Chapter 4: Discussion

The authors of the Northwest Forest Plan (the Plan) recognized the complex and dynamic nature of watersheds. Human activities in the past century have altered the processes that create healthy ecosystems (Bisson et al. 1992, Naiman et al. 2000). These processes occur on the scale of decades or centuries. Given the temporal scale of these ecological processes and that degradation of watershed processes has probably occurred gradually for decades, it is unlikely that restoration activities will restore habitat in a short period (Larsen et al. 2004). From this perspective, it is not surprising that changes observed here in the roads and vegetation were very small, except in a few watersheds.

Most of the watersheds had higher condition scores in time 2 than in time 1 across the entire Plan area and in each of the land use allocations except nonfederal. Relatively few watersheds decreased in condition. Given that (1) the growth rate of trees exceeded harvest rates, (2) more roads were decommissioned in the last 10 years than were built, (3) the watersheds that had large increases in drivers condition scores were all targets of road decommissioning, and (4) those watersheds that had lower condition scores were all exposed to wildfire (and not management activity), it appears that the strategy has had positive effects on the condition scores of watersheds in the Plan area. Further, over 70 percent of key watersheds, which were supposed to have first priority for restoration activities, increased in condition. Less than 50 percent of the non-key watersheds increased in condition.

The monitoring program has been charged with answering the following questions:

- **Are the key processes that create and maintain habitat conditions in aquatic and riparian systems intact?**
- **What is the status of upslope processes as indicated by vegetation and roads?**

Because we currently lack the understanding and ability to measure watershed processes directly, we rely on attributes that are surrogates for these processes. Upslope vegetation generally has higher condition scores (median 0.2) than upslope roads. Because the full range of conditions extend from -1 to 1, upslope vegetation appears to be in good condition overall. The median upslope road condition score is about 0, so about half of the watersheds have positive upslope road condition scores and half have negative road condition scores. Roads tend to carry more weight in the models than vegetation; therefore, decommissioning of upslope roads would have a greater impact in improving watershed condition scores with respect to the upslope attributes.

- **What is the status of riparian processes as indicated by vegetation and roads and stream crossings?**

Many of the watersheds had low condition scores for riparian attributes. Riparian vegetation condition scores were lower than those of the riparian road attributes. For riparian vegetation, we examined the percentage of the riparian area with trees 20 in diameter or larger, and about half of the watersheds had very low riparian vegetation condition scores (less than -0.75). Because stand-replacing harvest rates in riparian areas have declined since the Plan was implemented, the condition scores for riparian vegetation should increase in the future as the trees grow into that larger size category. Nearly 40 percent of the watersheds had riparian road condition scores equal to -1, and only 16 percent had scores of +1. Roads in riparian areas can significantly affect the condition of watersheds, and they are heavily weighted in most of the evaluation models. Therefore, removal of roads in riparian areas would have the greatest impact on increasing watershed condition scores.

- **What is the status of inchannel processes as indicated by pools, substrate, water temperatures, large structure in the channel, and rates of channel movement?**

Inchannel attributes tend to have fairly high condition scores. None of the watersheds had reach condition scores less than -0.5. The stream reaches within the 55 sampled watersheds appear to have sufficient numbers of pools and substrates dominated by gravel and cobble. However, adequate amounts of large wood appear to be lacking in many streams.

Smith River, Bureau of Land Management, Umpqua Field Office, Oregon

Fish passage restoration (culverts)—
The Bureau of Land Management Umpqua Field Office implemented an aggressive program for fish-passage culvert replacement and modification in the Smith River watershed during 2003. Eleven fish-passage-barrier culverts were replaced, two culverts were modified to provide adult and juvenile fish passage, and one culvert was removed to allow the site to reestablish the natural grade during winter high flows before it is replaced in 2005. This work improved passage to about 13 mi of upstream habitat.

Under the authority of the Wyden Amendment, the Umpqua Field Office also cooperated with two watershed councils for the replacements of two tide gates, one in the lower Smith River and one in the lower Coos River.

Coos Bay BLM District

Coos Bay BLM District

Upstream fish passage was not possible at these old, poorly installed culverts (left) on South Sisters Creek. A newly installed culvert (right) allows fish passage at all flows. Contact Bill Hudson (bill-hudson@or.blm.gov) for more information.

- **Has the distribution of key indicators shifted in a direction that indicates improved or degraded habitat and biotic condition?**

Currently we have inchannel data to assess habitat and biotic condition for 55 watersheds from the current period only. We are not yet able to look for changes in these attributes.

- **How does the aggregate quality of the key indicators used to evaluate watershed condition, (i.e., the distribution of watershed condition scores) change through time under the Plan?**

The drivers condition scores were at least 0.1 higher in time 2 than in time 1 in 57 percent of the watersheds. Three percent of the watersheds had lower drivers condition scores in time 2, and condition scores stayed the same in the remainder of the watersheds. Most of the watersheds had higher drivers condition scores in time 2 than in time 1 across all land use allocations, with the exception of the nonfederal land use allocation.

Of the 250 watersheds, seven had drivers condition scores that changed by more than 0.2 from time 1 to time 2. Wildfires that burned 31 to 55 percent of the watershed area explain the decrease in drivers score in four of the seven watersheds. The remaining three watersheds had higher condition scores in time 2 than in time 1. Each of these

watersheds was the target of road decommissioning. A total of 16 mi of road was decommissioned in one watershed, more than half of which was in the riparian zone. A reduction in the number of road-stream crossings, which were also evaluated in the decision-support models, often accompanied decommissioning of riparian roads. In this case, 34 road-stream crossings were removed. In another watershed, just over 9 mi of road was decommissioned, of which 3 mi was in areas prone to mass wasting and 4.6 mi was in the riparian area. Fifty road-stream crossings were removed. Nine miles of road was decommissioned in the last watershed, which resulted in the removal of 3 mi of road in the riparian area and 41 road-stream crossings.

The complexity of interactions among watershed components, the natural variability of stream conditions, and the lack of data have led most people conducting watershed-based assessments to use methods based on expert judgment rather than statistical analyses (Consulting Science Team 2001, FEMAT 1993, Hulse et al. 2002, O'Keefe et al. 1987, Rieman et al. 2001). Although using expert judgment appears to be the most effective way to synthesize such diverse and incomplete information, such assessments are not necessarily consistent or transparent. To address these shortcomings, we used explicit decision-support models in this assessment to provide a replicable and explainable method (Reeves et al. 2004, Reynolds and Reeves 2003).

The model structures and evaluation criteria provided in appendix 4 identify the attributes used in the evaluation, the weight of each attribute, how each attribute was evaluated, and how the evaluation scores for individual attributes were aggregated. The tables also document the source used to determine the evaluation criteria. The information provided in the appendix should allow readers to understand and replicate the watershed condition assessments we conducted.

Reeves et al. (2004) specified using regional expert teams to build local knowledge into the evaluation models. Experts who participated in the two rounds of workshops covering the seven aquatic provinces seemed to adapt easily to the modeling approach and see its value. The approach was amendable to integrating relationships based on existing data and literature where available, as well as professional judgment. The models clearly reflected regional differences, such as potential natural vegetation conditions, so that the model results would better reflect the conditions on the ground.

Because we used different models in each province, some models are less sensitive to changes in specific attributes than others. We attribute these differences between the models to differences in ecological processes across provinces that affect the condition of watersheds; e.g., they reflect inherent differences in how roads affect watersheds in the different provinces. Reducing the frequency of road crossings by 50 percent produces an increase of about 0.10 in the watershed condition score in the Washington/Oregon Coast province, but, only 0.02 in the North Cascades province. The North Cascades model was more sensitive to riparian road density than to road crossings, in contrast to the Coast model.

The assessments of watershed condition in this exercise lacked critical information. The trend analysis was based exclusively on roads and vegetation. Inchannel data were available for only 20 percent of the watersheds, and data on fish, amphibians, and other aquatic- and riparian-dependent species were not included. These omissions are significant because they are the ultimate response variables for management activities. Many natural resource management decisions consider these species; thus, we must use them to assess the effectiveness of our management activities. Other watershed-scale processes such as mass wasting were also omitted from the analysis. The monitoring program is working toward including biological and mass-wasting attributes in future iterations of the models.

In addition to omitting some key watershed processes, the attributes used in the model to describe watershed condition may be too simplistic. For example, few watersheds with low drivers condition scores were detected in the Klamath/Siskiyou region in Oregon and California. Given the history of mining and channel alterations in that area and the relatively poor condition of the fish populations there, the attributes included in the model may not be sensitive to the management activities in the area. The drivers condition scores are currently affected only by road building and decommissioning, and the growth and loss

of vegetation owing to harvest or fire. Vegetation losses are treated the same whether the loss is due to fire or to regeneration harvest, even though these two disturbances likely have different effects on the condition of watersheds. Further, the effect of fires in watersheds may be different depending on whether management activities such as salvage logging or restoration activities were implemented following the fire. Although many management and restoration activities have occurred in the Plan area, we are unable to document how these activities affected the condition of watersheds. Currently, management agencies do not track harvest or road building, decommissioning, or improvement spatially in a database. Consequently, improvements from culvert replacements or other restoration activities are not reflected in watershed (or drivers) condition scores.

The condition scores of roads and vegetation in 250 watersheds extended across the full range of possible scores (-1 to 1). However, the watershed condition scores we found were clumped in the center of the distribution. At least three hypotheses can be posed to explain this finding: thus far, we have sampled only watersheds that were in the center of the distribution; the inclusion of the inchannel data pulls the watershed condition score toward 0; and inclusion of the inchannel data increases the watershed condition score relative to the drivers condition score. In other words, the streams are in better condition than the riparian and upslope areas. The 55 watersheds sampled are a subset of the 250, and some have drivers condition scores that approach or equal -1. Further, watersheds were sampled in the order in which they were selected, so the 55 watersheds should reflect the full range of variation in the target population. Therefore, we reject the first hypothesis. We examined the relationship between the watershed condition score and the drivers condition score in the 55 sampled watersheds and found a positive relationship between the two. Drivers condition score explains 86 percent of the variance in the watershed condition score, but the slope of the equation is only 0.6 and the intercept is 0.14. When the drivers and watershed condition scores from the 55 sampled watersheds are compared, the watershed condition scores are about 0.22 higher than drivers scores (range = -0.2 to 0.74). We conclude that including the habitat data from the sampled reaches has positive effects on the overall watershed condition score.

The participants in the workshops that helped build and refine the models had more trouble building the portion of the model that evaluates the inchannel data than the roads and vegetation portions. Stream channels have a very large range of natural variation, and determining what qualities any particular reach should have is difficult. Consequently, the model may serve only to highlight those stream reaches that are dramatically different from the norm.

The quality and accuracy of the geographic information system (GIS) layers affected the outcome of these results more than model issues. The results of this assessment could change if updated GIS layers are constructed. Problems with the vegetation layers were specific to particular provinces. The Interagency Vegetation Mapping Project (IVMP) layers were built for each of the vegetation provinces (Moeur et al. 2005). In the High Cascades Washington province, the map does not accurately account for large trees. According to the map, about 5 percent of the federal land base is populated by stands of trees greater than 20 in d.b.h. However, according to vegetation plot data from the same area, about 20 percent of the federal land base is covered by stands of large trees.[2] Consequently, vegetation condition scores were lower than they should have been in this area.

Perhaps the largest source of error in the analysis was tied to inconsistent mapping of stream density across the Plan area. Generation of riparian area for road and vegetation analyses was based on the 1: 24,000 stream layer. The layer used was acquired from individual units and pieced together, but the method used to generate the layers was not consistent across units. Consequently, the density of streams changed across administrative unit boundaries (fig. 48). The example in figure 48 shows the difference in stream densities in the Olympic National Forest and the Olympic National Park. The problem exists within individual units as well. For example, stream densities range from 0.7 to 9.5 mi of stream per square mile of watershed

[2] M. Moeur. 2004. Personal communication. Vegetation monitoring lead, Resource Planning and Monitoring, USDA Forest Service Pacific Northwest Region, 333 SW First Ave., Portland, OR 97204.

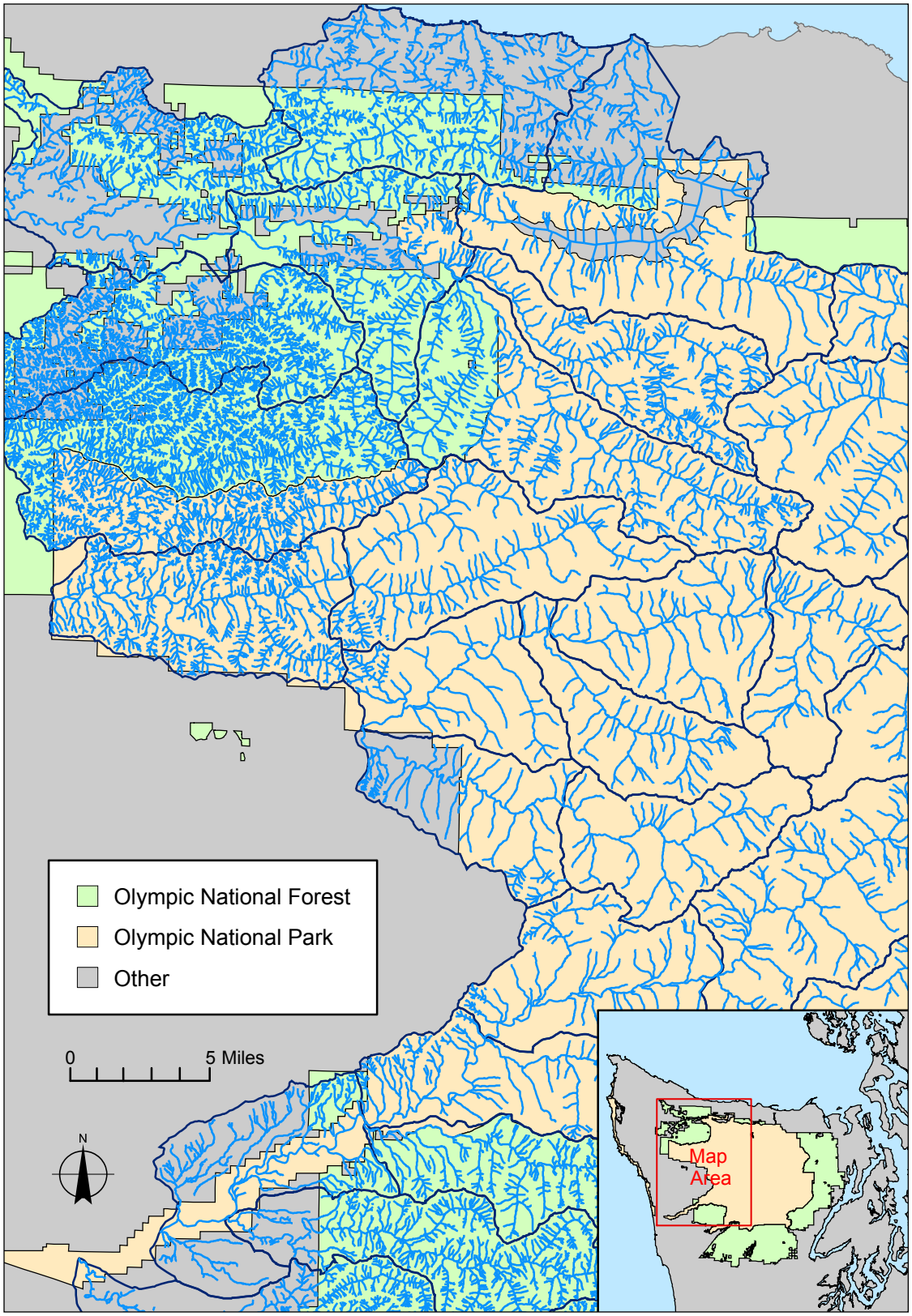
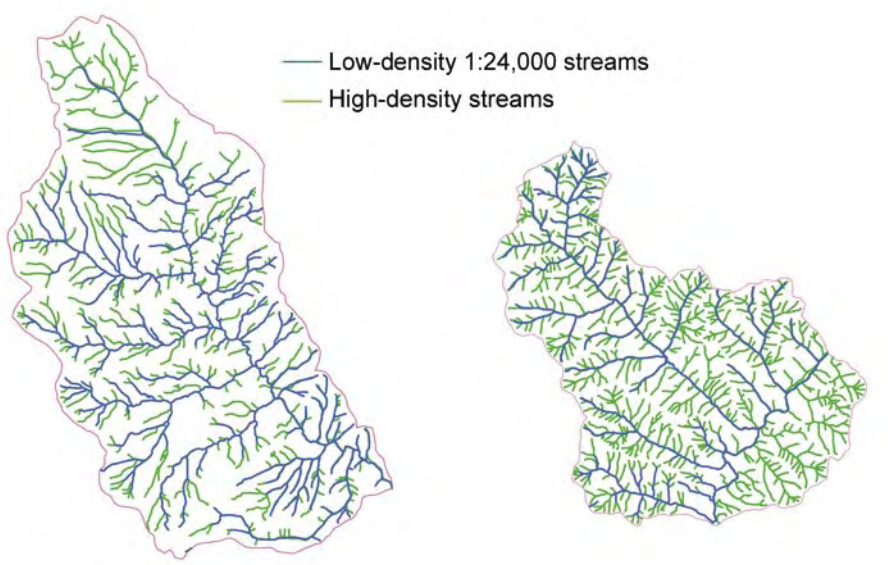


Figure 48—Comparison of stream densities on agency stream layers on the Olympic National Park and the Olympic National Forest.

on the Willamette National Forest. Precipitation and geology, two factors that influence the density of streams, are relatively homogeneous in the forest, so such a large difference in streams is unexpected. The Willamette National Forest was not atypical. In the Methow Valley on the Okanogan National Forest, stream densities ranged from 1 to 13 mi per square mile of watershed.

Stream density differs naturally across the Plan area, but we do not know by how much. We were not able to determine how much of the variation in the stream layer was due to true variation in stream density and how much was due to map error. Nor were we able to assess the effect the stream layers had on the analysis. We considered comparing data from the high-density layers with the lower density 1:24,000 layer, which grossly underestimates stream miles, particularly those that are nonfishbearing. As an example, two watersheds from the Medford BLM district were selected (for no particular reason), and frequency of road crossings and riparian road density were calculated by using the high-density and low-density layers (fig. 49). Although the example clearly showed that we have more road crossings and riparian road density by using the high-density layer, we still have no determination of how accurate the data are or the effect that the increased stream density has on the assessment.

All analyses are based on an underlying assumption that the necessary data are available and of acceptable quality. In this analysis, the validity of this assumption is questionable because the results of the analysis could change if the analysis were repeated on updated GIS layers. This problem illustrates the data management problems faced by all of the Plan's monitoring programs. An information management document (Palmer et al., in press) was prepared in conjunction with the Plan's status and trends documents that identifies the data problems encountered by the monitoring programs and proposes solutions to these problems.



Upper Trail Creek

	Low density	High density
Stream miles	76	138
Road crossings	168	314
Riparian mi^2 (50-m buffer)	4.6	8.2

Hawk Creek

	Low density	High density
Stream miles	57	183
Road crossings	131	491
Riparian mi^2 (50-m buffer)	3.5	10.8

Figure 49—Comparison of high- and low-density stream layers in two watersheds on the Medford Bureau of Land Management district.

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