SECTION I
INTRODUCTION

This report is a first iteration watershed analysis for the East Fork Coquille 5th Field watershed, and is organized within reasonable conformity to the format described in the *Federal Guide for Watershed Analysis Ver. 2.2* (REO 1995).

Watershed analysis is a major component of the ecosystem-based management strategy mapped out in the *Record of Decision for Amendments to Forest Service and Bureau of Land Management Planning Documents within the Range of the Northern Spotted Owl* (USDI 1995a). The stated purpose of watershed analyses is to develop and document a scientifically-based understanding of the ecological structures, functions, processes, and interactions occurring within a watershed, and to identify desired trends, conditions, data gaps, and restoration opportunities. The information, recommendations, and data gaps documented in a watershed analysis are intended to be used to help plan land management activities that are appropriate for the analysis area, support the NEPA process, and direct future data collection efforts. Watershed analysis was designed as an iterative process, with reports being revised as additional information becomes available.

We are directed to take a "landscape level" view of the entire watershed in the Guide, although federally-managed lands comprise a little over half of the land base. The Guide directly addresses inclusion of private land information into watershed analysis (REO 1995:11):

> Even though the Federal watershed analysis process is in no way intended to regulate non-Federal lands, analysis teams...will consider the interactions of various land ownerships in the watershed. Federal land management decisions based on the results of watershed analysis need to consider conditions and activities on adjacent non-Federal lands, especially to evaluate cumulative effects, as they affect public lands....Voluntary participation by non-Federal landowners will enhance each team's ability to...better understand the interactions of various land ownerships in the watershed....In those instances where landowners do not voluntarily choose to participate, publicly available information about topography, soils, geology, hydrology, transportation systems, and vegetation may be available, for example, through aerial photos, or state and local government records.

It is with this guidance in mind that we prepared this document. Topics addressed which included descriptions of non-federal land in the watershed are those mentioned in the guidance above; soils, geology, hydrology, roads and vegetation. Our methodology also follows the Guide; we used publicly-available aerial photographs, soils, geology and vegetation information to develop our characterizations. Information gathered by direct examination (in field visits) and specific recommendations were restricted to federally-managed land.

The interdisciplinary team members initially convened to identify issues and questions pertinent to the analysis area, then worked independently to write sections covering the analysis questions for their respective fields of expertise. The team reconvened to synthesize the information into a cohesive watershed analysis report. A draft version of the report was circulated to local governments and major private land owners for review. We thank all the people who invested time to make this a better watershed analysis.

SECTION II
ISSUES AND KEY QUESTIONS

SECTION II
ISSUES AND KEY QUESTIONS

The five identified “Issues”, with associated Key Questions and Outcomes, listed below, were developed by the interdisciplinary team to highlight areas of particular emphasis for this watershed.

In order to better organize and display the analytic information developed to deal with these issues, this document has been divided into eight major sections (designated by upper case roman numerals):

Section I - Introduction
Section II - Issues and Key Questions
Section III - Physical Characteristics
Section IV - Aquatic Ecosystem
Section V - Terrestrial and Riparian Ecosystem
Section VI - Human Uses
Section VII - Riparian Reserve Evaluation
Section VIII - Recommendations

Each of these sections has been further sub-divided into topics as necessary (designated by arabic numerals). Analytic Questions (AQ) help focus the analysis of each topic and provide for readability and tracking. They are designated by a three-part number over an enclosed text block. The first and second parts of this number are the numeral of the section and sub-section, for example IV.2. The final arabic numeral is the sequential number of the question within subsection.

ISSUE 1
MAINTAIN OR ENHANCE TERRESTRIAL HABITAT TO PROVIDE FOR LATE-SUCCESSIONAL WILDLIFE AND BOTANICAL SPECIES.

KEY QUESTION - What management activities are appropriate for special status, Survey and Manage, and other species of management concern (e.g.; identified non-native pests, including Port-Orford-cedar root rot and noxious weeds)?
See Section V.3 - Species of Management Concern and V.4 - Non-Native Pest Species for background information.

OUTCOME(S) - Identification of appropriate management actions and delineation of potential project areas.
See Section VIII.3 - Terrestrial and Riparian Ecosystem Recommendations

KEY QUESTION - What management actions are beneficial for maintaining or enhancing connectivity?
See Section V.2 - Terrestrial and Riparian Habitat (AQ: V.2.3, V.2.8, and V.2.10) for background information. Also see Section VII - Riparian Reserve Evaluation.
OUTCOME(S) - Delineation of management techniques and list of proposed project areas.
See Section VIII.3 - Terrestrial and Riparian Ecosystem Recommendations

KEY QUESTION - What management opportunities exist within Late-Successional Reserves (LSRs) to enhance the habitat?
See Section V.2 - Terrestrial and Riparian Habitat (AQ: V.2.3, V.2.5, V.2.8, V.2.9,and V.2.11) for background information.
OUTCOME(S) - Identification of appropriate enhancement techniques and delineation of potential project areas.
See AQ V.2.11, Table V.4, and Map A.25; and Table VIII.1.

KEY QUESTION - What opportunities exist to meet RMP road density objectives?
See Section VI.3 - Transportation System.
OUTCOME(S) - List of potential road segments to be decommissioned.
See Appendix J.

ISSUE 2
MAINTAIN OR ENHANCE AQUATIC HABITAT TO PROVIDE FOR SALMONID FISHERIES AND AQUATIC SPECIES.

KEY QUESTION - What management opportunities exist to maintain and/or improve water quality and quantity?
See Section III.5 - Climate, III.8 - Hydrologic Processes, and IV.1 - Water Quality for background information. Also see Section VII - Riparian Reserve Evaluation.
OUTCOME(S) - Define suitable management activities, delineate management techniques and provide a list of proposed project areas.
See Section VIII.2 - Aquatic Ecosystem Recommendations

KEY QUESTION - What management activities are suitable to improve water quality in Oregon DEQ 303d listed streams?
See IV.1 - Water Quality for background information. Also see Section VII - Riparian Reserve Evaluation.
OUTCOME(S) - Define appropriate management activities, delineate management techniques and provide a list of proposed project areas.
See Section VIII.2 - Aquatic Ecosystem Recommendations.

KEY QUESTION - What management opportunities exist to maintain and/or enhance stream and riparian habitats?
See IV.2 - Aquatic Habitat. Also see Section VII - Riparian Reserve Evaluation.
OUTCOME(S) - Delineation of management techniques and list of proposed project areas.
See Section VIII.2 - Aquatic Ecosystem Recommendations.

KEY QUESTION - What management opportunities exist to maintain and/or restore desired populations of aquatic species?
See IV.3 - Aquatic Species. Also see Section VII - Riparian Reserve Evaluation.
OUTCOME(S) - Delineation of management techniques and list of proposed project areas.
See Section VIII.3 - Terrestrial and Riparian Ecosystem Recommendations.

ISSUE 3
PROVIDE RECREATIONAL OPPORTUNITIES TO MEET A VARIED EXPERIENCE.

KEY QUESTION - What types of dispersed or developed recreation are appropriate in the watershed, and how should future increased demand be managed?
See Section VI.1 - Human Uses - General (AQ: VI.1.2, VI.1.5, VI.1.6, and VI.1.7) for background information.
OUTCOME(S) - Delineate appropriate recreation uses and provide a list of potential projects.
See Section VIII.4 - Human Uses Recommendations.

ISSUE 4
IDENTIFY AREAS FOR POTENTIAL HARVEST OF TIMBER AND OTHER FOREST PRODUCTS.

KEY QUESTION - Where are potential timber harvest areas which can contribute to the District's probable sale quantity (PSQ) for FY 2000-2003?
See Section VI.2 - Human Uses - Timber Harvest (AQ: VI.2.1, and Map A.20) and Appendix I for background information.
OUTCOME(S) - Prioritized list of potential harvest units.
See Map A.20 and Appendix I.

KEY QUESTION - What are appropriate locations and levels for removal of special forest products?
See Section VI.2 - Human Uses - Other Forest Products (AQ: VI.2.4 - Vi.2.6.) for background information.
OUTCOME(S) - Identification of appropriate levels and timing for removal of special forest products.
See AQ: VI.2.6.

ISSUE 5

EVALUATE THE CONDITION OF RIPARIAN RESERVES AS THEY RELATE TO MANAGEMENT DECISIONS.

KEY QUESTION - What are the trends of altered riparian plant communities and seral stages?

OUTCOME(S) - Completed RR Module (including: revised Interim RR map; description of major vegetative characteristics and composition within the RR network; large-scale classification of Rosgen types for stream channel systems; list of species that are strongly influenced by RR management; and RR relative physical and biological value ranking map).

See Section VII - Riparian Reserve Evaluation.

KEY QUESTION - What are the management objectives for terrestrial and riparian vegetation?

OUTCOME(S) - Delineation of management techniques concerning six areas of concern:

- Restoration
- Changing the Boundaries
- Management within Riparian Reserve Boundaries
  - Actions with special standards and guidelines
  - Actions that must be neutral relative to the ACS
  - Actions that must be positive relative to the ACS
- Cumulative Effects
- Risk Assessment and Management
- Monitoring

See Section VII - Riparian Reserve Evaluation.

KEY QUESTION - What management actions could be undertaken that would maintain and/or restore the integrity and productivity of the riparian habitat?

OUTCOME(S) - Develop a list of proposed projects.

See Section VII - Riparian Reserve Evaluation.

SECTION III
PHYSICAL CHARACTERISTICS

MAPS REFERENCED

APPENDICES REFERENCED

SECTION III
PHYSICAL CHARACTERISTICS

III.1 - LOCATION

The analysis area is the East Fork Coquille watershed (Appendix A - Map A.1a), one of six REO 5th Field watersheds comprising the Coquille River Basin. This watershed covers 12.7% of the Coquille River Basin. The analysis area is almost completely contained within the Coos Bay BLM District, although the easternmost two partial sections of public land are within the Roseburg BLM District (Appendix A - Map A.1b). For analytical purposes, the area was divided into six subwatersheds (Appendix A - Map A.2), although it is composed of 18 drainages (Appendix A - Map A.3).

The Coquille River is the largest system in the South Coast River Basin, draining 1058 mi^2 from the Coast Range and Siskiyou mountains westward to the Pacific Ocean. The confluence of the East Fork Coquille River with the North Fork Coquille River is at Gravelford, at river mile (RM) 9.2, which is about four miles northeast of Myrtle Point, Oregon.

III.2 - OWNERSHIP AND LAND USE ALLOCATIONS

CURRENT CONDITIONS

ANALYTIC QUESTION III.2.1

What are the ownership and land use allocations?

All BLM lands are designated according to the categories set forth by the Record of Decision for the Coos Bay District Resource Management Plan (RMP) and the Record of Decision (ROD) for the *Supplemental Environmental Impact Statement on Management of Late-Successional and Old-Growth Forest Related Species Within the Range of the Northern Spotted Owl* (SEIS) (USDA and USDI 1994). Mapped allocations for BLM land within the analysis area include; late-successional and marbled murrelet reserves, connectivity blocks, and general forest management areas. The analysis area does not contain Tier 1 Key Watersheds (as defined in the SEIS). Riparian Reserves are superimposed upon the land use allocations.

The East Fork Coquille watershed includes 85,785 ac (≈134 mi^2) of land. Acreage for land use allocations are shown in Table III.1 and areas are identified on Map A.4, (in Appendix A).

Late-Successional and Marbled Murrelet Reserves (LSR/MMR)

This allocation is defined in the SEIS (pp.7). The analysis area contains a portion of LSR #261. Occupied marbled murrelet sites, known spotted owl activity centers and protection buffers are unmapped, and are not included in Table III.1 or shown on Map A.4. This is proprietary information under the ESA.

General Forest Management Areas (GFMA)

This allocation includes federal lands outside of designated reserve areas. The RMP (pp. 22) designates the GFMA and Connectivity/Diversity Blocks (CONN) (see below) as Matrix.

Connectivity/Diversity Blocks (CONN)

This allocation was designated in the Revised Preferred Alternative of the ROD (with District modifications). While CONN lands (along with GFMA) constitute Matrix, management action/direction differ.

Coquille Forest

On October 1, 1998, ownership of the lands designated by Congress to become the "Coquille Forest" was transferred from the BLM to the Bureau of Indian Affairs (BIA). These lands now are being managed by the Coquille Indian Tribe.

Table III.1
Ownership and Riparian Reserve Acreage

OWNERSHIP	TOTAL	OWNERSHIP % (OF TOTAL)	RIPARIAN RESERVES	RIPARIAN RESERVE % (OF TOTAL)
Private	38,970	45.43	N/A	N/A
BIA - Coquille Forest	1,367	1.59	637	46.60
BLM - LSR/MMR	23,414	27.29	12,453	53.19
BLM - CONN	2,991	3.49	1,551	51.86
BLM - GFMA	19,033	22.19	11,043	58.02
BLM - TOTAL	**45,448**	**52.98**	**25,047**	**55.11**

This watershed contains a relatively high proportion of public land (nearly 53%). In most Coos Bay District watersheds, BLM lands primarily are composed of alternate sections, which create a "checkerboard" land ownership pattern. This pattern also is evident in the majority of the East Fork Coquille watershed. However, in the Brummit Creek subwatershed, many additional sections also are public land. This creates relatively large contiguous blocks of public land (see Appendix A - Map A.4).

China Wall Area of Critical Environmental Concern (ACEC)

The analysis area also contains the China Wall ACEC (within T27S, R10W, Section 29). This 240 acre area is entirely within LSR #261. It is located between BLM Road 27-10-29.0 and Brewster Rock Road. China Wall is designated an ACEC for the following resource values:

- Special Status Species - it provides habitat for northern spotted owl and several plant species associated with dry meadows.
- Natural Plant Communities - Several small dry meadows are located along the unique geological feature called the "China Wall."
- Historic/Cultural - it contains visible remnants of the historic Brewster Trail and a prehistoric site potentially eligible to the National Register of Historic Places.

III.3 - GEOLOGY

CURRENT CONDITIONS

The analysis area is within the Oregon Coast Range, near its southern boundary with the Klamath Mountains. Exposures include five Tertiary-age marine sedimentary and volcanic formations; Otter Point, Roseburg, Lookingglass, Flournoy and Tyee geologic formations (Appendix A - Map A.5). The geologic history is presented in Appendix B.

ANALYSIS QUESTION III.3.1

What are the geologic influences on ecosystem processes?

The effect of geology on ecosystem processes in the analysis area is based largely on weathering of parent materials, mostly sandstone and siltstone. These geologic formations were created by erosional processes depositing materials in layers within an ocean basin environment.

As parent materials weather in place, they assume different chemical and physical qualities which produce a variety of soil types. The coarse-textured sandstone of the Tyee formation weathers to soils that have high infiltration rates and few materials that produce turbid waters. In contrast, the Otter Point formation soils are slow to infiltrate while producing great quantities of fine (clay-sized) materials that quickly cloud water.

The placement, movement, and subsequent lifting of the parent materials produces the landscape that we see today. The weathering of the bedrock over millennia gave rise to the cliffs surrounding the Dora area. The flood plains of the Sitkum and lower East Fork valleys were formed by the erosion, transport and deposition of sediments during major flood events. In Tyee formation areas, the main river and its tributaries are influenced by the underlying geologic materials. Areas of hard-to-weather basalt or sandstone gave rise to falls, riffles and bedrock channels found along the Coquille river above Sitkum (as well as in the Elk, Brummit, Camas and Dead Horse creeks). Little downcutting of these channels has occurred, and transport of materials to the lower section of the river is relatively rapid compared to the gentle gradient below Brewster Gorge.

The stream network is controlled by the geologic formations, particularly through orientation of their bedding planes and axes. The eastern two-thirds of the analysis area is underlain by the Flournoy and Tyee formations, which dip gently east. The stream network dissecting these formations tends to have a trellis pattern with nearly perpendicular stream junction angles. The high angle tributary intersections impede downstream movement of LWD and sediment. In contrast, the western third of the watershed is underlain by the Roseburg formation. In this area, ridges and streams have a southeast-northwest trend that roughly parallels the strike of the folded bedrock. This produces a more dendritic pattern, with stream junction angles at ≤70 degrees. This pattern facilitates downstream delivery of LWD and sediment (Benda 1985).

Geologic uplifting and erosional downcutting of the basin gives rise to different stream channel gradients across the watershed. These gradients control the origin, transport, and subsequent deposit of weathered materials. The steeper (Tyee and Flournoy) formations are the primary source areas of weathered materials, that are then moved downstream by water. Once the steams flow across the gentler Roseburg and Lookingglass formations the stream channels become meandering and tend to provide sediment depositional areas. The Quaternary-age disconnect of these streams and flood plain areas continues today under the influence of gradual tectonic uplifting. Thus materials moved downstream are in short-term storage along the banks and behind embedded materials.

Deposition of coarse-grained geological materials (medium sand-size through pebble-size quartz) from the Tyee formation provides a different stream sediment regime than does the fine-grained geological materials (silt-size through clay-size) found both in the lower portion of the Lookingglass and in the Otter Point formations. Under normal conditions, this geologic difference tends to produce clearer water earlier and for a longer period in the higher-elevation (eastern) portions of the watershed than in the western portion (below the Sitkum valley).

In times of heavy precipitation and disturbance within stream channels, sediment previously stored adjacent to the banks can be expected to be dislodged and move downstream. Heavy runoff will dislodge coarse materials in the upper portion of the watershed and this material will scour the banks and beds, and increase the amount of fine materials in the water in the lower portion (see Section III.8).

The watershed has been heavily impacted by barriers in the main channel which limit distribution of anadromous fish to the lower portion (one-third to half) of the watershed. Blockages to fish passage have resulted from past landslide events. For example, the closure of the Sitkum valley by the massive landslide 3,100 years ago (Lane 1987) prevented the migration of anadromous fish upstream beyond the Brewster Gorge area.

Land uses today also are governed by past geologic processes. In past times, redeposition of materials from hillsides to plains was controlled by rising and falling ocean levels, land surface uplifting, and climatic factors. Flood plains in the main river channel and the depleted ancient lake (which was created by the Brewster Gorge landslide) now are prime agricultural areas, while adjacent tributary hillsides support tree growth and provide a forest landbase.

III.4 - SOILS

CURRENT CONDITIONS

ANALYTIC QUESTION III.4.1

What are the general soil types?

According to digitized data from the *Soil Survey of Coos County, OR* (USDA 1989), the East Fork Coquille Watershed is comprised of 51 different soil map units. Each soil map unit represents an area on the landscape consisting of one or more soil types. The same soil type may be included in several soil map units, because each soil type has different properties depending on slope. Differences in soil properties due to slope are indicated by an alphabetic extension to the numeric designation. For example, the Preacher-Bohannon loam soil (46) is found on slopes ranging from 30-60% (46E) or 60-90% (46F). These two units have different erosional properties due to slope. Eight of the 51 soil map units together comprise 76% of the watershed (Appendix A - Map A.6). The largest soil map unit in watershed is the Milbury-Bohannon-Umpcoos (38F) association, covering almost 18% (Table III.2).

Table III.2
Main Soil Map Units

MAP UNIT	MAP UNIT DESCRIPTION (SOIL TYPE)	% SLOPE (RANGE)	TOTAL ACREAGE FOR MAP UNIT	% OF WATERSHED
14F	Digger-Preacher- Umpcoos association	50 - 80	6,175.72	7.2
15F	Digger-Umpcoos-Rock outcrop association	50 - 90	4,723.97	5.5
38F	Milbury-Bohannon-Umpcoos association	50 - 80	15,169.59	17.7
44D	Preacher-Blachly association	12 - 30	6,339.36	7.4
44E	Preacher-Blachly association	30 - 60	8,459.68	9.9
46E	Preacher-Bohannon loams	30 - 60	8,725.98	10.2
46F	Preacher-Bohannon loams	60 - 90	9,548.53	11.1
58F	Umpcoos-Rock outcrop association	70 - 99	6,319.51	7.4
	TOTAL		65,462.34	76.3

Soil types commonly are associated with certain positions on a landscape. Making site-scale soil type designations depends upon numerous variables including:

- local patterns of topography or relief;
- soil parent material;
- time of formation of the soil;
- soil-water relationships, and;
- their relationship to vegetation and microclimate (FEMAT 1993).

After a review of the eight main soil types, several general trends were observed. Soil types located on broad ridgetops and benches consist of the Preacher, Bohannon, and Blachly series. Soils are moderately deep to deep, slopes are moderate to steep, and textures are gravelly to loamy. In contrast, the soils on narrow ridgetops usually consist of the Umpcoos, Rock Outcrop, and Digger series. Soils are shallow to moderately deep, slopes are very steep, and textures are gravelly to loamy. Hillsides have a wide range of soil types, depending on configuration, gradient, and slope position. Most soils in the watershed are derived from sedimentary rock. The complex arrangement of soil map units is displayed on Map A.6, (in Appendix A).

ANALYTIC QUESTION III.4.2

How do these soils affect ecosystem processes?

Soils may individually or collectively affect ecosystem processes. Defining a scale is the first requirement when analyzing how soils relate to ecosystem processes. For example, nutrient cycling can range from single soil type under a tree to several soil map units under a forest stand. For this watershed analysis, soils will be discussed on a soil type or map unit basis. Single soil types will be analyzed individually when a certain property (physical or chemical) influences ecosystem processes profoundly.

The impact of soils on ecosystem processes cannot be inferred accurately from soil map units, because it is the individual soil types that affect ecosystem processes. For example, the Milbury-Bohannon-Umpcoos association is the largest map unit in the watershed, but its individual soil types are not the most common.

Within the eight main soil associations, there are seven soil types. The most common soil type is the Preacher loam soil type covering 35% of the watershed (Figure III.1). It is important to look beyond soil map unit classifications and assess common types within all soil associations present.

Soil may affect the ecosystem processes of weathering, nutrient cycling, microbial activity, plant growth, water quality, water movement and water storage. The physical, chemical, and hydrologic properties, and descriptions from the *Soil Survey of Coos County, OR*. are the foundation for interpretations of soil types.

Water Quality

The watershed is a mosaic of soil types, weathered from differing parent materials (see Section III.3). The most outstanding difference among these soil types is their effect on water turbidity.

In the lower part of the analysis area, the 4D, 4E, 22E, 50D and 50E soil types consist of fine clay particles which cloud the water quickly and remain in suspension for a long time.

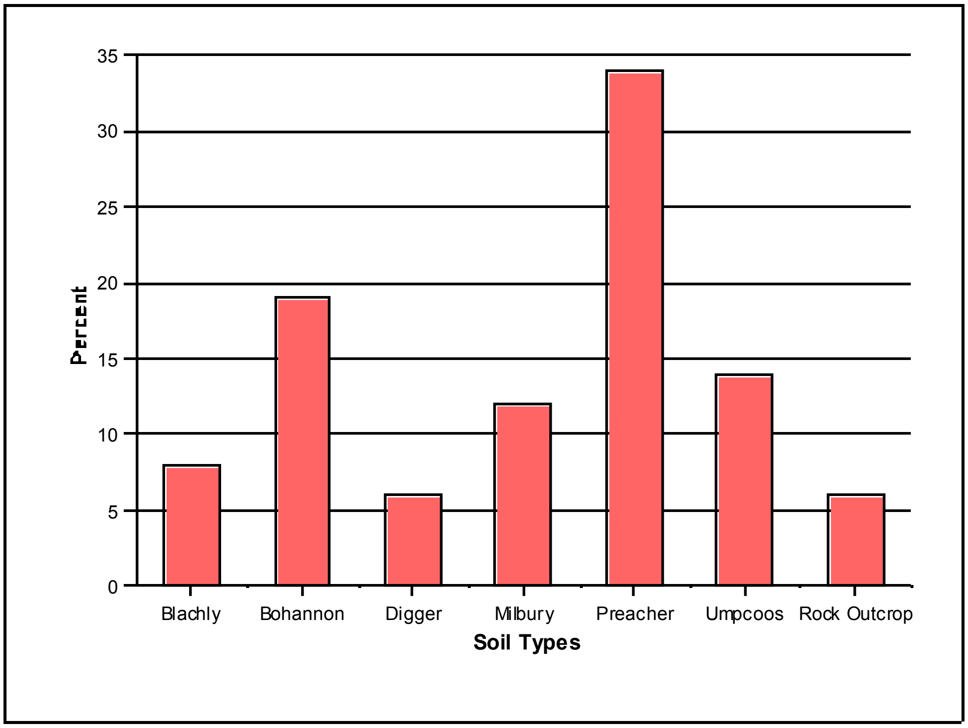

Figure III.1. Proportion of main soil types.

Water Movement and Storage

Soil-water relationships are critical elements when analyzing a soil's influence on ecosystem processes. Large quantities of water must be supplied through the soil to satisfy the requirement of growing plants (Brady 1990). Also, water in the soil medium is a critical element in soil erosion, nutrient cycling, and nutrient absorption. Soil texture is a key physical property that has considerable influence on runoff and absorption of water. Texture also indirectly influences plant growth and biological activities within the soil.

According to Brady (1990), loamy soils contain 7-27% clay, 28-50% silt, and 23-52% sand. All seven main soil types in the watershed are classified as loam. In general, as textural fineness increases, there is a corresponding increase in available water capacity (Brady 1990). For example, more water is available from the Preacher soil type than the Umpcoos soil type (Table III.3).

The permeability of soil also is related to texture. These physical processes relate to the ease with which water moves vertically and horizontally through the soil. Sandy soils are more porous and have a higher permeability rate than finer textured (silt and clay) soils. For example, sand-dominated loams such as the Digger soil type have a faster permeability rate than clay-dominated loams such as the Blachly soil type. Nonetheless, all seven soil types are broadly classified as "well-drained" by the *Soil Survey of Coos County*. Well-drained is defined as follows (USDA 1989): "water is removed from the soil readily but not rapidly, and water is available to plants throughout most of the growing season." By this definition, all soil types have at least some water storage capacity. Table III.3 illustrates that the loam- and clay-dominated soils (Blachly, Preacher) have higher water storage capacities, with lower runoff hazard and water erosion rating. In contrast, the Digger, Milbury, and Umpcoos have higher runoff hazard and water erosion ratings, and slightly lower water storage properties, both due to higher percentages of sand and gravel. The Rock outcrop areas are exposures of fractured, hard sandstone. These areas are relatively impermeable to water, so all precipitation is considered runoff.

Table III.3
Physical Characteristics of Main Soil Types

MAIN SOIL TYPES	PHYSICAL CHARACTERISTICS					
	TEXTURE	DRAINAGE	RUNOFF	PERMEABILITY	HAZARD OF WATER EROSION	O.M %
Blachly	Silty clay loam	Well-drained	Medium - Rapid	Moderately slow	Moderate - High	3-6
Bohannon	Loam-gravelly loam	Well-drained	Medium - Rapid	Moderately rapid	Moderate - High	4-6
Digger	Gravelly loam	Well-drained	Rapid	Moderately rapid	High	3-5
Milbury	Very gravelly sandy loam	Well-drained	Rapid	Moderately rapid	High	2-5
Preacher	loam	Well-drained	Medium - Rapid	Moderate	Moderate - High	5-8
Umpcoos	Very gravelly sandy loam	Well-drained	Rapid	Moderately rapid	High	1-3
Rock outcrop	Exposures of fractured hard, sandstone					

Plant Growth and Microbial Activity

Most soils of agricultural significance are some type of loam (Brady 1990). The main soil types in the watershed are well suited for the production of a wide variety of vegetation, because they have excellent physical and chemical properties and support the necessary microbial communities. All the main soil types are well suited for the production of valued commercial species and support ecological processes.

Nutrient Cycling

The ability of soil to store, process and return nutrients to growing plants is directly related to the amount of organic matter on the surface. In general, fine-textured soils have higher organic matter contents than coarse-textured soils. Since the soils in the analysis area have a loam base, this trend is only slightly evident. Clay-dominated loams do have a slightly greater percentage of organic matter than do the sand-dominated loams (see Table III.3). Organic matter creates physical conditions favorable both for optimum plant growth and for microbiological activity and growth. Soil organisms breakdown and reduce organic matter to simple forms which higher plants can use. The main soil types have adequate amounts of organic matter for plant growth and biological activity.

Weathering

As parent materials breakdown over time they produce the medium we know as soil. Among other things, soil provides an anchoring medium for plants and a home to many large and microscopic animals. The speed of soil formation depends on the nature of the parent material. The Tyee and Roseburg formation-derived soils breakdown relatively slowly. In contrast, the Flournoy, Lookingglass and Otter Point formation have portions which breakdown relatively quickly, so that soil is created after exposure to local climate. In these areas, parent material exposure during road building or repairs can lead to sloughing of cutbanks and production of sediment above expected levels.

SYNTHESIS AND INTERPRETATION

ANALYTIC QUESTION III.4.3

What environmental limitations do soils have?

Although the soils are productive, they are not without limitations. These include: compaction of the surface layer, steepness of slope, hazard of erosion and plant competition (Table III.4). The finer-textured soil types are more susceptible to compaction by timber harvest and other ground-disturbing activities. Intensive site preparation and maintenance is required to achieve reforestation by desired species.

Table III.4
Limitations of Main Soil Map Units

LIMITATION	SOIL MAP UNITS							
	14F	15F	38F	44D	44E	46E	46F	58F
Susceptibility of surface layer to compaction	X			X	X	X	X	
Hazard of erosion	X	X	X		X	X	X	X
Plant competition	X	X	X	X	X	X	X	X
Steepness of slope	X	X	X		X	X	X	X
Hazard of windthrow	X	X	X					X
Seedling mortality			X					X

ANALYTIC QUESTION III.4.4

What are management objectives for soils on Federal lands?

When planning activities that can impact the soil resources on Federal lands, a closer examination of the local area will need to be undertaken. The action proposed may or may not be an impact to the soils of the area. Overall, the land manager must strive to limit compaction, surface erosion and degradation to the organic matter components of the soil. Following Best Management Practices for road construction, site preparation and harvest of timber will minimize landslide rate and impacts to future stands of forest timber on Federal lands. This watershed is in excellent condition with respect to the soil resources. Protection of those resources is demonstrated in current land management practices.

III.5 - CLIMATE

CURRENT CONDITIONS

ANALYTIC QUESTION III.5.1

What are climatic features and how do they affect ecosystem processes?

Temperatures generally are mild. Maximum temperatures seldom exceed the low 90s (°F), and cold temperatures rarely fall below freezing. Most precipitation occurs as rainfall, ranging from 55 inches annually in the lower elevations, to more than 95 inches at the eastern end of the watershed near 3,200 ft. elevation (OSU 1993).

Precipitation varies strongly with elevation. Precipitation is higher in the upper elevations of the drainage, declining from west to east for any given elevation. Aspect and drainage orientation to prevailing southwest winter winds also influence precipitation amounts. Cool and moist air lifting over the Coast Range can produce snow above 1800 ft. The eastern 40% of the watershed (particularly Brummit, Upper East Fork Coquille and Camas Creek subwatersheds) can accumulate snow for a few days to weeks during the winter. These intermittent snow packs melt quickly with warm winds and rain. Extra water storage as snow can elevate flood waters.

Approximately 90% of the average annual precipitation occurs between October and April, and 50% occurs from November to January. Heavy rainfall can occur with winter storms, but most precipitation is low intensity and falls as "light rain" or "drizzle." Precipitation during the summer months (May - September) is 6-9 inches (OSU 1982); about 10% of the annual average (Figure III.2). Areas west of Dora and in the eastern reaches of the watershed generally have about 3 inches less precipitation than the rest of the watershed during the spring/summer.

Maximum precipitation periods occur infrequently. but are responsible for high runoffs, and often result in flooding, erosion, slides, and debris torrents. The combination of heavy rainfall on snow can intensify flooding. Data from local NOAA Cooperative Weather Stations show damaging storms (with daily precipitation of at least four inches) have a return frequency of 5+ years. Cumulative precipitation of 9+ inches over several days correlates with a higher incidence of landslides and torrents (see Section III.7).

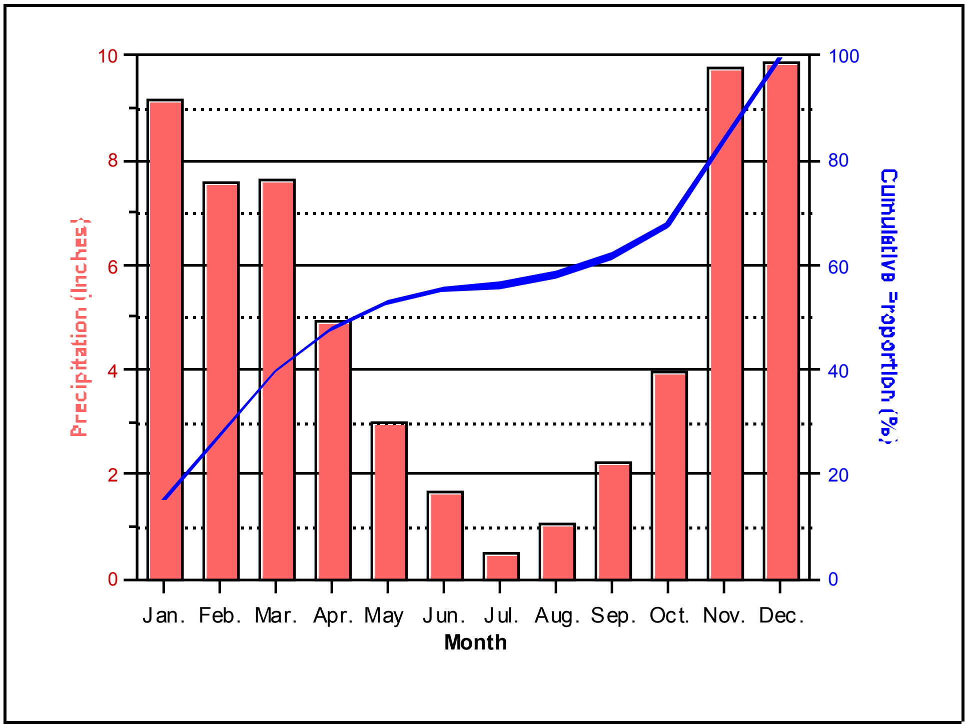

Figure III.2. Mean yearly precipitation.

III.6 - GEOMORPHOLOGY

CURRENT CONDITIONS

ANALYTIC QUESTION III.6.1

What are the basic geomorphological characteristics and ongoing processes and how do they affect other ecosystem processes?

The Coast Range is a northeast-southwest trending anticline, dissected by trellis or dendritic stream networks (Appendix A - Map A.7). The analyses area supports a high drainage density of 7.4 mi/mi^2. This is the normal situation in the Coast Range of Oregon. About 762 stream miles are 1st and 2nd order, and comprise 76% of the total drainage density (Table III.5)[1]. These are generally steep headwater channels draining small catchments. Many 1st and 2nd order streams become intermittent by late summer. The remaining 24% of stream miles are 3rd order or greater, ordinarily flow all year, and may be classified as perennial.

Table III.5
Stream Order Miles by Subwatershed

SUBWATERSHED	MILES OF STREAM BY STREAM ORDER*							
	1	2	3	4	5	6	7	TOTAL
Brewster Canyon	97.2	45.2	24.2	5.9	1.0	4.6	10.8	**188.9**
Brummit Creek	80.0	39.5	22.8	11.7	8.8	4.3	0.0	**167.1**
Camas Creek	100.4	39.6	19.1	8.1	7.7	4.0	0.3	**179.2**
Elk Creek	65.0	26.5	9.7	5.0	5.0	4.3	0.0	**115.5**
Lower East Fork Coquille	94.0	40.5	19.3	11.8	1.5	0.0	15.2	**182.3**
Upper East Fork Coquille	101.7	32.5	13.6	9.5	7.2	0.2	0.0	**164.7**
TOTAL (miles)	**538.3**	**223.8**	**108.7**	**52.0**	**31.2**	**17.4**	**26.3**	**997.7**
Drainage Density (mi/mi^2)	**4.0**	**1.7**	**0.8**	**0.4**	**0.2**	**0.1**	**0.2**	**7.4**

* Relative position of streams, where all exterior links are order 1, and preceding downstream, the confluence of two like orders result in existing stream order +1. The junction of two different orders retains the higher order, and the main stream always has the highest order (Strahler 1957).

The East Fork Coquille has a very low gradient for a coastal stream. The river and streams in the Lower East Fork Coquille and Brewster Canyon subwatersheds (except the Brewster Falls reach) have an average gradient less than 1%. These are low energy depositional streams. In contrast, tributary drainages have narrow canyons and steeper channel gradients. Tributary streams drain rugged mountainous land forms and usually start below steeply sloped headwalls (Appendix A - Map A.8). Longitudinal profiles of streams are useful to compare morphology between stream reaches and from one stream to another. Brummit Creek, Camas Creek, Elk Creek, and Upper East Fork Coquille subwatersheds have the highest average gradients. These high-energy, erosional streams can move significant amounts of water and sediment. However, all streams contain low gradient reaches, which provide high habitat value.

III.7 - EROSION PROCESSES

Erosion is the wearing away of the land surface by water, wind, ice, or other geologic agents and by such processes as gravitational creep (USDA 1989). Erosion is the removal of soil from

[1] Oregon and Washington Bureau of Land Management units are currently updating and standardizing their hydrographic information. This will likely result in changes to the number of miles by stream order summarized here. The new information will be used for project planning and incorporated in the next round of watershed analysis.

the landscape and the displacement from an upper to a lower slope position. Long-term and gradual wearing away of mountains and build-up of flood plains is natural (geologic) erosion. Accelerated erosion associated with human land uses is of particular concern to land managers.

REFERENCE CONDITIONS

ANALYTIC QUESTION III.7.1

What were the dominant historical erosional processes?

Many forest lands in the Pacific Northwest have the potential to be unstable because of the geologic, hydrologic, and soil cohesion conditions of the land base. In the East Fork Coquille watershed, all erosional processes have been examined and mass wasting and surface erosion have been determined to be significant sediment contributors. The dominant historical erosional process was mass wasting (landslides).

Mass wasting involves the transport of large quantities of soil and debris (wood and rock) downslope primarily by gravity, to and within streams (Sidle 1980). There have been several mass wasting processes at work, including; shallow-rapid, debris-flow, and large-persistent landslides.

- **Shallow-rapid debris failures** are slides which only move the top few feet of soil short distances, potentially contributing fine sediments to stream channels.
- **Debris flows** (or torrents) are characterized by rapid downslope movements of large amounts of soil and organic debris, under the influence of water, down a stream channel or other confined area.
- **Large-persistent deep-seated rotational failures** are the extreme case of mass wasting; often resulting in a large soil mass moving downslope under the influence of gravity. These failures usually are caused by the undermining slope toe.

The landslide process can be conceptualized as a mix of two forces acting on a block moving down an inclined plane. The force of gravity acts on the block to pull it down the plane. Frictional resistance to this movement keeps the block in place, preventing downslope movement. This resistence is a function of gravity and parent material conditions. Whenever resistance is lower than gravity the block moves (e.g., a landslide results). Although the basic concept seems simple, there are many site-specific factors which preclude accurate forecasting of slide events.

The process of landsliding is cyclic. It begins with landslide failure. After the failure relieves the tension between gravity and frictional resistence, the area begins gradually to recharge with additional sediment. When gravity again exceeds resistive forces another failure occurs and the cycle begins again. Depending on local conditions, one cycle in this process may take centuries. For the Coast Range of Oregon, it appears one cycle may be closer to 100 years for in-channel failures.

Surface erosion is a process where individual soil particles are detached and transported downslope by the movement of water. The delivery of sediment by surface erosional processes has been determined to be negligible under most forested environments (Fredriksen and Harr 1979). Removal of streambank areas is considered bank erosion and during periods of high runoff or channel downcutting (5 year precipitation events) this is a source of sediment.

ANALYTIC QUESTION III.7.2

Where and when have landslides occurred?

Geologic, hydrologic, and vegetative factors control the location and occurrence of landslides and other mass erosional processes. Past historic landslides in the watershed range from the very large (1.5 mi^2) slide that closed Brewster Gorge, to the in-channel debris torrents that occur after large precipitation events (i.e., during November, 1996). Although slides occurred across the landscape during November, 1996, they were particularly frequent in steeper portions of the watershed.

Landslides often are associated with large-scale disturbances such as wildfire. It is probable that landslides followed large fire episodes (see Section III.9). The most recent fire episode in the Brewster-Sitkum area was during the 1930s, and this also was the last wildfire-related disturbance associated with landslide delivery to the stream system.

CURRENT CONDITIONS

ANALYTIC QUESTION III.7.3

What is the average current rate of landslides?

It is not possible to accurately determine a long-term average landslide reference rate for the analysis area using photographic interpretation. Recent analysis by the Oregon Department of Forestry concluded that the use of aerial photographic interpretation for identification of shallow-rapid debris failures "results in biased and incomplete landslide inventories. This bias significantly underestimates the landslide frequency and erosion volume across all forest stand age classes." (Robison *et al.* 1999:ii). The alternative to aerial photographic interpretation (a complete pedestrian survey) is not feasible, given the size (≈135 mi^2) of the analysis area. Therefore, we have calculated landslide "indices", based on those slides visible in forest road prisms as a means of temporal comparison.

ANALYTIC QUESTION III.7.4

What approximate volume of sediment has been delivered to the stream channels from landslides?

Although estimates of landslide area were calculated, estimates of landslide volume could not be made. This calculation would require site-specific determinations of average landslide depth, and calculation of the slide portion delivered to the stream channel. Even with this information, analysis could only estimate recent, not historic volumes. Furthermore, it appears current landslides are not representative of past historic landslides. While recent landslide areas ranged from 0.03 to 23 ac, the largest historic slide was upwards of 1.5 mi^2 in area. Considering the costs of data collection and minimal additional interpretation benefits, volumetric measures were not obtained.

ANALYTIC QUESTION III.7.5

What are the dominant current erosional processes?

Two erosional processes are potentially important in forested environments; surface erosion and mass wasting. Surface erosion is not normally important unless vegetation is removed and the soil surface is exposed to precipitation. Inventory of surface erosion was not conducted for the analysis area. However, surface erosion was modeled with the Modified Soil Loss Equation (MSLE), presented in Chapter VII. The dominant erosional process in the analysis area is mass wasting, which produces landslides.

Three different landslide types were analyzed using five aerial photographic coverages taken over a 47 year time period (from 1950 to 1997).These are: Shallow-rapid debris failures, Debris flows, and Large-persistent deep-seated rotational failures. Note that these types were defined in answer to AQ III.7.1 above. An index of landslide frequency was developed to understand the relationship between landslide occurrence and both underlying geology and soil map units.

For all slide types the potential for sediment delivery to a stream or downslope is dependent upon:

- Proximity of the failure to a stream channel;
- Intensity of the slide’s downhill momentum, and;
- Capabilities of the surrounding vegetation and soil to filter the sediment load.

Of the 151 slides identified, 107 (71%) were shallow-rapid debris failures, 35 (23%) were channelized debris-flows and nine (6%) were large-persistent deep-seated rotational failures. The aerial photo interpretation utilized a representative sample (≈38%) of the analysis area (Appendix A - Map A.9), which was carefully selected to include all watershed features (soil type, stream types and geology) and ownership patterns.

It should be understood that this analysis (including all graphs and tables) is based on this 38% sample of the analysis area, so the total landslide frequency would be roughly three times that of the sample. Aerial photographs from 1950, 1970, 1981, 1992, and 1997 were analyzed for a variety of data including; soil type, geological formation, and the number and location of landslides. The methodology used follows Robison *et al.* 1999. However as discussed above, inherent limitations of aerial photography interpretation should be taken into consideration when evaluating the results.

The location of 150 of the 151 identified landslides exhibit a substantial correspondence with underlying geologic formations, but are not strongly associated with stream channels (see Appendix A - Map A.9). The index of slide occurrence, expressed as # of slides/1000 acres, gives a indication of what geologic areas may be sensitive to landslide occurrence (Table III.6).

Table III.6
Landslide Index for Geologic Formations

GEOLOGICAL FORMATION NAME (AND MAP UNIT DESIGNATION)	# OF SLIDES IN SAMPLE	PERCENT OF SLIDES	PERCENT OF ACRES	SLIDE INDEX (# OF SLIDES/ 1000 ACRES)
Tyee (Tet)	105	70.0	18.8	6.5
Flourney (Tef)	27	18.0	5.6	5.6
Lookingglass (Telg)	8	5.3	4.1	2.3
Roseburg (Ter)	10	6.7	6.2	1.9
TOTAL	150	100.0	34.7	

Landslides occurred mainly on the Tyee formation (70%), although this formation accounted for not quite 19% of the land area sampled. The Flournoy formation accounts for 18% of the slides on less than 6% of the area. The Flournoy and Tyee formations are formations where landslides are most likely to occur, and they display similar landslide indices (see Table III.6). In contrast, slides on the Lookingglass and Roseburg formations occur in close proportion to the proportion of the land area sampled and their landslide indices are about one-third as great. One additional slide was located on a fifth formation, Roseburg Basalt (Terv). This formation underlies such a small proportion (<0.1%) of acres in the watershed (see Appendix A - Map A.9), that the calculated slide index (6.2) may not be accurate reflection of the actual landslide potential.

Mass soil movement occurs when a certain set of physical characteristics are present within the soil. Soil depth, shear strength, slope gradient, water storage and water movement through the soil are among the factors that correlate with slope stability and therefore, with landslides.

Soil map unit groupings were determined from *k*-means cluster analysis of soil map unit slide rates. Landslides were found to occur most frequently on three soil map units; 58F, 38F and 15F (see Appendix A - Map A.6 and Table III.7). Note that the background colors used in Table III.7 corresponds to those portrayed in Map A.6. While these three map units cover 31% of the analysis area, they account for 66% of all failures. These soil map units all have the steepest slope gradient rating ("F" slopes range from 50-99%). Obviously, the steeper the slope, the greater the gravitational force available to pull soil and water downslope. These three soil map units also exhibit shallow soil depths (16 in to 31 in). However, it should be understood that Map A.6 provides only a broad-scale view of the analysis area, a more detailed approximation of landslide potential for small-scale areas will be found using the ISE (Infinite Slope Equation) modeling results, presented in Chapter VII.

Table III.7
Landslide Index for Soil Map Units

SOIL MAP UNIT	# OF SLIDES IN SAMPLE	PERCENT OF SLIDES	PERCENT OF ACRES	SLIDE INDEX (# OF SLIDES/ 1000 ACRES)
58F	30	19.9	7.4	11.2
38F	50	33.1	17.7	10.0
15F	19	12.6	5.5	8.7
14F	13	8.6	7.2	5.8
46F	16	10.6	11.1	5.2
50E	2	1.3	1.9	3.9
46E	8	5.3	10.2	2.9
44E	7	4.6	9.9	2.2
46D	2	1.3	3.8	2.2
4D	1	0.7	2.1	1.4
45E	2	1.3	3.5	1.3
44D	1	0.7	7.4	0.5
Total	**151**	**100.0**	**87.8**	

It also should be understood that the criteria used to define "High Landslide Potential" areas on Map A.6 are not the same as used by Oregon State to define "High Risk Sites." ODF "High Risk Sites" are specific locations based on risk of landslide-related damage to state waters. Criteria defining these sites may include (but are not limited to) slopes greater than 65%; steep headwalls; highly dissected land formations; areas exhibiting frequent high intensity rainfall periods; faulting; slumps; or debris avalanches. These factors, as well as "risk to human life" and "runout rate" are the basis for the ODF rating (Seward 1999).

The middle of the analysis area (covered by R10W) is the most prone to land sliding due to its steep slope (Appendix A - Map A.10), while the adjacent Range to the east (R09W) is second-most prone. Nearly 66% of identified slides in the sample occurred on extremely steep slopes (those identified as greater than 65% on Map A.10), although this comprises only 18% of the land surface.

A watershed must have not only the potential for failure, but also a sufficiently large storm event before an increase in sediment production begins (Beschta 1978). Based on studies of the 1996 storms, most landslides occur on steep slopes, correlated to large-scale precipitation events. However, not all large precipitation events will produce a landslide, and sometimes a small rain event will provide the trigger. A land mass will slide when the force of resistance is exceeded by the force of gravity (Hammond *et al.* 1992).

The temporal distribution of landslides provides a prime example of the influence of strong climatic factors on landslide movement. Evidence of past landslide timing may assist in forecasting future events. Over the 47 year sample period, 54% of the slides occurred between the years of 1992-1997 (Figure III.3). This dramatic increase in landslide frequency was likely due to two high magnitude storm events (in February and November, 1996). These episodic events are characteristic of the type and nature of landsliding in the Coast Range. In this case, the number and magnitude of slide events during the last five years surpassed the previous 42 years in sediment delivery and woody debris recruitment across the landscape. During 1964 heavy flooding largely was due to a rain-on-snow event that produced large runoff, so the soil may not have had the saturated conditions necessary to produce large scale landslide events across a large geographic area. Low rainfall conditions throughout the later 1970s and 1980s in the Coast Range may have reduced the amount of failures during that time.

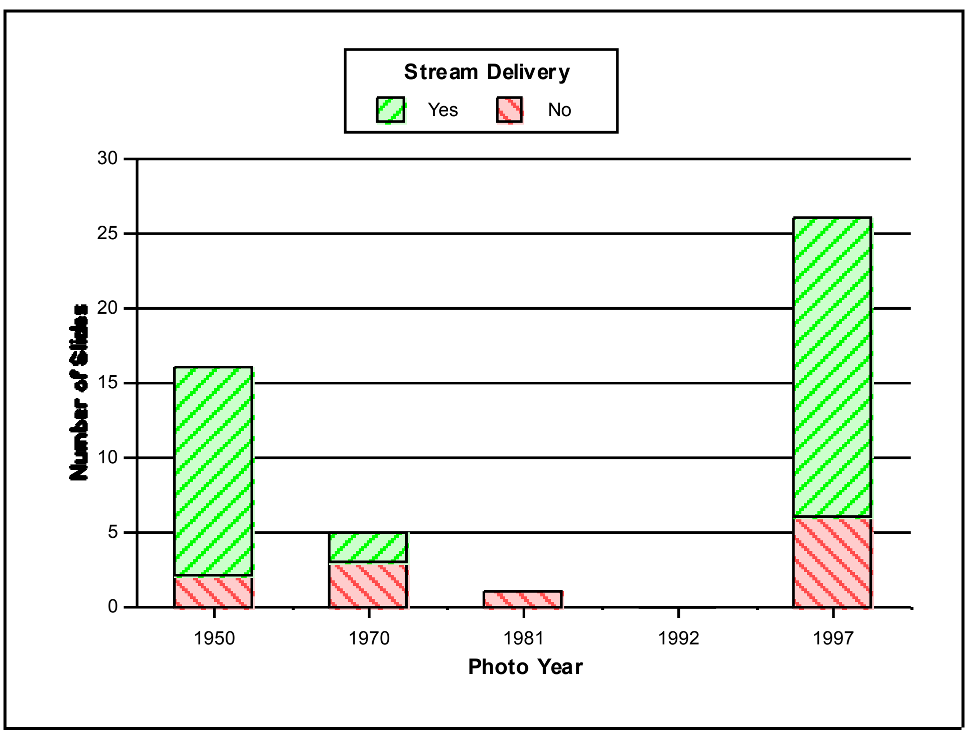

Figure III.3. Index of landslides originating from roads by photo year, divided into delivery types.

An attempt was made to determine whether landslides delivered sediment to a stream, in order to define the extent of erosional processes. From the aerial photos, landslide delivery was assumed to occur if the slide could be seen contacting a channel or moving downstream. Sediment volumes were not available due to lack of data.

Fully 75% of the slides within the sample delivered at least a portion of their material to an adjacent stream (see Figure III.3). However, this proportion is not evenly distributed across the three slide types. Nearly all debris-flow slides (89%) delivered sediment to streams, compared to 67% of large-persistent slides and 72% of shallow-rapid slides. This difference is understandable, as debris flows normally are associated with water and channel environments.

ANALYTIC QUESTION III.7.6

Have management activities played a role in producing landslides?

During the past 125+ years, human activities have resulted in an altered response to climatic events. These activities include building roads within and through the valley connecting population centers and removal of forest environment from hillsides and tributaries in the watershed. Throughout this period, human activities produced a greater proportion of younger-aged forest stands, which has increased the landslide rate (Robison *et al.* 1999).

The trend of lower failure rates originating from roads was present until the intense storms of 1995 and 1996, when failure rates in all initiation locations increased dramatically. However, road-associated failures still occurred at a lower rate in older than in younger (< 30 years) stands.

The type of landslide failure initiated by roads appears to be related to the quality of roadbed fill, and fill quality often relates to road construction period (Schroeder and Brown 1984). Before about the mid-1970s, construction methods using sidecast and woody debris fills produce more failures than modern methods. Roads built after that time employ more full bench-type construction and end-hauling of materials to designated waste areas. These standards provide a more stable road that is less likely to fail during extreme precipitation events. During the large storms of 1996 many of the slides initiated at roads seemed to be related to aging fills or inadequate drainage on roads built 25 to 35 years ago.

A major factor in determining failure rates originating from roads is climatic cycles. Figure III.3 shows a decrease in landslide frequency from 1950 to 1992 for all slide types, followed by a sharp increase in 1997 photographs. The 1997 increase is tied to the combination of a 20 year period of dryer weather, followed by the intense storms during 1995 and 1996. These slides would not have occurred without the intense storms as a trigger. Once an unstable area slides, it may take 100 years (Robison *et al.* 1999) to again develop conditions capable of being triggered by intense storm activity.

Landslides in younger forest stands generally result in sediment delivery to a stream. However, the delivery of sediment to streams does not always produce degraded conditions. Degraded conditions also can resulting from too little sediment retention. These are as detrimental to fish habitat as those resulting from excessive sediment delivery. The concept of balance between input and output is critical to maintenance of proper stream functioning. To ensure proper functioning conditions in both the aquatic and terrestrial environments, it is necessary that sediment delivery be consistent with the storage and transport capacity of the drainage (Rosgen 1996).

The longer time that streams remain turbid and fine sediments cover gravels, the longer time that aquatic organisms must seek shelter from such impacts. The more protracted the turbidity recovery time, the more stress introduced to the aquatic organisms. This is most relevant to the lower portion of the analysis area (Yankee Run Creek and Weekly Creek areas).

The slide type also affected average slide size. Debris flows had the largest average size (≈ 2 ac), while Large-persistent deep-seated rotational failures averaged the smallest (≈ 0.5 ac). No substantial difference was found between Federal and non-federal ownership.

The majority of the future slides probably will come from failing old fills along roads, mature draws that accumulate debris loads, and newly-harvested plantation lands. Because of the reduction in harvest levels on federally-managed lands and the addition of Riparian Reserve areas, landslide probability and subsequent sediment delivery from these forest lands probably will be closer to those of the pre-management activity era. On the Siuslaw National Forest, annual harvest levels have dropped to less than ten percent of earlier levels and restoration projects have been initiated. Four years of observation indicate lower management-associated landslide rates on this National Forest than on adjacent lands (USDA 1997). Large wood and a mixture of sediment sizes will enter stream channels at a rate that will fulfill habitat requirements.

ANALYTIC QUESTION III.7.7

How has the delivery of sediment affected hydrologic processes?

Sediment delivery that creates imbalance between storage and export rates mainly impacts aquatic habitat and water quality. The type of material delivered over the last 50 years has not been the same as in historic times. The recent past has seen a combination of coarse and fine soil material delivered to streams, both with and without large woody debris. For the most part, however, this material has been heavily skewed towards fine material. Past “natural” land failures delivered substantially greater amounts of LWD. A lack of LWD results in accelerated routing of materials downstream. This difference has degraded water quality, as an increase of sediment either in suspension or moving as bedload produces higher turbidities for longer times. Since timber harvest has become the main source of large-scale disturbances in place of wildfire, landslides associated with this and other modern land uses deliver a different suite of materials to streams than did wildfire-produced slides (Beschta 1978; Rice *et al.* n.d.).

Landslides associated with modern land uses provide less large woody debris and possibly more soil materials than those associated with natural events.

Retention of both large and fine soil materials in stream channels cannot occur without LWD. The lack of sediment storage makes less gravel available for spawning or covering bedrock areas when stream velocity is low. Without LWD, sediment material also moves within the water column at lower flows. This produces turbid water, and if allowed to continue for extended periods of time, can adversely impact fish. High sediment loads also adversely impact aquatic macroinvertebrates.

The type and quantity of fine sediment that can be produced from soil changes from the upper (eastern) to the lower (western) ends of the analysis area (see Appendix A - Map A.5). In the eastern half, coarse sand from the Tyee formation produces 14F, 15F and 38F soil types. These contain little clay and silt. In contrast, Otter Point and Roseburg formations (at the western end) form the basis for the 4D and 4E, 50D and 50E, and 22E soil types. These tend to weather into sediment that is higher in clay and silt. The combination of higher erosion rates on Preacher and Bohannon soil types (14F, 38F, 44D and E, 46E and F) and location (at the easternmost end of the drainage system) raises the importance of greater sediment storage capacity in these upper-channel systems. Coarse sediment produced at the eastern end of the drainage falls out in the lower gradient portion in the west. The fine sediment continues to the main Coquille River and the ocean. For a more detailed discussion on sediment transport within stream channels see Section IV.

ANALYSIS QUESTION III.7.8

What effect does the current vegetative cover have on soil and erosion processes?

The current vegetative cover allows the yearly precipitation to infiltrate the soil, and to store this moisture for long-term release (in late summer). The forest cover provides organic matter, which initiates the nutrient cycling process. Fungi, bacteria, and larger soil arthropods make up a unique community that functions to breakdown and process the complex carbon and nitrogen components into nutrients, which become available for plant growth. The lack of either organic matter or soil biota can be a limiting factor for plant growth on some soils.

The analysis area supports a vast community of microbiological organisms and does not appear to be limited in function at this time. The level of compaction is low, forested areas have not been recently or catastrophically burned, and much of the public land base still supports late-successional communities.

There is a high level of surface protection from precipitation effects afforded soil by the current forest canopy. Road surface conditions are good, with a few dirt spurs in need of erosion protection measures. Little evidence of rill and gully erosion are present. Re-vegetation by shrubs occurs within one to three years in the lower elevations and two to five years in the upper portions of the analysis area. Once vegetation is reestablished, surface erosion does not readily occur on these protected land surfaces.

The root strength supplied by the forested stands provides stability and reduces the risk of mass movement (or landslide). Even though the November 1996 storm broke numerous daily and monthly rainfall records in coastal Douglas and Coos counties, this alone does not explain the large quantity (84) of fresh landslides identified in 1997. A combination of localized variations in storm intensity, geology, slope steepness, vegetation and land management factors resulted in the observed increased landslide frequency.

Robison *et al.* (1999) determined that the highest landslide rate occurs on very young forest stands (aged 0 - 9 years), and declines as stands get somewhat older. After age 30, the rate continues to decline until examining stands which are “mature” (100+ years old), where the rate again increases. If this pattern is accurate for the analysis area and no further large-scale actions disturb the landscape, it is reasonable to expect that in the near future slide rates will be lower on managed lands and higher on mature forests. Since most unstable areas were unloaded by the November, 1996 storms, landslide activity could be reduced in the foreseeable future.

ANALYTIC QUESTION III.7.9

What level of soil compaction exists?

The level of soil compaction was determined indirectly by using the GIS data base of road miles in the watershed. A total of 550.9 mi of road are shown in the GIS data base. These cover ≈1068 ac of the total watershed (85,783 ac). Road length was converted into acres by estimating the average road width as 16 ft.

The overall mileage value does not include old dirt spurs and cat trails. According to the GIS data base, these add at least an additional 79 miles. The condition of the majority of these old spur roads and cat trails is unknown, but can range from a hydrologically and vegetationally restored state to a severely degraded state. Also, their mileage is an estimate, as their existence is difficult to determine from aerial photos. Road history was not part of this analysis, so the exact acreage of these old spur roads and cat trails can be considered a data gap. No assessment of the recovery rates for these compacted surfaces was undertaken, as overwhelming problem areas were not evident during field review and the proportion of surface area impacted is low.

The average proportion of the land base subject to road surface compaction is 1.25%. It appears that the compaction effects are relatively evenly distributed throughout the analysis area, as the six subwatersheds show little difference (Table III.8). The relatively low proportion of compacted land in the Brewster Canyon subwatershed could be a reflection of the steeper slopes in this drainage than in the other subwatersheds.

Table III.8
Percentage of Compacted Lands due to Roads by Subwatershed

SUBWATERSHED	FEDERAL	ALL
Upper East Fork Coquille	1.65	1.71
Brummit Creek	1.06	1.11
Lower East Fork Coquille	1.27	1.26
Brewster Canyon	1.01	0.90
Elk Creek	1.02	1.24
Camas Creek	1.17	1.38

The type of logging system used also influences subsequent compaction percentage, and thus the amount of surface water runoff. Harvest systems using tractors have been found to compact between 20-40% of the ground surface, while compaction from cable systems is much lower, about 8% (Cromac *et al.* 1978). Minor changes in stream flow rates have been noted by Megahan (1987) when the level of compaction exceeds 12%.

The Upper East Fork and Camas Creek subwatersheds have been extensively harvested using tractor-type systems. Sampled areas in these subwatersheds indicate compaction levels between 8-13%. These two subwatersheds could be most sensitive to future increases in compaction levels.

The level of compaction in the other four subwatersheds does not to appear to approach limits suggested by Megahan (1987), for several reasons. The terrain does not lend itself to indiscriminate “loggers choice” type development of skid trails. The length of time since these trails have been created has allowed some recovery of the compacted surfaces. Trees growing adjacent to the trails appear to show few signs of stress resulting from compaction. This makes it difficult to determine from aerial photographs if compaction is occurring in these areas. It would require compaction of at least 6% of the area to observe large-scale runoff during storm events and no such areas or damage resulting from such events have been observed, either on the ground or on aerial photos (Jackson and Haveren 1984).

Compacted surfaces are thus estimated to be between three and five percent of the total watershed. This is based on the amount of land as roads and harvested trails from all types of timber removal systems.

SYNTHESIS AND INTERPRETATION

ANALYTIC QUESTION III.7.10

What are the management objectives to restore natural rates of erosion and sediment delivery on Federal lands?

- Minimize management-related landslides.
- Employ "Best Management Practices" for surface and channel erosion control when building new or maintaining old roads.
- Coordinate with BPA on maintenance of access roads that are likely to bleed.
- Implement the TMO recommendations for road closure/improvement on those roads identified as sediment sources or otherwise preventing/retarding attainment of ACS objectives.

III.8 - HYDROLOGIC PROCESSES

Forest hydrology is the study of the occurrence, movement, and distribution of water across forested watersheds, as affected by soils, geology, land form, vegetation and climate. Rainfall (most of which becomes runoff) drives hydrology. Precipitation events interact with land form, soil, geology, and vegetation. The interaction affects hydrological characteristics such as floods, frequent discharge, low flow, and distribution of flow.

REFERENCE CONDITIONS

ANALYTIC QUESTION III.8.1

What were the historic hydrological characteristics (e.g., peak flows, minimum flows) and features?

Current hydrologic conditions include rapid runoff because of the shallow soils, limited soil water storage, and bedrock units resisting groundwater accumulation. Peak flows depend on the occurrence of frontal storms. Historic hydrological conditions were similar, although fewer roads and regeneration units, and greater channel complexity (LWD and beaver dams) may have slightly delayed flows compared to current conditions. Annual flow and yield likely were less due to dense conifer/hardwood forests. High evapotranspiration may have lowered minimum flows, but in-channel water storage was greater.

CURRENT CONDITIONS

ANALYTIC QUESTION III.8.2

What are the morphological characteristics and processes?

The Rosgen Stream Channel Classification (Rosgen 1996) system is used to group similar hydraulic and morphologic stream features. The text "Applied River Morphology" (Rosgen

1996) explains this classification system in detail. Rosgen stream types in the analysis area (Appendix A - Map A.11) include:

Very High Gradient Channels, Rosgen Aa+ Stream Types

The Aa+ stream types are very high gradient (>10%), V-shaped, erosional, straight, channels. Aa+ stream types are found at the upper ends of drainages in dissected topography. These channels usually are 1st order streams.

High Gradient Channels, Rosgen A Stream Types

The A streams types are high gradient (4-9.9%), V-shaped, erosional, straight channels which lack a flood plain. They are found at the upper end of drainages. Many are confined by bedrock channels and steep banks. They are usually 1st and 2nd order streams.

Type Aa+ and A streams in mature (old-growth) timber stands are representative of the historic condition.

Moderate Gradient Channels, Rosgen B Stream Types

The B stream types are moderate gradient (2-3.9%), slightly meandering, step/pool streams with no, or very limited, flood plains. B types have larger drainage areas, greater flows, and most are 3rd or 4th order perennial streams. Few reference areas remain in the analysis area. This channel type contained steps formed by large woody debris (LWD) that dissipated stream energy and prevented lateral adjustment or bankcutting. Embedded LWD spanning the channel created low velocity flats onto which sediments were deposited for long term storage.

Low Gradient Channels, Rosgen C and F Stream Types

C stream types are low gradient (< 2%), meandering, wide, slightly entrenched to entrenched, pool/riffle streams with adjacent flood plains. They have large watershed source areas and usually are 4th order or greater streams located lower in the drainages. Most C channels are perennial; found in flats which develop upstream of channel restrictions (e.g., narrow valley widths, partial debris dams, etc.) or in alluvial valleys. These channels dissipate energy by meandering and flowing over rough material along the bank and streambed. The probable historic condition for these channel types included narrow streams which overflowed the stream bank and used the flood plains during floods. Their stream banks were stabilized by root masses including myrtle, maple, cedar and other tree species. Greater numbers of LWD were in these channel types, but living trees provided bank stability and were more important than the influence of log steps. These channels dissipate energy by meandering and flowing over roughness elements along the banks and streambed.

Beaver dams and high densities of LWD in log jams are thought to have contributed a larger role in maintaining pools and storage of water in the channel. This water would slowly be released during the summer low flow period.

F stream types are similar to C types, but are vertically lowered and have no flood plain. Historically, this stream type was probably absent in the analysis area.

ANALYTIC QUESTION III.8.3

What are the dominant hydrologic characteristics and other notable hydrological features and processes?

Overland flow seldom is observed in the Coastal forests, except from compacted sites such as roads and landings. Nearly all runoff occurs by soil infiltration and subsequent subsurface routing to streams. Infiltration capacity exceeds two inches per hour due to the low water storage capacity (because of shallow, coarse-textured soils and impermeable underlying bedrock). This infiltration rate is much greater than the hourly rate for the most intense storm likely to occur in this area (four inches in six hours) (NOAA 1973).

Stream networks expand during storms, especially storms continuing for several days to weeks. As the soil becomes saturated, live flow reappears in low-order intermittent channels. Estimates made from precipitation and stream flow records show total runoff as about 70% of annual precipitation. The remaining percentage is lost to soil recharge, transpiration, and evaporation. Steep slopes and stream gradients combined with low groundwater storage capacity cause quick hydrographic response and flashy flow after the onset of rain. Stream hydrographs for an individual storm event underscore this short lag-time with a steep rising curve and rapid recession (Figure III.4).

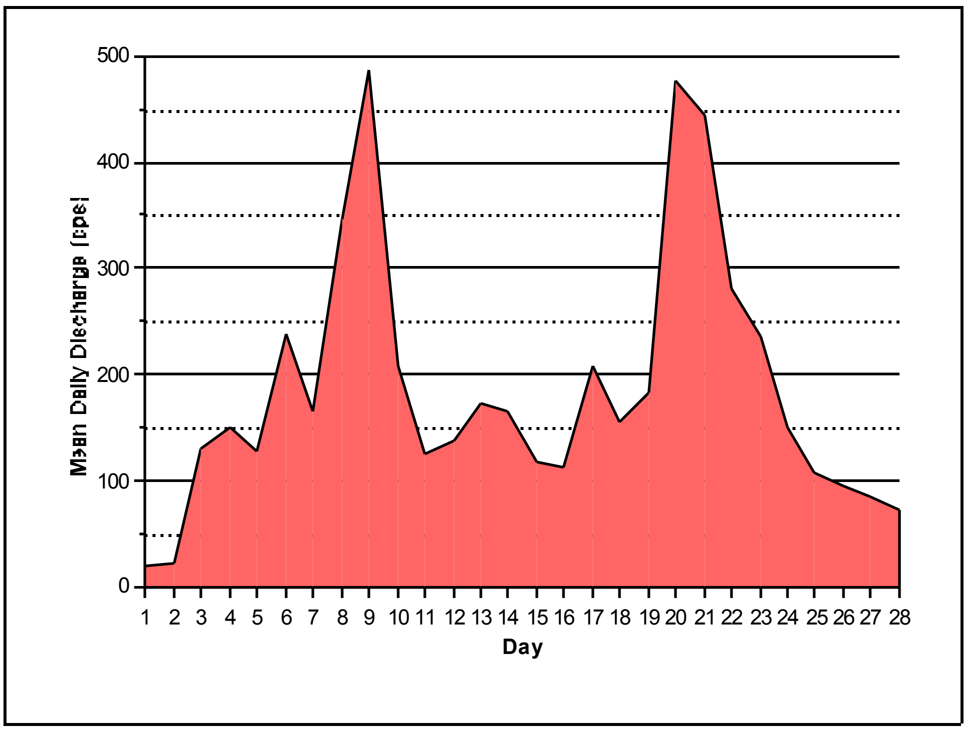

Figure III.4. Typical storm event hydrograph (West Fork Brummit Creek, Nov. 25 - Dec. 22, 1995).

Low flow volumes in the watershed are typical of Coast Range streams (Wellman *et al.* 1993). Bank-full flow is estimated at 6,000 cubic feet per second (cfs), extreme flood flows at greater than 20,000 cfs and low flows at 6-10 cfs. Annual yields are estimated at 306 thousand acre-ft./year.

Several characteristics are used to describe the hydrologic nature of the analysis area. These include; peak flows, annual flow and yield, flow distribution, and minimum flow.

Peak Flows

Runoff is described as instantaneous peak flow in cfs, as calculated from a flood frequency curve or estimated by other methods. Annual peak flow for a given drainage is highly variable from year to year. A frequency analysis establishes a relationship between the magnitude of the flood and its return period.

The BLM has maintained a gaging station on lower West Fork Brummit Creek (10 mi/mi^2 drainage area) since 1986. Bankfull discharge has not been determined and correlated with station stage (flow level) readings. Also, there are too few flow measurements taken at high flows to extend the rating curve or complete a flood frequency analysis. Therefore, bankfull and over-bank flood flow frequencies were estimated using a basin characteristic method (Harris *et al.* 1979). Results are summarized in Table III.9.

Table III.9
Bankfull and Extreme Streamflow Rates (cfs) by Subwatershed

SUBWATERSHED	2 YEAR FLOW ESTIMATE (NEAR BANKFULL)*	100 YEAR FLOW ESTIMATE (OVERBANK)*
Lower East Fork Coquille	2,030	4,930
Elk Creek	1,226	3,042
Brewster Canyon	2,105	5,108
Brummit Creek	1,916	4,666
Camas Creek	1,765	4,313
Upper East Fork Coquille	1,606	3,940
Total Watershed	**9,915**	**22,555**

* Harris *et al.* 1979

Estimates for each subwatershed are similar in predicted high flow runoff response (i.e., bankfull discharge is 74 cfs/mi^2, while extreme discharge is 168 cfs/mi^2.) This is because the six subwatersheds have similar drainage areas, and high flows are strongly correlated with drainage area in the Coastal region. Bankfull flow, with a recurrence interval of 1.5 to 2.0 years, ranges between 1,200 and 2,100 cfs. Floods with a recurrence interval of 100 years range between 3,000 and 5,100 cfs. The effective discharge (the flow that maintains the channel and moves the most sediment in the long-term) is closer to the bankfull flow. Descriptions of historic floods with a 20-year return frequency or greater, can be found in Appendix C.

Snow can accumulate in the higher elevations (above 1,800 ft.), but it is temporary, lasting a few days to weeks each winter (Appendix A - Map A.12). Warm winds and rain (Chinooks) usually melt any snow pack rapidly. Snow accumulates and melts faster in openings than in the surrounding forest. This process can increase peak flows, depending on drainage factors and vegetative age, structure, and composition. Upper East Fork Coquille, Camas Creek, and Brummit Creek subwatersheds are most susceptible to this phenomenon since 88%, 75%, and 61% of these drainages (respectively) can retain snow for short periods.

Interviews with local residents suggest that 1955, 1964, 1971, and 1996 were the worst flood years in the recent past.

Annual Flow and Yield

January produces the highest monthly runoff, with approximately 60% of the annual runoff occurring between December and February (Figure III.5). June through October contribute only 4% of the annual runoff which results in very low stream flows. The annual runoff distribution very closely follows the precipitation pattern.

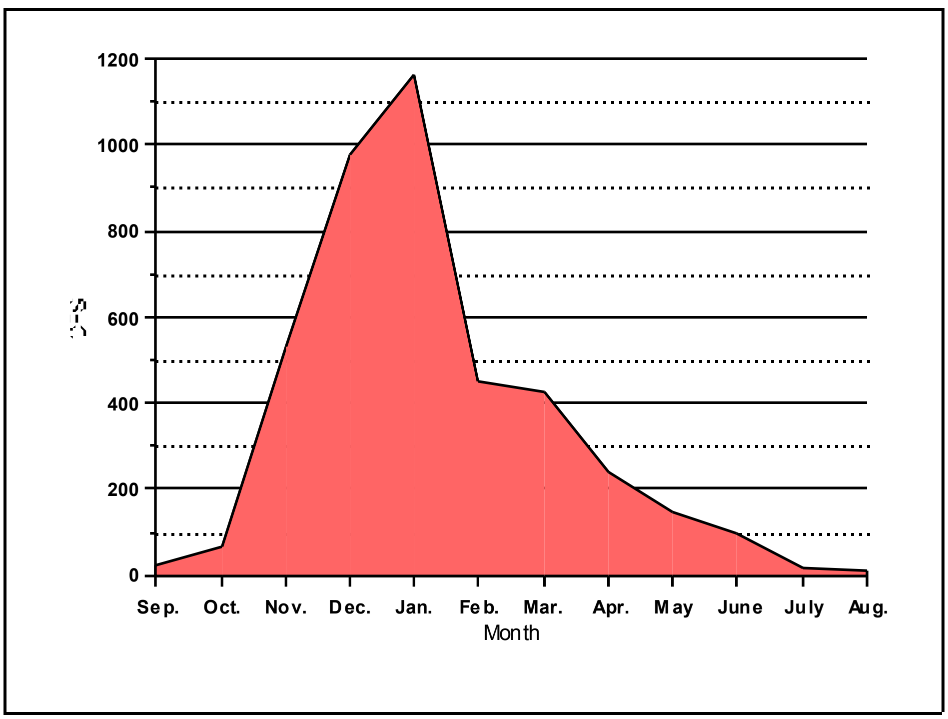

Figure III.5. Mean monthly flow (derived from USGS Gauge Station 14327000).

Flow Distribution

Figure III.6 illustrates how flow duration is distributed throughout the year. Large to extreme flows occur less than 5% of the time, moderate flows occur 45% of the time, and low flows occur half the time. Channel formation is accomplished by flows which fill the channel to bankfull or beyond, while channel dimensions are maintained by frequent flows (flows near or less than bankfull).

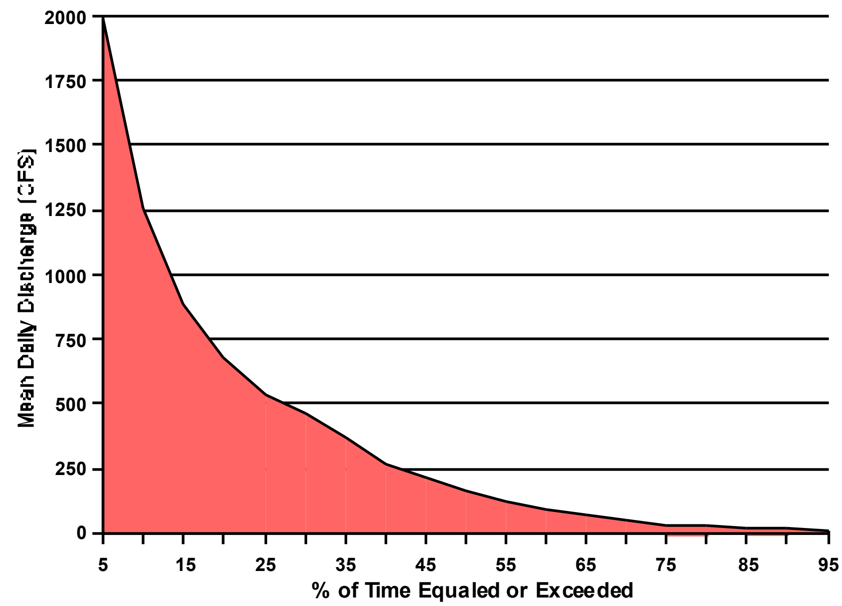

Figure III.6. Daily flow duration (based on USGS Gauge Station 14327000).

Minimum Flow

Typically, a stationary high pressure system develops over the northwest in the summer. This forces storms north, causing dry conditions and extremely low stream flows mid-August through October. Figure III.7 shows the magnitude and frequency of low flow in the East Fork Coquille watershed. (Please note these are estimates of the lowest flows in East Fork Coquille for a consecutive seven day period for the indicated return period or years. This estimate does not consider flow which becomes subterranean further down the channel.) The average 2 year, 7-day, low flow is about 0.085 cfs/mi^2 and <0.095 cfs/mi^2 for consecutive periods of up to 30 days.

Information from the USGS stream flow gage (#14325000) near Powers, OR was used because it provides 80 years of record. It indicates significant seven-consecutive-day, low flows occurred September - October in 1931, 1933, 1939, 1974, 1987, 1991, 1992, and 1994. It is likely that low flows also occurred during these years. The return period is 20 years or greater for these seven-day, low flows. The low flows in 1933, 1991, 1992, and 1994 were 100 year events (Wellman *et al.* 1993). During these periods, there was essentially no flow.

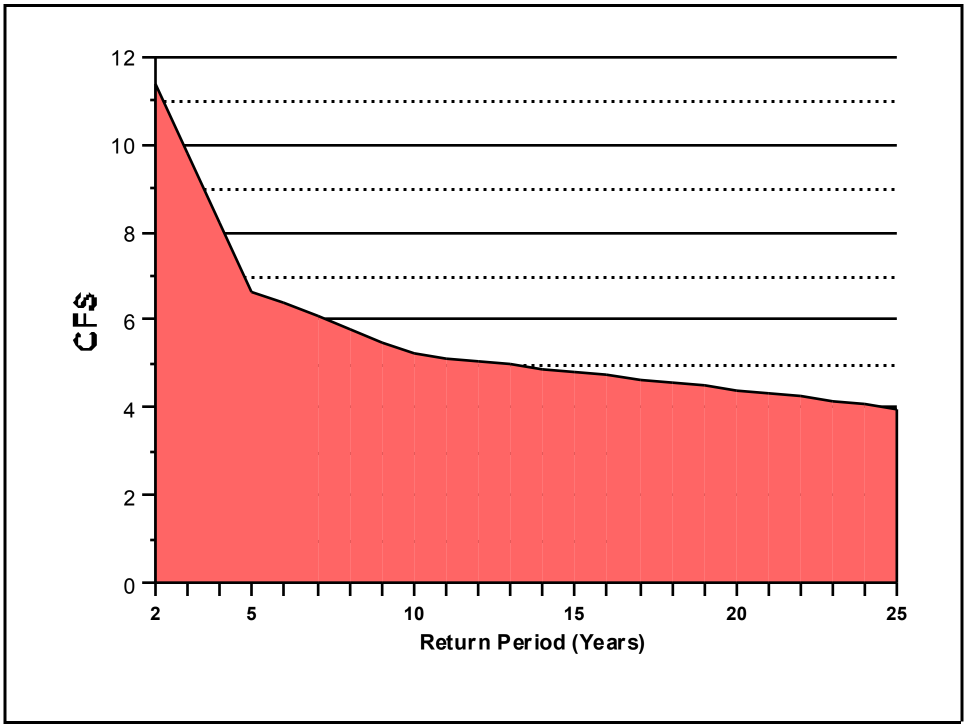

Figure III.7. Magnitude and probability of annual low flow (derived from USGS Gauge Station 14327000).

Many headwater (1st order) streams are formed on coarse-textured, highly-permeable soils and dry up as the summer progresses. Streams originating from seeps and draining fine-textured, deep, high-porosity soil types have very low, constant flows, but may have in-channel “dry spots” in late summer. Higher order channels may have pools in late summer, but little live flow. During the summer/fall period, live stream flows are so low they are measured in gallons per minute. Stream flows actually may increase slightly at night, because evapotranspiration demand is at its lowest point.

ANALYTIC QUESTION III.8.4

What are the current conditions and trends of stream channel types and sediment transport and deposition processes prevalent in drainages?

The Aa+, A, and B stream types rapidly transport coarse and fine sediments because of their steep gradients. Their drainage areas are usually small, so stream flow normally is low and most of the sediment is carried only in a few storms each winter. The debris flow process, although infrequent, is the most important transport mechanism of coarse and fine sediments in these stream types. Brummit Creek and Brewster Canyon subwatersheds show the highest evidence of these channel torrents from natural conditions and road failure at channel intersections (see Section III.7). Mid-slope roads (acting as interceptors), channel constrictions, LWD, and debris torrent deposits slow the routing process. As depressions behind obstructions are filled by sediment, an equilibrium is reached. Incoming sediments then will be held in suspension and moved downstream during the frequent flows. Sediment stored behind LWD or in debris fans remains in storage for long periods. It can be mobilized again when the organic debris decays or a flood flow rearranges channel debris.

The active channel dimensions of low-gradient C channels are maintained by the frequent flows. These channels are unconfined at flood stage and entrained sediments are deposited on adjacent lateral flood plains. Coarse and fine sediments cannot be held in suspension in slow-moving flood water that has spread out across flood plains covered by vegetation. C channels tend to be fairly stable. Aggradation will occur at moderate flows if chronic or frequent pulses of sediment from upstream activities overwhelm the transport capability of the stream. With an excessive sediment supply, high flows build up the flood plain, however, the C channel retains its approximate channel dimensions, but at a higher base level in the valley. Pebble count information shows sand/silt/clay particle sizes range between 5-28% of the surface bed material for C-type streams. Although the sediment supply is moderate to high, the surface streambed armor layer does not appear to be overwhelmed with fine sediments. It appears that sediment transport is flow limited rather than supply limited because a large percentage of coarse and fine sediments are near the bankfull stage at the margins of the active channel.

F channels have converted from C-types, including much of middle and lower East Fork Coquille. These are low-gradient, entrenched, moderate-width channels. Cycles of scour and fill and movement downstream will continue in these channels at moderate flows. When the cross-sectional area widens enough that water velocity decreases, sediments will be deposited during frequent or high flows. In this way the river builds a new flood plain within the entrenched channel.

Bank erosion, particularly in entrenched B and F channels, contributes sediment to the stream system. During high flows, a larger channel is required to convey the discharge and dissipate the high stream energy. The removal of LWD in B channels has allowed many to downcut to bedrock leaving no way to reduce the water velocity in plunge pools. Consequently, the channel adjusts laterally, cutting away the streambank and causing sediments to be entrained in stream flow.

F-type channels also exhibit bank cutting during frequent flows. This is most evident on the outside of bends where stream flow is cutting into banks below tree roots. Brush and trees on the banks above the entrenched channel can slow, but not stop this widening process.

ANALYTIC QUESTION III.8.5

What effect does the current forest cover have on hydrologic processes?

Annual water yield typically increases as a result of timber harvest and road building (Ziemer *et al.* 1996). This increase results from reduced evapotranspiration following the removal of forest trees. Table III.10 shows forested acres converted over the last 25 years. Immature timber stands use water at less than potential transpiration rates. The increased annual runoff in the analysis area is not known, but is suspected to be in the range of 10-20%. Due to increased evaporation and soil water storage on cleared land, not all additional water is available for runoff. As forest vegetation reaches hydrologic maturity (≈20-40 years old), water yields begin to decline.

Forest vegetation modifies the distribution and retention of snow and affects the timing of runoff. Snow accumulates and melts faster in openings than the surrounding forest.

Table III.10
Converted Forest Stand Acreage by Subwatershed

SUBWATERSHED	BLM STANDS WITH BIRTHDATES AFTER: (ACRES)			PRIVATE STANDS WITH BIRTHDATES AFTER: (ACRES)			NEW STANDS (%) IN SUBWATERSHEDS BY DECADE CLASS*		
	1960	1970	1980	1960	1970	1980	1960	1970	1980
Lower EF Coquille	1,869	2,965	8	415	5,092	2,778	14	49	17
Elk Creek	203	2,234	77	327	2,759	0	5	51	1
Brewster Canyon	650	1,113	86	1,159	4,819	3,141	11	34	19
Brummit Creek	1,576	2,676	1,063	1,377	2,261	2,236	19	32	21
Camas Creek	2,355	1,981	1,007	4,494	1,672	561	48	26	11
Upper EF Coquille	1,776	1,687	1,018	250	3,491	2,463	16	40	27
Total Watershed	**8,429**	**12,656**	**3,259**	**8,022**	**20,094**	**11,179**	**19**	**38**	**17**

* Includes percent of forest stands with birthdates after the selected year through 1997.

SYNTHESIS AND INTERPRETATION

ANALYTIC QUESTION III.8.6

What are the natural and human causes of change between historical and current hydrologic conditions? What are the trends?

Extreme Flood Flows

Little evidence exists to determine whether forest management activities have had an effect on the infrequent peak flows in the precipitation-dominated Coast Range. Watershed studies in the northwest show that following road building and timber cutting, peak flows may increase, decrease or remain unchanged. The magnitude of the change varies from a 36% decrease to 200% increase and depends on specific watersheds and storm factors (Reiter and Beschta 1995). Harvest in the Upper East Fork Coquille subwatershed may increase peak flows if enough area in the intermittent snow accumulation zone is less than 20-40 years old.

Extreme flood flows (>20-year return frequency) are the result of natural weather patterns and flashy watershed response. Forest management has had little to do with significantly increasing the magnitude of these events (Harr *et al.* 1975).

Frequent and Moderate Flows

Minor increases in the amount of daily flow in the spring and fall may result following harvest activities. This is because younger vegetation transpires less water and allows more water to route to the stream channel. This increase is usually considerably less in magnitude than the frequent flows (those flows that occur several times each winter, but are less than the annual high flow) and has little effect on overall flow.

Frequent flows and the bankfull flow (return period of 1.5-2 years) are responsible for maintaining channel dimensions and moving most of the sediment load. Major channel adjustments have resulted from infrequent extreme flood flows. Studies have shown that relative differences in peak flow between cut and uncut areas are less as storm magnitude increases. In one study, after harvest, the first large storm of the rainy season increased peak flows by 40-200%, average annual peak winter flows increased up to 24% and flows large enough to cause significant out of bank flooding did not increase (Rothacher 1973).

Annual Yield

Annual yield has increased in the analysis area. The level of increase is not known, but suspected to be ≈10-20%. It can be inferred from Table III.10 that the watershed vegetative condition is recovering, after a period of high regeneration harvest during the 1970s and early 1980s. As young, pole-sized stands become more efficient at transpiring water, annual yield will decline to natural levels.

Timing of Flows

Forest management can have an effect on the timing of flows. Reduced transpiration from trees <40 years old results in increased soil moisture content. As fall rains occur, less precipitation is needed to saturate these soils and the excess water enters the stream system. This process results in a small rise in streams levels earlier in the year than under undisturbed conditions.

The response time of streams to storms has always been "flashy," because of limited soil and groundwater storage. It is thought that roads and clearcuts in a watershed act additively in advancing timing for a particular storm (Jones and Grant 1996). Roads and ditch lines may act as extensions of the stream network, channeling precipitation directly into the stream system (Wemple 1994). Mid-slope roads could be intercepting subsurface flow. These factors could result in a quicker rise and fall of the stream flow than occurred in the past. Runoff from compacted areas can also advance this timing in tributary streams, however, compaction in the analysis area is thought to be low (refer to Table III.8).

Minimum Flows

Average two-year recurrence interval, 7-day low flow is about 0.085 cfs/mi^2, and less than 0.095 cfs/mi^2 for consecutive periods of up to 30 days. These values are typical of Coast Range streams. Extremely low flows (those with greater than a 20-year return interval) have occurred eight times in this century, with notable lows in 1933, 1991, 1992 and 1994. During these periods, there was essentially no live flow.

The magnitude of low flows undoubtedly has been increased by regeneration cutting in the watershed (Harr and Krygier 1972, Harr *et al.* 1979). However, species conversion to hardwoods (that are more efficient at transpiring water during the summer) and changes in stream channel condition may have diminished these increases. Removal of beaver dams and log jams probably has had the main effect on reducing in-channel storage that formerly augmented naturally occurring low flows (Olson and Hubert 1994). Beaver dams functioned to release water slowly over the summer and probably supplied cooler water due to thermal stratification in the deeper pools. Management activities that change riparian areas from conifer to hardwood could have some effect on reducing flows during the low flow period, because of increases in the transpiration rate (Hicks *et al.* 1991).

Summer flows result from the release of subsurface water. This is primarily dependant upon soil types, soil depths, and porosity. The soils and geology in the watershed do not allow for the retention of much water.

Trends

As young timber stands age and become more efficient at transpiring water annual yield will decrease. The maturation of forests may also diminish the magnitude of frequent flows. Extreme peak and minimum flows are dependant on climatic patterns.

ANALYTIC QUESTION III.8.7

What are the management objectives for hydrologic processes on Federal lands?

The management objectives for the hydrologic processes on Federal lands are:

- Continue forest management and other activities in a way that minimizes the risk of increased peak flows or altered runoff timing.
- Encourage activities that retain or increase flows and pool volume during the ‘low-flow’ summer months.
- Protect existing domestic water users, source areas, and transmission lines under the ACS strategy.
- Provide uninterrupted supplies of high quality water at the boundaries of BLM-administered lands for maintenance of instream flows, and beneficial consumptive uses.

III.9 - DISTURBANCE PROCESSES

REFERENCE CONDITION

ANALYTIC QUESTION III.9.1

What naturally caused disturbances occurred and how extensive were they?

At the most elemental level, all of the naturally occurring processes affecting vegetation can be related to:

- Climatic conditions (rainfall, length of growing season, temperature, and humidity.)
- Extreme weather (extreme drought, strong winds, and high intensity storms.)
- Geology (nutrient and water availability, and topography.)

The disturbance processes historically at work in the assessment area are categorized below. More information on ecological processes including disturbance can be found in Appendix D.

- **Extensive disturbances that cause stand replacement:** severe fire, large-scale blow down, and clear-cut logging.
- **Extensive disturbances that modify existing stands:** moderate severity fires.
- **Fine scale disturbances that create gaps and patches:** blow down, low severity fire, insect, disease, snow break, and soil movement.
- **Biological processes, including:** succession, vegetation competition, and suppression mortality.

Fire

Fire was the most important disturbance process affecting landscape pattern in the watershed. Fire can be a primary stand replacing disturbance or can influence stand structure and composition. A fire history of the East Fork, up to the present, can be found in Appendix E. Topography strongly influences fire behavior. A description of the interaction of topography and fire on landscape patterns is presented in Appendix F.

The following fire history for the East Fork Coquille Watershed is based on visits to 14 regeneration units where annual rings were counted on 153 stumps. Fire histories prepared for adjacent drainages supplemented this data and put the East Fork Coquille watershed fire history into a larger context. The process used to analyze the data is based on work by Morrison and Swanson (1990).

This fire history is the result of a reconnaissance survey. The sample size and distribution are too small to map out fire boundaries or to sample all fire occurrences. The probability of the data detecting a fire is proportional to the sample size and distribution of plots, and the size of the fire. Small fires are likely under represented in the sample, and some large fires at the extreme east and west ends of the watershed may have not been detected.

Fires, indicated by scars and regeneration pulses, usually occurred in clusters or episodes separated by periods of low fire activity. Those periods were the years:

- **1534-1590** - This complex of stand replacement fire(s) and re burns burned most if not the entire watershed.
- **1735-1798** - These fires were stand replacing events on the west end of the watershed and modified stands on and near the north-central rim.
- **1845-1868** - These fires modified stands in the western and middle parts of the watershed by setting back the shrub layer and opening the over story. That allowed establishment of the under story hemlock stands in the watershed. These fires were stand replacing events on those sites that now support single story one and two cohort late-successional stands.
- **1912-1936** - The fires from 1912-1932 burned in the Brummit Creek drainage and on land to the north of the watershed. These fires prepared the site for understory hemlock regeneration on many upper slope sites and for the establishment of several ridge top single story Douglas-fir stands. The 1936 Sitkum Fire burned the Sitkum Valley/ Brewster Rock area and was one of several fires that burned concurrently with the Bandon Fire.

Large stand replacement fires are associated with periods of severe regional drought (Heinselman 1983). Regional drought conditions could explain why several fires observed in the watershed occurred about the same time as fires in the Klamath, Cascades, Olympic and Rocky Mountains (Franklin and Hemstrom 1981, Heinselman 1983, Agee 1991).

On average, fires occurred every 21 years between 1534 and 1936 at the watershed scale. If only large fires are considered (those documented on at least three sites, including sites in adjacent watersheds), the average time between fires is 31 years. The occurrence and distribution of fires are unpredictable, so using an average is inappropriate. However, an average does indicate that disturbance was extensive in the watershed over time.

At the watershed scale, the longest time between known fires is 112 years and the shortest is four years. At the site scale, the shortest period between fires is four years. No fires were detected at a site in Knepper Creek since the stand initiation event in or before 1626. That suggests the longest period between fires, at the site scale, is more than 372 years.

Documented fires since 1931 are shown on Map A.13 (in Appendix A), and presented (by decade) in Table III.11. It can be seen that only 11% of the fires documented were lightning caused. For additional information on fire history and fire frequency in this watershed refer to Appendix E.

<u>Wind</u>

Winter windstorms are common disturbance agents in the Coast Range. Windstorms usually cause fine scale disturbances. Occasionally, winds blow down tens even hundreds of acres during a single storm causing stand replacement.

Severe winter storms originating offshore regularly hit this region with heavy rains and strong winds. Warnings for wind speeds of 60-80 mph on the headlands are made in most years. Most winter storms come out of the southwest quadrant. If the winds come more from the west than from the south, they are strongest on the coast and decrease in strength inland. Thenorth-south orientation of the Coast Range slows these winds through surface roughness. The most destructive winds come from the south and blow parallel to the ridges. Wind gusts to 150 mph and sustained winds of 110 mph occur on exposed ridges at intervals of five to 10 years (PNWRBCMC 1968).

Table III.11
Modern Fire Frequencies and Extent by Decade

DECADE	LIGHTNING		MAN CAUSED		TOTAL	
	# OF FIRES	ACRES	# OF FIRES	ACRES	# OF FIRES	ACRES
1931-1939	0	0.00	30	11,868.02	30	11,868.02
1940-1949	2	6.05	7	776.02	9	782.07
1950-1959	1	0.30	10	540.57	11	540.87
1960-1969	3	0.55	18	116.31	21	116.86
1970-1979	2	8.00	15	94.23	17	102.23
1980-1989	4	0.51	15	21.56	17	22.07
1990-1996	2	0.05	10	82.01	12	82.06
TOTAL	**14**	**15.46**	**105**	**13,498.72**	**119**	**13,514.18**

The distribution or occurrence of blowdown is unpredictable beyond the following generalities:

- It usually occurs when soaking rains are followed by strong winds.
- Trees along edges facing prevailing winds are more susceptible than those on edges at angles to the wind (Alexander and Buell 1955).
- Corners and gaps downwind of clear-cuts[2] or other canopy openings are vulnerable because the wind accelerates as it funnels into constrictions (Smith 1962.)
- Blowdown is most likely to occur on the lee side of sharp ridges and on the windward side of gentle slopes.

Examinations of timber sale records reveal that very little extensive blowdown has occurred in the watershed. Storms that hit the South Coast in Nov. and Dec. 1951[3] resulted in widely scattered, small patches of blow down. Most of the data describe blow down as ranging from a

[2] For further discussion on stand level attributes and individual tree characteristics that affect the risk of blowdown see Smith (1962) pp. 413-414, 422, and 499; Oliver and Larson (1990) pp. 100-106; Agee (1993) pp. 9.

[3] The Coos Bay BLM office had only been established a few years before the 1951 storms. According to John Lanz, a retired BLM employee, the salvage effort that followed the 1951 storm made it necessary to hire additional staff and that made the shift from custodial management to timber management on the District possible. In 1952 the USFS and BLM jointly undertook an aerial survey looking for both blowdown and insect infestation covering all ownerships. Blowdown was mapped on topographic maps by George Francis and John Lanz, both now retired from the BLM. If information on blowdown occurrence is pursued in a future watershed analyses, it would be worth while to relocate this data.

couple of trees to 200 MBF, generally less than 10% of each timber sale. The notable exception was a sale in T28S, R11W, Section 17. Thirty four percent of this sale (1,385 MBF) was blowdown.

Of all recorded storms, the 1962 Columbus Day storm[4] had the largest impact. Two resulting sales contained a total of 6,700 MBF where downed material comprised 54% and 50% of each sale volume. These sales, located in T27S, R11W, Section 35, and T28S, R11W, Section 3, are within a couple of miles from the 1951 storm sale.

The Nov. 10, 1975 storm resulted in only one large blow down area. This sale (76-29) was in T28S, R8W, Section 7, where the East Fork Coquille River valley funnels toward the upper boundary of the analysis area. New blowdown (3,500 MBF) comprised 28% of this sale.

It appears that most of the analysis area is not susceptible to a large-scale blow down. Possibly the ridge systems to the south (Bone Mtn., Eden Ridge, White Mtn.) offer some protection. The northwest portion of the area may be the most susceptible to wind storms.

Snow Damage

Snow damage is uncommon below 1,800 foot elevations. Elevations above 1,800 ft. can be found around the perimeter of the eastern half of the watershed (see Appendix A - Map A.12).

Early, wet snow falling on leafed-out hardwoods results in snow break. Repeated snow breakage can release conifers from over topping red alders and may be a reason alders were a minor component in stands above 1,800 ft. before road construction or logging. Heavy wet snow can also damage conifers, particularly recently commercial thinned wild stands that had not been pre-commercially thinned. Trees in these formerly dense stands have small branches and stem diameters relative to their heights making them vulnerable to breakage when overloaded with wet snow or ice.

Snow damage may be a selection mechanism acting on the genetically controlled aspect of crown shape. Young stands with natural fill-ins on sites above 2,100 ft. have many trees with a narrow candle-like crown form. The narrow crown form of Douglas-fir is most often observed on the ridge reached by the Middle Fork Brummit Creek Road. This form is similar to that of mountain hemlock and subalpine firs. The narrow candle-like form is believed to be an

---

[4] The October 12, 1962 storm, commonly called The Columbus Day Storm , developed off the coast of California. It approached the coast from the southwest and then turned so that it came directly out of the south when the storm hit the Oregon Coast. Some official reports for sustained wind speeds and peak gusts are Astoria 44 and 96 mph, Eugene Airport 63 and 86 mph, Troutdale 66 and 106 mph, and Salem Airport 58 and 90 mph (PNWRBCMC 1968). Winds reached 152 mph at the Air Force radar station at Houser (The World Newspaper 12, 1995). The barometric pressure measured at the North Bend Airport was 28.42 (The World Newspaper 12, 1995).

The Coos Bay District laid out and sold several large timber salvage sales as a result of this storm. A partial list of those sales includes 113 acre Sale No. 66-45 on Wilson's Folly Creek in the Tioga Subwatershed, the Yankee Run Salvage Sale No. 63-32, 129 ac and the 186 ac Sale No. 65-36 in Skeeter Camp. The last two sales were in the East Fork Coquille Watershed. The Wilson's Folly unit is on an east facing slope in a canyon where the creek flows S20°W. Similarly, the Yankee Run blowdown was on an east facing slope adjacent to the creek, which flows in a S10°W to S30°W direction. The Skeeter Camp unit is on a ridge top. There were many other large and small salvage units, and there is still blowdown from that storm on the ground today. A witness who was trapped out in the storm on a landing in the Yankee Run area told of watching old growth tree crowns being spun around by the wind causing the bole to be twisted in two. The wind then lifted the tops up and carried them for some distance before the tops finally fell to the ground (the witness's name was not recorded).

adaptation for shedding snow, thereby avoiding snow break. In contrast, most all low elevation Douglas-firs have broader crowns[5].

Disease and Insects

These agents often work in concert and modify stands by initiating gaps or patches. They only rarely cause stand replacement. These agents include:

Disease

Laminated root rot (*Phellinus weirii*) and black stain disease (*Verticicladiella wageneri*) kill patches of sapling and pole size trees. The laminated root rot causal agents can survive up to 50 years in buried debris and stumps. It is transmitted through root grafts and by root contact with infected debris. Black stain disease is more closely associated with managed forests. It kills conifers on inherently stressful sites impacted by compaction or loss of top soil. Black stain disease is a management concern. It can be controlled by reducing stress to plantations, and timing treatments to avoid attracting the insects that vector the disease. *Armillaria* root disease is occasionally observed in westside forests. Within the Coos Bay District, the few confirmed cases were on tractor damaged soils.

Insects

Insect attack is a secondary disturbance in the Coast Range forest. The following discussion is based on a personal communication with Don Goheen, of the Southwest Oregon Forest Insect and Disease Technical Center. The Douglas-fir bark beetle (*Dendroctonus pseudotsugae*) and Douglas-fir engraver (*Scolytus unispinousus*) attack stressed trees and fresh blow down. The Douglas-fir bark beetle is more economically significant because it attacks large trees. Douglas-fir engraver attacks are limited to the tops and branches of large trees, and to small trees. Black stain disease is the primary cause of stress that predisposes small trees to Douglas-fir engraver beetle attack in the watershed.

Douglas-fir bark beetle epidemics are rare in the Coast Range, occurring after large blow down events. The two biggest bark beetle epidemics occurred in response to the 1951/52 windstorms and the 1962 Columbus Day Storm. The epidemic of 1952/53 was the biggest, due to the back to back windstorms combined with the lack of a road system for aggressive salvage logging.

Individual Douglas-fir bark beetle attacks are not successful against healthy Douglas-fir. It takes beetles emerging from three to four wind thrown trees to kill a single standing green tree. The Burnt Mountain Unit Resource Analysis (USDI 1978) describes normal bark beetle attacks as limited to clumps of a dozen or fewer trees widespread through the forest. The clumps are likely to be laminated root rot centers. Bark beetles cause weakened standing trees to die creating snags inside root rot pockets.

Defoliator insects have not caused significant economic damage to Coast Range forests. However, wooly aphids caused considerable grand fir mortality in the lower East Fork Coquille

---

5 An alternate explanation is that the narrow crown form may be less reflective of what is necessary to survive today and be more an indication of the selection pressures controlling tree establishment and survival at the time the dominant seed source regenerated. The dominant Douglas-fir seed source on the north rim of the East Fork Coquille Watershed, where narrow crown trees are most commonly noted, is old growth that regenerated in the 1500s towards the end of the Little Ice Age.

watershed during the late 1960s. Grand firs are less prominent in low elevation valley sides and riparian zones today.

Landslides

Landslides usually affect small areas, but the severity of the disturbance can be very high. Landslides result in the loss of top soil and the organic layer at the point of origin. In extreme cases, all soil down to bedrock is lost. Developed soil profiles are buried by material that is predominantly subsoil and fractured rock at the toe of slides. Landslides that reach creeks can deliver structural material (woody debris, and boulders), gravel, fine sediment, and fine organic matter [See Section III.7 for a discussion of landslides.]

The loss of top soil and the organic layer sets back plant succession, favoring pioneer species. Red alders are particularly successful regenerating in slide tracks and deposits. Its small winged seeds allow long distance dispersal, it grows rapidly, and can fix nitrogen.

Floods

Floods affect only a small part of the landscape but they too are significant processes. Flooding damages or kills by breaking or burying plants. Flooding affects species composition on the flood plain by killing plants that cannot tolerate saturated soils. This creates openings for those plants that have mechanisms to survive saturated soil conditions or can regenerate on sediment deposits. See Appendix C for a discussion of historic floods.

CURRENT CONDITIONS

ANALYTIC QUESTION III.9.2

What are the human-caused disturbances and how extensive are they?

As interpreted from 1943 aerial photos, approximately 9% of the analysis area had been harvested, either clearcut or partial cut. The main access roads through the area were already constructed by this time. Areas of harvest, private and federal land together, were concentrated in the Lower East Fork and Brewster Canyon subwatersheds and along the East Fork Coquille River itself. Agricultural lands accounted for approximately 3% of the watershed. In addition, large fires in the 1930s burned approximately 14% of the watershed with varied intensity; see Appendix A - Map A.13. At this time, human activities have altered approximately 63% of the watershed (some acres are on their second harvest rotation). General information on the present distribution of age classes can be found in Section V.1.

Timber Management

Logging has had the greatest impact on vegetation since the 1940s. Except for the 1960s, the proportion of lands harvested has been relatively consistent each decade (Table III.12). Because of the early harvest of private lands, logging of the second rotation of timber has begun. This pattern is expected to continue for private ownership as the timber stands reach 40 to 50 years of age. As part of their forest management practices, herbicide application to control noncommercial species generally occurs within the first 15 years following harvest. Fertilization of older stands may also occur.

Table III.12
Logging Disturbance by Decade

DECADE	ACRES HARVESTED	% TOTAL
1930s & 40s	7,373	8.6
1950s	9,921	11.6
1960s	15,115	17.6
1970s	11,006	12.8
1980s	9,767	11.4
1990 to 1997*	8,201	9.6
Total	**61,383**	

* includes some second rotation harvest of areas previously harvested in 1940s and 1950s

There was a District policy to salvage dead or dying trees during the mid-1960s to early 1970s. In addition, it was common practice on timber sales during the 1970s to fall or harvest dead trees within 200 ft. of roads or the boundaries of clearcut units.

Human-caused Fire

There have been 109 human-caused fires within the analysis area since 1931, based on documentation from the Oregon State Board of Forestry (see Table III.11 and Appendix A - Map A.13). Typically, these fires were small and "incendiary" in origin (Appendix E - Table E-3). Larger and more frequent fires occurred during the 1930s, as these were drought years. Although there are records of lightning fires in the watershed, their impact was negligible. Wide-scale fires due to lightning in the Coast Range are rare.

SYNTHESIS AND INTERPRETATION

ANALYTIC QUESTION III.9.3

How have disturbances affected vegetation patterns?

A general discussion of the effects of natural and human disturbance processes on vegetation are can be found in Appendix D. How these processes influence vegetation is summarized in Table III.13.

Table III.13
Disturbances and their Affect on Vegetation Patterns

PROCESS	INFLUENCE ON UPLAND VEGETATION		INFLUENCE ON RIPARIAN VEGETATION	
	STAND REPLACING	STAND MODIFYING	STAND REPLACING	STAND MODIFYING
Fire (Lightning & Human Caused)	X	X	X	X
Wind	X	X	X	X
Management (Timber & Ag.)	X	X	X	X
Disease (Primarily Root Rot)		X		X
Insects		X		X
Snow Break		X		X
Landsliding/ Mass Wasting		X	X	X
Stream Bank Erosion				X
Plant Competition		X		X

The historical landscape, composed of large blocks of similar-aged stands, has been replaced with a highly fragmented pattern characterized by hard edges (distinct contrast between adjacent stands) and small patch size (≈40 ac). During the 1970s and 1980s the BLM restricted clearcut size to ≈40 ac, and attempted to distribute their locations so that adjacent areas were at least ten years old. The belief, at that time, was that this practice would benefit wildlife due to the resultant edge effect (Thomas 1979). On private lands, larger areas were clearcut and clearcuts were often adjacent to the previous years harvest, resulting in larger, uniform-age tracts of forest.

Currently 77% of federal land (42% of the 5th field watershed) is in Reserve land allocations. Plant communities associated with late-successional forests will be well represented over time. Eventually, the landscape will become less fragmented in Reserve areas as vegetation matures and the contrast between edges decrease. Based on past uses, private lands and those federal lands designated as GFMA will be maintained in an early to mid-seral stage (40-80 years old). While it may be desirable from many perspectives to mimic natural disturbance patterns, it is not practical to do so at this time given management constraints, ownership patterns, land-use allocations, and Survey & Manage protocol. Some edge effects will continue where harvest areas abut Reserves.

ANALYTIC QUESTION III.9.4

What are the management objectives for control of sedimentation and other disturbance mechanisms on Federal lands?

Ground-disturbing activities will be located away from fragile soils prone to landsliding. The District's TPCC inventory will be revised by the soil scientist as necessary to exclude unstable lands from Matrix lands. Furthermore, the Riparian Reserves will be expanded as necessary during timber sale planning to include unstable landforms near stream channels.

Siting of new facilities in flood plains will generally be avoided, unless there is no other reasonable alternative. When required, structures will be designed to pass the 100-year flood. Facilities designs and development will ensure flood flows can pass without obstruction and minimize undo stream channel adjustments to the local area and downstream.

Prescribed fire will generally be of low-moderate intensity. Restorations plans will be developed and implemented to limit surface erosion and sedimentation to streams from wildfires. This may include installation of natural silt fences and/or seeding.

Environmental analysis will be conducted before salvaging timber in the aftermath of large-scale disturbance events.