III PHYSICAL CHARACTERISTICS

III.1 GEOLOGY

The North Fork Chetco analysis area is comprised of formations characteristic of the Coast Range Physiographic and Klamath Mountain Physiographic Provinces (Figure III-1).
The Dothan - Otter Point Formations (Jdo, Jv) are the primary rock units within the Coast Ranges Province. Both are of the same age and somewhat similar lithologies. They consist of a fractured to highly sheared sequence of graywacke-mudstone with subordinate chert, andesitic and keratophyric breccia, pillow basalt, minor conglomerate, and occasional limestone lenses in the graywacke-mudstone. This formation covers over 90% of the analysis area with the remaining comprised of Tertiary intrusive rocks (Ti). A number of dacitic and rhyolitic dikes and sills intrude the Dothan Formation (State of Oregon, 1977).

III.2 SOILS

According to digitized data obtained from the Soil Survey of Curry County, OR. (in publication), there are twenty seven (27) different soil types on differing slope classes in the analysis area (Figure III-2). At this time, the data does not allow for these soil types to be categorized or interpreted other than through a limited database of physical characteristics. No groupings of soil types by similar properties have been constructed. Subsequent analysis may provide data to allow computer modeling of surface erosion and landslide vulnerability.

Review of data shows several trends within the analysis area. There is a pattern where many ridges have deep soils with clay subsoils, rather than shallow rocky soils. These cap soils have low permeabilities, hold water for longer periods of time, and may provide water to the stream channels below. Where soil types change on sideslopes, becoming shallower, water may be forced to the surface just below these perched ridge water tables. This process sustains perennial flow higher upslope than normally expected.

An assessment of the analysis area for slope hazard is displayed in Figure III-3. The majority of the analysis area has moderate slopes less than 60% and a few areas of steeper 60-90% slopes. Unstable areas are those slopes greater than 91% and are found most often adjacent to the stream channel up to the first inner gorge. These areas are most often associated with the lower portions of the main streams, but are also a feature on the upslope areas in first and second order channels.

The Timber Productivity Capability Classification (TPCC) rates the ability of the land to produce a given amount of timber from the landscape. The areas given protection due to fragile gradient (ie., commonly used as an index of instability) are largely located in the stream channel margins of the Bosley, Lower Bravo, Middle NFC, and Ransom Creek drainages (Fig. III-4). The majority of the land withdrawn from commercial timber harvest is due to low moisture and low site potential. Using the slope hazard map to determine the inoperable areas would be a better guide for management activities.

Figure III-1 Geological Formations and Fault Lines

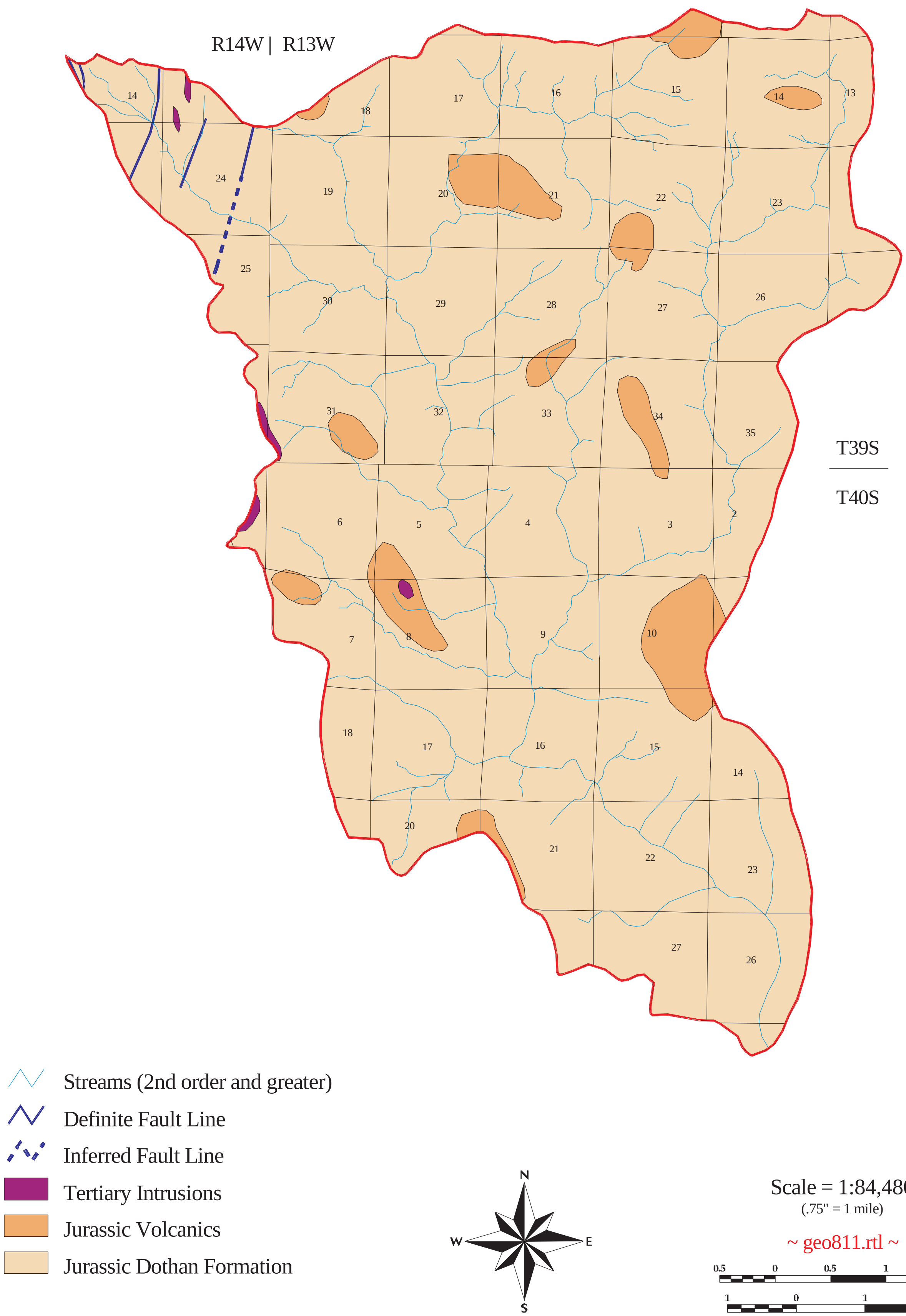
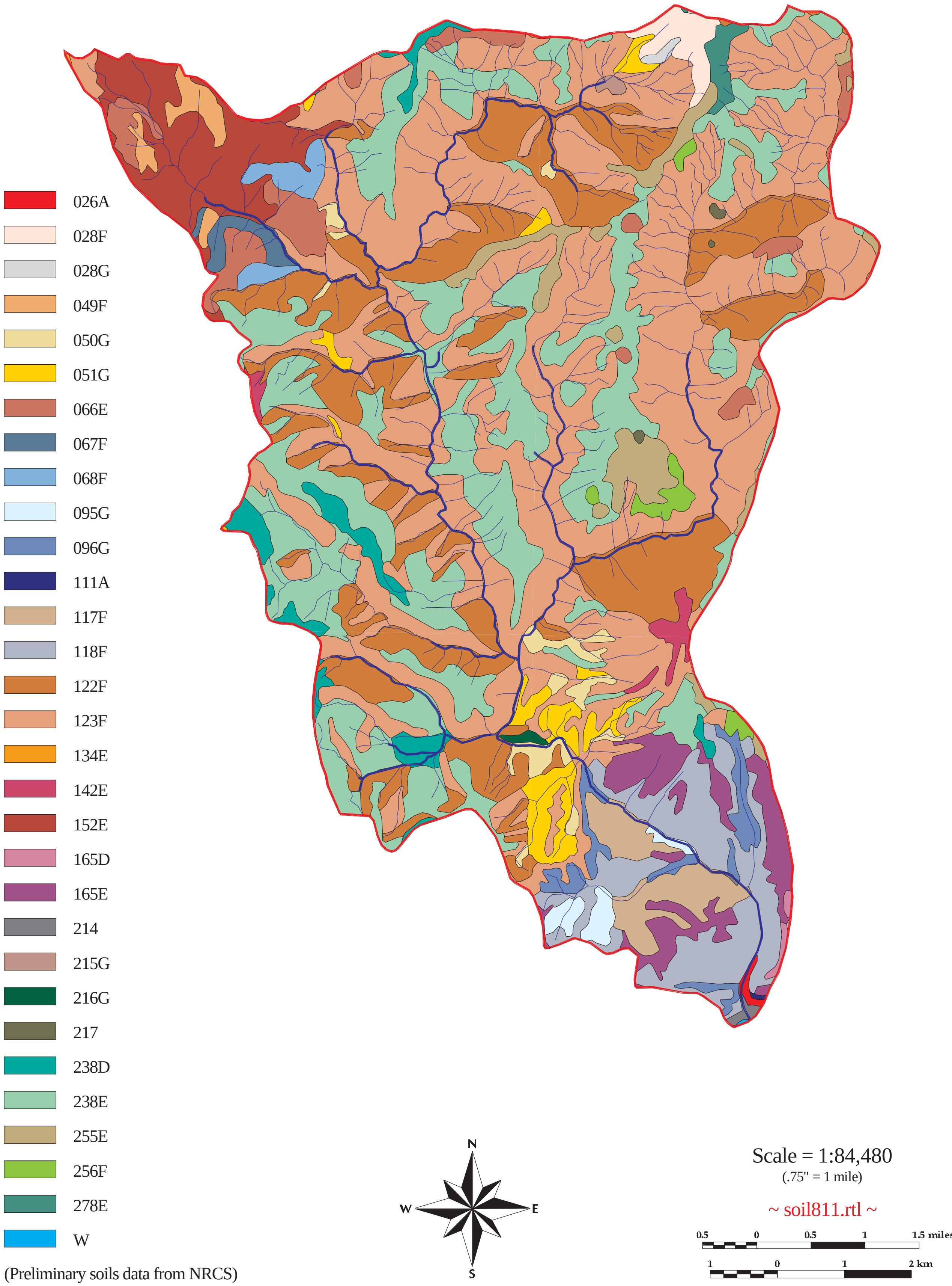


Figure III−2 Soil Types



(Preliminary soils data from NRCS)

Figure III−3 Slope Hazard Classes

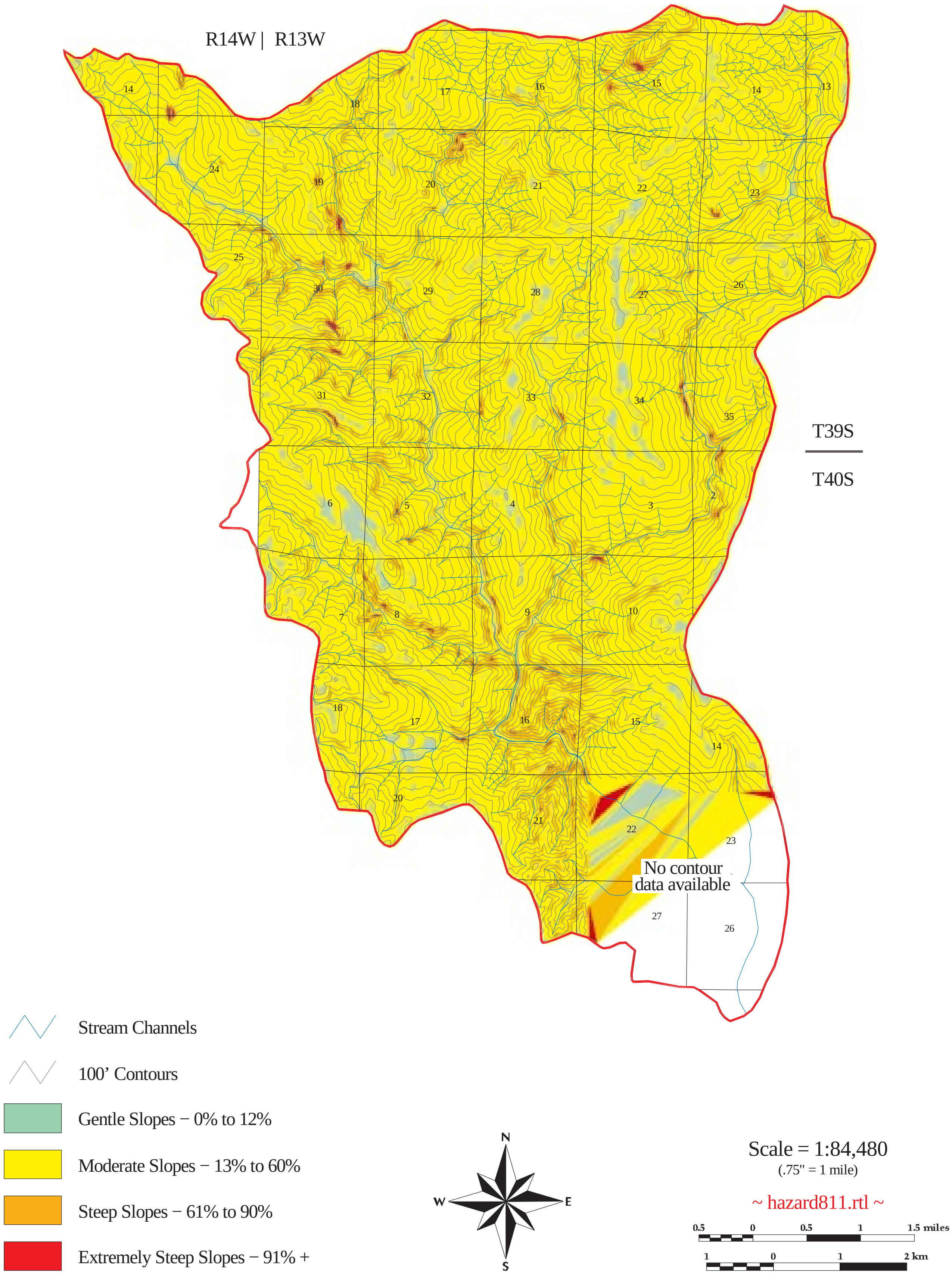
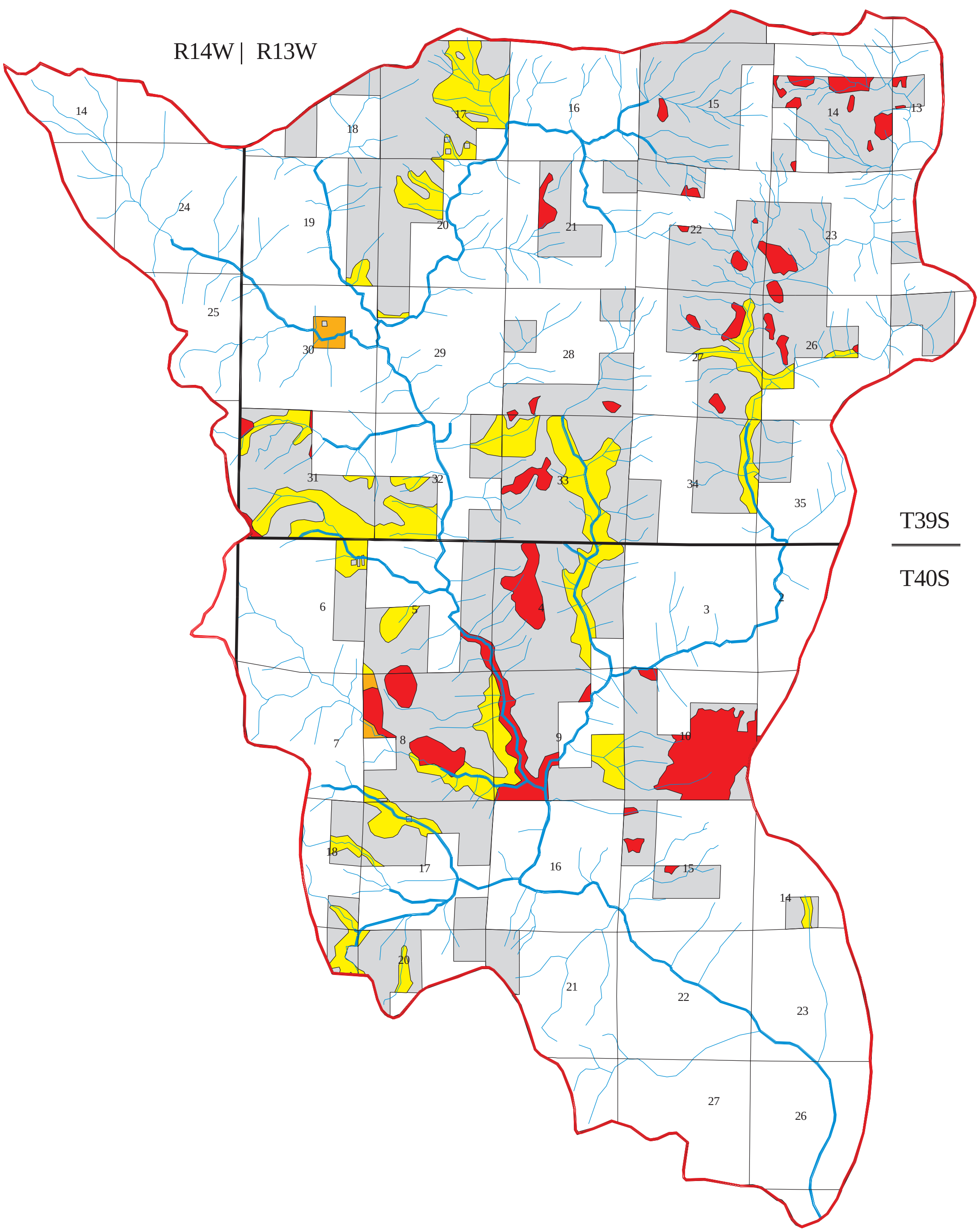


Figure III−4 TPCC Fragile and Withdrawn Areas



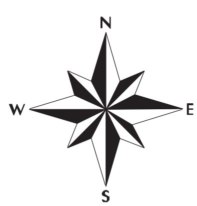
Fragile Nonsuitable Woodlands*

Fragile Site (FGR2)

Fragile Site (FGR1)

Non−fragile BLM Lands

*The fragile nonsuitable areas include FGNW, FSNW, & FNNW (Slope gradient, soil moisture and soil nutrient limiting).



Scale = 1:84,480
(.75" = 1 mile)

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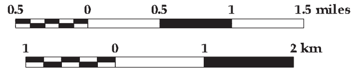
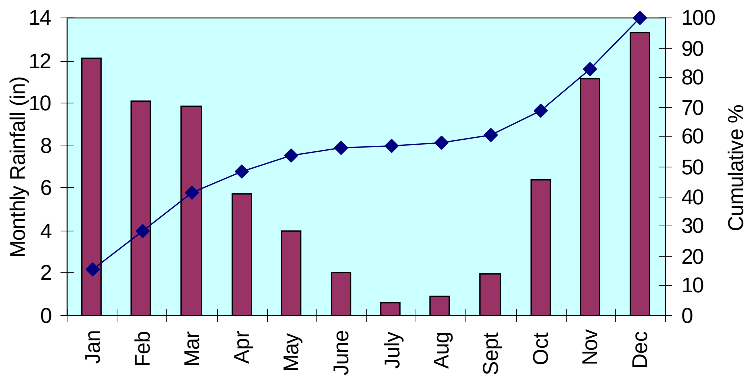


III.3 CLIMATE

Annual precipitation occurs mostly as rainfall varying strongly with elevation, with greater amounts in the higher portions of the analysis area. Precipitation ranges from 100 inches in the low elevations and river valleys along the North Fork Chetco, to more than 140 inches in the upper areas near 3400 feet (OSU 1993). Aspect and drainage orientation to prevailing winter Southwest winds also influence precipitation amounts. Cool, moist air masses lifting over the Coast Range can produce snow over 2000' elevations. These are intermittent snow packs, which usually persist on the ground for only a few weeks and sometimes melt quickly with warm winds and rain. This extra water storage as snow water equivalent can elevate flood waters.

Approximately 90% of the average annual precipitation occurs between October and April, with 50% occurring during November-January (Figure III-5). Although heavy rainfall occurs with winter storms, much of the precipitation is low intensity. Precipitation during the May through September summer months is only about 10% of the annual average, the dry season precipitation being 10-14 inches (OSU 1982).

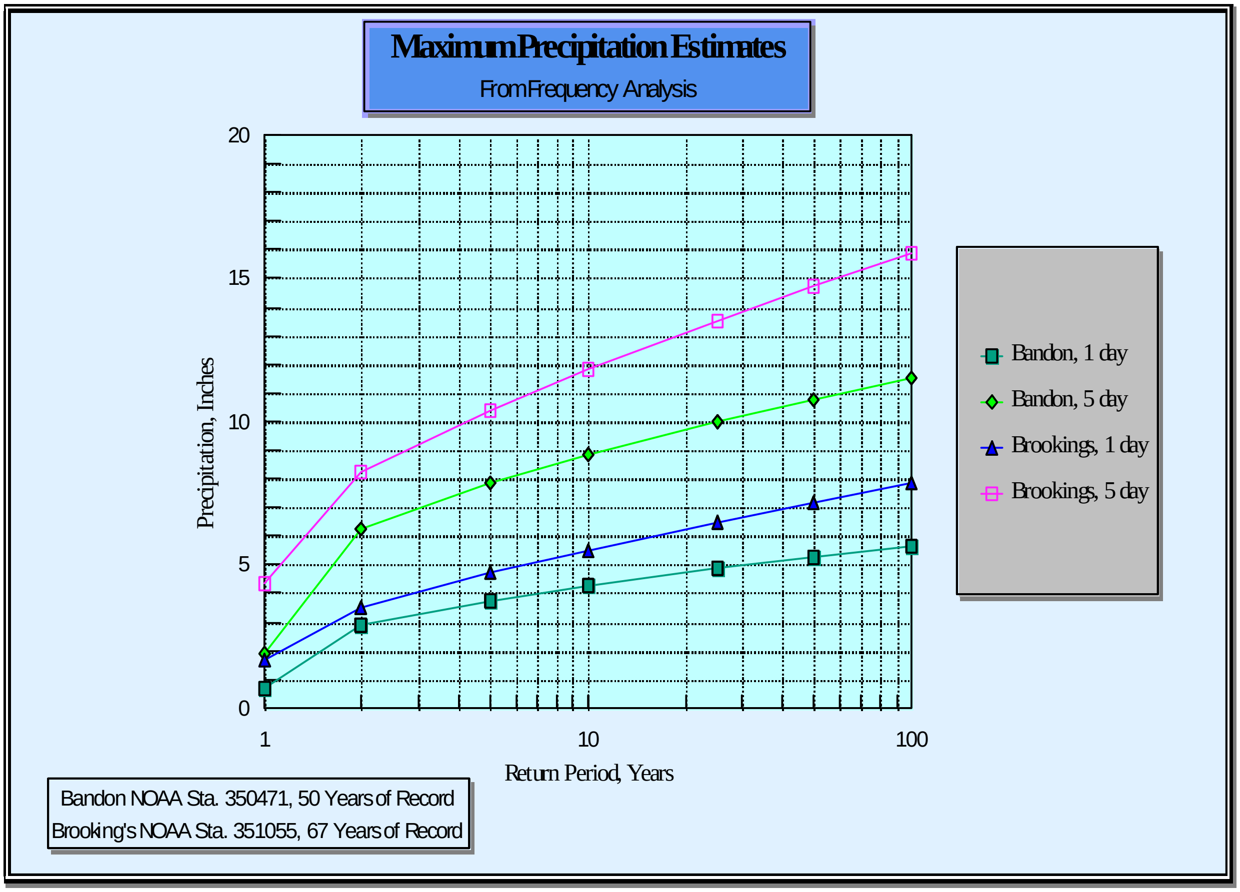
Figure III-5 National Weather Service Data for Brookings OR, 1931-1997



The periods of maximum precipitation are responsible for high runoff, including flooding, watershed erosion, slides, and debris torrents. However, this occurs on an infrequent basis. High precipitation combined with the melt of existing shallow snow packs can worsen flooding. Frequency analysis from the Brooking’s NOAA Cooperative Weather Station indicates that a cumulative 5 day-5 year recurrence interval storm could be expected to have precipitation of at least eleven inches (Figure III-6). Actual rainfall depths for the analysis area are higher for a given return period than shown in Figure III-6. This is because precipitation intensity is highly correlated with elevation along the Oregon Coast and the mean elevation is about 1500' higher than the Brooking’s NOAA weather station. A higher incidence of landslides and torrents has been correlated with storms which totaled 11" or more in several days (refer to Section III.5-Erosion Processes).

Temperatures are generally quite mild with maximum temperatures seldom exceeding the low 90's, nor falling much below freezing.

Figure III-6 Maximum Precipitation Estimates



III.4 WATERSHED GEOMORPHOLOGY

The North Fork Chetco analysis area is a minor component of the Chetco River Basin, comprising 11% (25,563 acres or 39.94 mi^2) of the Basin and forms the lower elevation portion. Streams in the analysis area are oriented north-south. Elevations are lowest along the southern boundary (100') and highest along the northeastern edge near Bosley Butte (3400'). Drainages are situated north-south to east-west and vary from 1300 to 4000 acres. Drainages have broad ridgetops, smooth to convex sideslopes that are punctuated with moderate stream dissection. Valley bottoms are very narrow with many inner gorge steep hillslope and cliff features. The valley width index is often 1.0, which means that the valley bottom width equals the active stream width. Floodplains are essentially absent, except for the lower mainstem and isolated reaches along tributary streams. The majority of observed landsliding is concentrated near streams along inner gorges and steep toeslopes (refer to Section III-5- Erosion Processes).

The North Fork Chetco has a length of 12.7 miles and has its confluence with the Chetco River near rivermile 5.1. The drainage pattern is dendritic with a drainage density of 4.3 mi/mi^2., which is among the lowest observed in the Coast Range. About 124 miles of streams are found of which first and second order streams comprise 72% of the total drainage density (Table III-1). These are generally moderately steep headwaters channels draining small catchments. It is estimated that approximately half of the first order streams (46 miles) become intermittent by late summer. This figure is based on modeling and the actual miles of intermittent streams is judged to be slightly higher (refer to Section VI-Riparian Reserve Evaluation). Most of the remaining 126 miles (71%) of streams are perennial.

Table III-1 Miles of Stream by Stream Order for the North Fork Chetco Analysis Area.

Drainage	Miles of Stream by Stream Order [1]					
	1	2	3	4	5	Total
Lower Lower North Fork Chetco	1.3	1.3	2.7	-	3.3	8.6
Lower North Fork Chetco	5.4	2.5	0.6	0.2	1.8	10.5
Middle North Fork Chetco	12.9	7.0	4.5	4.3	-	28.7
Upper North Fork Chetco	6.7	4.1	3.1	-	-	13.9
Mayfield Creek	5.0	2.1	2.1	0.5	-	9.6
Jim Ray Creek	4.6	1.5	2.2	-	-	8.2
Cassidy Creek	4.0	1.3	1.8	-	-	7.1
Bosley Butte	16.8	6.4	2.6	3.4	-	29.2
Ransom Creek	6.2	1.7	3.4	-	-	11.4
Upper Bravo Creek	15.5	3.4	2.0	1.8	0.9	23.6
Lower Bravo Creek	12.4	1.6	1.9	-	4.9	20.8
Total (%)	**90.8** 53	**32.9** 19	**26.9** 16	**10.2** 6	**10.9** 6	**171.6**
Drainage Density, mi/mi^2	**2.3**	**0.8**	**0.7**	**0.3**	**0.3**	**4.3**

[1] 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).

North Fork Chetco has a low gradient for a coastal stream. In contrast, the tributary drainages consist of narrow canyons with much steeper channel gradients. Tributary streams drain rugged mountainous land forms, from near sea level to 3400 feet at the northeastern end of Bosley Creek and generally start below steeply sloping headwalls. Longitudinal profiles of streams are useful to compare morphology between stream reaches or from one stream to another. Upper portions of Bosley, Cassidy, Upper Bravo and Upper North Fork have the highest average gradients. These are high energy erosional streams with a high capacity to move water and sediment. Lower portions of Bosley, Cassidy, Upper North Fork and portions of other streams are moderate to steep gradient streams. These are moderate to high energy erosional streams, with a moderate to high capacity to move water and sediment. Lower and Middle North Fork Chetco and flats along other streams are low gradient, which provide high habitat value. These are low energy, depositional streams.

III.5 EROSION PROCESSES

What are the dominant historical and current erosional processes within the analysis area (e.g., surface erosion, mass wasting)?

The dominant historical and current erosional processes are the same. Shallow rapid landslides adjacent to perennial channels, occasional deep seated persistent slides, gullying, and overland surface erosion are the four major erosional processes found in the analysis area. Shallow rapid landslides are by far the most common. Surface erosion, including gully and rill erosion, occurs on disturbed areas during intense rainfall or snowmelt events. Some slow earthflow creep is occurring in the northwest portion of the Upper North Fork drainage, but it is a very minor component when compared to the other erosional processes.

The relative percentage of each type of process has fluxuated since 1939. A fire in 1939, which removed much of the protective vegetation, increased the proportion of surface and gully erosion. As the land became revegetated, the relative proportion of surface and gully erosion subsequently decreased. In other parts of the analysis area, management activities, such as timber harvest, became the influencing disturbance mechanism increasing the level of mass wasting. Currently, there appears to be a reduction in the number of landslides and there is adequate vegetation cover to control surface erosion.

These erosional processes are the source of sedimentation in the stream system. The sediment routing mechanism involves; 1. initiation of a slide event or displacement from the surface, 2. delivery to the stream channel, 3. removal of the sediment from the high gradient streams, 4. deposition in the lower gradient portions of the channel, and 5. movement over time out of the watershed.

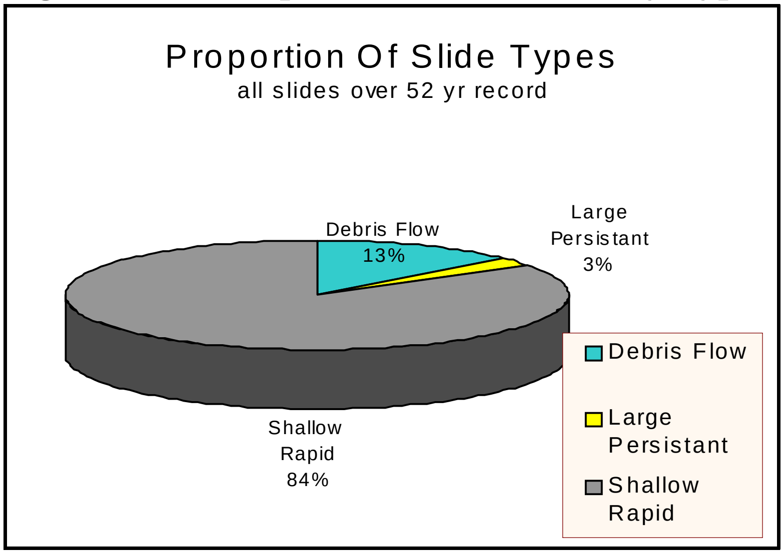
A major source of sediment comes from the stream undermining stream banks and adjacent debris slides. Rain storms increase the amount of water in the channel, which in turn influences higher areas of the streambank not normally available. This process increases the sediment contribution from stream banks and slides. In addition, this removal of bank materials steepens the hillslope and can initiate a shallow rapid debris slide in the riparian area.

What number of landslides have been observed within the analysis area and how are they distributed in time and space?

The 1940, 1955, 1970, 1986 and 1992 photo years were inventoried for a variety of data (Appendix A). From that data, the probable accuracy of the data, the number of slides per year, the number of slides by type, and the proportion of each slide type of the total for the photo year was determined.

It is difficult to determine natural rates of landsliding through forested canopies. It has been determined (USDA, 1997) that slides less than one half an acre are only detected with only a moderate degree of confidence with aerial photo methods. For slides that were visible on the aerial photos coverage from 1940 to 1992, it is felt that at least 78% of the time, the observed slide was not a road or narrow stream channel.

Figure III-7 Proportion of Landslides by Type

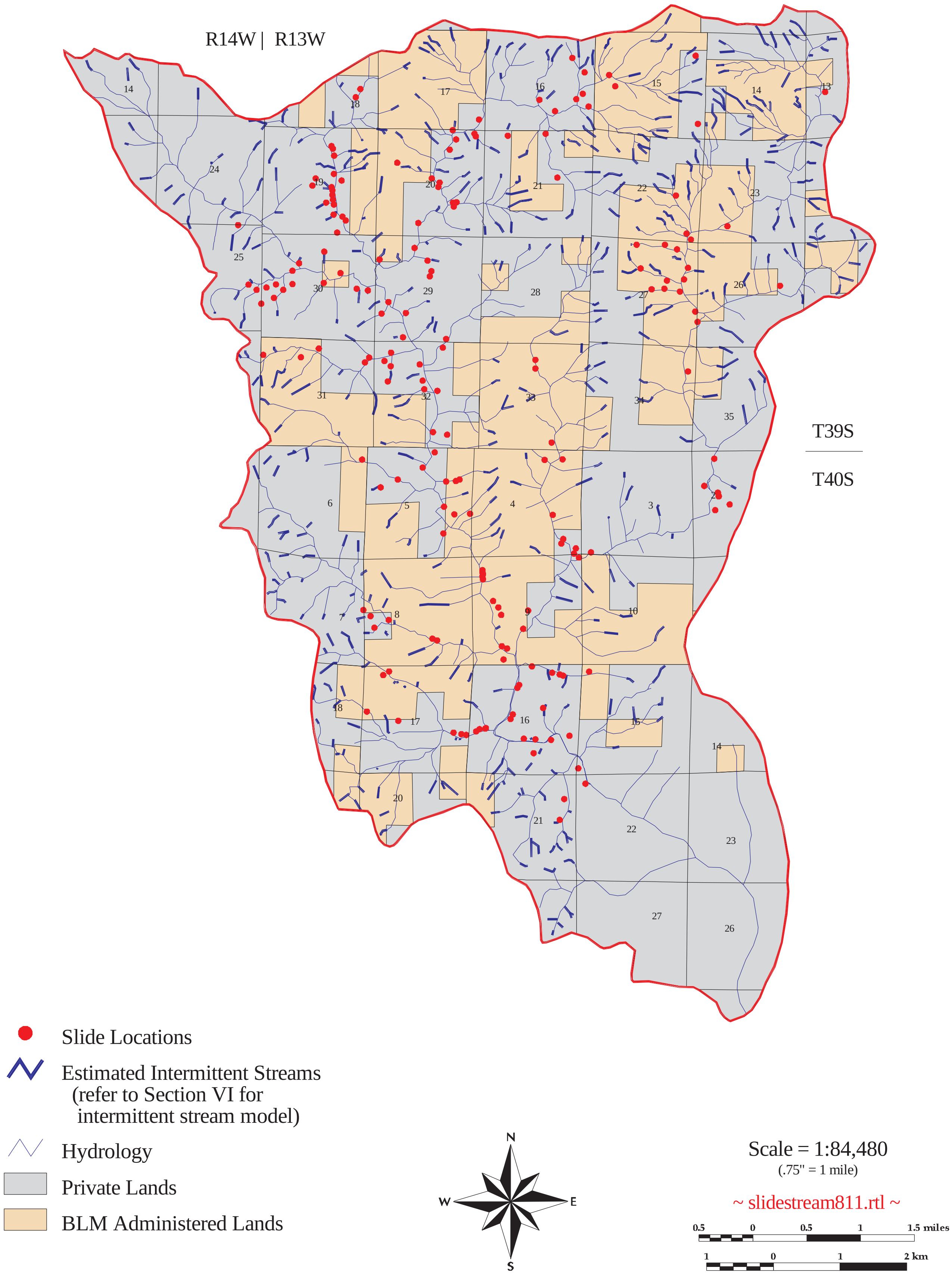


From the aerial photos, a total of 188 slides were identified. Shallow rapid landslides were 84% of the total slides, with channelized debris flows (torrents) being 13%, and large-persistent-deep seated flows comprising only 3%. (Fig. III-7) The average size of the shallow rapid slides was 0.9 ac on BLM lands and 1.2 acres on private lands.

The location of the shallow rapid slides is strongly associated with the combination of steep slopes adjacent to perennial streams (Fig. III-8) (refer to Section VI-Riparian Reserve Evaluation for determination of perennial and intermittent streams). Slides are most frequently associated with roads when located next to, or upslope from, steep perennial stream channels or on steep midslope areas. Due to the uniformity of the geology of the area (Dothan Formation), no correlation was found between slide locations and geologic formations. In addition, no strong correlation was found between slides and soil types.

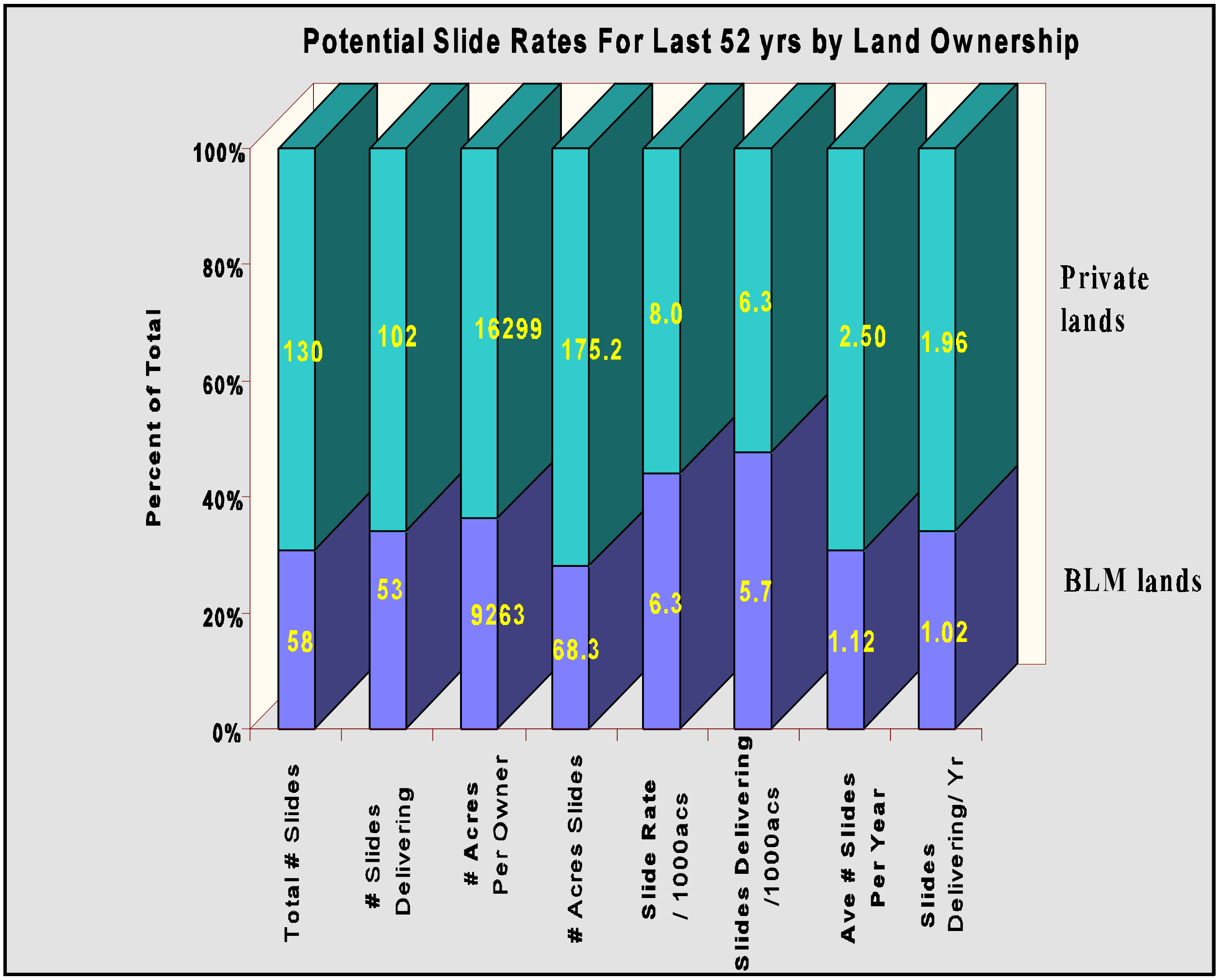
The likelihood of slide occurrence expressed as # of slides/ 1000 acres, was calculated as a measure for comparison of ownership, management activities, and drainage sensitivity. Because sediment delivery is of a primary concern, the incidence of those slides that delivered sediment to the streams was also determined. An overall landslide rate for BLM administered lands was calculated to be 6.3 slides/1000 acres, whereas, the rate on private lands equaled 8.0 slides/1000 acres (Fig III-9) . The number of slides which appeared to actually deliver sediment to the stream system was lower; 5.7/1000 ac for BLM and 6.3/1000 acres for private lands. Based on the confidence level of the inventory and these numbers, it appears that there is not a significant

Figure III-8 Landslide Distribution in Relation to Perennial and Intermittent Streams



difference in landslide rates between the different land ownerships.

Figure III-9 Landslide Information by Land Ownership



A yearly rate was calculated based on the 52 years of photo coverage and yielded overall rates of 1.12 slides/ yr. for BLM administered lands and 2.5 slides/yr. for private lands. A slight reduction was exhibited for slides that potentially delivered sediment to the stream; with 1.02 slides/yr. and 1.96 slides/yr. This rate is roughly equal to the ownership breakdown within the analysis area.

The Cassidy hydrological unit is the most sensitive at 19 slides/1000 acres (Figures III-10 and III-11). The Bosley, Lower Chetco, and Middle NFC drainages fall into the second most sensitive class with 9 to 11 slides/1000 acres. The Lower Lower NFC drainage was the least sensitive with less than 1 slide/1000 acres.

Figure III−10 Landslide Distribution by Hydrologic Unit

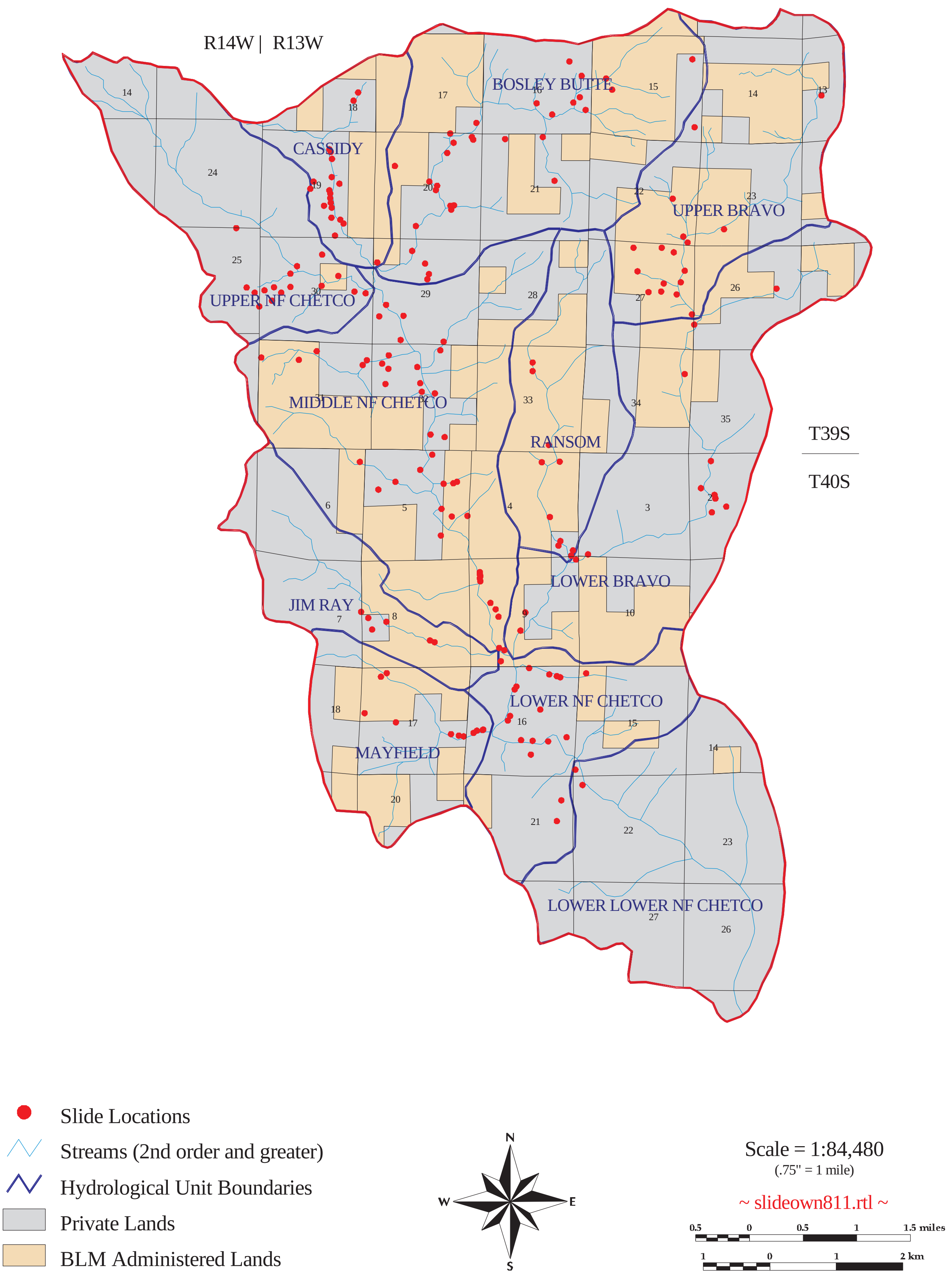
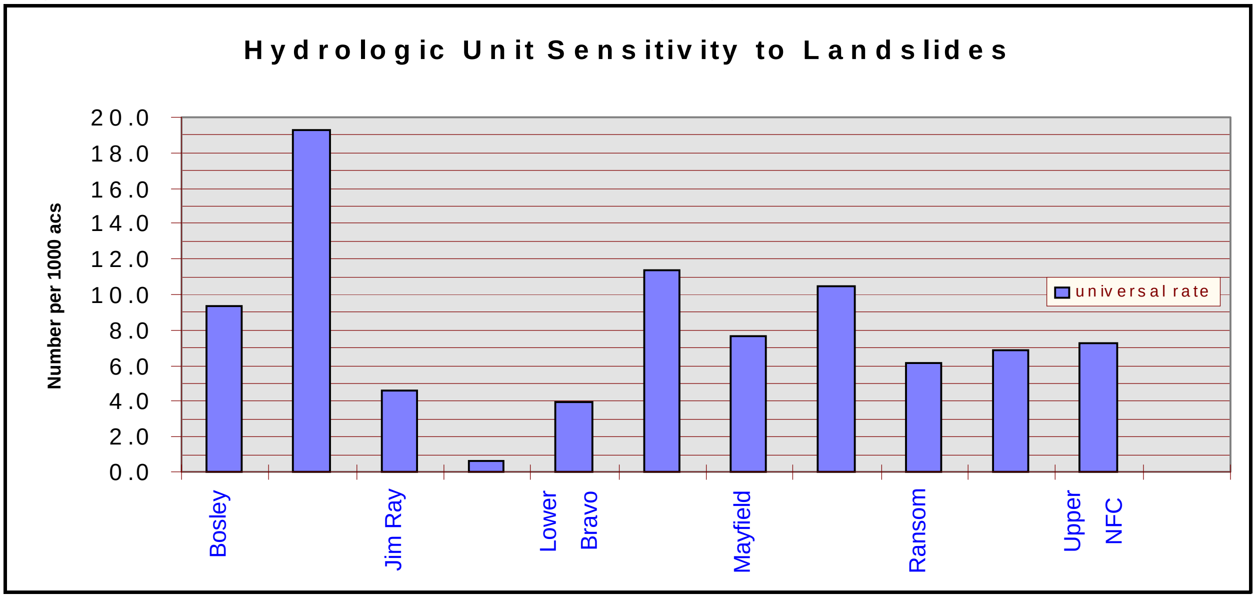
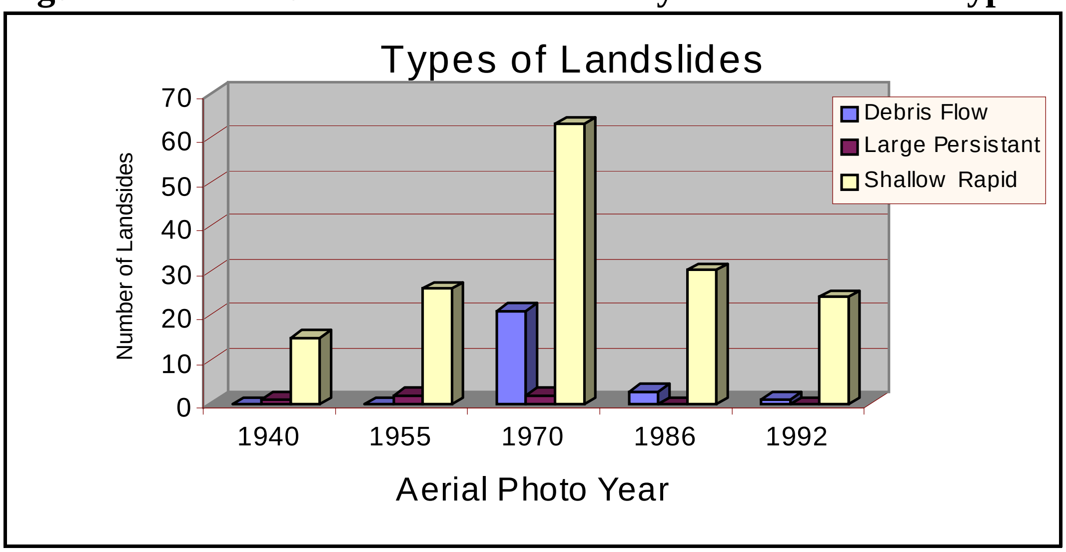


Figure III-11 Landslide Rates by Hydrologic Unit



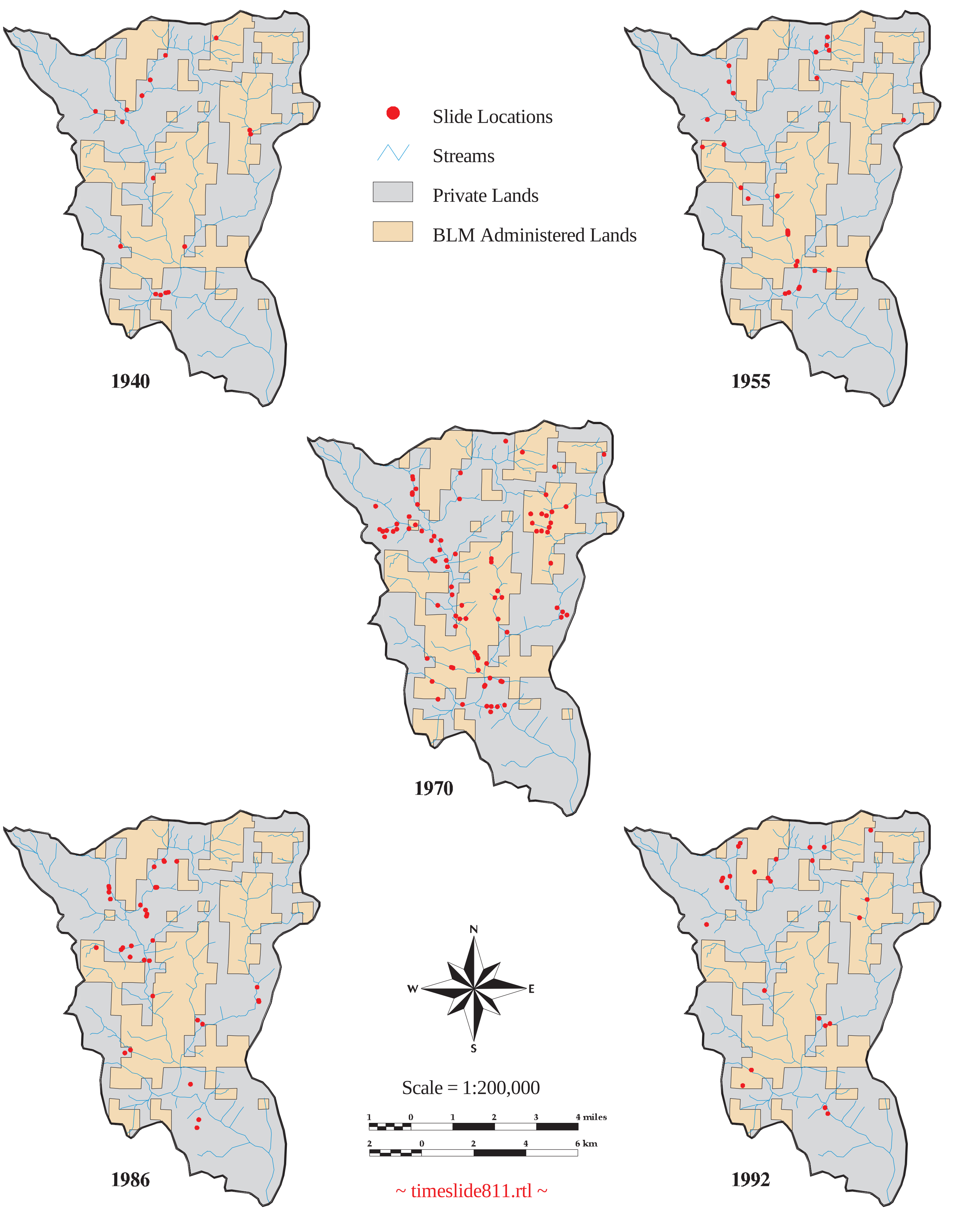
The number of landslides increased steadily from 1940 to a peak in 1970, followed by a reduction in 1986 and 1992. The 1992 level is slightly higher than that for pre-management levels in 1940. It should be noted that debris flows were not a component of the total prior to 1970, but were found to be approximately 25% of the total in that year and only 4% in 1992 (Figure III-12). The large persistent slides present in 1940 accounted for 6% of the total, were reduced to 2% in 1970 when all slides were at their peak, and were not present there after.

Figure III-12 Numbers of Landslides by Photo Year and Type



The spatial distribution of landslides by each photo year is shown on Figure III-13.

Figure III-13 Landslide Distribution Through Time (1940-1992)

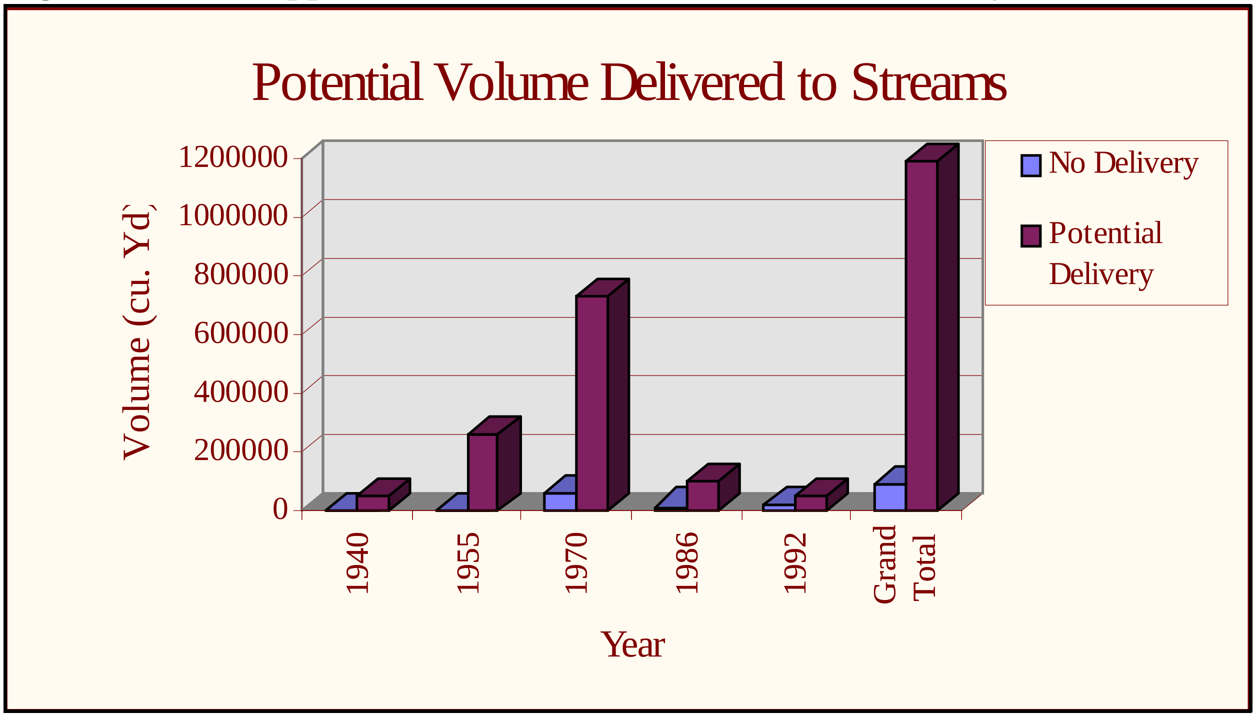


What approximate volume of sediment has been delivered to the stream channel from these slides?

The volume of slide material was estimated by measuring the surface area of the slide from aerial photos and assigning it an average depth by slide type. Shallow rapid slides were assigned a depth of two feet based on visual observations. A four foot depth was calculated for debris flows and a six foot depth for large persistent slides. As part of the photo interpretation, it was determined which slides deposited their material into or adjacent to the stream channel. These slides were classified as delivering sediment into the stream system. No field verification of actual delivery or delivery index was performed. For this analysis, all volumes are assumed to have been delivered as a worst case scenario.

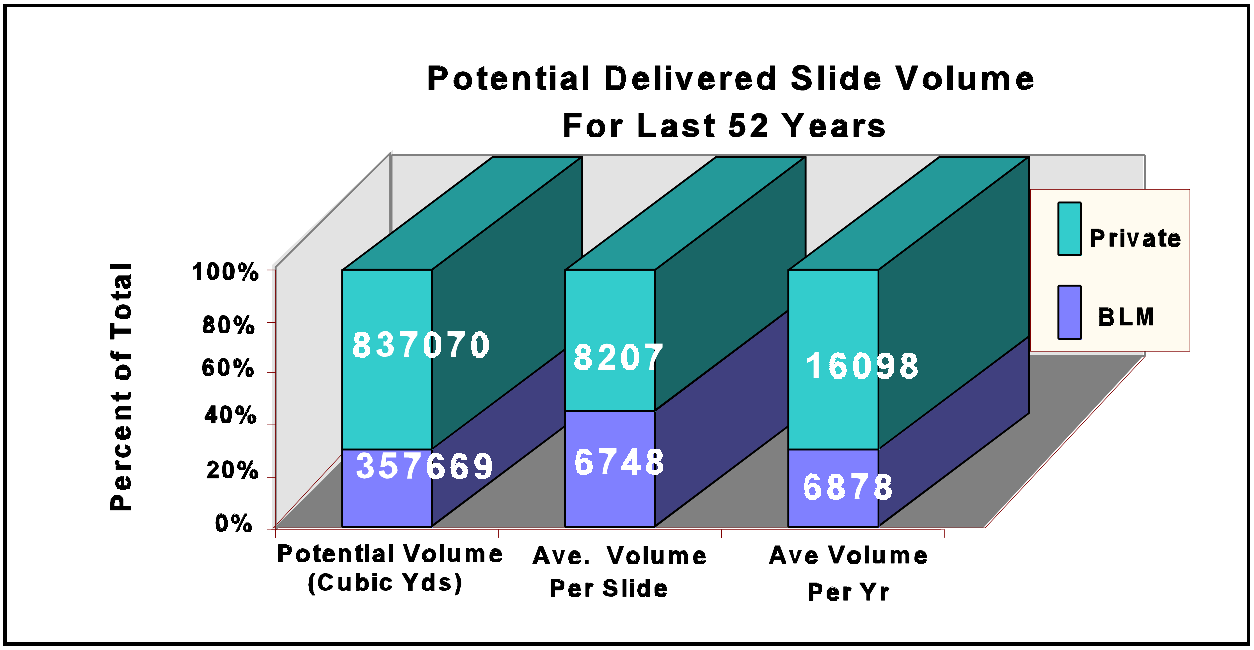
The amount of sediment delivered to the stream channel coincides with the numbers of slides over the years of study. The largest amount of delivery occurred in 1970, while the 1992 volumes approach that of 1940 (Figure III-14).

Figure III-14 Approximate Volume of Delivered Sediment by Photo Year



The entire analysis area receives approximately 23,000 cubic yards of materials each year, with an average of 15,000 cubic yards per slide. The majority of the volume per photo year comes from private lands (Figure III-15), but is in proportion to their percentage of land ownership. The average volume per slide is higher for BLM administered lands and may be a function of the steeper narrow channels that are found on the land surface.

Figure III-15 Volume Averages of Delivered Sediment by Land Ownership



A more common measure for the delivered volume was developed by estimating the area encompassed by the volumes. Assuming an average depth of 1 yard, the number of acres that the resulting volume calculates to be is 173 acres for private land and 74 acres for BLM lands. Over the 52 year photo period, private lands delivered 3.3 acres of land area into the stream system per year. On BLM lands, this acreage amounts to 1.4 acres per year. This method of analysis reveals a lower delivery rate for BLM lands with respect to its percentage of land ownership in the analysis area. At the peak of sediment delivery in 1970, all ownerships contributed a total of 151 acres of land to the stream system. In contrast, all ownerships reduced that contribution to only 10 acres in 1992.

Have management activities played a role in producing landslides?

Slide initiation was categorized as natural, harvest-related, or road-related. Slides that occurred 15 years after harvest were identified as natural (Zimmer, 1981). Management activities are responsible for 70% of observed slides. Harvest-related slides were 44%, road-related slides were 26%, and natural were 30% of the total.

Management related slides were first evident in 1955 and peaked by 1970. There has been a decrease in both natural and management related slides since then. The overall number of slides in 1992 approaches the level of natural slides in 1940. This pattern may be explained by drought years, change in management practices and/or the time since most of the more unstable slides have slid out during the 1955 and 1964 floods.

Management activities on all ownerships has resulted in more slides than would have occurred naturally (Table III-2). It appears from the distribution and numbers of slides that road building in the analysis area has elevated the number of slides above the natural rate on private lands, but not on BLM administered lands. Road building on BLM administered lands produced only less than one third the number of slides/ 1000 acres than the natural rate. Harvesting is the most significant land management activity for initiating slides in the analysis area. A one and one half fold increase above the natural rate was noted to occur across ownerships for this activity.

Table III-2 Landslide Rates by Various Management Activities

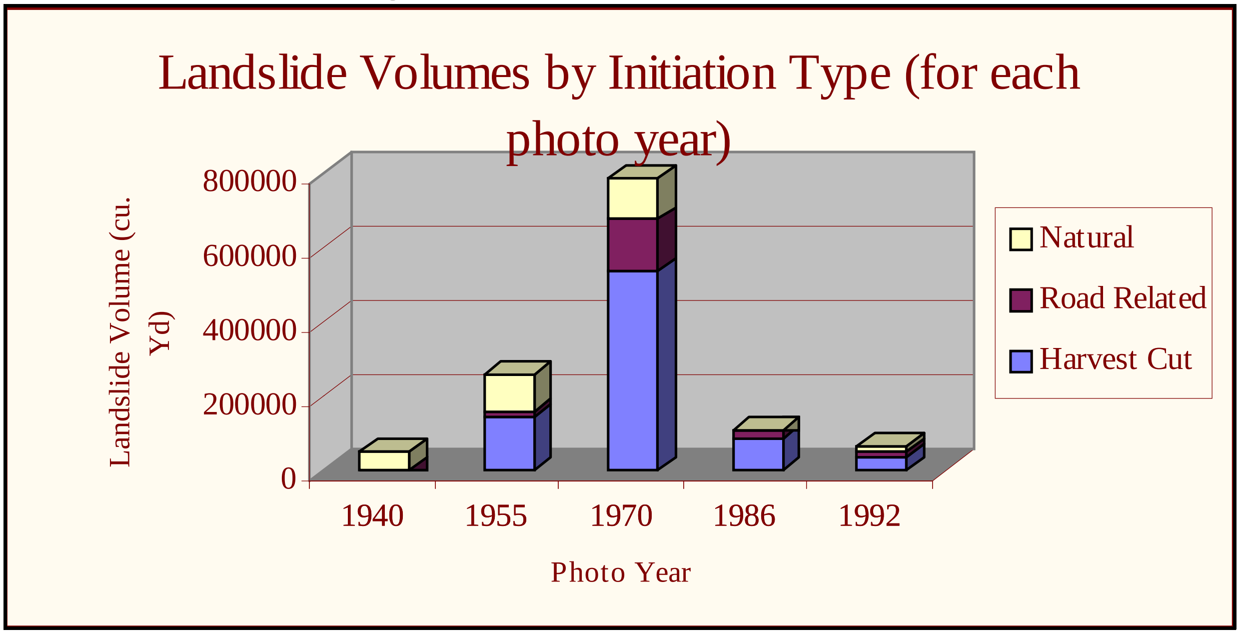
Number of Slides	BLM Administered Lands	Private Lands	Grand Total	Landslide Type # of Slides / 1000 acres	BLM	Private	A n a l y s i s a r e a Average
Harvest Cut	30	53	83	Harvest cut	3.24	3.25	3.25
Natural	22	34	56	Natural	1.35	2.09	2.19
Roads	6	43	49	Roads	0.65	2.64	1.92
Total	58	130	188	Overall Rate	6.26	7.98	7.35

Increase from Land Management Actions over the Average Natural Rate for all Lands Within the Analysis Area

	Land Ownership Landslide Rate (# of Slides/1000 acres)		
Slide Types	BLM	Private	Overall Ownerships
Harvest	1.48	1.48	1.48
Natural	0.62	0.95	1.00
Roads	0.30	1.20	.88

Landslide volumes were estimated for natural, harvest-related and road-related slides (Figure III-16). Volume of material delivered was calculated to be the highest in 1970 with harvest related landslides made up the greatest percentage of the total. The total volume delivered reduced drastically after the peak in 1970. In 1992, harvest-related slides still contributed the greatest percentage of the volumes, but it was reduced by a factor of nearly 15 times below that of the 1970 value. The total volume delivered in 1992 is approximately equal to the 1940 volumes, but there was a shift from natural to harvest-related initiated slides. This pattern of landslide volume coincides with the number of each type of slide during that same time period.

Figure III-16 Volume of Delivered Sediment by Photo Year and Management Activity



The increase in delivered sediment volume between 1940 and 1970 is coincident with the highest harvest rate (43% of the analysis area) and road construction rate in the analysis area (refer to Section III.7-Disturbance Process). This time period also contained the 1955 and 1964 floods. Between 1970 and the present (27 years), an additional 25% of the analysis area has been harvested (some of the acreage harvested a second time). Along with the reduced harvest intensity, the harvest methods have changed as well. Most of the early harvest was performed by crawler tractor equipment and concentrated on removing only the Douglas-fir, leaving a partial canopy cover of tanoak. Later, harvest methods emphasized the use of cable systems capable of suspending at least one end of the log during in-haul.

How has the delivery of sediment affected other ecosystem processes (is., water quality, water channels, etc.)?

The delivery of sediment affects the aquatic resources most directly through the removal of habitat or increasing the turbidity in the water to such an extent that organisms are force to move out or perish from the increase. The turbidity measurements taken during the 10/94 through 11/95 time period provide some insight to the levels of turbidity expected in the analysis area. Generally, the water is very clear. Only after major storms have saturated the soils or a two inch per 24 hour event occur, does the level of turbidity increase over the 10 NTU level (refer to Section IV.1-Water Quality). Personal observations show that recovery of the stream to pre-turbid conditions happens fairly quickly after the recession leg of the passing storm. The sampling stations most affected by turbidity are the Cassidy and the North Fork Chetco sites. This may be due to the high clay contents within the drainages of Cassidy Creek and the Upper NFC.

High precipitation events move the sediment through the system downstream. As this occurs, other sediments are being removed from their storage places within the channel. During the early harvest and road building activities prior to the 1970's, this process added more sediment to the system than was able to exit. The high intensity 1964 flood may have caused the low gradient sections of the streams to aggrade by delivery of greater than normal sediment loads.

After the removal of timber from steep areas along 1^{st} and 2^{nd} order stream channels they commonly downcut adding sediment above the normal rate. This continues until the channel reaches a base level (bedrock or boulders) and the channel stabilizes. The amount of added sediment to the stream depends largely on the amount of rock in the parent materials and the velocity of the water in the channel. If few high precipitation storms are encountered, it seems that the channel can protect itself from further downcutting from then on. If channel flows get high and the rock layer is removed the process must start all over.

What level of compaction due to roads and other management activities exists within the analysis area?

Of the 222 miles of roads and identified equipment trails present in the GIS database, 79% are on private lands and 21% are on BLM administered lands. This overall mileage includes old dirt spurs and cat trails which comprise make up 35% (77 miles) of the total. Of these old spurs/trails, the majority 81% are on private lands and the remaining 19% are on BLM administered lands. These older spurs/trails can be either in a hydrologically restored state or in a severely degraded state, the condition is unknown for the majority of them. Field observations of these older spur roads disclosed no severely degraded roads on BLM lands.

The level of compaction from the road surfaces within the analysis area amounts to 1.7%. A width of 10' for older equipment trails and 20' for the established roads and adjacent cut banks was used. Compacted areas from roads on BLM lands amount to 1.1% of its land base and 2.1% for private lands. The GIS database appears to have captured the majority of the road surfaces normally associated with ground based systems, providing a more accurate calculation of the level of compaction. Normally these features are hidden by canopy cover and an assumption of the level of such features must be made.

The level of compaction due to harvesting on any land surface was not determined. However, given the rock content of the soils in the analysis area and amount of logging done with cable equipment, the expected impacts would be well below the amount for roads in the drainage.

What are the management objectives for erosional processes and sediment within the analysis area?

The management objective for the erosional and sediment processes within should strive to balance the input and export from the drainage over time. There should be an effort made to limit the delivery of sediment from the management activities such that it does not increase over the natural rate. Determining harvest areas that are with drainages sensitive to both sediment transfer and deposition is one way this objective could be met. Restoration of the transportation system to correct runoff and road surface problems is another example. Reducing the fine sediment delivery from the roads to the stream system is an objective that could be met in limited manner. Simply grading the roads to slightly outslope or crown most of the roads would reduce the fine sediment to many streams. The installation of additional culverts or more importantly the installation of drivable water dips would keep the buildup of ditchline runoff from occurring.

Reduction of compacted surfaces is often an objective of many restoration efforts. Sub-soiling of roads to remove compacted surfaces should not be a high priority in this analysis area. The high rock content of the soils keep infiltration rates high, even on road surfaces, and the amount of land out of production by compacted surfaces is low.

Removal of large fills at stream crossings to reduce the risk of sediment delivery is usually not an option in this analysis area. The presence of these fills themselves do not pose a problem. It is the culvert velocities and outlets that extend out past the fills that are causing increased sediment to be delivered to the stream. Most of the roads that are adjacent to the stream channels are main roads that have been improved and receive some level of maintenance. Most of the early roads (those built in the 1950 - 1960's) within the riparian area and did not get recent improvement may have been removed from use by the flooding in 1964. If not they are in some state of hydrologic recovery at this time, some where between moderate and full hydrologic recovery.

Overall meeting the Aquatic Conservation Strategy of the Northwest Forest Plan will accomplish the goals for management of the erosional processes within the analysis area. The levels of sediment delivery will not return to the past levels experienced in the 1960 and 1970 decades. Our past practices have changed, and they will not increase the amount of delivery during harvest and road building activities. Future activities under the NFP will ensure riparian protection and channel stability through the extensive network of Riparian Reserves.

III.6 HYDROLOGIC PROCESSES

What are the historical hydrological characteristics (eg., peak flows, minimum flows), and the current conditions and trends of the dominant hydrologic characteristics and features prevalent in the analysis area?

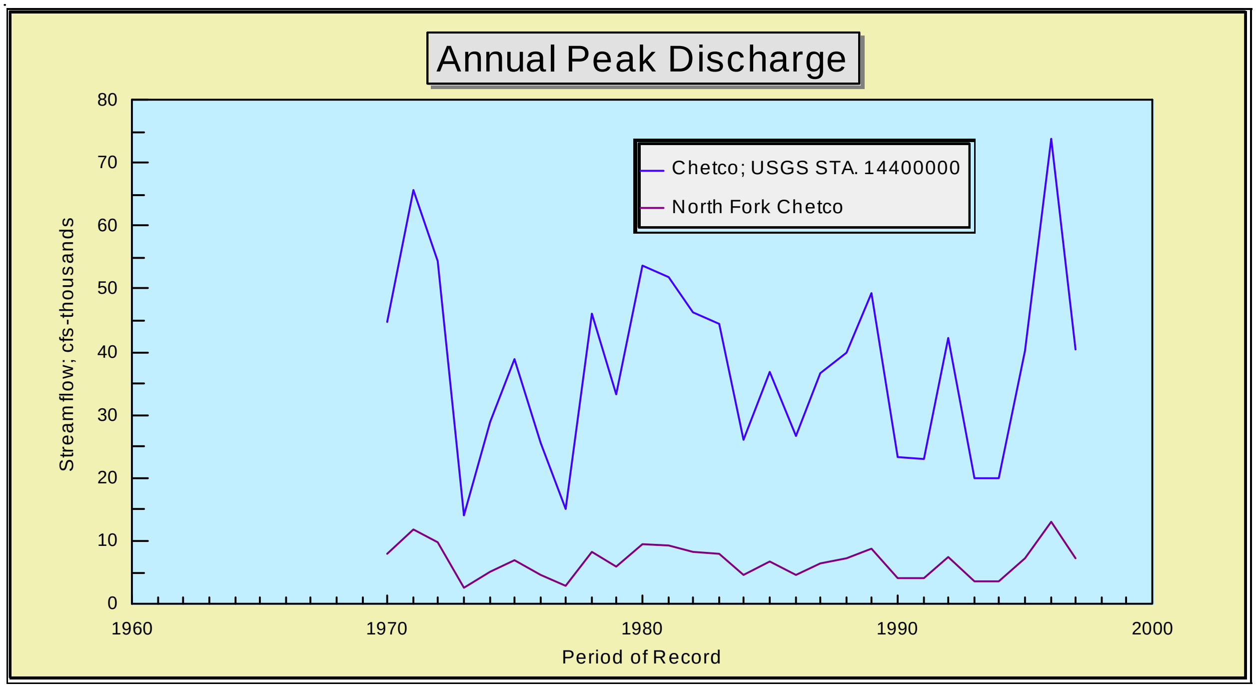
Forest hydrology is the study of the occurrence, movement, and distribution of water across forested watersheds and how they are affected by soils, geology, land form, vegetation and climate. The principal driver of hydrology in the analysis area is precipitation as rain of which a high percentage ends up as runoff. Precipitation events interact with landscape elements and this interaction has an effect on hydrological characteristics such as, floods, frequent discharge, low flow, and distribution of flow.

<u>Peak Flows and Runoff Processes</u>

Peak flow runoff is described as instantaneous flow, measured in cubic feet per second (cfs), as observed from long term stream gaging station data or calculated by basin characteristics regression models, channel geometry methods, or estimated by other methods. Annual peakflow for a given drainage is highly variable from year to year. A frequency analysis of stream gaging station data establishes a relationship between the magnitude of the flood and its return period.

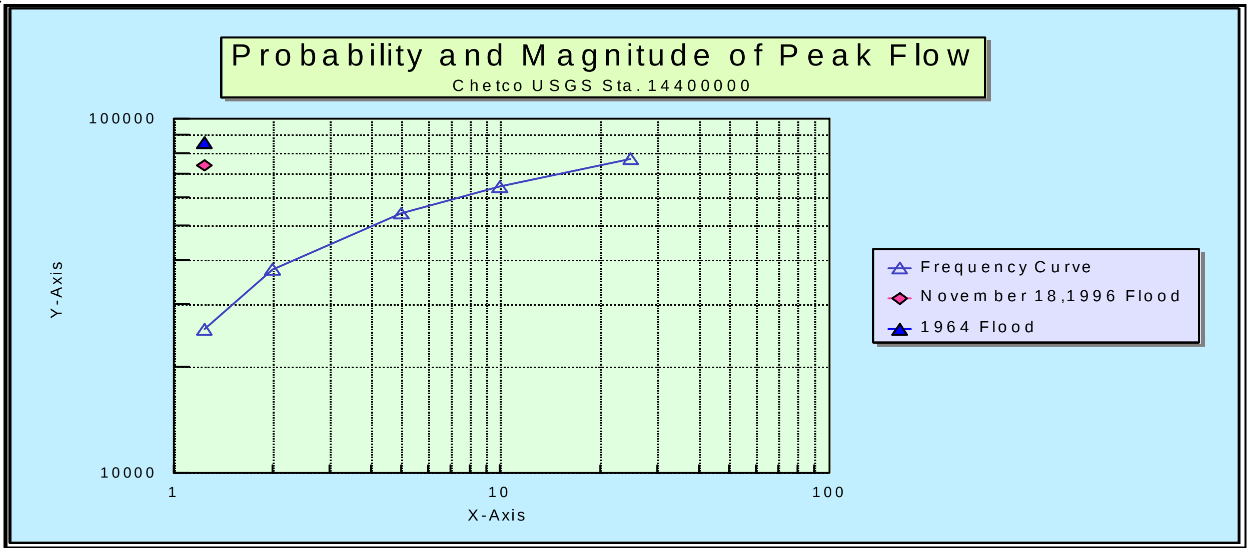
There are no precipitation or runoff gaging stations in the North Fork Chetco area, but a US Geological Survey gaging station is located nearby on the Chetco River. This station has been in operation since 1969 (28 years) and has a drainage area of 297 mi^2. Figure III-17 shows annual instantaneous peak flows for the period of record at the Chetco USGS station and a estimated hydrograph for the North Fork Chetco, developed by an area relationship. The 1964 flood, estimated from floodmarks, had a discharge about 16% higher than the November 18, 1996 flood.

Figure III-17 Comparison of Annual Peak Discharge between North Fork Chetco and Chetco Rivers



A flood frequency analysis is shown in Figure III-18 for the nearby USGS Chetco River gage. The analysis could not be extended upward from 25 years, due to the short period of record.

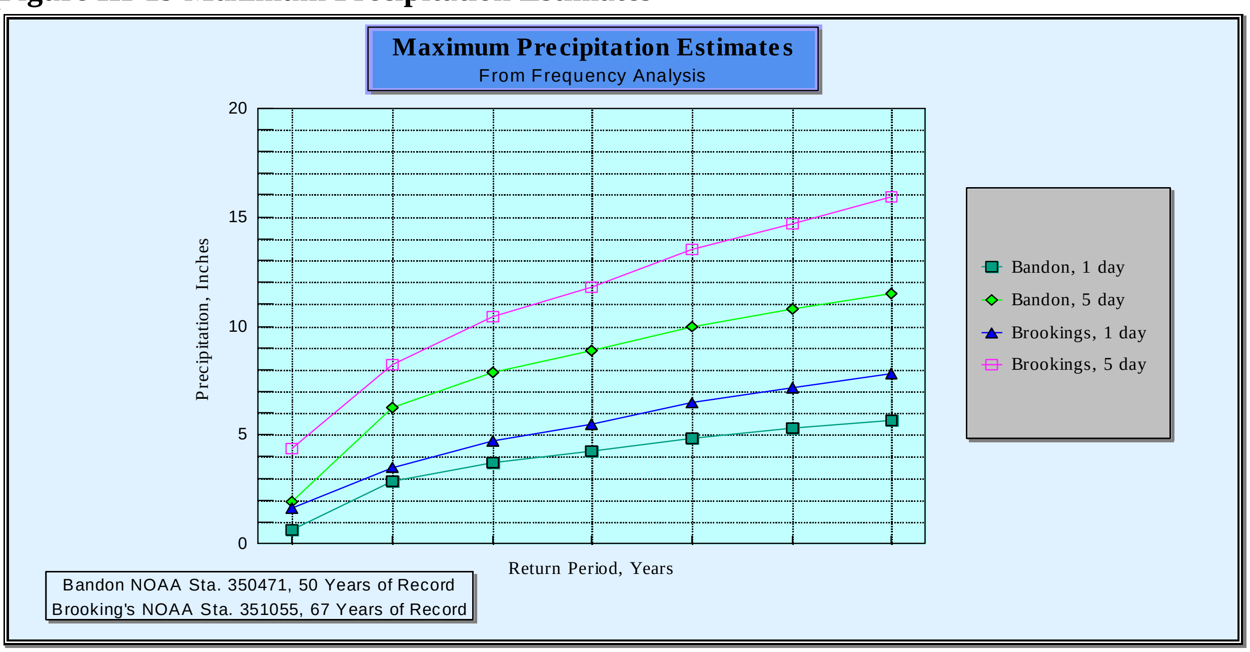
Figure III-18 Probability and Magnitude of Peak Flows



Examination of area gaging station records and interviews with local residents suggest that 1964, 1955, 1971, and 1996 were the worst flood years in the recent past.

Flooding that occurred on November 18, 1996 was probably less severe in the analysis area than in areas to the east and north, including the eastern parts of the Chetco, Pistol, Elk and River basins, and portions of the South Fork Coquille basin (personnel communication, Cindy Ricks, Siskiyou Nat. For.). The RAWS weather station at Red Mound, at 1753' elevation, and just west of the North Fork Chetco received 5.56" of rainfall on November 18,1996. Figure III-19 estimates that this precipitation frequency has a 14 year return period probability. According to the previous Figure III-18, this indicates that runoff from this storm imitated a 23 year event for the Chetco watershed.

Figure III-19 Maximum Precipitation Estimates



Discharge of bankfull and extreme flood flows were estimated for the analysis area using several methods (Table III-3).

Table III-3 Estimated Bankfull (2-year) and Extreme (100-year) Flows

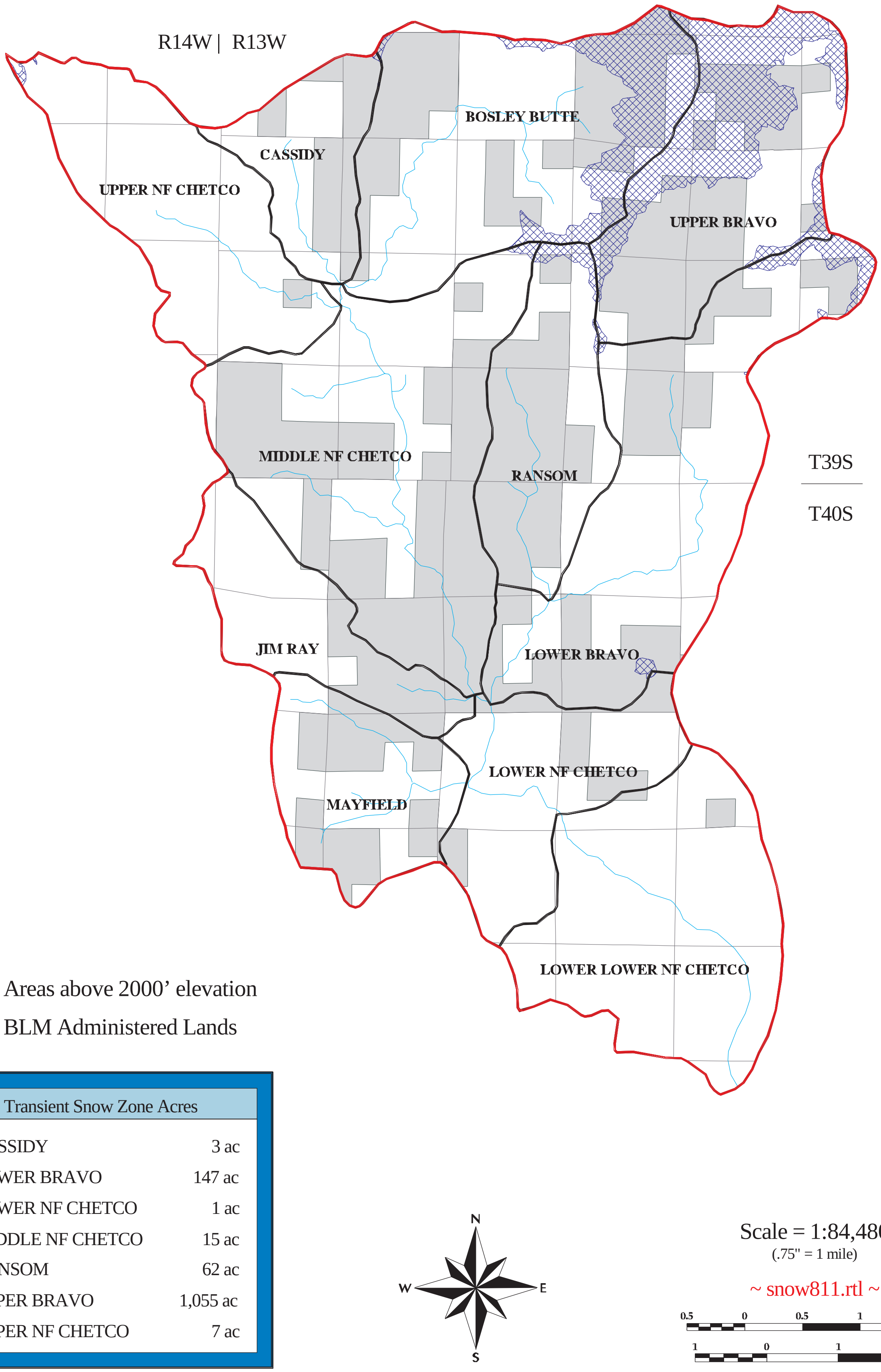
Method*	2 Year Flow (Bankfull) Estimate (cfs)	100 Year Flow Estimate (cfs)
Channel Geometry**	1050	5839
Basin Characteristics*** Regression with USGS Coastal Gaging Stations	4104	12993

* Estimated flows are for the entire analysis area (39.94 mi^2).
** Grant 1992
*** Adams, Campbell et. Al. 1986

Persistent rainfall or storms, especially those lasting several days to weeks, cause the stream network to expand as more of the soils become saturated and live flow again reappears in low order intermittent channels. To a large degree, runoff occurs by infiltration into the soils and subsequent subsurface routing to streams, once soil moisture deficits are satisfied. Exceptions are direct interception into streams or overland flow from roads or other compacted areas. Overland flow in undisturbed forest is seldom observed in Coastal forests because infiltration capacities are in excess of 2 inches per hour, which is much higher than the most intense hourly storm likely to occur in this area (4.5 inches in 6 hours) (NOAA 1973). Examination of available precipitation and stream flow records, reveals that about 85% of the estimated total runoff results from annual precipitation. The remaining losses include soil recharge, transpiration from the dense vegetation, and evaporation. Steeply inclined drainages, little groundwater storage, and steep stream gradients cause quick hydrograph response and flashy flow after the onset of rain. Stream hydrographs for an individual storm emphasize this short lag time with a steep rising curve, but a more moderate recession.

Precipitation as snow can accumulate above 2000' in the analysis area, but usually is transient and only persists a few days to weeks each winter. About 1300 acres (5% of the analysis area) has susceptibility to this come and go snow accumulation. This snow retention area is restricted to Upper Bravo (43%) and Bosley drainages (22%) (Figure III-20). Weather conditions including warm winds and rain can cause rapid melting of the stored water equivalent as snow pack. Snow will accumulate and melt faster in openings than the surrounding forest. This process can increase peak flows, depending on drainage factors and vegetative age and condition.

Figure III−20 Intermittent Snowzone Areas (Elevations above 2000')



Areas above 2000' elevation

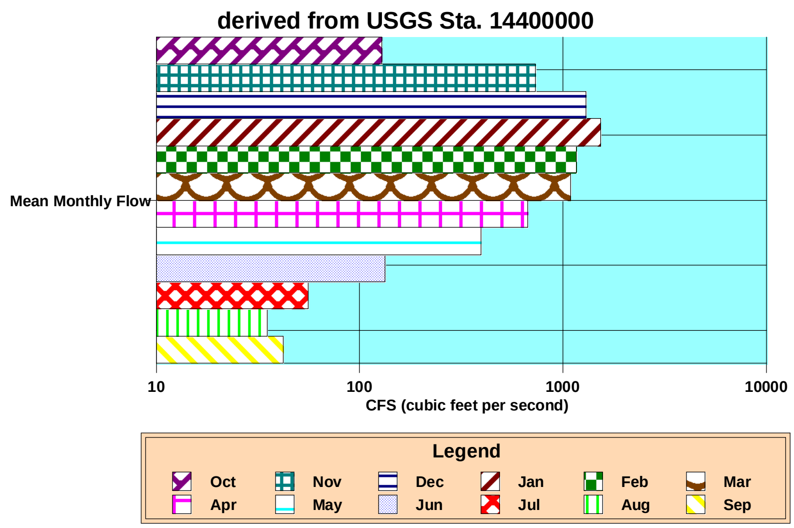
BLM Administered Lands

Transient Snow Zone Acres	
CASSIDY	3 ac
LOWER BRAVO	147 ac
LOWER NF CHETCO	1 ac
MIDDLE NF CHETCO	15 ac
RANSOM	62 ac
UPPER BRAVO	1,055 ac
UPPER NF CHETCO	7 ac

Annual Flow and Yield

Approximately 60% of the annual runoff occurs between December through February, with January being the highest month (Figure III-21). June through October contribute only 4% of the annual runoff and results in very low stream flows. This annual runoff distribution very closely follows the precipitation pattern. Annual runoff for the analysis area is estimated at 227,000 acre feet.

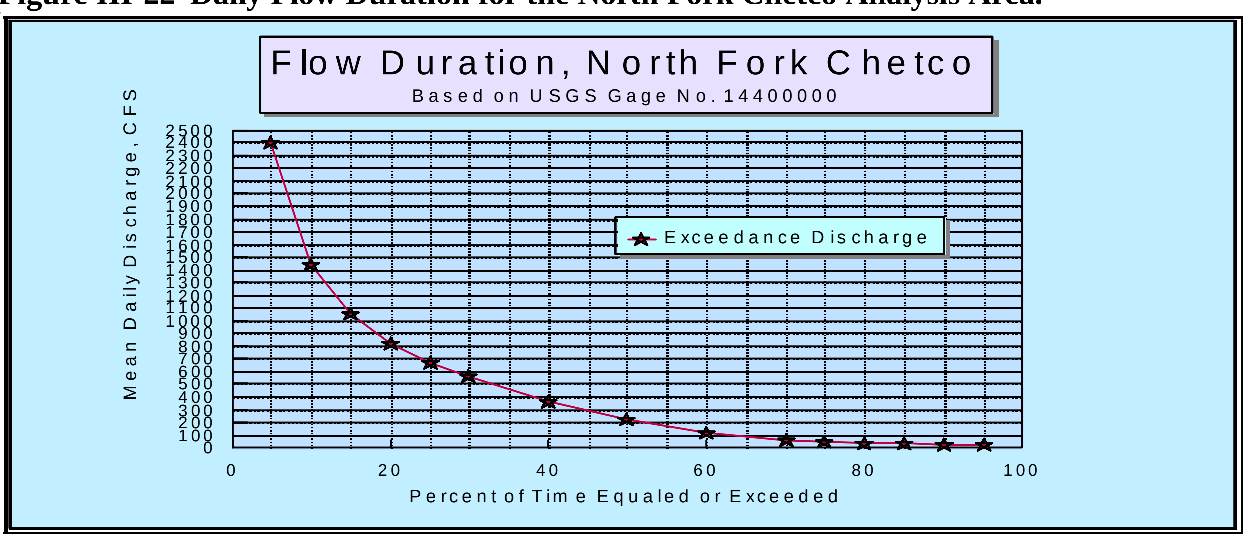
Figure III-21 Mean Monthly Flow for the North Fork Chetco Analysis Area



Flow Distribution

Figure III-22 shows how flow is distributed throughout the year in terms of flow duration. Bankfull to extreme flows occur less than 5% of the time, moderate flows occur 65% of the time, and low flows occur 30% of the time. Channel formation processes are caused by flows which fill the channel to bankfull or beyond, while channel dimensions are maintained by the frequent flows (flows less than bankfull).

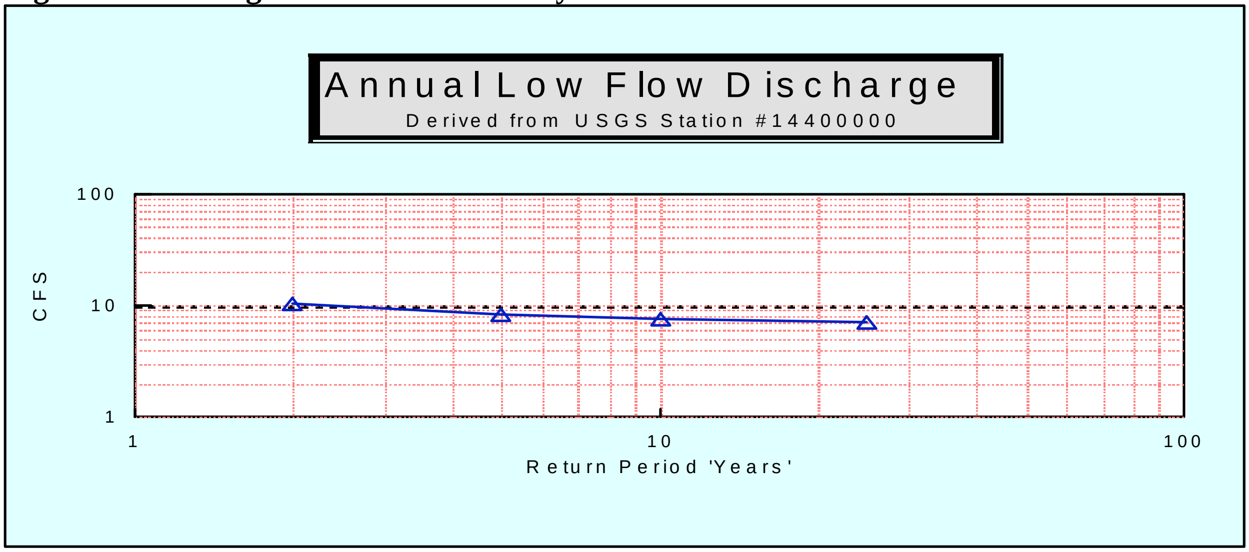
Figure III-22 Daily Flow Duration for the North Fork Chetco Analysis Area.



Minimum Flow

Because rain is infrequent in the summer, streams follow a normal recession and flows become extremely low in mid August-October along North Fork Chetco and other tributary streams. Tributary streams whose base level is above the water table can dry up. Figure III-23 shows an estimate of the magnitude and frequency of low flow in the North Fork Chetco analysis area. It should be kept in mind that these are estimates of the lowest live flows in North Fork Chetco for a consecutive seven day period for the indicated return period or years. This estimate does not consider live flow which may become subterranean and move under the channel in valley alluvium. The average 7-day low flow is about 0.25 cfs/mi^2 for a two year recurrence interval and <0.26 cfs/mi^2 for consecutive periods of up to 30 days. These values are nearly six times higher than other streams in the Coast Range Province.

Figure III-23 Magnitude and Probability of Annual Low Flow



Information from the long term USGS stream flow gage 14325000, near Powers OR. indicates that significant 7-consecutive-day low flows occurred between September-October in 1931, 1933, 1939, 1974, 1987, 1991, 1992 and 1994. It may be interpreted that low flows also occurred within the analysis area during these years. The return period for these 7 day low flows are 20 years or greater. The low flows in 1933, 1991, 1992 and 1994 were near 100 year events (Wellman et al. 1993).

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

Assumptions about flow changes from natural events or management activities are made based on hydrologic processes theory and research monitoring results elsewhere in the Coast Range. No stream gaging data exists in the analysis area to indicate if flows have conclusively changed from natural events or management activities.

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 have shown 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 et. al. 1995). Historic flood flows (greater than a 20-year return frequency) have occurred in 1934, 1955, 1964, 1971, and 1974, and 1996. These floods were 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.

Frequent and Moderate Flows

Frequent flows return several times each winter season and fill the active channel. These flows are responsible for maintaining channel dimensions and moving most of the sediment load. There is little evidence to suggest that these flow magnitudes, nor return periods, have changed for most of the precipitation dominated watershed. Regeneration harvest and road building in the Upper Bravo and Bosley drainages may have some effect on frequent flows, perhaps increasing them by 10-20%, if enough area in the intermittent snow accumulation zone is less than hydrologic recovery. Surface runoff contributions from roads, and water intercepted by midslope roads may be additive in the Upper Bravo and Bosley drainages. A considerable amount of rilling and gullying from compacted areas is apparent in this region (BLM personal observation).

Minor increases in the amount of daily flow in the spring and fall may result following harvest activities. This is a result of the younger vegetation transpiring less water and allowing more water to route to the stream channel. This increase is small and has little effect on overall flow.

Annual Yield

The amount of increased annual runoff in the analysis area is not known, but suspected to be in the range of 10-20%. Annual yield typically increases as a result of the effects of forest harvest and road building, or fire, as shown by studies in the Coast Range (Ziemer et. al. 1996). This increase is a result of reductions in evapotranspiration following the removal of coastal forest vegetation. The current vegetative condition shows 18% of the analysis area is less than 20 years of age and 38% less than 40 years of age. These are hydrologically immature timber stands, which use water at less than potential transpiration rates. As more acres of forest vegetation reach hydrologic maturity (±40 years old), this increased yield will decline. Sites where Douglas-fir and other conifer species are replaced with tanoak and red alder may reach hydrologic recovery at a younger stand age and rapidly decrease soil moisture storage and excess. (Hardwood stands have higher leaf area and evapotranspiration rates.) This stand conversion, whether by fire or harvest, may actually decrease annual yield when compared to conifer stands.

Timing of Flows

The response time of streams to Pacific storms have always been "flashy" because of limited soil and groundwater storage. It is thought that roads and clearcuts in a watershed act positively in advancing timing for a particular storm (Jones et. al. 1996). Roads and ditchlines may be acting as extensions of the stream network and channel the precipitation directly into the stream system. Midslope roads could be intercepting subsurface flow moving in a downslope direction. These factors result in a quicker rise of the stream flow followed by a quicker drop than may have happened in the past. Runoff from compacted areas can also advance this timing in the tributary streams.

Forest management may have a slight effect on advancing the timing of flows in the analysis area because of compaction, changes in evapotranspiration rates, and harvesting in rain-on-snow zones. However, the degree is uncertain.

Surface runoff from roads and skid trails can advance timing of flows, if more than about 8-12% of the analysis area is compacted. A cursory review of past aerial photography reveals that road, tractor roads and skid trail density may approach 5-8% of localized areas within drainages. Some of these roads have channeled water as gullies and captured stream channels, thus extending channels.

Where large areas are in young age classes, flows can occur earlier in the fall than in the past. Reduced transpiration from hydrologically immature trees results in increased soil moisture content. As the fall rains occur, less precipitation is needed to saturate these soils and the excess water enters the stream system either through primarily subsurface flow. This results in a rise in streams levels earlier in the year than under undisturbed conditions.

Rain-on-snow areas in the analysis area will respond with quicker runoff.

<u>Minimum Flows</u>
Low flows have undoubtedly been increased by regeneration cutting in the analysis area. However, changes in stream channel condition and species conversion to hardwoods, especially tanoak that are more efficient at transpiring water during the summer, may have diminished these increases. Management activities that change riparian areas from conifer to hardwood could have some effect on reducing low flows, because of increases in the transpiration rate.

Summer flows are a result of subsurface flow being released during the late spring/summer and is primarily dependant upon geology, soil types, soil depths and porosity. Upper North Fork, Lower North Fork Chetco, and a series of ridges throughout the analysis area have deep fine textured soils with moderately low permeability. Streams draining these areas have longer summer durations of streamflow.

Notes taken by U.S. Government surveyors on Sept 24, 1875, indicated that the North Fork Chetco River was dry near its confluence with the Chetco River in T.40 S., R.13 W., Sec 35, North ½ (Curry County Surveyor's Office). This channel drying condition was also observed in 1982 and may have been the result of channel aggradation from coarse sediments in the lower stream reaches. Much coarse and fine sediments entered the channels, during intense logging from 1950-1970, coincident with the 1955 and 1964 floods, and a high degree of inner gorge shallow rapid landsliding. Channel widening and inundation in many stream reaches are evident on 1969 aerial photography. It is plausible that aggradation occurred in many of the low gradient depositional stream types and this material was moved downstream and exported out of the analysis area over the next decade. Remaining coarse alluvium in the lower portion of the analysis area could cause channel drying, by allowing low summer flows to recede under the streambed.

During the 1990's, drought years some channel drying was again evident, leaving isolated pools in late summer.

Trends

Because of the ownership pattern, it is estimated that 50% of the vegetation will be in a early-seral condition at any one time. Annual yield may be permanently increased by 10-20% for sites with young vegetation, under this management strategy. Stand conversion to tanoak could decrease annual yield. A legacy of compacted roads and gullies over the last forty years will continue to deliver water to streams at a slightly faster rate. Full road decommissioning could disconnect ditches from streams and may slightly correct advanced timing. Risk of peak flow increase, probably in the range of 10-20%, may occur in higher elevation areas of Bravo and Bosley Creeks, depending on intensity of land management. Extreme peak and minimum flows are dependant on climatic patterns.

How have natural and human caused changes in water quantity and timing of flows affected water quality?

Changes in water quantity or timing, whether natural or management related effect slope stability and channel processes. Changes in sediment delivery could affect water quality and is the chief parameter of concern from flow changes in the analysis area.

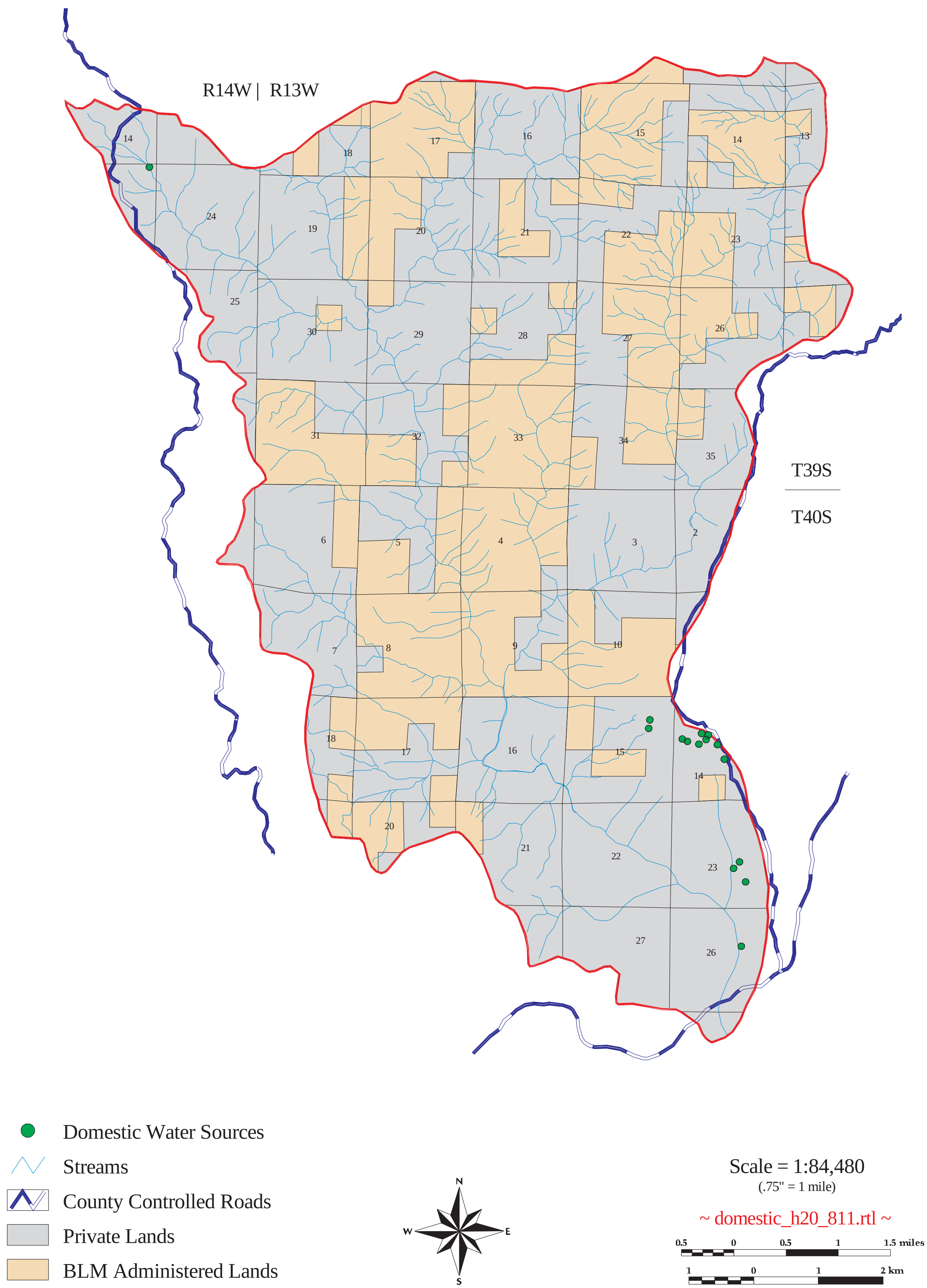
There is insufficient information to evaluate if natural flows or timing have changed. Precipitation is a stochastic processes and depends on probabilities and sequences of events. Discharges larger than channel forming frequent and annual flows that occur less than 5% of the time carry the majority of the sediment load. There are many source areas for sediment including historic shallow rapid slides from the inner gorges along streams that fuel the sediment supply. Sediment delivery is most active during large events. Turbid water decreases water quality during these events, but is short term and normally clears up in 1-5 days after precipitation slows.

Because of the pattern of road building, and regeneration harvest including tractor yarding and involving small first-second order streams in the last 40 years, many small drainages are not fully hydrologically recovered. Annual yield and perhaps peak flows for some of these small catchments either in the snow zone or that have high compaction density has increased. The degree of increase and the degree to which sedimentation is affected is not known.

How much surface water is being used for out of stream uses, and where are points of diversion (including domestic sources)? What effect does this have on available summer flow?

Surface water, springs and wells in the analysis area supply a small amount of drinking, domestic, and irrigation water to local residents living mostly along Gardner Ridge (Figure III-24). In addition, numerous wildlife and plant species are dependent upon the drainages for both

Figure III−24 Domestic Water Sources



drinking water and habitat. Available records obtained from District XIX Watermaster department in Coquille show that there are six permits or water rights for surface sources. Total withdrawal from springs and surface water is 0.2 cfs. Three sources are along Lewis Creek, tributary to the North Fork Chetco, one source is on the North Fork Chetco, and two sources are springs. A door to door water use survey was conducted and all willing occupants of residences within the analysis area were interviewed. Of the 10 residences contacted, four use springs, four use groundwater from wells and 2 use surface and groundwater. Surface sources use include the North Fork Chetco and a tributary Lewis Creek.

The known water withdrawals amount to only 2% of the 2 year 7 day low flow. This diversion amount is diverted low in the analysis area and appears to be insignificant to stream flows.

Water quality data of drinking water in North Fork Chetco is not available at present. Water quality testing is not required by state or federal laws because any one water system does not supply more than three households. Many of the surface-water withdrawal systems include a catch basin and/or settling tank to reduce particulates; some systems have neither.

ODFW has applied to the Oregon Water Resources Department for various minimum instream flows on the Chetco River (ODFW 1992). Application #70887 has a summer minimum flow of 55 cfs, or the natural streamflow, and is located between the confluence with the South Fork and Bravo Creek, with a priority date of 11/08/90. This application would greatly exceed the amount of available water during the dry period. Other streams in the analysis area do not have any instream minimum flow protection pending, but are at low risk for water withdrawals or flow modification.

What are the influences and relationships between hydrologic processes and other ecosystem processes (eg., sediment delivery)?

Peak flows have played secondary role in initiating debris flows and shallow rapid streamside slides. Limited floodplains, high stream flows may access and remove the toe of hillslopes along inner gorge, increasing the vulnerability of sliding (refer to Section III.5-Erosion Processes). Major channel adjustments have resulted from infrequent extreme flood flows (refer to Section IV.2- Aquatic Habitat). Low flows can affect the distribution of aquatic habitat and restrict the movement of fishes. Runoff and sediment delivery was higher for several winter seasons after fires, like the 1939 occurrence in Upper Bravo and Bosley Creeks.

What is the management objective for the hydrologic processes in the analysis area?

The management objective for the analysis area is to: A) continue with forest management and other activities in such a way as to minimize the risk of increasing peak flows or altering timing of runoff, and B) provide uninterrupted supplies of high quality water at the boundaries of BLM administered lands to domestic and other water uses.

III.7 DISTURBANCE PROCESSES

What naturally-caused disturbances occur in the analysis area? and how big are they?

Wildfire

Fire can be assumed to be the primary natural disturbance process for this part of southern Oregon Coast. Agee (1991) suggests a fire frequency of 90-150 years for coastal forests in southwest Oregon. Documentation as to how often, to what scale, and to what intensity that fire occurred, prior to the influence of Native Americans is not known. The Chetco Watershed Analysis (USFS 1996a) determined that lightning caused fires were relatively infrequent in number, averaging one lightning caused fire every 5 years since 1910. However, they were large in size, averaging 10,000 acres per occurrence. Fire activity reports from the Chetco Ranger District similarly support this relatively low level of lightning activity. The Chetco Watershed Analysis (USFS 1996a) also suggested that low intensity fires were more frequent than the more intensive stand replacement fires.

In order to determine a detailed fire history, an intensive analysis involving field examination of stumps and stand ages is needed.

Fine scale disturbance

Fine scale disturbances like individual tree and patch blow down, low severity fire, insects, disease, drought, snow breakage, flooding, stream bank erosion, and soil movement create small gaps throughout the landscape. These disturbances are present, but a determination of their frequency or scale was not conducted. Most stands were influenced by combinations of all these disturbance processes, occurring at varying frequencies and unevenly distributed throughout the stand and the subwatershed. These natural processes provide vegetative complexity and diversity at a variety of scales across the landscape.

Landslides - While landslides usually affect only small areas at a time, they appear to be a common form of disturbance in riparian areas within this analysis area. Far the most common form of landslides (84%) was determined to be the shallow rapid type, averaging 1.1 acres in size. The severity of this type of disturbance can be very high, resulting in loss of all soil down to bedrock in extreme cases. Landslides that reach the stream can deliver structural material (woody debris, and boulders), gravel, fine sediment, and fine organic matter. (refer to Section 1 - Erosion Processes for detailed information on landslides)

Wind - Wind has played a very limited role as a disturbance factor. For this part of the southern Oregon Coast, storms generally originate from the south and southwest. The orientation of North Fork Chetco itself is northeast-southwest. Areas of windthrow are generally located along east-west orientations, which parallels the current understanding of how wind storms affect windthrow (Andrus and Froehlich 1992).

A search through historical timber sale files reveal only one salvage sale which could be attributed to wind damage. The five acre sale (TS 71-57), was located in Sec. 21, T.40 S., R.13

W., adjacent to a recent clearcut, and on the southernmost ridge forming the analysis area boundary. Very small patches of blowdown, generally .5 acre or less, are observed scattered throughout the area in stands predominately dominated by tanoak. In 1995, a commercial firewood permit was issued for removal of this patch-type blowdown along roadsides in Section 17, T.39 S., R. 13 S.

Insect and disease - Laminated root rot and black stain disease can kill patches of sapling and pole size trees, but little evidence of these is noted in the analysis area. Bark beetles usually kill trees already weakened by other agents like drought, fire or disease, but may become epidemic following extensive fire or blowdown. Other pathogens and insects attack trees in this analysis area but none are known to cause significant mortality in established stands. (refer to Section V.4 for discussion on Port-Orford cedar root rot)

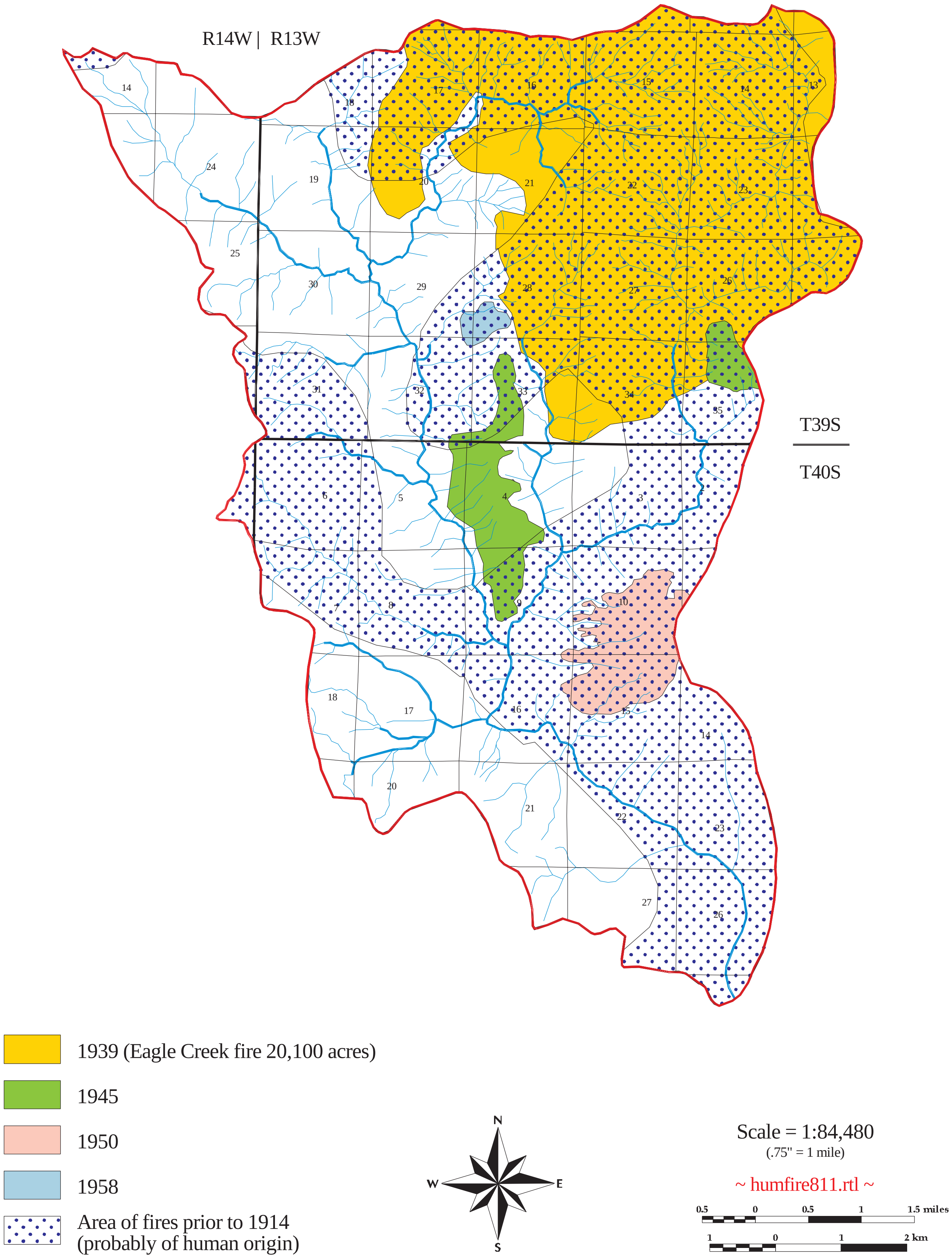
What are the human-caused disturbances in the analysis area?

Human-caused Fire

The historic landscape throughout most of the entire Coast Range, including the analysis area, was characterized by large, similar aged patches (ranging in age from 0 to 500+ years old) on the order of many square miles. Most of these patches were the result of large scale stand-replacement fire disturbances. Within and between these patches, scattered old-growth trees (i.e., remnant trees >160 yrs. old), patches of old-growth, and small patches of various younger age classes formed a varied mosaic pattern. Research by Ripple (1994) calculated that 61% of all conifer Coast Range forests were in old growth condition prior to the widespread fires of the late 1840s. These fires, thought to set by early white settlers, burned approximately 35% of the Coast Range (Teensma et. al. 1991) resulting in only 43% of the forests in old growth condition.

Repeated fires have occurred around the Bosley Butte area, in the northeast corner, and Palmer Butte area, in the southeast corner (Figure III-25). Prior to early Euro-American settlement, evidence exists that Native Americans played a large role in using fire to modify the vegetation for their purposes (Agee 1993). It is unclear as to the origin of fires prior to 1911, but the fires from 1939 on were of human origin based on documentation from the Oregon State Board of Forestry, (Appendix B-1). All of the fires occurred between August to October. Humans may have also been the cause of the fires prior to 1911. Zybach (1993) and Atzet and Wheeler (1982) concluded that European settlers started extensive and frequent fires throughout the Coast Range and Klamath Province in the mid 1800's. Anecdotal information supports this. Conversations with the Fire Management Officer at the Chetco Ranger District reveal that at the turn of the century, settlers in the Chetco basin frequently set fires to improve grazing conditions for sheep and prospectors set fires to remove the vegetation prior to explorations. Thus, most of the vegetation in the analysis area may have been altered in one way or another by human-caused fire.

Figure III-25 Location of Human Caused Fires Since 1914



Grazing

Around the turn of the century, many areas in the Klamath Province were grazed heavily by sheep and cattle (Atzet and Wheeler 1982). Fencing is still visible around some of the meadows in the analysis area suggesting that at least some of the area's meadows received some domestic grazing pressure.

Logging

Since the 1950's, logging has had as the most impact on vegetation. To date, 85% of private ownership has been harvested compared to only 18% of BLM's ownership (Table III-4). Aerial photography reveals that private landowners harvested over 60 % of their ownership by the late 1960's. Harvest on private lands began in the 1950's and was concentrated in the lower portions of the North Fork Chetco River in the southeast corner and along Old Highway 101 in the northwest corner of the analysis area.

Table III-4 Logging Disturbance by Decade

BLM Ownership (9,263 ac)			Private Ownership (16,299 ac)		TOTAL (25,562 ac)
Decade	Acres harvested	% of Federal ownership	Acres harvested	% of PVT ownership	
1950's	0	0 %	5833	36 %	23 %
1960's	69	< 1 %	4970	31 %	20 %
1970's	345	4 %	1156	7 %	6 %
1980's	641	7 %	2339	15 %	12 %
1990's	621	7 %	1010	6 %	7 %
Totals	1676	18 %	15,308**	85 %	61 %

** includes a total of 1485 acres of previously harvested areas in 1960's

Harvest methods during the 1950's and 1960's differed from the clearcut practices in the recent past. Most of this early harvest was performed by crawler tractor equipment and concentrated on removing only the Douglas-fir, leaving a partial canopy cover of tanoak. In some areas, this had the effect of converting mixed conifer/hardwood stands to those dominated by nearly pure tanoak.

A few areas which were harvested in the 1960's were harvested for a second time in the mid-late 1980's. Portions of private land in the lower portion of the analysis area, Secs. 21, 22, 26, & 27, T. 40 S., R. 13 W., appeared to have been poorly reforested, judging from aerial photos, and this harvest was concentrated in areas with a high red alder component. The commercial removal of hardwoods (red alder and tanoak) is strongly correlated with the fluxuations in the price of wood chips or other pulpwood raw materials.

The District policy to salvage of dead or dying trees during the mid-1960's to early 1970's was very limited. Documentation of timber harvest showed that only one salvage sale occurred, Section 9, T. 40 S., R. 13 W., between the Main Road and the North Fork Chetco River. The partial cut area was 38 acres. In addition, it was common practice on timber sales during the 1970's to fall or harvest dead trees within 200 feet of roads or the boundaries of clearcut units. Therefore, most snags and down logs within remnant stands may be at or near natural levels in the remainder of the BLM managed lands (refer to V.2-Terrestrial Habitat).

As part of forest management practices, herbicide application (on private lands) or manual cutting of noncommercial species to control competition generally occurs within the first 15 years following harvest. This has the effect of reducing the percentage of tanoak and increasing the percentage of Douglas-fir in these managed stands. However, visual observations and studies by Harrington and Tappeiner (unpublished) reveal that these treatments do not preclude the presence of tanoak as a viable component later in the stands development.

How have disturbances effected other ecosystem components (eg. hydrology, stream channel, vegetation, etc.)?

The hydrologic processes were most effected by the timber harvest during the 1950's and 1960's, which resulted in 43% of the analysis area being disturbed. Typical timber harvest practices during this time were tractor-logging and sidecast road construction. These practices were exacerbated by the 1955 and 1964 floods, both 100 year events, to produce the highest rate of landslides found in the analysis area (refer to Section III.5-Erosion Processes). These landslides resulted in the input of large amounts of sediment into the aquatic system (refer to Section IV.2-Aquatic Habitat).

Steam channels were similarly effected during this same time frame. The combination of the removal of large down wood and high inputs of sedimentation had degraded the aquatic habitat. Large trees, which act as recruitment potential for down wood, were removed in some areas (refer to Section IV.2-Aquatic Habitat). Currently, as the age of residual stands increase, the aquatic habitat is trending towards recovery.

The overall vegetation has been most effected by frequent fires, predominately human-caused. These fires have altered the species composition of the vegetation towards stands predominant in tanoak (refer to Section V.1-Vegetation). Early logging practices of high grading (removing the large Douglas-fir left from the fires) completed the transformation in some areas.

Terrestrial habitats have similarly been effected by timber harvest. 61 % of the analysis area has been transformed into younger generally, structurally simplified stands. Key components, such as down logs and snags have been removed during the process (refer to Section V.2-Terrestrial Habitat).