Use of a Regional Watershed Analysis Approach in Long-term Forest Management Planning in California

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Introduction

Environmental regulations (such as the Endangered Species Act and the Clean Water Act) and state Forest Practice Rules (FPRs) have given large industrial timberland owners in California strong incentives to develop long-term forest management plans that ensure the continuous growth and harvest of commercial forest tree species while protecting fisheries, wildlife, soil, and water resources. Three types of legal documents are currently being created and filed with state or federal agencies: Sustained Yield Plans (SYPs) and Programmatic Timber Environmental Impact Reports (PTEIRs) for state agencies, and multi-species Habitat Conservation Plans (HCPs) for federal agencies. Several forest landowners, including Louisiana-Pacific Corporation (L-P) and the California Department of Forestry and Fire Protection (CDF), are in the process of creating combined or coordinated SYPs and HCPs to fulfill both state and federal requirements.

Stillwater Sciences and VESTRA Resources have been working with L-P and CDF to develop SYPs and HCPs for their forestlands in coastal northern California. This article provides a brief overview of our planning approach, and focuses on the L-P SYPs and HCP as a case study. The L-P project involves conducting assessments and developing plans for approximately 300,000 acres of L-P-owned timberlands and over 800,000 acres of associated watershed lands (located in more than 100 planning watersheds, as defined in the CalWater database). This project has required expanding the scale of watershed analysis to the regional level and modifying the scope of the analysis to include elements such as forest growth and yield, terrestrial wildlife and habitats, and economic factors.

Limits of Traditional Forest Planning Approaches

The region of northwestern California, like many other ecosystems around the world, has a history of timber resource use based on economic goals, with limited understanding or consideration of long-term sustainability and ecosystem processes. Until recently, efforts at long-term forest planning that incorporate broader ecological and economic goals have been hampered by the technological limitations of the available planning tools. Some of the limitations of traditional forest management approaches include:

- Landscapes are not viewed as systems so that linkages among processes and landscape elements are not addressed;
- Harvest planning is typically done on a project-by-project basis;
- Conservation programs are applied on species-by-species basis;
- The outcome of each action and the spatial and temporal cumulative effects of many actions cannot be predicted;
- Planning procedures and regulatory guidelines for resource protection rely on simple thresholds and uniform prescriptions to deal with complex problems (e.g., riparian protection) in highly variable landscapes, resulting in guidelines that are too restrictive in some cases and not restrictive enough in other more critical areas;
- Planning processes lack adequate mechanisms for incorporating science directly into decision making, so management cannot readily adapt to new information.

Watershed Analysis As An Approach to Ecosystem Management

Ecosystem management has been promoted as an approach to land management that is more effective than the traditional project-by-project, species-by-species approach. The goal of ecosystem management is to preserve biodiversity and land capabilities by managing landscapes, habitats, and communities of organisms in such a way that resources can be utilized on a sustainable basis while protecting ecosystem integrity and biological diversity. Ecosystem management should be driven by explicit goals, and made adaptable by monitoring and research based on our understanding of the ecological processes and interactions necessary to sustain ecosystem composition, structure, and function (Christensen et al. 1996). Although most scientists and members of the public support the concept of ecosystem management, it has generally proved difficult to implement.

Watershed analysis has been developed as a framework for implementing ecosystem management and is being widely implemented throughout the Pacific Northwest (WFPB 1994, FEMAT 1993, Montgomery et al. 1995). At the watershed scale, methodologies have been developed to examine the cause-and-effect relationships linking forest management actions to direct impacts and their subsequent indirect impacts. For example, timber-harvest disturbance is linked to hillslope stability, which affects sedimentation of streams, influencing stream channel morphology and fish habitat and thereby survival and reproduction within fish populations.

The development of watershed analysis and its application to land management issues has provided a valuable tool for conducting scientific analyses of potential environmental impacts and enabling government agencies, industry, and local landowners and citizens to make informed decisions about how their lands will be managed. The available methodologies, such as the Washington DNR (WFPB 1994) and federal (USDA 1994, RIEC 1995) approaches, continue to develop and improve as users assess their applicability and limitations. Some of these limitations include the following:

- The impacts of geomorphic processes on fish habitat are addressed, but other linkages

between forest management prescriptions and ecosystem impacts receive less attention or are not analyzed;
- Terrestrial ecology is not explicitly considered;
- Management prescriptions are not explicitly linked to long-term economic effects;
- Sustained yield timber production is not identified;
- The potential costs of resource protection measures are not determined;
- The intensive (Level 2) approach may be too labor-intensive and time-consuming to allow large areas to be analyzed quickly.

A Landscape-scale Approach to Watershed Analysis and Sustained Yield Planning

In response to some of these limitations, the L-P SYP team has worked together to develop an analytical approach to forest ecosystem management that integrates watershed, fish, and wildlife resource capabilities and sensitivities with timber growth and yield modeling to develop a true long-term sustainable yield forest management plan.

The approach we are using for the L-P SYPs and HCP is based largely on the Washington DNR approach, with modifications such that it:

- Takes advantage of recent advantages in computer mapping and digital terrain modeling so that it can an be applied at a larger landscape scale, on a relatively fast schedule, and in a cost-effective manner;
- Includes analyses of both terrestrial and aquatic ecosystems at multiple spatial scales;
- Incorporates forest growth and yield models to model impacts of management on wildlife habitat;
- Links various resource models and analyses into an integrated system;
- Allows spatially explicit delineation of areas where resource protection measures or specific timber management prescriptions can be applied (using a geographic information system, or GIS);
- Helps predict and avoid long-term, cumulative impacts of land management prescriptions on wildlife habitats and watershed resources during the 120-year planning horizon;
- Is well-suited for comparing the economic and environmental costs and benefits of alternative plans;
- Allows for avoidance or mitigation of potential impacts to be addressed directly in the planning process by eliminating management activities that produce undesirable conditions;
- Generates an efficient harvest schedule based on resource capabilities and management-defined goals for ecosystems and products;
- Is based on clearly defined and easily reviewed data, maps, models, and policy decisions, and therefore can be updated and improved as science and policy change;
- Encourages adaptive management by incorporating monitoring of the impacts of applied prescriptions on environmental and socioeconomic factors.

A primary goal of watershed analysis is to establish the linkages between natural and management-induced hazards and their potential effects on vulnerable aquatic and terrestrial resources. A key to achieving this goal is the synthesis process (see the XX issue of the WMC Networker for some interesting discussions of the need for synthesis in watershed analysis), which involves integrating the analyses for separate ecosystem elements to provide a more complete understanding of the whole system.

The Synthesis Process

An interdisciplinary team approach is used to ensure that linkages among timber, fish, wildlife, and watershed resources are considered at each step in the planning process. The process used is described briefly below, with the primary focus on the watershed, fisheries, and wildlife resource protection perspective. Olson and Orr (1997) and Olson, Holmen, and Angelides (1997) provide more details on how the watershed analysis components fit into the larger timber modeling and decision analysis framework that is used to create a balanced forest plan.

Step 1: Conduct Resource Capability Analysis.

This step includes the basic watershed, fisheries, and wildlife resource assessments (including hydrology, mass wasting, hillslope erosion and sediment yield, streamside shade and water temperature, fish distribution, stream channel, fish habitat, vegetation and wildlife), in which the current status of and potential threats to sensitive non-timber resources are identified and described for each assessment area (assessment of timber resources is also conducted at the same time). Results of these assessments then feed into the synthesis and cumulative effects analysis, which is conducted at several spatial scales: planning watershed (generally 3,000 to 10,000 acres), watershed and wildlife assessment areas or WWAAs (10,000 to 50,000 acres), and management unit levels (total L-P ownership in a region, ranging from 75,000 to 230,000 acres).

Elements of the resource capability analysis include:

- Identification and characterization of valuable resources in the watershed, such as threatened, endangered or sensitive (TES) species and sensitive aquatic and terrestrial habitats (including assessment of current conditions and comparison with an undisturbed reference state that is determined using available information on past conditions, key ecological processes and disturbance factors, and best professional judgement about potential conditions in the absence of management-induced disturbances);
- Determination of the vulnerability or sensitivity to disturbance for each of the identified valuable resources (based on existing knowledge of past and current conditions and ecological processes);
- Identification of potential hazards (i.e., sources of natural and human disturbance) that might adversely impact valuable resources;

- Assessment of the risk of significant adverse direct, indirect, and cumulative impacts to these resources of value (based on the distribution of resources on the landscape, the likelihood of disturbance and the sensitivity of these resources to disturbance).

The results of Step 1 are used to define specific areas ("areas of special concern") in each watershed that may require special management policies to minimize or avoid risks to sensitive resources. Examples include wetlands, riparian areas, areas with high mass wasting hazards, and habitat linkages (i.e., designated "wildlife corridors"). These areas of special concern are then used, along with site quality, topography, and vegetation, to define the land types considered in the harvest allocation and scheduling modeling process (see Step 4). The key principle in defining and delineating land types is to differentiate among landscape units with regard to their capabilities to support various resources (e.g. timber, fish, wildlife, soil, and water resources). Land types containing areas of special concern will have only a very limited range of silvicultural prescriptions allowed (e.g. no harvest or special late seral prescriptions for riparian management areas and wildlife corridors).

Step 2: Assess Potential Cumulative Effects and Watershed Sensitivity

An important objective of the synthesis process is to integrate the results from various watershed assessments, with an emphasis on identifying the relative sensitivity of planning watersheds to direct and cumulative impacts associated with sediment, water temperature, and organic debris so that significant impacts can be avoided, minimized, or otherwise mitigated. Watersheds with higher sensitivity to cumulative effects of forest management practices may require a higher level of resource protection to prevent or minimize future cumulative impacts. Examples of the tools used in this step include the watershed relative risk index and the road erosion relative hazard rating systems.

- *Watershed Relative Risk Index (WRRI)*. The sensitivity of watersheds to sediment loading impacts can be evaluated using a WRRI and rating system that combines a measure of the potential for hillslope sediment production with the value and vulnerability of downstream beneficial uses (primarily fisheries, water supply, and water-contact recreation). The WRRI approach allows comparison among watersheds of the estimated potential for adverse cumulative watershed effects related to sediment delivery to stream ecosystems. The WRRI rating system is intended to serve as a screening tool to identify watersheds that might require extra resource protection measures or more intensive monitoring. It can also be used to help assign priorities for watershed mitigation, enhancement, or monitoring studies. At present, the WRRI rating system should be viewed as a hypothesis, based on the best available information, that is useful for regional assessments of the relative risks of degradation of aquatic resources caused by natural and accelerated sediment inputs. Testing of the WRRI hypotheses in specific watersheds can be accomplished with a combination of Level 2 watershed analysis and longer-term monitoring (see Step 5).

- *Road Erosion Relative Hazard (RERH) Ratings.* The WRRI ratings address mass wasting hazards associated with hillslopes and existing roads, but they do not specifically address the hazards associated with delivery of fine sediments to streams from the surface wash off of existing roads. A relative rating system was developed to help L-P prioritize its road management activities, particularly road inventory and mitigation. Unlike the WRRI rating system, the road erosion relative hazard (RERH) rating system focuses only on potential hazards (i.e., production of fine sediments and likelihood of delivery of these sediments to the stream network) and not on downstream vulnerable resources (i.e., fisheries habitat and human water uses). The RERH represents a hypothesis about the severity of problems related to fine sediment production caused by existing roads in various watersheds. Like the WRRI approach, the RERH uses a relative ranking to identify those watershed most expected to have problems. It does not attempt to set absolute standards, or thresholds of concern, to determine if an actual fine sediment problem exists, but instead focuses on setting priorities for road inventory and management efforts.

Step 3: Develop Resource Protection Measures.

The overall goal of this planning process is to maintain or enhance habitat conditions, conserve biodiversity, and preserve ecosystem functions. The results of steps 1 and 2 are used to develop resource protection measures to meet the specific management goals and objectives for watershed, fisheries, and wildlife resource conditions. An interdisciplinary team of resource scientists, foresters, and resource managers reviews the results of steps 1 and 2, defines key issues, reviews and refines L-P management goals and objectives to make sure that management policies adequately address all appropriate resources, and develops implementation standards and guidelines (i.e., resource protection measures) that are consistent with resource conditions and ecosystem capabilities. Resource protection measures are incorporated into silvicultural prescriptions and land allocation whenever practical so that the effects of the measures on timber production and long-term sustained yield can be modeled. For example, silvicultural techniques for riparian zones and sites with high landslide potential can be incorporated into the harvest optimization and land allocation modeling. Many protection measures, however, do not lend themselves to modeling, but rather address specific implementation measures and standards (e.g., standards for snag or downed wood retention) that will need to be followed in developing each future timber harvesting plan that falls under the SYP or HCP.

Examples of the types of resource protection actions that might be tied to watersheds with high WRRI ratings include:

- Limiting silvicultural prescriptions to those with reduced levels of ground disturbance (for example, applying only silvicultural regimes with extended time between entries);
- Applying additional riparian buffers to selected streams to reduce potential for sediment delivery;
- Limiting timber harvesting in areas with high mass wasting potential and requiring additional field review by a licensed geologist to evaluate mass wasting hazards prior to harvesting;

- Conducting additional more intensive (Level 2) watershed analysis;
- Giving highest priority to road inventory, monitoring, and management actions directed at reducing road-related erosion and sediment production in watersheds with high WRRI or RERH ratings.

Step 4: Conduct Resource Capability Modeling and Harvest Scheduling.

The results of the watershed, fisheries, and wildlife assessments next need to be integrated into the SYP resource capability, harvest scheduling and allocation modeling components of the ecosystem planning approach. The key components of this process include:

- Identification and GIS mapping of resources of special concern that should be included in the development of land types (e.g., areas of high mass wasting potential, wetlands and riparian areas, and potential wildlife corridors);
- Limitation on the range of allowable silvicultural prescriptions in areas of special concern (e.g., no harvest without review in areas of high mass wasting potential, or allowing only no harvest or late seral forest prescriptions in Riparian Management Areas and designated wildlife corridors);
- Development of specific desired future condition goals for each watershed or management unit (e.g., percentage of forested lands in late seral habitat by a certain period in the planning horizon);
- Constraints on harvesting in a given period or for a specific area (e.g., no net decline in percentage of forested lands in late seral condition, or limitations on the amount of clearcutting allowed per watershed per decade);
- Running the timber harvest scheduling and optimization model and production of maps, tables, and charts to illustrate the results;
- Review of planned harvesting schedules and evaluation of potential impacts and resource trends, and repeating the process if the results are not acceptable.

Step 5: Develop Framework for Adaptive Management and Monitoring

The final step in completing the integration of watershed analysis into the forest ecosystem planning process is to develop an appropriate framework for adaptive management and monitoring. Adaptive resource management is an integral component of L-P's planning strategy because current scientific understanding of cause-and-effect relationships among management actions, ecological processes, and resource conditions is often incomplete. An adaptive management approach requires a carefully planned structure for monitoring, reviewing management actions, and refining management actions (Holling 1978). The initial focus should be directed largely at designing monitoring studies to test or validate key assumptions, hypotheses, and models used in the watershed analysis. An example of a first step in this direction would be to identify which of the underlying assumptions or models used in the watershed analysis and forest planning process have both a high level of uncertainty and are likely to have a significant impact on the final forest plan.

A Note on Use of Computer Models

It is important to recognize that much of the regional watershed analysis approach described in this article is based on GIS and other computer models, such as the shallow landslide potential digital terrain models or the stream channel flow accumulation and channel slope models, or indexes derived from GIS models (such as the WRR index or the RERH index). The accuracy of these models depends on the quality of input data as well as the validity of the models themselves (or the specific algorithms developed to apply a model in a GIS framework). One of the best ways to test these models is to conduct more intensive, field-oriented watershed analysis in selected watersheds. The use of intensive watershed analysis (i.e. a Level 2 analysis following Washington DNR or federal manual approaches) in this context is a key component of L-P's adaptive management and monitoring program.

Additional information on the ecosystem modeling and decision analysis process and the various modeling components used can be found in Olson and Orr (1997), Olson et al. (1997), Montgomery et al. (1997), and on the home pages of VESTRA (http://www.vestra.com) and Stillwater Sciences (http://www.stillwatersci.com).

Literature Cited

Christensen, N.L. et al. 1996. The report of the Ecological Society of America Committee on the scientific basis for ecosystem management. Ecological Applications 6:665-691.

FEMAT (Federal Ecosystem Management Assessment Team). 1993. Forest ecosystem management: an ecological, economic, and social assessment. USDA Forest Service, U.S. Fish and Wildlife Service, National Marine Fisheries Service, National Park Service, Bureau of Land Management, and Environmental Protection Agency.

Holling, C.S., ed. 1978. Adaptive environmental assessment and management. John Wiley and Sons, New York. 377 pp.

Montgomery, D.R., W.E. Dietrich, and K. Sullivan. 1997. The role of GIS in watershed analysis. In: Lane, S.N., K.S. Richards, and J.H. Chandler (eds.), Landform Monitoring and Analysis. John Wiley & Sons Ltd.

Olson. C.M. and B.K. Orr. 1997. Combining tree growth, fish and wildlife habitat, mass wasting, sedimentation, and hydrologic models in decision analysis and long-term forest planning. Presented at the Forest Ecology Workshop, USFS. June 1997. North Carolina. *[http://www.vestra.com/landplan.htm]*

Olson, C.M., S. P. Holmen, and D.P. Angelides. 1997. Ecosystem planning in the real world. Presented at the ESRI User Conference. July 1997. San Diego.

[http://www.vestra.com/ecosyst.htm]

RIEC (Regional Interagency Executive Committee). 1995. Ecosystem analysis at the watershed scale: A federal guide for watershed analysis, Version 2.2. Portland, OR. 26 pp.

USDA (U.S. Department of Agriculture). 1994. A federal guide for pilot watershed analysis, Version 1.2. Portland, OR. 202 pp.

WFPB (Washington Forest Practices Board). 1994. Board manual: standard methodology for conducting watershed analysis, Version 2.1.