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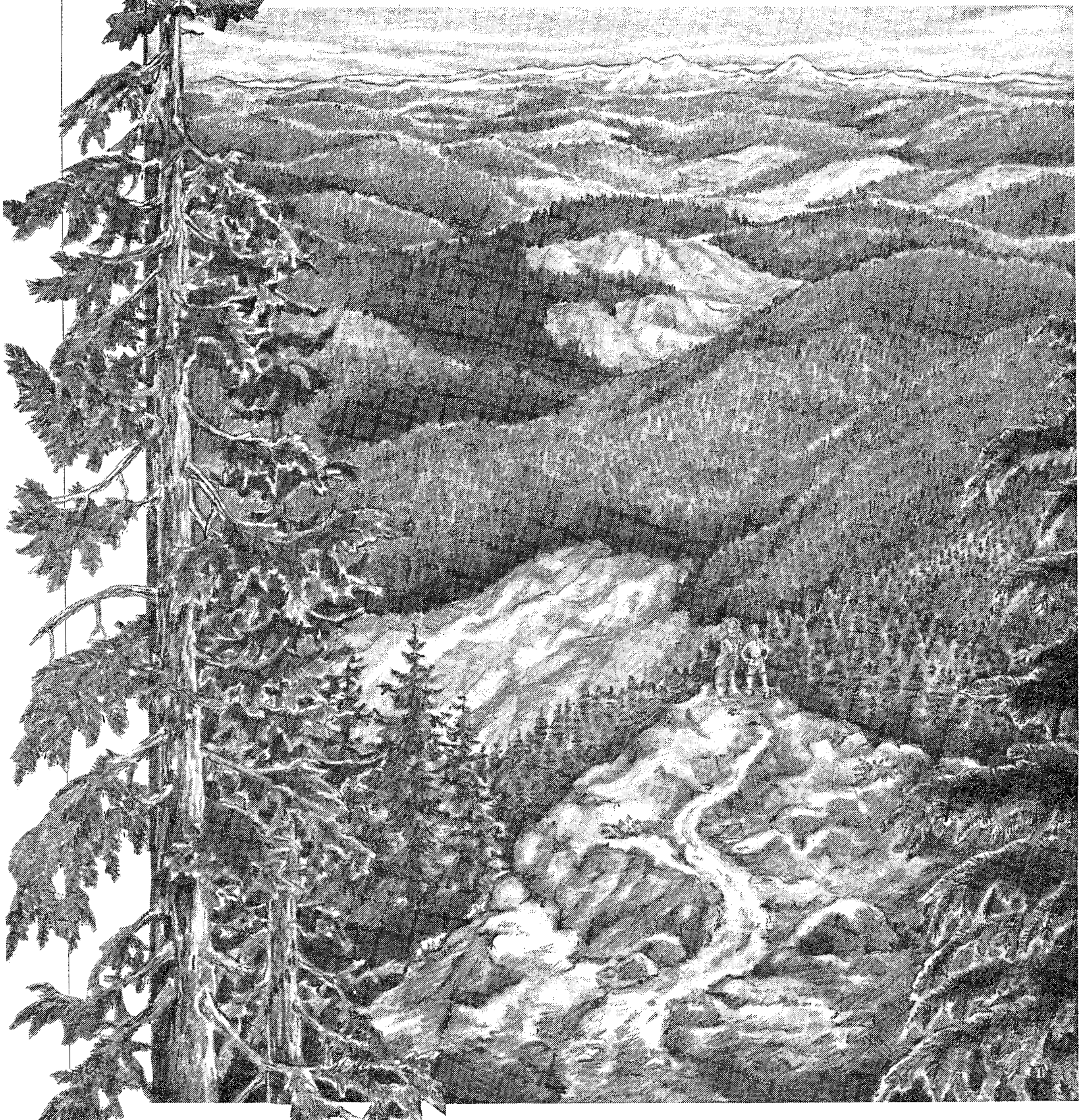

INSIDE: *Broadening Perspectives*

Cumulative Effects of Forest Practices

by Gordon E. Grant and Fred Swanson

Issues surrounding the analysis and mitigation of cumulative effects of forest practices on watersheds and ecosystems have been with us for a while. In 1970, the National Environmental Protection Act CNEPA) provided the first legal mandate to address cumulative ecological effects of federal projects. Yet two decades later, cumulative effects analysis still resists sharp definition. Most refined analyses to date have been developed within the hydrologic and geomorphic arenas, such as altered peak and low streamflow and sediment loads. The term "cumulative effects," however, has come to encompass topics as diverse as wildlife loss, forest fragmentation, and long-term site productivity.

Analysis of cumulative effects historically has been treated as a separate issue from the shifting management and societal concerns embodied in the term "New Perspectives." Changing perceptions of forests are, however, paralleled by shifting concepts of assessing and managing cumulative effects. Here we focus on evaluating hydrologic cumulative effects and consider the thinking that underlies existing methods of analysis as well as suggest future paths.

Current Approaches

Many of the current methods for evaluating cumulative effects have encountered technical, legal, or political problems because they have not explicitly addressed the complexity of biological-physical interactions spread over large areas and long time frames. Among the many approaches developed by federal land managers for analyzing cumulative effects, two dominant conceptual models stand out, both of which have this limitation.

In the first, cumulative watershed effects have been referred to as the *UFO's of hydrology*-phenomena that are not well documented or explained but which a sizeable fraction of scientists, managers, and publics believe to exist. At least in part, this view comes from the rather limited number of well-documented studies which clearly demonstrate cumulative effects. A few studies in the Idaho Batholith, north coastal California, and western Oregon, demonstrated altered hydrologic regimes and downstream changes in stream channels following timber harvests. Upland areas provide much of the technical basis for cumulative watershed effect analysis throughout the Pacific Northwest—at least as reflected in national forest plans.

These and other more anecdotal studies that form the "lore" of cumulative effects do not, however, provide managers with clear guidelines for basing prevention or mitigation strategies in specific landscapes. Managers thus have turned to applying "best management practices," which are usually site-based standards and guidelines designed to minimize impacts and to fulfill their obligation to consider cumulative effects. While in some landscapes this may be an appropriate short-term strategy, it does not directly address potential synergism among multiple activities distributed through time and space—and actually avoids the "cumulative" aspect of cumulative effects.

A second common model treats watersheds as *deterministic systems* which involve well-behaved relationships among key system processes and their response to disturbance. For

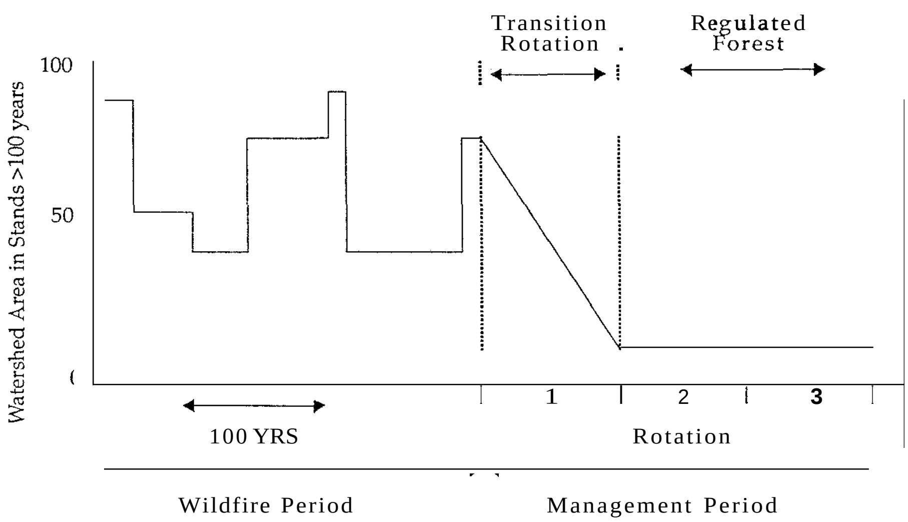

FIGURE 1: Hypothetical change in areal extent of forest age classes exceeding 100 years in a large watershed

example, a number of national forest plans have used fish habitat models as part of their cumulative effect analyses. These models are intended to predict (or index) the effects of roads and timber harvesting on basin output of smolts. They assume simple mathematical relationships between harvest levels and quality or quantity of fish habitat, between fish habitat and fish production, and so forth. Development of these types of models has been fueled by the pervasive use of linear programming models *(e.g.,* FORPLAN) as a basis for forest management decisions.

A variant on this approach is to assume that relations among system elements may not be linear, but involve thresholds, where large abrupt changes in system response can occur from a small increment of applied stress. Hence, one might build thresholds into the above model so that major negative changes to fish habitat occur once a certain level of management operations is exceeded in a particular watershed. Implicit in this approach are the assumptions that natural systems are governed by thresholds that can be determined and used to set the limits of acceptable change-in essence nature will "tell" us the limits of management intensity.

Watershed systems are far too complex for this approach. Almost by definition, cumulative effects do not conform to simple cause-and-effect mechanisms essential to such approaches. Instead they tend to be dominated by unexpected results and quirky behavior, and are highly contingent on particular sequences of events.

A New Approach to Cumulative Effects

We still have quite a long way to go toward articulating a coherent vision of how to analyze the long-term behavior of large watersheds to land-use and other disturbances. We can, however, identify some fundamental components of landscape analysis that recognize the highly contingent nature of watershed change and the social aspect of risk taking involved in long-term natural resource decision making.

Consider Appropriate Time Frames

Some cumulative effects emerge only after activities have accumulated over long periods of time. Some of the most controversial ecological issues facing forest management, such as the decline of interior forest habitat and species and forest fragmentation effects, were entirely predictable from the basic strategy used during the last four decades of distributing harvest units over watersheds; but they were not recognized until we were a third of the way through the rotation.

Realistic analysis of effects of forest management must be done at the scale of single and multiple cutting cycles (rotations), with regard for natural disturbance patterns in both management and pre-management periods. In a simple example, Figure 1 displays hypothetical variation in percent of basin area in stands greater than 100 years in age, based on typical fire and management patterns in For-

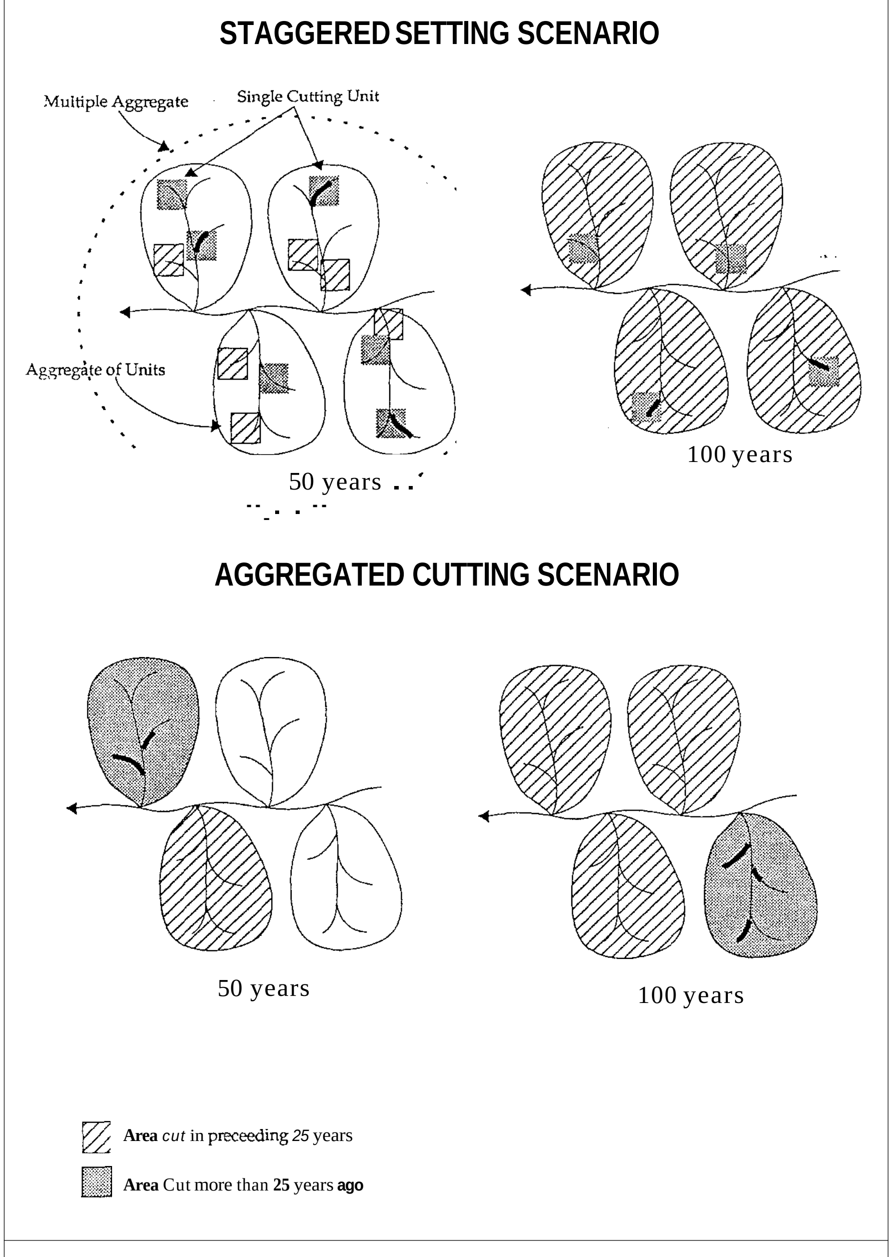

FIGURE 2: Schematic maps showing areas cut under aggregated and dispersed cutting systems for hypothetical landscapes composed of four sub-basins using a 100-year rotation. Total area cut per time period is constant under both systems. Scales indicated correspond to those shown in Figure 3.

est Service lands of the central Cascade range in Oregon. During the pre-management wildfire period, large fires periodically burned significant portions of large basins. A period of fire suppression prior to significant timber harvesting resulted in an aging of the forest. In approximately 1950, we began the first rotation (here assumed to be 100 years) which marks the transition from a natural to a fully managed (or regulated) forest.

Two points should be noted here. First, the cumulative effects of this forest development on a simple measure of landscape structure (percent area in stands older than 100 yrs) is evident only by considering a time scale extending into the second rotation. Analysis of only a decade or two in the midst of the transition rotation fails to reveal cumulative effects. Second, management practices may greatly alter both the mean landscape condition (e.g., percent area in certain age classes) and the variance (e.g., decade to decade variation in that measure of landscape structure). An accurate cumulative effects analysis should consider both.

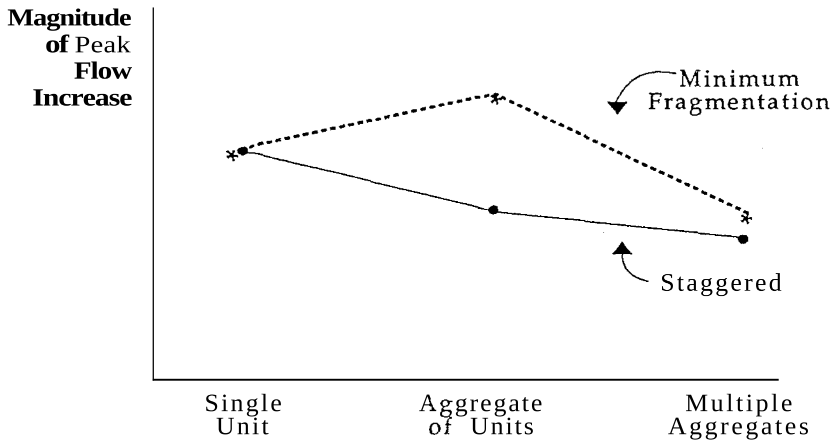

FIGURE 3: Relative magnitude of increased peak steamflow for the hypothetical cutting systems (Figure 2) at the spatial scales of single cutting units (approx. 40 acres), aggregates of cuts (approx.1500 acres), and multiple aggregates (approx. 6000 acres) shown in Figure 2.

Consider Appropriate Spatial Scales

Effects of management practices may be expressed differently at different spatial scales. Both the rate of landscape change (e.g., proportion of area cut per decade) and spatial arrangement of cutting are significant considerations. Consider, for example, the effects of aggregated and dispersed cutting patterns on flood flows in a very simplified conceptual model which relates peak flow increases directly to the proportion of area harvested (Figure 2). At the scale of a single cutting unit, and in large basins with multiple aggregates of cutting units, there is likely to be little significant difference in the magnitude of flood flows (Figure 3). The greatest differences in peak flows is likely to occur at the intermediate scale—the scale of aggregates of cuts—because the maximum contrast between the two cutting strategies in the percent of basin harvested occurs at this scale. In short, the outcome of a cumulative effects assessment can be highly scale dependent.

Construct Landscape-Specific Scenarios

Progress in analysis of cumulative watershed effects rests on using geographic information systems (GIS) and other tools to develop spatially explicit models of change in landscape structure due to cutting, regrowth, and other processes. The temporal and spatial sideboards for this analysis are discussed above. The next step is to analyze the effects of these landscape patterns on key system properties such as hydrology, wildlife, and susceptibility to disturbance, using computer models and other techniques.

Yet, unlike traditional deterministic approaches, the highly contingent nature of watershed behavior should be explicitly recognized. That is, large complex systems such as watersheds can take a great variety of developmental paths depending on the relative timing of management activities, natural disturbances, and major storms. The effects of a particular event are highly contingent on conditions created by preceding events. Therefore, the analysis should consider the range of possible future landscape conditions that may arise from a particular management plan and consider worst as well as best case outcomes. Analytical approaches should include deterministic simulation models as well as conceptual, historical, and intuitive models. Uncertainties and risks should be identified, evaluated, and mapped.

Explicitly Acknowledge Uncertainty and Risk

Given the uncertainty and risks involved in landscape management, decisions regarding cumulative effects are as much societal value judgements as technical issues. We need to more effectively communicate that risk is inherent in the forest management enterprise. Rather than try to convince the public that management of forest lands is a tried and true science, resting on well-known deterministic principles, we should acknowledge the grand experiment in land management that we are collectively conducting. This involves a shift from a technocenter world view to an adaptive management approach in which we derive new information in part from results of management activities. This is the gist of taking a "new perspective" in watershed management. FP

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