REVIEW OF THE "SALMON MATRIX" PREPARED FOR THE PACIFIC LUMBER COMPANY AS PART OF THEIR HABITAT CONSERVATION PLAN

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1. Executive Summary

a. Impetus and goals for the review

In March 1997, federal and state agencies developed an aquatic matrix for the Pacific Lumber Company Habitat Conservation plan (hereafter "salmon matrix"). The matrix puts forth a condition for the landscape which ash been determined to be properly functioning in order to meet the habitat needs of anadromous salmonids and other aquatic species in northern California on Pacific Lumber Company (PALCO) properties in Humboldt County.

In October 2000, The University of Miami (UM), through the "UM Independent System for Peer Reviews" and Rosenstiel School of Marine and Atmospheric Sciences (RSMAS), formed a panel of experts for the purpose of evaluating the salmon matrix. Each consultant was to prepare a report based on his individual opinions of the science in his area of expertise and not that of the group. Thus, no consensus report was to be produced. The itemized tasks of the consultant include:

1) reading and analyzing the relevant documents provided to the consultant;

2) participating in a 4-day meeting with the other consultants and NMFS officials in Arcata, CA, from 27-30 November 2000;

b. Main conclusions and recommendations

1. It is critical to measure the success for all life stages of salmonids while in the freshwater: egg mortality, survival-to-emergence, spawning success, carcass counts, etc.

2. Salmonid abundance is affected by stream habitat conditions, and some species (i.e., coho) are more sensitive to habitat than others (i.e., steelhead, fall chinook). Moreover, it is important to remember that salmonid abundance is affected by factors other than habitat. Therefore, one must be careful to recognize that the "properly functioning" habitat prescribed by a matrix may not be sufficient alone to meet the needs of anadromous salmonids and other aquatic species.

3. Little seems to be known about the degree to which "properly functioning" measures can possibly be obtained in salmonid streams of northwest California given the geology and natural disturbance regime. It would be unwise to promulgate regulations based on habitat that cannot be justified without a reasonable evaluation of past and existing habitat conditions in those streams. The thresholds between properly functioning, at risk, and not properly functioning

habitat, are difficult to justify. It would be better to deal with distributions of data (i.e., probabilities of occurrence) rather than thresholds.

4. The "properly functioning conditions" of the salmon matrix do not identify an acceptable timeframe in which habitat should be expected to improve as various entities follow habitat conservation plans. This means that some habitat elements may indeed reflect recent land use history while others are still adjusting to geologic events that occurred before human interference in the system. Therefore, it is important not to ascribe all negative aspects of habitat conditions to recent land use out-of-hand. One of the most difficult challenges in geomorphology is to separate change due to human activities from change that would have occurred without human interference. This single statement explains why the "one size fits all" prescriptions of the salmon matrix are unworkable.

5. The matrix claims "All indicators are interrelated, many are interdependent, and should be viewed together as a functioning system." However, the matrix does not follow through on this claim. Instead, the indicators are treated separately. Still, these variables do not adjust to watershed disturbances over a time frame against which land management activities can be assessed. A more perplexing problem is that it is difficult to compare intact versus impacted watersheds in the region. So few intact watersheds remain. The cumulative effects are not well-thought out in the matrix.

6. The salmon matrix was meant to be an evolving document, subject to revision as new literature appeared. However, it is apparent that no procedure was put into place to guide these changes. Thus, the document has fallen short of the promise to serve as a tool in adaptive management. Specifically, it is not clear *who* should update it, nor is it clear *when* it should be updated. The matrix does not answer the question for which it was designed: is land management working?

c. Interpretation of the findings with respect to conclusions and management advice

I recommend that the matrix be abandoned altogether. To replace it, a system should be established that will encourage the exchange of data and collaboration to acquire new data between regulatory and management agencies, researchers, consultants, and private companies.

Habitat monitoring, other than of suspended sediment concentrations, will not achieve the objective of obtaining viable populations of smolt. Agencies should move away from inflexible rules that cannot be justified for specific streams. Instead, management prescriptions should be treated as an experiment using conceptual models that link watershed disturbance directly with smolt. This is the intent of adaptive management.

Chose indicator variables that: 1) are sensitive to timber harvest activities in a timeframe that allows adaptive management; and 2) can be measured in an accurate, precise, and reliable manner that is affordable. I suggest that *suspended sediment concentrations* would be the best indicator. They can be measured with accuracy, precision, and reliability. They can be measured quickly and inexpensively. Suspended sediment is a variable that responds over very short time frames to watershed disturbance. Every effort should be made to train citizen volunteers (I understand a group is already operating) to collect and analyze samples for suspended sediment.

2. Introduction

a. Background

In March 1997, federal and state agencies developed an aquatic matrix for the Pacific Lumber Company Habitat Conservation plan (hereafter "salmon matrix"). The matrix puts forth a condition for the landscape which ash been determined to be properly functioning in order to meet the habitat needs of anadromous salmonids and other aquatic species in northern California on Pacific Lumber Company properties in Humboldt County.

In October 2000, The University of Miami (UM), through the "UM Independent System for Peer Reviews" and Rosenstiel School of Marine and Atmospheric Sciences (RSMAS), formed a panel of experts for the purpose of evaluating the salmon matrix. Each consultant was to prepare a report based on his individual opinions of the science in his area of expertise and not that of the group. Thus, no consensus report was to be produced. The itemized tasks of the consultant include:

3) reading and analyzing the relevant documents provided to the consultant;

4) participating in a 4-day meeting with the other consultants and NMFS officials in Arcata, CA, from 27-30 November 2000;

5) no later than 15 January, 2001, submit a written report of findings, analysis, and conclusions to Dr. David Dies, UM/RSMAS, 4600 Rickenbacker Causeway, Miami, FL 33149.

b. Terms of Reference

Consultants were asked to address the following questions for the salmon matrix (scanned copy in appendix b):

1) Are the metrics used in the matrix appropriate for assessing aquatic and associated riparian habitat condition to meet the needs for threatened and candidate salmonid species? If not, which metrics would be appropriate and at what landscape scales?

2) Are the values provided for the metrics appropriate for assessing aquatic and associated riparian conditions to meet the needs of threatened and candidate salmonid species in coastal redwood systems? If not, which values would be appropriate and at what landscape scales?

3) Which metrics are the most appropriate for the assessment, monitoring, and adaptive management of aquatic candidate salmonid species in coastal redwood systems?

4) How should in-stream and riparian metrics be functionally and practically linked with upslope and watershed scale processes that, in part, determine their expression?

c. Panel membership

Members of the panel were: Michael Bradford, Richard Cunjak, Larry Marshall, Richard Marston, and Chris Soulsby. Bradford, Cunjak and Marshall are aquatic ecologists; Soulsby is a hydrologist. As a fluvial geomorphologist, I am restricting my comments to aspects of the salmon matrix that relate to my area of expertise.

d. Date and place

The panel was provided with background materials by mail. The panel met in Arcata, CA, at offices of the National Marine Fisheries Service (NMFS) on 27-30 November 2000, during which time the panel met with representatives from various federal agencies (e.g., NMFS, NPS, USFS), California state agencies (e.g., Fish & Game), and private firms (e.g., consulting firms, Simpson Timer Company). Additional materials were acquired during that meeting and thereafter.

e. Acknowledgements

I wish to acknowledge the efforts of John Clancy, fish biologist with NMFS in Arcata, and local coordinator of the November 2000 panel meeting. John made our job much easier by putting key background materials in our hands, arranging meetings with knowledgeable local scientists and resource managers, and adding clarity and focus to the issues at hand. I would also like to thank Matthew House and Nick Dusseau of Simpson Timber Company for conducting a field tour of their timberlands and Randy Klein of Redwood National Park for conducting the field tour of Prairie Creek National Park.

6. Summary of Available Information

Appendix a contains the bibliography of materials provided by the Center for Independent Experts (CIE). The reference list at the end of the report identifies the literature that I have reviewed in my own literature search. In addition, the panel met with the following individuals (listed in alphabetical order):

Greg Bryant, NMFS, fish biologist
Bill Condon, California Department of Fish & Game
Sam Flanagan, NMFS geologist
Randy Klein, National Park Service, hydrologist
Sharon Kramer, Stillwater Sciences, fish biologist
Maryann Madej, USGS, geologist
Leslie Reid, USFS, geologist
Margaret Tauzer, NMFS, hydrologist
Bill Trush, McBain & Trush, fluvial geomorphologist & fish biologist

4. Review of Information used in the Assessment

In this section, I will comment on selected individual indicators as used in the salmon matrix.

a. Water quality

TEMPERATURE: no comments.

SEDIMENT/TURBIDITY: A convergence of opinion exists that suspended sediment may be the key variable in salmonid habitat of coastal redwood streams. Chronically high suspended sediment concentrations during low flow conditions are more important than concentrations at peak flows. Suspended sediment can be lethal to fish, but also has sub-lethal effects (e.g., damage to tissues and organs, growth rates) and behavioral effects (e.g., feeding efficiency). Suspended sediment concentrations are easily monitored, whether by automated (e.g., ISCO) samplers or by citizen groups. Suspended sediment is a habitat element that, to a large degree, responds quickly to geomorphic change on hillslopes or in stream channels. The Regional Water Quality Control Board has established TMDLs that are 20% over the background value. By this measure, every PALCO watershed exceeds the standard. New standards need to be set that are useful as indicators of improving or degrading watershed conditions. Habitat conservation plans (HCP) should be devised that relate the rate of timber harvest (e.g., percent watershed harvested per year) to changes in suspended sediment rating curves, and these changes could be related to changes in the smolt length-size class distribution. The goal of a HCP could then be set to move the size class distribution "to the right."

CHEMICAL CONTAMINATION/NUTRIENTS: no comment.

b. Habitat access

PHYSICAL BARRIERS:

c. Habitat elements

SUBSTRATE: The matrix is not sensitive to the relation between substrate composition and parent material. The Pleistocene, Plio-Pleistocene, and Mesozoic units produce contrasting sizes of substrate. One prescription cannot be expected to apply to all. The substrate composition has also changed with episodes of aggradation after the major mass movement events of 1955 and 1964. Subsequent winnowing of small gravels from these deposits has, in some cases, left an armor layer of lag gravels. This process is translated from upstream to downstream through time and could overwhelm any local inputs of bed material, making it difficult to apply a uniform prescription. It may take more than 100 years to evacuate sediment from mass movement events that occur once every 50 years. Thus, substrate conditions may forever be assessed as "not properly functioning." One must be careful to make this conclusion because much of the sediment (i.e., the fines) is being evacuated but older sediment may remain stored where it doesn't have a major impact on the channel.

LARGE WOODY DEBRIS: The prescriptions for large woody debris (LWD) that require a stream reach to have just the right number of pieces in each size class are completely impractical. The size class distribution of LWD depends on the forest stand conditions in the riparian zone adjacent to, and upstream of a given reach. It depends on the size of the stream, mosaic of channel unit types, and stream reach pattern. The matrix vales developed from the work by Bilby and Ward in western Washington cannot be assumed to apply equally to Alaska, Oregon, and indeed California. The rates of LWD loading and in-stream residence for redwood trees will contrast strongly with rates developed for alder, Douglas-fir, or other species. The sizes are different and so are the decay rates. Finally, the LWD size class distribution in a given reach depends on antecedent flood events prior to when the LWD was surveyed. Were large log jams broken-up by peak flows, or did they trap LWD in transport and grow in size? A more reasonable criterion for assessing LWD would be to describe the "percent of channel affected," a variable that would be expected to vary from upstream to downstream.

POOL FREQUENCY: It is not reasonable to prescribe a uniform criterion for pool spacing to all types of reaches. The thresholds between properly functioning, at risk, and not properly functioning, are difficult to justify. The spacing will differ between various subtypes of meandering reaches and braided reaches. The spacing will differ depending on the size of the stream and the condition of the riparian vegetation. Because of the long response time between hillslope disturbances and changes in pool frequency, this is not a reliable criterion for monitoring channel conditions. What is ideal for habitat diversity may not be geomorphically reasonable given position in the drainage network?

POOL QUALITY: The filling of pools by fines is widely recognized as a seasonal phenomenon and is one that will vary by geologic setting. The Wildcat and Gold Bluff formations are Pleistocene nearshore marine units that are poorly consolidated, and produce abundant silt and sand, but low volumes of gravel. It cannot be expected that pool quality can attain the properly functioning condition as easily as in other geologic units.

OFF-CHANNEL HABITAT: no comment.

HOT SPOTS AND REFUGIA: no comment.

d. Channel condition and dynamics

WIDTH/DEPTH RATIO: This varies too widely with channel unit type to prescribe a uniform value. Again, what is optimum for fish habitat may not also be realistic geomorphically.

STREAMBANK CONDITION: The relation between streambank condition and suitable habitat may be inverse, contrary to what the matrix suggests. If the streambanks are undercut (i.e., vegetated but eroding), hiding habitat may be increased. This variable has not been fully explored in the matrix.

FLOODPLAIN CONNECTIVITY: I strongly believe that this variable is important in a number of ways and I have devoted a good portion of my career demonstrating it. The floodplain width:bankfull width ratio has been used by Dave Rosgen, Gordon Grant, and others to explain the relative abundance of various channel unit types. This relation sorely needs to be explored for streams in the redwood region of northern California. If streams are downcutting, an increase will be observed in the frequency of overbank flows and floodplain disturbance. The response time, however, is on the order of decades that may not be practical for adaptive management,

e. Flow hydrology

CHANGE IN PEAK/BASE FLOWS: The best fall Chinook (King) salmon catch in years has been reported off the northern California coast in 2000. It is reasonable to attribute this to good runoff conditions in the Sierra Nevada in the last three years (personal communication, Greg Bryant and Allen Grover, California Department of Fish & Game). The ability of adult salmonids to migrate and the timing of that depends on flow conditions. This must be one of the key elements of any habitat conservation plan. The findings from the Caspar Creek experimental watershed studies should be used to craft standards that mirror those for suspended sediment: relate the rate of timber harvest (e.g., percent watershed harvested per year) to changes in base flows, and these changes could be related to changes in the smolt length-size class distribution. The goal of a HCP could then be set to move the size class distribution "to the right." At present, the hydrologic impacts of land management have been essentially ignored in the matrix. Caspar Creek studies indicate that timber harvest increases base flows and may decrease small peak flows, while the higher peak flows may be increased. This would be significant if the suspended sediment concentrations at low flow are indeed problematic for salmonids.

INCREASE IN DRAINAGE NETWORK: See comments on roads below.

f. Watershed conditions

ROAD DENSITY AND LOCATION: The importance of roads cannot be overstated. They are significant sources of sediment through surface erosion and mass failures at crossings of steep channels. Federal and state agencies should do more to work with timber harvest firms to inventory roads, culverts, and old Humboldt crossings. "Hydrologically connected roads" should be redesigned at a rates that is negotiated between agencies and companies…sloping the road so runoff and sediment spills onto native soil rather than fill; using rolling dips (not berms, water bars), armoring the downslope side of roads, etc. Much potential exists for interaction between regulatory agencies and private firms in this area, especially considering the observation that road maintenance amounts to 80 percent of the operations budget of a timber firm.

DISTURBANCE HISTORY: At present, the rate that timber is harvested in a watershed is based on the rate of regrowth. Thus, a watershed will experience a 2.5% cut in any one year if the regrowth rate is 40 years. Unfortunately, we know little about measuring the cumulative effects of this strategy on stream habitat and fish abundance, so this indicator cannot be justified in the matrix.

RIPARIAN BUFFER: no comment.

5. Summary of Findings

1. Salmonids are on the decline in California waters, regardless of which ESA is examined. However, I am bothered by the lack of any systematic surveys for documenting these trends in a reliable (accurate and precise) manner. The data appear to be antidotal on which major decisions are being formulated. Considering that salmonid species in coastal redwood streams are candidate species for endangered or threatened status, and with so much acrimony over the impact of timber harvest on their status, the agency responsible for tracking the status of these species under the FESA, California Department of Fish & Game, ought to devote the necessary resources to survey salmonid abundance. Even more critical, fish counts at selected locations, repeated over time, will reveal much more about salmonid abundance than mere monitoring of habitat conditions. Massive expenditures for habitat inventories reveal little about what matters the most: fish abundance. The matrix protects habitat, not fish. It should be the goal of habitat conservation plans to protect a viable population of smolts that will lead to a sustainable population of salmonids over time. It is critical to measure the success for all life stages of salmonids while in the freshwater: egg mortality, survival-to-emergence, spawning success, carcass counts, etc.

2. Salmonid abundance is affected by stream habitat conditions, and some species (i.e., coho) are more sensitive to habitat than others (i.e., steelhead, fall chinook). Moreover, it is important to remember that salmonid abundance is affected by factors other than habitat, including:

    1) interspecies competition;
    2) estuary habitat degradation;
    3) sport and commercial fishing;
    4) Native American fishing;
    5) shift in ocean currents;
    6) worms have been known to eat the salmon eggs after deposition in the gravel; and
    7) predation in the ocean by seals, sea lions, waterfowl.

    Therefore, one must be careful to recognize that the "properly functioning" habitat prescribed by a matrix may not be sufficient alone to meet the needs of anadromous salmonids and other aquatic species.

3. The indicators in the matrix were compiled based on a reasonable evaluation of the literature, and for this the authors of the matrix are to be commended. The matrix was developed in a short time frame. However, so little seems to be known about the degree to which "properly functioning" measures can possibly be obtained in salmonid streams of northwest California given the geology and natural disturbance regime. The Franciscan assemblage of geologic that dominate watersheds of the region are subject to mass movement, especially earthflows, and the entire region is experiencing rapid uplift. Some of the younger Pleistocene formations (e.g., Wildcat, Gold Bluff) near the coast are poorly consolidated and contribute massive amounts of fines. Major earthquakes have occurred in the region about once every 300 years; major floods have occurred every 25 years. It would be unwise to promulgate regulations based on habitat that cannot be justified without a reasonable evaluation of past and existing habitat conditions in those streams. The thresholds between properly functioning, at risk, and not properly functioning habitat, are difficult to justify. It would be

better to deal with distributions of data (i.e., probabilities of occurrence) rather than thresholds.

4. The "properly functioning conditions" of the salmon matrix do not identify an acceptable timeframe in which habitat should be expected to improve as various entities follow habitat conservation plans. Stream habitat elements are essentially geomorphic features that are adjusting to sudden as well as gradual environment change in the past. The rate of geomorphic adjustment over time is proportional to the spatial scale of the feature. For example, the longitudinal profile adjusts over 1000s and 10,000s of years, responding to episodes of uplift, changing sea level, and progressive denudation through contrasting lithologic units. Moderate-scale features such as channel unit types adjust over decades, while smaller-scale features such as channel bedforms adjust over a year or less. This means that some habitat elements may indeed reflect recent land use history while others are still adjusting to geologic events that occurred before human interference in the system. Therefore, it is important not to ascribe all negative aspects of habitat conditions to recent land use out-of-hand. One of the most difficult challenges in geomorphology is to separate change due to human activities from change that would have occurred without human interference. This single statement explains why the "one size fits all" prescriptions of the salmon matrix are unworkable.

5. The matrix claims "All indicators are interrelated, many are interdependent, and should be viewed together as a functioning system." However, the matrix does not follow through on this claim. Instead, the indicators are treated separately. It is necessary to cross-correlate the parameters using field data from northwest California salmonid streams. One possible approach would start by stratifying the region by ecoregion (overlay of geology, vegetation, soils, landforms). The timber harvest history for each watershed could be mapped. Next, a spatial model could be developed that predicts the type of stream reach given position in the watershed (i.e., distance from headwaters), proximity of hillslopes (i.e., width of the floodplain), and bankfull width. Then, for each stream reach, develop a probability model that identifies the expected frequency of channel unit types (e.g., pools, riffles, glides, runs, cascades, steps). Still, these variables do not adjust to watershed disturbances over a time frame against which land management activities can be assessed. A more perplexing problem is that it is difficult to compare intact versus impacted watersheds in the region. So few intact watersheds remain. The cumulative effects are not well-thought out in the matrix.

6. The salmon matrix was meant to be an evolving document, subject to revision as new literature appeared. However, it is apparent that no procedure was put into place to guide these changes. Thus, the document has fallen short of the promise to serve as a tool in adaptive management. Specifically, it is not clear *who* should update it, nor is it clear *when* it should be updated. The matrix does not answer the question for which it was designed: is land management working?

6. Recommendations

a. Data collection and analyses

I recommend that the matrix be abandoned altogether. To replace it, a system should be established that will encourage the exchange of data and collaboration to acquire new data between regulatory and management agencies, researchers, consultants, and private companies.

Habitat monitoring, other than of suspended sediment concentrations, will not achieve the objective of obtaining viable populations of smolt. Agencies should move away from inflexible rules that cannot be justified for specific streams. Instead, management prescriptions should be treated as an experiment using conceptual models that link watershed disturbance directly with smolt. This is the intent of adaptive management.

b. Assessment methods

Chose indicator variables that: 1) are sensitive to timber harvest activities in a timeframe that allows adaptive management; and 2) can be measured in an accurate, precise, and reliable manner that is affordable. I suggest that *suspended sediment concentrations* would be the best indicator. They can be measured with accuracy, precision, and reliability. They can be measured quickly and inexpensively. Suspended sediment is a variable that responds over very short time frames to watershed disturbance. Every effort should be made to train citizen volunteers (I understand a group is already operating) to collect and analyze samples for suspended sediment.

7. Implications

If these recommendations are implemented, I believe it will serve to reduce the suspicion and acrimony that exists between regulatory agencies and land management firms. The distrust of both by the public should be alleviated. Most everybody agrees that a viable salmonid population is a desirable goal. Any change that takes the process out of the hands of attorneys and puts it back into the hands of scientists and timber managers, working together, would be a worthwhile endeavor.

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9. Appendices

a. Bibliography of materials provided by the Center for Independent Experts

<u>PART I: Matrix Cited Literature</u>

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PART III: Other Documents

Public/Private Comments on Matrix for Pacific Lumber HCP (INCLUDES SEVERAL COMMENTS)

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b. Statement of Work (scanned version on following page)

STATEMENT OF WORK

Consulting Agreement Between the University of Miami and Richard Marston

October 23, 2000

General

In March 1997, federal and state agencies developed an aquatic matrix for the Pacific Lumber Company Habitat Conservation Plan (hereafter "salmon matrix"). The matrix puts forth a condition for the landscape which has been determined to be properly functioning in order to meet the habitat needs of anadromous salmonids and other aquatic species in northern California on Pacific Lumber Company properties in Humboldt County.

Consultants shall need to address the following questions for the salmon matrix review:

1. Are the metrics used in the matrix appropriate for assessing aquatic and associated riparian habitat conditions to meet the needs for threatened and candidate salmonid species? If not, which metrics would be appropriate and at what landscape scales?

2. Are the values provided for the metrics appropriate for assessing aquatic and associated riparian habitat condition to meet the needs of threatened and candidate salmonid species in coastal redwood systems? If not, which values would be appropriate and at what landscape scales?

3. Which metrics are the most appropriate for the assessment, monitoring, and adaptive management of aquatic candidate salmonid species in coastal redwood systems?

4. How should in-stream and riparian metrics be functionally and practically linked with upslope and watershed scale processes that, in part, determine their expression?