IMPROVING THE ASSESSMENT OF CUMULATIVE WATERSHED EFFECTS WITHIN THE TIMBER HARVEST PLANNING PROCESS

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INTRODUCTION

The California Forest Practice Act and implementing regulations require that Registered Professional Foresters (RPF) preparing Timber Harvest Plans (THP) and Non Industrial Timber Management Plans (NTMP) disclose the "cumulative" effects of their management proposals on watersheds, streams and associated aquatic life. Since 1985, there has been criticism of the manner in which these effects are evaluated and reported. The purpose of this paper is to summarize recommendations from past reviews of this process and use this information to provide an improved framework for assessing cumulative watershed effects. Specifically, we:

- Reviewed the requirements for assessing cumulative watershed effects in the current Forest Practice Rules (FPR)
- Reviewed critiques of THP related cumulative watershed effects assessments
- Reviewed alternative methods for conducting assessments
- Interviewed RPFs and CDF timber harvest plan reviewers
- Developed recommendations for improving the existing process

The quest to accurately assess and predict cumulative watershed effects has resulted in a proliferation of methods and guidance documents throughout the Pacific Northwest (WFPB 1997, OWEB 2001, REO 1995, IDL 2000, Province of British Columbia 1999, EPA 2000, others). Critiques (Dunne 2001, Collins and Pess 1997, Reid and Ziemer 1997, others) and critiques of the critiques (Munn 2003, Bedrossian 2001) have also flourished in the fertile ground of uncertainty that surrounds the various methods and reviews. Although each method has contributed something to the advancement of the field, none have been universally endorsed as "the answer". However, some common themes have emerged from all of the noise: 1) accurately defining the appropriate spatial and temporal scales is crucial; 2) parcel by parcel assessments are not sufficient: 3) uncertainty abounds; 4) forecasting is an important element of the analysis process and: 5) clear assessment objectives are essential. This paper will focus on the technical elements, but the influence of politics and economics should not be underestimated when searching for solutions.

CURRENT METHODS OF CUMULATIVE WATERSHED EFFECTS ASSESSMENT

Cumulative Impact Assessment within the California Forest Practice Rules

The Cumulative Impacts Assessment section (Technical Rule Addendum No. 2) in the FPR provides guidance to the RPF on which elements, or "resource subjects" to consider when assessing the potential cumulative impacts of their projects (CDF 2003). Addendum No. 2 lists a variety of existing information sources that could be used in the assessment, including local experts and organizations and, reports, maps, aerial photographs, databases etc. No new information is required for the assessment. The timescale for assessment of these factors is, "past and reasonably foreseeable probable future." The spatial scale for assessing cumulative watershed effects is a vaguely defined "Watershed Assessment Area" that encompasses the locations of "on and off site cumulative effects on beneficial uses of water."

The majority of the cumulative impacts section is contained in the Appendix to the Addendum. The appendix includes a list of 'factors' to consider in the assessment divided into 6 groups: watershed resources, soil productivity, biological resources, recreational resources, visual resources and, vehicular traffic impacts.

Currently the cumulative impact section within THPs functions primarily as a place to disclose available information sources and/or reiterate "boilerplate" language- rather than providing an analysis of potential cumulative effects at a watershed scale (THP Task Force 1999, Dunne 2001). The disclosures generally include a list of other harvest plans from the past 10 years, results of contacts with adjacent landowners regarding future plans, results of a search of the Natural Diversity Database and any information available for the stream course, usually DFG habitat typing reports and in some cases data from studies conducted by the landowner. Larger landowners may refer to existing Sustained Yield Plans (SYPs), Habitat Conservation Plans (HCPs), "Option A" documents, or other larger scale planning studies.

A key deficiency in the current assessment process is the analysis of future management activity. The current definition in the FPR (CDF 2003) is "reasonably foreseeable probable future projects (which) means projects with activities that may add to or lessen impact(s) of the proposed THP". If the project is within a larger area controlled by the THP submitter, this may include other THPs expected to commence within 5 years. In practice this means that only THPs that are currently being prepared are included in the projection of future management activities (Marshall pers.comm. 2003). The result is a consistent underestimate of future management activities and commensurate underestimate of potential cumulative watershed effects.

A second major challenge in preparing an assessment is identifying practices or conditions that may result in cumulative effects occurring. There are several definitions of cumulative effects that apply to the THP process. According to the Council on Environmental Quality (CEQ Guidelines, 40 CFR 1508.7, issued 23 April 1971,

> *"Cumulative impact" is 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 (Federal or non-Federal) or person*

undertakes such other actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time.

The FPR Addendum No. 2 cites 14 CCR 898 as the language requiring cumulative impacts assessments. This rule (14 CCR 898) contains two definitions of cumulative effects depending on the legal status of the receiving water body. For 303(d) listed waterbodies the following definition applies,

> *When assessing cumulative impacts of a proposed project on any portion of a waterbody that is located within or downstream of the proposed timber operation and that is listed as water quality limited under Section 303(d) of the Federal Clean Water Act, the RPF shall assess the degree to which the proposed operations would result in impacts that may combine with existing listed stressors to impair a waterbody's beneficial uses, thereby causing a significant adverse effect on the environment. The plan preparer shall provide feasible mitigation measures to reduce any such impacts from the plan to a level of insignificance, and may provide measures, insofar as feasible, to help attain water quality standards in the listed portion of the waterbody.*

The distinction between the two categories is that impairment of "beneficial uses" needs to be considered for THPs draining to 303(d) listed waterbodies, whereas the more general definition of "significant adverse effect on the environment" applies to THPs draining to non-303(d) listed waterbodies.

However, applying either of these legal definitions to on the ground practices has proven difficult and controversial (Dunne 2001, Loughlin pers. comm. 2003). Clearly interpretable, numeric standards do not exist for how much sediment is too much, how much large woody debris in a stream is enough, or how few pools are too few. In the absence of agreed upon numeric standards for individual parameters, perhaps providing examples of watersheds that are generally agreed to be "cumulatively effected" would assist managers in assessing the relative condition of their own watershed. There are five watersheds in the state that have been recognized by the THP review agencies as having, "varying degrees of significant adverse cumulative watershed impacts, with timber harvest a contributing factor." The five watersheds are: Bear Creek, Jordan Creek, Stitz Creek, Freshwater Creek and Elk River- all are on the North Coast (CDF 1997, ISRP 2002). It may be useful to develop detailed descriptions of these impaired watersheds in order to improve the recognition of trends towards "significant and adverse effects" in other watersheds under consideration.

Although Addendum 2 directly addresses cumulative impact assessment, there are other sections within the FPR that are applicable to cumulative watershed effects issues and could be used to improve CWE assessment. The Interim Watershed Mitigation Addendum (IWMA) (Section 916.13, 936.13, 956.13) is a voluntary process wherein a landowner defines an evaluation area, identifies limiting factors to anadromous salmonids and proposes site specific mitigations to address the limiting factors. This section contains guidelines that could be used to clarify the cumulative watershed effects assessment process. For example, the IWMA section defines the evaluation area as being, "a watershed no smaller than third order watercourse" and, "no larger than a Cal Water 2.2 planning watershed" unless a larger area is explained and justified. This language could be used to define the Watershed Assessment Area referred to in Addendum 2, as it explicitly recognizes that a meaningful assessment of limiting factors and proposals for mitigations cannot be conducted over an area smaller than a 3rd order watershed.

Another element within the IWMA section that could be useful within the context of any cumulative watershed effects analysis is a pre-consultation phase where the landowner and the reviewing agencies have, "the opportunity to identify issues and concerns associated with the interaction of site specific watershed conditions in the IWMA evaluation area and limiting factors for anadromous salmonids." The pre-consultation could improve the cumulative watershed effects analysis by focusing on a smaller number of high priorities, rather than addressing the entire range of watershed issues listed in the appendix to Addendum 2 that may not be important in every watershed.

Finally, the IWMA rule addresses the concept of making the required depth and intensity of the analysis commensurate with potential risk posed by the project. This language is useful because it formally acknowledges the utility of the concept of "risk" in cumulative watershed effects assessment and also uses the finding of risk to scale the rest of the assessment. The IWMA rule explicitly links the intensity of the required analysis to the perceived risk of the management activities, as follows: "916.13.4, 936.13.4, 956.13.4 (c) The sufficiency of information or evaluation included in the IWMA shall be guided by the principles of practicality and reasonableness considering . . . the risks to anadromous salmonids posed by the scope and intensity of anticipated management activities."

The FPR section that explicitly recognizes 303(d) listed watersheds (Section 916.12, 936.12, 956.12) may also be useful in improving cumulative watershed effects assessments and mitigations. The section states that CDF shall help the appropriate RWQCB and SWRCB develop TMDL problem assessments, source assessments or load allocations related to timber operations and notably, "if existing rules are deemed not to be sufficient, develop recommendations for watershed-specific silvicultural implementation, enforcement and monitoring." Within this rule package CDF has committed to working with agencies, landowners and "other persons or groups" to develop watershed specific assessments and management prescriptions, although it has not committed to this level of cooperation for standard cumulative watershed effects assessments.

There is also a section that prescribes alternate BMPs and mitigation measures in order to reduce impacts to watershed conditions that affect limiting factors for salmonids. The Protection and Restoration in Watersheds with Threatened or Impaired Values (Section 916.9,936.9,956.9) section applies to, "any planning watershed where populations of anadromous salmonids that are listed as threatened, endangered, or candidate under the State or Federal Endangered Species Acts with their implementing regulations, are currently present or can be restored." This section, also known as the "T & I rules" applies to a large portion of timberland in California. Some of the alternate on-the-ground BMP and mitigation measures included in the T&I rules are: retention of the 10 largest conifers per 330 feet within 50 feet of Class I streams, retention of understory and midstory trees 25-50 feet outside of Class I WLPZs depending on slope, increased shade levels within the WLPZ, prevention of evenaged harvest on inner gorges within 300 feet of the channel, geologic review on inner gorge slopes >65% above Class I and II streams, and road surface treatment requirements on logging roads to reduce fine sediment generation. It is unclear what effect these measures will have on limiting factors, but it is an indication that CDF recognizes that additional measures may be required to avoid cumulative watershed effects in some watersheds.

The "T & I rules", 303(d) rules and IWMA rules are scheduled to expire on December 31, 2003. They are expected to be renewed before they expire.

Critiques of the Cumulative Watershed Effects Assessment Process

EPIC vs. Johnson

In 1985, the Environmental Protection Information Center, Garberville, CA successfully sued the California Department of Forestry and Fire Protection (CDF) over the matter of cumulative impacts assessment during the THP regulatory process. The Department argued that the FPR provide "best management practices" (BMPs) that offset potential impacts of THPs. If activities are designed to conform to BMPs, they are considered acceptable. EPIC v. Johnson specifically disallowed the BMP approach for addressing cumulative impacts. The judge first noted that CDF had stated that "To address the cumulative effect issue the Department has taken the tact [*sic*] that if the adverse effects are minimized to the maximum on each individual operation, then the total effect in the surrounding area will also be minimized to an acceptable level." The judge then responded that "This statement is at odds with the concept of cumulative effect" (EPIC v. Johnson, 170 Cal.App.3d 604; 216 Cal.Rptr. 502 [July 1985]).

EPIC vs. Johnson stimulated the revision of the FPR to include the aforementioned Technical Rule Addendum No. 2. However, the addition of Addendum 2 was not sufficient to quell controversy regarding the assessment of cumulative impacts within the FPR. There have been many more critiques of the cumulative impacts process since the Epic v. Johnson case.

Little Hoover Commission

This report summarized the results of a critical review of the THP process based on interviews, public hearings, literature review and compilation of relevant data from state agencies by a panel of industry, environmental, agency and public representatives (Little Hoover Commission 1994). The focus was on the policies and procedures of regulating and approving timber harvest plans in the State of California. This was not a review of the technical merits of cumulative impacts assessment techniques. However, the conclusions reached by the Little Hoover Commission were remarkably similar to those reached by subsequent studies that focused on the technical aspects (THP Task Force, SRP, Dunne Report).

The Little Hoover Commission succinctly described the THP review and cumulative impact analysis process as a, "microcosm of what can go wrong when government focuses on process rather than outcome." The authors chronicled the increase in THP related regulations, volume of paper required to meet the ever expanding rule package, increased cost to plan submitters and notable lack of evidence that the regulations were effective at protecting the environment or even being carried out as described in the lengthy THPs. The Commission observed that review agencies devoted more time to the process of preparing a legally robust document than ensuring a credible analysis of potential environmental effects and implementation of measures to avoid them. Shifting the focus from plan approval to monitoring and enforcement was recommended.

A key finding regarding cumulative watershed effects analysis and control was that analyzing and regulating on a parcel by parcel basis was, "inefficient, costly and open to questions about credibility." The Commission recommended a watershed level or ecosystem assessment type process. However, determining who would pay for or conduct multi-ownership assessments was cited as a key impediment to this approach. It was also acknowledged that the scientific community was not able to define exactly what measurements to take and what size area to analyze for these types of assessments. A tiered approach to cumulative impact review was proposed in which the level of assessment and review was proportional to the environmental risk posed by the plan. Lower risk plans and/or timber owners recognized by the state to be environmentally sensitive would have a lower burden of proof and level of scrutiny regarding cumulative impacts.

<u>Director's THP Task Force</u>

This report, written largely by staff at CDF, provided an overview of the weaknesses of the cumulative impacts analysis process used in THP review and a list of specific recommendations for improvement (Cromwell et. al. 1999). A basic problem cited in the review was that current assessments may or may not contain sufficient information but in either case there was very little analysis. This was partially due to a lack of guidance from CDF on how the analyses should be carried out. The authors concluded that in order to systematically improve cumulative impacts assessments, "there must be agreement (among agencies) about what resources are at risk, the nature of possible impacts of timber harvesting on these resources, what kinds of mitigation are appropriate, and what are meaningful baselines and ways to measure progress."

Two general recommendations for improvement to the cumulative impact assessment process from the CDF Task Force Report were:

1. Require RPFs to provide citations for the information sources used in the assessment.

2. Require RPFs to provide a clear rationale for their conclusions, including a clear linkage between the proposed mitigations and the factor or potential cumulative impact it is intended to address and an assessment of how well the mitigation will address the issue.

The Task Force also provided a discussion of specific recommendations to improve the process under five subject categories: 1) better information on natural processes, 2) watershed level analysis, 3) clear guidance on cumulative impact analysis, 4) clear guidance on mitigation measures and, 5) expanded monitoring, training and information. Many of the recommendations contained in the five categories would require considerable effort and/or expense to accomplish. For example, systematic watershed assessments and improved agency cooperation were recommended. The authors recommended developing a listing of 'resources at risk' for each planning watershed where timber harvest has the potential to add to the cumulative impacts. The listings would be based on watershed scale data and improved agency cooperation. The Task Force also recommended more training for THP preparers and reviewers.

The authors proposed changes and additions to the FPR rules that would make the cumulative impact assessment process more explicit and potentially more comparable between plans. One of the tools proposed was a detailed checklist to be used by plan reviewers to consistently assess how well RPFs explained their findings in the cumulative impact analyses. Presumably this checklist would be used to screen out incomplete cumulative impact analyses as a basis for denying a plan or requiring additional information.

Scientific Review Panel

The Scientific Review Panel (SRP) report provided an insightful review of the effectiveness of the FPR in preventing cumulative impacts that combined interviews with many stakeholders, reviews of scientific literature and an obvious working knowledge of the rules. The most notable conclusion of this review was that, "the FPR, including their implementation (the "THP process") do not ensure protection of anadromous salmonid populations." The authors cited the lack of an adequate watershed analysis procedure capable of detecting cumulative watershed impacts as the primary deficiency of the current rules. The Washington Watershed Analysis (WWA) and Federal Interagency Watershed Analysis (FWA) methods were reviewed, evaluated and ultimately not recommended by the SRP.

The Panel recommended development of a new multi-disciplinary and multi-agency watershed analysis procedure in California. The new watershed analysis procedure was recommended for every watershed within the Northern California and Klamath Mountains Province steelhead Evolutionarily Significant Units (ESUs). The panel further recommended initiation of a state coordinated "directed science program" to perform hypothesis based effectiveness and validation monitoring. In response to these recommendations, a state sponsored multi-disciplinary and multi-agency watershed analysis program, the North Coast Watershed Assessment Program (NCWAP), was initiated. Although NCWAP met the SRP recommendation of a state sponsored watershed assessment program, it does not appear that it provided the type of results envisioned by the SRP. The SRP specifically recommended that watershed analyses result in three types of THP related management actions: 1) specific prescriptions, 2) performance targets, and 3) prioritized mitigation opportunities. It is unclear what spatial scale the SRP was referring to when they recommended "specific prescriptions", i.e., THP level, watershed by watershed, regional, etc.

The SRP also recommended specific changes to the FPR that would result in reduced impacts to salmonid bearing streams, i.e., improved Best Management Practices (BMPs). Notable examples of suggested BMPs include: alterations to stream buffer regulations to promote rapid tree growth, decreased buffer width next to selection silviculture systems, a requirement that Class I stream crossings have natural bottoms, increased oversight of the harvest process by the RPF and an extension of the mandatory maintenance period for forest roads beyond 3 years. Most of the BMP recommendations were based on extensive interviews with stakeholders and supported by current scientific literature. The SRP recommended rule changes would likely result in decreased cumulative impacts- though no estimate of the magnitude of this potential response was given.

A Scientific Basis for the Prediction of Cumulative Watershed Effects

This report ("the Dunne Report") makes the case for developing the capability to predict risks of cumulative impacts under various management scenarios using computer models (Dunne et al. 2001). However, a scathing review of the talents and motives of nearly everyone involved in the current process of planning and reviewing timber harvest activities detracted from the presentation of the fundamentally sound concept of risk based modeling.

A central tenet of the report is that predicting risk is different than predicting cause and effect, and is often more achievable. To make this point the authors reflected on a question they were often asked during preparation of the report, "If timber is harvested in this watershed, will it cause landsliding? And will that be significant?" The only scientifically defensible answer is "it depends" because if timber harvest occurred during a ten-year period of relatively dry weather with no large rainstorms it is likely that no landslides would occur in the harvested area. Whereas, if the harvest activity was followed by a series of wet years with large rainstorms it is possible that many landslides would originate from logged hillslopes or roads, significantly damaging instream habitat through deposition of sediment. The authors point out that in the case of timber harvest followed by large rainstorms, salmon advocates would likely blame the timber harvest activities for the landslides and stream damage, while timber interests would blame the large rainstorms. Thus, when the question is framed in terms of cause and effect there is often no satisfactory answer to the question: "Did the harvest or the rainstorm cause the sedimentation?"

The authors argue that it makes more sense to ask, "Did the timber harvest *increase the risk* of slope failures and sedimentation." Answers based on analysis of risk combine a statement of probability of an event with an identification of its magnitude (its severity or potential improvement). Examples of results of risk based analyses include: "there is a 0.01 probability of a stand re-setting wildfire occurring in this watershed in any one year", or "there is a 10 percent chance of the occurrence of five channel-intersecting landslides per square kilometer of watershed within five years of timber harvest", or "there is a 20 percent chance that the average annual production of salmon smolts from this watershed will decline below 5,000 for the decade following timber harvest."

Risk based analysis facilitates comparing alternative management scenarios for relative risk during the planning stage and then selecting scenarios which best balance extractive and ecological values. Computer models are the tools proposed for this task. The authors assert that use of computer models to predict risk, "allows us to envision and represent our best communal understanding of how whole, complex systems behave, and then to discuss and analyze the consequences of that behavior in a rational, structured manner." Although models are not a panacea or immune to distortion, they facilitate decision making better than current cause and effect type empirical studies which often cannot meet the burden of proof required to demonstrate causation. The inability to 'prove' that some proposed management activity will or will not lead to cumulative impacts leads to stalemates in decision making, even though there may be sufficient information to estimate the risk of a proposed activity's contribution to cumulative impacts.

Comparing alternative scenarios based on predictions from computer models is a feasible way to evaluate potential cumulative impacts at the appropriate temporal and spatial scales. The authors of the report note that it is impossible to analyze and predict cumulative effects at a watershed scale in every watershed using experimental or other empirical approaches due to the complexity and cost of the approach. Even if cumulative effects could be detected empirically, it would be too late by the time they were detected to prevent their impact. Only models can facilitate a formal and systematic examination of how risk changes under hypothetical scenarios. This approach known as "gaming" can be used to evaluate the relative risk of various proposed management activities over large areas and time spans.

After making the case for predictive risk based modeling at a landscape scale, the authors briefly reviewed the current understanding of various ecological processes and the models available to simulate them. The processes and models reviewed in the Appendix include: 1) cumulative effects on terrestrial vertebrates, 2) cumulative effects on riparian biota, 3) cumulative hydrological effects, 4) cumulative effects of watershed changes on sediment sources, 5) sediment supply and sediment routing along channel networks, 6) modeling geomorphic response and the formation of aquatic habitat to sediment delivery, 7) cumulative effects on aquatic habitat and aquatic biota, and 8) cumulative effects on water quality. Modeling capability was generally more advanced for physical effects than for response of organisms, with hydrology and stream water temperature being the most advanced fields of modeling at this point. All models were best suited to predicting trends and average conditions at a coarse scale, rather than responses at a specific stream reach or hillslope location. The authors conclude that there are currently enough models to begin using them to assess cumulative impacts, but more work is needed to improve accuracy and applicability.

The key concepts presented in this paper that have the potential to improve the ability to assess cumulative impacts were: 1) use of "risk" as a basis for making decisions and, 2) use of computer models to predict cumulative impacts of proposed management activities at appropriate temporal and spatial scales. These two concepts are not employed in the current FPR and it may not be possible to adequately address cumulative watershed effects without them. The authors of the Dunne report assert that forming a new state agency and hiring an elite team of hand picked scientists is the best way to implement these concepts. Although this approach to implementation may not be politically or economically feasible in the near term, it should not detract from the merits of the concepts presented regarding risk and modeling.

It should be noted that there is considerable debate as to the relative merit of the concepts presented in the Dunne report. The State Mining and Geology Board (Baca 2002), California Geological Survey (Bedrossian 2001) and the California Department of Forestry and Fire Protection (Munn 2003) each submitted critical and detailed reviews of the Dunne report. The main criticisms of the Dunne report centered on the fact that the models proposed in the report are not well developed or accurate at this time. The landslide hazard model SHALSTAB came under particular criticism for not being able to predict deep seated landslides and relying exclusively on topography rather than geology of the site to assess slide risk. The reviewers also criticized the Dunne report for exhibiting a poor understanding of the CEQA and THP processes. The assertion by Dunne that none of the reviewing agencies had any staff qualified to evaluate CWE's also elicited detailed refutations. In general, the reviews were confined to criticism of the Dunne report rather than articulation of an improved process for CWE assessment.

Due to the complexity, cost and controversy associated with the approach advocated by the authors of the Dunne report, it would be prudent to validate the concepts before attempting to implement them. One way to do this would be to investigate an analogous system that is already in place and functioning. The Coastal Landscape Analysis and Modeling Study (CLAMS) in the Coast Range of Oregon may be suitable for this purpose due to the similarity in landscape and advanced state of the Study. The goal would be to use outputs from the CLAMS study to formulate concrete examples of how a computer model based cumulative watershed effects assessment would function and how it would inform management decisions. This would familiarize California agencies with power of the tools proposed in the Dunne report, but also reveal the necessary steps to go from modeling scenarios and evaluating risks to actually making decisions regarding the cumulative effects of proposed management activities.

Summary of Critiques of Cumulative Watershed Effects Analysis

All of the aforementioned reviews recommended expanding the cumulative watershed effects assessment to a watershed or larger scale- there is no scientific basis for assessment on a THP-by-THP basis. In order to facilitate this, most reports recognized the need for better information at larger spatial scales and more qualified people to interpret this information. There was also agreement that the State was the only entity capable of generating and/or coordinating the collection of information at this scale. The Dunne report recommended extending the timescale of the assessment to include historic management activities and projected future management-beyond the 'reasonably foreseeable future', which usually only extends a couple months or very few years into the future. The Dunne report and SRP report both recognized that limiting rates of harvest on an area specific basis may be an important tool for limiting cumulative watershed effects and more research on this topic was recommended.

Watershed analyses, risk based decision making and computer modeling of landscape level processes are tools that may be necessary to address the cumulative watershed effects issue. However, they are not ready for off the shelf application today and are not a solution unto themselves. Even with these powerful tools, decisions regarding what combination of landscape conditions constitutes a significant effect will be based on risk tolerance of decision makers, not an irrefutable algorithm synthesized by a computer model. The tools discussed in the Dunne report, if developed, could provide decision makers with a better understanding of the relative tradeoffs of different management scenarios, but ultimately the question of what constitutes a significant adverse cumulative watershed effect will still have to be agreed upon and defined in order for the concept to be implemented.

There was agreement amongst the critiques that identifying resources at risk, validating the effectiveness of mitigations and establishing baselines for evaluating impacts need clarification. Regarding resources at risk, the Board of Forestry's designations of impaired watersheds (T & I) and the Regional Water Quality Control Boards' list of 303(d) impaired watersheds now provide some guidance. The designations of threatened and endangered species by NOAA-Fisheries, California Department of Fish and Game and US Fish and Wildlife Service further direct THP preparers to address biological resources. Other programs that are relevant include Wild and Scenic Rivers designations, Coastal Zone designations and local (county) ordinances and rules.

Understanding the effectiveness of mitigation measures for offsetting cumulative effects of timber operations is critical, but little progress has been made on this subject. There is a general perception that certain practices, such as clearcutting on unstable slopes, forest roads and excessive harvesting in streamside zones contribute to cumulative watershed impacts (Reid 1998, Reid and Hilton 1998, Harr 1976, Montgomery et al. 2000, Murphy 1995). Consequently, most THPs are required to mitigate these impacts. However, the benefits of implementing mitigation measures for these activities have not been well quantified. For example, there is little evidence that geologic review of steep slopes prior to harvest actually reduces landslide rates, although it is a required mitigation in the FPRs (Spittler pers. comm. 2003).

Recently, there has been increased emphasis on mitigating the impacts of road systems, either those used in timber harvesting or so-called "legacy" roads that persist from previous management. Timber companies and others have been investing substantial sums in upgrading and decommissioning roads. There are data indicating that decommissioned abandoned roads reduce sediment contributions compared with non-decommissioned abandoned roads (Madej 2001) and that post project erosion due to decommissioning can be relatively minor (Klein 2003). There are also data which indicate that modern road construction and maintenance practices including road outsloping, stream crossing culverts sized for 50-100 year events, and frequent road drainage using rolling dips has reduced road related sediment production compared to pre FPR (1973) era roads (Rice 1999). However, there is little data available that links improvements in road construction practices or removal of abandoned roads to changes in in-stream habitat conditions or channel morphology.

Baselines for defining or monitoring cumulative watershed effects have not been established. Probably the closest thing to establishing baselines has been the TMDL process using narrative criteria and numeric indicators. For some watersheds, this process has identified where problems exist, estimated causes and prescribed remedies. NCWAP has also contributed to establishing baselines for some north coast watersheds. Of course the validity of these baselines is not universally accepted.

In summary, the primary constraints to successfully assessing cumulative watershed effects within the current THP regulatory framework are: the lack of clear and measurable definitions of cumulative watershed effects, the THP-by-THP assessment approach, and the lack of any credible forecasting or evaluation of potential effects. Faced with these constraints, Dunne (2001) called for a revolution in the process, rather than incremental improvements. Revolution offers no guarantee of success and is a politically and economically remote possibility at this point, so we offer a more conservative approach in our Recommendations.

Alternative Methods for Cumulative Watershed Effects Assessment

ALCES

One model that was specifically designed to predict cumulative effects is called ALCES (A Landscape Cumulative Effects Simulator) (http://www.foremtech.com/). This model has been under development for seven years and was designed for the boreal forests of Alberta, Canada. Originally the model was built to assess effects of timber harvest with funding from a large paper and pulp company, Alberta Pacific (Al-Pac), but additional modules have been added to address energy exploration and development. The ALCES model is unique in that it simulates ecosystem factors such as forest growth and yield, wildlife habitat characteristics, plant community dynamics and water quality parameters, as well as demographic trends such as human settlement expansion, road network expansion and economic implications such as job creation/loss and finally natural disturbances such as fire and insect outbreaks.

Although the ALCES model does not relate directly to forest types in California it was reviewed because it provides an example of a working cumulative effects model that is being used to guide management activities. The model attracted international press attention (Knudsen 2003) and created a political stir in Canada when the results of a model run were published in the April 2003 edition of Conservation Ecology (Schneider 2003). The model was calibrated to predict the implications of forest harvest and energy exploration activities on a 14.6 million acre "forest management area" or FMA that Al-Pac operates on. The model predicted that if trends of timber harvest, road construction and energy exploration continued at the current pace:

- Old-growth softwood forests such as spruce and pine would disappear in 20 years. Old-growth stands of aspen would disappear in 65 years.
- Habitat for woodland caribou, a threatened species, would shrink from 43 percent of the area to 6 percent.
- By 2065, there would be shortfalls in available timber because current harvest rates are based on rates of tree growth, but do not account for losses due to fire or energy exploration.
- The quantity of roads constructed and associated costs could be dramatically reduced if forest industry and energy industry harmonized their road networks.

The model itself does not define what a cumulative impact is, that must still be interpreted and decided upon by land managers. Conservation biologists may be able to provide a statement of risk associated with decreases in caribou habitat, such as, "if habitat area remains stable there is a 10 percent probability that populations will decline below 5,000 individuals within the next 100 years. However, if habitat area is degraded to 20 percent of the area there is a 75 percent probability that populations will decline below 5,000 individuals within the next 100 years." After predictions have been made, alternative management scenarios explored and risks of various scenarios estimated using a model like this one- a decision will have to be made regarding land management. Even a sophisticated landscape level model cannot generate decisions, only information.

CLAMS

Another modeling effort that may be more applicable to issues and forest types in California is the CLAMS project. CLAMS is not a single model, it is a joint research effort of the USDA Forest Service, Pacific Northwest Research Station, Oregon State University, College of Forestry and the Oregon Department of Forestry. According to the website (http://www.fsl.orst.edu/clams/intro.html) the six objectives of the project are:

1. Characterize the spatial pattern and history of ecological and socio-economic components of the Coast Range;
2. Develop ecological and socio-economic models, measures and linkages;
3. Develop spatial policy evaluation tools and data for use by technical specialists;
4. Project aggregate effects of current and selected alternative forest policies on key resources and outputs;
5. Evaluate consequences of alternative fundamental strategies to natural resource management;
6. Synthesize multi-scale assessments and provide information for joint learning among stakeholders.

Although the words "cumulative impacts" are not explicitly included in these objectives, the six objectives are essentially a recipe for addressing cumulative impacts. The study includes data and models to simulate aquatic habitat, terrestrial habitat, landslide hazard, forest growth and yield and forest regeneration. Economics and recreation potential can also be evaluated. All of these factors are being evaluated using existing models such as Organon, ZELIG and IMPLAN and new models are being developed as part of the study.

Despite seven years of work with leading scientists and cutting edge methods, team members point out some obstacles regarding cumulative effects at large spatial scales. "For example, we are currently unable to quantitatively project the effects of different policies on aquatic and terrestrial habitat and socio-economic outputs across an entire multi-ownership province or region. Without more rigorously developed conceptual and analytical models, it will not be possible to evaluate the potential for cumulative impacts of these different policies on ecological and socio-economic values over large landscapes as a whole (e.g., provinces or regions) and long time frames (>50 years)."

Results of the CLAMS project indicate that they have been able to predict trends across provinces or regions, such as future stand age composition, but have not been able to make quantitative links to beneficial uses at the same scale. Many of the models employed have been more successful at the stand or small watershed scale- which would still be an increase in scale compared to the THP-by-THP scale currently being assessed in California. It would be beneficial for a contingent of timber harvest review professionals from California to make contact with CLAMS team members and further explore this promising technology.

ESI

Development of a defensible methodology for assessing cumulative watershed effects must be based on an accurate understanding of landscape dynamics at large spatial and temporal scales. This understanding is necessary so that the effects of timber harvest can be accurately placed within the context of natural disturbance agents such as fires and floods that historically shaped vegetation patterns, hydrology, channel form and habitat suitability. Earth Systems Institute (ESI), in collaboration with the USDA Forest Service, recently released a CD of multimedia presentations based on computer model simulations. The simulations graphically illustrate (movies) the effects that fires and floods have on landscape pattern- primarily forest stand age and LWD and sediment loading in channels (USDA 2002). The results of the landscape simulations provide some conceptual tools for evaluating cumulative impacts and provide a context for interpreting the effects of timber harvest relative to "natural disturbances".

The first useful concept is that while events such as fires, floods and landslides may be detrimental to aquatic communities in the short term, they deliver the building blocks of channel habitat that become important over the long term (Miller *in press*). For example landslides and debris flows bring boulders and LWD into the channels that provide channel roughness and complexity and the associated sediment pulses form berms, terraces and fans that shape the valley floor and create side channels and riparian surfaces over time. This leads to the second important concept, which is that the context for interpreting the effects of these events is based on understanding the magnitude and frequency distributions of these events through space and time, not merely their presence or absence at discreet locations. The landscape simulator models are tools that facilitate this understanding.

Results of the simulations indicate that conditions encountered in the landscape (e.g., forest stand age, LWD volume in the channel, etc.) are directly related to the scale at which measurements are made and that variability decreases as scale increases. For example, the landscape simulator modeled mean forest stand age over a 2500 year period in the Oregon Coast Range where fires occur on average once every 300 years and range in size from 1 to 1000 km^2. The results indicated that within a randomly selected 40 km^2 unit mean stand age ranged from 11 to 560 years over the simulation period, while at the scale of 20,000 km^2 units mean stand age ranged from 270-370 years, a much narrower range (Benda 2001). Modeling large scale landscape processes provides insight on the natural range of variability of various indicators, such as forest age class distribution, LWD loading in channels, landslide frequency, etc. The simulations facilitate a dynamic view of the range of natural variability, rather than relying on the concept of static "reference stands", usually old growth stands, which is more common.

Thus far the ESI simulation models have not been used to simulate the effects of timber harvest on landscape processes. Instead the ESI models have been used to refine and demonstrate the validity of the underlying concepts regarding landscape dynamics. A key lesson that has emerged from the simulations is that single value thresholds or static 'reference' conditions, which are often used in a regulatory framework, are at odds with observations of landscape processes at large spatial and temporal scales. Cumulative frequency or probability distributions at a specified scale may provide more accurate descriptions of the natural range of variability or desired future conditions than single value thresholds which are generally more common and convenient in a regulatory framework (Benda 2001).

For example, in-channel LWD loading targets are currently expressed in volume or pieces per mile as a single value on a reach by reach basis. Thus if one reach is below the target value, it is considered deficient and some management action may be recommended to increase LWD loading. Whereas a cumulative distribution target would require LWD data to be collected across the watershed at a stated scale (e.g., 25 km^2) and then the loading values for each reach would be plotted and the cumulative distribution of all reaches would be evaluated. This acknowledges that at smaller scales (individual reaches) the variability of LWD loading varies greatly (from no LWD to lots of LWD), but at the larger watershed scale patterns of LWD loading become apparent and the shape of the cumulative distribution curve becomes the parameter to evaluate. For evaluating cumulative effects the analysis might focus on how changing LWD loading in one stream reach would affect the shape of the cumulative distribution curve for the entire watershed, or comparing the shape of the measured curve to the simulated range of natural variability curve for a watershed of the same scale (Benda 2001).

The ESI models may not be applicable to THP related cumulative effects analysis in the short term, but they could become an important tool in the future- particularly if regulatory agencies seriously confront the issues of scale and variability. This may mean abandoning the demand for quantitative and precise answers at small scales (e.g., which pools in this stream-reach below this THP will decrease in residual pool volume by how much in the next 2 years due to this harvest), which are often unknowable. Whereas qualitative information at larger scales with lower precision (e.g., what is the probability that the cumulative distribution of residual pool volumes will shift towards lower volumes in 4th order streams due to planned harvests within the watershed over the next 10-20 years) is more realistically attainable and ultimately more useful for cumulative effects assessment and management.

MacDonald

Dr. Lee MacDonald has published a conceptual approach to cumulative watershed effects analysis (MacDonald 2000). The method is not a cookbook that can be directly implemented in the THP process in California, but it offers a comprehensive framework for approaching the issue. The framework includes three inter-related phases: scoping, analysis and management. MacDonald notes that the phases should be approached iteratively not necessarily in strict sequence.

Within the scoping phase there are 5 components.

1. *Explicitly identify the issues and resources of concern, including their location.* Presumably, this is done using existing information, such as TMDLs, locations of endangered species, sensitive watershed designations, etc.

2. *Define the time scale of the assessment.* This can be somewhat arbitrary but should be related to the assumed recovery rates. It may be necessary to include a stochastic approach to account for events such as floods, fires, etc. that have a high probability of occurrence.

3. *Define the spatial scale of the assessment.* This too can be somewhat arbitrary but should be related to the processes affecting the resources of concern identified in step 1. Generally, larger scales diminish the significance of the effect, while smaller scales tend to maximize the effect.

4. *Identify the relative magnitude of risk to each resource, and adjust the scope of the assessment according to the likely cost of a wrong answer.* The emphasis should be on direct effects rather than indirect effects.

5. *Select the appropriate level of effort for the assessment.* Public concern and financial resources will have a disproportionate effect on this decision.

The Analysis phase also has 5 components.

1. *Identify key cause-and-effect mechanisms.* Focus on key mechanisms and avoid getting bogged down in the, "infinitely large universe of indirect effects and interactions."

2. *Estimate the natural range of variability and relative condition for the resource(s) of concern.* Generally, trends exhibit greater variability when viewed over longer time periods. Underestimates of the natural range of variability leads to overestimates of the significance of cumulative effects.

3. *Identify past, present and expected future activities in the area of concern.* This will be dependent on the temporal and spatial scales defined in the scoping phase, and can be expected to be quite difficult.

4. *Evaluate the relative impact of past, present and expected future activities.* This is essentially the heart of the cumulative watershed effects assessment where the past, present and planned disturbances are combined with the previously identified cause and effect processes to estimate cumulative impacts on the resources of concern. This can range from a qualitative assessment to something more complex involving computer simulation models. Given the inherent uncertainty and complexity within natural systems, this component of the assessment is generally most useful to compare alternative scenarios rather than attempting to accurately predict the future.

5. *Evaluate the validity and sensitivity of the predicted cumulative effects.* Comparing predictions to measured data is the best method, but is subject to error. Sensitivity analyses and external peer reviews are also good validation checks.

There are two components within the Implementation and Management phase.

1. *Identify possibilities for modification, mitigation, planning, and restoration.* This component can be used to modify proposed activities or set priorities for mitigation and/or restoration activities.

2. *Identify key data gaps and monitoring needs.* This step is meant to inform adaptive management decisions to improve the assessment or management activities.

After outlining this generic assessment method, MacDonald reiterated the key limitations in the process, which are: 1) variability and uncertainty in quantifying management effects; 2) the inability to predict secondary or indirect effects; 3) the difficulty in defining recovery rates; 4) the difficulty of validation; and 5) the uncertainty of future events. These limitations should temper expectations regarding accuracy or certainty of any assessment. Given this uncertainty, the author advocates limiting analyses to the issues of greatest concern and devoting proportionally more effort to limiting on-site effects and monitoring results.

Another interesting concept put forward was that cumulative watershed effects analyses should be hierarchical or tiered. In the context of THPs in California this would mean that property owners would assess site-level effects, while the state would analyze watershed or regional scale effects. In this case the state would coordinate site level assessments, serve as a repository for data and provide a context for interpretation of site level effects at the larger scale.

ERA

The USDA Forest Service in California adopted a mechanistic model of cumulative effects based on the concept that the potential for cumulative watershed effects increased with land-use intensity (USDA 1998). The metric used was "Equivalent Roaded Acres" or ERA. In this method all past and planned land uses were assigned a calibrated score relative to their similarity to a road in terms of effect. The scores for all land uses were then summed within the subject watershed and compared to threshold values. If the ERA value exceeded the threshold, this was a 'red flag warning' that indicated the need for a more detailed field investigation and a potential reduction in land use activity until sufficient recovery had occurred.

Reid (1993) reviewed this methodology and determined that, "the method contains flaws that undermine its technical adequacy." MacDonald (2000) also reviewed the ERA method and the similar ECA (Equivalent Clearcut Acres) method used on National Forests. Both authors pointed out that: 1) ERA/ECA was being used as a single index for changes in both peak flows and sediment loading, which undermines the need to define and analyze issues and resources of concern and their locations individually, 2) recovery time for the index was tied to the driving variables (forest cover) rather than the impacts (e.g., peak flows or channel aggradation) and the index was not spatially explicit and did not account for routing of materials through space or time- all of which could lead to cumulative impacts occurring in the channel even though the index indicated that recovery had occurred on the hillslope, 3) there has been little or no validation of the index, and 4) the index does not relate directly to any beneficial use such as coldwater fishery, domestic water supply, etc.

TMDL

The Total Maximum Daily Load (TMDL) process is basically a watershed or basin level cumulative watershed effects assessment for specific water quality parameters. MacDonald (2000) states that there are three basic components to a cumulative watershed effects assessment: scoping, analysis and implementation/management. The TMDL process includes all three components. The scoping phase of the TMDL process occurs when state water quality agencies review available information to determine which water bodies exceed which water quality standards. After development of the list, the EPA or Regional Water Quality Control Board

(RWQCB) moves to the analysis phase by completing a ‘technical TMDL’ for the listed water body. Based on the results of the technical TMDL the RWQCB develops a plan to control the pollutants of concern- which is equivalent to the implementation/management phase in MacDonald’s conceptual model. Non-point source TMDLs are an example of a large spatial scale, multi-ownership cumulative watershed effects analysis and mitigation planning process that has no equivalent within the THP process.

Scientific uncertainty and lack of adequate data have been cited as obstacles to conducting cumulative watershed effects analyses within the timber harvest planning process (THP Task Force 1999). This has not stopped the EPA and Regional Boards from listing waterbodies as impaired, conducting loading assessments and developing implementation plans for sediment loading and water temperature in North Coast Rivers, and elsewhere. Best professional judgment of agency staff has been a key supplement to “old”, “inconsistent” and sometimes “inadequate” data in the 303(d) listing process (Ruffolo 1999). Despite this uncertainty in the listing process it is legal (thus far) and has the support of some prominent scientists (Reid 1998).

Where adequate data are available, numeric criteria are typically used to define water quality standards. Data are usually available for chemical pollutants which naturally occur only at very low levels, such as heavy metals, or toxics, which do not occur naturally. Heavy metals and toxics also often have clearly defined thresholds above which they are hazardous or lethal to organisms. However, clean sediment and water temperature have widely varying background levels, originate from non-point sources, do not have clear thresholds for harm to organisms and data quality and quantity are lacking. For these types of non-point source pollutants the use of narrative criteria has allowed the EPA and Regional Boards to develop workable definitions for cumulative effects and proceed with listings.

Narrative criteria describe a condition that must be met in order for a water body to meet its beneficial use designation, but do not include a quantitative threshold for each pollutant (Ruffolo 1999). However, numeric indicators (i.e., measurements) are used to assess water quality conditions relative to the desired conditions for each beneficial use- but the numeric targets are not themselves enforceable criteria (USEPA 1999). The numeric targets are usually based on reference conditions found elsewhere or values described in the scientific literature.

After “beneficial uses” (RWQCB terminology) or “resources at risk” (THP terminology) and potential impairments to these have been identified, the next step in a TMDL assessment is an analysis to determine the nature of the effects from past, present and future management activities. Due to the widespread listing of sediment and water temperature impairment in forested watersheds a cumulative watershed effects and TMDL analyses would often overlap. Given the similarity in topics and general function of the two processes and given that one of the key recommendations from the THP Task Force (1999) was to provide clearer guidance to cumulative watershed effects preparers, it may be useful to refer to the EPA guidance documents on TMDL preparation to improve the cumulative watershed effects process within the FPRs. For example, the US EPA (1999) offers the following guidance on developing TMDLs for sediment discharge;

> The protocol emphasizes the use of rational, science-based methods and tools for TMDL development. The availability of data influences the types of methods analysts can use. Ideally, extensive monitoring data are available to establish baseline water quality conditions, pollutant source loadings, and waterbody system dynamics. If long-term monitoring data are lacking, however, the analyst will have to use a combination of monitoring, analytical tools (including models), and qualitative assessments to collect information, assess system processes and responses, and make decisions. Although some aspects of TMDLs must be quantified (e.g. numeric targets, loading capacity, and allocations), qualitative assessments are acceptable as long as they are supported by sound scientific justification or result from rigorous modeling techniques.

The guidance document indicates that the emphasis in the TMDL process is on using available data to conduct a credible and justified analysis and make decisions (USEPA 1999). Review of THPs and NTMPs indicates that the current cumulative watershed effects process is focused on gathering and disclosing data, but falls short on analysis (THP Task Force 1999). The EPA guidance documents indicate that a TMDL assessment should include the following elements (as summarized by Ruffolo 1999):

1. **Problem Statement**. A description of the water body or watershed setting, beneficial use impairments of concern, and pollutants or stressors causing the impairment.
2. **Numeric Target(s).** For each pollutant or stressor addressed in the TMDL, appropriate measurable indicators and associated numeric targets(s).
3. **Source Analysis.** An assessment of relative contributions of pollutant or stressor sources to or causes of the use impairment and extent of needed discharge.
4. **Loading Capacity Estimate.** An estimate of the assimilative capacity of the water body for the pollutants of concern. (This is also known as the "linkage analysis" linking water quality targets to sources).
5. **Allocations.** Allocation of allowable loads or load reductions among different sources of concern, providing an adequate margin of safety. These allocations are usually expressed as wasteload allocations to point sources and load allocations to nonpoint sources… *The TMDL equals the sum of allocations and cannot exceed the loading capacity* (EPA's emphasis). In the TMDLs that EPA has prepared so far, under court order, these allocations have been quite general.
6. **Monitoring Plan.** Plan to monitor effectiveness of TMDLs and schedule for reviewing and (if necessary) revising TMDLs and associated implementation elements.

This multi-step approach to conducting a TMDL analysis could be used for watershed level cumulative watershed effects analyses within the FPRs with only minor modifications. This is because the core components of all cumulative effects analyses are essentially the same: what is the problem, where is it coming from, how much is too much, and how do we control it. The EPA guidance document (1999) points out that decisions regarding specific methodologies to use in each analysis must be made on, "a site-specific basis as part of a comprehensive problem-solving approach… no 'cookbook' approach can be applied." Although most approaches to cumulative watershed effects analysis are essentially similar, the balance between risk to the resource due to inaction versus aversion to restricting management activity based on uncertain analyses seems to control the effort each agency devotes to the process and may be partly responsible for the divergent outcomes of TMDLs versus cumulative watershed effects analyses within THPs.

The analysis tool used for all of the North Coast sediment TMDLs has been the construction of sediment budgets. Sediment budgets or 'sediment source analyses' generally include estimates of actual or potential sediment loading from hillslopes and streambanks to receiving waters, estimates of instream storage and transport of sediment and estimates of the net sediment discharge or yield from the basin (Reid and Dunne 1996). This tool has a range of uncertainty from 40-50%, depending on the methods used (Kramer et al. 2001). Despite the inherent uncertainty in this method, it is the best tool available for analyzing sediment loading in wildland settings using a minimum of time and money. In order to account for the uncertainty in loading estimates and natural variability (for all pollutants, not just sediment) the TMDL process includes an important conceptual tool that is absent from the FPRs - *a margin of safety*. The margin of safety (MOS) is an incremental decrease in the allowable pollutant loading beyond the exact loading estimate calculated in the analysis process[1] to account for unknown system responses or errors in methods used to develop loading estimates.

Of course the TMDL process has been subject to criticism, controversy and legal challenges every step of the way. Just as Epic v. Johnson initiated the cumulative impacts analysis provision of the FPRs, the TMDL process was initiated through lawsuits. The first of the TMDL related lawsuits occurred in the 1980's in Illinois. In California, TMDLs on the North Coast Rivers were initiated after a 1995 lawsuit by the Pacific Coast Federation of Fishermen's Associations against the EPA. There have been lawsuits challenging the criteria used to list waterbodies as impaired in the first place (Sacramento Regional County Sanitation District v. SWRCB) and lawsuits challenging the authority of the TMDL process to address non-point sources (California Farm Bureau v. EPA). The National Research Council (NRC) (2001) recently conducted a review of the TMDL process and recommended a variety of changes, including: review designated uses of water bodies to ensure that they are appropriate and attainable, narrative criteria should be used to place water bodies in a pre-listing category but not be used to support a final listing, statistically based monitoring programs should be used for listing and assessment, and a process of "adaptive implementation" should be used to monitor, test and modify implementation plans.

Perhaps because of this controversy, the North Coast RWQCB has only managed to complete one entire TMDL - on the Garcia River in Mendocino County. The implementation plan, which set a goal of 60% reduction in sediment discharge to the Garcia River, may have a significant effect on land management activities in the watershed, including activities typically regulated by the FPR (RWQCB 2001). Under the TMDL implementation plan landowners are required to inventory all sediment sources on their lands and develop an erosion control plan or comply with the basin wide erosion control plan developed by the Regional Board, known as, "The Garcia River Management Plan". The Garcia Plan prescribes road and crossing design standards, rock surfacing regulations, season of use restrictions, and additional restrictions on timber harvest in

[1] A recent review of the TMDL process noted that although the MOS should account for data uncertainty and natural variability, most MOS have been arbitrarily defined (NRC 2001). The NRC recommended a formal uncertainty and error propagation analysis to define the MOS.

the WLPZs. A basin wide monitoring plan will also be implemented to gauge progress toward sediment reduction goals. Monitoring data will be compared to numeric targets defined in the TMDL implementation plan (RWQCB 2001).

Despite the controversy and slow pace, the TMDL process is moving forward and having a significant influence on the THP review and implementation process. The Garcia Plan indicates that BMPs and mitigation measures arising out of the TMDL process can supersede regulations contained in the FPR- even if the individual cumulative watershed effects analyses for each harvest plan conclude that their plan will not contribute to cumulative watershed effects and need no further mitigation. The potential for inconsistent conclusions regarding cumulative watershed effects between TMDLs and harvest plan analyses indicates the need for coordination between CDF and the Regional Board on this issue. The interim rules regarding Section 303(d) Listed Watersheds in the 2003 FPRs indicate that CDF has recognized this need (CDF 2003). However, CDF has not adopted a cumulative watershed effects analysis process that is equivalent to or compatible with the TMDL process in terms of spatial scale, goal setting, or analytical rigor.

CEQA Approaches

The California Environmental Quality Act (CEQA) requires that cumulative impacts be addressed for any discretionary project proposed or regulated by a public agency that requires an Environmental Impact Report (EIR). Thousands of EIRs have been prepared since enactment of this requirement in 1973. Many contain sophisticated analyses of cumulative impacts. The topics commonly evaluated include:

- Public services (schools, water, waste water treatment, public safety)
- Transportation systems and traffic
- Public finances
- Biological resources (vegetation, wildlife, wetlands)
- Hydrology and water quality

The commonly used conceptual framework for these studies includes several components. There is an evaluation of current system "capacities" or thresholds. Examples would include school capacities, available water supplies, waste water treatment plant capacities, road system capacities, areas of biological resources (e.g., acres of habitat, etc.) There is an estimate of the marginal impacts of uses or activities. For example, school children generation factors per household, water consumption factors per person or household, lot sizes for different forms of development, nonpoint source pollutant runoff factors, etc. The current level of utilization or impact is then estimated by quantifying the existing number of generating uses or activities times the various unit generation factors and then comparing the total to system capacities. The marginal impacts of the new or proposed use or activity are then added. Results are then used as the basis for mitigation. For example, if a specific project will cause a street to become overly congested, road improvements may be required for the proposed project. This framework is intuitively satisfying and in practice, relatively straightforward. In one such study conducted by Harris in the early 1980's, the effects of future urban development in the I-80 corridor between I-680 and I-505 in Solano County were evaluated. Cumulative impacts on public services, natural vegetation communities and hydrology (storm drainage) were quantified using the General Plans for the cities of Fairfield, Suisun City and Vacaville as the basis for estimating future growth. Results revealed dramatic losses in natural habitat, serious deficiencies in available public services and increased flood hazard along area streams due to urbanization. This study was done for the US Department of Housing and Urban Development.

The existence of empirical methodology for evaluating cumulative impacts in the urban and regional planning disciplines suggests that the problem of conducting these analyses is not insurmountable. However, the many uncertainties inherent to activities in wildland settings makes direct use of similar approaches difficult.

Summary of Alternative Approaches

There are many ways to conduct cumulative watershed effects analyses, none has been universally accepted. Ice (2001) reviewed five watershed analysis methods[2] that address cumulative effects and came to the conclusion, "there are numerous technical and procedural problems with each approach which reflect, in part, the compromise between being comprehensive and integrative and being practical." However, lessons from other approaches can offer incremental improvements to the process, such as:

- The level of effort for each analysis should be proportional to the value of the resources in question and level of risk posed by the activity (MacDonald 2000).
- Although data collection and disclosure is important, analysis is the key to generating information that decisions can be based on (USEPA 1999).
- Definitions of cumulative effects based on single value thresholds are at odds with the wide range of natural variability in dynamic landscapes, distributions of responses may be more appropriate (Benda 2001).
- A combination of qualitative and quantitative assessment techniques can be used where data or scientific certainty are lacking (Benda 2002, USEPA 1999).
- Analysis methods that rely on indexes run the risk of oversimplifying issues and missing potentially important processes (MacDonald 2000, Reid 1998).

A common lesson amongst the methods reviewed was that cumulative watershed effects analyses require an evaluation of how future events (management and non-management related) will affect the designated resources at risk. Predictions may be qualitative or quantitative- depending on the objectives of the analysis. In either case the assumptions and data sources need to be explicitly defined. One method presented for structuring the prediction process was modeling. Models can be based on qualitative relationships, statistical relationships or physical processes. The CLAMS, ALCES and ESI projects are working analogs to the type of modeling efforts advocated within the Dunne (2001) report and have been operational for several years. These models have been most useful for comparing alternative scenarios rather than trying to make absolute predictions, but it is not clear how the results have been used for making management decisions.

MacDonald summarized the cumulative watershed effects issue as follows, "Uncertainty is the hallmark of cumulative effects assessments, and this must be recognized by managers, regulators and the public. The problems of scope, scale and predictability are based in science, but their resolution is a question of values and will therefore be a continuing source of controversy" (MacDonald 2000). Thus, the risk tolerance of the lead agency will be the key determinant in the control of cumulative watershed effects regardless of the methodology used to assess them.

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[2] The methods reviewed were: Washington Watershed Analysis, British Columbia Watershed Assessment Procedure, Idaho Cumulative watershed effects procedure, Oregon Watershed Assessment and the Federal Watershed Analysis (Ice 2001).

RECOMMENDATIONS

Our recommendations are presented in two forms. First, we present suggestions for immediate changes to THP preparation and implementation. These suggestions are drawn from various critiques of the THP related cumulative effects assessment process. The changes would either help prevent cumulative watershed effects or improve assessment of those effects. In our opinion, they could be implemented without significant changes to existing regulations.

Second, we suggest a comprehensive approach to cumulative watershed effects assessment. Although developed independently, this approach has many of the features suggested by MacDonald (2000). Adopting this approach would require changes to the current FPR (including Addendum 2), changes to the process for THP preparation and most importantly, changes to the way resource agencies participate in the THP process. The approach would bring the THP process more in line with CEQA processing for other types of regulated land uses. It also incorporates some provisions of past critical reviews and is flexible enough to accommodate innovative analysis techniques (e.g., modeling).

In formulating these recommendations, we have taken into consideration the comments of practitioners currently involved in doing or reviewing cumulative watershed effects analyses. Some innovative approaches, similar in many respects to the comprehensive framework presented here, are being used in watersheds where there is one major landowner. However, these are not typically being done for single THPs but for Sustained Yield Plans, Habitat Conservation Plans and pilot watershed assessments (IWMA). Any changes in practice must consider the financial and processing costs of assigning detailed documentation requirements to single THPs, especially in watersheds where it is difficult to anticipate reasonably future foreseeable activities. In cases where watershed conditions warrant in-depth analysis and only a single THP is currently proposed, provisions should be made for technical and financial assistance by agencies.

Immediate Steps

The following measures should be considered for immediate implementation. The sources for the measures are noted.

<u>MSG Hillslope Monitoring Report (2002)</u>

The Board of Forestry Monitoring Study Group (MSG) has been overseeing monitoring of FPR implementation and effectiveness for over a decade. Much valuable information is contained in the most recent MSG report. It includes several suggestions for improving the prevention of site-specific and potentially, cumulative watershed effects:

- Require more thorough and consistent inspection of watercourse crossings by CDF Forest Practice Inspectors and other reviewing agencies. Include training on effective watercourse crossing design and mitigation practices.
- Develop a Licensed Timber Operator (LTO) implementation guidance document for installation of watercourse crossings and road drainage structures.

- Upgrade existing watercourse crossings with problems, including old, existing structures. Implement upgrading through development of voluntary, cooperative Road Management Plans that would include a schedule for completing upgrades.

Since most of the THP-related problems identified by the MSG are associated with crossings, and since crossings are a principle source of direct sediment inputs to streams and fish passage problems, adopting these recommendations would help reduce cumulative watershed effects. Some progress has been made on these recommendations already. For example, the California Licensed Foresters Association (CLFA) recently conducted a workshop on crossing design for RPFs. A Board of Forestry ad hoc committee on road management has recently released a rule package for voluntary road management plans.

<u>CDF Director's THP Task Force (1999)</u>

The task force generally emphasized the need for cooperation among agencies in defining what data collection and analysis RPFs should do for THPs. However, it also made recommendations to improve the cumulative watershed effects assessment process:

- Require RPFs to provide citations for the information sources used in their cumulative impact assessments.
- Require RPFs to provide a clear rationale for their conclusions, including a clear linkage between proposed mitigation measures and the factor or potential cumulative impact it is intended to address and an assessment of how well the measure will address the issue.
- In conjunction with the California Geological Survey, provide listings of available maps and other slope stability data that are relevant to THP preparation.

These incremental steps would both improve the quality of documentation as well as make the analysis of cumulative watershed effects more than just a listing of information. The second recommendation has been incorporated into our proposed framework for cumulative watershed effects assessment (see below). The detailed recommendations of the THP Task Force are included its report.

<u>Scientific Review Panel (1999)</u>

The SRP report included a lengthy list of detailed recommendations, some of which have already been adopted as part of the Threatened and Impaired Watershed rules (due to expire this year but expected to be extended by the Board of Forestry). Other pertinent SRP recommendations have either not been acted on or have only been partially implemented. Relevant recommendations include:

- RPFs should have 'cradle-to-grave' responsibility for their THPs, and should work with LTOs to ensure that the THP (or NTMP) is properly implemented. Recent changes to the FPR have already increased the responsibilities of RPFs for overseeing operations but more could be done. The limits on RPF responsibility are defined by law with the filing of THP Completion Reports. .

- In order to provide trees for future recruitment of LWD to streams, the 10 largest trees per 100 meters of Class I stream channel within 50 feet of the watercourse transition line shall be marked for permanent retention. This provision is currently in the T&I rules package for the coast. It could be extended to all regions and provide benefits. There is no evidence available indicating that LWD recruitment is any less important in other regions.
- All permanent forest roads should be maintained throughout their useful life. When roads are no longer needed in the near-term, they should be temporarily or permanently abandoned by outsloping and the removal of watercourse crossings. There have been recent changes to the FPR to increase responsibilities for road maintenance on THPs. As previously mentioned, there is also proposed rule package for developing road management plan guidelines. Since roads are one of the most important sources of cumulative watershed impacts, any improvements in their design and maintenance will provide benefits.

Improvements in road maintenance and decommissioning of useless or poorly constructed roads would reduce the risks associated with roads and crossings during stressing events. Providing for long-term recruitment of LWD would make improvements over a period of years. Depletion of LWD in coastal streams especially, has been associated with degradation of habitat for anadromous fishes. It will take a long time to reverse these effects, but providing for long term LWD recruitment is a step in the right direction. There will remain a short-term need to improve habitat conditions in streams by strategic placement of LWD.

New Framework for Cumulative Watershed Effects Analysis

Introduction

Our recommended framework seeks to improve the content and substantive analysis in cumulative watershed effects reports without unduly increasing the review time for THPs. It would require the RPF and the review team agencies to define the scope of required inventory and analysis at the beginning of the assessment process. The level of required data collection and analysis would be commensurate with the resources at risk in the watershed. Risk in this context is a function of watershed conditions, the intensity and magnitude of proposed management, and potential responses to critical events such as floods, earthquakes, landslides, or fire. It would also require data on all reasonably foreseeable management activities in a watershed for at least a decade. This provision would allow projection of future effects beyond the scale of the individual THP.

Applications

There are three basic land ownership configurations in watersheds where THPs may be proposed: 1) multiple private owners of relatively small parcels; 2) mixes of public and private lands (federal lands included); and 3) single owners (usually industrial forest land)[3]. This variety

[3] Within this context, "single owner" watersheds refer to watersheds in which a single owner exerts management control over the majority of the forested portion of the watershed. A working definition could be: >70% of the TPZ zoned land in a 3rd order or larger watershed owned or controlled by the same entity.

of land ownership patterns presents major challenges to the equitable implementation of an improved cumulative watershed effects assessment process. At the present time, owners in category (3) may be compelled by regulatory agencies to conduct a more rigorous level of analysis than the owner of a single, small parcel. In mixed public-private watersheds, public agencies (e.g., US Forest Service) may have different standards for analysis than the THP process normally requires.

There are clearly better opportunities for conducting thorough and useful cumulative watershed effects assessments in single owner watersheds, especially where a single analysis can be used to support multiple THPs. Data collection procedures may be more efficient. Future management activities may be predicted with more certainty. The main drawbacks are that the single landowner would bear the entire cost and regulatory burden for the watershed and would have to conduct a more detailed analysis to cover future THPs. However, interviews with agencies and landowners and experience indicate that many industrial forest landowners already do many of the tasks associated with improved cumulative watershed effects assessment. However, they have been unwilling in some cases to share that information with regulatory agencies to avoid being “locked in” to future planning assumptions.

We have no definitive solutions for the problems of regulatory burdens or costs to land owners in single or mixed owner watersheds. In either, it is apparent that a collaborative spirit among agencies and landowners is essential if assessments are to be improved. The forms of collaboration may vary, including data sharing, cost-sharing and technical assistance. CDF can take the lead on promoting this. As noted below, the very first step in an improved process is to get the review team agencies themselves to collaborate.

The North Coast Watershed Assessment Program (NCWAP) was potentially a vehicle for conducting cumulative watershed effects analysis that transcended watershed ownership constraints. With its demise, the only other comparable watershed analyses are either being conducted on large private ownerships, in association with other planning efforts (e.g., SYPs, HCPs, restoration prioritization), or as TMDL studies. None of these necessarily includes all of the components of a desirable cumulative watershed effects assessment process (see below). However, they could potentially be adapted to meet that objective.

In the absence of a public agency assessment process, it is assumed that future cumulative watershed effects assessment will be done by RPFs and landowners proposing THPs or by local watershed groups with the financial support of public agencies or private foundations.

Key Underlying Principles

- The focus is on analysis of current and future cumulative impacts to watersheds, streams and associated aquatic life. While terrestrial wildlife cumulative effects issues are important, they are not considered here.
- Site-specific impacts of THPs will generally be mitigated by proper implementation of FPR but this will not eliminate the potential for cumulative watershed impacts.

- Documentation for individual THPs will be tiered to cumulative watershed effects assessments for entire watersheds, anticipating all reasonably foreseeable management activities.
- Although there are stipulated topics for inventory and analysis, the level of detail at which these topics will be addressed will depend on pre-assessment agency scoping, the significance of the resources at risk and the level of risk posed by management.
- The disclosure of adverse significant cumulative effects that cannot be mitigated on or off a specific THP site or in a watershed may be grounds for deferring management at the site or in the watershed or conducting management elsewhere, where significant adverse cumulative effects will not result i.e., watershed recovery may be necessary before further management in some cases.
- In watersheds where opportunities for on-site mitigation are limited, due to land ownership patterns or other constraints, off-site mitigation or "credits" through a process of mitigation banking may be used.

Timing

Currently, cumulative effects assessments are conducted in conjunction with the preparation of single THPs or NTMPs. The submittal of the THP and the cumulative assessment report then triggers the review process. CDF may reject the THP and associated documents as incomplete or technically insufficient, sending the RPF back to the drawing boards. Or, any of the review team agencies may ask for further information, analysis, or mitigations. These things have happened with increased frequency in recent years as issues such as sediment production and endangered species have gained prominence. This "missing the mark" with initial documentation can considerably lengthen the THP review process and increase costs for submitters. Several iterations may occur before documentation is acceptable to the review team agencies. Although these delays can ultimately improve the assessment, it would be far more efficient if they could be avoided.

Superior results in the analysis and reporting of cumulative watershed effects will be obtained if an RPF is provided with guidance on what to do *before* preparing a specific THP. This guidance should be given during a pre-submittal consultation and scoping with review team agencies (described in more detail below). An analogous process under CEQA would be the Notice of Preparation which is sent out to responsible agencies and published in the local newspaper of record by the lead agency to request identification of issues that must be addressed in an environmental impact report. This process could be called a "THP Notice of Preparation" (THP NOP).

This approach would mean big changes to the THP process. It could work as follows. When an RPF becomes aware that a THP (or multiple THPs in a single watershed) will be prepared, the first step would be to submit the following information to CDF: a map of the cumulative effects study area (see study area definition, discussion, below); a brief, general description of the proposed and likely future activities and; an outline of the relevant topics for a CWE analysis. CDF would then circulate these materials to review team agencies and others requesting comments on the required scope of a cumulative impact assessment. Based on the response to the THP NOP, a formal pre-project consultation between the review team and the RPF would be triggered. Only after all initial feedback has been given by the review team agencies does the RPF proceed with further planning on the THP and CWE preparation (see discussion, below under Steps in the Process). Beyond this point in time, agencies would be unable to demand analysis for topics in addition to those identified in the scoping session. However, in the event that additional significant topics are disclosed while the assessment is underway, these would be addressed.

This provision would certainly change the way THPs are prepared and reviewed, but it may not increase the amount of effort required for each THP. In fact, it could reduce the effort required for THPs submitted subsequent to the initial watershed wide CWE analysis. In cases where a single assessment is prepared for an entire watershed including multiple THPs, costs may be less and quality of analysis higher than preparing separate assessments for each THP individually. A similar process of pre-project consultation for development projects has been used in many cities and counties for years. Our interviews and review of background information indicates that some RPFs already engage in pre-planning consultation with agencies.

Steps in the Process

The framework for cumulative watershed effects assessment is summarized below:

Step 1: RPF develops study area map, preliminary description of proposed THP(s) and outline of CWE assessment, submits to CDF
Step 2: CDF circulates a Timber Harvest Plan Notice of Preparation to review team agencies and others
Step 3: Review team evaluates RPF's outline of CWE assessment and provides feedback on resources at risk, necessary studies, and time frame for assessment (meetings with RPF may be required)
Step 4: RPF finalizes assessment study plan based on feedback from agencies
Step 5: Review team agencies review and approve study plan
Step 6: RPF undertakes inventory of conditions, develops estimates of future management (including current THP), predicts future risks, identifies measures that will reduce risk, and documents how measures will reduce risk
Step 7: RPF files THP and cumulative watershed effects assessment with CDF
Step 8: Review team evaluates THP and assessment, proposes additional mitigation measures (if necessary)
Step 9: THP approved or denied
Step 10: THP implemented
Step 11: Implementation and effectiveness of mitigation measures monitored through MSG hillslope monitoring, Modified Completion Reports and instream monitoring
Step 12: Future THPs filed, cumulative watershed effects assessment used in the review process

Define the study area: this task is performed by the RPF. Below, we refer to the study area as the watershed assessment area. The study area for the assessment should be at least a 3rd order watershed containing the area of the potential THP(s) and main watercourse extending down to the first three depositional reaches <2% gradient, >1,000 feet in length. Depositional reaches are places where some watershed effects (sedimentation and LWD jams) will tend to manifest.

Initiate the cumulative effects assessment process: after the watershed assessment area has been defined by the RPF or designee, the assessment process is initiated by the preparation and circulation of the THP NOP by CDF. This notice will include the map, a general description of the intended project (i.e., rough idea of what management activities are proposed and where) and a request for information on resources at risk. The THP NOP should be circulated to review team agencies, other agencies and the interested public.

Responsibilities of agencies in response to THP-NOP: below, the issues that should be resolved by the review team agencies through response to noticing and/or through subsequent pre-project consultation are described. In most cases, it is assumed that the pre-project consultation would require one or more meetings with review team agencies and the RPF. In complex cases, the agencies will be acting as a de facto technical advisory committee.

Identify resources at risk: resources at risk must be defined by review team agencies and the RPF to the degree that data are readily available. Information submitted by other agencies and the public may be used by the review team. Resources at risk include not only generic concerns, such as the status of endangered species, but also the specific identification of places or things that are currently functioning well or poorly within the watershed assessment area. If conditions are unknown but potentially important, that should be noted. When formulating statements of resources at risk, review team agencies should consider that the scope and detail of subsequent inventory and analysis will be based on them.

Example statements of resources at risk might include the following:

- CGS may state that existing data indicate a high probability of slope instability or erosion hazard on specified geomorphic units within the watershed assessment area. The implications of this statement for future inventory and analysis would depend on the adequacy of existing data as well as the nature of potential management.
- CDFG may state that habitat surveys within the watershed assessment area indicate a paucity of suitable conditions for spawning and rearing of anadromous fish. If these conditions are well-known for the watershed, further inventory may be limited.
- Regional Water Quality Control Board staff may state that the watershed assessment area has impaired water quality conditions. This may be based on watershed-specific data such as TMDL studies. If impaired conditions are suspected but not verified, future studies should assess potential problems.

In developing statements such as the above, review team agencies should identify the sources of information upon which they are based. These may include other agencies such as NOAA-Fisheries or organizations such as watershed groups. These data sources may be consulted by the RPF for further information in the cumulative watershed effects assessment.

Identify needed studies: The review team agencies will provide guidance on what studies should be done to address the resources at risk. This will be their opportunity to define the scope of required analysis and their future roles. In relatively uncomplicated cases, responses to the THP NOP will be adequate for the RPF to proceed with the assessment and THP preparation. In more complicated (and probably, more typical) cases, responses to the notice will be the first step in a scoping and study planning effort.

Define time frame for assessment: the time frame for analysis should be based on two things: 1) the resources at risk; and 2) the period over which future management activities can be reasonably foreseen, ideally at least 10 years. Since the assessment may be used in conjunction with the review of THPs submitted in the future, consideration should be given to how long documentation will remain useful and relevant. Selection of the time frame for resources at risk should consider things such as frequency of stressing events affecting the watershed, biological cycles, natural recruitment rates of LWD, etc. For purposes of analysis, the baseline is current watershed conditions (see discussion, below). In documenting land management history, however, it may be desirable to consider important historical phases such as initial logging and transportation system development, mining, etc. These may have lingering effects on watershed conditions that are reflected in current indicators of cumulative impacts.

Responsibilities of the RPF in the pre-assessment phase: the main task for the RPF is to develop an outline of the CWE assessment for the watershed and respond to agency concerns and requests regarding this proposed CWE assessment. The study plan should state what data are available, what additional data will be collected (and by whom) and what analysis or modeling techniques are proposed for developing results. The study plan should be considered a compact between the RPF and the review team agencies regarding the assessment. It should be the basis for later review when the THP and CWE assessment are submitted. That is, assuming that the study plan is approved and properly implemented (see below) then review team agencies would have no grounds for requesting additional studies or information. They may however, request specific mitigation measures on the basis of study outcomes. Also, in the event that additional issues are disclosed during the assessment, these would be addressed by the RPF after consultation with review team agencies.

Review and approval of study plan: the preliminary study plan would be reviewed, revised as necessary and approved by review team agencies before it is implemented. Granting this approval may constitute a legal step that must be defined in legislation and/or revision of the FPR. Collaborative efforts such as the current negotiations between Regional and State Water Quality Control Boards and CDF regarding cumulative watershed effects may be one forum for finding a way to facilitate this approval. The essence of the approval is concurrence that the expectations and decision-making needs of review team agencies will be met by the final products.

Evaluate conditions within the watershed assessment area: after approval of the study plan, the assessment process begins. Depending on the resources at risk and available data, the following topics are recommended as the minimum covered in the cumulative watershed effects analysis. The topical areas are summarized in the table, below.

Topic	Scale	Data Provided	Sources of Data	Comments
Upland forest	Watershed	Composition, age class, acreage of stand types	California Land Cover Mapping, timber type maps, aerial photos	Public data may be needed if landowner data are considered proprietary. This

				could also be considered a confidential portion of the assessment, as with SYPs.
Riparian forest	Stream reach, stream system	Continuity, composition, width	California Land Cover Mapping, timber type maps, aerial photos	Difficulties in mapping from aerial photos on smaller streams.
Hydrology	Stream reach, stream system, watershed	Map of stream system, streamflow, peak flows, flood prone areas, sediment deposits, bank erosion	GIS hydrography, gaging stations (rare), modeling, field studies	Difficult to obtain for most watersheds.
Stream habitat	Stream reach, stream system	FPR stream classes, habitat types, limiting factors	DFG habitat typing, field studies	Habitat typing available for many coastal watersheds, not elsewhere. A list of potential limiting factors should be provided by review team agencies.
Geology and soils	Watershed	Slope stability, landslides, erosion hazards	CGS mapping, mapping by other agencies (USGS, USFS, NRCS), modeling	Available for many coastal watersheds, limited elsewhere.
Species of concern	Watershed, stream system	Known or potential locations and habitats for aquatic wildlife and fish	DFG, Natural Diversity Data Base, NOAA-Fisheries, other agencies (USFWS, USFS)	Confirming presence or absence of species of concern would require field work.
Management history	Watershed	Existing road system, known erosion sites, failing roads and	Aerial photos, field studies, historical records	Main objective is to determine potential locations for

		crossings, harvest history, unregenerated harvest units, agriculture, development, other land disturbances		restoration or watershed improvements
Indicators of cumulative effects	Stream reach, stream system, watershed	Degraded stream or riparian habitats, LWD, stream temperature, etc.	Watershed assessments, agencies, TMDL studies	Working list of potential indicators should be provided by review team

Upland forest cover and structure

The distribution of forest stand age classes across the watershed assessment area is both a measure of watershed history as well as an index of current and potential cumulative watershed effects. A preponderance of young stands, indicating a recent history of changes due to harvesting, fire or other causes, may be correlated with hydrologic conditions, sediment production and vulnerability of streams to cumulative effects. Concentration of young stands on unstable sites may have implications for their response to future stressing events, increasing the risk of mass wasting. Although an up-to-date map of current stand age structure is the most desirable presentation, in some cases such mapping may not be available. Some landowners may not be willing to provide spatially explicit data. At the minimum, the remote-sensing-derived spatial vegetation data developed by the California Land Cover Mapping and Monitoring Program should be used to delineate stand characteristics for the study area.

The current stand age/stand structure distribution represents the baseline for analysis of future changes. As described below, in assessing potential impacts, similar projected data should be provided for the status of the vegetation at the close of the analysis period, anticipating all reasonably foreseeable activities.

Riparian forest cover and structure

Riparian forest conditions affect stream temperature as well as recruitment of large wood to streams. These are important functions on all California forest lands. At the minimum, a cumulative watershed effects analysis should include mapping and description of riparian forests for all Class I and Class II streams. Maps should indicate the continuity and width of the riparian zone. Riparian vegetation descriptions should include species composition and stand age and/or stand structure. Where large wood recruitment or water temperatures are considered resource risk factors, field studies may be required. Otherwise, large scale aerial photographs or vegetation data from the California Land Cover Mapping and Monitoring Program can often provide the necessary inventory information. Existing vegetation maps may also be available for a watershed assessment area and may separately classify riparian communities.

Hydrology
Hydrologic conditions that are of interest in a cumulative watershed effects assessment will depend to some degree on the resources at risk. At the minimum, existing rainfall-runoff relationships should be discussed and if possible, quantified. Emphasis should be placed on the frequency and magnitude of stressing events including peak precipitation, earthquakes, fire, and their hydrologic results. Consequences of hydrologic conditions such as flood-prone areas, bank erosion and sedimentation should also be determined. To identify risk and places susceptible to impact (depositional stream reaches mainly, but including pool habitats on steeper reaches) stream classification using gradient, at the minimum, should be employed (Montgomery and Buffington 1997). The level of classification required and the need for site-specific data collection will depend on the resources at risk and available data.

Stream habitat
Instream habitat conditions within Class I streams, at the minimum, but possibly Class II streams as well (depending on the resources at risk) should be described at a level commensurate with the risks posed by management activities. In many watersheds, CDFG habitat typing data and assessments will be available. In the absence of such information and depending on the resources at risk, habitat typing can be conducted. There are alternative levels of detail in CDFG habitat typing and the level required for a watershed assessment area should correspond to the resources at risk. Habitat typing will yield information on specific limiting factors such as sediment loads, temperature, shelter or habitat structure (Flosi et al. 2002).

Geology and soils
The information needed for a cumulative watershed effects assessment will vary by region and by watershed. On the north coast, where slope stability concerns are extremely important, the minimum required information will include a watershed-wide evaluation of slope stability. The level of detail for this information will depend on resources at risk, existing information and the nature of future potential management actions. This may include an estimate of the number of acres within each stand age class currently located on unstable terrain. Existing California Geologic Survey (CGS) slope stability maps may be used where available (Spittler pers. comm. 2003). In other cases models such as SHALSTAB, aerial photo interpretation, field review by a registered geologist or other appropriate methods may be used.

In other regions, such as the interior and Sierra, mass wasting may not pose the same risks and potential for causing cumulative watershed effects. Surface erosion potential, as reflected in geologic and soils conditions may be more important. The minimum required information may be an erosion hazard rating for different soil types and slopes within the watershed assessment area.

Regardless of the region, the potential stressing effects of earthquakes, large landslides, peak precipitation and fire should be explicitly considered.

Species of concern
The species of concern that are dependent on aquatic habitat will normally be identified by CDFG but other agencies such as NOAA-Fisheries and US Fish and Wildlife Service may

provide information. Confirmed or presumed presence of species of concern and the adequacy of existing data will dictate whether field surveys are required.

Management history

The main purposes for providing an evaluation of past management is to identify existing conditions that may require treatment to reduce their ongoing impacts or decreasing future management intensity if legacy effects are still increasing in magnitude. Some activities associated with future management can actually make existing conditions better. If legacy problems such as poor stream crossings, abandoned roads, inadequate riparian cover or unregenerated harvest units are corrected, then there may be improvements in watershed conditions. Therefore, the inventory of past management should focus on identifying where legacy problems exist so that opportunities for improving watershed conditions may be considered. These may not be limited to forestry-related features. They may include for example, other land-disturbances such as gravel extraction, ditches, residential roads, homesteads, etc.

Since road systems are associated with so many negative cumulative watershed effects (Adams et. al. 1994, Madej 2001, Reid and Dunne 1984), the inventory of past management should provide a mapping and evaluation of road conditions, crossings, etc. The level of detail for this will depend on the resources at risk.

Indicators of cumulative watershed effects

The cumulative watershed effects assessment should include a diagnosis of watershed conditions based on recognizable symptoms. While in some watersheds, an overall assessment may be available (e.g., TMDL or NCWAP watersheds) it will rarely be at a level of resolution suitable for an assessment at the third order watershed level. Consequently, a key element of the cumulative watershed effects assessment will be a listing and mapping, as appropriate, of signs either observed in the field or obtained from existing data sources that indicate the level of cumulative effects. Although the signs will vary by region and by watershed to some degree, some include:

- Aggraded stream reaches or pools due to excessive inputs of sediment or reduced streamflow (Lisle 1982, Murphy 1995)
- Bank erosion or channel incision due to increased peak flows (Frissell 1992))
- Lack of large woody debris in the streams (Bilby and Ward 1989)
- Patchy or sparse riparian canopy, lack of large riparian trees
- Excessive stream temperature (Beschta et.al. 1987)
- High landsliding rates from recently managed areas compared to older or unmanaged areas (PWA 1998)
- Area harvested within a decade exceeds 20% of watershed area (Stednick 1996)

To render a professional opinion on the status of the watershed assessment area, it may be necessary to compare observed conditions to reference conditions for watersheds that are properly functioning or to refer to literature values from watershed studies elsewhere in the Pacific Northwest region. Sources of reference information can include Basin Plan water quality standards, the CDFG Salmonid Habitat Restoration Manual, thresholds used by NCWAP in its EMDS modeling and TMDL studies. In addition, the MSG has compiled a list of “reference watersheds" for most of California. These are considered to be properly functioning and in good condition. Data availability for these watersheds is variable. If a large ownership is being managed under a single landscape scale plan and adequate computer modeling is available it may be relevant to refer to a simulated range of natural variability across the landscape in evaluating CWEs (USDA 2002). Another approach for evaluating the status of CWEs in the watershed is comparison of current conditions to conditions described in the literature. A comprehensive review of cumulative forestry effects was prepared by Beschta et al. (1995) and could be used to evaluate the relative condition of the subject watershed in light of proposed activities. CDF (1998) also prepared a summary of cumulative effects information that is specific to California, which could be referred to for evaluating watershed condition.

Whatever sources or methods are used to evaluate the existing status of the watershed assessment area should be cited and a rationale presented for their use.

Develop estimates of future management: after completing the evaluation of existing conditions, the RPF needs to project out what management activities are likely in the watershed assessment area over the analysis period (recommended to be at least 10 years). This projection will include preparation of the specific THP for which approval is being sought. There will often be difficulties in projecting future activities, especially in watersheds with multiple owners of relatively small parcels. It will also be difficult in single owner watersheds where, for business reasons, landowners may be reluctant to disclose their future plans. Nevertheless, without a projection of future management it is impossible to predict future impacts or assess potentially beneficial practices. The success of this proposed framework hinges on the willingness of RPFs and landowners to provide this information.

Estimates of future management should, to the extent possible, be spatially explicit. That is, future harvest locations, road locations and other activities should be shown on a map, ideally in relation to resources at risk. The minimum data needed includes the harvesting methods to be employed, potential road standards and total treatment areas. Some latitude must be allowed, both spatially and temporally because of uncertainty. In the absence of mapping future vegetation conditions, there should at least be an estimate of the number of acres by stand age class or structure for comparison with pre-project baseline conditions. The anticipated access system must be shown at least in general on a map. When resources at risk (e.g., unstable terrain) intersect with proposed management activities, it should be noted.

If future management projections cannot be reasonably estimated based on information provided by landowners, a "worst case" projection could be made on the basis of stand age data. That is, it can be assumed that all potentially harvestable stands will be harvested over the analysis period. It can further be assumed that historical or typical harvesting practices (evenaged or unevenaged) will be used and that access will be developed as necessary. This approach is clearly less desirable or realistic than using estimates based on landowner objectives. However, without some projection of future management, a cumulative watershed effects assessment will fail to provide the information required by review team agencies for decision making.

Projecting future stand age distributions for the watershed assessment area based on the "worst case" scenario is potentially a task that could be performed by CDF. These projections could be used for individual cumulative watershed effects assessments as a future baseline. Similar projections were made in past studies by the Timberland Task Force to evaluate future wildlife habitat conditions.

It should be noted that this sort of "worst case" or "build-out" approach has been used for many years by other cities, counties and other public agencies to do CEQA cumulative effects analysis. For example, water districts will commonly assess impacts of future development on water supplies and infrastructure by assuming build-out in their service area according to General Plan and zoning designations. This type of approach is not specifically mandated by CEQA guidelines but has become the common practice. Some of our interviewees have indicated that projections of future harvest have been prepared for Sustained Yield Plans and for other planning purposes.

Predict future risks: in this phase of the cumulative watershed effects assessment, the resources at risk, existing conditions and proposed future management activities are analyzed to predict future watershed conditions. In line with CEQA, predictions should first be made assuming no future activities in order to establish a baseline: is the watershed stable, recovering or degrading? What does the future hold in the absence of additional management activities? Then, future conditions should be estimated based on projected management activities. This estimate will have to be made with due consideration of the risk posed by alternative types of management.

In general, the management activities that pose the most risk to resources include timber harvesting on steep slopes, new construction of roads and skid trails, and new stream crossings (Dunne 2001). "Doing nothing" also can be a highly risky activity in watersheds where chronic sources of sediment delivery to streams remain untreated. Consequently, one basis for predicting future risk is anticipating the behavior of legacy features identified in the management history assuming that they are not treated.

As the first step in the risk assessment, harvesting and access proposals should be ranked in relation to where they are occurring (proximity to places either exhibiting or prone to cumulative effects), intensity and timing. That will permit the identification of situations that may require mitigation above and beyond the standard FPR BMPs. For example, of the various timber harvesting methods, evenaged management (clearcutting, shelterwood, seed tree) may pose the greatest risks if undertaken in places that are naturally susceptible to impact (unstable slopes, inner gorges) (Spittler pers. comm., Montgomery et.al. 2000, Amaranthus et.al. 1985). Evenaged management also tends to have the greatest impact on peak flows compared to uneven aged management (Beschta et.al. 1995).

At the scale of the entire watershed, risk from harvesting can be evaluated using qualitative or quantitative modeling techniques. For example, the literature suggests that harvesting 20-25% of a watershed over a decade has the potential for increasing moderate flood peaks (Stednick 1996). This effect has been documented for many different kinds of watersheds (Beschta et al. 1995). Higher peak flows, in turn, can trigger channel changes or increase downstream flooding. At site-specific scales, operations affecting riparian zones, unstable lands, erodible soils or known habitats for species of concern can be described.

Evaluation of the risk associated with road construction and use and stream crossings should consider that different construction standards may have different potential for causing or contributing to cumulative watershed effects. It is generally accepted that road risk is related to standards (width and slope), drainage (insloped versus outsloped), crossing design and location (geologic conditions and hillslope position). Sediment production is greatest when roads are wide, steep, insloped, heavily traveled and close to streams (Bilby et.al. 1989, Reid and Dunne 1984). The more information that can be provided on these characteristics, the more certainty there will be in predicting future risks. Different types of stream crossings likewise have different associated risks. Although the FPR require sizing of drainage to accommodate anticipated peak flows (up to 100 year flows on the coast and 50 year flows elsewhere), that is not the only concern. Many culvert failures are not due to flows but rather to plugging with debris. The special problems in watersheds with anadromous fish require different crossing designs to allow fish passage. Again, one approach is to rank the proposed road and crossing treatments by risk category and then determine if inherently vulnerable land areas or streams will be affected.

The final element in the prediction of future risk is the assessment of the potential performance of existing facilities in the watershed assessment area. These include roads and crossings that may or may not be used for management during the analysis period. Facilities located on unstable terrain or near streams should be evaluated, especially in terms of their potential response to stressing events. Existing crossings should be evaluated in terms of their capacity, condition, diversion potential, and ability to pass fish. If inadequacies or deficiencies in facilities are disclosed, they represent opportunities for mitigation and improving watershed conditions.

Depending on the resources at risk, results of scoping and conditions in the watershed, there may be a need to identify additional risk factors not associated with timber management activities. These factors may include (but are not limited to) land development (especially within floodplains or landslide runout zones), residential roads, water diversions and agricultural activities, including grazing. Although not controllable through the THP regulatory process, these risk factors can have an effect on the future conditions of the watershed.

Given the potentially large amount of data required to document current conditions and project future conditions for complex projects, it may be necessary to use computer databases, GIS systems and computer models, as Dunne (2001) suggested, to credibly forecast future conditions. Where resources at risk are minimal or management presents only minimal risk, a simple qualitative description of future conditions may be sufficient.

Identify measures that will reduce risk: the prediction of future risks and potential impacts is the starting point for evaluation of mitigation. Normally, mitigation measures will come from one or more of the following sources: 1) existing watershed, fish, or habitat assessments, 2) FPR; 3) RPF recommendations; and 4) review team recommendations either during the scoping phase or during the THP review phase. Final review team mitigation recommendations will come after the THP and cumulative watershed effects assessment have been filed. In the assessment itself, which will be prepared before THP filing, the RPF should confine the discussion of measures that will reduce risk to those in the FPR that are proposed by the RPF or landowner, or are proposed by review team agencies or the public during the THP NOP process. The review team can then add or modify measures on the basis of the documentation and pre-harvest inspections (see review step, below).

An underlying concept in this framework is that site-specific impacts of timber management activities can be mitigated through the proper implementation of FPR. Mitigations may include measures to reduce the risk of activities (alternative silvicultural and yarding prescriptions, alternative access or crossing designs), measures to avoid inherently vulnerable locations (avoidance of unstable areas, avoidance of streams) or preventative treatments (buffer strips, erosion control measures). Depending on watershed condition, additional measures may be proposed by the RPF or review agencies. These may include restoring habitats, upgrading roads, decommissioning abandoned roads or crossings or other improvements. In exceptional cases where the status of the watershed is severely impaired, proposed management is particularly risky, and/or rates of harvest are high, other methods such as deferring harvesting in specific locations, controlling watershed wide harvesting rates, implementing protective construction practices, or designating conservation areas through easements may be proposed.

As implied above, the identification of measures that will reduce risk is not confined to the specific THP currently proposed. Rather, it should be done for the entire watershed assessment area and for all anticipated future activities.

Document how measures will reduce risk: the capstone in the cumulative watershed effects assessment process is the analysis of how mitigation measures either required by the FPR or recommended by the RPF will actually reduce risk and offset any increases in cumulative impacts. This analysis can be initiated by creating a matrix in which specific potential impacts or resource risks are listed and cross-referenced to specific proposed mitigation measures. To meet the requirements of the FPR and CEQA, all potentially significant adverse effects should be mitigated. However, these are not limited to the effects of the THP currently proposed, but should include all reasonably foreseeable activities. To offset cumulative effects of all activities, measures applicable to future THPs may be required. Evaluating the effectiveness of such measures may require both qualitative and quantitative analysis. The documentation of these measures in the cumulative watershed effects assessment serves as a constraint on future operations. That is, the approval of future THPs may be contingent on implementing the measures proposed in the watershed-scale study.

The table below indicates how this part of the assessment might be presented. The example is simple and more elaborate documentation may be required, depending on watershed conditions and risks. The proposed mitigations are given as examples only and are not intended to be prescriptive.

Impact/Risk	**Scale(s)**	**Proposed Mitigation**	**Effectiveness**
Stream temperatures currently exceed optimums for fish. Harvesting in riparian zones could aggravate this condition.	Proposed and future THPs, stream network	Stream buffers on all THPs, limits on number of stream crossings, restoration of poorly stocked riparian zones	Shade canopy >85% will be maintained or created on all Class I and II watercourses

Certain portions of the watershed are susceptible to mass wasting. Harvesting or road construction on these lands could trigger landslides.	Proposed and future THPs, road system	No evenaged harvesting on unstable sites, no road construction or reconstruction on unstable sites	Avoidance of unstable sites and maintaining forest cover on unstable sites will reduce risk of mass wasting
Harvesting a large proportion of the watershed during the analysis period could increase the frequency and magnitude of moderate flood events.	Watershed, stream network	Harvesting will be limited to <15% of the watershed area over the analysis period	Controlling the extent of harvesting will reduce potential for increased runoff and peak flows

Measures to reduce risk may apply to existing conditions that are not associated with the present or future THPs. For example, the risk of culvert failures on legacy roads could be mitigated by decommissioning.

Completion of this task concludes the RPF’s assessment process.

Review of the THP and cumulative watershed effects assessment: it is assumed that the preparation of the THP and cumulative watershed effects assessment will occur simultaneously and when completed, the package will be filed for continued processing. At this point, the “normal” THP process would resume. That process would be constrained by the results of previous consultations and agreements by the review team agencies. However, the sufficiency of the cumulative watershed effects assessment in meeting the requirements of the approved study plan would be judged during the review process. If those requirements are met, review team agencies would not be permitted to bring up new issues. Review team agencies may determine that additional mitigation measures beyond those included in the cumulative watershed effects assessment are needed. In that case, they should be justified on the basis of their direct effect on risk.

Since the public also engages in THP review, there may be issues brought forward at this time that were not considered in the scoping phase. This is a potential snag in the process. The review team will need to consider issues of the public when responding to the THP NOP and conducting the scoping process.

Assuming that the THP is approved, the cumulative watershed effects assessment becomes part of the public record. It also becomes the required documentation for future THPs that may be proposed in the watershed. When future THPs are submitted, some amendments to the cumulative watershed effects assessment may be required to bring it up to date.

Monitoring implementation and effectiveness: the vehicle for monitoring the implementation and effectiveness of mitigation measures is the MSG THP monitoring program, including yearly hillslope monitoring, Modified Completion Reports and support for instream monitoring at the watershed scale. The MSG program may require some changes if monitoring effectiveness of measures intended to reduce cumulative watershed effects is to be accomplished. For example, monitoring could be focused in one to several watersheds where cumulative watershed effects have been assessed in order to validate predictions.

Personal Communications

Jim Able, RPF, June, 2003.

Dean Cromwell, CDF, JUNE 26, 2003.

Comments received from joint State and Regional Water Quality Control Board/CDF committee on cumulative effects, July 22, 2003.

Mark Jameson, CDF, July 3, 2003.

Shana Jones, CDF, July 2, 2003.

Jim Loughlin, CDF, July 2, 2003.

John Marshall, CDF, July 1, 2003.

Charlie Martin, CDF, July 3, 2003.

Pete Ribar, Campbell Timber Company, July 1, 2003.

Bob Rynearson, Beatty and Associates, July 1, 2003.

Tom Spittler, California Geological Survey, July 1, 2003.

Jeff Webster, Roseburg Forest Products, July 17, 2003.

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