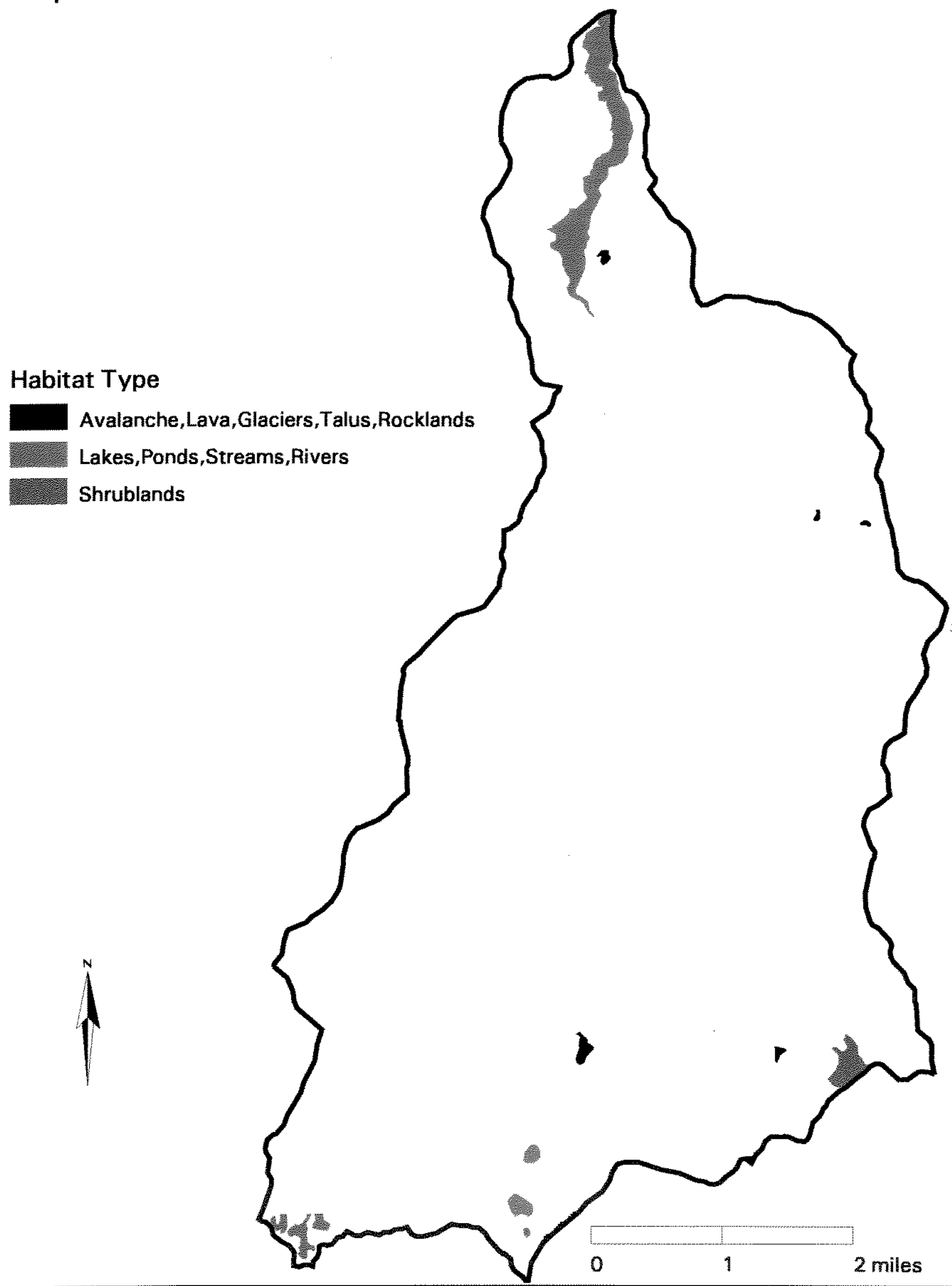
TABLE 3-12: Acres of NWI Wetlands Within the Little Nisqually Analysis Area

Wetland Type	Total Acres	Percent of Total Area
Palustrine Emergent	8	~
Palustrine Shrub-Scrub	17	0.001

Map 10

LITTLE NISQUALLY WATERSHED ANALYSIS

Special Habitats



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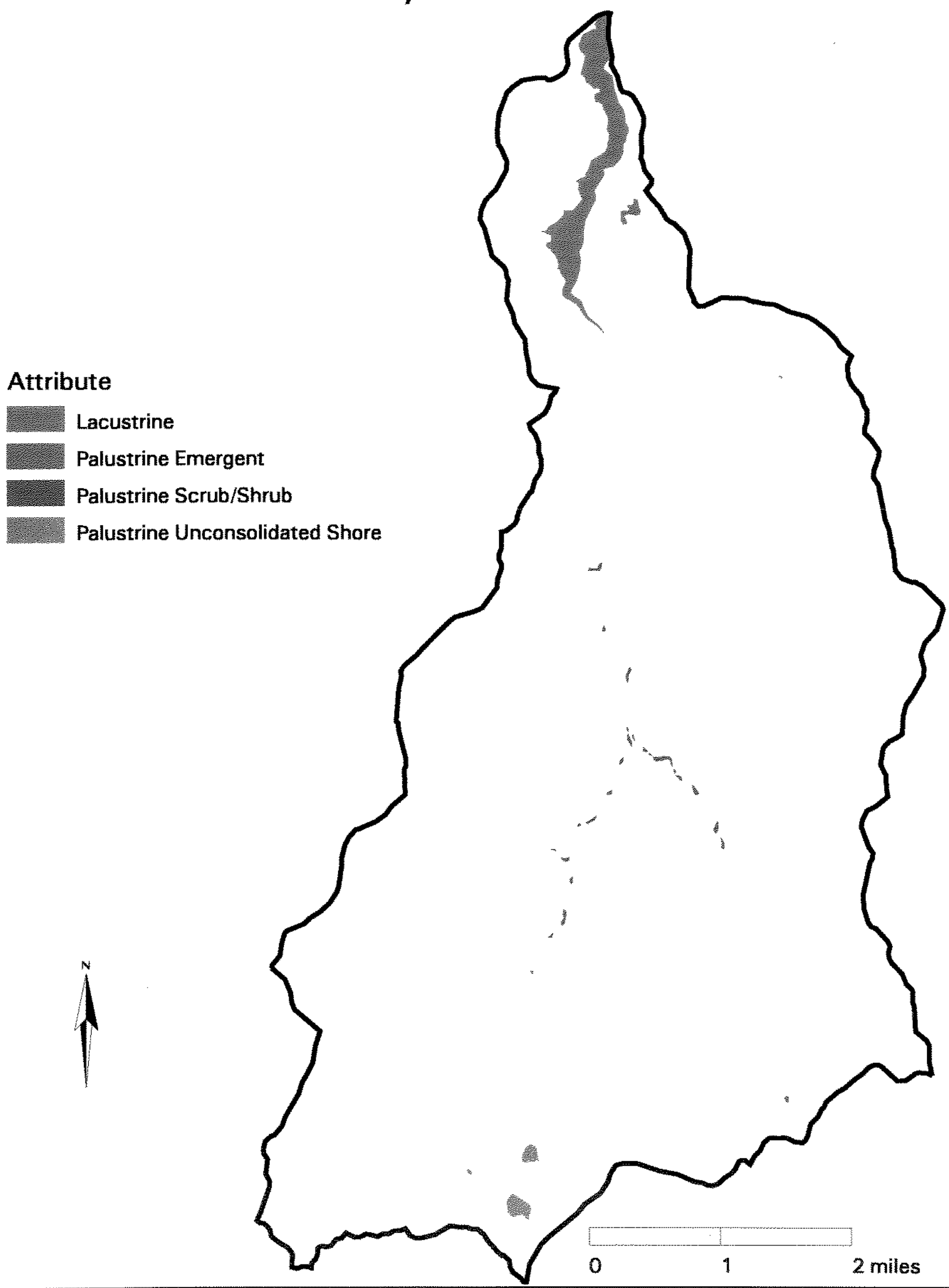
Map 11

LITTLE NISQUALLY WATERSHED ANALYSIS

National Wetland Inventory



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Riverine	3	~
Other (includes open water)	258	0.01

The distribution of special habitats within the analysis area are shown in Map 10, Special Habitats and Map 11, National Wetland Inventory.

Survey and Manage Botanical Species

Survey and manage botanical species include those species of fungi, lichens, bryophytes, and vascular plants that are listed in Table C-3 of the Northwest Forest Plan. No information on the historic condition of these species groups was available for this report. It is assumed that viable populations existed within some areas of suitable habitat.

No new inventories were conducted for these species as a part of this watershed analysis, and because very little inventory or tracking has been done for these species locally, or on a regional level, a data gap exists regarding the actual distribution and location of many of these species. Many strategy 4 species, especially those in the nitrogen-fixing lichen group, are found within the analysis area, though detailed site information is lacking. Species other than strategy 4, with documented sites within the analysis area include the vascular plant *Allotropa virgata* (3 known sites) and the rare lichen *Pilophorus nigricaulis* (1 known site).

Without much available data on actual species locations, evaluation of habitat conditions can be useful in predicting which species may be present. Areas that may provide suitable habitat for survey and manage species were derived from the existing vegetation layer in GIS by querying the associated database for parameters that would identify old-growth or late-successional stands. Further stratification of this habitat was achieved by overlaying a map of potential vegetation that indicates the major vegetational zones (i.e. western hemlock, Pacific silver fir, etc.) with a map that shows late-successional stands, and another that shows riparian areas. Information on the habitat requirements for individual survey and manage species is compiled in Appendix J2 of the Northwest Forest Plan and is not repeated here. That information can be used in conjunction with the habitat data provided here to predict which species may be present within the analysis area.

Based upon the database query described above, acreages of potential habitat for survey and manage species within the analysis area can be summarized as follows in Table 3-13.

Table 3-13: Summary of Acres of Late-Successional Habitat Within the Analysis Area by Potential Vegetation Type

	Outside Riparian	Inside Riparian	

Total Size of Analysis Area	Western Hemlock	Silver Fir	Western Hemlock	Silver Fir	Total	% of Area in Late Successional
17,873	1,891	395	1,275	258	3,819	21%

Noxious Weeds

No information on the historic condition of this species group was available for this report though it is assumed that these species have invaded the area concurrently with human disturbance. The history of road and trail development within the analysis area would likely provide an interesting look into the historic invasion of weeds into the area.

No surveys were conducted for noxious weeds within the analysis area in conjunction with this watershed analysis. Noxious weed species commonly encountered in large populations on the Cowlitz Valley Ranger District and likely to occur within the analysis area are shown in Table 3-14.

TABLE 3-14:
Noxious Weeds Likely to be Found in Large Populations Within the Analysis Area

Scientific Name	Common Name
Chrysanthemum leucanthemum	oxeye daisy
Cirsium arvense	Canada thistle
Cirsium vulgare	bull thistle
Cytisus scoparius	Scotch broom
Hypericum perforatum	St. John's wort
Phalaris arundinacea	reed canary grass
Potentilla recta	erect cinquefoil
Senecio jacobaea	tansy ragwort

Primary corridors for noxious weed dispersal within the analysis area include roads, trails, and riparian areas. Disturbed sites, including parking areas, log landings, trail heads, quarries, etc., provide potential population centers for these species.

Wildlife

Data Sources/Data Gaps

This report was compiled from the knowledge of Forest Service and Washington Dept. of Fish and Wildlife biologists, wildlife sighting databases, aerial photo interpretation, Geographic Information System (GIS) produced maps and literature reviews. There was no field reconnaissance conducted for this report. The following data is either not presently available or was not collected for this analysis:

- Data on down log and snag densities, their size distribution, and decay class is generally unavailable.
- Current and historical information about the location and status for most species on federal lands.
- Wildlife sighting observations may vary in their reliability. Normally, a "confidence" factor such as confirmed, probable, etc. are attached to the report based on viewer experience, weather conditions, and habitat suitability for the species being reported.

Assumptions

The following assumptions were made for this analysis:

- Habitat conditions are a major determinant in defining wildlife distribution and abundance. Therefore, in the absence of a sighting record, a species may occur in the watershed if its habitat occurs in sufficient patch size. For very large home range species such as the grizzly bear and wolverine, species may also depend on suitable habitats being present on adjoining watersheds.
- Fire, volcanic events, timber harvests, and road construction have the greatest influence on wildlife presence and distribution.
- Wildlife species that presently occur in the watershed are assumed to have been present prior to European settlement in the valley with the exception of introduced species.
- Fire and volcanic disturbances, timber harvest, and roads accessing habitats have had the greatest influence on wildlife distribution. Wildlife species abundance is determined by

several interacting factors, including habitat conditions, human use (i.e. hunting, trapping, both legal and illegal), and , in the case of wide-ranging migratory species, habitat and human factors far from the watershed area.

General Wildlife and Habitats

The Middle and Upper Cispus River Pilot Watershed Analysis (USDA 1995) listed 264 wildlife species potentially present in that watershed. The Little Nisqually watershed contains approximately the same number of species. Several introduced species are also assumed to occur in the Little Nisqually watershed, including: European starling, house sparrow, Virginia opossum, Norway rat, and the bullfrog. Also, the aforementioned list contains some "east-side" Cascades species that likely occur in the watershed on a very rare basis, or not at all. Documentation on population estimates and the current range of many species in the watershed is not known. Not included are a number of mollusks which are assumed to occur within the watershed.

Special or Unique Habitats

Special and unique habitats such as rock outcrops, talus slopes, wet meadows, shrublands, lakes and ponds are present in the watershed and are displayed on Map 10, Special Habitats. Overall, this watershed has fewer of these special habitats than some others due to it's relatively low elevation and terrain, thereby resulting in an absence of alpine and subalpine meadows, avalanche chutes, and large cliffs. This in term limits the number of species that occur here; the mountain goat, for example, is absent from the watershed.

Proposed, Endangered, Threatened and Sensitive Species

Several wildlife species have been documented, or have the potential to occur, in the Little Nisqually River watershed that are listed as proposed, endangered, threatened, sensitive, or as a federal candidate for listing. In addition there are eight species designated as federal "species of concern" Sensitive species are those on the Regional Forester's list requiring attention to prevent future federal listing. Federal candidates are those species for which the U.S. Fish and Wildlife Service has sufficient information to propose for listing as threatened or endangered under the Endangered Species Act. "Species of concern" are those species whose conservation status is of concern to the Service, but for which status information is still needed. Table 3-15 below lists all threatened, endangered, sensitive, candidate, and species of concern that are known or suspected to occur within the Little Nisqually watershed.

Table 3-15: Threatened, Endangered, Sensitive, Candidate, and Species of Concern Documented (D) or with Potential (P) To Occur in the Little Nisqually Watershed

Species/Occurrence	Endangered	Threatened	Sensitive	Candidate (c) or Proposed (p)	Species of Concern
Gray wolf (P)	X		X		
Grizzly bear (P)		X	X		
Northern bald eagle (D)		X	X		
Northern spotted owl (D)		X	X		
Marbled murrelet (D)		X	X		
North American lynx (P)* **			X	p	
California wolverine (P)*			X		X
Larch Mountain salamander (P)			X		X
Cope's giant salamander (P)			X		
Townsend's big-eared bat (P)			X		X
Western pond turtle (P)			X		X
Common loon (P)			X		
Oregon spotted frog (P)				c	
Northern goshawk (P)					X
Olive-sided flycatcher (P)					X
Pacific fisher (P)					X
Long-legged myotis (P)					X
Long-eared myotis (P)					X
Fringed myotis (P)					X
Tailed frog (P)					X
Cascade frog (P)					X
Bull trout				p	

* May occur rarely or as transients, due to very limited amounts of suitable habitat
** The lynx has also been officially proposed for listing under the ESA

The following section provides a brief summary of selected species listed in the above table, including habitat requirements and where it is located in the watershed, and if the species has been documented to occur.

Gray Wolf

Wolves were thought to be eliminated as a breeding resident in Washington by 1930 (Young 1944). However, Laufer and Jenkins (1989) suggest wolves may be re-colonizing former ranges based on numerous reported sightings. This is consistent with the increasing number of wolf sightings reported on the Cowlitz Valley Ranger District over the last 20 years. No records of gray wolves are known in the watershed, although they may occur year-round. High road densities in some sections of the watershed, and surrounding lands, may limit the potential for gray wolf occurrence, as this has been shown to be a limiting factor for this species.

Peregrine Falcon

Peregrine falcons typically breed near wetlands, lakes, rivers, or other water sources that provide an array of prey. Nests are normally found on high cliffs although nesting on man-made structures such as highway bridges and skyscraper ledges is increasing. The re-introduction of peregrine falcons to the Pacific Northwest has been occurring over the last decade with several hack-sites selected on the Gifford Pinchot and Wenatchee National Forests. Between 1991 to 1993, fifteen young peregrines were released in the Middle Cispus River watershed, Cowlitz Valley Ranger District of the Gifford Pinchot National Forest. Two breeding pairs have been confirmed on the Gifford Pinchot National Forest though neither pair is within the Little Nisqually watershed. The lack of suitable nesting cliffs within the watershed means that peregrines would likely occur here only as migrants.

Grizzly Bear

Grizzlies have never been very common in Washington state although they were hunted to near extinction in the late 1880's. Grizzlies are the largest omnivores in North America with males reaching 400 to 800 pounds. Their diet include vegetation and insects, including a variety of forbs, berries, and grasses. These foods are also supplemented by winter-killed ungulates and ground squirrels. Grizzly bears require large home ranges to encompass the various seasonal habitat types necessary to supply their diverse diet. Grizzlies are not territorial and home ranges of individual bears do overlap. Small remnant populations exists in the North Cascades and in the Selkirk Mountains in the northeastern part of the state. Both of these areas have been designated as recovery zones for the species. There have been no confirmed sightings on the Gifford Pinchot National Forest although suitable habitat is available. The nearest occupied grizzly habitat is on private timber company lands west of Mt. Rainier National Park. The tracks of two grizzlies were confirmed in 1993. Those grizzly tracks represented the first species confirmation south of Interstate 90.

Grizzly bears may occur in the watershed, although high road densities may again limit the potential of this area to support grizzlies. Food and cover appears plentiful however, at least in the short-term. No sightings of this species have been reported in the watershed to date, and excellent documentation of sightings is required to avoid confusion with brown-phase black bears.

Northern Bald Eagle

Bald eagles are highly territorial and exhibit strong site tenacity, with paired birds returning to the same area year after year. A good territory for eagles has suitable nest trees, many perch trees within and along the perimeter of their territory, and foraging areas. In Washington, potential habitats are riparian areas along rivers, lakes, and streams. Wintering eagles commonly roost in large groups and studies from the Lewis River watershed in southern Washington suggests north facing slopes with older multi-canopied stands are preferred night communal roosting areas (Anderson and Ischisaka, 1986). Bald eagles have been observed during the winter along the Little Nisqually River, and are common on Alder Lake, where they have also nested. There are no known communal night roosts in the watershed although surveys have never been conducted; these roosts are more likely along Alder Lake than along the Little Nisqually itself.

Northern Spotted Owl

Overall habitat conditions for the northern spotted owl are poor in the watershed. Much suitable owl habitat has been removed due to logging, and the remaining habitat is generally fragmented. A notable exception to this is the Scatter Creek drainage, which does contain a block of contiguous, suitable habitat. See Map 12, Northern Spotted Owl Habitat/Critical Habitat Unit WA-35. Compounding the marginal habitat conditions in the watershed is the fact that much of the surrounding landscape is unsuitable habitat for spotted owls, creating a "habitat island" effect in the Little Nisqually.

Suitable spotted owl habitat can be categorized into two components: "nesting and roosting" habitat, and "foraging" habitat. "Nesting and roosting" habitat is typified by large trees and snags, abundant coarse woody debris, and a multi-storied canopy. There are 3,462 acres of this habitat type in the watershed presently. This compares with 6,799 acres of "foraging" habitat that usually does not present nesting opportunities for spotted owls, but does provide snags and coarse woody debris that their prey species utilize. As many of these stands here are almost 150 years old, and some contain remnant large trees and snags, they may in fact be providing nesting opportunities. Further survey work would be needed to determine this.

At present, there are only 8 acres of "dispersal" type habitat in the watershed. These are younger forest stands that provide cover as well as some limited foraging opportunities for dispersing juvenile owls, but are not as yet considered to be suitable nesting, roosting, or foraging habitat. The amount of this "dispersal" habitat should increase dramatically over the next 20-40 years as logged stands succeed towards this condition. This will also tend to reduce fragmentation, and thereby improve habitat capability for the spotted owl.

There are four known spotted owl pairs that occur within the watershed boundary, and one additional pair that occurs outside of it, but whose home range likely extends into the watershed. There are also five "territorial single" owls within the watershed, and one additional single just outside the boundary. This is a relatively large number of birds for such a limited habitat base, and this may be due to "packing" of birds from adjacent areas (where suitable habitat has been eliminated or severely fragmented) into suitable habitat within the watershed. No spotted owl surveys have been conducted in the watershed since the early 1990's, so the current status of many of these pairs and singles is unknown.

Two of the four owl pairs within the watershed (522 and 532) are below the "take thresholds" established by the U.S. Fish and Wildlife Service of 500 acres of suitable habitat within .7 miles of the pair center, and 2663 acres within 1.82 miles. At least one of the territorial single owls is also below the take thresholds. These birds may not have sufficient suitable habitat remaining within their home ranges to allow them to persist over the long-term.

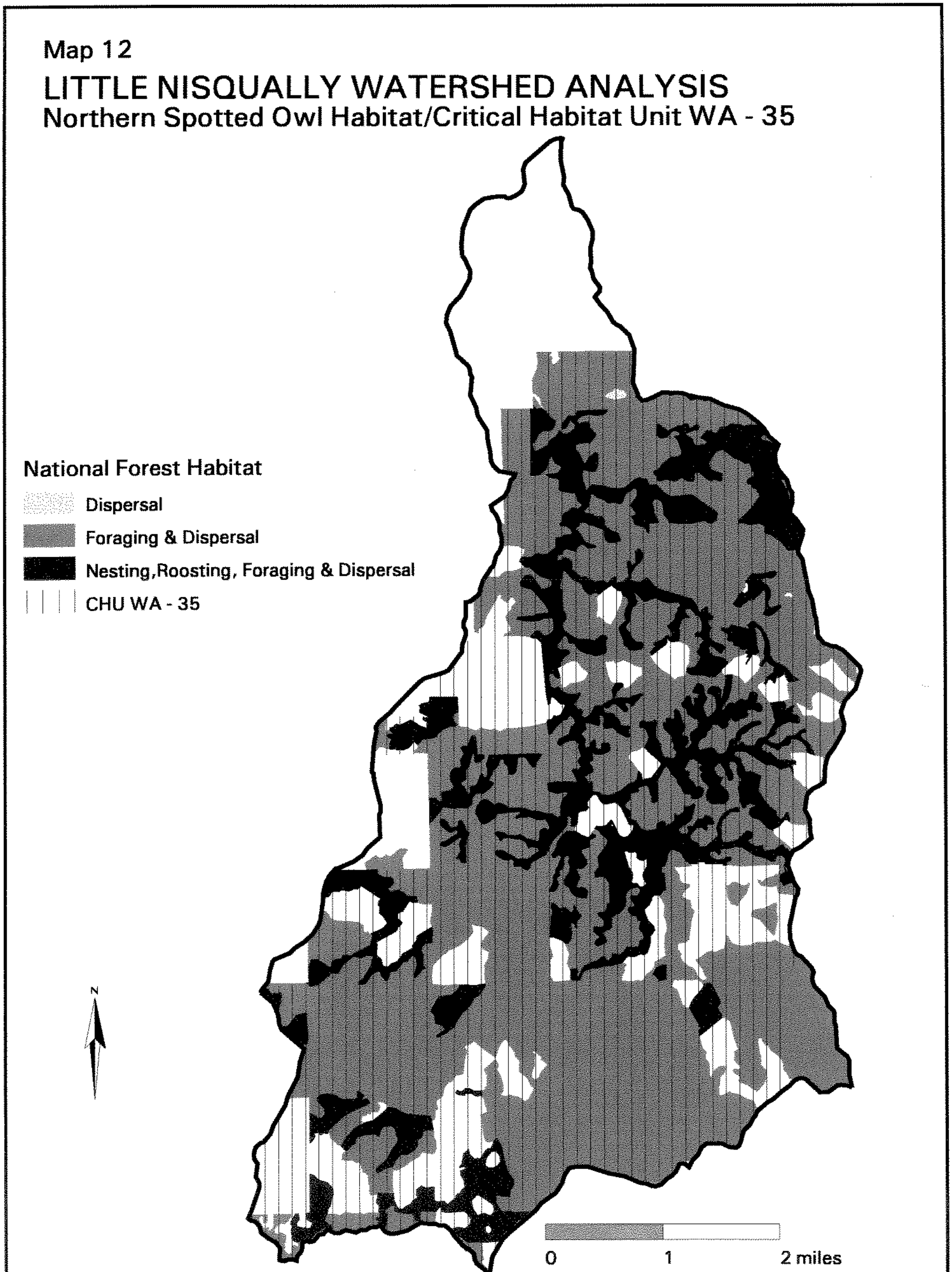
Table 3-16: Spotted owl pairs and territorial singles with home range acres, Little Nisqually Watershed.

Pair or single name/number	Acres, .7 mile radius circle	Acres, 1.82 radius circle
Little, #507*	622	3028
Mona, #509	759	2842
Ware, #519	648	3537
Winston, #522	*324*	*1777*
Fly, #532	*378*	*2167*
Single #5209*	649	*2602*
Single #5221	573	*2561*
Single #5234	803	4521
Single #5235	739	3270
Single #5237	698	3945
Single #5238	799	3116

* Occurs outside WA boundary, but home range potentially extends into it

Spotted Owl Critical Habitat

The entire Little Nisqually watershed is classified as Spotted Owl Critical Habitat (CHU WA-35). See Map 12, Northern Spotted Owl Habitat/Critical Habitat Unit WA-35. The CHU coincides with a Late-Successional Reserve under the Northwest Forest Plan, so the goals of each designation are highly compatible. As described above, overall habitat



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conditions for spotted owls are poor in the watershed and CHU at present due to direct habitat removal and fragmentation. As harvested areas regenerate and succeed towards a mid-seral condition, fragmentation will gradually decrease, and dispersal habitat will be provided. This may be accelerated by commercial thinning, particularly if snags are created and coarse woody debris levels are increased in conjunction with the thinning.

Marbled Murrelet and Critical Habitat

The marbled murrelet is a small seabird that nests inland in late-successional forests containing suitable nesting platforms, usually horizontal, moss-covered limbs at least 5 inches in diameter. Suitable nesting habitat is defined as within 55 miles from the nearest saltwater; the Little Nisqually watershed is within 35 miles of saltwater (i.e. Puget Sound), so it is well within this suitable habitat range.

The marbled murrelet has been documented in the watershed, based on surveys conducted by Cowlitz Valley Ranger District personnel during 1992. Single birds or pairs were located on at least four separate occasions, and nesting was suspected although not documented. Murrelets have been observed on other surveys within the Mineral Block near the watershed boundary, so this species occurs, and probably nests, in this area with some frequency. There are 3,462 acres of suitable murrelet nesting habitat within the watershed, although this should be considered a minimum figure as it includes only "classic" old-growth stands. Many of the younger, "mid-seral" stands are likely providing some suitable nesting habitat, particularly those containing remnant, old-growth trees. In the future, the amount of this suitable habitat will increase as these stands mature, and trees develop larger limbs that can potentially provide nesting substrate for marbled murrelets.

The watershed is also classified as Marbled Murrelet Critical Habitat due to it's occurrence in a Late-Successional Reserve. Although large areas of it no longer function as suitable nesting habitat due to logging, the remaining forest stands do provide this habitat. As survey activity here has been very limited, additional work is needed to determine the extent and locations of murrelet nesting activity in the watershed.

North American Lynx

The lynx is a rare and locally endemic species in the Pacific Northwest and has recently been classified as a candidate species by the U.S. Fish and Wildlife Service. While historical data is not available on population estimates, the current population is estimated at about 200 animals, primarily occurring within or near the Okanogan and Wenatchee National Forests. Lynx trapping and hunting was legal in Washington state until November of 1991. Habitat modifications that reduce the amount and availability of foraging and denning habitat, combined with fire suppression and the effects of prior trapping, may be the major reasons for the continuing population decline.

Lynx are associated with high elevation, boreal forests and found primarily above 4000 feet elevation in Washington. High quality lynx habitat is comprised of a mosaic of early successional forests with high prey densities (snowshoe hares) for foraging and late-successional forests with an accumulation of down logs used for denning, thermal and security cover (Koehler and Brittell 1990). The vast majority of the Little Nisqually watershed occurs below 4000 feet in elevation, therefore lynx habitat is very limited here, and this species would not be expected to regularly occur in the watershed.

The North American lynx is listed as a strategy 3 survey and manage species. Surveys within the region are being conducted and include portions of the Gifford Pinchot National Forest.

California Wolverine

The wolverine is the largest member of the terrestrial mustelid family with males reaching 12-18 kg. and females averaging 8-12 kg. The skull and teeth are robust and the musculature especially of the head, shoulders and neck is well developed. The adaptations allow the wolverine to feed on frozen flesh and bone. All studies have indicated large mammals are important food sources for wolverines year-round and that they are too large to survive entirely on small sized prey such as snowshoe hares. Berries, squirrels, and insect larvae are also included in their diet on a seasonal basis. The wolverine is one of the rarest and least known mammals in North America. Within their geographic range, the wolverine occupies a variety of habitats however a general trait defining occupancy is remote lands with little human disturbance. A majority of winter habitat use occurs in montane coniferous forest. Known wolverine natal dens in Idaho were found in high elevation basins with talus of large boulders where tunnels were dug beneath the boulders.

Due to the high road density in the watershed and adjacent lands, and the lack of sufficient high-elevation habitat in the watershed, it is unlikely that the wolverine occurs here except perhaps as a transient.

Pacific Fisher

Fishers are members of the mustelid family, similar in body form to the weasel. Males average 3-6 kg. and are twice as large as females. Their diets are typically diverse with studies indicating snowshoe hares, ungulate carrion, squirrels and chipmunks, and voles as primary food sources. They are vulnerable to trapping and are frequently caught in the sets for other species. Home ranges can be as large as 41 square kilometers for females and 85 square kilometers for males. In the western United States, fishers seem to prefer conifer dominated forests and are closely associated with forested riparian areas. Research by Aubrey and Houston (1992) show fishers to be a relatively low elevation species in the west-side of the Cascade Mountains. They are extremely rare in the Cascades, and perhaps have even been extirpated from this region based on the absence of recent verified sightings.

No fisher sightings have been reported in the watershed, although habitat does appear suitable for this species due the low-elevation, late-successional forests present, particularly in the northern half of the watershed. Camera surveys operated during 1996-1998 on the Cowlitz Valley RD to detect marten and fisher did not include the Little Nisqually, and no other surveys have occurred in this area.

Common Loon

The common loon is known to breed at only a few locations in western Washington. From September to May the loon frequents estuarine and suitable marine habitats along the Pacific coast. This species require deep freshwater lakes with an abundance of fish for breeding areas. Nests are usually on the ground very close to water, concealed by vegetation or rocks. The species is also very susceptible to human disturbance during the nesting period. Common loons likely occur with some frequency on Alder Lake, however the two small lakes in the watershed (Duck and Goose) are too small to be utilized by loons.

Northern Goshawk

In Washington, evidence suggests that goshawks nest in mature forests with large, tall trees and dense canopies. Criteria adapted from Fleming (1987) indicated that potential nesting habitat would be defined by these criteria: average dbh => 30cm; average tree height =>24 m, tree density = 250-750 stems/acre, and conifer composition at least 70 percent. However, work by Bosakowski and Vaughn (1996) in Washington suggests that habitat suitability models need to be designed from regional or local data wherever possible because of some variability observed in the choice of nesting locations. A simplified model using only forest age, with greater than 35 years being the lower limit, may be adequate for mapping goshawk nesting habitat.

Goshawks forage in mature forests having stand openings and structural diversity, essential in allowing the birds to maneuver as they pursue prey. Dense, large tree stands that have not developed adequate openings and understory as a result of past harvest practices provide little foraging habitat for goshawks. Goshawks feed on a diverse range of prey, primarily medium sized birds such as grouse, Stellar's jays and robins, and mammals such as rabbits, hares, and squirrels. Goshawks may hunt from a perch or while flying through the forest.

The northern goshawk has historically been considered uncommon throughout its range. Goshawks experience population fluctuations due to variable nesting success, and possibly in response to varying prey availability. No goshawk surveys have occurred in the Little Nisqually watershed, although there are active territories nearby. Portions of the watershed, such as the large block of mid-seral forest in the Scatter Creek drainage, appear to be highly suitable nesting habitat for this species. Habitat capability for the northern goshawk should increase over the long-term due to the Late-Successional Reserve allocation.

Survey and Manage Amphibians and Mollusks

Survey and Manage amphibians and mollusks are listed in Table C-3 of the Northwest Forest Plan. Of that extensive list, two amphibian species and eight mollusk species are either known to occur, or are presumed to occur, on the Gifford Pinchot National Forest. This list represents those mollusks that have been documented on the national forest or have been confirmed on adjacent private lands. There is no information available on the historic presence or distribution of any of these species, with the exception of the Van Dyke's salamander which has been documented in the watershed. The ten survey and manage species and a brief habitat description are listed in the accompanying table.

Table 3-17: Known Or Suspected Survey and Manage Wildlife Species

Species	Suitable Habitat
Larch Mountain salamander *(Plethodon larselli)*	Steep, talus slopes, cave entrances, mature and old growth forest
Van Dyke's salamander *(Plethodon vandykei)*	Streams, seeps, cave entrances, lake shores
Columbia Duskysnail (*Lygogyrus* n. sp. 1)	Cold, well oxygenated springs
Puget Oregonian Snail *(Cryptomastix devia)*	Moist conifer forest with hardwoods
Evening fieldslug *(Deroceras hesperium)*	Forested areas below 2000 feet .
Warty jumping-slug *(Hemphillia glandulosa)*	Mesic to moist conifer forest
Malone jumping-slug *(Hemphillia malonei)*	Conifer forests to at least 4200 ft elevation
Panther jumping-slug *(Hemphillia pantherina)*	Deep forest floor litter below 3000 feet
Blue-gray tail-dropper slug *(Prophysaon coeruleum)*	Conifer forests
Papillose tail-dropper slug *(Prophysaon dubium)*	Conifer forests with hardwood component

At the present time, there have been no formal surveys or inventories conducted for any of the species listed in the above table. This is due to the absence of ground-disturbing activities proposed since the "survey and manage" requirements have been in effect. Several forested talus slopes were noted on field visits, and these potentially provide habitat for Larch Mountain salamanders, and possibly some of the mollusks. Suitable habitat for the Van Dyke's salamander was also noted along some high-gradient streams, where the one known site occurs. Until some survey activity occurs for these species, their distribution and occurrence in the watershed will remain a mystery.

ROD Protection Buffer Species

The ROD afforded extra protection for a selected group of wildlife species that were considered rare or locally endemic. This group of species with the potential for occurrence in the watershed include: black-backed woodpecker, fringed myotis bat, silver-haired bat, long-eared myotis bat, long-legged myotis bat, and the pallid bat. None of these species have been documented to occur although surveys have not been conducted.

The black-backed woodpecker is found at higher elevations on the Forest, usually above 4000 ft. Nesting has been documented on the Cowlitz Valley R.D., although this species is uncommon to rare. It is unlikely that it occurs with any regularity in the Little Nisqually watershed due the limited amount of higher elevation habitat. Within NFP matrix and adaptive management areas, surveys are required of caves, mines, abandoned wooden bridges and buildings to determine the presence of roosting bats. No bat surveys have occurred in the watershed, and no sightings of these species have been recorded.

Harlequin Duck and Golden Eagle

Although not included in the previous lists and tables, these species are uncommon to rare on a landscape level and their status is of concern to biologists and others. The Little Nisqually River appears highly suitable habitat for the harlequin duck, which prefer wider, fast-running streams.

This species has nested at several locations on the Cowlitz and Cispus river systems, although no surveys have been conducted on the Little Nisqually, and no historic sightings have occurred. The golden eagle is a rare nester in western Washington, but is sometimes found near large openings created by timber harvest such as those that exist in the watershed. Washington Dept. of Fish and Wildlife records indicate that active golden eagle territories exist outside the watershed boundary, and it is possible that a presently unknown territory occurs within it.

Big Game Habitat

Black-tailed Deer and Roosevelt/Rocky Mountain Elk

Deer and elk have been designated as management indicator species, and the Gifford Pinchot National Forest Management Plan has specific guidelines for the management of deer and elk winter range habitat. Approximately 28 percent of the watershed (5,022 acres) is within the elevational range defined as big game winter range, below 2,200 feet in elevation. See Map 13, Deer and Elk Biological Winter Range. The following table displays the current habitat condition of the deer and elk biological winter range. For table summary purposes, winter range cover/forage conditions within national forest and privatelands have been combined.

TABLE 3-18: Deer and Elk Biological Winter Range Acres* and Percent By Cover Condition for the Little Nisqually Watershed

	Optimal Cover	Thermal Cover	Hiding Cover	Open Forage	Total
Acres	1,456	1,221	809	1,536	5,022
Percentage	29%	24%	16%	31%	100

* These acres were developed from a vegetation database and have not been field verified.

Optimal cover would be defined as those forested stands averaging greater than 21 inches dbh with four canopy layers and an overstory generally exceeding 70 percent canopy closure. Thermal cover stands are defined as forested stands averaging 9-20 inches dbh and greater than 60-70 percent canopy closure. Hiding cover is usually reached when forested stands are tall enough to screen animals, approximately four and a half feet tall. Open forage include both natural openings (meadows, shrublands etc.) and regeneration harvest openings up until about age 20. Occasionally, heavy commercial thinnings can also be considered as temporary forage openings if the retention trees have a canopy closure less than 50 percent.

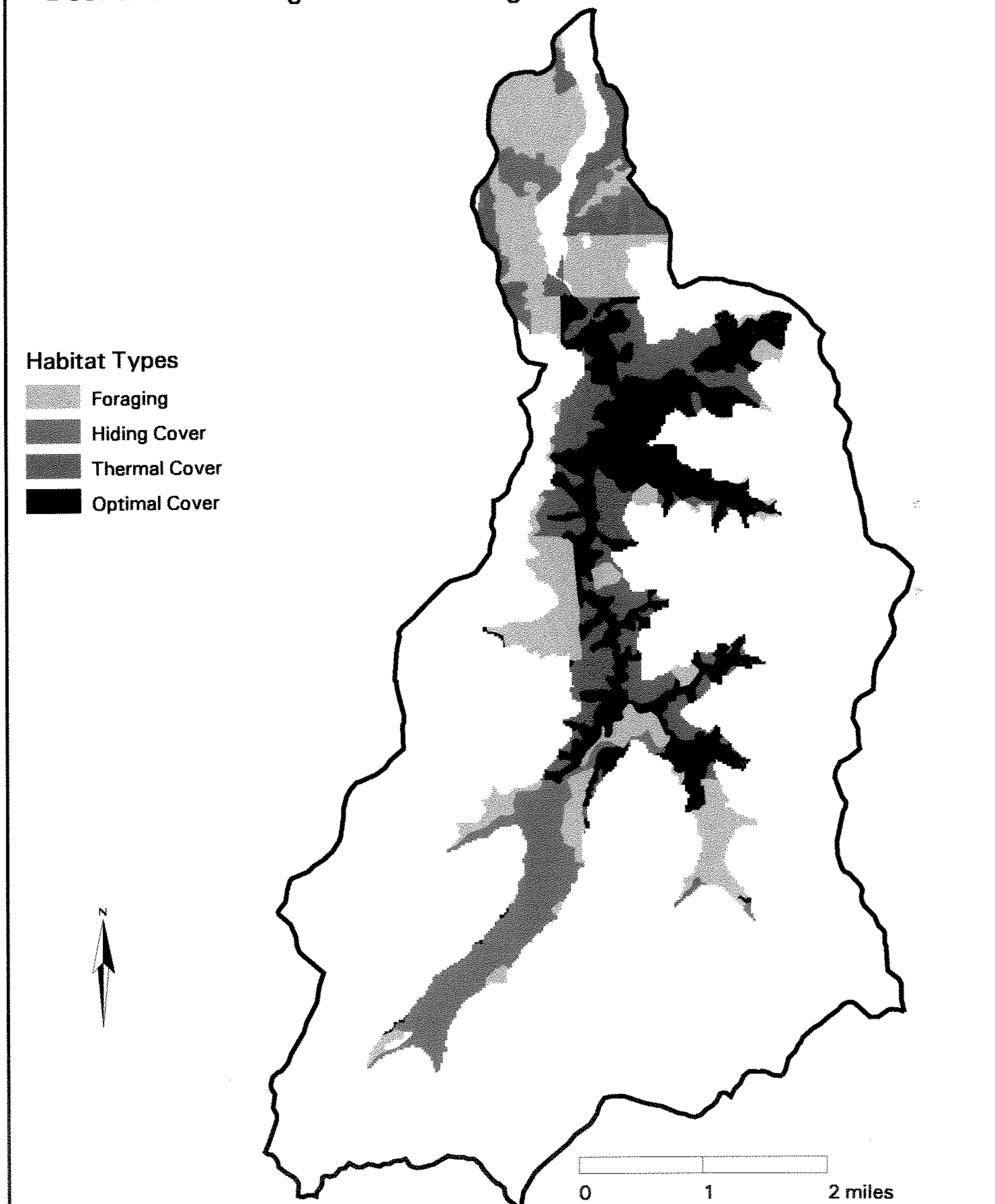
The Gifford Pinchot NF Plan sets a goal of maintaining 44% of the winter range in an optimal cover condition. Although the watershed is below this goal at present, this condition will improve as thermal cover stands succeed towards optimal cover. Many of these thermal cover stands, in fact, may be optimal cover now; field investigations would be needed to verify this.

Although there are no specific goals for forage, a total of 10-15 percent is generally considered as a desirable goal for winter range (R. Scharpf, GP forest biologist, pers. comm.). Therefore, the current 31% in forage is about twice the desired level, although this will be declining rapidly in the short-term (10 years) as the existing forage openings grow

Map 13

LITTLE NISQUALLY WATERSHED ANALYSIS

Deer and Elk Biological Winter Range



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into hiding cover. At that point, forage will be in short supply, as few additional openings will be created due to the Late-Successional Reserve land allocation.

As important as the amounts of cover and forage in this watershed are the distribution of these types. Virtually all of the forage openings occur in large blocks, the majority of which are a long distance from any cover. This decreases their utility to big game, who prefer not to travel long distances from cover during the winter. The poor distribution of cover and forage in this watershed results in a relatively low habitat capability for deer and elk, one that is expected to decline further as existing forage areas are lost. This hold true for other early-seral species dependent on openings and edges, such as red-tailed hawks, olive-sided flycatchers, and great horned owls. This low habitat capability will be a long-term condition due to the LSR allocation, which favors interior forest species.

Road densities in deer and elk winter range should not exceed 1.7 miles of open road per square mile of land (GP Forest Plan, p. IV-26). The road density on National Forest land in the Little Nisqually winter range is 2.4 miles per square mile. This includes open roads only, and does not include an additional .6 miles per square mile of roads that have been closed or decommissioned. There is also 1.2 miles per square mile of roads on private lands within the watershed, the exact status of which is unknown. Some of these private roads are undoubtedly open however, pushing the total open road density in the Little Nisqually winter range to over 3 miles per square mile.

Habitat Connectivity

Connectivity can be defined as the measure of the extent to which the landscape pattern of the late-successional/old growth ecosystem provides for biological and ecological flows that sustain late-successional/old growth animal and plant species (FEMAT 1995). Connectivity is species specific and is related to each species' mobility, population size and distribution, and degree of dependence on a particular habitat type. Animals interact with the landscape at three different scales: within the home range, within a population, and between populations. If habitat patches are not large enough to support self-sustaining populations, connectivity can compensate for the deficiency.

From a historical perspective, connectivity was influenced primarily by fires, volcanic events, and floods. Fire events ranged from less than one acre burns to those involving thousands of acres which could drastically alter connectivity between patch types. More recently, timber harvest has resulted in patches of early successional stands scattered across the landscape that can affect connectivity.

Riparian Connectivity

The following table displays the current and historical condition of the riparian zones within the Little Nisqually River watershed.

Table 3-19: Riparian Zone Vegetation Composition

Year	Large Tree Acres / (%)	Small Tree Acres / (%)	Grass / Pole Acres / (%)	Non-Forest Acres / (%)	Total Acres
1999	1532 (29%)	798 (15%)	2695 (51%)	288 (5%)	5313
1900	1975 (37%)	2813 (53%)	247 (5%)	287 (5%)	5322

Riparian connectivity for species oriented to late-successional habitats is poor overall in the watershed. As displayed above over half of the watershed's riparian areas are presently in early-seral "grass/pole" habitat or non-forest. The only area with good riparian connectivity is the middle and southern sections of sub-watershed 20Q, along the Little Nisqually River, and along Scatter Creek. This sub-watershed contains 46% of the large tree riparian habitat in the entire watershed.

On a landscape level, connectivity has been severely compromised in adjacent watersheds, probably affecting the ability of some species to reach the Little Nisqually area. Connectivity will improve gradually in the Little Nisqually watershed over the long-term as early-seral forests succeed towards a late-seral condition. The effectiveness of these corridors will depend on the management of riparian corridors in adjacent watersheds, particularly for late-seral species with larger home ranges.

Pileated Woodpecker and American Marten Network

To meet management objective for these species, the Gifford Pinchot National Forest Land and Resource Management Plan required the establishment of dedicated land allocations for the marten and pileated woodpecker. There were no allocated areas set aside for these species within the Little Nisqually watershed.

AQUATIC ELEMENTS

Disturbance Regimes - Geological Processes

Data Sources/Data Gaps

Information regarding seismic activity was taken from the literature and from data stored in the Pacific Northwest Seismograph Network (PNSN) database housed at the University of Washington Geophysics Department, and is given a high degree of reliability at the scale of the total project area. Information related to volcanic activity in the study area is taken from the literature, and the USGS Cascade Volcanic Observatory (CVO) web page.

Locations for mass wasting events were identified using a GIS coverage called ``GeoHaz' (see Map 14 - Mass Wasting Inventory). Four major flood events have occurred since the original version of GeoHaz was completed early in 1994; these floods occurred in 12/94, 11/95, 2/96, and 12/96. The GeoHaz cover for the forest has subsequently had an initial update using special flight photography, aerial video and still photographic footage, and site visits; a comprehensive review and update for this area has not yet been completed. GeoHaz is generally accurate, meaning that most landslides out on the ground have been identified by GeoHaz, and most of the slides shown by GeoHaz will be found out on the ground. However, a known weakness of GeoHaz is that small failures along stream channels and roads are under-represented; more of these small failures exist on the ground than are shown on the coverage. Due to time limitations, neither a field review nor a complete air photo review of the entire watershed was conducted for the Mass Wasting part of this watershed analysis; this is an office exercise, with information derived from the most readily available data sources. Additionally, air photo sequencing to compare the rate of 'naturally occurring' mass wasting events to 'human-caused' mass wasting events was not undertaken for this project. However, the existing GeoHaz cover and air photo reviews for past projects in this study area has allowed the writer to make qualitative determinations regarding the rate of human-related mass failures compared to naturally occurring mass failures throughout the rest of the watershed during a given time span. This time span, referred to below as Reference Conditions, for this watershed refers to the 1973-1993 period of air photo coverage. This brief time span is entirely too short to use for determining a Range of Natural Variability for mass wasting, so the term Reference Conditions has been used instead. When discussing the comparison of management-related mass wasting events to historic conditions, the following qualitative descriptions were used:

Slight: a few small road and harvest related failures have occurred, separated in both time and space; these occurrences are virtually indistinguishable from the background rate of mass wasting.

Moderate: several road and harvest related failures have occurred over space, with some of these being repeat failures in the same location through time.

High: numerous road and harvest related failures have occurred over space, with several of these being repeat failures in the same location through time.

Severe: numerous road and harvest related failures have occurred over space, with numerous repeat failures occurring chronically at the same location through time.

Information for hillslope erosion was taken from the forest GIS coverage Soil Resource Inventory (SRI) map. Polygons delineating soil types are thought to be accurate at the watershed scale, although details will vary in accuracy at the site level. Interpretations of 'surface soil erosion potential' were taken from the SRI handbook, and applied across the watershed as a rating of 'Low, Moderate, or High' (see Map 15 - Soil Erosion Potential). No information on historic levels of hillslope erosion is known to exist for this watershed. It is surmised that hillslope erosion increased following fires known to have burned in the area, but no data is currently available with which to quantify those changes.

Road Condition (Access and Travel Management, Phase II) Surveys are not available for this watershed analysis. However, another source of information regarding road conditions used is the Historic Flood Damage database on file in the Forest Headquarters office in Vancouver, Washington. A summary of these reports lists flood damage sites from high water events in 1977-97, and estimated costs to repair these sites to a similar standard as before the flood events (Restoration Database, Jones, 1999 - in prep).

Volcanic Eruption and Seismic Activity

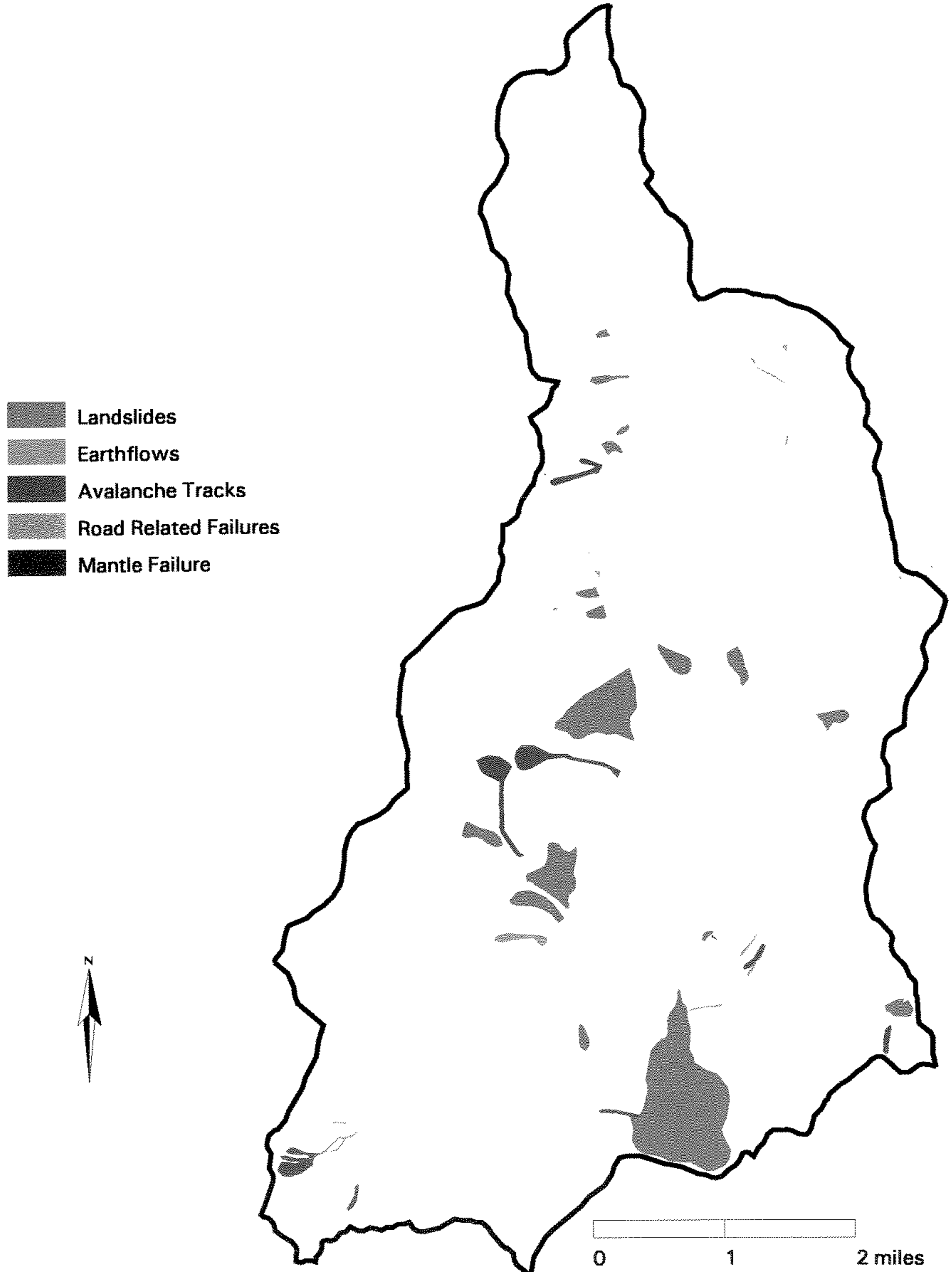
While Mount St. Helens has deposited ash and pumice across the headwaters of the Nisqually River basin at least twice over the last 500 years [once during the eruption of about 3,500 years ago (Mullineaux, et.al, 1975) , and again Spring/Summer, 1980], these deposits are more readily seen to the east, and are not easily identified in the Little Nisqually watershed. Local deposits of fine pumice and ash have been observed in some locations near the eastern boundary of the watershed (i.e., Ladd Mountain). The erosion of ash into streams accounts for a substantial proportion of the fine sediment delivered to streams further to the east, but does not appear to be a substantial factor in this watershed. Mount St. Helens has erupted about once every century for the last 500 years, and is expected to follow a similar pattern into the centuries ahead (Crandell and Mullineaux, 1978); the potential effects of volcanic ash deposition on sediment delivery to streams in the future will depend upon the ash-plume trajectory of future eruptions.

Mt. Rainier is a historically active, though currently dormant, stratovolcano that dominates the headwaters of the Nisqually watershed. At least ten tephra-producing eruptions from this volcano have occurred over the last 6,550 years, with additional mudflow deposits found that do not correlate with known eruptive events (Scott and others, 1995; Crandell, 1971). Several mudflows from Mount Rainier have travelled varying distances down the Nisqually River valley over the last 10,000 years. The National Lahar occurred about 2,300 years ago, while smaller mudflows such as the Kautz Creek and Little Tahoma creek mudflows have occurred in this century. "Mt. Rainier is potentially the most dangerous volcano in the Cascade Range because of its great height, frequent earthquakes, active hydrothermal system,

Map 14

LITTLE NISQUALLY WATERSHED ANALYSIS

Mass Wasting Inventory



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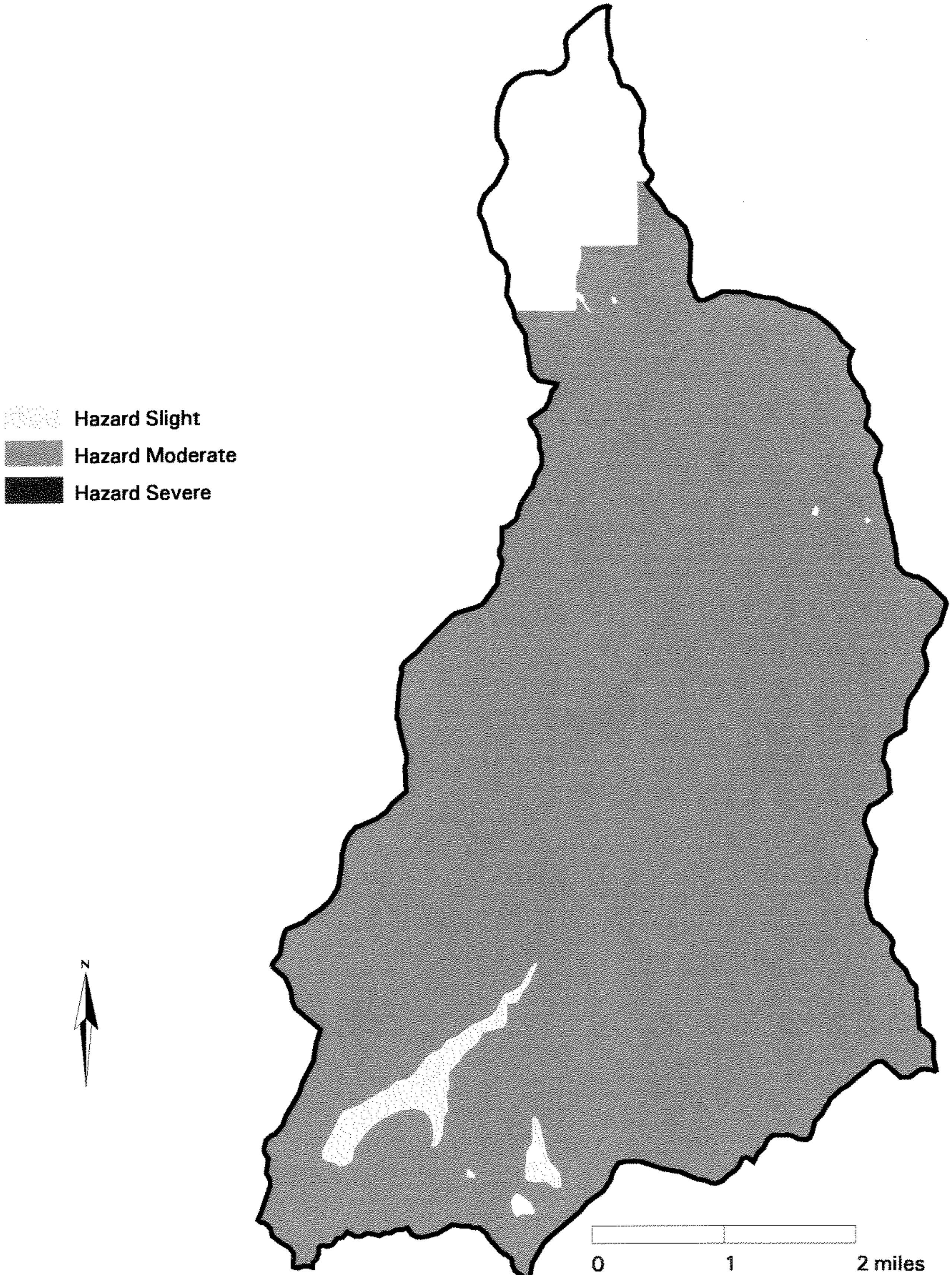
Map 15

LITTLE NISQUALLY WATERSHED ANALYSIS

Soil Erosion Potential



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and extensive glacial mantle. Many debris flows and their distal phases have inundated areas far from the volcano during postglacial time." (Scott and others, 1995). According to recent hazard maps published for the area (Scott and Vallance, 1995), much of the Nisqually River valley downstream of this study area could be inundated by a mudflow to a depth up to many tens of feet, with or without an associated volcanic eruption. However, only the confluence of the Little Nisqually watershed with the mainstem Nisqually River appears to be at risk for experiencing these mudflow events. See Map 16, Hazards from Mt. Rainier. It seems possible that the Little Nisqually watershed might serve as a refuge watershed for aquatic species during such mudflow events.

Seismic activity in the form of small earthquakes (most less than 2.0 magnitude) occurs on the average of approximately 2-5 per decade underneath the planning area, with two larger earthquakes of magnitude 3 to 4 having occurred under the headwaters of this watershed in the last 25 years (PNSN data, 1999). Sixteen larger earthquakes (magnitude 5 to 7) have occurred across western Washington and Oregon during this century (PNSN data, 1999), and great earthquakes (magnitude 9.0) appear to have occurred across Cascadia (southern British Columbia to northwestern California, including western Washington) six times over the last 3,000 years (Carver, et al., 1999). It is possible that one or more of the larger, deep-seated landslides in this study area were caused or reactivated during these large seismic events.

Mass Wasting

In describing the mass wasting history of the Little Nisqually watershed, it is important to be aware of some geologic conditions found here that are not so prevalent across much of the rest of the Cowlitz Valley Ranger District. The Cenezoic volcanic rocks in the area of the Mineral Block have been weathered and decomposed to an extent not commonly found elsewhere on the district; this has resulted in a greater proportion of plastic soils that are susceptible to mass movement under natural conditions, and when disturbed by human activities. This factor, combined with deposits of compact glacial till that often support locally elevated water tables, contributes to the informal reputation of the Mineral Block as an area more prone to mass wasting events.

Watershed 20Q

Several small, naturally-occurring rotational slides have been mapped in glacial deposits along the Little Nisqually river channel. Seeps and springs, indicating areas of elevated groundwater, are found in the headwaters of Spencer Creek, and near the lower stretches of Wildcat and Mona Creeks. A number of small, unmapped landslides and debris flows not readily visible in air photos are believed to occur under the forest canopy and along steeper stream channels. There are numerous small road failures (both sidecast and cutbank) known to occur within this watershed, primarily along the 74 and 7409 roads. The confluence of this watershed with the mainstem Nisqually River also has an additional source of mass wasting in the form of mudflows from Mount Rainier. These mudflows may be associated with volcanic eruptions, or may occur when unstable portions of this massive volcano simply give way to gravity.

The Reference Condition for mass wasting in this watershed is considered to be Moderate. Mass failures related to management activities occur at a High rate compared to Reference Conditions in this watershed.

Watershed 20R

Several medium to large translational landslides occur in this subwatershed. The largest is the informally named Cougar Mountain slide; it covers about 1/4 square mile, and occupies the west bank of the Little Nisqually River between Spencer and Scatter Creeks. Most of the slide is believed to be dormant (past-active), but an active component has been mapped along the southern margin of this slide. Another complex of dormant and slow-moving slides is found along the west bank of the Little Nisqually River south of Winston Creek. In addition, a number of small, unmapped landslides and debris flows not readily visible in air photos are believed to occur under the forest canopy and along steeper stream channels. Numerous road-related failures have occurred in this watershed primarily along the 74 Road. These sites have been documented as ERFO flood damage sites (1990-1997) and previous failures picked up on the mass wasting inventory (GeoHaz).

The Reference Condition for mass wasting in this watershed is considered to be Moderate-High. Mass failures related to management activities occur at a High rate compared to Reference Con- ditions in this watershed.

Watershed 20S

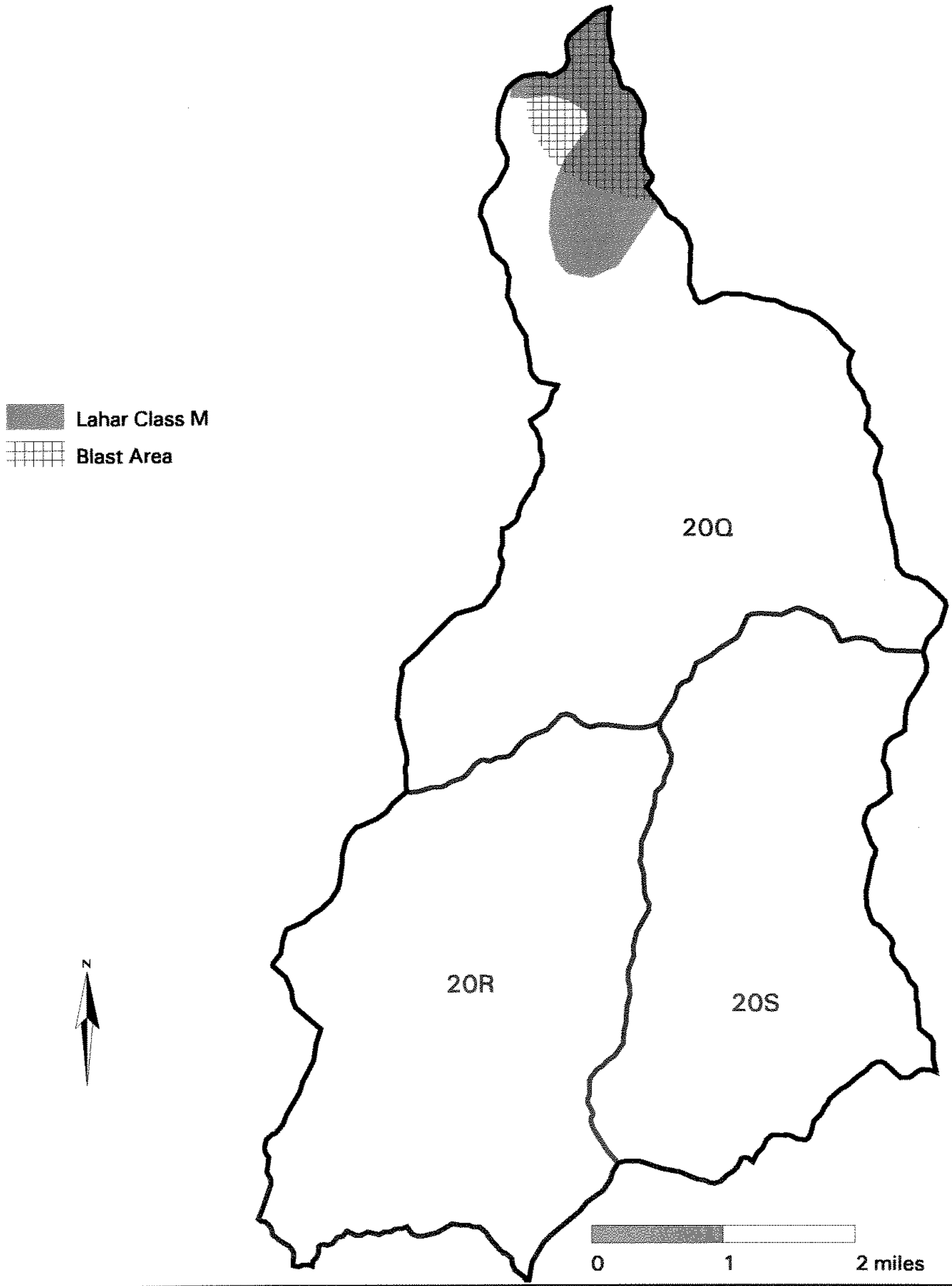
There is one large, apparently dormant translational slide located in the headwaters of Hiawatha Creek There are a couple of smaller, naturally-occurring rotational landslides along the steep banks of Hiawatha, Trap, and Scatter Creeks. It is believed that an additional number of small, unmapped landslides and debris flows not readily visible in air photos are believed to occur under the forest canopy and along steeper stream channels. There have been a number of road-related failures along many of the spur roads leading off the 74 Road system.

The Reference Condition for mass wasting in this watershed is considered to be Moderate-High. Mass failures related to management activities occur at a *High* rate compared to Reference Conditions in this watershed.

Map 16

LITTLE NISQUALLY WATERSHED ANALYSIS

Hazards from Mt. Rainier



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Hillslope Erosion

Hillslope erosion occurs at low levels when bedrock is hard, sideslopes are shallow (less than 30%), and/or vegetative cover is dominant. Hillslope erosion increases as the sidelsopes increase, when the bedrock is weak and crumbling, when vegetative cover is removed, and/or when flowing water is routed onto hillsides where water does not ordinarily flow. Based on the SRI, soil map units for almost the entire Little Nisqually area were rated with a ``Moderate' surface erosion potential.

Road Conditions

Erosion and mass wasting associated with roads have been identified as a primary contributor of both coarse and fine sediments above the natural (background) rate to streams in this watershed. Note that there is no historic equivalent for erosion or mass wasting from roads; the natural processes of erosion continue, and all road-related sediment produced is *additional* to the background rate.

Approximately 130 miles of road currently exist on private and Federally administered land within the watershed. There are 25+ flood damage sites along the existing road system on Federal land in the Little Nisqually watershed. Total estimated costs (ERFO only) for these flood damage sites is about $498,307 for the time span 1990-1997; this equals about 1% of all estimated ERFO flood damage costs across the entire GPNF during 1977-1997 (Jones, 1999 - in prep).

Hydrology

Introduction

For any given location there are four primary components that regulate landscape development or expression. These four components frame the fundamental signature of a landscape and must be described to properly evaluate a watershed's function. These components are parent geology, topography, geography, and climate. The long term interaction of these components create three dominant landscape features: soils, hydrography, and vegetation (McCammon, 1999). This hydrologic analysis describes the first three components under the heading "Drainage Basin Description" and the fourth under "Climate". These primary landscape components and features are then subject to a variety of natural and human-related disturbances that occur at varied frequencies and magnitudes across the landscape. These interactions and the resulting conditions are described under the headings "Watershed Conditions" and "Riparian Conditions". Finally, watershed and riparian conditions can affect the balance between the multiple processes acting to form and maintain the physical channel and associated aquatic habitat. These processes and conditions are discussed in the section titled "Stream Conditions." See Map 17, Stream Classes for the locations and classes of streams within the watershed.

Drainage Basin Description

The Little Nisqually is a north aspect watershed with elevations ranging from 1300 (at Alder Reservoir) to 4300 feet (the Rockies). The stream network drains 17,873 acres (28 sq.miles) through 180 miles of perennial and intermittent streams. The dominant land types have slopes ranging from straight to slightly convex-concave and are dissected by deeply incised V-shaped valley bottoms. Hillslopes have gradients ranging from 45-70%, with an average of 60%. As a result of these steep slopes and V-shaped valley bottoms, "A" stream types (Rosgen, 1994) are the most common stream type in the watershed. "A" channels have steep step/pool channels with bedrock, boulder, cobble, and gravel substrates. These channels are highly dependant upon large woody debris for their stability. Many of these streams flow through steep inner gorges which are extremely sensitive to disturbances. This watershed has a moderate erosion rating and a high to very high hillslope sediment delivery efficiency. Surface erosion and soil creep are the dominant "natural" erosion processes, although naturally occurring landslides and earthflows may also occur. This is especially true within the inner gorge areas. When this parent material is subject to erosive forces, it breaks down into sand and fine gravel sized particles. This mineralogy is important in determining sediment delivery, sediment routing, and water quality effects. See the Geological Processes sections (pp. 3-54 to 3-58) for more information.

Climate - Precipitation

Expressions of climate, such as precipitation, play a vital role in determining the character of the physical landscape. In fact, precipitation is one of the dominant drivers (along with fire) of hillslope and hydrologic processes and disturbances in mountainous watersheds. While precipitation is a dominant driver, it is difficult to predict exact conditions and the consequences of various events due to the highly stochastic nature of this element.

Data Sources/Data Gaps

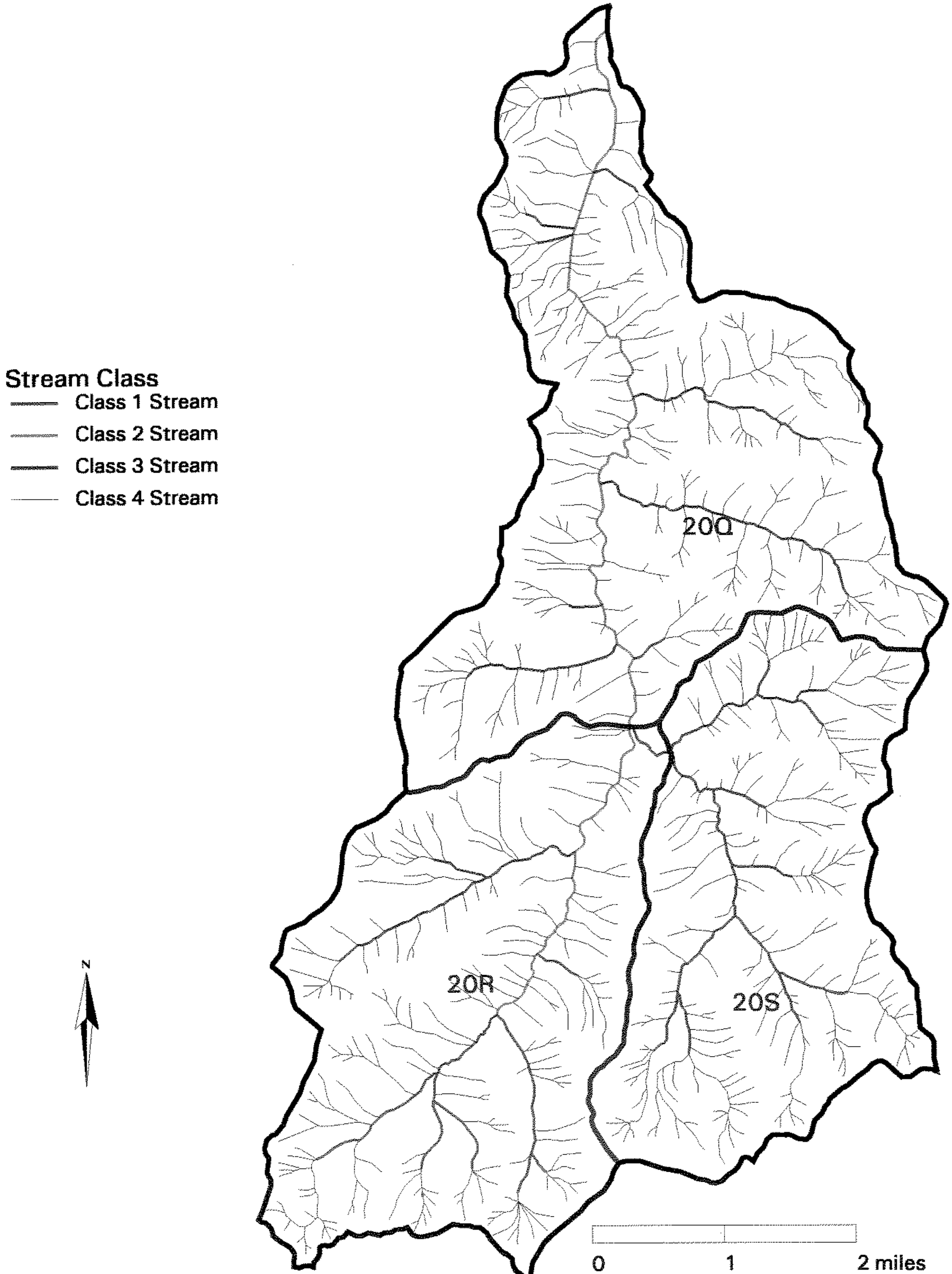
- Data was obtained from the National Weather Service Cooperative Network Station "Mineral 1 SW, Washington" (455425).

- The forest's GIS system was used to determine the amount of each subwatershed located in various elevation zones.

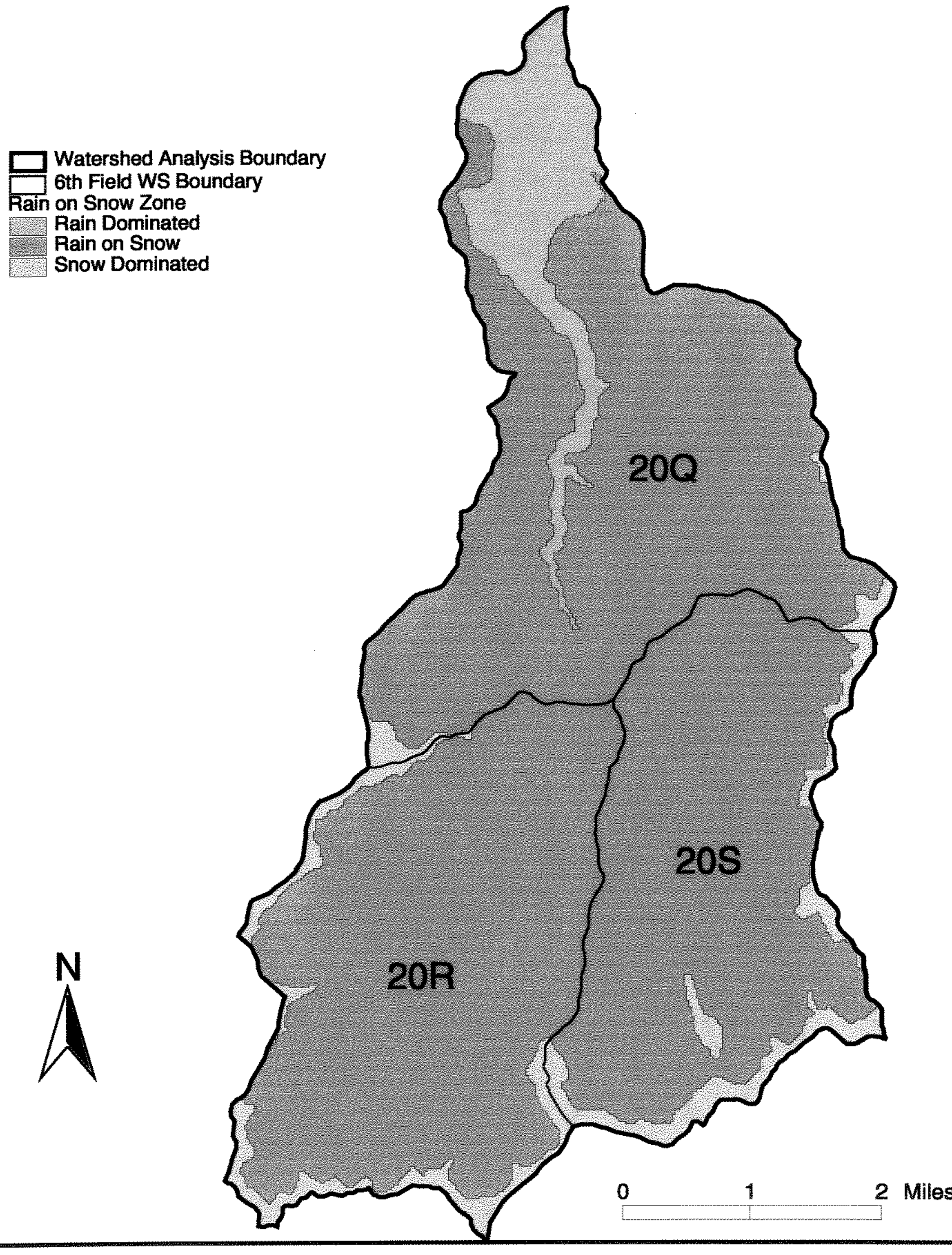
Map 17

LITTLE NISQUALLY WATERSHED ANALYSIS

Stream Classes



Map 18
LITTLE NISQUALLY WATERSHED ANALYSIS
Rain on Snow Zones



Assumptions

- The Mineral Climate Station was assumed to represent average conditions in the Little Nisqually Basin.
- An elevation zone model was used to determine precipitation inputs and the associated hydrologic response. Although this model does not consider variables such as aspect and adjacent landforms, it's assumed that it accurately reflects the precipitation inputs for this basin.

Analysis Results

Analysis 1: A Review of the Mineral WA Precipitation Data

Annual precipitation averages 85 inches, with 60% occurring between Nov 1-Feb 28 in the form of snow and winter rains. Between December and February annual snowfall averages 42 inches although average snow depth remains relatively low. Since winter temperatures are low and precipitation rates are high, this lack of accumulation is attributed to rain-on-snow events which can melt a substantial portion of the snow pack. Following a Rain-on-Snow event, snow can once again accumulate. These Rain-on-Snow events are also evident in the daily snow depth records which show a series of accumulation and melt cycles occurring throughout the winter. In my professional judgement, the Little Nisqually basin functions much like the Mineral basin although rain-on-snow events are likely less frequent but of a greater magnitude due to the slightly higher elevations. Table 3-20 summarizes the climate data for the Mineral Station.

Table 3-20: Precipitation Data from Mineral Washington

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Ave PCP (in)	14.7	10.6	9.2	5.5	3.6	2.9	1.3	2.0	3.2	7.0	11.9	13.6	85.4
Ave Total Snowfall (in)	24	9	10	1	0	0	0	0	0	0	3	9	56
Ave Snow Depth (in)	5	4	2	0	0	0	0	0	0	0	0	1	--

Analysis 2: Precipitation and Rain-on-Snow Zones

This analysis area consists of three precipitation zones each with unique input processes: rain, rain-on-snow, and snow (See Map 18, Rain on Snow Zones). These zones vary in the amount of annual precipitation, snow melt-off rates, and site specific geographic and climatic influences.

- Rain-dominated zone: Geographic zone below 1500 feet where the dominant form of precipitation is winter rain. This zone accounts for less than 7% (1,249 acres) of the analysis area and is primarily located adjacent to Alder Reservoir in subwatershed 20Q. This area can produce large runoff events depending upon precipitation intensity and watershed alterations which reduce infiltration or expand the drainage network.

- Rain-on-snow zone: In the Little Nisqually subbasin, the largest flows occur between December and February resulting from "rain-on-snow" events. Warm pacific maritime air masses move into this area providing the moisture and energy necessary to rapidly melt existing snow packs. In general, two scenarios are likely to produce undesirable effects. The first is where openings result in differences in snow water equivalent and snow depth. These differences result from eliminating canopy interception and melt, and the redistribution of the snowpack. Consequently, the opening would accumulate more snow, and be able to contribute more water than the closed stand during a subsequent rain-on-snow event. In the second case, greater wind speed and turbulence in an opening could increase the transfer of sensible and latent heats to the snow pack resulting in a release of water during a rain-on-snow event (Harr 1986). In these transient snow zones, it is not unusual for shallow snow packs to melt completely during rainstorms. Of the three precipitation zones, events in the rain-on-snow zone pose the greatest threat to aquatic resources because they can produce very large and rapid runoff responses. These responses often exceed the channels ability to process the flow and can result in channel instability. The vast majority of this watershed lies within this zone. The rain on snow zone is assumed to be located between the elevations of 1,500 and 3,500 feet and accounts for 87% of the analysis area.

- Snow-dominated zone: Geographic zone where normal winter precipitation is snow and deep snow pack accumulations occur. This zone accounts for 6% of the analysis area and is primarily located on high ridges in the West Fork (20R) and the Hiawatha Creek (20S) subwatersheds. While rain-on-snow may occur in this zone, effects can be mitigated by the lag time of percolation through the snow pack. Therefore, rain-on-snow events do not produce the same runoff responses that are produced in the rain-on-snow zone. Events in the snow dominated zone pose the least risk threat to aquatic resources because these events generally result in an accumulation of "water" not an immediate release. In these areas, spring snow melt is the primary runoff mechanism. This type of runoff can generally be processed by the streams.

Conclusions

The two types of climatic analysis found that the primary runoff driver in the Little Nisqually watershed are rain-on-snow events. Therefore, activities which alter either snow accumulation or melt rates could increase the magnitude of the associated runoff response.

Watershed Conditions

Watershed condition is a commonly used term loaded with personal interpretation. In its simplest form, watershed condition can be viewed as the status of the drainage basin components as a result of disturbances. The interaction of these conditions must consider both the spatial and temporal variability of the various disturbances. Therefore, this analysis used three sub-watersheds (sixth field), as well as the entire basin, to evaluate spatial conditions. Time was also incorporated into the definition of risk to address temporal scales. This definition is purposely restricted to aquatic systems and the terrestrial components that influence the aquatic processes.

Assumptions

- For all analysis in this section, precipitation was assumed to be the dominant driver of potential effects. Therefore, risk was evaluated using precipitation as the key driver.

- For all analysis in this section, the following definition of risk is used:

  Given the current condition of the indicator(s) the risk to the aquatic system is:

  1. low if there is little chance that the watershed alteration would result in channel effects (even during large events);

  2. moderate if under "normal" conditions (2-50 year events) channel degradation is not expected, but large events (50+ year event) would likely affect channel conditions; and

  3. high if channel degradation is expected to occur, even under "normal" conditions.

Watershed Conditions Resulting from Roads

Roads have been identified as an important factor in the decline of water quality. Culverts that do not pass fish and/or road crossings that alter the flow of large woody debris (LWD) and sediment through the stream network fragment the aquatic system. Roads can affect sediment production through episodic failures or chronic surface erosion. They can also alter the amount and timing of runoff by intercepting sub-surface flows and directing snow melt and precipitation directly to stream channels.

Data Sources/Data Gaps

The information used for this analysis was generated from the Forest's GIS database. Since roads are not a part of the "natural system" a historic perspective is not provided.

Assumptions

- Road decommissioning is assumed to have fully restored the hydrologic function of the old road prism. Approximately fourteen miles of road have been decommissioned in this watershed.

- The analysis of riparian reserve road densities was not updated to account for the road decommissioning. Since the main 74 road is the primary riparian reserve road, and it was not among those decommissioned, it is assumed that the risk category for this variable would not have changed.

Current Conditions/Conclusions

Several indices were used to evaluate the effects of roads on watershed conditions. The road-stream interface is where roads have the greatest affect on channel conditions. This is because sediment and intercepted water is delivered directly to the stream system at this point. Rather than simply counting intersects (which provides no perspective - is 100 crossings a little or a lot?), stream crossing densities were used to describe potential effects. This index is also useful since it considers the interaction of sediment and flows. Since available sediment is a function of stream crossings and stream flow is a function of area, this ratio evaluates the potential impacts resulting from the interaction of sediment and flow. A recent study in Colorado found that stream crossing density is closely tied to channel conditions (Schnackenberg and MacDonald, 1998). The stream crossing densities for the three sixth fields, as well as the overall watershed, is given in Table 3-21. Also, see Map 19, Stream Crossings by the Road Network.

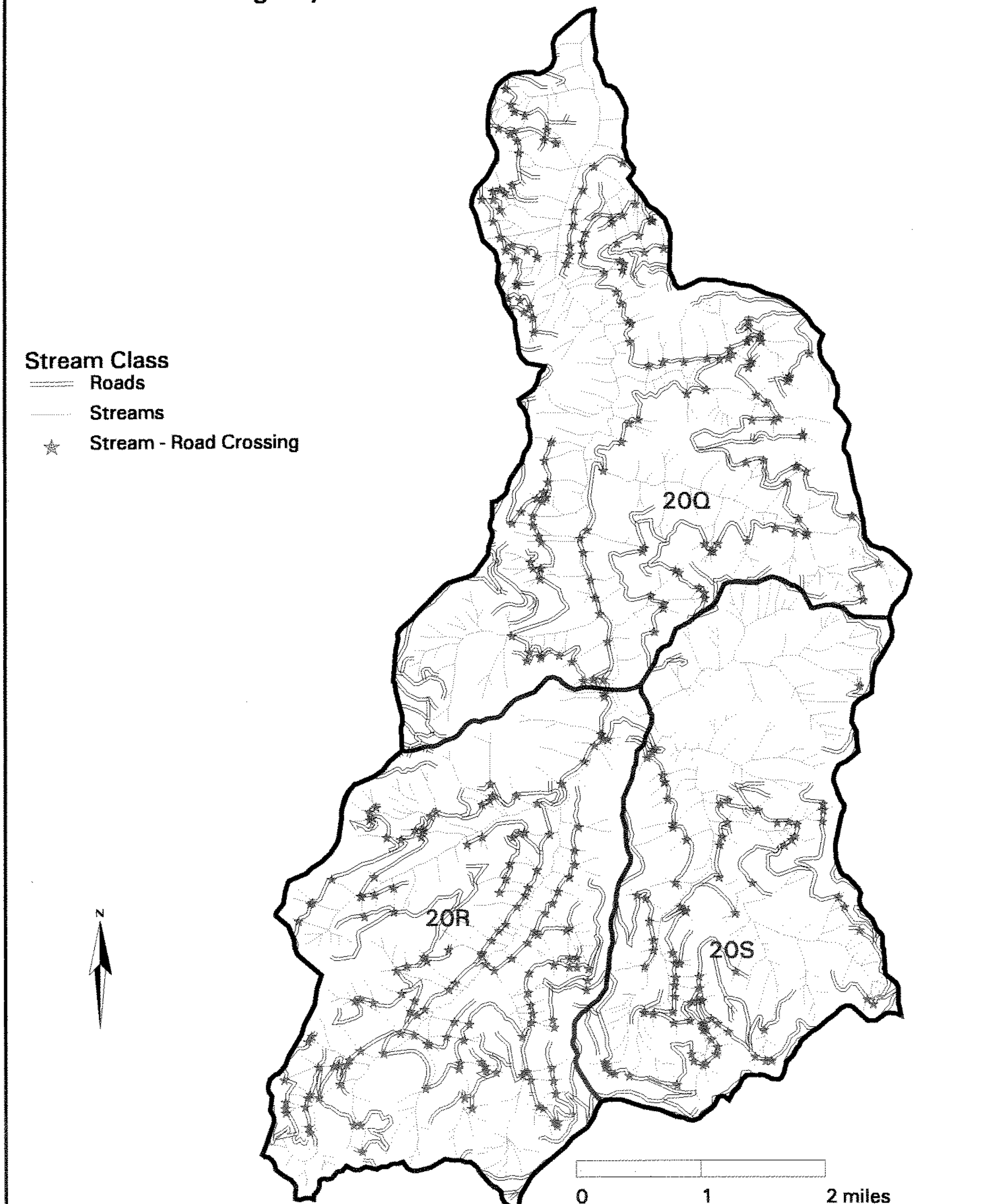
Table 3-21: Road Related Indices Related to Watershed Conditions

	Road Density	RR Rd Density	Stream Density	X-ing Density	Potential for Watershed Impacts from Roads
Little Nisqually	4.5/High	3.6/High	6.4/High	15.0/High	High

Map 19

LITTLE NISQUALLY WATERSHED ANALYSIS

Stream Crossings by the Road Network



WF Little Nisqually	4.2/High	4.0/High	6.3/High	15.2/High	High
Hiawatha Creek	3.4/High	3.3/High	6.6/High	8.7/High	High
Total	4.1/High	3.7/High	6.4/High	13.4/High	High

Thresholds used for Table 3-21

Variable	High Risk	Mod.Risk	Low Risk
RR Road Density	>3	2-3	<2
Road Density	>3	2-3	<2
Stream Density	>5	3-5	<3
X-ing Density	>7.5	5-7.5	<5

These high risk ratings suggest the following:

1. sediment may be a limiting factor in this watershed;
2. the basins runoff response may be altered by an increase in the "effective stream length" by the road system (since the road and stream networks are connected at crossings). This is often referred to as the drainage network expansion.

While road densities themselves do not effect beneficial uses, they can be used as an indicator of potential problems. This analysis used a road density of 3 miles/square mile as an indicator of high risk. Within the Little Nisqually watershed, road densities exceed 3.0 in all three sixth field watersheds as well as for the overall basin (table 2). Road related concerns can also be evaluated using road densities within Riparian Reserves. Again, a road density exceeding 3.0 is assumed to result in an altered hydrologic response. All three sixth field watersheds, as well as the overall watershed, were found to have high Riparian Reserve road densities (High Risk). These results are presented in Table 3-21.

These high risk ratings suggest the following:

1. roads are likely affecting water infiltration and routing;
2. roads are likely affecting fine sediment production;
3. roads are likely affecting course sediment production due to their abundance in this steep watershed (mass wasting);

4. where road densities are high in riparian reserves, the probability of problems increases since less hillside is available to filter/reduce impacts.

Finally, where both road and stream densities are high (table 2) the likelihood of sediment delivery is greatly increased. This is because the average distance between these features gets smaller as the densities increase.

Summary: Roads have likely impaired watershed function in all three sixth field watersheds, as well as the overall Little Nisqually drainage. These impairments were identified earlier (in bold) in this section.

Watershed Conditions Resulting from Vegetative Alterations

Vegetative alterations can affect watershed conditions by altering snow accumulation patterns, snow melt rates, evapotranspiration rates, the size and distribution of LWD incorporation, and the frequency and size of mass wasting events.

Data Sources/Data Gaps

- The information contained in this document has been compiled from the Forest's GIS database.

- The ARP cumulative effects model was used to evaluate potential changes in watershed condition. This model is described in the Gifford Pinchot Cumulative Assessment Process Final Report (1988).

Assumptions

- It is assumed that the ARP model can accurately evaluate changes in vegetative maturity.

Historical Conditions

- See the sections of this watershed analysis that deal with vegetative structure.

Current Conditions/Conclusions

While the current ARP ratings indicate a moderate risk, these subwatersheds are primarily located in the Rain-on-Snow Zone. This combination, along with a high degree of riparian alterations, create a high potential for watershed impacts resulting from vegetative alterations (Table 3). These impacts would likely include:

1. an increase in runoff responses associated with Rain-on-Snow events;
2. a greater frequency and size of mass wasting events;
3. a reduction of LWD accumulations.

Table 3-22: Vegetation Related Indices Related to Watershed Conditions

	Stream Types	ARP# /Risk	% in ROS Zone	Riparian Maturity	Potential for Watershed Impacts Resulting From Vegetative Alterations
Little Nisqually	B2, B3	76/Mod	81/High	33%/High	High
WF Little Nisqually	B3, B4	72/Mod	91/High	25%/High	High
Hiawatha Creek	B2, B3	73/Mod	89/High	27%/High	High
Total	B2, B3	74/Mod	86/High	29%/High	High

Thresholds Used in Table 3-22:

Variable	High Risk	Mod.Risk	Low Risk
ARP	<70	70-85	85+
% in Rain-on-Snow	>50	25-50	<25
Riparian Maturity	≤33	34-66	67+

Riparian Conditions

Properly functioning riparian areas are critical in maintaining healthy and diverse aquatic systems. These areas influence water quality and fish habitat by providing: (1) shade to regulate water temperatures, (2) large woody debris, (3) inputs of fine organic material and invertebrates as a food source, (5) sediment and water filtration, and (6) cover for fish.

Inner Gorge

An important feature included in many riparian areas is referred to as the inner gorge. Inner gorge is defined in the *Final Environmental Impact Statement on Management of Habitat for Late-Successional and Old-Growth Forest Related Species Within the Range of the Northern Spotted Owl, Volume I* (USDA, USDI 1994c) as a "stream reach bounded by steep valley walls that terminate up slope into a more gentle topography - common in areas of rapid stream down cutting or uplift". This definition differs slightly from the definition that the Gifford Pinchot National Forest has adopted, in which the inner gorge is delineated as the area consisting of narrow steep valleys which are smaller than the canyon and more steep-sided than a ravine. Slopes along the steep-walled canyon are greater than 65 percent. The inner gorge is an area that is extremely sensitive to management activities. Due to the close proximity of the inner gorge to the creek, sediment filtration is limited and soil displaced in the gorge would be delivered directly to the channel.

Data Sources/Data Gaps

- Primary streams were field reviewed for the presence of inner gorges. However, this review was very limited and project level reviews are necessary to determine the extent of these features.

Assumptions

- While disturbances such as debris torrents can create new inner gorges, none of these disturbances were found during field reviews. Therefore, the historic distributions and abundance of inner gorges is assumed to be the same as the current condition.

Current Conditions/Conclusions

The 1999 field review found that most third and forth order streams had inner gorges associated with them. These features are located adjacent to steep A and Aa+ stream types (Rosgen, 1994) as well as B types flowing through canyons. All field reviewed streams had extensive reaches with adjacent inner gorges (table 4). This would imply that the Riparian Reserves in the Little Nisqually watershed would be very sensitive to disturbances.

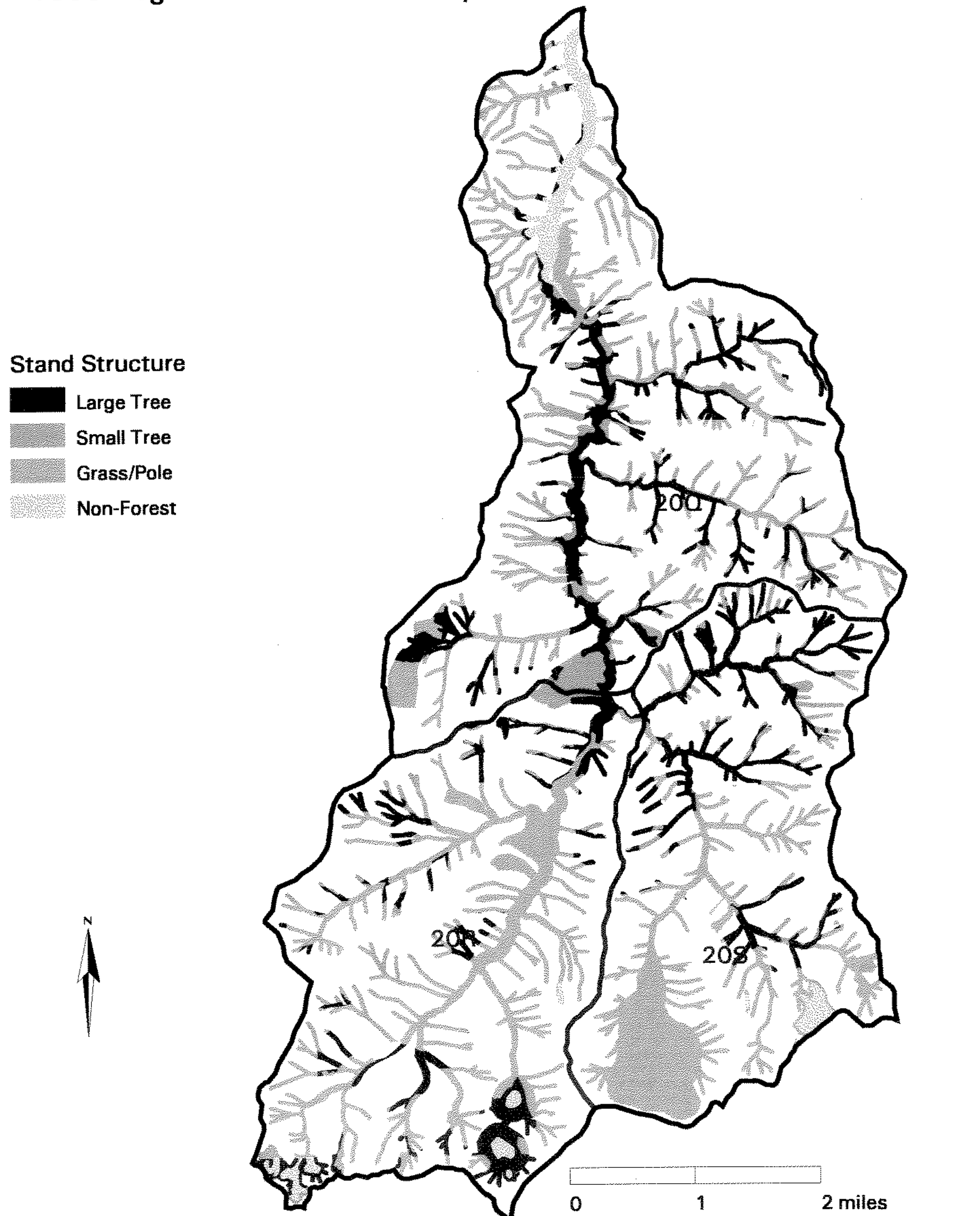
Table 3-23: Sixth-field Watersheds Known to Have Inner Gorge Areas

Sixth-field Names	Field Verified Inner Gorge Area Locations
Little Nisqually River	Little Nisqually, Mona, Wildcat, and Spencer Creeks
WF Little Nisqually River	WF Little Nisqually and Winston Creeks
Hiawatha Creek	Hiawatha and Scatter Creeks

Map 20

LITTLE NISQUALLY WATERSHED ANALYSIS

1999 Vegetation Structure in Riparian Reserves



10/25/99 /cv_gis/wa/ltnisq/vegrrplt.aml bgr

Flood Plain and Wetland Conditions

Data Sources/Data Gaps

- Data was obtained through photo interpretation, stream survey information (1984), and the Nisqually Hydroelectric Project Packet of Information, First stage Consultation (1989).

Historic Conditions

The Little Nisqually River and its principle tributaries were confined streams flowing through narrow bedrock controlled valley bottoms. The known exceptions were the first 2.5 miles above the Nisqually River confluence, a reach of the West Fork between Fly and Lake creeks, and small alluvial inclusions along the main Little Nisqually River. These exceptions had small flood plains and riverine wetlands which were created and maintained by flows occurring every one-two years. These overbank flows provided sediments, nutrients, and vegetative diversity to these areas.

Current Conditions/Conclusions

The creation of Alder Lake inundated the alluvial reach of the lower Little Nisqually River and thereby greatly reduced the amount of flood plain located in this watershed. Currently, only the West Fork reach and the small inclusions remain. However, the amount of wetlands greatly increased (albeit a different type of wetland) with the creation of the Little Nisqually arm of Alder Lake.

Riparian Vegetation - Stream Shading and Potential Large Woody Debris

Data Sources/Data Gaps

- Forest structural stage was used to evaluate stream shading and potential Large Woody Debris (LWD). This was accomplished using the GPVEG database and GIS.

Assumptions

- The structural stage of the riparian vegetation is assumed to be directly related to the amount of available stream shading and potential large woody debris. Therefore, it is assumed that the closer the existing distribution and abundance of large trees are to historic conditions, the closer the basin is to functioning properly.

- Riparian stands were not delineated in this watershed. Therefore, it is assumed that the adjacent upland stand represents riparian conditions. See Map 20, 1999 Vegetation Structure in Riparian Reserves.

- It is assumed that the riparian corridors in the Little Nisqually watershed historically had the following forest structural stages. This assumption was based mostly on professional judgement, relying on fire history and existing data.

Forest Zone	Large Tree	Small Tree	Grass/Pole
Western Hemlock	80%	10%	10%
Silver Fir	60%	20%	20%

- It is assumed that the percentages within each structural stage is similar for all stream classes. That is, the eighty percent in a large tree condition is assumed to be valid for all streams and not clumped along the Little Nisqually River.

Historic Conditions

It is likely that stream bank erosion and riparian tree mortality and blow down would have been the dominant input processes for LWD. Based upon historic vegetative conditions, we assume that LWD recruitment and shade would have been good throughout the analysis area.

Current Conditions/Conclusions

As shown in Table 3-24, the percent of the riparian reserves in the various structural stages is much different than the assumed historical levels. The ramifications of this change are described below under "Shade" and "Potential Large Woody Debris."

Table 3-24: Current Percent of Each Structural Stage in Riparian Reserves

Sixth-field Watershed	Miles of Stream	Acres of Riparian Reserve	Grass / Pole	Small Tree	Large Tree	Non-Forest*
Little Nisqually	73	2126	35	23	33	9
WF Little Nisqually	57	1694	62	9	25	4
Hiawatha Creek	50	1502	60	10	27	3
Total	180	5322	51	15	29	5

Shade

When using the structural stage approach to evaluate stream shade potential, the large tree class is assumed to represent areas meeting potential shading. When evaluating shade we need to concentrate on perennial streams since intermittent streams will likely be dry when water temperatures are an issue. A review of watershed Map 20, Vegetation Structure in Riparian Reserves, shows that the main Little Nisqually (sixth field 20Q) is likely close to natural shade levels while the West Fork (20R) and Hiawatha Creek (20S) have reduced shade potential. This is especially true on the West Fork where all perennial tributaries have grass/pole and small tree sized vegetation. Hiawatha Creek appears to have areas where adequate shading would still exist (Scatter Creek).

Potential Large Woody Debris

LWD is necessary in all stream classes although it would have different functions in different areas. Potential woody debris levels appear to be at near natural levels along the Little Nisqually River, Mona Creek, Wildcat Creek, and Scatter Creek (see Map 20). All other reaches have low levels of potential LWD. The large tree structural stage (>21 inch diameter) is considered to represent old, large trees that are desirable as woody debris to dissipate stream energy and create quality aquatic habitat. These areas may be actively providing LWD through dying trees or have the potential to supply large wood through catastrophic events (windthrow, fire, debris slides). The small tree structural stage stands (tress with diameters between 9 and 21 inches) are those that could supply large woody material in the next 10 to 70 years, depending on vegetation zones and the current condition of the stands. Grass/pole stands are not expected to provide large woody debris for a very long time. Using these time frames we can see that the West Fork and Hiawatha creeks will be deficient in LWD for several decades (table 5).

Stream Conditions

In all stream systems there exist a unique balance between many interrelated variables including: stream flow, sediment quantity and size, and large woody debris. A major shift in any of these variables may initiate a series of channel adjustments leading to a new channel form. This section will discuss these variables and potential adjustments. High intensity but infrequent fires and floods are the primary natural disturbances in the Little Nisqually watershed. These events, individually or together, have produced large sediment and water yield increases which have effected channel conditions. Following a disturbance, material accumulates in both headwater streams and localized areas of the primary channels. This material is then routed downstream delivering nutrients, sediment, and structure. While this pulse creates a short term impairment, it is important in maintaining the long term physical and biological functioning of the system. Following the disturbance is a period of recovery during which time the channel stabilizes and provides morphological features which provide habitat for a variety of aquatic species. This recovery period continues until the next infrequent disturbance "reloads" or "resets" the system.

Stream Conditions

Increases in the magnitude of peak flows can affect aquatic resources through channel incision, bank erosion, and increased sediment transport capacity. Typically, peak flow increases are realized in the smaller watersheds (sixth fields) and dampened out in larger streams. In the Horse Creek watersheds of central Idaho, King (1989) found large increases in maximum daily and instantaneous stream flow in first and second order streams where 25-36% of the vegetation had been removed. At the mouth of the third order stream, increases in these stream flow variables did not occur. Similar increases have been found in the west by Van Haveren (1988) and Troendle and King (1985). Increasing the size of peak flows in these small watersheds has several implications for both on-site and downstream processes. If coarse sediment (bedload) is available, greater water velocities associated with the higher flows could move more material than would otherwise be the case. This is also true with suspended material and turbidity. Troendle and Olsen (1994) found that off-site sediment levels were highly dependent on flow, with stored sediments being released during large events. A second implication is that higher peaks in several small watersheds can have a cumulative effect downstream. This effect would depend upon whether the individual tributaries peak at the same time or not.

Data Sources/Data Gaps

- Data used in this analysis was collected by the U.S. Geological Survey (USGS). Stations included the Little Nisqually River, the Nisqually River @ National, and Mineral Creek.

- The primary data gap is that the Little Nisqually guage was discontinued in 1942.

Assumptions

- The period of record is assumed to be adequate to determine bankfull flows.

- Although the periods of record for the three USGS gaging stations do not overlap, comparisons in bankfull flows are assumed to be appropriate (due to the first assumption).

- It is assumed that watershed conditions are correlated with stream flows. Watersheds with a high potential for road and vegetation management impacts (tables 2 and 3) were evaluated for stream flow alterations (table 7) using the following definitions of risk:*

Low - The existing runoff response (to the entire range of precipitation events) would be similar to "natural" levels.

Moderate - While "normal" precipitation events would likely produce normal runoff responses, responses to large events (50+ year events) would likely be even greater.

High - The existing runoff response is likely highly altered. Even "normal" precipitation events (2-50 year events) would likely result in rapid runoff responses.

* Actual channel conditions always override information derived from models or other surrogates. If channel conditions indicate that the stream is not processing current stream flows or is in a declining condition, a high risk is assigned.

Historic Conditions

While the annual hydrograph historically peaked in December, rain-on-snow events occurred throughout the winter. In fact, ninety-five percent of the yearly peak flows occurred between November and February. This watershed was very flashy and responded rapidly to precipitation events. This is illustrated by a comparison with the Nisqually River and Mineral Creek gages. Table 3-25 shows that the per unit area runoff generated during the Little Nisqually's bankfull event was 37% greater than for the upper watershed. This was because almost all acres are contributing to a bankfull event while higher elevations in the main stem Nisqually are not. The "so what" is that the Little Nisqually would be a relatively sensitive watershed as we move up in scale to the Nisqually River Fifth Field. This is because since almost all acres are contributing to the bankfull event, effects to these acres could affect the runoff response.

Table 3-25: Comparisons of Bankfull Flow and Contributions per Unit Area

Basin	Area	Qbf	Ratio
Nisqually River	133 sq.mi.	4760	35.8 cfs/sq.mi.
Mineral Creek	75 sq.mi.	3700	49.3 cfs/sq.mi.
Little Nisqually River	28 sq.mi.	1576	56.3 cfs/sq. mi.

Current Conditions/Conclusions

While the overall hydrograph is likely similar to historic conditions (the timing and the flashiness of the basin), localized stream flows have likely been altered from natural levels.

ARP values, the percent of the basin in the Rain-on-Snow zone, Riparian Reserve road density, road density, and stream crossing density are all in the high risk category for the entire watershed as well as for all subwatersheds. Table 3-26 summarizes the analysis of altered watershed conditions. These indices are supported by a visual observation of channel bed features, the location and size of deposition, and the size of bedload on depositional features as compared to the size of material within the wetted channel. These observations indicated that bedload transport is likely elevated in Spencer, the West Fork, Winston, and Hiawatha creeks.

Table 3-26: Potential for Stream Flow Alterations

Sixth Field Watersheds	Potential for Watershed Impacts From Roads (table 2)	Potential for Watershed Impacts from Vegetative Alterations (table 3)	Potential for Stream Flow Alterations
Little Nisqually	High	High	High
WF Nisqually	High	High	High
Hiawatha Creek	High	High	High
Total	High	High	High

Sediment Regime

Data Sources/Data Gaps

- The forest soils and geohazard GIS layers were used to evaluate the potential for sediment delivery as well as existing sediment sources.

Sources: Current Conditions/Conclusions

The primary sources of sediment can be placed into three categories: (1) channel erosion; (2) mass wasting; and (3) surface erosion. Of these sources, channel erosion and mass wasting are the key sediment producers since they deliver large pulses of material in all size classes. Surface erosion is a distant third since it produces fine sediments which are rapidly transported through this high energy system.

Channel Erosion: Channel erosion is important since it produces both suspended and bedload sized particles. The coarser material such as sands and fine gravels are transported as bedload which can have negative effects on channel morphology. These sediments are also input directly to the stream system as opposed to sediment from roads which must be delivered. In this watershed, the main causes for channel erosion are in-channel debris torrents, unbuffered timber harvest and associated channel erosion, increased peak flows in low order streams, decreased woody debris from riparian timber harvest, and the interception and rerouting of streams (the 74 road).

Mass Wasting: Mass wasting also produces both coarse and fine sediments. This input has had a dramatic effect on the Little Nisqually since the pulses are so large. Approximately five percent of the watershed (923 acres) has been effected by mass wasting. The main causes of mass wasting are timber harvest in the steeply incised inner gorge, road failures, and natural events. For a complete discussion on mass wasting see the Geological Processes section (pp. 3-54 to 3-58).

Surface Erosion: The vast majority of surface erosion is generated from the existing road prisms. While road prism erosion displaces soil particles, this material must be delivered to a stream to effect water quality. This delivery generally occurs where roads are either close to or cross a stream. Where roads are not close to streams, sediment is efficiently trapped on the hillslopes with fine gravels (2-8 mm) and sands (.05-2mm) being filtered out first and silts and finer particles being delivered further down slope. Since this delivery would occur during high flows (storm events or snow melt) the fine material would then likely remain in suspension and move rapidly through this high energy system. Overall, the Little Nisqually road network is likely contributing sediment from 30.4 miles that either cross or are located within the riparian reserves (the 74 road makes up the majority of this distance). In addition, there are 14.8 road/stream crossings per square mile which greatly increase the sediment entry pathways into this stream system.

Turbidity: In my professional judgement, the Little Nisqually River meets state turbidity standards. Turbidity is influenced by suspended silt, clay, finely divided organic matter, plankton, and microorganisms (MacDonald, et.al 1991). As reported under "drainage basin description", the dominant parent material decomposes into sand and fine gravel particles. These particles are generally transported as bedload and do not effect turbidity. While turbidity was not measured in this drainage, turbidity measurements have been recorded throughout the Cowlitz Valley Ranger District. With the exception of the aftermath of Mount St. Helens and summer glacial runoff (finely ground glacial flour is a major contributor to turbidity) measured turbidites have been very low.

Sediment Transport

Sediment that reaches small creeks must be transported into larger streams before it influences fish populations. Therefore, understanding the factors that influence sediment transport to and through these small streams, is required. Duncan, et.al (1987) found that sediment transport from an introduced source to the mouths of two experimental streams (95 and 120m) did not exceed 45% of the material added. Silts and clays were moved efficiently through the system, at all but the lowest flows, while sizes between fine sand and course sand were retained at progressively higher rates. In fact, only 10% of course sand was delivered to the mouth. Megahan (1982) estimated that on average fifteen times more sediment was stored behind obstructions than was delivered to the mouths of his experimental streams. This equates to 6% being routed through the basin which is consistent with the 10% found by Duncan. These studies illustrate the importance of channel storage in sediment transport. The three dominant types of channel storage are: (1) short term storage in channel bedforms as a function of flow conditions and sediment particle size; (2) moderate duration storage caused by obstructions; and (3) long-term storage in floodplain deposits.

Channel morphology is important in four major ways: accessibility of the floodplain, system structure (step-pool vs riffle-pool etc..), channel geometry [high width to depth ratio (W/D ratio) vs low], and frequency of obstructions. A stream that can access its floodplain (B, C, and E stream types) has the ability to deposit sediment in long term storage effectively removing material from the system. Streams with step-pool systems (A stream types) can store sediment behind woody debris which provides moderate duration storage, while riffle-pool systems (B and C stream types) store sediment in relatively short term bed features (bars). Streams with low W/D ratios (A, E, and G stream types) are more efficient at processing sediment than those with higher ratios (C and F streams types) at similar flows. Finally, woody debris (the most frequent obstruction) is extremely effective in retaining sediment.

Historic Conditions

During storms and catastrophic events, it's believed that sediment moved through the system in pulses as opposed to a continuous even flow. Most tributaries had moderate to very steep gradients and were primarily source and transport reaches (A stream types). These streams were characterized by a high rate of sediment delivery to the low gradient stream reach located above the confluence with the Nisqually River. Within these A stream types, moderate duration woody debris storage was the primary storage component. The three main streams; Hiawatha Creek, West Fork Little Nisqually, and the Little Nisqually River; were primarily B stream types with inclusions of low gradient response reaches. While most B stream types are able to access their flood plains, these specific streams do not have flood plains. Therefore, most storage would have occurred in moderate duration debris storage and short term bed storage. Overall, since most storage areas were short or moderate duration types, sediment moved quickly through this system into the lower three miles of the Little Nisqually River where deposition would have occurred.

Current Conditions/Conclusions

The main change from the historic transport system is that the depositional reach is now inundated by Alder Lake. Therefore, the entire stream network is now a transport dominated system. As with historical conditions, the ability of a stream to store or transport sediment is dependent upon channel morphology, particle size, flows, and large woody debris. Since large woody debris is currently lacking in most streams, the moderate duration storage component would be reduced and most storage would occur in short term bed features. This would result in larger sediment pulses than would have occurred naturally. Since most sediment storage would be in bed features, cobble embeddedness and surface fines would likely be increased during low flow periods (when the sediment is in storage). Although our field reconnaissance did not observe high levels of fine sediment, we could have missed this material since our review occurred during high flows. Overall, since most storage sites are short term locations, sediment moves quickly through this system and into Alder Lake.

Large Woody Debris

Large woody debris is important in many western Cascade streams for maintaining the physical integrity and function of the channels. It protects downstream water quality by storing sediments resulting in a slow regulated export as opposed to large pulses which can adversely effect water quality. Large wood also dissipates stream energy and promotes scour and turbulence that provide habitat for aquatic organisms, especially fish. The wood itself provides nutrients and a food source for many aquatic organisms. The dominant source of large woody debris are trees that grow near a channel and then fall into the stream through mortality, windthrow, or bank erosion. In small streams, the input is often a random tree fall which produces individual pieces. Generally these streams are too small to transport the pieces and they stay on-site. In large streams input processes are similar with the addition of wood delivery from upstream sources. In these larger systems, transport processes would result in accumulations of LWD as opposed to individual pieces.

Data Sources/Data Gaps

- Data was obtained during field reconnaissances in 1999.
- There has not been a systematic inventory of LWD in this watershed.

Assumptions

- Where potential woody debris levels have been reduced from natural levels it is assumed that the balance between input and export processes have been altered and LWD levels are low.

Historic Conditions

It is well documented that LWD levels were very high in western cascade streams. Historical debris loading included a variety of sizes which were consistent with the size classes of the adjacent riparian stand. This LWD was found in large complexes at river bends and constrictions where transport processes would have deposited the trees. These areas provided excellent habitat for aquatic organisms.

Current Conditions/Conclusions

Current levels of woody debris are very low due to past riparian timber harvest, channel clearing, and stream transport. Exceptions to this include Wildcat, Mona, and Scatter Creeks where LWD is abundant. Where a piece of LWD does exist, it is an individual log as opposed to being part of an accumulation.

Stream Channel Morphology/Stability

Historically Little Nisqually streams would have been in a state of "dynamic equilibrium." This means that the channel would be in balance - not aggrading or degrading. Following the geomorphic theory that channels form to accommodate the watershed products (water, sediment, and woody debris) that they normally process, we would not expect a stable stream to show more than isolated channel erosion. Widespread erosion would imply that the current conditions were outside of the range that formed the existing channel. Stream types play a large role in stability as the inherent stability of the various stream types vary considerably.

Data Sources/Data Gaps

- Data for this section came from field reconnaissance, professional interpretation of watershed and riparian conditions, and map and aerial photo interpretation.
- Current stream survey data is lacking for this watershed
- Historic stream information is a data gap. However, professional judgements were used to evaluate changes from estimated natural conditions.

Assumptions

- It is assumed that the ground truthed segments truly represented overall stream conditions.

Historical Conditions

Determining historical conditions was accomplished by evaluating the drainage basin's characteristics and the forces acting upon them and then reconstructing the historic stream system from the existing conditions. Based upon this analysis the average stream would be similar to the following description:

- channel migration was limited to the alluvial reaches;
- stream stability was excellent due to the bedrock and boulder control;
- bank stability in the alluvial reaches ranged from very good to fair depending upon the abundance of LWD;
- sensitivites to flow and sediment increases were low (due to the inherent stability of the stream types);
- mature riparian vegetation contributed large quantities of woody debris in a wide range of sizes;
- LWD would have accumulated at river bends and constrictions (debris jams and multi-log complexes) due to transport in this high energy system.
- tributary streams buffered the main river from disturbances by providing ample LWD sediment storage;
- tributaries were a source of large woody debris following large storm events;
- canyon reaches had a boulder/cobble substrate;
- alluvial reaches had wider sections with gravel substrates (due to bedload deposition);
- fine sediment levels were very low due to the steep channels and excellent ground cover;
- fine sediment only accumulated along the channel margins.

At the watershed scale the range of conditions would not have varied much due to the bedrock controlled canyons. However, at the reach scale the abundance of LWD would have played a significant role in affecting channel conditions within the alluvial valley bottoms.

Current Conditions/Conclusions - Watershed Scale

At the watershed scale the system appears to be functioning properly. However, there are human related changes at the reach scale. The primary change, from expected historical conditions, is that LWD currently exist as infrequent isolated pieces as opposed to frequent and large accumulations. As a result the alluvial reaches are at the low end of the expected range of stability. We also expect that pool frequency, size, and quality would be reduced in the alluvial reaches as LWD is an important element forming these features. There are also reductions in stream resiliency due to changes in watershed and riparian conditions. This has resulted in an increased sensitivity to increased peak flows and sediment in the West Fork Little Nisqually, as well as Spencer, Hiawatha, and Winston creeks (table 8). While these streams are likely within their historical range of variability, those with high sensitivity are likely at the edge of the range.

Current Conditions/Conclusions - Subwatershed Scale

The Little Nisqually begins at the confluence of Hiawatha Creek and the West Fork Little Nisqually. It is comprised of B3, B2, and A3 channel types which are moderate gradient boulder/cobble reaches. Channel stability is excellent as a result of bedrock and boulder controls in the narrow canyons. Primary tributaries include Mona, Wildcat, and Spencer Creeks. The inherent characteristics of the Little Nisqually River are allowing it to maintain its stability even though the watershed has been hydrologically altered (tables 2 and 3). However, when the stream enters alluvial valley bottoms (small inclusions) we see a stream response and a reduction in channel stability. This response is an increase in bedload deposition and some bank erosion associated with these deposits. Fine sediment levels are very low as there are very few areas conducive to fine sediment depositions. In fact, the only areas showing fine sediment deposition are along the channel margins. As noted under historical conditions, these patterns and responses to sediment deposition are similar to what we would naturally expect to see. LWD levels are low throughout the river in contrast to the expected jams and complexes. This is likely adding to the decreased stability of the alluvial reaches.

Mona and Wildcat creeks are moderately steep boulder/bedrock tributaries with very good stability. Both streams flow through narrow inner gorge areas, have small bedrock falls, and abundant woody debris. In fact, the north branch of Mona Creek is likely a reference condition for LWD in the Nisqually watershed. Mona Creek appears to be setting up for an episodic delivery of woody debris and course sediment to its lower reach. A natural debris jam at the confluence of its two forks will likely release its stored wood and sediment during the next large flow event. This is an example of the debris storage and natural "tributary loading" and subsequent delivery mentioned previously. A poorly aligned culvert on the 74 road may accelerate this process by ponding and failing (this is a high risk culvert).

Spencer Creek is an unstable A3 channel that has been highly impacted by management activities. The stream has been impacted by elevated peak flows, large sediment increases, debris flows, and under-sized stream crossings. This is currently the most impacted and unstable stream in the Little Nisqually watershed. Channel conditions are expected to worsen as a new fill failure has delivered a pulse of sediment to the system and a majority of the bedload particles show a clumpy distribution which appear to be ready to move at the next high water. I'd estimate that almost all bedload particles are within the size classes being moved by the stream. This stream is extremely sensitive to further disturbances.

The West Fork Little Nisqually is a moderately stable stream consisting of B3, B2, and B4 channel types. Its stability is very good in reaches influenced of bedrock and boulders but falls to fair in alluvial reaches (between Lake and Fly Creek). The inherent characteristics of the Little Nisqually are allowing it to maintain its stability even though the watershed has been hydrologically altered (tables 2 and 3). However, when the stream changes from a bedrock controlled channel to an alluvial channel (the B4 stream type) we see the stream respond and there is a reduction in channel stability. This response is an increase in bedload depositions and some bank erosion associated with these deposits. Fine sediment levels are very low as there are very few areas conducive to fine sediment deposition. In fact, the only areas showing fine sediment deposition are along the channel margins. As noted under historical conditions, these patterns and responses to sediment deposition are similar to what we would naturally expect to see. LWD levels are low throughout the river in contrast to the expected jams and complexes. This is likely adding to the decreased stability of the alluvial reaches.

Winston Creek is the primary tributary to the West Fork (estimated to contribute one-third of the West Fork's flow). This is an A2 stream with good overall stability. While an A2 stream is an inherently very stable stream type, watershed alterations appear to have slightly decreased Winston Creek's overall stability. Field observation indicate that bedload transport is elevated which could be the result of increased stream energy and/or an increase in the supply of coarse sediments. However, only minor channel adjustments have occurred and overall stability is still good. While A channels are typically dependant upon LWD for their structure (step/pool morphology) and stability, Winston Creek's boulder substrate is providing the step/pool structure thereby maintaining stability. Overall, this stream is moderately sensitive to further watershed disturbances.

Hiawatha Creek is a moderately stable stream consisting of B3, B2, and A2 channel types. Its stability is good in all reaches. Primary tributaries include Scatter and Trap creeks. The inherent characteristics of Hiawatha Creek are allowing it to maintain its stability even though the watershed has been hydrologically altered (tables 2 and 3). Fine sediment levels are low and deposition is limited to one reach and along the channel margins. As noted above, this is consistent with what we would naturally expect to see at these locations. LWD levels are low in all but the lowest reach in contrast to the expected jams and complexes.

Scatter Creek is a relatively unmanaged drainage and is in very good condition. In fact, this would be considered a reference A3 stream type for the Little Nisqually Watershed. A reconnaissance visit to the lowest reach found very good stability, very low levels of fine sediment, and abundant LWD. Overall this is the best example of a minimally disturbed stream in the analysis area.

Table 3-27 summarizes current stream stability, estimated sensitivities to alterations in key channel forming processes, and the priority for restoration.

Table 3-27: Stream Sensitivities and Restoration Priorities

Watershed	Stream Types	Physical Stability	Sensitivity to Changes in		Restoration Priority
			Stream Flow	Sediment	
Little Nisqually					
Little Nisqually	B2, B3, A3	Excellent	Low	Low	Low
Mona Creek	A1, A2, B3	Very Good	Low	Low	Low
Wildcat Creek	A3, A2	Very Good	Low	Low	Low
Spencer Creek	A3	Poor	High	High	High
WF Little Nisqually					
West Fork Nisqually	B3, B4, B2	Fair	Mod-High	Mod-High	High
Winston Creek	A2	Good	Moderate	Moderate	Low
Hiawatha Creek					
Hiawatha Creek	B2, B3, A2	Good	Moderate	Moderate	Moderate
Scatter Creek	A3	Very Good	Low	Low	Low
Trap Creek	Data Gap	Data Gap	Data Gap	Data Gap	Data Gap

Water Quality - Temperature

Data Sources /Data Gaps

- No water temperature data exist for this watershed.

Assumption

- Riparian Structural class and channel width can be used to accurately evaluate water temperature.

Historic Conditions

Water temperatures were fairly cool due to the mature vegetation in the riparian areas and the topographic shading provided by the narrow valley bottom. The narrow valley bottom also resulted in a narrow stream which would provide less surface area for solar radiation. The only factor preventing very cold temperatures would be the low elevation of the drainage.

Current Conditions/Conclusions

Water temperatures are expected to be elevated in the Hiawatha (20S) and West Fork Little Nisqually (20R) subwatersheds. This is especially true in the wide alluvial reach of the West Fork (between Lake and Fly creeks). Temperature would then be expected to decrease as these tributaries come together and enter the narrow canyon. In the Little Nisqually subwatershed (20Q), only Spencer Creek is expected to be delivering relatively warm water with all other tributaries and the main river having adequate riparian shade and a narrow width.

Aquatic Organisms and Fish Distribution

Data Sources

Data sources include:

- Cowlitz Valley Ranger District 1984 stream survey for the Little Nisqually River.
- Limited field reconnaissance of the Little Nisqually River and its tributary streams in 1999.
- Personal Communication with Shane Scott of Tacoma Public Utilities.
- Bob Lucas of Washington Department of Fish and Wildlife.
- Edward Cupp former Fisheries Biologist, Forest Service, Cowlitz Valley Ranger District.

Data Gaps and Limitations

- Historical fishery and habitat information are non-existent for the area.

- Existing surveys only reported trout species; therefore, the distribution of other species is a data gap.
- The Forest Service records do not distinguish between the native rainbow and stocked rainbow, or coastal cutthroat and stocked strains of cutthroat.
- The lone existing stream survey is 15 years old and only covers the Little Nisqually River from its mouth to Winston Creek.
- Limited field data collection, or validation was done for this analysis.
- Some potential habitat and unknown populations may exist in the watershed.
- The records for species distribution do not include the extent of fish use for unnamed tributaries to occupied habitats.

Assumptions

Species occupy all sections of stream between the upper and lower ends of the distribution.

Fish Species Distribution

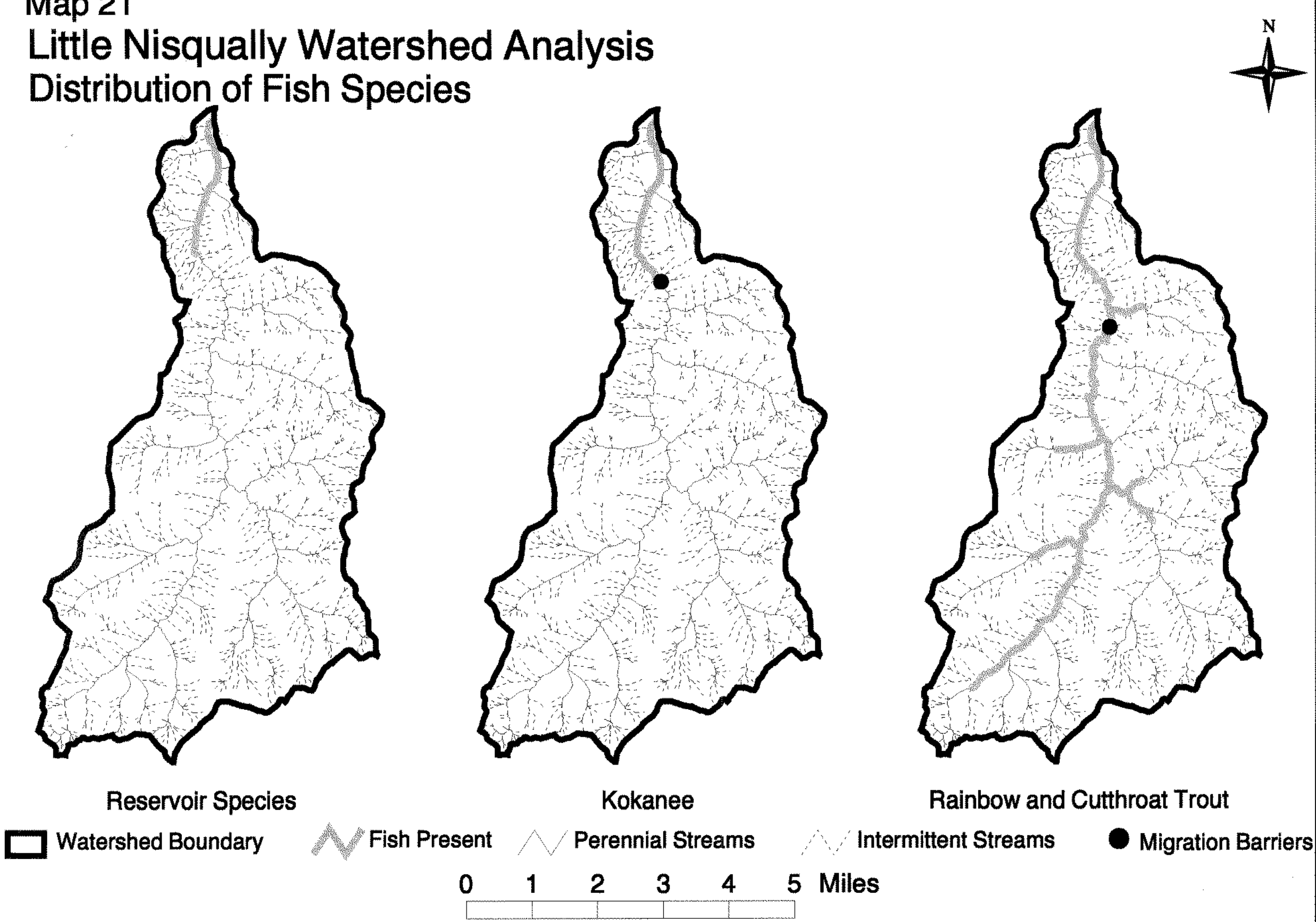
Any species in Alder Lake will have access to at least the lower 800 feet of the Little Nisqually River where a barrier to many species exists. Although they have not been reported, it is likely that Kokanee use this section of the river. Resident rainbow trout and resident coastal cutthroat trout have been reported in the Little Nisqually drainage. It is not known if the cutthroat and rainbow trout are migrants from Alder Lake or a resident population in the river. Map 21, Distribution of Fish Species, and Table 3-28 below display the approximate known distribution of fish in the watershed.

Table 3-28: Distribution of Fish Species - (This table summarizes the miles of fish habitat and percentage of fish habitat for each water body in the analysis)

Watershed	Stream	All Species	Kokanee	Resident Cutthroat and Rainbow Trout	Lake Cutthroat and Rainbow Trout	% of Total Fish Habitat
20Q	Reservoir	2.5	2.5	0.0	2.5	17.0
20Q	Little Nisqually River	0	0.2	8.5	0.6	61.9
20Q	Mona Creek	0	0	0.6		4.0
20Q	Wildcat Creek	0	0	0.1		0.1
20Q	Spencer Creek	0	0	0.8		5.4
20R	West Fork Little Nisqually River	0	0	4.3		29.3

Map 21

Little Nisqually Watershed Analysis
Distribution of Fish Species



20R,	Winston Creek	0	0	0.9		6.1
20S '	Hiawatha Creek	0	0	1.2		8.2
20S	Scatter Creek	0	0	0.4		2.7

Because the distances reported here were obtained from a map they are best used as an index of distance rather than actual distances.

Migration Barriers

Two potential migration barriers were reported in the 1984 Little Nisqually River stream survey. The first was a four-foot tall waterfall approximately 800 feet upstream from Alder Lake. This is barrier to kokanee and other less mobile species found in Alder Lake. The second was approximately was approximately 1700 downstream from the confluence with Winston Creek. Both of these are questionable as barriers for cutthroat and rainbow because they are relatively short falls, 4 feet high, and fish were reported above each of them.

A report for the Nisqually Project (Hoesy And Associates, 1989) relicensing reports a waterfall at about river mile 3.3. This barrier is based on the Washington State Stream Catalog (Wilson et. al, 1979). A 1990 Forest Service report discussed a 10 foot high waterfall in a similar location. It separates reservoir populations of cutthroat and rainbow from stream populations of cutthroat and rainbow. The location of this barrier and the lack of spawning gravel in the main Little Nisqually River make Mona Creek the key spawning area for the lake populations of cutthroat and rainbow in the Little Nisqually River.

Field reconnaissance for this report revealed natural migration on barriers Mona Creek downstream of the 74 road.

The field reconnaissance in 1999, found a 6-foot high water fall in Wildcat Creek. It was approximately 500 feet upstream from the mouth of Wildcat Creek.

Aquatic Population Viability

Based on extensive electrofishing across the ranger district, the cutthroat population was one of the strongest on the Cowlitz Valley Ranger District (personal communication, Edward Cupp, 1999).

Threatened, Endangered, and Sensitive Fish Species

No Threatened, or Endangered or Proposed species naturally occurred in the Little Nisqually River Basin. A natural waterfall blocked the migration of anadromous species prior the construction of the LaGrande and Alder reservoir system. Resident populations of coastal cutthroat trout on listed on the Regional Forester's Sensitive Species list.

Although there is anecdotal evidence of Bull trout in the lower Nisqually River (below La Grande Dam), Bull trout have never been reported in the Little Nisqually River or in Alder Lake (Personal Communication, Shane Scott, Tacoma Public Utilities).

Native Species

Coastal cutthroat (*Oncorhynchus clarki*), resident rainbow trout (*O. mykiss*), large-scale sucker (*Catostomus sp.*), sculpin (*Cottus sp.*) were probably present before the construction of Alder dam.

Introduced Species

Alder Lake reservoir, kokanee (*Oncorhynchus nerka*), large mouth bass (*Micropterus punctulatus*), yellow perch (*Perca falvescens*), black crapie (*Pomoxis nigromculatus*), catfish (*Ictalurus sp.*), and brown bullhead *(Ictalurus nebulous)* all of which are introduced species. Stocking of fish introduced several exotic species and subspecies of fish. Eastern Brook trout (*Salvelinus fontinalis*) were introduced from the Eastern United States. Brown trout (*Salmo trutta*) are native to Europe. Although rainbow and coastal cutthroat trout are native to the area they have been planted in lakes and streams where they did not originally occur.

Aquatic Habitat

Effects of Natural Processes on Habitat and Aquatic Organisms

Salmonid habitats are products of the existing geology and soils, topography, vegetation, climate, and hydrology of a watershed. Any changes in these conditions can bring about changes in the existing habitat that may greatly affect the fish habitat (Meehan 1991). Salmonids are adapted to a dynamic landscape. Stocks of salmon and trout have evolved in stream systems with fluctuations in flow, turbidity, and temperature and have often developed behaviors that enable survival despite the occurrence of temporarily unfavorable conditions (Bjornn and Reiser 1991). This flexibility is not unlimited and has evolved for the existing environment under each stock.

Floods

Floods large and small have had major influence on the existing aquatic ecosystem within the Little Nisqually River Basin. Flood events such as the 1990 and 1996 incidents have the potential to cause adverse impacts to stream channels and fish habitat. These events are likely to occur during the late fall to early spring time, from November to early March. Rain-on-snow effects as described previously in this chapter, further compound flood impacts in those watershed areas. Floods are and have been part of natural disturbance history in the Little Nisqually basin. Periodic major floods (ex. 1990, 1996 flood), along with fire, have altered and changed the stream channel and fish habitat conditions through time. The amount of time (years, to decades) between such major events and relatively intact refuge watersheds allowed fish populations to respond and adjust to altered channel and habitat conditions. These populations remained intact, viable, and self-sustaining. The ability to respond and cope with this natural disturbance regime is probably changed when the effects of man's activities (road construction, timber management, and riparian stand or streambank alterations) in the Little Nisqually River basin began to exacerbate the damage done by naturally occurring floods. Refer to the following section for further description of effects of human influences on habitat and aquatic organisms.

Land Slides

Periodic erosion, mass wasting and flood events deliver large woody debris and fresh sediments (usually cobble sized with relatively large percentages of finer sands and silts) to streams and rivers. A certain amount of natural erosion or disturbance to both upslope and instream channel conditions is beneficial to the aquatic habitat within the area. Such sediment delivery processes provide substrate that provides for fish spawning purposes. Periodic flushing of sediments clean out gravel areas that are negatively impacted by accumulation of fine silt-rich sediments and scours out sediments or maintains pools for fish rearing and other life history requirements. Fish populations have evolved over time in stream channels that are relatively balanced with bedload transportation and deposition and a stable channel condition. Increases in sediment influx during a flush event such as a heavy storm will negatively affect fish habitat as the sediment settles in depositional or low gradient areas and pools. Channels shift and residual pool depth is lost, changing fish habitat. In depositional areas, the effects of increased sediment supply are expected to correspond with accumulation of sediments. The development of salmonid eggs and alevin (fry) typically occurs in gravelly substrate in freshwater streams and rivers (Schuttes-Hames et al., 1993). Eggs and fry require a stable streambed, and an adequate supply of clean water to prevent dehydration and loss of oxygen and to continue standard metabolic waste removal while they develop (McNeil 1969).

Fine sediments that lodge in the spaces between gravel particles reduce the permeability and slow the flow rate through the gravel substrate (Johnson 1980). Numerous other studies associated higher fine sediment loads with elevated rates of mortality and reduced fitness of the surrounding fish (Chapman 1988; Everest et al. 1987; Koski 1975). WDFW (and participating agencies) in the Wild Salmonid Policy (first draft, 1995) will consider spawning gravel impaired if fine sediments exceed 11 percent (based upon Peterson et al. 1992). The survey reports and limited field reconnaissance suggest that fine sediments are not at levels, which would limit spawning success.

Stream channel scouring events resulted in both positive and negative impacts to the existing resident fish habitat in the analysis area. The upslope scouring provides a source for spawning-sized gravel and cobbles, which when concentrated in areas of moderate flow, are excellent sites for redd placement. It should be noted that sediment diameter and flow velocity preference varies among the salmonid species. In areas of high volume of sediment inputs, such as those during higher peak flow events, redds get covered and temperatures and oxygen flows are affected. Such events have been found to frequently occur within the analysis area.

Effects of Human Influences on Habitat and Aquatic Organisms

Several aspects of impacts to stream habitat and aquatic organisms are addressed below. The Riparian Condition section also describes impacts.

Timber Management

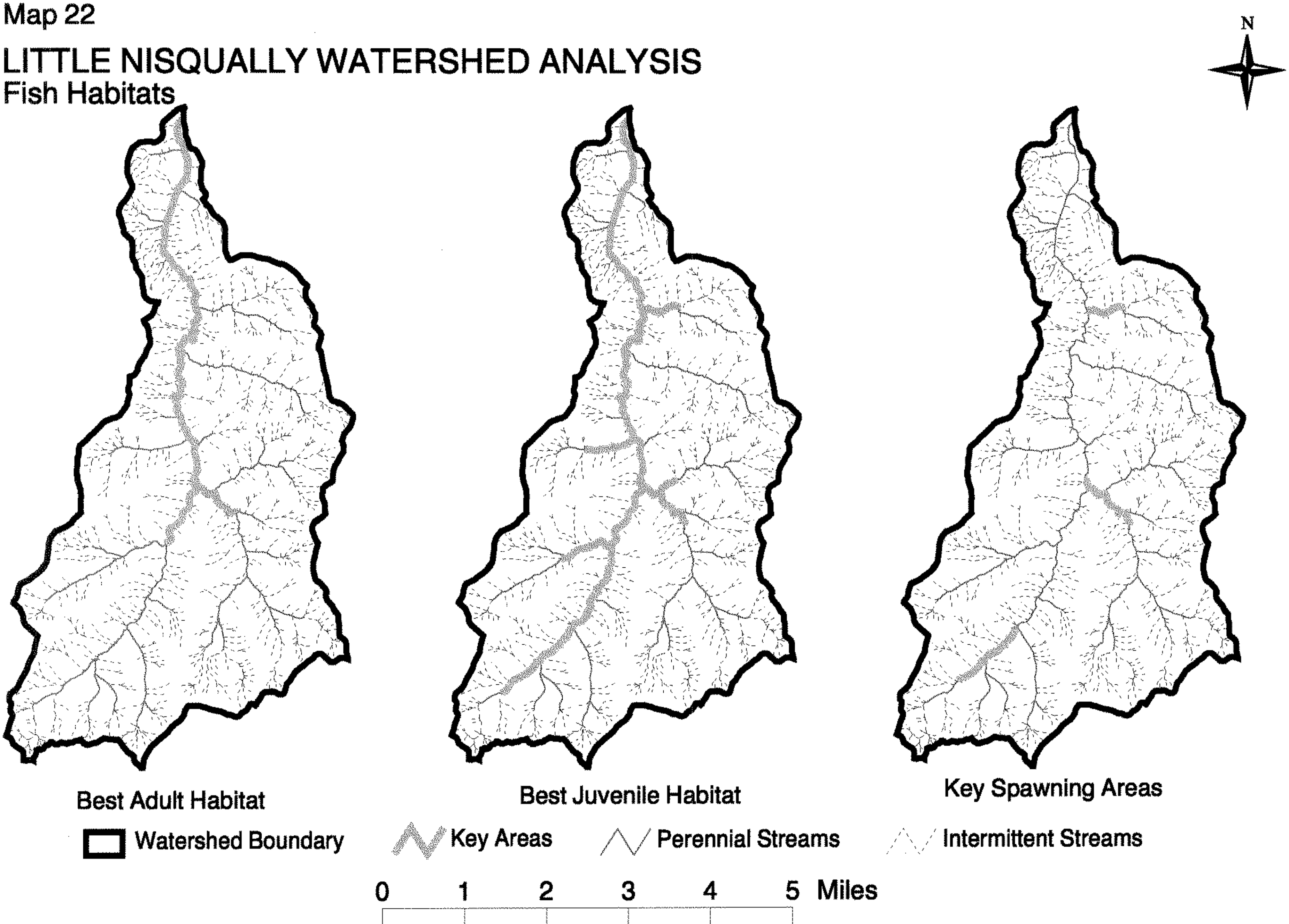
Logging has affected stream habitats within the Little Nisqually Watershed Analysis area over the past 30 - 40 years. Fine sediments are typically more abundant where land-use activities such as road building or vegetative disturbance expose soil to higher erosion potential and increased mass wasting potential (Swanson et al. 1987; Chamberlin et al., 1991). Reconnaissance suggests that most of the fine sediments have washed out of Little Nisqually River basin.

Harvesting timber can modify hydrologic processes and stream morphology (Chamberlin et al., 1991). Increases in peak flows from rain-on-snow events can increase scouring and accelerate bank erosion. Increases in sediment causes aggradation in pools, and degrades spawning gravel (both quality and quantity). Stream habitat diversity declines due to removal of instream structure-forming agents such as woody material (Hicks et al., 1991; Chamberlin et al. 1991). The size, number, and density of timber harvest clear-cut units and constructed roads done in a relatively short time period (1940s-1990s) is suspected to have

Map 22

LITTLE NISQUALLY WATERSHED ANALYSIS

Fish Habitats



played a major influence on channel and aquatics habitat conditions. Such road related flood damage is associated with the following aquatic concerns:

- Severe stream channel aggradation associated with upslope failures.
- Mass failure of fillslopes and/or cutbanks into stream channels.
- Fluvial erosion of fillslopes, cutbanks, or road surface.
- Road-crossing failure at stream crossing sites.
- Diversion of streams at streams crossings.
- Fish passage blockage at stream crossing sites.

Stocking of Exotic Fish Species

When fish are stocked, resident fish populations must compete for space and food. Interbreeding opportunities are also introduced. The planting of Alder has introduced kokanee and other hatchery stocks of native species to the Little Nisqually River. The Little Nisqually River was likely stocked in the past by either Washington Department of Fish and Wildlife (or it predecessor) or ambitious anglers. Duck and Goose Lake have been stocked with brook trout, brown trout and rainbow trout cutthroat trout and Twin Lake cutthroat trout. Alder Lake has been stocked with large mouth bass, yellow perch, black crapie and brown bullhead.

Recreational Fishing

Current information on recreational fishing use is limited. Main fishing interests at this time are the resident cutthroat, rainbow, and brook trout that are found in the Little Nisqually River, West Fork Little Nisqually and larger tributary streams as well as the lakes. Both Duck and Goose lakes are deep enough to sustain a fish population.

Other Recreational Impacts

Habitat degradation along riverbanks and lake shores are widespread. Dispersed camping compacts soils in riparian areas, campers often cut down trees which provide both shade and future LWD needs, and trash is frequently deposited in both stream and lake areas. Lack of nearby toilet facilities leads to water quality concerns.

Poaching

Poaching concerns are very limited and expect to be scattered about the analysis area. Such events are thought to be most predominant within the main fishing areas.

Spawning and Rearing Habitats

Map 22, Fish Habitats, show the best adult, juvenile, and spawning habitats within the watershed. The best potential for spawning habitats is based on stream gradient, substrate sizes and known migration barriers. The best spawning habitat is located in Mona Creek, Hiawatha Creek and West Fork Little Nisqually River upstream from Lake Creek. Juvenile rearing habitat is spread throughout the accessible habitat in the Little Nisqually watershed. The best adult habitat is found in Little Nisqually River and the Alder Reservoir portions of the watershed.

Refugia

The Scatter Creek Basin is the only relatively unmanaged area in the Little Nisqually River basin large enough to meet any criteria as a refugia. This stream is small (provides only 2.7 of available habitat) and is not large enough to house a population of fish large enough to reseed the basin and has little adult habitat.

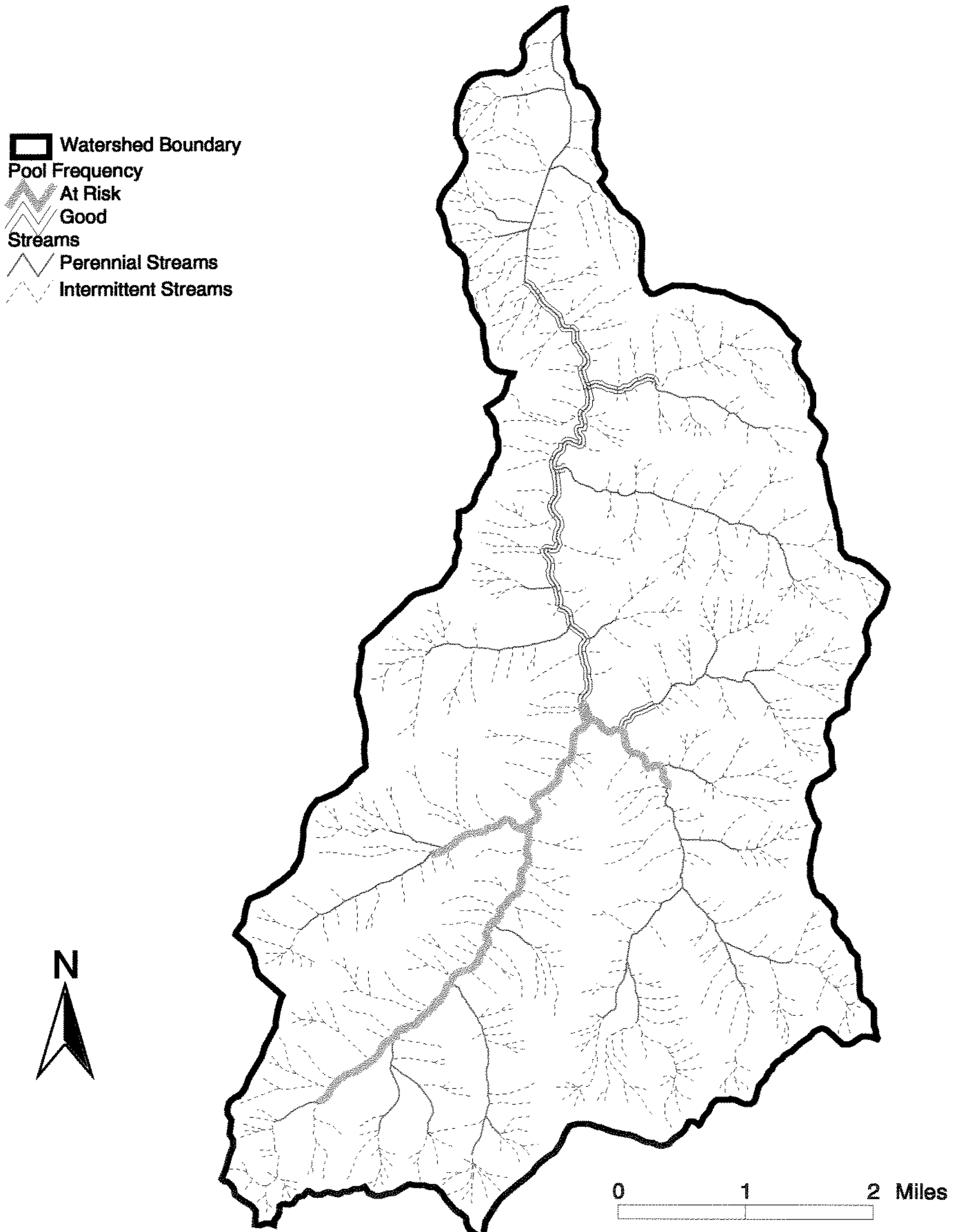
Limiting Factors Analysis

Analysis Procedures

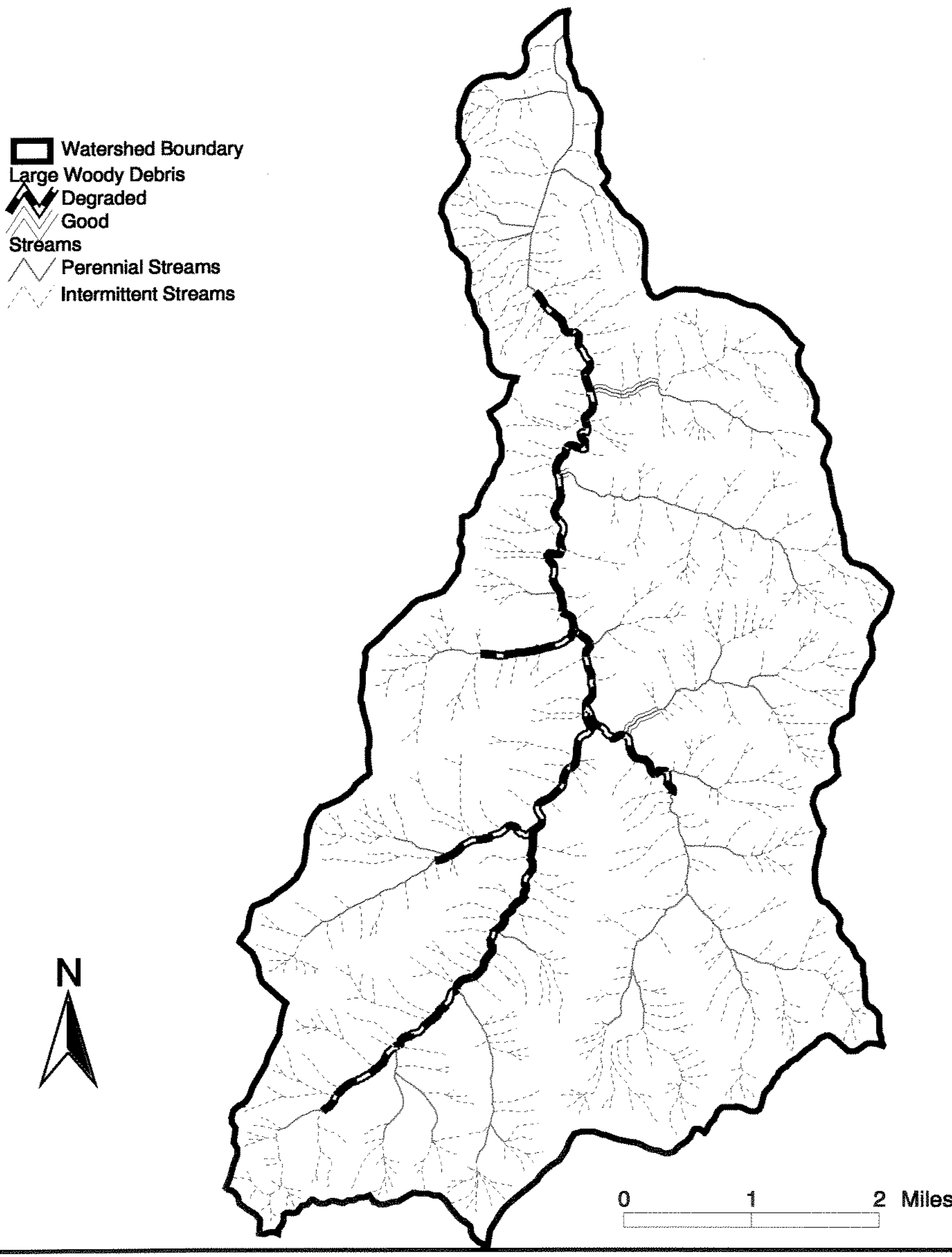
This procedure is purely a rating of habitat conditions and as such does not factor in the potential of the stream. These limiting factor analyses rate four fish habitat elements as good, fair or poor by stream survey reach. A habitat element was considered limiting if most of the stream length that is available to fish rates as fair or poor. The degree of limitation increases as the percentage of the stream length rated as fair or poor increases. Streams in ideal condition have no limiting factors, while streams in the worst condition are limited by all four habitat variables. The limiting factor table identifies the limiting factors for surveyed stream sections. The data and rating for individual stream reaches are found in the Stream Survey Data Appendix.

Four elements were chosen to evaluate the habitat requirements of salmon and trout. All four of elements were chosen, because if they are in less than good condition they can limit population size or create a bottleneck for fish populations. Pool frequency was chosen as one of the variables because is a measure of amount of suitable rearing habitat (deep slow water) (Bjornn and Reiser, 1991). Woody debris was chosen because of importance in forming pools, trapping sediments, providing hiding cover, and providing nutrients (Hicks et al. 1991). In addition, woody debris has been correlated with fish population size (Burnett and Reeves, 1998). Spawning gravel gives an estimate of the amount of gravel that is suitable for

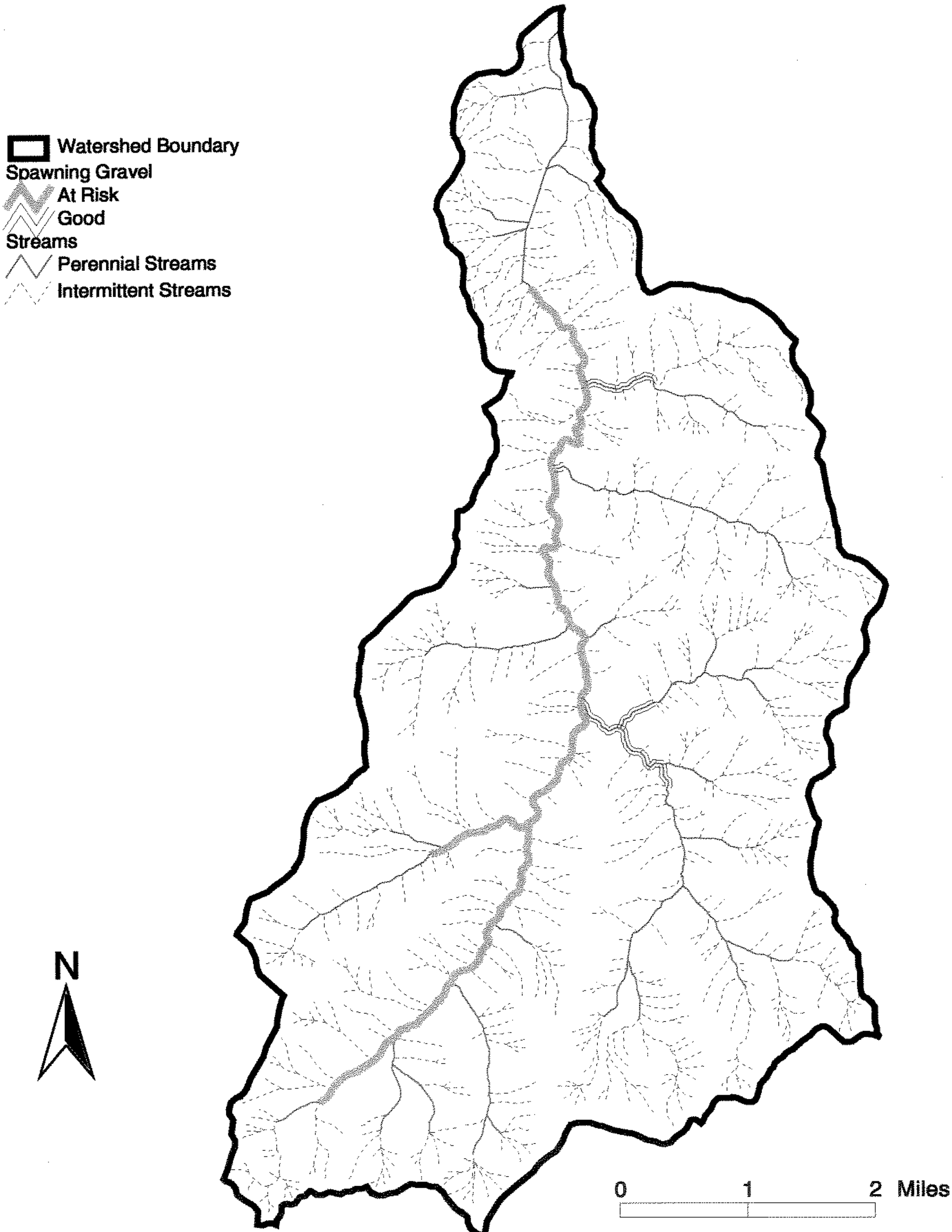
Map 23
LITTLE NISQUALLY WATERSHED ANALYSIS
Aquatic Concerns - Pool Frequency



Map 24
LITTLE NISQUALLY WATERSHED ANALYSIS
Aquatic Concerns - Large Woody Debris



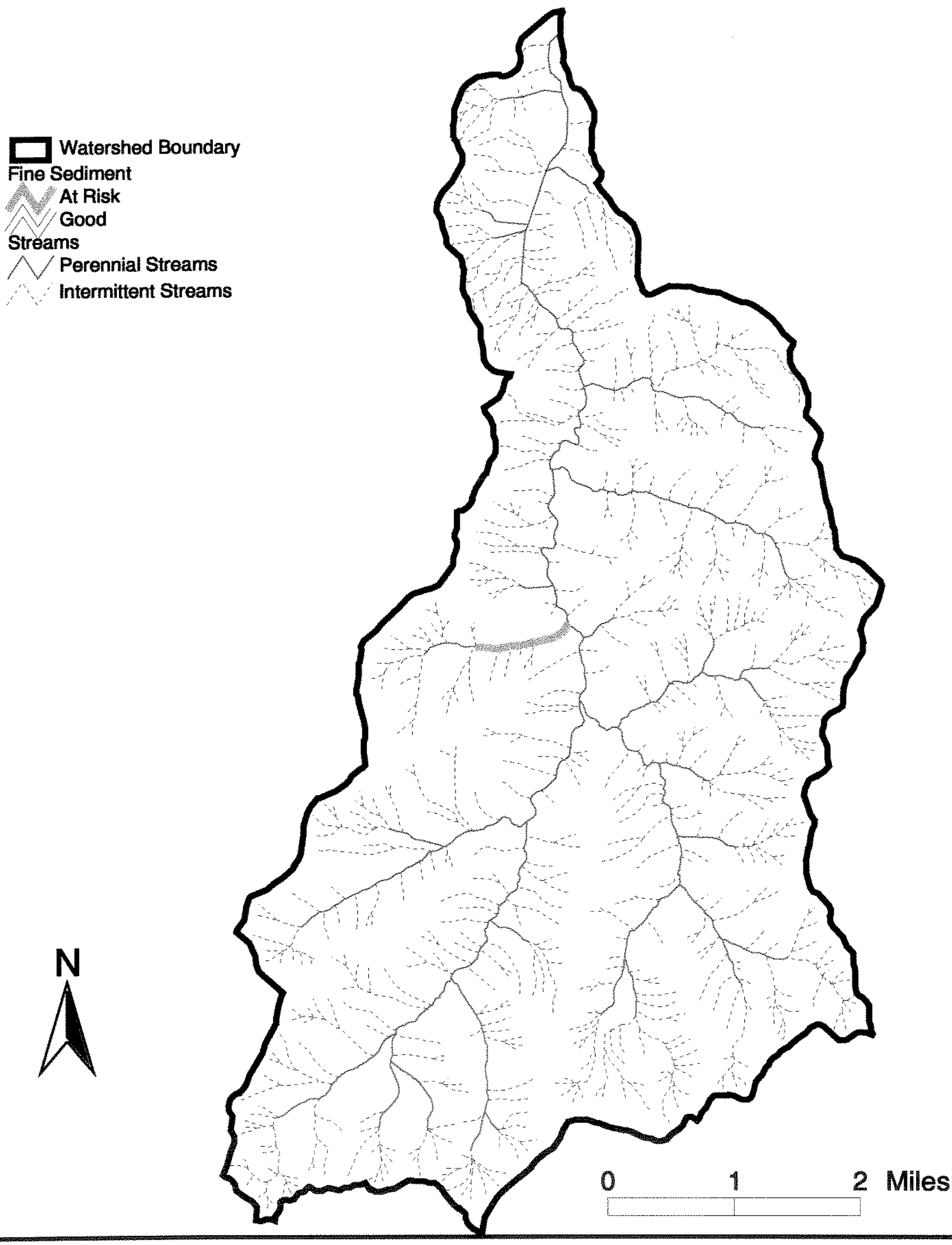
Map 25
LITTLE NISQUALLY WATERSHED ANALYSIS
Aquatic Concerns - Spawning Gravel



Map 26

LITTLE NISQUALLY WATERSHED ANALYSIS

Aquatic Concerns - Fine Sediment



spawning, provided a measure of streams suitability for reproduction. Fine sediment gives a measure of the quality of the spawning gravel and measure of the spaces between rocks that are available for hiding cover and aquatic invertebrate production. Effects of fine sediment become noticeable when fine sediments make up approximately 11% of the substrate. Egg to fry survival begins to dramatically decline when fine sediments make up 20% or more of the substrate (Bjornn and Reiser, 1991). Stream temperature was not chosen, because existing information does not indicate that stream temperatures are limiting. Other habitat variables (such as hiding cover) were not chosen, because they were rarely gathered, not gathered in a consistent manner, or it was not possible to extract the data needed in the time frame of the analysis.

Data Sources

The data used in this analysis was collected in stream surveys from 1984 and a 1999 field review.

Habitat Element Rating Criteria/Reference Conditions

Pool Frequency

The 1984 survey did not directly count pools so we use the percent of the stream area that was classified as pool habitat. The rating is based on the percent of stream in pool habitat and the quality of the pools. The reach is first rated on the amount of habitat. Then that rating is adjusted based on the amount of adult holding pools and the size of the stream. If a large proportion of the pool habitat was adult holding habitat the rating is raised one category. If most of the pool habitat is juvenile habitat the rating is lowered one category. See Map 23, Aquatic Concerns - Pool Frequency for locations of rated streams.

Table 3-29: General Rating Criteria for Percent Pool Habitat

Rating	Criteria for rating % pool habitat.
Good	> 60% of the stream is pool habitat
Fair	50% of the stream is pool habitat
Poor	< 40% of the stream is pool habitat

Woody Debris

The woody debris rating is based on the 1984 survey and spot checks completed in 1999. Based on the 1999 spot checks none of the mainstem Little Nisqually River is rated as good. See Map 24, Aquatic Concerns - Large Woody Debris for locations of rated streams.

Table 3-30: Rating Criteria For Woody Debris

Rating	Number of pieces of wood per 100 feet
Good	> 2 pieces per 100 feet of the stream.
Fair	1 to 2 pieces per 100 feet of the stream.
Poor	< 1 piece per 100 feet of the stream.

Spawning Gravel

The spawning gravel rating criteria table displays the rating criteria for spawning gravel. See Map 25, Aquatic Concerns - Spawning Gravel for locations of rated streams.

Table 3-31: Rating Criteria for Spawning Gravel

Rating	Areas of spawning gravel.
Good	> 5% of the reach length.
Fair	1% to 5% of the reach length.
Poor	< 1% of the reach length.

Fine Sediment

The fine sediment rating criteria table below displays the criteria for rating fine sediment. See Map 26, Aquatic Concerns - Fine Sediment for locations of rated streams.

Table 3-32: Rating Criteria for Fine Sediments

Rating	Criteria for Rating
Good	Fine sediments make up less than 11% of substrate or cobble embeddedness is less than 20%
Fair	Fine sediments make up less than 20% of the substrate or cobble embeddedness is less than 35%
Poor	Fine sediments make up more than 20% of substrate or cobble embeddedness is 35% or greater.

Data and Analysis Limitations

The limitations for the data are:

- There are no data for historic conditions.
- The stream survey data is 15 years old and several floods have occurred since the data was collected and analyzed.
- The stream survey data is difficult to interpret, because records of the protocol used in 1984 do not exist.
- Measures of spawning gravel and sediment are highly subjective and may be different from surveyor to surveyor.
- The ratings for the tributary streams and Little Nisqually River are based on spot checks in 1999.
- No data from relatively unmanaged streams exists to serve as reference data for these stream systems, and determine management effects exists.
- We use the criteria for good fish habitat used National Marine Fisheries Matrix of Pathways and Indicators, which may not be the indicators of stream potential.

Limiting Factors Results

The summary of limiting factors table displays overall rating for the habitat elements for a stream. A habitat element is considered a limiting factor on fish populations when most of a stream rates as fair or poor. The limitation is less if the stream rates as fair, than when a stream rates as poor. The overall condition of the stream is combination of all of the ratings.

Table 3-33: Summary of Limiting Factors Analysis

Watershed Number	Stream	Pool Frequency	Woody Debris	Spawning Gravel	Fine Sediment
20Q	Little Nisqually	Good	Limiting Poor	Limiting Poor	Good
20Q	Mona Creek	Good	Good	Good	Good
20Q	Wildcat Creek	Good	Good	Limiting Fair	Good
20Q	Spencer Creek	Limiting Fair	Limiting Poor	Limiting Fair	Limiting Fair
20R	West Fork Little Nisqually	Limiting Fair	Limiting Poor	Limiting Fair	Good
20R	Winston Creek	Limiting Fair	Limiting Poor	Limiting Fair	Good

20S	Hiawatha Creek	Limiting Fair	Limiting Poor	Good	Good
20S	Scatter Creek	Good	Good	Good	Good

The discussion of limiting factors, for each stream, briefly describes which factors are considered limiting and why they are considered limiting. The discussions of limiting factors are arranged by sixth field watershed and stream.

20Q - Little Nisqually River Watershed Results

The limiting factors analysis for this section is based on the 1984 stream survey and limited spot checks in 1999.

Table 3-34: Percent of Streams in WS with Rating of Key Habitat Elements - WS 20Q

Rating	Pool Frequency	Woody Debris	Spawning Gravel	Gravel Quality
Good	65	0	0	100
Fair	15	22	15	0
Poor	20	88	85	0

Pool Frequency

Pool frequency for this section is considered good. Pool frequency rated as good for most of the section. Large proportions of the pools were adult rearing habitat. The best pool habitat is located near the Alder lake where it is accessible to fish in the reservoir.

Woody Debris

Woody debris is considered a limiting factor. Most of this section of the stream rated as poor for woody debris. There are very few pieces of large woody debris along the Little Nisqually River.

Spawning Gravel

Spawning gravel is considered a limiting factor for this section stream. Spawning gravel is limited to isolated pockets behind boulders for most of this section of stream.

Gravel Quality

Overall gravel quality is considered good for the stream section, but it is considered limiting in lower the 3/4 of a mile because of a "organic sludge" (1984 Stream Survey) covering the bottom. The "organic sludge" is probably limited to the fluctuation zone. Otherwise both the stream survey and a spot checks have indicated clean substrates.

Mona Creek Results

Information on this tributary is limited to field reconnaissance, below the 74 road, in the spring of 1999.

Pool Frequency

Pool frequency for this section is considered good. Although the number pools of is low it was meeting potential for the stream type.

Woody Debris

The amount of woody debris was considered good. Woody debris was so abundant, that it was difficult to walk up the North Fork of Mona Creek during the field reconnaissance.

Spawning Gravel

The amount of spawning gravel is considered good for the mainstem of Mona Creek. Appropriately sized gravel was abundant in the tails of the pools. Considering the apparent lack of spawning gravel in the main Little Nisqually River, Mona Creek is considered a key spawning area for the lower river.

Gravel Quality

The quality of spawning gravel is considered good. The substrate the substrate is clean of fine sediments.

Wildcat Creek Results

Information on this tributary is limited to field reconnaissance, below the 74 road, in the spring of 1999. Only the 500 feet of Wildcat Creek is accessible from the Little Nisqually River. If fish are found above this point they are either remnant populations or more likely have been planted there.

Pool Frequency

Pool frequency for this section is considered good. Spot checks indicated that pool frequency was fairly high.

Woody Debris

Woody debris is considered good for this small section of stream.

Spawning Gravel

Spawning gravel is considered a limiting factor for this stream. Spot checks in 1999, found only pockets of spawning gravel. This is another key spawning are for the lower river.

Gravel Quality

Spawning gravel quality is considered good for this stream. The 1999 spot checks indicated the substrate was relatively clean.

Spencer Creek Results

Information on this tributary is limited to field reconnaissance, below 7413 road, in the spring of 1999.

Pool Frequency

Pool frequency for this section is considered limiting. Field reconnaissance indicated that pool frequency was low between the 7400 and 7413 roads. Loose bedload movement appears high which would result in a loss of pools.

Woody Debris

Woody debris is considered a limiting factor for this stream. Field reconnaissance in 1999 indicated that there is little woody debris in this stream.

Spawning Gravel

Spawning gravel is considered a limiting factor for this stream. Field reconnaissance in 1999, found only pockets of spawning gravel.

Gravel Quality

Spawning gravel quality is considered a limiting factor for this stream. The 1999 field reconnaissance found a large pulse of fine sediment making it way down stream and potential further addition of fine sediment. The degradation was limited to a rating of fair, because of some uncertainty about how concentrated the sediment would be in fish habitat in the future.

20R - West Fork Little Nisqually Watershed Results

Information on this section of the river is based on the 1984 stream survey and limited spot-checks in the spring of 1999. The data below only extends from Hiawatha Creek to Winston Creek. The spot checks above Winston indicated similar conditions.

Table 3-35: Percent of Streams in WS with Rating of Key Habitat Elements - WS 20R

Rating	Pool Frequency	Woody Debris	Spawning Gravel	Gravel Quality
Good	10	0	0	100
Fair	30	10	90	0
Poor	60	90	10	0

Pool Frequency

Pool frequency for this section is considered limiting. Spot-checks and the stream survey indicted that pool frequency was fair near Winston Creek but decreased to poor above the 7400177 road. Adult holding habitat also decreased above this point.

Woody Debris

Woody debris is considered a limiting factor. Most of this section of the stream rated as poor for woody debris. Woody debris was rarely observed in the West Fork of the Little Nisqually River.

Spawning Gravel

Spawning gravel is considered a limiting factor for this section stream. However, this section of river contains most of the spawning gravel found in the mainstem. Even though the amount of spawning gravel is low this is an important spawning area. This is due to alluvial nature of the stream.

Gravel Quality

Overall gravel quality is considered good for the stream section. Spot checks have indicated that spawning gravel is relatively clean.

Winston Creek Results

Information on this tributary is limit spot checks in the spring of 1999.

Pool Frequency

Pool frequency is considered a limiting factor. Winston Creek is a Rosgen A2 (step pool complex) down stream from the 7400 road crossing. The number of pools for this section is considered good. These pools are however small in area and difficult to access. Spot checks from the 7400174 area indicated that pool frequency is low. Overall pool frequency ranked as fair and is considered a limiting factor. The stream above the 7400 appeared to recovering from a debris torrent that occurred 5 to 10 years ago.

Woody Debris

Woody debris is considered a limiting factor for this stream. Spot checks in 1999 indicated that there is little woody debris in this stream.

Spawning Gravel

Spawning gravel is considered a limiting factor for this stream. Spot checks in 1999, found only pockets of spawning gravel.

Gravel Quality

Spawning gravel quality is considered good for this stream. The 1999 spot checks indicated the substrate was relatively clean.

20S - Hiawatha Creek Watershed Results

Information on this tributary is limited to field reconnaissance below the confluence of Scatter Creek in the spring of 1999.

Pool Frequency

Pool frequency is considered a limiting factor. Reconnaissance of Hiawatha Creek below Scatter Creek found that pool frequency and quality were good in the area where riparian reserve had not been cut. Pool frequency and quality declined in the areas adjacent to timber harvest. Examination of aerial photos from 1993 shows that approximately half of area providing fish habitat and the vast majority of this stream has had timber harvest along the at least one edge of the stream. Therefore pool frequency receives a ranking of fair.

Woody Debris

Woody debris is considered a limiting factor. Reconnaissance of Hiawatha Creek downstream from Scatter Creek found that amount of woody was adequate in the unharvested area, but low in the harvested section. Examination of aerial photos shows that most of the stream has been harvested relatively recently. Therefore woody debris receives a ranking of poor.

Spawning Gravel

The amount of spawning is considered good. The field reconnaissance found adequate amounts of spawning gravel in the lowest section of Hiawatha Creek.

Gravel Quality

The quality of spawning gravel is considered good. Field reconnaissance in 1999 found that the gravels were fairly clean.

Scatter Creek Results

Information on Scatter Creek is based on reconnaissance of the first 200 feet of the stream and correlations between timber harvest and habitat observed in other portions of the Little Nisqually River watershed.

Pool Frequency

Pool frequency is considered good. Reconnaissance of Scatter Creek found that pool frequency was adequate.

Woody Debris

Woody debris is considered good. Field reconnaissance in 1999 found that woody debris was adequate near the mouth of Scatter Creek. In addition, the watershed for this tributary is largely unharvested.

Spawning Gravel

The amount of spawning is considered good. The field reconnaissance found adequate amounts of spawning gravel in the lowest section of Scatter Creek.

Gravel Quality

The quality of spawning gravel is considered good. Field reconnaissance in 1999 found that the gravels were fairly clean.

Forest Service Fisheries Habitat Improvement and Watershed Restoration

Woody debris was removed from the stream primarily in conjunction with timber sales. The purpose was two fold: as a flood control/prevention measure (reduce the potential a log jam has to downstream bridge or road segment), and to remove the suspected fish blockages these jams were interpreted as being. With new studies and research results available, the Forest has attempted to adopt the information available and restrict any human activities within the riparian area that are suspected to alter aquatics habitat conditions. One of the exceptions to this condition is where woody debris or large bedrock/boulders that are present within the stream channels may pose a threat to the existing road or bridge systems.

Woody debris was reintroduced to the West Fork Little Nisqually River just above the old crossing of the 7400177 road. The vast majority of this wood was washed downstream during the floods in the winter of 1995 and 1996.

Monitoring

Monitoring on this stream has been limited the monitoring of the woody debris placed in the stream in 1994. Most of these structures are gone or non-functional.

Chapter 4 - Interpretations/Areas of Concern

Introduction

This chapter focuses on the interpretation of data presented in Chapter 3 as it pertains to current and proposed management within the watershed. It is through understanding of the function of the various ecosystem elements that the context for future management is set. As in Chapter 3, the information is presented for the major terrestrial, aquatic, and social elements known from the Little Nisqually watershed.

SOCIAL ELEMENTS

Human Ecology

Information pertaining to past human use of the watershed was examined from the perspective of ecosystem management. Maintenance of a ``properly functioning, self-sustaining ecosystem" is described as a necessity of management, identified previously in this document as Issue 4, Ecosystem Function (see Chapter 2). The principal questions addressed by this analysis relate to the retention of native plant and animal species within the watershed including adequate distributions of suitable habitat and populations.

Past human use of the Little Nisqually watershed analysis area by indigenous people included hunting, fishing, and gathering of a variety of native plants and animals. These resources were important components of the naturally functioning ecosystem prior to the late-1800's, when non-native people began settlement of the nearby river valleys, to the north and south of the analysis area. Historic shifts in local land use practices and the resource demands of an increasing *regional* population resulted in impacts to the natural distribution of some species, especially in the past fifty years.

Populations of six species of fish were sufficient to have contributed to the subsistence base of the indigenous culture. Historic data suggest the salmonids (*Onchorhynchus sp.*) were the most abundant. Identifications have been based largely on Sahaptin fish taxonomy (Hunn 1990) which uses the noun *sinux* for coho, or silverside salmon, *tk^{w}inat* for Chinook, *shushaynsh* for steelhead, or the generic *núsux* for all salmonids. Construction of hydroelectric dams on the Nisqually River has eliminated the native runs of all three species. This situation suggests a significant imbalance within the structure of the aquatic ecosystem.

Recreational Uses

Known and suspected activities include garbage dumping, poaching, and other possible illegal activities that occur primarily because of remoteness, poor access, and lack of management presence.
The area is not a high priority for investing the limited funds and staffing available for recreation management on the District. This situation is unlikely to change in the foreseeable future. Recreation management of this area is largely by reaction to significant problem situations when they are discovered. In general, the most significant problem situations that we are aware of are garbage dumping and littering in dispersed sites. Poaching is also considered to be a problem but is not addressed by recreation management.

Special Forest Products

Special forest products have been actively managed for the past decade. Permits are now issued to build a database of information about the demand for products and to better administer the harvest. Research into how forest products are reacting to harvest is just beginning. There is also interest in the local community to expand the gathering, storage, and processing of forest products to provide additional local employment. Currently the demand for traditional and non-traditional forest products is increasing. This creates management challenges, opportunities and concerns. Following are several identified areas of concern.

1) Road access: Where feasible, road closures to designated harvest areas should allow ATV access.

2) Adequate funding: Unlike the sale of timber, revenue from the sale of special forest products permits/contracts do not return money to the local Ranger District. Returning a portion of the proceeds is essential to effective management.

3) Deciding where management emphasis should be.

4) Dealing with emerging products and markets.

5) Coping with increased use.

6) Maintaining accountability.

Lands, Minerals and Special Uses

Mining

While the apparent level of mining activities in this WA area is minimal, mining is a legitimate activity on National Forest lands, as recognized by a century and-a-quarter of Federal mining laws. Proposed mining activities are not discretionary; i.e. the Forest Service cannot choose to defer consideration of a mining proposal, as it could an application for a Special Use Permit. As they occur, mining proposals are matters that the Forest Service must deal with. The Forest Service's function is to evaluate a mining proposal pursuant to all pertinent Federal laws and regulations, and to help shape resulting on-the-ground operations pursuant to same.

Special Uses

Private Use of National Forest Roads - The Forest Service, by law, must allow access across National Forest lands for the benefit of adjacent private lands, when such access across the National Forest is reasonable.

TERRESTRIAL ELEMENTS

Disturbance Regimes

Insects and Disease

Our limited knowledge indicates that current insect and disease occurrences in this watershed appear to be within the range of natural variability. However, we don't know the precise limits of that range. In general, the insects and diseases residing in western Washington forests (and in this watershed) seem to have a relatively narrow range of natural variability. There are no records or data that indicate any past insect or disease disturbance in this watershed that was of such magnitude as to adversely affect the ecosystem.

The generally moderate environment of western Washington forests leads to less drought and other tree stresses that are often related to insect outbreaks (and sometimes to disease occurrence). Consequently, insect outbreaks will tend to be infrequent, small in size (usually less than 5 acres), and very low to moderate in severity. We can expect most insect and disease occurrences to be widely and irregularly distributed across the parts of the watershed occupied by their respective hosts, with attacks often being associated with host trees under environmental stress.

Insects

We can expect the Douglas-fir beetle (mostly in small, scattered patches) to continue killing Douglas-fir in this watershed, especially in connection with areas of unsalvaged windthrow and/or root disease. Large, significant outbreaks of this insect are possible in portions of the watershed where Douglas-fir is dominant, but that would be most likely to happen in conjunction with a large windthrow event or wildfire, especially if there was no significant salvage of the dead/down material.

We can expect the balsam woolley adelgid to continue (mostly in scattered, small patches) affecting the growth and vigor of Pacific silver fir (as well as causing mortality) in this watershed. As an introduced species, this insect has no natural enemies to help control it. Outbreaks of this insect are possible in portions of the watershed where Pacific silver fir is dominant, but that is most likely to happen only in those areas of high site productivity where this species is most susceptible.

Disease

Disease infections generally move slowly through the forest. In this watershed, root disease centers are generally small in size (<1 acre to 5+ acres), and the number of infection centers in the Western Hemlock Zone portion of the watershed is generally low. The damage severity of disease occurrences in the watershed ranges from very low to low, but for most diseases it is most often in the very low range.

Laminated root rot is expected to continue causing mortality as the infections move through the stands where they are currently located. In some managed stands reforested with highly susceptible Douglas-fir during the 1960's. and 1970's, where laminated root rot was located prior to harvesting, the level of disease inoculum and the virulence of the disease may increase.
In the recent past (1980's and 1990's), efforts have been made to reduce the level and spread of laminated root rot through regeneration harvest of infection centers, followed by planting intermediately susceptible, tolerant, resistant, or immune tree species to grow for a rotation. Managing regenerated infection centers with a mix of tree species less susceptible to the disease will slow or limit damage and spread of the disease.

Windthrow

Available evidence indicates that timber harvest activities (mainly regeneration harvest by clearcut) have increased the amount of windthrow and the number of windthrow events in this watershed. Prior to the start of timber harvest activities in the 1960's it appears (from looking at the aerial photographs) that very little windthrow of significance took place in the watershed. Future windthrow events are likely to occur along the margins of existing clearcuts and future commercial thinning units. Future regeneration harvest should not be an issue in this watershed unless some catastrophic event occurs which allows salvage of areas impacted which are greater than 10 acres in size. Under the right conditions (high wind and water-saturated soils) these events could impact significant acres, but not necessarily in large patches, more likely in a large number of smaller patches.

Forest Vegetation

Vegetation Structural Stages

Chapter 3 described what is known about the forest vegetation structural stages at two discrete points-in-time (1900 and 1999). Natural variability is a complex temporal and spatial property of all ecosystems. There is insufficient vegetation data over a long span of time to accurately or meaningfully describe the range of natural variability for forest vegetation in this watershed. It would be erroneous to conclude that the differences described between forest vegetation in 1900 and 1999 constitute the range of natural variability. Therefore, we will simply compare the historic or reference forest vegetation structural stage data to the current forest vegetation structural stage data to determine trends and possible areas of concern within the watershed.

The current structural stages existing in this watershed are significantly different than those found in 1900 (Table 4-1). From 1900 to 1999, the dominance of forest vegetation has shifted from small tree forest to grass/pole forest. During this period, the following factors have influenced forest vegetation structure: a large amount of regeneration timber harvest in the watershed (7,266 acres in the last 40 years), the vigorous suppression of wildfires, and forest growth (natural succession).

The amount of large tree forest has decreased in this watershed by 1,920 acres since 1900. This is a result of a large amount of regeneration harvest and much of the small tree forest that existed in 1900 not having grown into large tree forest condition over the last 100 years.

Table 4-1: Comparison of Historic and Current Vegetation by Structural Stage				
Structural Stage	**Year 1900**		**Year 1999**	
	Acres	**%**	**Acres**	**%**
Grass/Pole	1,456	8	8,846	50
Small Tree	10,299	58	4,824	27
Large Tree	5,716	32	3,819	21
Non-Forest	*378	2	*366	2

* Note: The difference in these two non-forest acreage figures is not known.

With the advent of fire suppression activities in the 1930's, the number of acres lost to wildfire has dropped substantially. This means that the grass/pole forest component of 1900 moved undisturbed into the small tree condition of today. The amount of grass/pole forest in 1999 is primarily attributed to regeneration harvest activity. Regeneration harvest acted as a surrogate for wildfires.

A major difference exists in the location, size, structure, shape, and timing of initiation of the grass/pole forest patches created by timber harvest from the grass/pole forest patches that are created by wildfire events. The grass/pole patches resulting from clearcut harvest and broadcast burning contain very few snags; large, live remnant trees; or large down woody material (as a general rule). Until recently, the nature of timber harvest activities (both regeneration harvest and salvage cutting) across the watershed has meant the simplification of forest structure. Harvest activities tended to eliminate snags, live remnant trees, less vigorous/diseased/damaged trees, large down wood, and multi-layered canopies. Often patches were created with hard, distinct, straight edges, single-layered canopies, a less diverse species composition, and generally healthy, undamaged trees with few deformities (i.e., a much simpler and less diverse structure -- both vertically and horizontally).

As these simplified grass/pole patches grow into small tree forest, (and eventually large tree forest patches) they will carry forward the more simplified structural characteristics of their clearcut harvest origins. Future management activities (e.g., precommercial thinning and commercial thinning) should attempt to create more diversity in the current grass/pole stands over time.

The large tree forest currently forms the most highly fragmented forest patches in the watershed. Most of the large tree forest which existed in 1900 has been regeneration harvested since the 1960's. however much of the small tree forest in 1900 has grown into large tree forest or is within one to three decades of becoming large tree forest. Even though the large tree forest looks extremely fragmented, much of the small tree forest will soon become large tree forest. In many of the small tree forest stands, especially those which have maintained high tree densities on some of the less productive sites, management through the use of thinning or creating gaps could accelerate the natural succession process and move these small tree stands into a large tree category. One concern for the future will be how to restore larger, more connected patches of large tree forest in this area of heavy fragmentation that will have the structural and spatial characteristics needed to meet this area's management direction (which is currently LSR).

The Northwest Forest Plan's emphasis on leaving snags, live remnant trees in various states of health and condition in patches and as scattered individuals; pieces of large down wood, more varied tree species composition, unthinned patches and canopy gaps in thinnings, variety in tree sizes and spacings, etc., will slowly return some of the structural complexity lost over the past few decades through clearcut timber harvest.

Under today's emphasis of an ecosystem approach to management, the rate, type, and nature of timber harvest has changed dramatically, altering the successional trends in the watershed as well as the locations and configurations of current and future vegetation structural stage patches. The watershed is dominated by management allocations/direction that limits the amount of future timber harvest. 100% of the Forest Service land which is 89% of the watershed is managed as Late-Successional Reserves (LSR). In the LSR, only treatments that will hasten the development of late-successional forest (such as precommercial thinning and commercial thinning in stands up to 80 years of age) are permitted. Most of the current grass/pole forest (past clearcuts) which amounts to 87% on Forest Service land resides in the LSR. Over the next few decades, much of the grass/pole forest in the LSR will become small tree forest. Much of the current small tree forest will succeed to large tree forest. This means that over the next 80-90 years it is possible that a large portion of the forested landbase in the watershed will be large tree (late-successional) forest, assuming continued absence of large wildfires.

One of the tools used to control the stocking of managed grass/pole stands to meet a variety of resource objectives is precommercial thinning. Since 1991, the budgets and acres treated for timber stand improvement have dropped precipitously, while the acres of grass/pole stands needing stocking control (those acres initiated by clearcut harvest in the late 1970's and early 1980's) continue to come on line each year. There is an immediate concern that the stocking levels of many of those grass/pole stands will not be managed, foregoing the opportunity to accelerate the early and important development of various desired conditions, depending on the management allocations in which they reside (thus affecting future wildlife habitat, hydrologic recovery, production of large woody debris and large snags, etc.). There are currently about 2000 acres of known/documented precommercial thinning needs in this watershed. There is an additional 650 acres that will be in need of stocking control in the next few years (based on past regeneration harvest rates in the early 1990's). These have not yet been documented due to insufficient funding for stand exams necessary to track the development of the grass/pole stands.

Botanical Species of Concern

TES Plant Species

No TES species have been found in the analysis area, however, surveys for TES species have been specific to individual project boundaries and thus do not accurately portray the possible distribution of these species across the landscape.

Survey and Manage Botanical Species

Population dynamics of known sites of survey and manage species have not been monitored. Without information on population trends it is difficult to assess how these species are responding to changes within the watershed. The historic condition of vegetation within the analysis area was not analyzed for this report, thus it is not possible to compare historic to current habitat conditions. Currently (1999), approximately 21% of the analysis area supports late-successional habitats (Table XXd). While we do not know what percentage of the analysis area supported late-successional habitats in the past, we can assume from other analyses of this scale that the current pattern of late-succcssional habitat on the landscape is quite different today than it would have been historically. The current distribution of late-successional habitat has been largely determined by timber harvest activities and has resulted in a highly fragmented landscape with patch sizes which are generally much smaller than those found on managed landscapes.

No specific surveys for survey and manage botanical species have been conducted for this project within the analysis area. Known sites are not based upon thorough surveys and thus do not accurately portray the distribution of these species across the landscape. The known sites of *Allotropa virgata* were located during the TES plant surveys for the proposed Mineral Four Wheel Drive Trail Project which was later dropped from consideration as a project. The site for *Pilophorus nigricaulis* within the analysis area was found by a member of the public while recreating in the area. All of these known sites of survey and manage botanical species within the analysis area are at least partially protected by virtue of the land allocation (Late Successional Reserve) within which they are located. Since no regeneration harvest will occur within this allocation, potential threats to these species from land management activities are reduced. All known sites of survey and manage species that are part of component 1 (manage known sites) require consideration during the planning phase of management activities, thus these sites still need to be considered during other projects that may occur within the late successional reserve.

Noxious Weeds

There are currently no control measures in place for these species within the analysis area and new introductions and future spread into previously uninfested areas is highly probable given the many sources, variety of dispersal methods, and corridors that are available. Current Forest Service policy on the management of noxious weeds is defined in FSM 2080. Where funds and resources are not available to permit the timely undertaking of all desirable control measures, priorities have been outlined as follows:

1) Prevent the introduction of new species.
2) Conduct early treatment on new infestations.
3) Contain and control established infestations.

The Northwest Forest Plan provides additional direction relative to non-native species in Late-successional reserves (ROD pp. C-19) and this species' group was also considered in the "Forestwide Late Successional Reserve Assessment" (USDA Forest Service, 1997). In order to minimize the chances of new species of noxious weeds becoming established within the analysis area (and the establishment of new populations of species already present within the analysis area) it is recommended that a provision that requires heavy equipment to be``weed free" be included in contracts for all management activities within the analysis area that involve large amounts of ground disturbance.

No specific surveys for these species have been conducted within the analysis area, thus it is not possible to identify and prioritize specific weed populations for treatment at this time. An environmental assessment for the treatment of noxious weeds on a forestwide basis is currently being drafted and may provide additional guidance on the treatment of this species' group within the Little Nisqually analysis area.

Wildlife

Big Game Habitat (Deer and Elk)

As mentioned in Chapter 3, there is presently a shortage of optimal cover in the watershed, and a poor distribution of forage and cover within it. In the short-term, forage will decrease as early-seral forest succeed to hiding cover, and over the long-term the amount of optimal cover will increase as tree sizes increase and canopy layering develops.

Due to the Late-Successional Reserve allocation, habitat capability for big game is expected to be at relatively low levels in this watershed. Eventually, it will be typified by large amounts of thermal and optimal cover and little forage. Some animals will be supported by the forage that exists within the optimal cover stands in canopy gaps and other small openings, the numbers being determined by the amount and nutritional quality of the understory vegetation.

Road densities in the watershed's winter range are above the desired GPNF Forest Plan's goal of 1.7 miles per square mile. Although much of this road density is derived from FR 74, the major access route into the watershed, there are opportunities to reduce road densities with closures of arterial roads and spurs. Due to the remote nature of the watershed, closures such as gates may not be effective, and decreasing budgets will likely preclude the ability of personnel to open, close, and maintain these types of closures.

Survey and Manage Wildlife Species

The concern with respect to survey and manage species is that nothing is known of their occurrence or distribution within the watershed. Therefore, a conservative approach must be taken when dealing with newly discovered sites, as there is no context in which to analyze their relative abundance here. Surveys are likely to be conducted only in conjunction with proposed ground-disturbing activities such as commercial thinning. A more generalized inventory of these species would be desirable to establish a baseline for conservation of survey and manage salamanders and mollusks in the watershed.

Threatened and Endangered Species

As with "survey and manage" species, little is known about the occurrence and distribution of most of the proposed, threatened, endangered, sensitive, and "species of concern". Some survey and sighting data is available for the northern spotted owl and marbled murrelet, however no surveys have been conducted within the last 5 years for these species. Although it would be useful to have some survey data for all listed species, it would be particularly valuable to have current survey data for the marbled murrelet, as this is the one watershed on the Gifford Pinchot N.F. where this species likely occurs with some frequency. Northern goshawk and current spotted owl surveys would also be valuable, as suitable habitat exists for both species where late- and mid-seral forests occur.

Connectivity (Riparian and Upland)

As stated previously, connectivity in the watershed is presently poor except for some localized areas. It will improve gradually over the long-term as young forest stands succeed towards a late-successional condition in the riparian reserves. In the mean-time, some species will be forced to travel through sub-optimal habitat, or leave the riparian corridors to use upland habitats if available.

Habitat Improvement Projects

There are no known habitat improvement opportunities in the watershed, although an inventory of potential opportunities has not been conducted. At present, the most likely way to potentially improve wildlife habitat in the watershed appears to be through silvicultural treatments involving pre-commercial and commercial thinning of managed stands, and possibly densely stocked natural stands. Road closures are another potential method of improving habitat conditions for species such as deer and elk, and possibly gray wolves, grizzly bears and others.

AQUATIC ELEMENTS

Disturbance Regimes - Geological Processes

Seismic Conditions and Volcanic Eruption

Earthquakes and volcanic eruptions are natural processes that will take place regardless of consequences to human populations. The most we can do is be aware of the potential for occurrence, and where possible, try to describe possible consequences and plan to get out of the way in time. Mount St. Helens has erupted, on average, once per century over the last 500 years, and at least two of these eruptions have deposited ash and tephra across portions of the Nisqually River basin farther to the east. Currently available information does not indicate that ash deposition has played a significant role in the sediment regime of this watershed (certainly much less than fire) over the last five hundred years.

Mt. Rainier has also inundated the floodplain of the Nisqually River with mudflows since the retreat of the last glaciation, and will do so again, with or without an actual volcanic eruption (Scott and Vallance, 1995). Given the relatively short travel times expected for mudflows traveling from Mt. Rainier to the towns of Ashford and Elbe, warning for the Nisqually River Valley inhabitants during such an event will be minimal, and the potential consequences quite severe for the residents of this valley.

Seismic activity in the area will also continue, usually in the form of smaller earthquakes (Magnitude 0.5 to 3.0) but with occasional larger earthquakes greater than M 3.0 occurring several times per century, and Great Earthquakes (magnitude 9.0) possibly occurring approximately every 500 years (Carver, et. al., 1999). Larger earthquakes can pose the additional hazard of causing landslides that either directly effect human habitations, or block stream drainages that then form dam break floods that rush downstream. Communities and citizens located near the confluence of streams with the Nisqually River would be vulnerable to such an event.

Mass Wasting

Mass wasting in the form of large landslides has been occurring in the Nisqually drainage for thousands of years. Portions of these features are stable or marginally stable and not overly sensitive to disturbance by management activities, whereas some other areas are. Site specific investigation is required to further refine areas of these slides that are active/dormant/past active.

Increased levels of mass wasting related to roads and timber harvest have occurred throughout the Little Nisqually river drainage. In particular, segments of the road systems within these drainages are in need of reconstruction and/or decommissioning efforts to reduce sedimentation. See Road Conditions, below, and Chapter 6, Management Recommendations.

Hillslope Erosion

Hillslope erosion is generally not a concern in this watershed except in local situations where mass wasting has exposed tracts of soil, and revegetation has not yet successfully occurred. Local erosion and delivery of sediment to streams along the deeply incised stream channels could be a concern, but given the low-level of management activities taking place in this watershed today and into the foreseeable future, particularly within the Riparian Reserves defined by the Northwest Forest Plan, substantial impacts from hillslope erosion are not expected except in areas where mass wasting has already occurred. These areas with mass wasting occurrences will likely be identified for erosion control measures as part of the ERFO and Supplemental ERFO repair work.

Road Conditions

A number of roads within the watershed have been identified as contributors of elevated sediment levels to streams. In particular, segments of roads in the Spencer, Winston, West Fork, and Hiawatha Creek drainages been identified as concerns. Listed below, by watershed, are roads noted for needing some type of restoration work. This listing is not all inclusive, but does identify a majority of road restoration projects.

watershed 20Q	74, 7409, 7409-040, 7413 rds.
watershed 20R	74, -186, 7415 rds.
watershed 20S	74, 7424-033, -271 rds.

Hydrology

Climate-Precipitation

Eighty-six percent of this watershed is located in the rain-on-snow zone. This ranges from a high of 91% in the West Fork (20R) to a low of 81% (20Q) in the lower Little Nisqually. Therefore, activities which alter snow accumulation or melt rates could increase the magnitude of the associated runoff response.

Watershed Conditions

Watershed Conditions Resulting from Roads

Several indices were used to evaluate the effects of roads on watershed conditions (table 3-2). All of these indices suggest that there is a high potential for road related impacts at both the watershed and the sixth field scales (20Q, 20R, and 20S). This potential will remain high until road mileage is reduced through active management.

Watershed Conditions Resulting from Vegetative Alterations

Several indices were used to evaluate the effects of vegetative alterations on watershed conditions (table 3-3). All of these indices suggest that there is a high potential for impacts at both the watershed and the sixth field scales (20Q, 20R, and 20S). This potential will remain high until existing plantations reach hydrologic maturity in an estimated 25-40 years. Since hydrologic maturity is actually a stand condition (as opposed to age), activities which accelerate the achievement of mature characteristics are desirable in all three subwatersheds.

Riparian Conditions

Inner Gorge

Inner gorges are common along the Little Nisqually and West Fork Little Nisqually rivers and Mona, Wildcat, Spencer, Hiawatha, Scatter, and Winston creeks. This implies that Riparian Reserves in the Little Nisqually watershed would be very sensitive to disturbances at both the watershed and sixth field scales.

Flood Plain and Wetland Conditions

The West Fork has the largest remaining flood plain in the Little Nisqually watershed. This flood plain has been disturbed by past activities and is very sensitive to further disturbances. Actions which improve the resiliency of this area are desirable.

Riparian Vegetation - Stream Shading and Potential Large Woody Debris

Shade

The area of greatest concern is the West Fork Subwatershed (20R) where all perennial tributaries have grass/pole and small tree sized vegetation. In this subwatershed, existing shade is inadequate to maintain cold water temperatures. While shading is also reduced along Hiawatha Creek (20S), there are some areas where adequate shading does exist (Scatter Creek). The main Little Nisqually (sixth field 20Q) is likely close to natural shade levels due to topographical and vegetative shading.

Potential Large Woody Debris

Potential woody debris levels are at near natural levels along the Little Nisqually River, Mona Creek, Wildcat Creek, and Scatter Creek. All other reaches have low levels of potential LWD. It is expected that these low levels will exist for decades although active management may be able to accelerate the development of large woody debris.

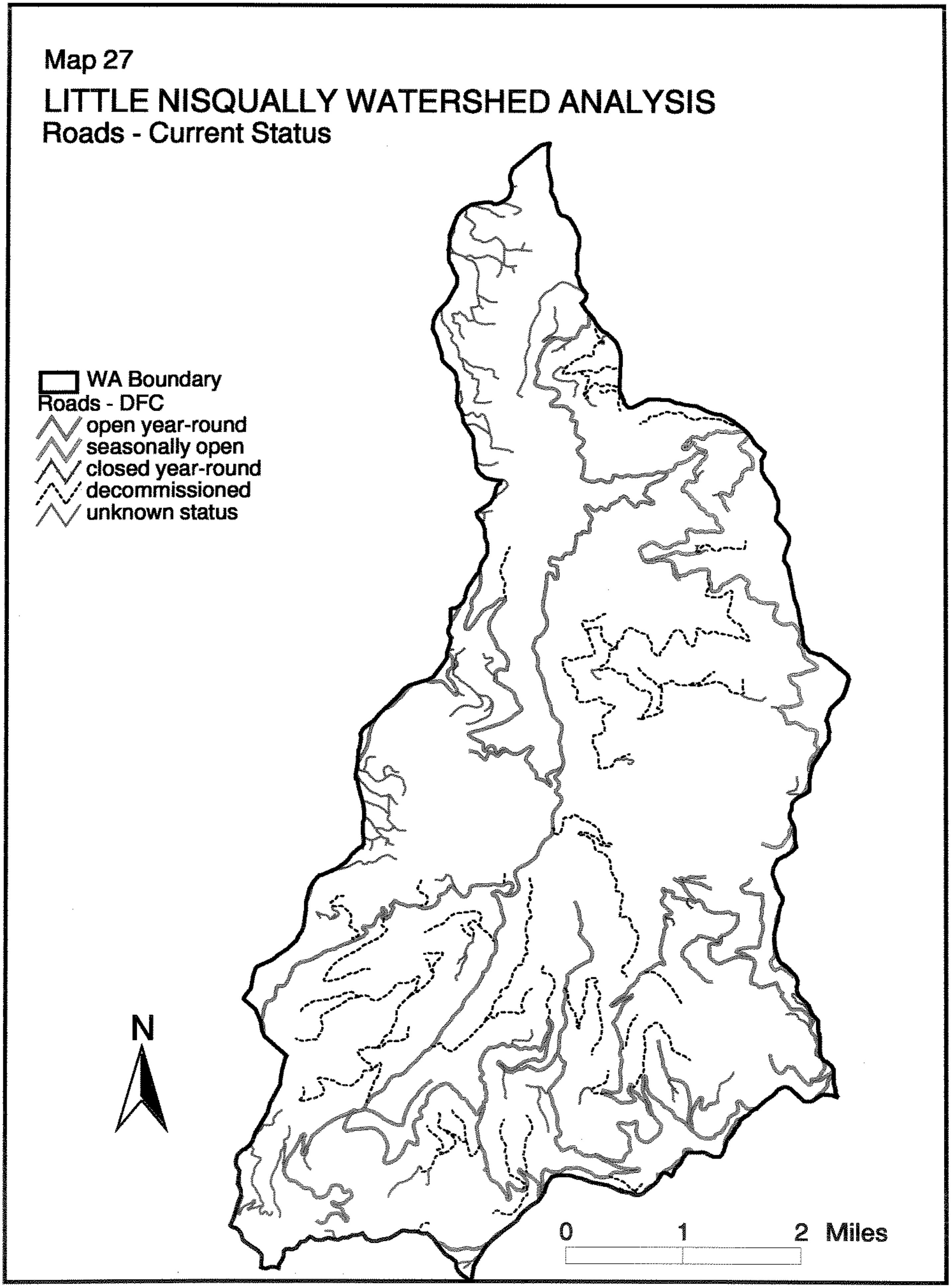
Summary:

While active management may be able to accelerate the development of shade and large woody debris, the sensitive inner gorges will minimize this potential. The greatest potential for developing these conditions is on the flood plain along the West Fork (20R) between Lake and Fly creeks.

Stream Conditions

Stream Flow Regime

While the overall hydrograph is likely similar to historic conditions (the timing and the flashiness of the basin), localized stream flows are likely altered from natural levels. This determination is supported by several indices (Table 3-7) as well as visual observations of channel features. Flows are likely altered in Spencer, the West Fork, Winston, and Hiawatha creeks.

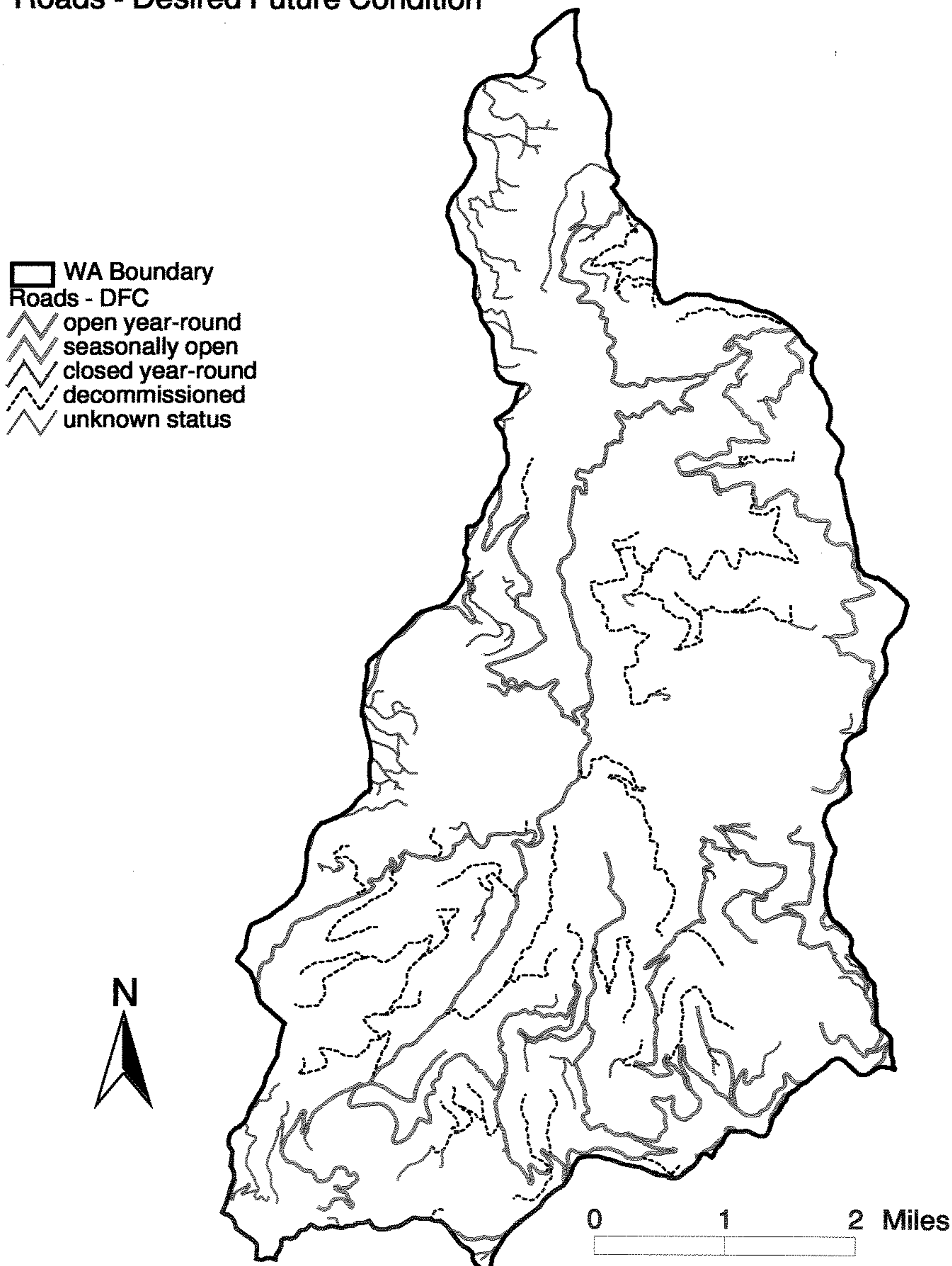


Map 27
LITTLE NISQUALLY WATERSHED ANALYSIS
Roads - Current Status
WA Boundary
Roads - DFC
open year-round
seasonally open
closed year-round
decommissioned
unknown status
N
0
1
2 Miles

Map 28

LITTLE NISQUALLY WATERSHED ANALYSIS

Roads - Desired Future Condition



Sediment Regime

Channel Erosion:

The main causes for channel erosion are in-channel debris torrents, unbuffered timber harvest and associated channel erosion (resulting from decreased LWD), increased peak flows in low order streams, and the interception and rerouting of streams (the 74 road). Regeneration harvest in the Spencer Creek drainage (20Q) and stream crossing problems on the 74 road (20Q and 20R) poses the greatest risk of increasing channel erosion.

Mass Wasting:

Approximately five percent of the watershed (923 acres) has been effected by mass wasting. The main causes of mass wasting are timber harvest in the steeply incised inner gorge, road failures, and natural events. For a complete discussion on mass wasting see the geology/soils section.

Surface Erosion:

Overall, the Little Nisqually road network is likely contributing sediment from 30.4 miles that either cross or are located within the riparian reserves. Of this mileage, the 74 road makes up the majority of this distance (20Q and 20R). In addition, there are 14.8 road/stream crossings per square mile which greatly increase the number of sediment entry pathways into this system. Impacts are likely greatest in the Little Nisqually (20Q) and West Fork (20R) sixth fields with a lower level of impacts in Hiawatha Creek (20S). This is the result of the recent decommissioning work done in the Hiawatha Creek drainage.

Turbidity:

There are no known areas of concern with regard to turbidity.

Sediment Transport

The main change from the historic transport system is that the depositional reach is now inundated by Alder Lake. Therefore, the entire stream network is now a transport dominated system.

As with historical conditions, the ability of a stream to store or transport sediment is dependent upon channel morphology, particle size, flows, and large woody debris. While tributary sediment inputs and stream flows are likely altered from natural levels, they appear to be in balance with one another. This balance could be lost in several first through third order streams as hydrologic recovery occurs and stream flows are reduced. If this were to occur, sediment inputs could exceed the streams transport potential and deposition could occur.

Large woody debris is also lacking in most streams. Therefore, the moderate duration storage component is reduced and most sediment is being stored in short term bed features. This would result in larger sediment pulses than would have historically occurred. In addition, since sediment storage would be in bed features, cobble embeddedness and surface fines would likely be increased during low flow periods (when the sediment is in storage).

Large Woody Debris (LWD)

Current levels of woody debris are very low due to past riparian timber harvest, channel clearing, and stream transport. Exceptions to this include Wildcat, Mona, and Scatter Creeks where LWD is abundant. Where LWD does exist, it is an individual log as opposed to being part of an accumulation. This has effected basin wide sediment storage as well as channel stability in the West Fork (between Lake and Fly creeks).

Stream Channel Morphology/Stability

At the watershed scale the system appears to be functioning properly. This is largely the result of the inherent stability of the stream types present in this watershed. However, there are human related changes at the reach scale. The primary change, from expected historical conditions, is that LWD currently exist as infrequent isolated pieces as opposed to frequent and large accumulations. As a result, the alluvial reaches (primarily on the West Fork between Lake and Fly creeks) are at the low end of their expected range of stability. We also expect that pool frequency, size, and quality would be reduced in these alluvial reaches as LWD is an important element forming these features.

There are also reductions in stream resiliency due to changes in watershed and riparian conditions. This has resulted in an increased sensitivity to increased peak flows and sediment in the West Fork Little Nisqually, as well as Spencer, Hiawatha, and Winston creeks. While these streams are likely within their historical range of variability, those with high sensitivity are likely at the edge of the range. Table 3-27 summarizes current stream stability, estimated sensitivities to alterations in key channel forming processes, and the priority for restoration.

Water Quality - Temperature

Water temperatures are expected to be elevated in the Hiawatha (20S) and West Fork Little Nisqually (20R) subwatersheds. This is especially true in the relatively wide alluvial reach of the West Fork (between Lake and Fly creeks). Temperature would then be expected to decrease as these tributaries come together and enter the narrow canyon. In the Little Nisqually subwatershed (20Q), only Spencer Creek is suspected to be delivering relatively warm water with all other tributaries and the main river having adequate riparian shade and a narrow width.

Aquatic Organisms and Stream Habitat

Interpretations/Areas of Concern: In Chapter II we evaluated several streams and rated habitat elements as good, fair or poor. If most of the stream is rated as fair, then the habitat element is in an "at risk" condition. When a habitat element is in an "at risk" condition, loss of fish habitat would be detrimental to trout species. Efforts should be made to recover "at risk" habitat where feasible. If most of the stream falls into the poor category, the stream is considered to be "degraded". Efforts should be made to recover "degraded" habitat, where feasible.

Table 4-2: Summary of Areas of Concern and potential for improvement.

Stream	Pool Frequency	Woody Debris	Spawning Gravel	Fine Sediment
Little Nisqually	Good	Degraded	At Risk	Good
Potential For Natural Recovery/Maintenance	Good	Short Term Poor Long Term Good	Short Term Poor Long Term Fair	Good
Mona Creek	Good	Good	Good	Good
Potential For Natural Recovery/Maintenance	Good	Good	Good	Good
Wildcat Creek	Good	Good	At Risk	Good
Potential For Natural Recovery/Maintenance	Good	Good	Good	Good
Spencer Creek	At Risk	Degraded	At Risk	At Risk
Potential For Natural Recovery/Maintenance	Fair	Short Term Poor Long Term Fair	Short Term Poor Long Term Fair	Short Term Poor
West Fork Little Nisqually	At Risk	Degraded	At Risk	Good
Potential For Natural Recovery/Maintenance	Fair	Short Term Poor Long Term Good	Short Term Fair Long Term Good	Good
Winston Creek	At Risk	Degraded	At Risk	Good
Potential For Natural Recovery/Maintenance	Short Term Poor Long Term Fair	Short Term Poor Long Term Fair	Short Term Poor Long Term Fair	Good
Hiawatha Creek	At Risk	Degraded	Good	Good

Potential For Natural Recovery/Maintenance	**Short Term Poor Long Term Fair**	**Short Term Poor Long Term Fair**	**Good**	**Good**
Scatter Creek	**Good**	**Good**	**Good**	**Good**
Potential For Natural Maintenance	**Good**	**Good**	**Good**	**Good**

Limiting Factors

Pool Frequency

Pool frequency is a function of water, wood and sediment delivery (Rosgen, 1996). Decreases in woody debris generally result in a decrease in the number of pools. A balance of sediment and water maintains the optimum pool frequency. When the balance between sediment and water is upset pool frequency decline.

"At Risk" Streams - Pool frequency is considered a limiting factor for West Fork Little Nisqually upstream from Winston Creek, Spencer Creek, Winston Creek, and Hiawatha Creek. Of these streams, Hiawatha Creek appears to have been the most resilient. Possibly because of the relatively unmanaged nature of Scatter Creek.

The West Fork Little Nisqually, Winston Creek and Spencer Creeks have experienced debris flows within the last 10 years. Spencer Creek is unstable. All of these creeks lack woody debris, and lack the pool habitat needed to be considered good fish habitat.

The "at risk" condition for these streams is due to a combination of natural and management influences. The moderate (3% to 5%) to steep (5% +) gradient on Winston and Spencer Creek limits the formation of large pools. A larger factor in these cases, however, is the relatively heavy harvest within their riparian reserves. This harvest has removed much of the woody debris from these stream systems. The removal of wood from the riparian and watershed increased stream energy and removed anchor points for the formation of pools. The influences of timber management are likely to decrease as harvested areas revegetate and more emphasis is placed on the recovery of watershed function.

Potential for Natural Recovery - The potential for natural recovery is poor in the short term and fair long term. Pool formation in this system is dependent on the stability of the stream and the recruitment of woody debris. The riparian harvest and roading on steep slopes has increased sediment delivery and set the recruitment of woody debris and recovery of pool habitat back by 5 or more decades. Sediment delivery will normalize as the side slopes revegetate and stabilize. It is estimated that it will take at least 50 years for current plantations to begin contributing useful woody debris. Given relatively slow rates of natural recruitment these sections of stream are likely to remain somewhat slightly degraded even in the long term.

Potential for Improvement through Management Actions - Restoring natural drainage and re-contouring of roads would expedite the recovery sediment regimes. Management actions such as commercial thinning can improve growth rates and shorten the time needed to obtain trees of adequate size to function as woody debris. Care must be taken in these action to not upset sediment balances and reduce streamside shading. The relatively easy access to the upper West Fork of the Little Nisqually make it the only good candidate for active placement of well design woody debris structures.

Woody Debris

"Degraded" Streams - Woody debris is in a "degraded" condition in the following streams: Little Nisqually, Spencer Creek, West Fork Little Nisqually, Winston Creek and Hiawatha Creek.

The streams are moderately high-energy streams that route small pieces wood through the system relatively quickly. But the energy of the stream is not great enough to prevent the retention of large woody debris. The lack of large woody debris is due to past riparian harvest practices and associated stream cleaning as evidenced from field reconnaissance and aerial photography interpretation.

Potential for Natural Recovery - It is estimated that it will take at least 50 years for current plantation to contribute useful woody debris . Given relatively slow rates of natural recruitment, these sections of stream are likely to remain somewhat degraded even in the long term.

Potential for Improvement Through Management Actions - Management actions such as commercial thinning can improve growth rates and shorten the time needed to obtain trees of adequate size to function as woody debris. The relatively easy access to the upper West Fork of the Little Nisqually make it a good candidate for active placement of well designed woody debris structures.

Spawning Gravel

"At Risk" Streams - Spawning gravel is in an "at risk" condition in the following streams: Little Nisqually, West Fork Little Nisqually, Wildcat Creek, Spencer Creek, and Winston Creek.

The existing stream energy of these systems limits the location of suitably sized spawning gravel to slack water areas (e.g., behind boulders, along channel margins, and behind large woody debris accumulations). Of these, only the woody debris has the potential for creating extensive spawning areas. Therefore the lack of extensive spawning areas (stream survey and field reconnaissance) is related to the reduced amount of woody debris.

Potential for Natural Recovery - The recovery potential is tied to the accumulation of large woody debris in the system. Large woody debris will collect gravel and create quiet areas where gravel will settle. Another factor which influences gravel accumulation is stream energy. As adjacent forested stands approach hydrologic maturity, flows will decrease, energy will be reduced, and gravel export through the system will be lowered. This will be a relatively small decrease. The more significant factor for an increase in spawning gravels will be the additional recruitment of large woody debris to the streams that will occur as the stand matures. The decrease in energy will be most observable in the vicinity of large woody debris in the stream.

Potential for Improvement Through Management Actions - Management actions such as commercial thinning can improve growth rates and shorten the time needed to obtain trees of adequate size to function as woody debris. The relatively easy access and smaller size of the upper West Fork of the Little Nisqually also make it a good candidate for active placement of well design woody debris structures that will increase the potential spawning area.

Fine Sediment

Fine sediment is not considered a limiting factor for most the streams at this time. These streams presently appear to be routing fine sediment through the system to Alder Lake. As stream energies decrease with the recovery of forested stands and the recruitment of woody debris more fine sediment may accumulate in the channel. The key for reducing this potential is recovery of a natural sediment regime.

"At Risk" Streams - The exception to rule above is Spencer Creek. A large pulse of sediment was in the channel and there is the potential for the introduction of more sediment from road failures and mass wasting.

Potential for Natural Recovery - Because of the potential for further addition of sediment the potential for natural recovery is low.

Potential for Improvement through Management Actions - The keys to recovering a natural sediment regime are stabilizing road failures and potential failures, reducing and stabilizing stream crossings, and reducing road density in riparian reserves.

Recreational Fishing and Poaching

Increased hooking mortality associated with increased fishing is expected to range from 1-5 percent as fishing grows in popularity.

Poaching is expected to continue in scattered portions of the Little Nisqually watershed. Poaching is probably most dominant in the lakes that are hiked into and in the heavy recreational areas.

Increased environmental education and awareness programs will help to discourage habitat pollution and poaching.

Chapter 5 - Watershed Evaluations

In the ensuing table, the entire watershed is evaluated in terms of meeting the nine Aquatic Conservation Strategy (ACS) objectives and one additional management objective of maintaining late-successional habitat across the landscape. A brief description of each of the ten objectives follows, with an explanation of the evaluation criteria that were used to assign the various ratings. For the most part these are qualitative ranking based upon the best professional judgement of the district hydrologist, fisheries biologist, and geologist. Where quantitative rankings are presented, more information on the tools used in the analysis and the risk ratings can be found in the appropriate sections in chapter 3. We used fish (the top of the aquatic food chain) as an indicator of aquatic species health for all ACS objectives. These objectives are presented as they appear in the *Northwest Forest Plan* (USDA, USDI 1994).

1. "Maintain and restore the distribution, diversity, and complexity of watershed and landscape-scale features to ensure protection of the aquatic systems to which species, populations and communities are uniquely adapted." (ROD, page B-11)

Evaluation Criteria - Compare historic/reference and current conditions, examine watershed and landscape scale features such as perennial streams, intermittent streams, wetlands, lakes and ponds. It also evaluates the presence of source, transport, and depositional reaches. Note: We interpret this ACS objective to refer to the continued physical existence of the variety of aquatic features from historic or reference times to the present. It does not address the quality of aquatic conditions, as these are addressed in the other ACS objectives.

The following ratings were used:

Good: Watershed and landscape features are present at near natural levels. This includes the abundance of perennial and intermittent streams; as well as source, transport, and depositional (alluvial) reaches.

Fair: Watershed and landscape features have been adversely effected but changes are not resulting in substantial changes in aquatic habitat.

Poor: Watershed and landscape features have been altered to the extent that the abundance or character of aquatic habitat is limiting fish production.

2. "Maintain and restore spatial and temporal connectivity within and between watersheds. Lateral, longitudinal, and drainage network connections include floodplains, wetlands, upslope areas, headwater tributaries, and intact refugia. These network connections must

provide chemically and physically unobstructed routes to areas critical for fulfilling life history requirements of aquatic and riparian-dependent species." (ROD, page B-11)

Evaluation Criteria - Compare historic/reference and current conditions, examine spatial and temporal connectivity of aquatic and riparian systems. Note: The basis of this evaluation was on *hydrologic* connectivity; *riparian* connectivity is addressed in ACS # 8.

The following ratings were used:

Good: Fish, flows, sediment, and large woody debris can freely move through the system. There are no human caused disconnects between the floodplains and the streams.

Fair: Stream Crossings can not process the full range of stream flows, sediment and woody debris. Some wetlands and floodplains are disconnected from channels.

Poor: Fish barriers are preventing migration upstream or into tributaries.

3. "Maintain and restore the physical integrity of the aquatic system, including shorelines, banks, and bottom configurations." (ROD, page B-11)

Evaluation Criteria - Compare historic/reference and current conditions, examine the physical integrity of the following aquatic systems: a) shorelines (lakes and ponds); b) stream banks - includes observations regarding channel widening, channel migration, and occurrence of large woody debris (LWD) as it relates to pool formation and stream bank cutting; c) stream bottom configurations; and d) condition of upper banks and inner stream gorges of deeply incised streams.

The following ratings were used:

Good: Streams and lakes are properly functioning. The streams are in dynamic equilibrium whereby excessive scour and deposition is not occurring. Large woody debris is present and contributing to habitat formation and stream stability.

Fair: While there are signs of accelerated channel scour or deposition it appears to be seasonal or not at the watershed scale. Large woody debris is present but as small individual pieces which have limited aquatic value. Fish habitat is likely "at risk" due to current channel conditions.

Poor: Streams and lakes are out of equilibrium. This is evident by excessive scour and deposition. Large woody debris is nearly absent from the bankfull channel. Fish habitat/production is likely degraded by poor channel conditions.

4. "Maintain and restore water quality necessary to support healthy riparian, aquatic, and wetland ecosystems. Water quality must remain within the range that maintains the biological, physical, and chemical integrity of the system and benefits survival, growth, reproduction, and migration of individuals composing aquatic and riparian communities." (ROD, page B-11)

Evaluation Criteria - Compare historic/reference and current conditions, examine water quality of aquatic, riparian, and wetland ecosystems:

The following ratings were used:

Good: Stream temperatures ≤ 12°C and no known nutrient or chemical pollutants.

Fair: Stream temperatures 12.1°C - 15.9°C and no known nutrient or chemical pollutants.

Poor: Stream temperatures 16°C + and/or Nutrient or chemical pollutants present.

5. "Maintain and restore the sediment regime under which aquatic ecosystems evolved. Elements of the sediment regime include the timing, volume, rate, and character of sediment input, storage, and transport." (ROD, page B-11)

Evaluation Criteria - Compare historic/reference and current conditions, examine elements of the sediment regime (input, storage, and transport) including: timing, volume, rate, and character of sediment.

The following ratings were used:

Good: The timing, volume, and rate of sediment delivery to streams is similar to historic conditions.

Fair: The timing, volume, and rate of sediment delivery to streams has been moderately altered due to management activities. However, sediment is being routed through the system and inchannel storage (positive = deposition; negative = scour) is not resulting in habitat impairment.

Poor: The timing, volume, and rate of sediment delivery to streams has been significantly altered throughout the basin area due to management activities. Substantial changes in stream storage (positive = deposition; negative = scour) are limiting the quality of aquatic habitat.

6. "Maintain and restore in-stream flows sufficient to create and sustain riparian, aquatic, and wetland habitats and to retain patterns of sediment, nutrient, and wood routing. The timing, magnitude, duration, and spatial distribution of peak, high, and low flows must be protected." (ROD, page B-11)

Evaluation Criteria - Compare reference and current conditions, examine the ability of in-stream flows to create and sustain riparian, aquatic, and wetland habitats by looking at timing, magnitude, duration, and spatial distribution.

The following ratings were used:

Good: The existing stream flow regime is similar to "natural" levels.

Fair: While modeling indicates that the existing stream flows have been altered from natural conditions (table 3-7) there is no apparent channel response.

Poor: Modeling (page 3-7) and instream conditions indicate that stream flows have been altered by management activities.

7. "Maintain and restore the timing, variability, and duration of floodplain inundation and water table elevation in meadows and wetlands." (ROD, page B-11)

Evaluation Criteria - Compare historic/reference and current conditions, examine floodplain inundation and the elevation of water tables in meadows and wetlands.
The following ratings were used:

Good: Wetlands, meadows, floodplains, and water tables are all minimally disturbed as a result of management activities.

Fair: Localized disturbances to wetlands, meadows, floodplains, and water tables as a result of management activities.

Poor: Watershed scale disturbances of wetlands, meadows, floodplains, and water tables as a result of management activities.

8. "Maintain and restore the species composition and structural diversity of plant communities in riparian areas and wetlands to provide adequate summer and winter thermal regulation, nutrient filtering, appropriate rates of surface erosion, bank erosion, and channel migration and to supply amounts and distributions of coarse woody debris sufficient to sustain physical complexity and stability." (ROD, page B-11)

Evaluation Criteria - Compare historic/reference and current conditions, examine the composition and structural diversity of plant communities in riparian areas, looking specifically for functions regarding the following:

a. thermal regulation (summer and winter)
b. nutrient filtering
c. rate of surface and bank erosion and channel migration
d. amount and distribution of coarse woody debris
e. structural diversity of forest in the riparian zone

Assumptions - Because we don't have specific data to address each of the functions (a. through e.) above, we are using forest vegetation structure to act as a surrogate for these functions. Large tree forest generally provides all of the above functions (a. through e.). Small tree forest generally provides functions a, b, and e. Grass/pole forest has the potential to provide functions b and e. For a description of the physical characteristics used to define large tree, small tree, and grass/pole forest structure, see Chapter 3, Forest Vegetation - Vegetation Structural Stages.

The following ratings were used:

Good: The Riparian Reserves contain the amounts and types of forest structure needed to adequately provide all five of the riparian functions listed in the evaluation criteria.

Fair: The Riparian Reserves contain the amounts and types of forest structure needed to adequately provide at least three of the riparian functions listed in the evaluation criteria.

Poor: The Riparian Reserves contain the amounts and types of forest structure that adequately provide less than three of the riparian functions listed in the evaluation criteria.

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9. "Maintain and restore habitat to support well-distributed populations of native plant, invertebrate, and vertebrate riparian-dependent species." (ROD, page B-11)

Evaluation Criteria - Assess current conditions and examine the ability of the area to support well-distributed populations of native plants, invertebrates, and vertebrate riparian-dependent species by reviewing the following conditions:

a. forested riparian habitat connectivity
b. percent and distribution of small and large tree habitat in Riparian Reserves
c. riparian-dependent species presence (plants and animals)

Note: Data on species occurrence and populations in riparian areas is non-existent in this watershed.

The following ratings were used:

Good: Riparian Reserves that are dominated by connected large tree forest, or by some combination of large and small tree forest. Grass/pole forest and/or non-forest disruptions in the connectivity would be very small and would not represent a significant dispersal barrier for less mobile species.

Fair: Riparian reserves that possess a varied combination of large tree, small tree, and grass/pole forest. Large and small tree forest do not provide consistent connectivity throughout the sixth-field. Patches of non-forest habitat may also represent a dispersal barrier for less mobile species.

Poor: Riparian Reserves that are dominated by grass/pole forest, or by some combination of grass/pole and small tree forest. Large tree forest may exist in small isolated stands. Patches of non-forest habitat may also represent a dispersal barrier for less mobile species.

10. Late-Successional Habitat - Evaluate late-successional habitat within the watershed.

Evaluation Criteria - Assess and examine the current condition of late-successional habitats with respect to amount, distribution and condition. The following criteria will be used:

a. fragmentation/connectivity of late-successional forest habitat patches and Late-Successional Reserves (LSRs)

b. condition of late-successional forest habitat with respect to insects, disease, windthrow, etc.

Late-successional forest habitat will be evaluated within each sixth-field in accordance with the objectives of the existing land management allocations.

The following ratings were used:

Good: The sixth-field meets the objectives of the current management allocation with only minor exceptions.

Fair: The sixth-field is near the margin for meeting the current management allocation objectives.

Poor: The sixth-field does not meet the current management allocation objectives.

Ratings Confidence

The evaluation ratings are assigned a level of confidence for accuracy according to the following scale:

High: High confidence that the assigned rating is accurate. That confidence is based on data gathered from recent exams, surveys, and/or personal on-the-ground knowledge. Data directly pertains to the condition being evaluated.

Moderate: Moderate confidence that the assigned rating is accurate. That confidence is based on data gathered from a combination of exams, surveys, personal on-the-ground knowledge, aerial photograph interpretation, and/or professional judgement. Data collected in stand exams and surveys may not be recent.

Low: Low confidence that the assigned rating is accurate. That confidence is based on data gathered from aerial photograph interpretation and/or professional judgement. Lack of field data or data that pertains directly to the condition being evaluated.

Watershed Evaluation Table

Table 5-1: Little Nisqually River (Overall)			
Management Objectives	**Rating**	**Confidence**	**Rationale**
1) Existence of aquatic features at landscape scale	Poor	High	The inundated reach (2.5 miles) of the lower Little Nisqually represents the vast majority of the historic alluvial stream habitat. The loss of this habitat is substantial at the watershed scale. The high stream crossing density also implies that the drainage network has also been substantially increased. This represents a large increase in the presence of "intermittent streams."
2) Connectivity between watersheds	Fair	High	There are several plugged culverts which are preventing the movement of watershed products. Others (plus bridges) are not properly sized or aligned to allow the unimpeded movement of these products. This is true even on the larger tributaries such as the WF Little Nisqually, Mona and Spencer Creeks. However, no fish barriers are known to exist.
3) Integrity of aquatic systems	Fair	Moderate	Overall stream stability is very good. However, channel features such as pools are less abundant than desired. This is likely the result of low levels of LWD. Confidence is moderate since ground truthing consisted of limited spot checks.
4) Water quality for healthy ecosystems	Fair	Moderate	Temperatures are slightly elevated but there are no know sources of nutrient or chemical pollution. Confidence is moderate since temperatures were obtained using limited spot checks.
5) Sediment regime	Fair	Moderate	Analysis indices suggest a high potential for an altered sediment regime. However, in-stream conditions are not being effected by changes in sediment storage. Confidence is moderate since ground truthing consisted of limited spot checks.

Table 5-1: Little Nisqually River (Overall)			
Management Objectives	**Rating**	**Confidence**	**Rationale**
6) Stream flow regime	Fair	Moderate	Modeling indicates a high potential for an altered runoff response but in-stream conditions do not show effects due to an altered hydrograph. Confidence is moderate since ground truthing consisted of limited spot checks.
7) Floodplain function	Poor	High	Alder Reservoir has had a significant effect on floodplains in this basin. The historic floodplain is now inundated and is not functioning as a true floodplain. The loss of this feature is substantial at the watershed scale.
8) Structural diversity of plant communities in Riparian Reserves	Poor	High	The riparian vegetation is only fully providing two of the five functions: nutrient filtration and the control of bank erosion and channel migration.
9) Habitat to support well-distributed populations of riparian species	Poor	High	Riparian habitat is highly fragmented in the southern half of the watershed, compromising travel and dispersal for many species.
LS) Late-successional habitat	Fair	High	The northern half of the watershed contains some intact, larger LS habitat patches. The southern half is highly fragmented, with LS patches small and isolated.

Chapter 6 - Management Recommendations

Introduction

The purpose of this chapter is to identify those management activities which will contribute to closing the gap between the present condition and the desired future condition of this watershed. All proposed activities will be consistent with the guidelines of the Gifford Pinchot Land and Resource Management Plan, as amended by the *Northwest Forest Plan.*

Historic/reference and current conditions of the watershed were described in Chapter 3. In order to best recommend the appropriate management activities that will close the gap between the present condition and the desired future condition of this watershed, we first need a picture of that desired future condition. It is important to note that current management direction plays a large role in defining future conditions. While we may desire to restore certain portions or elements of the watershed to conditions similar to those in historic times, the entire watershed will not reflect historic conditions.

Recommendations are provided for the entire Little Nisqually River watershed scale unless otherwise noted.

The following is a description of the desired future condition for the Little Nisqually watershed.

Desired Future Condition - Vegetation

There are two broad categories of management direction that drive the course of vegetation development in the Little Nisqually watershed: Late-Successional Reserves and Riparian Reserves.

Late-Successional Reserves

Late-Successional Reserves (LSR's) consist of lands set aside to protect and enhance conditions of late-successional and old-growth ecosystems. The long-term objective is to provide for the protection of current, and enhance the development of future, late-successional habitat for all species that depend on it. The goal of wildfire suppression is to limit the size of all fires. Regeneration harvest is prohibited, although it may have occurred in the past. Precommercial and commercial thinning may occur if the purpose is to benefit the creation and/or maintenance of late-successional forest conditions. Future vegetation will be primarily the result of natural disturbance and succession, except in past harvest plantations or natural stands where the purpose is to benefit the creation and/or maintenance of late-successional forest conditions where thinnings may occur. The desired future condition of vegetation in LSR is varied in size, age, and species; ranging from natural openings of young immature trees or herb/shrub species to old-growth trees. Over time, forest stands are expected to produce large trees, snags, multiple-layered canopies, and large coarse woody debris on the forest floor. Average tree diameters will exceed 21 inches on the majority of acres. Trees will be smaller in stands located on less productive sites. Douglas-fir, western hemlock, Noble fir or Pacific silver fir will be the dominant large trees in most of these stands. The proportion of each species is determined by elevation and aspect. Other associated tree species may include red alder, black cottonwood, bigleaf maple, western redcedar, western white pine, and Pacific yew. A relatively high percentage of the area (likely about 50%) is expected to remain in or develop into the large tree structural stage in the next few decades.

The objective of the following recommendations are to accelerate the growth and development of early through mid-seral stands into late-successional stands. The following opportunities were identified during the analysis; however, they do not represent the only opportunities. Through project level planning additional project areas and prescriptions may be found.

Riparian Reserves

Riparian Reserves provide an area along all streams, wetlands, ponds, lakes, and unstable and potentially unstable areas where riparian-dependent resources receive primary emphasis. Riparian Reserves are used to maintain and restore riparian structures and functions of streams, confer benefits to riparian-dependent and associated species other than fish, enhance habitat conservation for organisms that are dependent on the transition zone between upslope and riparian areas, improve travel and dispersal corridors for many terrestrial animals and plants, and provide for greater connectivity of the watershed. Riparian Reserves also serve as connectivity corridors among the Late-Successional Reserves.

Desired Future Condition - Wildlife

ACTIVITY: Wildlife (or Roads if you wish)

CONCERNS: Road densities in biological deer and elk winter range exceed Forest Plan guideline of 1.7 miles per square mile

RECOMMENDATION: Close roads in BWR to reduce road densities where feasible.

ACTIVITY: Wildlife

CONCERNS: Paucity of inventory information concerning most listed and survey and manage species.

RECOMMENDATION: Conduct baseline inventories for selected species, particularly salamanders, mollusks, northern goshawk, and further marbled murrelet surveys if funding is available.

Desired Future Condition - Aquatic Resources

The desired future condition of aquatic resources would be a recovery toward historic conditions. Based upon estimated historical conditions, the average stream would be similar to the following description:

- channel migration is limited to the alluvial reaches;
- stream stability is excellent due to the bedrock and boulder control;
- bank stability in the alluvial reaches ranges from very good to fair depending upon the abundance of LWD;
- sensitivities to flow and sediment increases are low (due to the inherent stability of the stream types);
- mature riparian vegetation contribute large quantities of woody debris in a wide range of sizes;
- LWD has accumulated at river bends and constrictions (debris jams and multi-log complexes) due to transport in this high energy system.
- tributary streams buffer the main river from disturbances by providing ample LWD sediment storage;
- tributaries are a source of large woody debris following large storm events;
- canyon reaches have a boulder/cobble substrate;

- alluvial reaches have wider sections with gravel substrates (due to bedload deposition);
- fine sediment levels are very low due to the steep channels and excellent ground cover;
- fine sediment only accumulates along the channel margins.

Desired Future Condition - Human Uses within the Watershed

Recreation

Under current conditions of recreation budget and staffing, the following are our recreation management objectives for the area:

1. Tolerate dispersed recreation use and mitigate impacts as possible.
2. Do not encourage use.
3. Restrict or eliminate recreational access as necessary to meet resource, aquatics, law enforcement, and other land owner objectives, and specifically to minimize adverse impacts associated with dispersed use.

Recommendations at the Fifth-Field Watershed Scale

Recommendations provided here span the sixth-field subwatersheds and are provided to eliminate the need for duplication within the sixth-field management recommendation tables. Recommendations, in some cases, are not consistant with the ROD's standards and guidelines. This watershed analysis, consistent with the LSR Assessment (1997), recognized the need for silvicultural treatments in stands older than 80 years. Although these stands exceed the maximum age for stand manipulation activities stated in the ROD, the team felt that some treatment would improve stand structure and resulting wildlife habitat. These recommendations are important because wildlife generally respond to ecological characteristics, not stand age (Hayes et. al. 1997).

Treatment Guidelines

The forested structural stages are defined as grass/pole, small tree, and large tree stands in the Little Nisqually watershed. Silvicultural treatments are designed to encourage the initiation of structural diversity, maximize individual tree developement, and encourage some understory vegetation development.

Thinning densely stocked young stands can accelerate the development of late-successional structure (Hayes, et. al. 1997). A stand can be precommercially thinned as early as age 10, after individual trees have started expressing dominance. Commercial thinning of older stands, starting roughly at age 40, can also hasten large tree development. There is a tradeoff in the benefits of stocking control at a young age versus an older age. Younger stands respond more quickly to thinning than older stands because of rapid individual tree growth rates. Thinning young stands also encourages large crowns. On the other hand, a thinned older stand can reach old growth characteristics sooner than a younger stand.

Precommercial and Commercial Thinning (Outside Riparian Reserves)

The following treatment guidelines are based on recommendations in the LSR Assessment (1997) and apply to small tree and grass/pole stands.
Thinning should be designed to leave:

10 percent or more of the resultant stand in unthinned patches
3-10 percent of the resultant stand in openings roughly 1/4 - 1/2 acre in size
3-10 percent of the resultant stand in heavily thinned patches of less than 50 trees/acre

The remaining 65 - 70 percent of the area should be thinned to a spacing considered appropriate for future management objectives.

Typical precommercial thinning spacing would range from 170 to 300 trees per acre (approx. 12 - 16 foot spacing). For commercial thinning, leaving post-thinning tree stocking with a relative density of 35 will maximize growth on residual trees while allowing for future suppression mortality. Such mortality will yield future snags and down wood.

Thinning should also be designed to maintain or increase existing species diversity. For example, minor species, such as western redcedar, should be left uncut. Existing microsites of low stocking, hardwood patches, and natural openings should be maintained.

Structural Enhancement

Snags may be created by various methods: the most desirable methods include introducing rot organisims and blasting tops off of live trees with explosives. Girdling at the base of the tree is less desirable because girdled trees tend to shear off where girdled.

Down logs can be created by falling or blasting live trees. As snags are likely limiting in most stands, they are not a viable option for felling. Blasting of live trees is most desirable because it creates a ragged edge for more rapid decomposition.

Canopy gaps should average 30 feet wide with a maximum width of 60 feet. A maximum of 15 percent of each stand should be in these canopy gaps.

Understory plantings of shade tolerant trees will accelerate multiple canopy layers. Such plantings should take advantage of increased light levels where snags or down wood have been created.

Treatment Opportunities

Recommended treatments to expedite late-successional habitat are listed by priority--grass/pole stands, younger small tree stands, and older small tree stands. Constraints on their implementation are discussed.

Grass/Pole--The highest priority is to precommercially thin the blocks of young, densely stocked stands that will develop into future large tree/late-successional forest habitat. ORGANON growth models show diameter growth of trees in heavily thinned stands to be almost double that of trees in unthinned stands (Hayes, et. al. 1997).

Some 2000+ acres of grass/pole stands (old harvest units) within and scattered throughout this watershed are in need of precommercial thinnning. It's recommended that stands between the ages of 11 and 20 years old, less than 5 inches ave. dbh, and greater than 400 trees/acre receive the highest priority for treatment. These stands should be targeted first because they are reaching the upper diameter limits suitable for precommercial thinning.

Younger Small Tree--Younger small tree stands are those stands in the small tree structural stage with origins 40-80 years ago. Currently there is very little opportunity for thinning within these stands, but within the next decade several stands will be of sufficient size and density to thin. Identified thinning opportunities within these younger age class stands include:

Stand tags 506581, 582, 585- Near the heads of Hiawatha and Trap Creeks along Rd. 74
Stand tags 5006193, 194, 195, 545, 554- Along the West Fork Little Nisqually River

Older Small Tree--Older small tree stands are those stands in the small tree structural stage that originated from the 1850 and 1880 stand replacement fires. Two stand ages are identified in the older small tree catagory: 120+ and 80-120 year old stands. These stands are small in diameter, relatively even-aged, lack vertical diversity and understory vegetation, primarily because of high stocking levels. It is recognized the the ROD Standards and Guidelines restrict activities in stands older than 80 years. However, This group of stands is the best opportunity for near term attainment of late-successional habitat.

To increase the quality and quantity of existing late-successional habitat blocks, priorities would be to commercially thin small tree stands adjacent to existing blocks of large tree forests with old-growth characteristics. Commercially thinning these small tree stands, within and adjacent to, large tree stands is intended to develop late successional corridors and increase old-growth blocks. Identified opportunities in the two older small tree age classes are:

Stand tag 501008- N. of Mona Cr. along 74 and 7409 rd.
Stand tag 501032- Sec.21, SE 1/4
Stand tag 501012- Near end of 7409.015 rd.
Stand tag 506050- Sec.28, SW 1/4, W. of Little Nisqually River
Stand tag 506037- Along 74 rd. and Wildcat Creek
Stand tags 506011, 031, 032, 058, 059, 061, 062, 063, 064, 065, 069, 070, 071, 072, 077, 082, 088, 092, 105- Areas along Scatter Cr., Hiawatha Cr, Trap Cr, Winston Cr, many broken up by stringers of large tree stands
Stand tag 506113- Sec. 19 above 7418 rd.

Commercial Thinning Within Riparian Reserves

Commercial thinning may be appropriate within Riparian Reserves when the harvest activities are *specifically designed to accelerate the improvement of aquatic/wildlife conditions and/or the development of late-successional corridors.* Site-specific review by an interdisciplinary team should be the mechanism by which such prescriptions are recommended. Measures to minimize disturbance to soil, vegetation, and aquatic features should be identified prior to implementation.

Other Silvicultural Activities (Inside and Outside of Riparian Reserves)

Other silvicultural activities (including precommercial thinning, pruning, fertilization, and conifer release) should be reviewed by an interdisciplinary team to develop joint proposals for such activities both inside and outside of Riparian Reserves. Within Riparian Reserves, proposals should be designed to improve aquatic conditions and promote the Aquatic Conservation Strategy objectives.

Special Forest Products

There are many opportunities to increase the harvest and gathering of special forest products while providing for their long-term sustainability. The Little Nisqually watershed has lands where new harvest opportunities should be explored, including those within Late-Successional Reserves (LSRs) following the Forestwide Late-Successional Reserve Assessment (USDA Forest Service 1997e). Where feasible, stewardship forest product contracts should be established. They allow for more close administration of on-the-ground harvesting. There is also interest in the local community to expand the gathering, storage, and processing of forest products to provide additional local employment.

Boundary Changes of Riparian Reserves

This watershed analysis does not identify site-specific, or general changes in Riparian Reserve boundaries. Interim Riparian Reserves, as they are prescribed in the *Northwest Forest Plan*, are recommended based on the evaluation of each sixth-field relative to ACS objectives 1 through 9. Deviation from this course should only occur after thorough review by an interdisciplinary team comprised of a hydrologist, soil scientist, botanist, wildlife biologist, fisheries biologist, and silviculturist. The most likely streams to have changes are Class IV streams. It is likely that project-specific surveys will identify many Class IV streams. Any changes to Riparian Reserves should be based on "on-the-ground" reviews, and determining that such a change would not affect maintenance of the Aquatic Conservation Strategy objectives. Any changes to Riparian Reserve boundaries are to be evaluated and documented as part of the NEPA process.

Aquatic Resources

Recommendations provided here span the sixth-field subwatersheds and are provided to eliminate the need for duplication within the sixth-field management recommendation tables.

Table 6-1: Aquatic Resources Recommendations at the Fifth-Field Watershed Scale

Priority	Wshd	Project	Risk of No Action	Risk/Benefit to Resources
1	20R	Road 74 Bridge Upgrade (Section 30). This project would widen the span to eliminate the channel constriction.	High. The existing crossing is not effectively passing LWD and bedload. As a result, channel aggradation will continue above the bridge.	High. This reach is immediately above the alluvial reach of the West Fork which is key fish habitat.
2	20R	WF Channel and Flood Plain Enhancement. Add multiple log complexes and manage riparian vegetation to accelerate the development of large woody debris and shade.	Moderate. Recovery will continue but at a slower rate then with an active approach.	High. This is the key spawning reach in the Little Nisqually watershed. Recovery is important to improve the overall fishery.
3	20Q	Stabilize Road 7413. This project would repair a long section of road with cracked fills, plugged culverts, and steep grades with surface erosion.	High. The road has already failed in one location and more failures are likely.	Moderate-High. This road is located immediately above Spencer Creek. Spencer Creek has been identified as the most sensitive stream in the watershed. However, Spencer Creek only has limited value for fish production.
4	20R	Road 74 Culvert Repair (I). A previous attempt was made to address this crossing by constructing a "relief valve" where ponded water would be released once it reached an elevation approximately equal to the ditch line. However, the main culvert is still plugged and this treatment only slightly reduced the overall risk. The main culvert should be cleared or the relief value should be lowered to minimize the potential for ponding.	Mod-High. The recent "treatment" still allows a 200 cubic yard pond to form which can lead to a fill failure directly into the West Fork. In addition, debris floating in this pond could block the "relief culvert" sending water down the ditch. This would result in substantial ditch erosion and overwhelm the water processing ability of the next draw increasing the potential for slope failure.	Moderate-High. The location is below the key reach but a failure could result in course sediment delivery into the alluvial inclusions which are important habitat features.
5	20R	Tributary Restoration. Restore a first order stream that was buried by an old slide.	High. The stream has been split into two streams. The new branch does not have a culvert to pass the 74 road and runs down the ditch for .3 miles. This is an existing condition leading to severe ditch and culvert outlet erosion (at the ditch relief culverts).	Moderate. While this is a major sediment source to the West Fork, it is below the alluvial reach. Fine sediment produced by this source will be likely move quickly through the system.

6	20R	Road 74 Culvert Repair (II) Replace a plugged culvert.	High. This is an existing condition which is leading to ponding and gullying through the road surface and down slope forest floor.	Moderate. While this is a large sediment source to the West Fork, it is below the alluvial reach. Fine sediment produced by this source will be likely move quickly through the system.
7	20Q	Road 74 Culvert Repair (Mona Creek). Replace an undersized and misaligned culvert.	High. This culvert is undersized and misaligned. As a result it is not passing flows and debris and channel aggradation has occurred. There is a high potential for blockage and failure.	Moderate. A large pulse of water and/or debris would likely mobilize the LWD present in the lower reaches resulting in channel scour and a lose of structure. However, the risk is moderate because the main debris jam will likely break down naturally during the next large discharge event. In addition, the crossing is located .25 miles above fish habitat.
8	20R	Removal of channel blockages. The failed crossing of Road 7400185 would be removed from the West Fork. The project would also address the Fly Creek crossing and the crossing on Road 7400177 (on the West Fork).	Moderate. While these log bridges are causing problems they are not unlike natural debris in structure they are not located at bends and constrictions as we would expect. This is resulting in a different set of consequences but not out of the natural range.	Moderate. The old bridge on Road 7400177 could interrupt bedload and LWD movement and further reduce downstream habitat feature.
9	20Q, 20R	Stabilize several small slides using woody debris, seeding, and tree planting.	Low to Moderate. These areas will naturally stabilize and this process has begun.	Low-Moderate. Most sediment would be fine material which would move quickly through this high energy system.
10	All	Reduce Road Density. Emphasis should be on Riparian Roads and those with multiple stream crossings.	High. All road indices are in the high risk category. This indicates that the existing condition poses a high potential for accelerated sediment delivery and water routing.	Low-High. Depending upon specific locations and problems.
11	All	Road Maintenance	Moderate -High. Roads will continue to produce fine sediment from all areas of the road prism. Culverts will become plugged and failures may occur or water may run down the roads (already occurring in some locations).	Low-High. Depending upon specific locations and problems.
12	All	Riparian Thinning to accelerate the development of LWD and shading.	Moderate. Recovery will continue but at a slower rate then with an active approach.	Low-High. Depending upon specific locations and problems.

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APPENDIX A

Access and Travel Management (ATM) Plan for Roads within the Little Nisqually Watershed

The following table provides road and section numbers for roads within the Little Nisqually watershed, as well as the length of each road section that is within the watershed. This table also lists the present and future desired condition of each road, along with closure dates for any road that is listed as closed to all traffic. Restricted roads are closed for certain periods to certain types of motorized vehicles. For further information, see the Randle District Access and Travel Management Plan (1994).

ROAD NUMBER	ROAD SECTION	LENGTH (miles)	ROAD MGMT PRESENT	CLOSURE DATES FROM	TO	ROAD MGMT DESIRED FUTURE	CLOSURE DATES FROM	TO
7000647	01	0.3	Open, not maintained			Remove		
7000648	01	0.1	Open, not maintained			Remove		
7100000	07	2.0	Open			Open		
7100000	08	1.2	Open			Open		
7100000	09	3.0	Open			Open		
7400000	01	3.5	Open			Open		
7400000	02	0.7	Open			Open		
7400000	03	4.0	Open			Open		
7400000	05	5.2	Open			Open		
7400000	06	9.5	Open			Open		
7400000	07	10.0	Open			Open		
7400000	08	0.9	Open			Open		
7400000	09	1.2	Open			Open		
7400026	01	1.4	Open			Open		
7400028	01	0.5	Open			Open		
7400075	01	0.8	Open			Open		
7400075	02	1.2	Open			Convert to trail		
7400120	01	1.5	Open			Open		
7400174	01	0.7	Open, not maintained			Remove		
7400175	01	0.6	Open, not maintained			Remove		
7400177	01	0.9	Closed	01/01	12/31	Remove		
7400185	01	0.2	Open, not maintained			Open		
7400186	01	1.3	Open			Open		
7400209	01	1.8	Open			Open		
7400210	01	0.7	Open			Remove		
7400211	01	0.3	Open, not maintained			Remove		
7400212	01	0.7	Open			Remove		
7400213	01	0.4	Open			Convert to trail		
7400214	01	0.6	Open			Remove		
7400234	01	1.0	Open			Remove		
7400235	01	1.5	Open			Open, not maintained		
7400270	01	0.9	Open			Open, not maintained		
7400271	01	0.9	Open			Open, not maintained		
7400295	01	0.8	Open			Open, not maintained		
7400307	01	0.2	Open, not maintained			Open, not maintained		
7400332	01	0.3	Open, not maintained			Open, not maintained		
7400351	01	0.6	Open, not maintained			Closed	01/01	12/31
7400505	01	0.1	Open			Open		
7400612	01	0.3	Closed	01/01	12/31	Remove		
7400617	01	0.2	Closed	01/01	12/31	Remove		

ROAD NUMBER	ROAD SECTION	LENGTH (miles)	ROAD MGMT PRESENT	CLOSURE DATES FROM	TO	ROAD MGMT DESIRED FUTURE	CLOSURE DATES FROM	TO
7400636	01	0.2	Open, not maintained			Remove		
7400637	01	0.2	Open, not maintained			Remove		
7400638	01	0.4	Open, not maintained			Remove		
7400645	01	0.5	Closed	10/01	12/31	Remove		
7400649	01	0.2	Open, not maintained			Closed	01/01	12/31
7400651	01	0.8	Open, not maintained			Open, not maintained		
7409000	01	7.0	Open			Restricted	12/01	04/01
7409000	02	0.8	Open			Restricted	12/01	04/01
7409000	03	4.2	Open			Restricted	12/01	04/01
7409015	01	2.1	Restricted	12/01	04/01	Restricted	12/01	04/01
7409017	01	1.2	Restricted	12/01	04/01	Convert to trail		
7409034	01	0.5	Open			Restricted	12/01	04/01
7409040	01	3.8	Open			Convert to trail		
7409043	01	2.8	Open			Convert to trail		
7409044	01	0.4	Open			Remove		
7409046	01	1.5	Open			Remove		
7409047	01	0.3	Open, not maintained			Convert to trail		
7409049	01	0.2	Open, not maintained			Convert to trail		
7409070	01	1.2	Open			Restricted	01/01	12/31
7409071	01	0.8	Open			Convert to trail		
7409078	01	0.4	Open, not maintained			Restricted	12/01	04/01
7409080	01	1.6	Open			Restricted	12/01	04/01
7409082	01	0.6	Open, not maintained			Restricted	12/01	04/01
7409100	01	0.8	Open, not maintained			Restricted	12/01	04/01
7409105	01	0.8	Open			Restricted	12/01	04/01
7409110	01	0.5	Open			Restricted	12/01	04/01
7409629	01	0.1	Open, not maintained			Restricted	12/01	04/01
7409630	01	0.6	Open, not maintained			Restricted	12/01	04/01
7409632	01	0.1	Closed			Convert to trail		
7409643	01	0.2	Closed	01/01	12/31	Closed	01/01	12/31
7413000	01	2.1	Open, not maintained			Restricted	12/01	04/01
7413020	01	0.4	Open			Open, not maintained		
7413035	01	0.4	Open, not maintained			Open, not maintained		
7414000	01	2.8	Open, not maintained			Remove		
7415000	01	2.9	Open			Remove		
7415000	02	1.1	Open			Open		
7415011	01	0.2	Open			Open		
7415022	01	0.3	Open, not maintained			Remove		
7415025	01	1.3	Open, not maintained			Remove		
7415030	01	0.7	Open			Remove		
7418000	01	3.2	Open			Remove		
7418014	01	1.1	Open			Remove		
7418020	01	0.3	Open			Remove		
7418024	01	0.7	Open, not maintained			Remove		
7418034	01	0.6	Open			Remove		
7418600	01	0.1	Open			Remove		
7424000	01	5.4	Open, not maintained			Remove		
7424000	02	2.5	Open			Open, not maintained		
7424046	01	0.5	Open			Open, not maintained		
7424047	01	0.2	Open			Open, not maintained		
7424054	01	0.9	Open, not maintained			Open, not maintained		
7424059	01	1.2	Open			Open, not maintained		
7424070	01	0.5	Open			Open, not maintained		
7424075	01	0.4	Open			Open, not maintained		

ROAD NUMBER	ROAD SECTION	LENGTH (miles)	ROAD MGMT PRESENT	CLOSURE DATES FROM	TO	ROAD MGMT DESIRED FUTURE	CLOSURE DATES FROM	TO
7424077	01	0.5	Open			Open, not maintained		
7424079	01	0.5	Open			Open, not maintained		
7424600	01	0.3	Closed	01/01	12/31	Remove		
7424601	01	0.1	Closed	01/01	12/31	Closed	01/01	12/31
7424602	01	0.2	Closed	01/01	12/31	Remove		
7424603	01	0.1	Closed	01/01	12/31	Closed	01/01	12/31
7424604	01	0.2	Closed	01/01	12/31	Closed	11/01	12/31
7424605	01	0.1	Open, not maintained			Open, not maintained		
7424606	01	0.2	Closed	01/01	12/31	Closed	01/01	12/31
7424607	01	0.2	Closed	01/01	12/31	Closed	01/01	12/31
7424608	01	0.2	Open, not maintained			Open, not maintained		
7430000	01	2.7	Open			Open, not maintained		

APPENDIX B. Stream Survey Data

Reach	Length	Percent	Pools	Rating	Adult Holding	Rating	Juvenile	Rating	Wood	Rating	Spawning	Rating	Gravel Quality	Rating	Gradient	Rosgen
1	4750	17.8	>1:1	Good	35%	Good	35%	Good	0	poor	25	Poor	Covered by organic	Poor	4	B2
2	3900	14.6	<1:1	Poor	720	Poor	3890	Poor	0	poor	17	Poor			3	D3
3	4750	17.8	>1:1	Good	4500	Good	6400	Good	0	Poor	43	Poor			3	B2
4	2970	11.1	=1:1	Fair	300	Poor	3100	Good	2	Fair	29	Fair			4	B2
5	3400	12.7	=1:1	Good	2040	Fair	3650	Fair	1	Fair	31	Poor			3	B2
6	1400	5.2	<1:1	Poor	85	Poor	1040	Poor	1	Fair	23	Fair			2	B3
7	1100	4.1	=1:1	Fair	195	Poor	1250	Fair	2	Fair	18	Fair			5	B2
8	2750	10.3	<1:1	Poor	75	Poor	2170	Poor	1	Fair	42	Fair			2	B3
9	670	2.5	>1:1	Fair	150	Fair	940	Good	0	Poor	9	Poor			2	B1
10	1000	3.7	=1:1	Fair	75	Poor	1400	Good	2	Fair	27	Fair			5	A2