

EXECUTIVE SUMMARY

Watershed Analysis for Mendocino Redwood Company's Ownership in the Greenwood Creek Watershed

This report presents the results of a watershed analysis performed by Mendocino Redwood Company (MRC) on their ownership¹ in the Greenwood Creek watershed. The MRC ownership in the Greenwood Creek watershed is considered the Greenwood watershed analysis unit (WAU). This section presents a brief overview of results from the watershed analysis performed by MRC. More specific information is found in the individual modules of this report.

Greenwood Creek and its tributaries support populations of steelhead trout, fisheries of concern in northern California. Greenwood Creek has been put on a "Watch List" by the State Water Quality Control Board for potential listing as sediment and temperature impairment under Section 303(d) of the Clean Water Act. For this reason MRC conducted a watershed analysis to assist in their efforts to reduce non-point source pollution, evaluate current and past land management practices and establish a baseline for monitoring of watershed conditions over time. The watershed analysis will also be used to identify needs for site-specific management planning and restoration in the watershed to reduce impacts to aquatic resources and potentially to improve fish and aquatic habitat conditions.

MRC's approach to the Greenwood Creek watershed analysis was to perform resource assessments of mass wasting, surface and point source erosion (roads/skid trails), hydrology, fish habitat, amphibian distribution, riparian condition and stream channel condition. Mass wasting, riparian condition and surface and point source erosion modules address the hillslope hazards. The fish habitat, amphibian distribution, and stream channel condition modules address the vulnerability of aquatic resources. Prescriptions are developed to address the issues and processes identified in the watershed analysis. Finally, monitoring is suggested to determine the efficacy of the prescriptions to protect sensitive aquatic resources. The monitoring will provide the feedback for MRC's adaptive management approach to resource conservation.

RESULTS

Mass Wasting

A total of 276 shallow-seated landslides (debris slides, torrents, or flows) were identified and characterized in the Greenwood Creek WAU. A total of 69 deep-seated landslides (rockslides and earthflows) were mapped in the Greenwood Creek WAU. The majority of the landslides observed in the Greenwood Creek WAU are debris slides and rockslides. Of the 276 shallow-seated landslides in the Greenwood Creek WAU, 165 are determined to be road associated (includes roads, skid trails, or landings). This is approximately 60% of the total number of shallow-seated landslides. There were 31 debris torrents and flows observed in the Greenwood Creek WAU. This is approximately 11 percent of the total shallow-seated landslides observed in the Greenwood Creek WAU. Of the 103 field observed shallow-seated landslides, 99% were initiated on slopes of 65% gradient or higher.

¹ It must be emphasized that only the Mendocino Redwood Company ownership is analyzed.

A total of approximately 223,000 tons of mass wasting sediment delivery was estimated for the time period 1960-2000 in the Greenwood Creek WAU. This equates to approximately 359 tons/sq. mi./yr. Of the total estimated amount, 58% delivered from 1960-1969, 21% from 1970-1978, 7% from 1979-1990, and 14% delivered in the 1991-2000 time period. Road associated mass wasting (including roads, skid trails, and landings) was found to have contributed 153,200 tons (247 tons/sq. mi./yr) of sediment over the 41 years analyzed in the Greenwood Creek WAU (Table A-6). This represents approximately 69% of the total mass wasting inputs for the Greenwood Creek WAU for 1960-2000.

The landscape was partitioned into six Terrain Stability Units (TSU) representing general areas of similar geomorphology, landslide processes, and sediment delivery potential for shallow-seated landslides (Map A-2). The TSU with the largest estimated sediment delivery is TSU 4, which is estimated to deliver 44% of the total sediment input for the Greenwood Creek WAU. This is partly due to the high road density within this unit which makes the actual hazard of the unit appear artificially high; 80% of the total delivered sediment in TSU 4 came from road related features. Combining all high hazard units (TSU 1, 2, and 3) would yield 72% of the estimated non-road related sediment input off approximately 18% of the MRC owned acreage. Combining the moderate and low hazard units (TSU 4 and 5) would yield 28% of the estimated non-road related sediment input off the remaining 82% of the property.

Surface and Point Erosion (Roads/Skid Trails)

It was determined that there are 108 miles of truck roads in the Greenwood WAU (skid trails not included). This represented an average road density of 7.5 miles of road per square mile.

Approximately 16.5 miles of road contributes surface erosion to watercourses (defined as contributing road length). This represents approximately 15% of the total road length in the Greenwood WAU.

Roads in the Greenwood WAU are estimated to generate, on average, 750 tons/mi²/yr of sediment from road-associated surface and point source erosion (Table ES-1).

Table ES-1. Road Associated Surface and Point Source Erosion Estimates by Planning Watershed for the Greenwood WAU.

Planning Watershed	MRC Owned (sq mi)	Surface Erosion (tons/sq mi/yr)	Point Source Erosion (tons/sq mi/yr)	Total (surface +point source) (tons/sq mi/yr)
Cuffey's Point	0.4	40	10	50
Lower Greenwood Creek	9.4	410	340	750
Upper Greenwood Creek	5.7	340	420	760
<i>Greenwood WAU Total</i>	<i>15.5</i>	<i>380</i>	<i>370</i>	<i>750</i>

The future potential for point source erosion was evaluated in the Greenwood WAU. This potential erosion or controllable erosion was identified during the road inventory during 2000-2003 then adjusted by road erosion control work performed in 1998-2003. A total of 60,549 cubic yards of controllable erosion (Table ES-2) is currently on the road network in the Greenwood WAU. Since 1998, when the company was formed, 9,705 cubic yards of erosion from the road network has been controlled. This represents an improvement of 7% of the total controllable erosion within the last 5 years.

Table ES-2. Controllable Erosion by Treatment Immediacy for the Greenwood WAU.

Location	Controllable Erosion Treatment Immediacy (yd ³)		
	High	Moderate	Low
Culverts	6660	3282	13623
Crossings	756	1863	14633
Landings	107	1000	5191
Erosion Features	0	1250	863
Road slides	278	4013	7030
Total	7801	11408	41340

The Greenwood WAU was evaluated for skid trail sediment delivery from the 1960s to 2000. The greatest sediment delivery from skid trails occurred during the 1960s and then in the 1980s. The 1990's represented the lowest sediment delivery.

Hydrology

Using the peak flow record from the Navarro River 1952-2002, the flood of record is 1955 (64,500 cfs) considered to be greater than a 50 year event for the Navarro River (Table C-1). In the last decade alone there has been 2 storms greater than a 10 year recurrence (1993 and 1995), 5 storms greater than a 5 year recurrence (1993, 1995(3) and 1998) and 8 storms greater than >2 yr. recurrence. This indicates a high number of extreme storms occurring within the last decade. The high occurrence of these extreme storms in the last decade suggests that the Greenwood WAU has been subjected to stressful hydrologic conditions, possibly creating a greater incidence of landslides, road failures or surface erosion.

Riparian Function

The riparian function assessment is divided into two groups: 1) the potential of the riparian stand to recruit large woody debris (LWD) to the stream channel along with the level of concern about current LWD conditions in the stream, and 2) a canopy closure and stream temperature assessment. Our analysis showed a need for large woody debris in most of the channel segments of the Greenwood WAU due to low instream LWD and low riparian recruitment potentials. Channel segments with LWD levels that are well below targets will need to be a priority for future recruitment and restoration work. Riparian LWD recruitment potential in the Greenwood WAU is moderate to low. Currently, the streams range primarily between deficient and on target LWD quality ratings. Several of the smaller tributaries of Greenwood Creek have on target LWD quality ratings. The mainstem of Greenwood Creek has deficient LWD quality ratings mainly due to a lack of larger key LWD pieces.

The Greenwood WAU generally has favorable stream shade conditions as demonstrated by the stream shade ratings. All of the tributaries rated have an "on target" stream shade rating. Greenwood Creek rates as "marginal" in both the upper and lower segments. However, both of these sections of Greenwood Creek are close to being "on target". It is anticipated that over time with policies promoting stream shade these ratings will improve. There are no "deficient" stream shade quality ratings in the Greenwood WAU.

Stream temperatures in the Greenwood WAU are well within a range preferred by steelhead trout, though above levels that is stressful to coho salmon (a species not currently utilizing the watershed). Air temperatures within the watershed increase as you go east from the ocean; similarly water temperature increase as you go east from the ocean corresponding to this increase in air temperature. A possible explanation for higher stream temperatures in Greenwood Creek is from very high air temperatures in the eastern portion of the watershed. This water is heated then travels through a relatively small watershed. The Greenwood Creek watershed is not large (as compared to many of the river basins in the area), so as

the warmer water travels west into the cooler air temperature areas of the watershed it is not subjected to cooler air long enough for the water to cool much. The tributaries in the lower portions of Greenwood WAU are subjected to cooler air temperatures, thus have lower water temperatures. But because these cool tributaries are relatively small they do not provide a lot of summer streamflow and are not able to provide much of a cooling influence to the water in Greenwood Creek. Current canopy levels provide good shade to Greenwood Creek but cannot overcome the higher air temperatures in the eastern portion of the watershed.

Stream Channel Condition

Baseline information on the stream channels of the Greenwood WAU was collected and reported (see Stream Channel Condition module). Individual channel segments were categorized into geomorphic units using the baseline stream channel information, topography the channel segments are found in, position in the drainage network, and gradient/confinement classes. Four stream geomorphic units were established to represent the range of channel conditions and sensitivities to input factors of coarse and fine sediment and LWD (Table ES-3). Long term channel monitoring observations have been collected on 1 monitoring segment in the Greenwood WAU in 2001 and 2003 the results for these observations are presented in the Stream Channel Condition module.

Table ES-3. Stream Geomorphic Units and Sensitivities for the Greenwood WAU.

Stream Geomorphic Unit	Channel Sensitivity		
	Coarse Sediment	Fine Sediment	LWD
Geomorphic Unit I. Confined Low Gradient Channels.	Moderate	Moderate	High
Geomorphic Unit II. Low Gradient Confined to Moderately Confined Transport Channels.	Moderate	Moderate	High
Geomorphic Unit III. Moderate Gradient Confined Transport Channels	Moderate	Moderate	Moderate
Geomorphic Unit IV. High Gradient Transport Channels.	Low	Low	Low

Fish Habitat Assessment

The anadromous fish species inhabiting the Greenwood WAU is steelhead trout (*Oncorhynchus mykiss*) and there is much debate as to whether or not coho salmon (*Oncorhynchus kisutch*) once existed in this watershed. Coho salmon do not currently reside in the Greenwood WAU. Other species include three-spine stickleback (*Gasterosteus aculeatus*), prickly sculpin (*Cottus asper*), coastrange sculpin (*C. aleuticus*), California roach (*Lavinia symmetricus*).

Habitat typing data indicated that spawning habitat was generally fair to good throughout most of the Greenwood WAU. However, permeability data indicated gravels with low permeability. Reduction of erosion rates should increase the quality of spawning gravel in the Greenwood WAU. Throughout most of the Greenwood WAU, summer rearing and over-wintering habitat were rated as poor to fair. Land management activities that promote woody debris recruitment and sediment reduction should directly increase the quality of rearing habitat in the Greenwood WAU.

Amphibian Distribution

The amphibian species detected in the Greenwood WAU represent most every species having geographical ranges in the area. Four amphibious 'Species of Special Concern' (as designated by the

State of California) were detected within the Greenwood WAU: red-legged frogs, tailed frogs, foothill yellow-legged frogs and southern torrent salamanders. To date, the results of MRC's amphibian distribution studies have only detected one other watershed within MRC's ownership where all four 'concern species' were present (Albion River). Aquatic habitat types in the Greenwood WAU have remained functional to support many species which have been extirpated both locally and regionally. One of the most significant problems pertaining to aquatic amphibians in the Greenwood Creek WAU is the presence of non-native bullfrogs.

Synthesis

The habitat quality ratings and sediment input summaries show that large woody debris and road associated sediment have the most significant need for improvement. Stream temperature and shade provide good conditions for steelhead trout, but are show less desirable conditions for coho salmon (a species not known to reside in Greenwood Creek). Currently MRC has made good strides toward controlling road sediment with 7% of the total controllable erosion addressed in the past 5 years. Although fine sediment levels in one long term monitoring segment are good, permeability levels are poor. Hopefully through increase road improvements and time the permeability observations will improve.

Land Management Prescriptions

The following prescriptions were specifically prepared for use in the Greenwood WAU. These prescriptions are meant to help address issues to aid in the stewardship of aquatic resources of the Mendocino Redwood Company ownership in the Greenwood WAU. The prescriptions are meant to be used in addition to the current California Forest Practice Rules and company policies. At the time of the publication of this watershed analysis MRC's forest management policies are governed by interim guidelines prior to the issuance of a Habitat Conservation Plan and Natural Community Conservation Plan (HCP/NCCP). Once the HCP/NCCP is approved, the conservation strategies set forth in these documents will become the company policies. A prescription is only presented if it deviates from or adds clarification to these policies.

Mass Wasting

Mass wasting map unit 1 – Inner gorge or steep streamside slopes adjacent to low gradient watercourses

Where there is inner gorge within MWMU 1 protections will extend from the edge of the watercourse transition line up to the break in slope of the inner gorge and 25 feet of additional slope distance after the break in slope of the inner gorge.

MWMU 1 Road construction:

- No new road or landing construction unless field reviewed and approved by a California Registered Geologist.

MWMU 1 Existing Roads:

- Roads or landings shall be maintained at the design standards that lower risk of mass wasting sediment delivery. Existing roads and landings within MWMU 1 should be considered for abandonment if no longer needed.

MWMU 1 Tractor Yarding:

- Equipment exclusion zones on inner gorge slopes. Equipment exclusion zones on steep streamside slopes (non-inner gorge) except for existing roads or where alternative yarding method creates potential for greater sediment delivery.

MWMU 1 Skid Trail Construction or Reconstruction:

- No new tractor trail construction unless field reviewed and approved by a California Registered Geologist.

MWMU 1 Timber Harvest:

- MWMU 1 will receive no harvest on inner gorge slopes unless approved by a California Registered Geologist. On steep streamside slopes within MWMU 1, in addition to the riparian protections set as company policy, timber harvest must retain a minimum of 50% canopy² dispersed evenly across the slopes.

Mass wasting map unit 2 – Inner gorge or steep streamside slopes adjacent to moderate to high gradient watercourses

Where there is inner gorge within MWMU 2 protections will extend from the edge of the watercourse transition line up to the break in slope of the inner gorge and 25 feet of additional slope distance after the break in slope of the inner gorge.

MWMU 2 Road construction:

- If inner gorge topography, no new road or landing construction unless field reviewed and approved by a California Registered Geologist. If steep streamside slope topography, road construction shall be minimized. If road construction must occur, the road must utilize the highest design standards to lower risk of mass wasting sediment delivery.

MWMU 2 Existing Roads:

- Roads or landings shall be maintained at the design standards that lower risk of mass wasting sediment delivery. Existing roads and landings within MWMU 2 should be considered for abandonment if no longer needed.

MWMU 2 Tractor Yarding:

- Equipment exclusion zones on inner gorge slopes. Equipment exclusion zones on steep streamside slopes except for existing roads or where alternative yarding method creates potential for greater sediment delivery.

MWMU 2 Skid Trail Construction or Reconstruction:

- No new tractor trail construction unless field reviewed and approved by a California Registered Geologist.

MWMU 2 Timber Harvest:

- No harvest on inner gorge slopes unless approved by a California Registered Geologist. On steep streamside slopes within MWMU 2, in addition to the riparian protections set as company policy, timber harvest must retain a minimum of 50% canopy (see footnote 2) dispersed evenly across the slopes.

Mass wasting map unit 3 – Steep dissected terrain

MWMU 3 Road construction:

² Only trees greater than 30 feet in height count towards canopy measurement.

- No new road construction across MWMU 3 unless field reviewed and approved by a California Registered Geologist unless it is the best road alternative³.

MWMU 3 Existing Roads:

- Roads or landings shall be maintained at the design standards that lower risk of mass wasting sediment delivery. Existing roads and landings within MWMU 3 should be considered for abandonment if no longer needed.

MWMU 3 Tractor Yarding:

- Equipment limited to existing roads or stable trails⁴.

MWMU 3 Skid Trail Construction or Reconstruction:

- No new tractor trail construction or reconstruction unless field reviewed and approved by a California Registered Geologist.

MWMU 3 Timber Harvest:

- Retain 50% canopy (see footnote 2, page v) with trees dispersed evenly across slope. Tree retention shall be emphasized in the axis of headwall swales. Deviations from this default must be field reviewed and approved by a California Registered Geologist.

Rockslides

No harvest or new road construction will occur on active portions of rockslides with a risk for sediment delivery unless approved by a California Registered Geologist.

Roads

High and Moderate Erosion Hazard Roads

The roads with a high erosion hazard rating should be given special attention for maintenance or erosion control. These roads should be considered high priority roads for rock surface, improved and increased road drainage relief, design upgrades or decommissioning.

The moderate erosion hazard roads should be given similar attention, but not as high a priority as the high erosion hazard roads.

³ Best road alternative – the placement has a lower potential for sediment production and greater cost effectiveness.

⁴ Stable trail – skid trail that has >85% of trail's tread intact, fill cracks or settling can have occurred provided the trail is still 85% intact and can have corrective action such that the trail presents little risk of future sediment delivery after use. Cut bank slumps can occur on stable trails, however, the slump cannot be removed if it buttresses failure of upslope soils.

High and moderate treatment immediacy sites for roads in the Greenwood WAU

The high treatment immediacy controllable erosion sites will be the highest priority for erosion control, upgrade, or modifications to existing design. These sites will be scheduled for repair based on operational considerations of harvest scheduling, proximity and availability of equipment, magnitude of the problem, and accessibility to the site.

The moderate treatment immediacy controllable erosion sites will be the next highest priority (relative to the high treatment immediacy sites) for erosion control, upgrade, or modifications to existing design. The moderate treatment immediacy sites will typically be addressed when in close proximity to high treatment immediacy sites.

Culvert #C51 on road 84-LG-048

Assess the culvert for replacement to a rocked ford or new culvert placement with an over-sized pipe placed at grade to facilitate torrent salamander migration.

Road 84-MB-053 and 84-CP-008-03

Assess these roads for feasibility of heavy equipment and controllable erosion repairs. Properly decommission these roads if feasible.

Riparian*Large woody debris recruitment*

The company policies for streamside stand retention are considered to be appropriate at this time for LWD recruitment. Monitoring of LWD recruitment will be done to determine if this is correct.

In the interim MRC will promote attempts to place LWD in stream channels to provide habitat structure. The stream locations with high instream LWD demand should be considered the highest priority for LWD placement. The moderate instream LWD demand segments would be next.

Stream Shade

The company policies for promoting streamside canopy and riparian management are considered to be appropriate at this time to improve stream canopy. Monitoring of stream temperatures and canopy will be done to determine if this is correct.

Monitoring

Aquatic resources monitoring will be conducted in the Greenwood WAU. This monitoring is to assist Mendocino Redwood Company to assess impacts to aquatic resources associated with past or future timber harvest and related forest management activities in the Greenwood WAU. The monitoring suggested in this plan is monitoring that MRC does across all its lands including the Greenwood WAU. However, other monitoring efforts not mentioned here may be conducted by MRC in the Greenwood WAU. Currently a comprehensive monitoring plan is being developed for the MRC lands. Once that plan is finalized it will supercede the monitoring presented here.

Monitoring Plan Goals:

- Test the efficacy of the Greenwood WAU prescriptions to address impacts to aquatic resources from timber harvest and related forest management activities.
- To assess long term channel conditions. Are current and future forest management practices inhibiting, neutralizing or promoting stream channel conditions for aquatic habitat?

A monitoring report will be produced each year that monitoring is conducted in the Greenwood WAU. The report will cover the monitoring and analysis that has occurred up to that year; if no monitoring is conducted in a given year than no report will be produced. Table ES-4 summarizes some of the monitoring to be conducted in the Greenwood WAU over time.

Table ES-4. Monitoring Matrix for Mendocino Redwood Company Lands Including the Greenwood Watershed Analysis Unit.

Monitoring Objectives	Reasoning, Comments	Technique
1. Determine effectiveness of measures to reduce management created mass wasting.	Management created mass wasting is significant contributor of sediment delivery.	Evaluation of mass wasting following a large storm event or after approximately 20 years.
2. Determine effectiveness of erosion control practices on high and moderate surface erosion hazard roads and landings.	Roads provide sediment delivery in the Greenwood WAU.	Evaluation of watercourse crossings, landings, and road lengths for erosion evaluation.
3. Determine in-stream large woody debris amounts over time.	Large woody debris is needed for stream channel and aquatic habitat improvement in the Greenwood WAU.	Stream LWD inventories and mapping of LWD designation areas in select stream reaches and long term channel monitoring sites.
4. Determine if stream temperatures are staying within properly functioning range for salmonids.	Stream temperature can be a limiting factor for salmonid growth and survival.	Stream temperature probes and assessment conducted in strategic locations.
5. Determine if fine sediment in stream channels is creating effects deleterious to salmonid reproduction.	Many forest practices can produce high fine sediment amounts. Need to ensure fine sediments are not impacting salmonid reproduction.	Permeability measurements on select stream reaches (bulk gravel samples if necessary).
6. Determine long-term channel morphology changes from coarse sediments.	Channel morphology can be altered from sediment increases, possibly affecting aquatic habitat.	Thalweg profiles and cross section surveys on select stream reaches.
7. Determine presence and absence of fish species in Class I watercourses.	Management practices and resource protections can affect distribution of aquatic organisms.	Electro-fishing and snorkeling observations at select locations to determine species composition and presence.