

## CUMULATIVE EFFECTS ASSESSMENT IMPACT THRESHOLDS: MYTHS AND REALITIES

*Robert R. Ziemer*

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### INTRODUCTION

A cumulative impact has been commonly defined as: "...the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency or person undertakes such other actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time." (U.S. Council on Environmental Quality 1978). A threshold is defined in Webster's as "the point at which a physiological or psychological effect begins to be produced."

Often the reason to identify thresholds is a desire to allow some management action to proceed unhindered until the magnitude of effect reaches a point at which regulation becomes necessary. That "threshold" often is not physically or biologically based, but is the point at which the public becomes adequately alarmed and demands action.

The level of "acceptable" risk has two components, biological and social. There is no common view of what level of risk is acceptable. The selected level of regulation then becomes based on some perceived risk. Both the biological and social perceptions of risk are almost always based on limited data in time and in space. A survey of any geographic area will result in a high variance in most parameters. For example, consider a hypothetical survey of streams to evaluate the risk of mortality of some species of fish (Figure 1). Some streams will have good habitat and a low risk of mortality from a given proposed action, while others will have a high risk. If the species is abundant, society may agree to adopt a

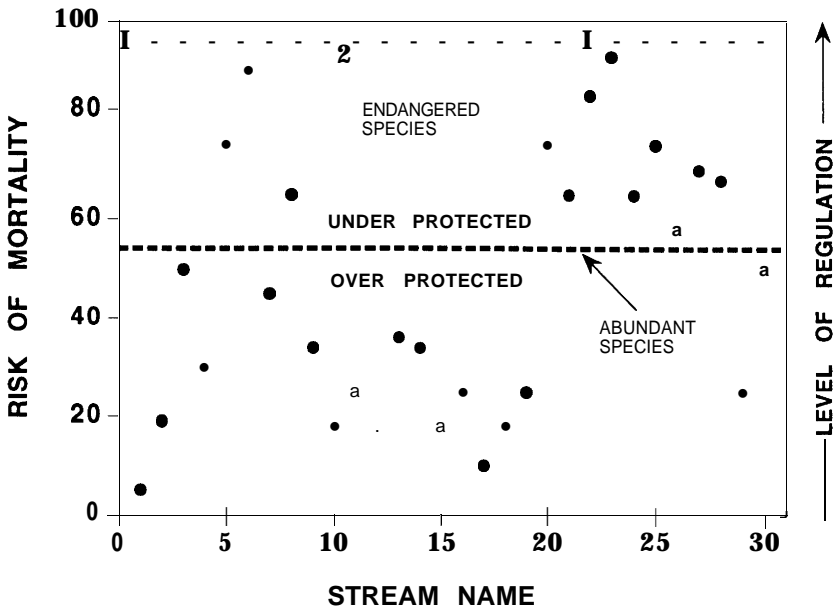
set of regulations that would over-protect some streams and under-protect others. If, however, the species is in imminent danger of extinction, society will usually demand a higher level of regulation. The appropriate level of regulation, then, depends on the consequences of making a judgment error. Society is usually more willing to accept a larger risk of error when dealing with an abundant species than with one in imminent danger of extinction.

Generalized regulations are inefficient. A higher level of regulation will result in more streams being over-protected. The closer that the regulations can be tailored to the variables associated with the risk, the less likely that proposed management actions will be curtailed needlessly, or, conversely, the less likely that the regulations will be inadequate to protect a desired resource.

### THE PROBLEM OF SCALE

To move from regulations that are general to those better tailored to an issue requires selecting appropriate scales. The relevant spatial and

Figure I. Hypothetical survey of streams for risk of fish mortality and the relationship between risk and the level of regulation needed to protect fish at two levels of abundance.



temporal scale for each analysis is dependent on the specific issue being addressed. There is no one scale appropriate for all issues. Historically, cumulative effects analyses have been deficient because the spatial scale was too small and the temporal scale too short. Analyses often have been limited to individual ownerships or to political boundaries.

As a general guide, one spatial analysis scale should encompass the distribution range of each species, and another scale, the home range of individuals. But, there are literally thousands of species. The relevant scales may be quite different for each species or each issue. For example, for a species of salamander having a limited distribution range, the appropriate larger analytical scale may be only several square kilometers ( $\text{km}^2$ ). If an individual of that species spends its entire life near a single decaying log, the smaller scale might be only several square meters ( $\text{m}^2$ ). That is, the analysis would focus on potential changes affecting the recruitment and loss of logs from the forest floor, microclimate around and under logs, predation, and other issues relevant to salamander viability.

For anadromous salmonids, the distribution range would be large and would include the entire Pacific northwest, from California to Alaska, including large portions of the ocean. The home range of an individual fish would include habitat components within a specific river system, the estuary, and substantial portions of the ocean. The analysis should consider the possibility that the proposed project may not directly affect fish numbers within the project area, but may indirectly influence the ability of the fish to compete successfully once they enter the ocean habitat.

Similarly, appropriate time scales vary by issue. A migratory species might depend on local habitat only several weeks out of a year. The local analysis would focus on whether proposed management actions affect that specific habitat for those periods of occupation each year. Long-lived and non-migratory species may require an analysis that evaluates the effects of proposed management over all seasons for several decades, or perhaps centuries.

## **DATA CONSTRAINTS**

Land use regulations increasingly require monitoring to detect change. Although this is an admirable objective, there is often a gulf between the requirement and the ability to successfully detect a change. Ecological systems usually exhibit large temporal and spatial variability. Such variability leads to an inability to separate the "signal" from the "noise."

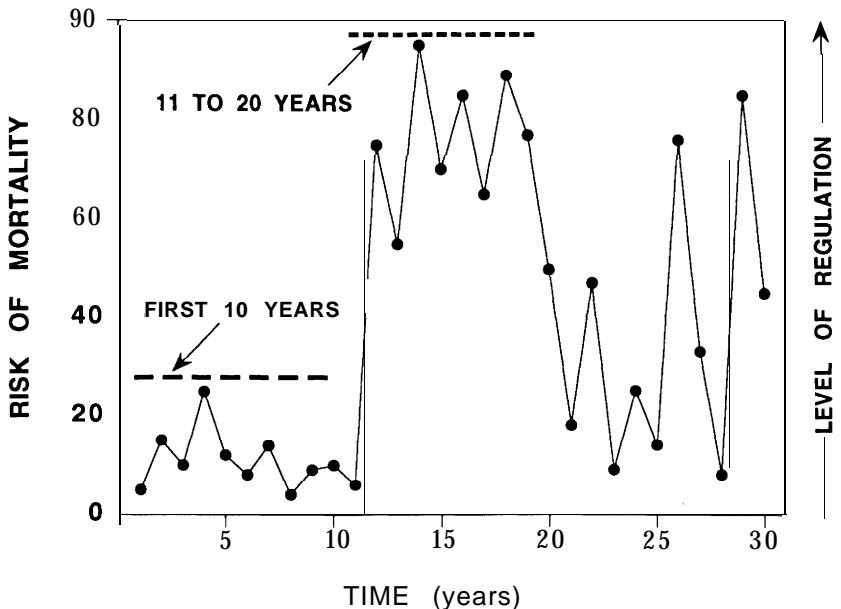
It is important to select a large well-distributed sample of anticipated conditions. If, from Figure 1, only streams 10 to 19 were sampled, a more relaxed set of regulations would have been devised than if streams 20 to 30 had been sampled.

Most environmental evaluations cover a short period of time. Data are almost always insufficient to identify even trends or trajectories of change until the impact is large or has been occurring for some time.

A set of regulations based on the environmental stresses occurring during the first 10 years shown in Figure 2, might be considered to be conservative. However, a more stringent set of regulations might be considered necessary if the period of observation had included the next 10 years. Unfortunately, lengthy data sets usually do not exist. The challenge is to place a limited range of observations within the context of an expected long-term response.

For many ecological issues, rare or unusual events are more important than average conditions. For example, the morphology of mountainous channels and much of the diversity in aquatic habitat is shaped by infrequent large storms. The larger the storm, the greater the effect. Such large storms occur only every 25 years or more. Any monitoring program has a low probability of measuring these types of rare events. However, regulations based measurements related to the consequences

Figure 2. Hypothetical risk of fish mortality based on monitoring streams for different periods of time and the effect of cycles or unusual events on the perceived level of regulation needed to protect a species.



of small "normal" storms would miss the critical and controlling geomorphic and biological issues.

The historical tendency is to discount rare events. There is not a good record for the ability of corporations, governments, or society to plan for disaster. Planning for rare events is most enthusiastically undertaken immediately after a disaster, but such enthusiasm fades rapidly with time. Within a few years or decades, during which "normal" conditions prevail, restrictive regulations developed to prevent future disasters tend to be ignored or considered not relevant.

Further, there is often a lag between some action and its observed effect. In the case of sediment production and movement, a large infrequent storm may be required to cause a significant erosion event. Then, a number of such storms may be required to route the eroded material from the place of origin to some downstream location of concern. A classic example is the sediment produced by placer mining in California during the 1850's. The fine sediments were transported downstream within a few decades, but the coarse sediments are still being routed to the lower Sacramento River, nearly 150 years later.

## **ADAPTIVE MANAGEMENT**

The problem of applying the concepts of cumulative effects and thresholds to ecology lies in the difficulty in understanding the complex interactions between components of ecosystems. A popular trend to deal with limited data and complex ecological linkages is to move toward a process of "adaptive management." The philosophy is that as we learn more about the interaction of management actions on ecosystems, we can adapt practices to better fit ecological concerns. This is expected to be a two-way street. That is, if regulations are too restrictive, they can be relaxed. Or, if regulations are too lax, they can be tightened. This is an attractive, but ecologically naive idea.

If the problem of space and time variability could be solved, we must still evaluate the effect of proposed management actions on species viability. The logical linkage is that management action changes habitat, and changes in habitat affect species viability. Unfortunately, in many natural ecological systems, we are still at the level of conducting taxonomic surveys. We debate the names of the species and argue about their distribution. For most species, we are far from identifying the range of habitat requirements across a landscape, let alone being able to make the linkage between management action, habitat change, and biologic response. Often the variables selected to monitor management effects are insensitive to ecological changes. The reason for insensitive variables may

be that measurements were taken at the wrong location, the variables are not adequately related to cause and effect, the variability is too great to detect a trend, or the lag between cause and effect is too lengthy.

Without an adequate data base of relevant events, or adequate understanding of ecological interactions, adaptive management efforts will surely fail.

## AN APPLICATION TO ECOLOGICAL PROBLEMS

In the Pacific Northwest, polarized views have produced law suits and counter law suits on every conceivable issue. The resultant gridlock concerning the use of public forest lands led to President Clinton's Forest Conference that was held just one year ago. Following the conference, a Forest Ecosystem Management Analysis Team (FEMAT) was assembled. Over 600 scientists, technicians, and support personnel contributed to producing a 1,000-page report (Thomas et al. 1993). Using the FEMAT Report, a 2,000-page Draft Supplemental Environmental Impact Statement was prepared. This Impact Statement elicited over 100,000 comments during the public review period. A Record of Decision is expected by April 14, 1994. That Decision will select the President's plan to provide for both the need for forest habitat and the need for forest products.

The FEMAT effort was a CEA on a grand scale. Conceptually, there are four spatial scales of analysis: region, river basin (physiographic province), watershed, and individual project. The region encompassed the range of the northern spotted owl in the U.S., about 230,000 km<sup>2</sup> within Washington, Oregon, and northern California. At this regional scale, conservation policy is formulated. Habitat and population viability assessments were performed for over 1,000 plant and animal species thought to be closely associated with late-successional forests. The time frame was 100 years. At the basin scale, about 2,500 km<sup>2</sup>, special issues are identified and management activities and strategies are coordinated. At the watershed scale, about 50 to 500 km<sup>2</sup>, the focus is to describe the physical, ecological, and social changes within the watershed and discuss how or why those changes came about. The purpose is to develop a holistic story of how a specific watershed works. From this story, a set of appropriate activities or projects will evolve. Individual project analyses, where site specific activities are planned and evaluated, are usually conducted on sites smaller than 1 km<sup>2</sup>. Concerns identified at coarser scales frame the scope of analysis and help prioritize decisions and emphasis at the next finer scale. Analyses at finer scales validate assumptions made at the next coarser scale, and can identify issues not apparent.

Here are two watershed-level short stories about Redwood Creek, a 720-km<sup>2</sup> watershed in northwestern California. In 1978, Redwood National Park was expanded to encompass the lower two-thirds of the Redwood Creek watershed to protect several redwood groves that included the World's tallest trees. These trees were growing in alluvial flats along Redwood Creek and were threatened by excessive sedimentation caused by the combination of poor logging practices and several large storms. The Park Service received several tens of millions of dollars over the past 15 years for restoration and erosion control and has been actively pursuing its assignment on National Park lands. The Redwood Creek story would reveal that most of the significant erosion sources within the Park that are capable of being controlled were fixed years ago. Meanwhile, there are extremely serious erosion problems in the two-thirds of the watershed above the Park that is in private ownership and upon which the Park Service has little influence. Additional expenditures within the Park will not protect the tall trees from sedimentation. By addressing the larger picture, the context of local actions becomes clearer.

The second story is about anadromous fish in Redwood Creek. Salmon stocks have been declining throughout the Pacific northwest, and Redwood Creek is no exception. Substantial efforts have been made to improve fish habitat in Redwood Creek. Migration barriers have been removed, structures have been constructed to provide better spawning gravels and better cover to protect fish from predation. Erosion control projects to provide cleaner water and substrate have been extensive. The list of improvements is long. Yet, the Redwood Creek watershed story would reveal that there is a small portion of privately owned land near the mouth of Redwood Creek. This land is periodically flooded when the water level in a small estuary rises and some hay fields or other crops are damaged. To prevent this damage, the farmer periodically breaches the sand spit and drains the estuary, flushing the salmon smolts prematurely into the ocean. Several millions of dollars of habitat improvement located upstream is being compromised to save several thousand dollars worth of crops.

The importance of telling the watershed story is to identify such dysfunction in watershed processes or in project activities that often get lost when dealing with narrower issues. The story must be told in a way that is clear to technical experts, land managers, politicians, and the public.

## **RESERVES**

Because of the rapid disappearance of the remnant old-growth forest ecosystem, the President's plan adopts an extensive system of "reserves."

The size of the reserve is determined by physical linkages to critical habitat elements. The riparian reserve includes all perennial and intermittent streams, lakes, and wetlands, and those portions of the landscape that are most important for delivering water, sediment, heat, nutrients, and structure to the aquatic ecosystem. On each side of the stream, lake, or wetland, the reserve width is one or two site-potential tree heights, or the width of the steep inner gorge, or the extent potentially unstable areas, or 100 to 300 feet, whichever is greatest. This reserve encompasses a large portion of the landscape, the proportion of which is strongly dependent on the drainage density. In the highly dissected sandstones of coastal Oregon, where the drainage density is about 12 km per km<sup>2</sup>, about 90 percent of the land area falls within a riparian reserve.

Management within the riparian reserves is constrained to activities that do not degrade specific riparian objectives. The burden of proof of non-degradation is shifted from those concerned about the loss of some beneficial use to those proposing the land management activity. Industry advocates decry the President's plan for being too restrictive, while environmental advocates proclaim that the plan is too lax. This plan will undoubtedly be tested in the courts or be modified by additional legislation.

## **CONCLUSION**

There are thousands of species that are dependent on late-successional forests. Management plans developed to address concerns for one species can immediately be challenged as inadequate for another species. There is no end in sight for such challenges. Success in dealing with complex ecosystem issues requires moving away from single species management toward a more integrated approach that uses ecosystem process and function to project future trends in response to proposed management options.

## **LITERATURE CITED**

- U.S. Council on Environmental Quality. 1978.40 CFR Parts 1508.7 and 1508.8, 29 November 1978. Washington, DC.
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