A decade of planning, design, implementation, and reporting the results of Northwest Forest Plan monitoring has produced the opportunity to assess the regional program put in place to evaluate Plan effectiveness. While opportunities for cost savings, increased efficiency, tighter focus on management issues, and the potential for enhanced information yield are important to consider, such factors are countered by the need for monitoring programs to be structured around spatially broad factors playing out over lengthy periods of time. Models, indicators, and protocols underwent extensive technical and policy review and approval as did the overall strategy for Plan monitoring (Mulder et al. 1999). By 2005, the monitoring program was able to report on trends occurring in the Plan region over a decade or more for forest vegetation and the northern spotted owl. For other modules, time series were shorter. In some cases, data collected could most realistically be considered initial inventory or baseline information. All monitoring modules have produced results that permit examination of underlying assumptions, conceptual models, analytical tools, development of descriptive or predictive models, and the efficiency of protocols used for Plan monitoring.

Although the methodologies employed in Plan monitoring were designed to be scientifically sound, choices about what and how to monitor were influenced by management information needs and cost. To the degree that such factors have changed or become better-understood, there may be cause to adaptively alter what is monitored and how monitoring is conducted (Ringold et al. 1996). Changes to enhance monitoring efficiency, or to be responsive to potential Plan alterations, can best be considered by first understanding what the monitoring program currently provides. However, an analysis of science-based monitoring factors cannot fully treat less-tangible benefits that are derived from Plan monitoring such as:

- Developing unbiased, scientific data for dialogue among decision makers on key management questions
- Providing substance for an interagency relationship through a system where Plan implementing agencies have a stake in the monitoring program and its products
- Fostering beneficial change to natural resources management by completing the essential monitoring step in the adaptive management process
- Establishing common mechanisms for analyzing and comparing management practices and ecosystem trends among units within the Plan region (e.g., forests, districts, watersheds), and between the Plan region and that of adjoining ecoregions (e.g., Columbia R., Interior Columbia Basin, Sierra Nevada).

The focus here is on technical issues that are common to all or most of the monitoring modules, not those pertaining to any one module. The intent is to generate productive dialogue about key factors, somewhat arbitrarily grouped into those pertaining to scale, integration, and efficiency, for consideration in future monitoring program implementation.

**Scale** - The Plan embodies conservation goals and implementation standards across a region of 22 million acres under federal ownership in the Pacific Northwest. At its finest level of resolution, the Plan is implemented via management decisions affecting as little as a few acres or restricted (<1 mi) stream segments. Between these extremes are multiple levels of ecological (e.g., watersheds, river basins, biophysical provinces) and institutional (e.g., land management units, designated reserves, stream buffers) hierarchy upon which both monitoring program design and natural resource management are focused. Given that the resources are never likely to be available to provide robust depictions of systems operating at all scales, there are persistent questions about how to best allocate effort for effectively meeting information needs at multiple levels. Aggregation of monitoring information from smaller scales should contribute to the ability to assess higher hierarchical levels, while monitoring at greater scales should provide valuable context for more localized questions (Trexler and Busch 2003). Choosing where to measure requires understanding the primary scales of interest to decision makers and how firm inferences must be at each scale. The default for Plan monitoring modules is to detect status and trend at the regional scale, but
opportunities should be examined for aggregating data, or intensifying sample frequency or density, in areas of special interest.

Integration - A dominant theme within the guidance on monitoring and adaptive ecosystem management is one of integration. One dimension of this theme is the presumption that systems will be managed adaptively based at least partly on information developed in monitoring programs. To do this, there is an expectation that monitoring programs will themselves be well-integrated. As cross-boundary functional relationships become better-understood and calls to coordinate management of species and lands intensify, the possibilities for developing contextual information using data derived from a spectrum of lands become more important. Monitoring collaborations (e.g., the Pacific Northwest Aquatic Monitoring Partnership) are beginning to make understanding of natural resource status and trend across ecoregions feasible. Related to this is a question of whether information about dynamic environments has been adequately incorporated into monitoring design. For the most part, Plan monitoring was not structured to detect the effects of environmental disturbance. Monitoring designs may be capable of detecting change due to disturbance, perhaps even more so than the relatively subtle changes resulting from Plan implementation. However, sample size limitations will constrain the ability to make inferences about various forms of disturbance, particularly within multiple levels of stratification (e.g., incidence of slope failure inside and outside of riparian buffers within key versus non-key watersheds). In order to ensure beneficial adaptive management under the Plan, increased emphasis on monitoring to improve understanding of cause and effect relationships is essential. In many cases, difficulties with integrating data bases across organizations and sub regions contributed to an inability to attribute causation to detected effects of the Plan.

Efficiency - In theory, one can think of the efficiency of a monitoring program as the information yield per unit of resource invested to produce that information. However, managers and scientists are rarely interested in the amount of raw data produced and are instead more focused on the trends pertinent to the questions facing them. Thus, the concept of monitoring efficiency must incorporate an element of how well targeted monitoring information is in relation to such questions. Unfortunately, scientific and management questions themselves are not stable over time and space since they evolve in response to societal factors as well as new information produced. A number of mechanisms were incorporated in Plan monitoring program design with the prospect of making the program operate efficiently and to become more efficient as implemented (Mulder et al. 1999). Benefits and risks of continuity or change in the monitoring of populations and ecosystems can be used to help structure monitoring alternatives. Understanding temporal aspects of anticipated responses in the systems being monitored is of key importance (Trexler and Busch 2003). Considering the temporal dimension anticipated for responses to Plan management actions, it is important to ask if the intensity of data collection is appropriate for detecting projected trends. Similar tradeoffs exist around approaches to monitoring sample design and analysis. Risks and benefits associated with the use of various forms of probabilistic sample design, scientific consensus, remote imagery, population meta-analyses, quantitative habitat models, etc. have become reasonably well-known. Thus, refinement of the approaches utilized should be possible. Clarity would be helpful about the acceptability of developing stronger inferences where data and analyses can be aggregated to the regional scale together with possible acceptance of weaker inferences for sub regional units.

Conclusion – Many of the above questions about Plan monitoring have been posed in an isolated or adhoc manner over the course of Plan implementation. It is anticipated that this synthesis of cross-cutting issues will catalyze productive dialogue about potential adaptive adjustments to the monitoring program. Collectively, questions about Plan monitoring pose a daunting challenge. However, making progress toward answers will benefit immensely from status/trend and synthesis reports produced by the monitoring program itself. Although the conceptual models underlying Plan monitoring remain sound, adjustments to these models are the appropriate starting point for any adaptive program change (Noon 2003). Factors that were less well understood at the time of conceptual model development are now known to have substantial influence on the systems of interest. Without first examining assumptions and conceptual underpinnings, consideration of monitoring alternatives might not provide sufficient rationale for change or could be viewed as unjustifiably producing winners and losers in terms of the systems monitored. Lastly, Plan implementation suffers from a lack of clearly articulated targets and triggers for management action. Information generated by the monitoring program can help rectify this, but because goal setting is ultimately a subjective exercise based on societal values and agency policies, dialogue with decision makers is required to better articulate targets.


SYNTHESIS REPORT- Adaptive Management & Monitoring

1Western Regional Office, U.S. Geological Survey- P.O. Box 3623, Portland, OR