Road Condition Monitoring – Concept Proposal

This document describes a concept proposal to monitor changes in key indicators of forest road performance that result from the implementation of the "Road Rules, 2013 Rule Package" (Road Rules). The proposed monitoring approach is part of a broader strategy to evaluate ecological performance in non-federal forestlands regulated by the California Forest Practice Act and Rules. Roads can alter hydrologic and geomorphic process in ways that can adversely impact aquatic ecosystems (Luce and Wemple, 2001) (Figure 1). As such, a process-based evaluation of the effectiveness of the Road Rules is vital to assessing the overall ecological performance of the California Forest Practice Rules and other forestry-related laws and regulations.

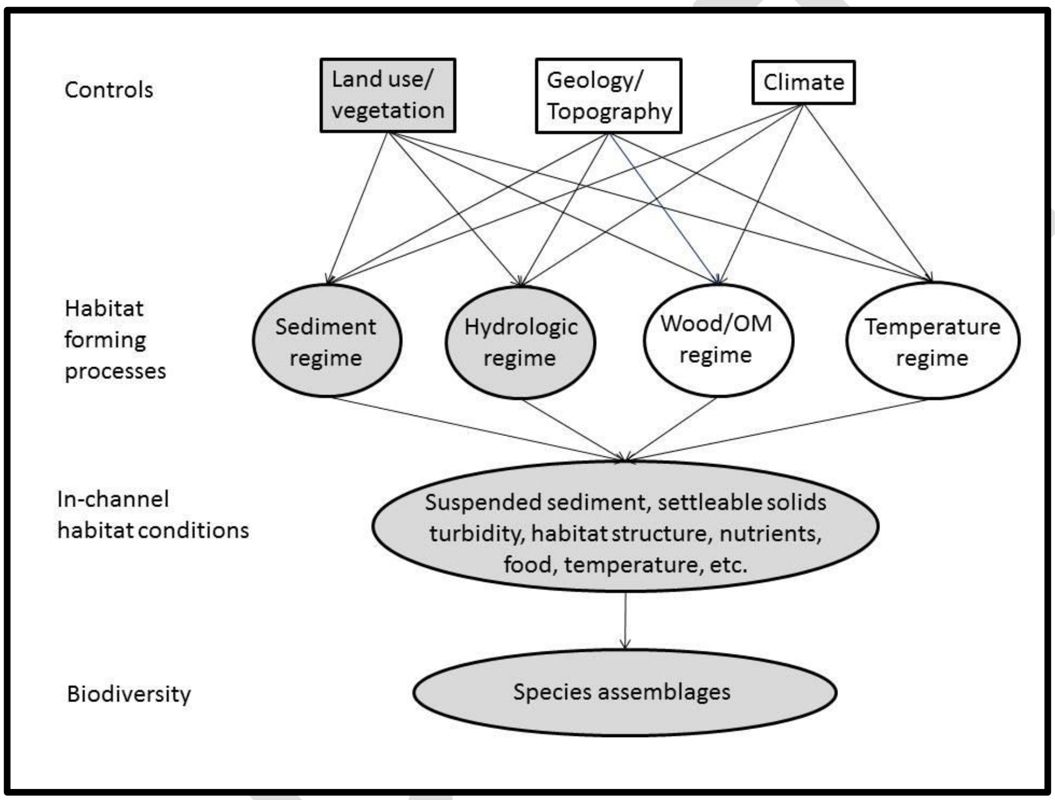

Figure 1. A simplified schematic diagram representing "ecological performance" for a riverine aquatic ecosystem. Shaded boxes represent elements of ecological performance potentially addressed directly or indirectly through a Road Rules effectiveness monitoring study. OM stands for organic material (modified from Beechie and Bolton, 1999).

Road Condition Monitoring (RCM) is part of an overall tiered monitoring strategy related to the evaluation of the Road Rules (Figure 2). Implementation of individual elements of the Road Rules can be monitored through existing monitoring programs such as the Forest Practice Rules Implementation and Effectiveness Monitoring program

(FORPRIEM). However, existing monitoring programs stop short of providing the necessary process-based information to link rules and best management practices to the resource(s) of concern (e.g., water quality, salmonid habitat condition, ecosystem function). RCM provides the intermediate step by assessing the integrated effects of the Road Rules on minimizing hydrogeomorphic process alterations that can drive ecosystem response. The final and most rigorous step would be that of validation/research monitoring, where the suite of Road Rules are evaluated to determine if they prevent significant sediment discharge, impacts to the beneficial uses of water, and aquatic species of concern (Figure 2). Validation monitoring is beyond the scope of this proposal but could be incorporated into future studies at intensively monitored watersheds such as Caspar Creek or Judd Creek.

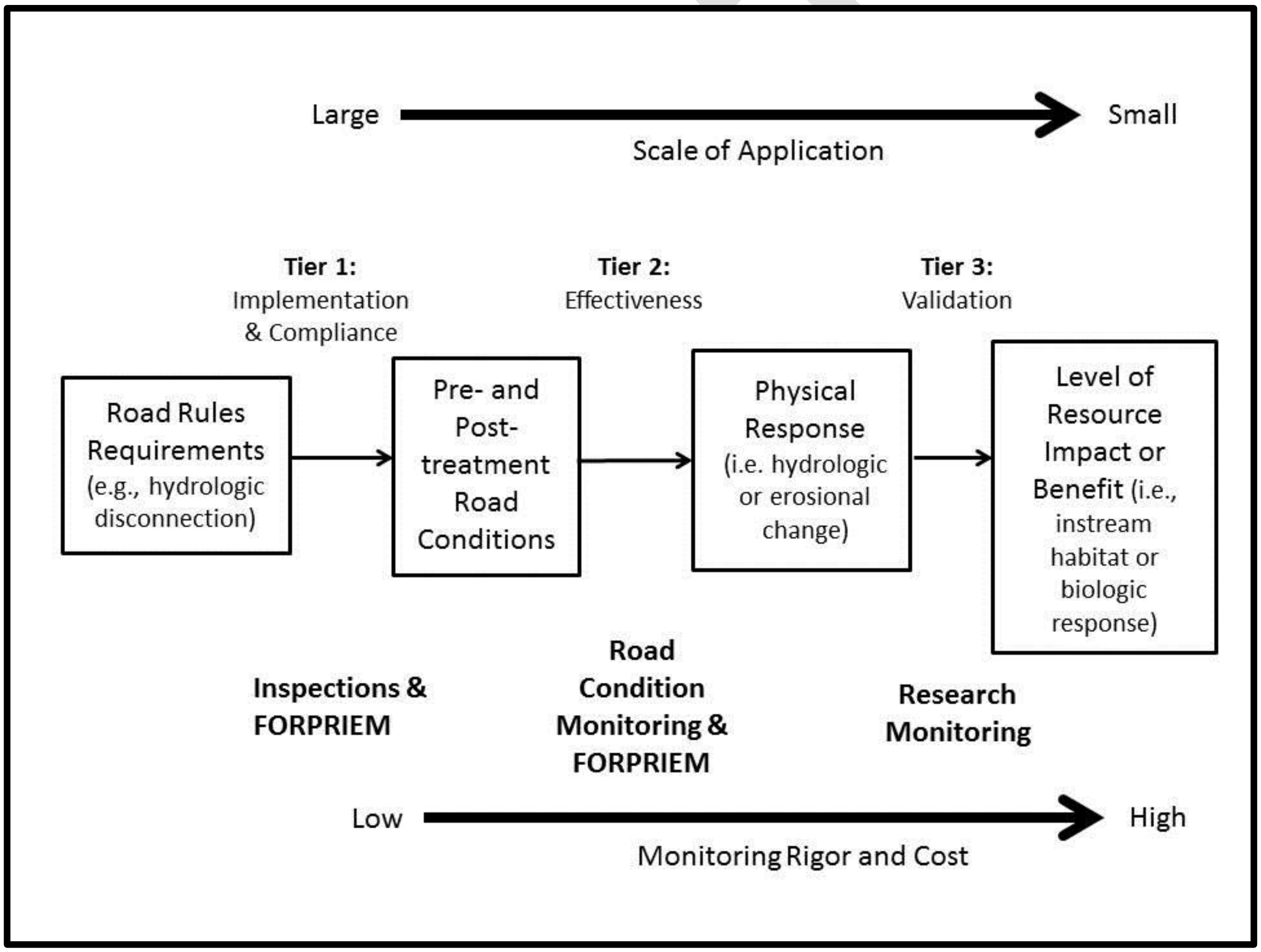

Figure 2. Schematic of a suggested tiered monitoring approach to address the Road Rules (adapted from Veldhuisen et al., 2000 and Raines et al., 2005)

General Monitoring Approach

Roads alter hydrologic and geomorphic processes (Luce and Wemple, 2001), which increases sediment and runoff delivery to watercourses, and can potentially affect beneficial uses and aquatic ecosystem function. Road Condition Monitoring would address how effective the Road Rules are at decreasing the magnitude of erosion, runoff, and sediment delivery at the road segment and THP/plan scale.[1]

Uncertainty regarding the effectiveness of the Road Rules can be addressed by posing the following general monitoring questions:

General Monitoring Question 1: Have road attributes that affect surficial sediment production (i.e., surface erosion) and delivery improved after implementation of the Road Rules?

General Monitoring Question 2: Have road attributes that affect mass wasting and the delivery of mass wasting sediments improved after implementation of the Road Rules.

RCM is intended to address general monitoring question 1, as general monitoring question 2 (i.e., road-related mass wasting) would require a more process-specific sampling strategy.[2] Since the connectivity and erosion potential of the connected road segment controls the magnitude of sediment delivery, the question can be addressed through the development of the following specific monitoring questions:

Specific Monitoring Question 1: Has the length/area of roads draining to watercourses decreased after the implementation of the Road Rules?

Specific Monitoring Question 2: Have the road attributes affecting surface erosion for connected road segments improved since the implementation of the Road Rules?

These specific monitoring questions allow us to generate some initial testable hypotheses such as:

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[1] Some data on previous road rule requirements and their effectiveness exist from past monitoring work conducted as part of the Hillslope Monitoring Program (Cafferata and Munn, 2002). For example, 85% of gullies recorded on random road transects and 70% of rills documented were judged to be caused by road drainage feature problems. Highly erodible surface material and steep road gradient were also frequently cited causes of rilling (see Table 11). Data collected from the FORPRIEM monitoring program (Brandow and Cafferata, in preparation) may be able to be used to beta test some of the parameters being considered for Road Condition Monitoring.

[2] Road Rules effectiveness monitoring related to mass wasting would likely utilize a post-mortem approach where a threshold storm of a predetermined recurrence interval would trigger post-storm sampling. A landslide triggering storm event is necessary to evaluate the effectiveness of the Road Rules related to mass wasting (for example, see Robison et al., 1999).

H_o 1: No reduction in road drainage connectivity to streams has occurred since implementation of the Road Rules[3].

H_A 1: Road drainage connectivity has been reduced after implementation of the Road Rules.

H_o 2: No improvement in road attributes that affect sediment production for connected road segments has occurred since implementation of the Road Rules.

H_A 2: Improvement in road attributes that affect sediment production for connected road segments has occurred since the implementation of the Road Rules.

Testing these hypotheses requires collecting road information at the THP/plan scale for hydrologically connected road segments. Information on the conditions (i.e., variables) that drive sediment production and delivery will be collected pre- and post-Road Rule implementation. Pre- and post-implementation data will also be compared against a theoretical target. For instance, could more have been done to minimize sediment delivery in a cost-effective manner? The preliminary list of proposed monitoring variables is listed below. Arrows indicate the dependence of sediment production on increases in each road attribute (e.g., sediment production goes up as road length increases):

1. Road length ↑
2. Road slope ↑
3. Road width ↑
4. Road drainage configuration (e.g., crowned, outsloped, insloped) ↕
5. Surfacing ↓
6. Presence and dimensions of erosion features (e.g., gullying, rutting, rilling, mass wasting features, etc. ↑
7. Ditch length ↑
8. Ditch width ↑
9. Ditch condition ↕
10. Soil type/erodibility class (e.g., EHR)
11. Slope stability class/rating
12. Drainage outlet condition ↕
13. Cutslope height ↑
14. Cutslope angle
15. Cutslope cover ↓
16. Fill height ↑

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[3] Hydrologic disconnection has been required for areas governed by the Anadromous Salmonid Protection Rules since 1 January, 2010.

17. Fill cover ↓
18. Connectivity class ↕ (see Table 1 for example)

These data can be used to test the null hypotheses presented in the preceding section. Changes in sediment production for connected road segments can be demonstrated by assessing changes in individual attributes (Figure 3), or by combining attributes into sediment production indices (Figure 4). For example, the product of road length and slope raised to an exponent between 1 and 2 (LS^n) is a commonly noted index of sediment production (Luce and Black, 2001; Ramos-Scharron and MacDonald, 2005), and the index provides recognition that some attributes are more important controls than others (i.e., slope). The data can also be integrated into a single metric of sediment production through the use of models (e.g., SEDMODL2, Road:WEPP, GRAIPE Lite). The benefit of modeling sediment production is that it takes into account the suite of interacting practices used to decrease road sediment production (e.g., road rocking and improved drainage). The disadvantage of modeling sediment production is that the absolute values of model outputs can be taken out of context. As such, it is suggested that modeled outputs be presented in a relative fashion, such as a percentage increase or decrease in sediment production relative to pre-implementation.

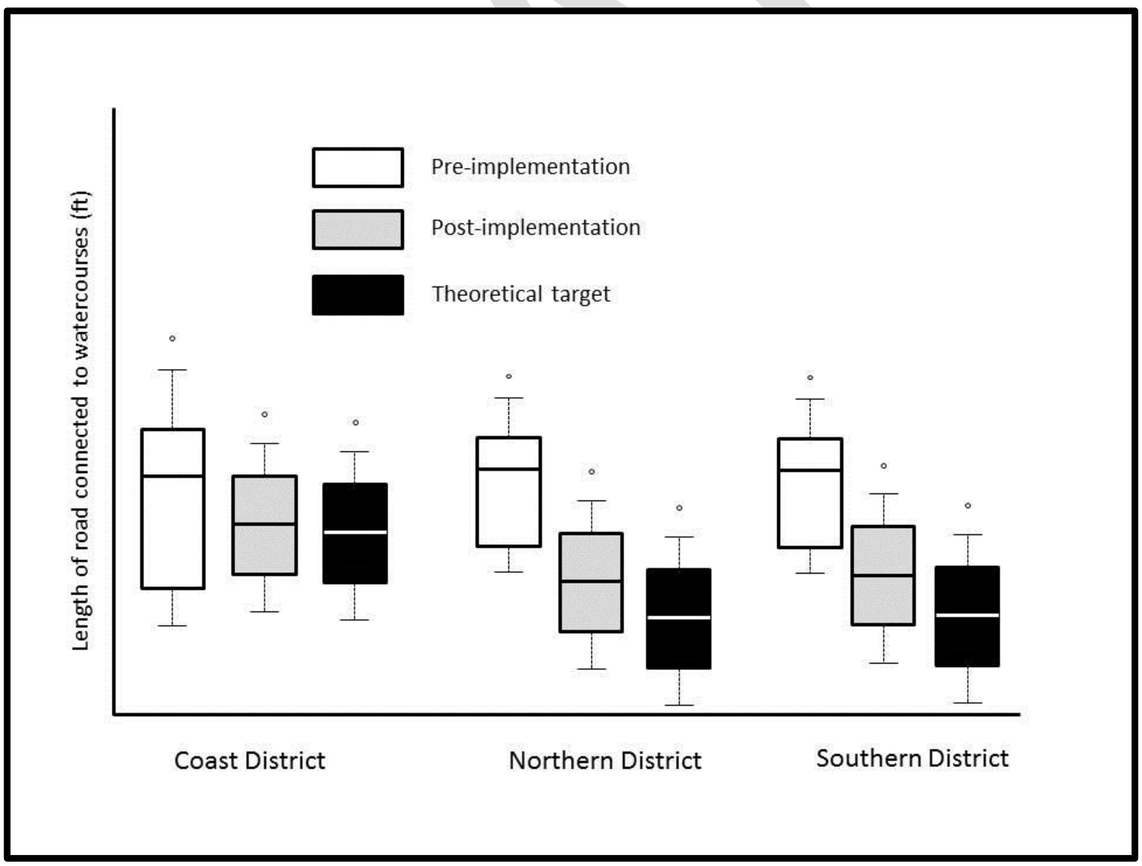

Figure 3. Hypothetical change in hydrologic connectivity for Timber Harvesting Plans by Forest Practice District pre- and post-implementation of the Road Rules. Reducing the length of connected roads decreases the likelihood for hydrologic and geomorphic impacts. The theoretical target refers to the least amount of road connected as per Technical Rule Addendum #5.

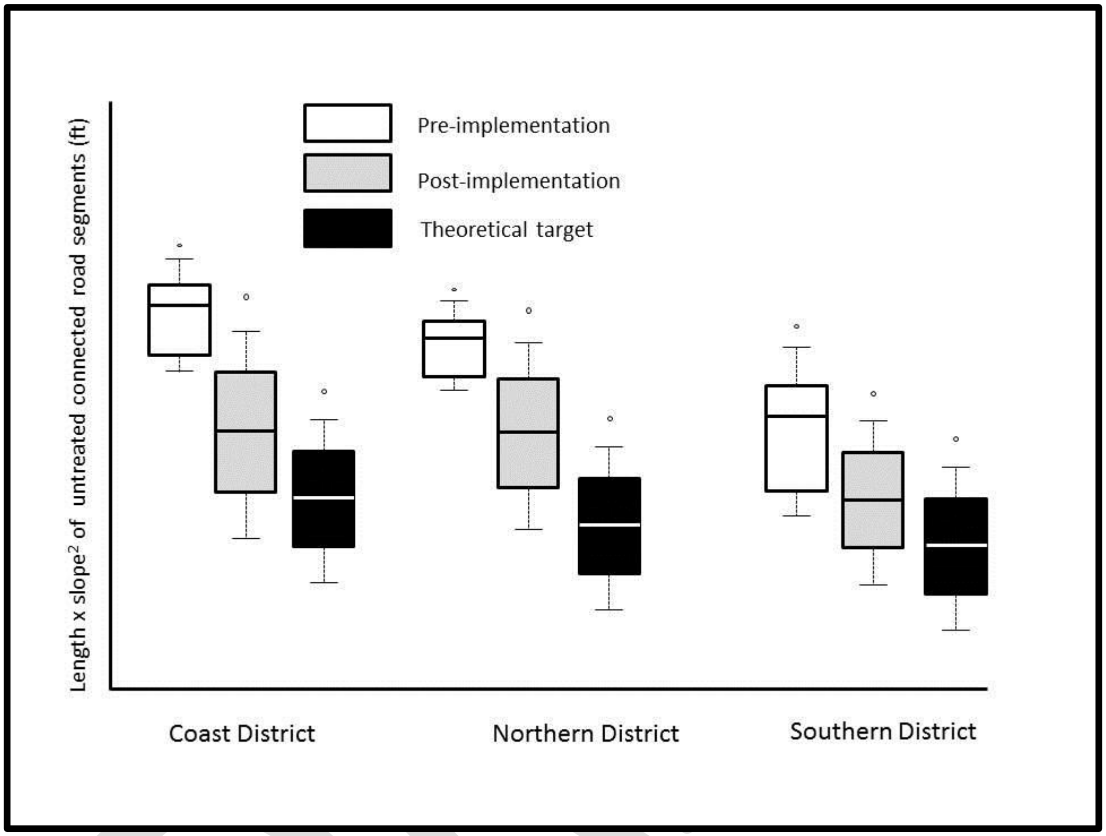

Figure 4. Hypothetical change in the length-slope product (LS^2) for connected road segments treated for surface erosion. LS^2 is highest for longer and steeper road segments. Higher values of LS^2 for connected road segments treated for erosion control represents a decrease in sediment delivery.

Table 1. Connectivity classes for the RCM proposal. Different classes have different causal mechanisms for hydrologic connectivity and different assumptions regarding the magnitude of sediment delivery. Tracking changes of road length/area by connectivity class will provide information on the effectiveness of the Road Rules.

Connectivity Class	Visible Geomorphic Impact	Sediment Delivery Potential	Percent of Sediment Delivery
0	No signs of connectivity below waterbreak outfall with or without evidence of sediment transport	None	0
1	Drains directly into watercourse at a road crossing.	High	100
2	Evidence of diffuse sediment deposit below drainage outlet that is within 50 feet of the bankfull (high flow) watercourse channel	Low/Moderate	35
3	Evidence of diffuse sediment deposits within 50-100 feet of the bankfull (high flow) watercourse channel	Low	10
4	Direct delivery below waterbreak outfall; is connected to watercourse via gully or landslide scar	High	100

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