Chapter 10.—Modeling Watershed Condition and Trend—How the Aquatic Riparian Effectiveness Monitoring Program (AREMP) is Evaluating Watershed Condition and Trend in the Pacific Northwest

Peter Eldred[1] and Kirsten Gallo[1]

The Aquatic and Riparian Effectiveness Monitoring Program (AREMP) is a multi-Federal agency program developed to assess the effectiveness of the Northwest Forest Plan (NWFP) in maintaining or restoring the condition of watersheds in the NWFP area. The NWFP encompasses the range of northern spotted owl habitat, about 58 million acres in western Washington, western Oregon, and northwest California. AREMP's goal is to evaluate the status and trend of watershed condition at the 6th-field subwatershed scale. To do this, a random sample of 250 subwatersheds was selected from 1,400 subwatersheds that have at least 25% Federal ownership along the stream channels. About 30 subwatersheds a year are visited to collect field data from 4 to 8 randomly selected stream reaches in each subwatershed. GIS and remotely sensed data are used to evaluate the upslope and riparian condition in the 250 sample subwatersheds, along with field data where available. This information was aggregated with a decision-support model to produce a watershed condition score for each subwatershed. The watershed condition was evaluated at time 1 (1994) and time 2 (2004) to assess trends. The results of the status and trend for the first 10 years was published in 2004. The program is now evaluating the trend and condition for the next 5-year period for a report update. This paper gives an overview of the analysis process and how the program is evolving.

Watershed condition and trend is evaluated using decision-support models. Decision-support models document decision processes and allow the same process to be applied consistently across time and space. The models developed by the monitoring program are used to evaluate whether the subwatersheds are in good condition, meaning the physical and biological processes are intact to create and maintain salmonid habitat. Decision support models work by evaluating individual attributes (such as road density) and calculating an evaluation score for each attribute that ranges between -1 and 1, with -1 being poor and 1 being good. The model then aggregates the evaluation scores of all attributes into a single watershed condition score. To account for the ecological diversity within the NWFP area, a decision-support model was constructed for each of the seven different physiographic provinces. The models were built in workshops attended by local agency professionals. Lacking onsite instream measurements, surrogates for watershed condition must be used, such as number of road and stream crossings. The workshops consisted of an informal group process through which participants came to consensus on how the model evaluated individual attributes and aggregated the scores of individual attributes. Each attribute has a "fuzzy curve" associated with it. The curve defines the values at which the attribute scores a 1 or a -1 and the shape of the transition between the two scores. The transition may be abrupt, such as water temperature reaching a lethal threshold, or gradual as the density of roads increase the habitat score gradually decreases. Following the workshops, models were constructed and run, and the results returned to the workshop participants. Participants compared the model results with their knowledge of the condition of watersheds and suggested refinements to the model as necessary.

Some of the watershed parameters evaluated in the model are road and stream crossings, road densities inside riparian areas, road miles by slope position, miles of road on unstable slopes, percentage of large conifers in riparian areas, percent of urban and agricultural areas, and area by fire condition class. These parameters rely on GIS data. The GIS layers for streams, roads, and vegetation did not exist in a continuous uniform layer for the Forest Plan area. Continuous layers were assembled from various sources. Compiling data from multiple agencies and sources is problematic because data standards (and therefore data layers) are not consistent between agencies. Available data for private lands generally are at a lower resolution than data for public lands. A Pacific Northwest hydrography framework layer exists for Oregon

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[1] USDA Forest Service, Aquatic and Riparian Effectiveness Monitoring Program, Corvallis, Oregon.

and Washington, but stream density on the layer varies greatly across ownerships, with a wide range of standards and mapping intensities being used. For vegetation, the interagency vegetation mapping project (IVMP) layer was used. This is a uniform layer for the Oregon and Washington portion of the NWFP area developed from Landsat satellite imagery. For California, a vegetation layer derived from a combination of Landsat imagery and aerial photograph interpreted polygons was developed (CALVEG). BLM, Forest service, and USGS map data (DLGs) were used for the GIS road layer. The GIS parameters were used with in-channel physical, chemical, and biological data where they were available in the decision-support models.

The watershed status and trend evaluation is expanding from the original sample of 250 to all 1,400 6th-field subwatersheds with at least 25% Federal ownership in the NWFP area. Because of the high cost of field visits and the large extent of the project area, the program is only able to visit a very small number of subwatersheds each year. So far about 170 subwatersheds have been visited since 2002. To determine the status and trend of all subwatersheds, the program will be relying on GIS and remotely sensed data. A new vegetation layer, the Interagency Mapping and Assessment Project (IMAP), is being developed from Landsat imagery. IMAP uses the Gradient Nearest Neighbor method to assign plot information to every pixel. IMAP rasters will be created for they entire NWFP area for 1994 and 2006. This method provides a wide range of vegetation attributes in a 30-m grid. Consequently, we can use more detailed information in evaluating vegetation and compare current attribute levels with the historic range of variability. Change detection overlays will be created by looking at all intervening years instead of just comparing 2 years as was done in the past. This creates a complex series of changes that can be thought of as a life history of a pixel. Subtle changes can be picked up with more confidence, and variation due to clouds and shadows become less important. The resulting change layer will have attributes not just for whether a pixel has experienced a stand replacing event, but also for how it is recovering and subtle changes such a thinning can be picked up.

A landslide model developed by Dan Miller calculates landslide susceptibility for each pixel of a watershed area using topography derived from DEMs, vegetation, and roads. To develop the parameters for the landslide model, landslides digitized from aerial photographs in 14 watersheds were combined with field data. Landslide polygons were overlaid with topography, vegetation, and road buffers to determine how these three factors influenced the occurrence of landslides. Because of the small sample size, it was not possible to tease out different parameters for different regions, so one parameter file is used for the whole NWFP area. Three rasters are created, the landslide susceptibility just for the topography, topography and vegetation, and landslide susceptibility with topography vegetation and roads. The effect of vegetation is portrayed by multiplying the landslide grid for topography by 0.5 for DBH greater than 4 in. and 1.48 for DBH less than 4 in.. The effects of roads can be overlaid on top of the vegetation and topography by multiplying landslide susceptibility within 100 m of a road by 2.73.

One way of addressing the problem of inconsistent stream mapping is to develop a new stream layer base on 10-m DEMs. This would provide a more consistent stream layer and allow the mapping of stream intrinsic potential based on topography and streamflow. Intrinsic potential is a measure of a stream’s capacity to provide high-quality habitat for salmonids based on channel gradient, valley constraint, and mean annual discharge. Having streams that match the DEMs allows the calculation of catchment size for stream reaches (required to model mean annual discharge) and stream gradient. We would like to combine this information in future watershed condition assessment to evaluate how much of high-quality habitat may be blocked by barriers.

We are currently rebuilding all our decision-support models and adding new attributes. This will allow us to take advantage of new information that has become available and incorporate the opinions of a new group of workshop participants. The more the program relies on GIS and remotely sensed data, the more important the quality of these data becomes. Acquiring and updating quality data for such a large area has always been a problem. The DEMs that are currently available were interpreted off old USGS topography maps. Looking to the future, the program would like to improve the quality of the data used. LIDAR is potentially a source of vastly improved DEMs that could be used for determining stream channels, streamflow, stream gradient, and topography. Improved topography will improve our landslide model and improved stream information will increase the quality of many of our decision-support model parameters for evaluating watershed condition. The size of our study area has made LIDAR data cost prohibitive, but hopefully through cooperation and increased usage of LIDAR, it will be possible to have complete coverage in the near future. LIDAR or some other remotely sensed imagery may be used to improve our road layer, especially on private land. As our program relies more on remotely sensed data, we will have to strive to remain aware of new technologies as they become available.