Watershed Analysis Results for Mendocino Redwood Company Lands in Coastal Mendocino and Sonoma Counties[1]

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Abstract

To assess the needs for conservation, restoration and condition of aquatic habitat within its land Mendocino Redwood Company (MRC) has been conducting watershed analysis. From watershed analysis completed to date, we estimate 73percent of the total sediment inputs over the last 30 to 40 years are road and skid trail associated. Of that percentage 30 percent is road and skid trail associated mass wasting, and 32 percent is road surface and point source erosion, the remaining 11percent is surface and point source erosion from skid trails. Hillslope mass wasting (not associated with roads or skid trails) represents 27 percent of the sediment inputs. Using controllable erosion as an indicator of future sediment yield, MRC estimates there is 2.2 million cubic yards of potential road sediment delivery to be controlled.

Watershed analysis has provided insights into aquatic habitat functions within coastal Mendocino and Sonoma Counties. The following qualitative indices by percent of streams demonstrate the quality of habitat functions: "on target" indicates habitat conditions that meet published targets for well functioning conditions, "marginal" indicates functional habitat conditions but not at optimal levels, and "deficient" indicates low habitat functions with need for improvement. Instream large woody debris (LWD) condition is mainly marginal and deficient with few streams being on target: one percent on target, 35 percent marginal, 35 percent deficient, and 29 percent no data. Stream shade conditions are mainly on target to marginal with some streams being deficient: 29 percent on target, 35 percent marginal, 12 percent deficient, and 24 percent no data. Stream temperature conditions for salmonids are found to be: 58 percent on target, 18 percent marginal, and 24 percent deficient. Salmonid spawning habitats are predominantly on target and marginal (15 percent on target, 35 percent marginal, three percent deficient, 48 percent no data). Salmonid rearing and over-wintering habitats are mainly marginal and deficient, with few on target streams (rearing habitat: one percent on target, 39 percent marginal, 13 percent deficient, 48 percent no data; over-wintering: two percent on target, 37 percent marginal, 13 percent deficient, 48 percent no data).

Generally speaking low LWD levels and high sediment inputs affecting rearing and over-wintering habitat for salmonids are the primary issues that need improvement, to a lesser extent stream temperature and spawning habitat. MRC has developed policies for improvement of riparian conditions for long term LWD recruitment needs of stream habitat. In the short term MRC is promoting the restoration of LWD in streams to improve current conditions. Sediment inputs are dominated by road issues. MRC has committed to upgrading and modernizing its entire road network, a process that will take approximately 30 years. To date MRC has made substantial headway in addressing road erosion and aquatic habitat impacts. In the five years that MRC has owned this land; MRC has removed 11 salmonid migration barriers, decommissioned approximately 10 miles of streamside logging roads, and controlled at least 400,000 cubic yards of controllable erosion. Further, a comprehensive monitoring program will test whether the MRC policies and restoration efforts are improving

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aquatic habitat and resource conditions.

Key words: aquatic habitat, forestry, Mendocino County, redwood, watershed analysis

Introduction

Mendocino Redwood Company, LLC (MRC) is a private landowner managing 232,000 acres of redwood and Douglas fir forest in Mendocino and Sonoma Counties, California. To assess the needs for conservation, restoration and condition of aquatic habitat within its land Mendocino Redwood Company (MRC) has been conducting watershed analysis. This report presents the summarization of results from watershed analysis efforts conducted by MRC. The results from the watershed analysis are used to formulate strategies for restoration and conservation of aquatic habitat in association with MRC's forest management activities.

Methods

The watershed analysis by MRC is conducted following modified guidelines from the Standard Methodology for Conducting Watershed Analysis (Washington Forest Practices Board 1995). MRC's approach to watershed analysis is to perform resource assessments of mass wasting, surface and point source erosion (roads/skid trails), hydrology, riparian condition, stream channel condition, and fish habitat. A prescription that guides land management activities is developed when current company policies do not address the issues and processes identified in the watershed analysis.

This report presents information from watershed analysis for 8 separate watershed analysis units[3] (WAU) conducted from 1997 to 2003; representing approximately 70 percent of MRC lands *(table 1)*. From each of the resource assessments of the watershed analysis key indicators of the watershed and aquatic habitat conditions are developed; only select variables are presented in this report to illustrate the general conditions observed regionally. These are:

- sediment input summaries for mass wasting, roads and skid trails;
- stream large woody debris (LWD) conditions;
- stream shade conditions;
- stream temperature conditions;
- fish habitat conditions for spawning, over-winter, and rearing life-stages.

[3] MRC land within major watersheds

Table 1—*Watersheds analyzed in this report.*

Watershed analysis unit	Watershed area (acres)	MRC owned (acres)
Albion River	27,500	15,800
Noyo River	68,000	20,000
Garcia River	73,000	11,800
Hollow Tree Creek	44,400	21,100
Navarro River	201,000	54,600
Willow/Freezeout Creeks	7,500	5,400
Gualala River	42,100	7,900
Big River	75,300	34,000

Sediment inputs are presented as a percentage of road, skid trail and mass wasting sediment inputs. The stream LWD, shade, temperature, and fish habitat conditions are presented in qualitative indices that demonstrate the quality of habitat functions: "on target" indicates habitat conditions that meet published targets for well functioning conditions, "marginal" indicates functional habitat conditions but not at optimal levels, and "deficient" indicates low habitat functions with need for improvement. The levels of habitat condition quality are developed for major tributaries and sections of major rivers within Calwater planning watersheds. The results are presented as percent of number of stream or river segments that demonstrate each habitat condition.

Stream and watersheds conditions are dynamic with natural disturbance occurring stochastically both temporally and spatially. It should not be expected that optimal habitat condition, at a regional scale, be "on target" everywhere at all times. Rather a range of habitat conditions should be expected spatially and temporally. Therefore interpretation of habitat condition is best considered through the distribution of conditions. A distribution of habitat condition skewed toward "on target" would be viewed more beneficial then a distribution skewed toward "deficient." Ultimately, the best indication of favorable habitat conditions should see the regional distribution skewed toward "on target" conditions over time, with deviations expected within watersheds following disturbances.

Sediment Inputs

Sediment input for each WAU is estimated from hillslope mass wasting, road associated mass wasting, road surface and point source erosion, and skid trail surface and point source erosion by Calwater planning watershed within each watershed analysis. The sediment inputs are calculated as an average rate per unit area for the entire time period assessed in each watershed analysis (typically the last three to four decades of the 20th century). From the sediment input rates by Calwater planning watershed the average percentage of sediment input was calculated and presented in this report.

The estimates of mass wasting sediment inputs are developed in watershed analysis through the interpretation of two to five sets of aerial photographs spanning a timeframe that varies from 30 to 40 years, depending on availability of aerial photographs. In addition, there is reconnaissance field-checking of the results. Mass wasting volumes and sediment delivery is estimated with a rate developed by aerial photograph dates completed in the mass wasting inventory. Mass wasting features associated with roads and skid trails are identified in the inventory. In this report the road and skid trail associated mass wasting are combined and reported as road associated mass wasting.

Road associated surface and point source erosion is estimated from a combination of field observations and use of a surface erosion model. Surface erosion is sheet wash and rill erosion from the road prism and point source erosion are gullies or wash-outs of fill material associated with watercourse crossings (excluding mass wasting). A road inventory was conducted in each WAU. Observations of past point source erosion and contributing road lengths for surface erosion sediment delivery is collected. A road-surface erosion model is used to estimate the amount of surface erosion from different road types and conditions observed from the road inventory. The model is found in *Standard Methodology for Conducting Watershed Analysis* (Version 4.0, Washington Forest Practices Board). Point source erosion observed in the field is added to the surface erosion estimate within each Calwater planning watershed to give a rate of road surface and point source erosion.

Future sediment yield is estimated by field observation of controllable erosion volume during the road inventory. Controllable erosion, a term developed by the North Coast Regional Water Quality Control Board for the Garcia River (NCRWQCB 2002), is that soil that can deliver to a watercourse, is human created, greater than 10 cubic yards in size and can be reasonably controlled by human activity. However for our purposes we measure and account for all sites, not just those over 10 cubic yards.

Sediment delivery from surface and point source erosion from skid trails was determined primarily from aerial photograph interpretation with field observations used to support the interpretation. The aerial photograph interpretation for skid trail activity consisted of determining the area harvested by ground based yarding by skid trail density (high, moderate, low) for each photo year. High skid trail density is estimated to contribute 600 tons/square mile/year of sediment[4]. Moderate skid trail density is estimated to contribute 400 tons/square mile/year of sediment, while low skid trail density contributing 100 tons/square mile/year. Results from the South Fork Caspar Creek in the early 1970s suggested that high density tractor logging, with practices used at that time, generated approximately 600 tons/square mile/year (Rice and others 1979) validating our skid trail delivery assumptions. The estimate was then divided by the MRC ownership in each Calwater planning watershed to provide a sediment rate (tons/square mile/year) for each planning watershed.

Stream LWD Condition

Through watershed analyses short-term (20 to 30 year) LWD-recruitment potential from riparian areas is evaluated. In addition, LWD has been sampled from stream segments throughout each WAU. Targets for number of Key LWD by stream size (see *table 6* "on target" category) have been derived to compare current LWD loading. The combination of LWD recruitment potential of riparian areas and instream LWD levels and consideration of the sensitivity of the stream channel to LWD provides for the LWD demand of stream segments *(table 2)*. Through the development of LWD demand the habitat condition is represented *(table 3)*.

[4] This is double the high density skid trail sediment delivery estimates that were used in the watershed analysis reports up to 2003. Therefore, the sediment estimates in this report were doubled from those presented in watershed analysis.

Table 2—*In-stream LWD demand.*

Riparian LWD recruitment potential[1]	Key LWD[2]	Channel LWD sensitivity rating		
		Low	**Moderate**	**High**
LOW	On Target	Low	Moderate	High
	Off Target	High	High	High
MODERATE	On Target	Low	Moderate	Moderate
	Off Target	High	High	High
HIGH	On Target	Low	Moderate	Moderate
	Off Target	Moderate	High	High

[1] Riparian LWD recruitment potential ranks large dense conifer stands as high, while hardwood or less dense riparian areas as low, with moderate in between.
[2] Large stable pieces of LWD, see Bilby and Ward (1989).

Table 3—*LWD habitat condition descriptions.*

On Target	>80 percent of watercourses have low or moderate LWD demand, and >80 percent of stream segments meet target number of key LWD pieces.
Marginal	50 to 80 percent of watercourses have low or moderate LWD demand, and >80 percent of stream segments have at least half of the target key LWD pieces desired.
Deficient	<50 percent of watercourses have low or moderate LWD demand, and low numbers of functional or key LWD.

Stream Shade Habitat Condition

Estimates of watercourse shading are derived from field observations and aerial-photograph interpretation. MRC determines effective shade for all perennial watercourses from curves that predict effective shade as a function of bankfull width (EPA 1999, 2000). The habitat condition for stream shade is represented *(table 4).*

Table 4—*Habitat condition quality for stream shade.*

On Target	>90 percent of perennial watercourses that are within or contribute to the stream/river segment have on-target effective shade.
Marginal	70 to 90 percent of perennial watercourses that are within or contribute to the stream/river segment have on-target effective shade or >70 percent canopy cover.
Deficient	<70 percent of perennial watercourses that are within or contribute to the stream/river segment have on-target effective shade or <70 percent canopy.

Stream Temperature Habitat Condition

Stream temperature has been collected within MRC lands since 1992. The MWAT value (annual maximum seven day average of the daily average temperature) for temperature observations was calculated. Comparing these MWAT values to optimal species-specific temperature ranges (EPA 2000) allowed us to rate water temperature quality for cold water species within watercourses *(table 5)*. To determine stream-temperature quality for individual streams or rivers, we selected the lowest species-specific stream-temperature rating among the salmonid species historically present in that particular watercourse.

Table 5—*Stream temperature habitat condition quality.*

MWAT (°C)	Species historically present		
	Coho only	**Steelhead only**	**Coho and Steelhead**
<15	On Target	On Target	On Target
15 to 17	Marginal	On Target	Marginal
17 to 19	Deficient	Marginal	Deficient
>19	Deficient	Deficient	Deficient

Salmonid Habitat Condition by Life Stage

The quality of fish habitat for spawning, rearing, and over-wintering habitats was rated based on targets derived from (Bilby and Ward 1989, Bisson and others 1987, CDFG 1998a, Montgomery and others 1995, Washington Forest Practices Board 1995) *(table 6)*.

The habitat data are combined into indices of habitat condition for the different salmonid life stages. Measured fish habitat parameters were weighted and given a numeric scale to develop a condition rating for individual life history stages. Parameters were divided into subsets that correspond with individual life history stages (spawning, summer rearing, and over-wintering habitat). Parameters were scored as follows: 1 (deficient), 2 (marginal), and 3 (on target). Parameter weights were applied to the total calculated score as shown below.

Table 6—*Fish habitat conditions.*

Fish habitat parameter	Feature	Fish habitat quality	Fish habitat parameter	Feature
		Deficient	**Marginal**	**On target**
Percent Pool/Riffle/Flatwater (By length) (A)	Anadromous Salmonid Streams	<25 percent pools	25-50 percent pools	>50 percent pools
Pool spacing (# pools/bankfull/reach length) (B)	Anadromous Salmonid Streams	≥ 6.0	3.0 to 5.9	≤ 2.9
Shelter rating (shelter value x percent of habitat covered) (C)	Pools	<60	60 to 120	>120
Percent of pools that are ≥3 ft residual depth (D)	Pools	<25 percent	25 to 50 percent	>50 percent
Spawning gravel (E)	Pool Tail-outs Quantity	<1.5 percent	1.5 to 3 percent	>3 percent
Percent embeddedness (F)	Pool Tail-outs	>50 percent	25 to 50 percent	<25 percent
Subsurface fines (L-P watershed analysis manual) (G)	Pool Tail-outs	2.31 to 3.0	1.61 to 2.3	1.0 to 1.6
Gravel quality Rating (L-P watershed analysis manual) (H)	Pool Tail-outs	2.31 to 3.0	1.61 to 2.3	1.0 to 1.6
Key LWD +Root wads/328 ft of stream (I)	Streams≤40 ft. BFW	<4.0	4.0 to 6.5	>6.6
	Streams ≥40 ft. BFW	<3.0	3.0 to 3.8	>3.9
Substrate for over-wintering (J)	All habitat types	<20 percent of Units Cobble or Boulder Dominated	20 to 40 percent of Units Cobble or Boulder Dominated	>40 percent of Units Cobble or Boulder Dominated

SPAWNING HABITAT
E (0.25) + F (0.25) + G (0.25) + H (0.25)
SUMMER REARING HABITAT
A (0.20) + B (0.15) + C (0.15) + D (0.15) + F (0.15) + I (0.20)
OVERWINTERING HABITAT
A (0.20) + B (0.15) + C (0.15) + D (0.10) + I (0.20) + J (0.20)

We rate the overall habitat condition as follows:

1.00 - 1.66 = Deficient

1.67 - 2.33 = Marginal

2.34 - 3.00 = On Target

Results

Sediment Inputs

From watershed analysis completed to date, we estimate 73 percent of the total sediment inputs over the last 3 to 4 decades are road and skid trail associated. Of the total sediment inputs 30 percent is road associated mass wasting, 32 percent is road surface and point source erosion, the remaining 11 percent is surface and point source erosion from skid trails. Hillslope mass wasting (not associated with roads or skid trails) represents 27 percent of the sediment inputs. Using controllable erosion as an indicator of future sediment yield, MRC estimates there is 2.2 million cubic yards of potential road sediment delivery to be controlled. The majority of this controllable erosion, approximately 90 percent, is represented at watercourse crossings with culverts installed.

Stream LWD, Shade and Temperature Habitat Condition

The habitat condition for Instream LWD, stream shade and stream temperature conditions are presented in *Figures 1* and *2. Figure 1* demonstrates that stream shade and temperature conditions are generally favorable for the species present within the MRC lands. The distribution of habitat condition quality for stream temperature skews toward on target conditions, particularly stream temperature. However a large portion of streams exhibit only marginal shade quality and deficient temperature quality suggesting that although shade and temperature conditions are generally favorable, improvements can be made. *Figure 2* demonstrates that instream LWD conditions are not favorable. The majority of the streams exhibit marginal or deficient LWD conditions with few streams being on target. This distribution skews toward deficient conditions.

Salmonid Habitat Condition by Life Stage

The quality ratings for salmonid habitat conditions by spawning, rear, and over-wintering habitat conditions are presented in *figure 3. Figure 3* demonstrates that salmonid habitat conditions vary by life stage. Spawning habitat demonstrates a distribution slightly skewed toward on target conditions however the majority of the observations indicate marginal conditions. Rearing and over-wintering habitat conditions skew slightly toward deficient conditions with the majority indicating marginal conditions; only a few streams show on target conditions. The general trend for all life stages demonstrates needs for improvement, particularly rearing and over-wintering habitat conditions.

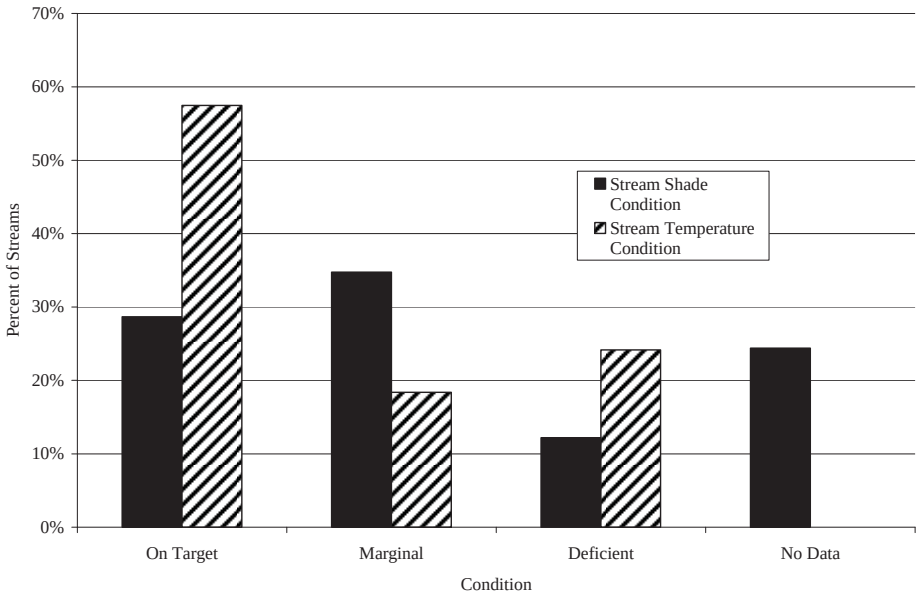

Figure 1—Stream shade and temperature condition.

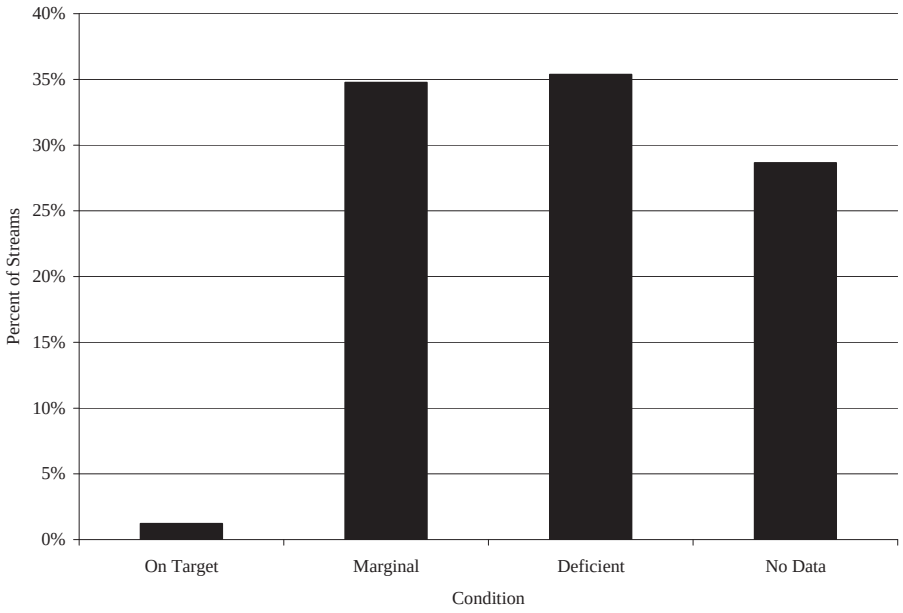

Figure 2—Instream LWD condition quality.

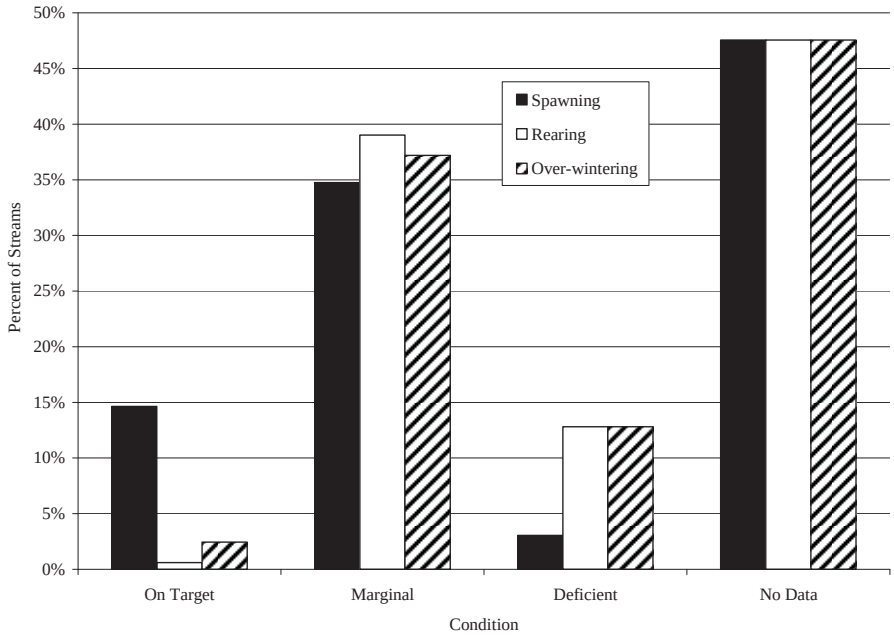

Figure 3—Salmonid habitat condition by life stage.

Discussion

The sediment input information directs our attention to the past effects of forest roads in sediment inputs. Although tractor yarding and hillslope mass wasting has created significant sediment inputs forest roads are highest. This suggests the single most important process that will control significant sediment inputs is in the appropriate design, placement and management of forest roads. This is further substantiated when considering the magnitude of controllable erosion on roads to be addressed (2.2 million yd^3).

The high amount of road associated sediment inputs indicates that a greater proportion of sediment, in the watersheds studied, is occurring from human activities. This indicates an increase in sediment inputs compared to a natural background rate that would not have road sediment associated with it. High sediment yield can be exhibited in stream conditions through several of the variables that relate to salmonid habitat quality such as decreased pool depths and frequency.

Stream shade and stream water temperature habitat condition quality shows a distribution of conditions skewed toward on target and marginal conditions. The data suggests that improvements in stream shade have the potential to improve stream temperature quality. However the habitat conditions suggest a reasonable distribution of stream temperature conditions.

Instream LWD and the riparian conditions to support LWD recruitment as shown by the LWD habitat condition show a need for improvement. A combination of forest harvest in riparian areas and extensive LWD clearing from streams in the past have contributed to these conditions. Large woody debris (LWD) is widely recognized as an important part of the aquatic ecosystem and a vital component of high quality habitat for anadromous fish (for example, Bilby and Likens 1979, Bisson

and others 1987, Swanson and Lienkaemper 1978). Improved instream LWD levels and recruitment needs to be managed for.

The increased sediment inputs observed, primarily from roads, and low LWD conditions are apparent in the salmonid habitat conditions within the MRC lands. Salmonid rearing habitat quality requires cold water with deep and frequent pools, over-winter habitat requires deep pools or structure (such as LWD) for aquatic organisms to escape high water flows. Spawning habitat requires sufficient spawning gravels with low levels of fine sediment. From the regional distribution of habitat conditions the conclusion reached is that reduction of sediment inputs and increased LWD are the major factors to improve aquatic habitat conditions and to a lesser extent stream temperature and spawning habitat.

Efforts for Watershed and Aquatic Habitat Improvements

MRC has developed policies for improvement of riparian conditions for long term LWD recruitment needs of stream habitat. In the short term MRC is promoting the restoration of LWD in streams to improve current conditions. Efforts by the California Conservation Corp and the Department of Fish Game to place LWD in streams is encouraged and supported on MRC lands. Further through efforts with State and Federal agencies MRC is attempting to receive permission for greater placement of LWD in streams.

Sediment inputs are dominated by road issues. MRC has committed to upgrading and modernizing its entire road network, a process that will take approximately 30 years. To date MRC has made substantial headway in addressing road erosion and aquatic habitat impacts. In the five years that MRC has owned this land; MRC has removed 11 salmonid migration barriers, decommissioned approximately 10 miles of streamside logging roads, and controlled at least 400,000 cubic yards of controllable erosion.

A comprehensive monitoring program is being developed to test whether the MRC policies and restoration efforts are improving aquatic habitat and resource conditions. This monitoring will be conducted with the intention of informing management decisions to reduce the effects of the forest management on aquatic habitats. This adaptive management process should not only reduce effects on aquatic habitats but work to improve aquatic habitat conditions over time.

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