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Research activities on cumulative watershed effects
Pacific Northwest Research Station
Cascade Center for Ecosystem Management

The issue of cumulative effects of timber harvest activities on watersheds and fisheries has been with us for awhile but still resists sharp definition and focus. Research has been slow to identify key processes and linkages and develop technically defensible approaches to analyzing cumulative effects in different landscapes. Resource managers and specialists have thus been placed in the uneviable position of designing analysis and mitigation procedures without sound scientific information.

A coordinated effort is underway at the PNW Research Station in Corvallis to address some of the shortcomings of current approaches to analyzing cumulative effects. These activities are being conducted through the Cascade Center for Ecosystem Management (CCEM), a consortium of PNW, Oregon State University, and Willamette National Forest. A wide variety of research methods is being employed, including retrospective analyses, computer modelling, field studies, and large-scale landscape experiments.

While some of these activities are geographically concentrated in the Willamette National Forest, the research itself is regional in scope and relevance. The hydrologic models, assumptions, and approaches that are being evaluated by this work are currently being used in many westside (and some eastside) Forests in Washington and Oregon, not to mention Alaska and Northern California. These projects address many of the key issues in cumulative effects throughout the region (generation of peak flows, importance of rain-on-snow events, sediment routing and disturbance propagation in forested watersheds, and impacts on fisheries). Improving the scientific understanding of these issues is vital to supporting the next round of Forest Plans and regional watershed and fisheries protection strategies.

Principal investigators in these studies include Gordon Grant (Research Hydrologist, PNW), Fred Swanson (Research Geologist, PNW), Julia Jones (Assoc. Prof., Dept. of Geosciences, OSU), Stan Gregory (Assoc. Prof., Dept. of Fisheries and Wildlife, OSU) as well as several Ph.D students and technical support personnel at OSU. Collaborators on one or more projects include Dennis Harr (PNW), George Leavesley (U.S. Geological Survey), and Gordon Reeves (PNW).

Current and planned activities include:

1) <u>Retrospective analysis of streamflow changes in relation to forest practices</u>: We are reevaluating the effects of forest landuse on peak and low streamflows in the six western Cascade watersheds used by Christner and Harr. An extensive GIS database on the ages, locations and sizes of clearcuts and roads for these six basins has been developed. Concurrently, we have developed a much more comprehensive streamflow record from U.S. Geological Survey data than was used by Christner and Harr. Preliminary results from this analysis suggest that there appear to be shifts in the pattern of peak flows from neighboring watersheds that coincide with the timing of entry for timber harvest. These shifts are not, however, strongly correlated with the percentage of basin area in unrecovered (i.e. pre-canopy closure) clearcuts. Other factors, such as

the road network density, may play a more important role in causing changes in peak flows than previously thought.

Justification and Products: This research is designed to test assumptions underlying current approaches to reducing hydrologic impacts used in many westside Forest Plans (i.e. ARP). Results from this analysis should be immediately applicable as improved guidelines for scheduling harvest over time and in space to reduce hydrologic impacts.

2) Distributed streamflow network to monitor changes in streamflow due to harvest activities: This is a new activity to be initiated in FY 92 if funding is available. The exisiting USGS streamflow network is inadequate to characterize changes in streamflow attributable to landuse on small forested watersheds. Most stream gagues are located either on regulated streams or in large watersheds where deciphering the effects of landuse is difficult. We plan to install a distributed streamflow network in 8-10 small to intermediate-sized watersheds (500 - 10,000 acre) with a range of past, present and future cutting histories. These watersheds are all located in the Blue River, Lookout Creek, and South Fork McKenzie drainage basins where they can be serviced from the H.J. Andrews Experimental Forest. Four classes with at least two replications each will be represented: i) watersheds heavily harvested in the past and programmed for additional harvest in the future; ii) watersheds harvested in the past with no future programmed harvest (i.e. HCAs); iii) watersheds with little or no harvest in the past but programmed for additional future harvest; and iv) wilderness areas (no past or future harvest). Measurements at each stream will include precipitation, air temperature, discharge, depth-integrated suspended sediment sampling, and stream temperature, and will be recorded automatically using data loggers.

Justification and products: This research serves several monitoring and research objectives: i) provide validation data for testing results from projects 1 and 3; ii) extend and test results of long-term monitoring of small watersheds at H.J. Andrews Experimental Forest to wider geographic region; iii) serve as long-term effectiveness monitoring for hydrologic assumptions and procedures built into Forest Plans; iv) provide short-term benefits as a 'sentinel' network designed to rapidly assess influence of land use practices on specific storms. This last objective would allow the Forest Service to address public concerns about contribution of harvest activities to downstream flooding in the event of a large-scale storm, such as the November 1990 storm in Washington.

3) Computer modelling of effects of alternative cutting patterns on hydrology and sediment transport: A new set of concerns about forest fragmentation has prompted the need to reevaluate the strategy of dispersing harvest units over the landscape. Evaluating the hydrologic effects of alternative cutting patterns requires development of watershed hydrologic models. We have begun to parameterize and test PRMS, a hydrologic model developed by the USGS, using hydrologic data sets for both small and large watersheds located in the H.J. Andrews Experimental Forest. In conjunction with Dennis Harr (PNW-Seattle) we are also examining the effects of rain on melting snow under different forest stand conditions.

We will be using the model to predict the hydrologic response to different cutting patterns, for example dispersed versus aggregated harvest units.

Justification and products: This work addresses both research and management needs for predictive models to be used for 'what-if' simulations and planning. Results from this effort will include both improved guidelines for distributing harvest activities over space and time and new tools for planning and hydrologic analysis. Future activities planned for the next three years include developing integrated models of sediment production, routing and channel change that can be used to forecast effects of alternative cutting practices on stream channels and aquatic resources.

4) Multi-basin analyses of stream and riparian dynamics in relation to land use: The objective of this project is to examine a population of watersheds in different physiographic regions of the Pacific Northwest. Our overall goal is to evaluate the historical and current behavior, structure, and ecology of streams and riparian zones with respect to varying land uses, climate, and disturbances. Results from these analyses will be used to contrast the sensitivities of watersheds, stream channels, and aquatic communities under different physiographic regimes to natural and anthropogenic disturbances.

Initial studies have focused on twelve 4th- to 6th-order watersheds (5,000 to 100,000 acres) located in the central western Cascades of Oregon, Drift Creek in the Oregon Coast Range, and the Elk and Pistol River drainages in the Siskiyou Mountains in southwestern Oregon. We have developed extensive data bases on these watersheds including information on streamflow, geomorphic disturbances, channel morphology, riparian vegetation, fish populations, and land use. Much of this information has been mapped or developed as GIS layers. In FY 92 we will begin to analyze these data and test hypotheses about the relationships among disturbances, land use, channel morphology, and fish population structure.

Justification and products: This work is designed to test hypotheses about linkages between natural and human-related disturbances and changes in riparian zones and aquatic resources. These hypotheses underlie most current standards and guidelines for riparian areas, cumulative effect assessment strategies as reflected in Forest Plans, and even regional conservation strategies such as the fisheries component of the Gang of 4 report to Congress. Other benefits to this work include developing assessments of current status of fisheries and aquatic habitat for the specific regions, evaluating the quality and effectiveness of historical monitoring activities for riparian issues, and identifying future monitoring directions. Results of these studies should also provide hypotheses which can be tested using the extensive habitat and stream survey information now being collected on many National Forests.

5. Integrated analysis and mapping of geomorphic hazards in forested drainage basins: Steepland watersheds are subjected to a complex and interacting suite of geomorphic processes and disturbances. These include hillslope and streamside landslides, earthflows, debris flows, and debris-laden and

dam-break floods. Predicting consequences of natural and land-use accelerated disturbances and erosion requires understanding the landscape setting and interactions among these processes. Using GIS, we are developing new approaches to identifying parts of watersheds and channel networks sensitive to these various disturbances and generating models of disturbance propagation through landscapes. Overlays of geologic, topographic, hydrologic, and land-use data are used to produce hazard potential maps for watersheds over time. These maps are being validated by comparison with empirical data from landslide, earthflow, debris flow, and riparian disturbance inventories. Future activities will include developing sediment and woody debris routing models to predict downstream effects of geomorphic disturbances.

Justification and products: These new approaches will provide resource planners with an improved information base and conceptual framework for evaluating cumulative effects of land-use activities. Hazard potential maps will distinguish hazard-prone areas of watersheds and help identify key sites for monitoring, mitigation, or restoration activities. Initial work is being conducted in the Blue River and Lookout Creek watersheds near the Andrews Experimental Forest but will be extended to include other western Cascade watersheds. Data from Project #4 will provide additional opportunity to test and validate these approaches.

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