

TIME, SPACE, AND REDWOOD TREES

Leslie M. Reid¹

Abstract: Our past concern with details gave us the type of information we needed to manage blocks of redwoods to produce the values we decided were important. But the values that have more recently been recognized as important—species viability, genetic diversity, and so on—cannot be managed on the scale of forest patches, and we must come to understand how biological, sociological, and physical processes interact to create the redwood ecoscape. These issues force us to look at the redwood ecoscape as a whole, and even the precepts of the problems are new. First, things change. The distribution of redwoods reflects the pattern of past climates and disturbances, and there has never been a steady-state distribution because conditions throughout the redwoods' potential range change continually through time. At the same time, the forest modifies its own environment as it grows. Second, normal isn't normal. In many systems, the rare, large disturbances ultimately control the character of the ecoscape. We thus cannot manage for average conditions, but must manage for the extremes, and this is difficult if our management history is so short that our methods have not yet been tested by the extremes. And third, the divisions between disciplines are relatively arbitrary. The nature of a question determines the information needed to answer it, and the questions increasingly demand interdisciplinary answers. These three conceptual hurdles have made it difficult to develop management strategies that address the spatial and temporal scales relevant to newly emerging issues.

Introduction

We know a lot about redwood trees, and we know a lot about redwood forests. We know very little about the redwood ecoscape, about how the biological, sociological, and physical settings conspire to create the look and feel of Redwood Country. In the past, our attention to details has served us well. We have the information about germination requirements, responses to flooding, and other details that we need to manage patches of redwoods to produce the values we have decided are important. Or at least we did until a new set of values arose that began to transcend the boundaries of the patches. Now we live in a world where the viability of the marbled murrelet, the genetic diversity of *Sequoia sempervirens*, the need for a diversified economic base, and the potential responses to global warming have become important; and these issues cannot even be conceptualized on the scale of manageable-sized patches. The issues have forced us to start looking at

the redwood ecoscape on the temporal and spatial scales defined by the redwood ecoscape and to start looking at the interdisciplinary aspects of the larger-scale problems.

The increasing demand for broader examination of environmental issues has resulted in the institutional development of watershed analysis procedures. Such analyses are now called for by Washington State as a step in the development of land-use plans (Washington Forest Practices Board 1993) and by the US Departments of Agriculture and the Interior for facilitating management of federal lands in the northwestern United States (USDA and USDI 1994). The State of California has also adopted watershed analysis as a strategy that can be used in developing sustained yield plans for timber management on private lands. There is, thus, an increasing call for evaluating the broader context for a proposed action, and satisfying this need requires an understanding of the spatial, temporal, and societal contexts for the existing ecoscape. This paper examines three of the aspects of this broader context that have proved to be difficult to evaluate not because of technical failings, but because the ideas are alien.

The Changing Environment

First, things change. It is difficult for most people to look at a familiar landscape and see in it the evidence for past upheavals, or to detect the features that will create future changes. Most of us make the unconscious assumption that what we see now is the way it has always been, and that what we see now is the way it should be. The first conceptual challenge is to develop an appreciation for the magnitude of the changes that have characterized the redwood ecoscape in the past and of those that might influence it in the future.

At the smallest scale, the forest creates its own micro-environment. The habitat we associate with riparian redwood groves—deep, organic-rich soils, massive logs criss-crossing the forest floor, torrential fog drip, cool shade in the summer—was not the habitat that gave rise to the groves. Instead, these ancient trees embarked on life on a barren, inhospitable, recently deposited floodplain. Only as the stands matured did they produce the conditions with which we are familiar.

¹ USDA Forest Service Research, Redwood Sciences Laboratory, 1700 Bayview, Arcata CA 95521

The forests, in turn, modified the channels that created the floodplains. It takes a lot of river to carry off a 12-foot-wide log, and most creeks don't even begin to qualify. It also takes a very long time for a redwood log to disappear through decay, and fallen trees often hang onto life through sprouts. Redwood-forest streams, thus, are more strongly influenced by logs than are those in other types of forests, and this influence makes streams change character as stands age.

The stability of floodplains also changes as riparian forests grow. More roots give more cohesion to the soils and banks, and increased vegetation slows flood waters, decreasing their erosive power. At the same time, more fallen trees increasingly arm the flows in large streams, giving floods the means to bulldoze down riparian stands, or to create old-growth log jams.

Redwoods are where redwoods are because of the pattern of past disturbances on the ecoscape—there has never been a “steady-state” distribution of redwoods because there has never been a steady-state distribution of processes controlling redwood distribution. Climates have fluctuated wildly even since the end of the Ice Age, and the present ecoscape integrates the past conditions. Redwoods can germinate and seedlings can become established under specific conditions that may have been present in some places for short intervals, but a redwood tree has several millennia of staying power once a seedling becomes established. In other words, there is no guarantee that a redwood stand, once removed, is capable of regenerating from seed. This is particularly true for stands near the margin of the species' range.

Work by Campbell (1979) demonstrates that genetic diversity among Douglas-firs is manifest at the scale of microhabitats: trees growing in damp microhabitats are genetically distinct from those growing nearby in drier sites. The same potential for genetic fine-tuning is present over the range of a species. This is the principle that prompts silviculturalists to ensure that sites are restocked with plants from local sources: seedlings from Cascade Douglas-firs are not used to re-stock coastal sites because they do not grow very well on the coast. Similarly, individuals that persist near the margin of a species' range are likely to be genetically distinct and best adapted to the conditions present there. These individuals become a very important genetic resource if the overall conditions shift to more closely resemble the conditions present at that margin; these individuals have developed and preserved the traits that may allow the species as a whole to survive the new conditions. For instance, it is the southern-most stands of redwoods that may be best adapted to conditions that might arise from global warming. As long as these stands are preserved, there is a possibility for those traits to spread north with the changing climate. As the continuity of stands decreases, however, this shift will increasingly become the responsibility of silviculturalists rather than of nature; isolated stands do not interbreed without help.

These considerations have important implications for the design of reserves. Often, marginal populations are considered the most expendable, and greater effort is put into preserving characteristic stands near the heart of a species' range. A broad understanding of the types of changes that have occurred in the past and might occur in the future is necessary both to determine the goals of management and to recognize the likely pitfalls.

The Events That Count

The second difficult message is that normal is not normal. To most, a stable ecosystem is a healthy ecosystem, and there is little recognition of the fact that many biological communities require periodic destruction if they are to remain a part of the ecoscape. We are coming to understand that it is the rare, large disturbances that ultimately control the character of many ecosystems; significant, high-intensity trauma happens. However, if the character of the large events changes through anthropogenic activities, then the entire system may become vulnerable to a new type of destruction from which it may not be able to recover in its accustomed form.

In the past, flooding was an important factor in the establishment and development of riparian redwood stands. Floods prepared the canvas; floods renewed the soils; and floods eventually destroyed the stands through channel migration and erosion. The stands, in turn, were uniquely equipped to take advantage of the floods' bounty and minimize their devastation. Adventitious roots developed to tap the nutrients in silty flood deposits, and the oversized boles, once fallen, often were stable enough to form a barrier to further battering of the stands. Now, however, conditions have changed. Accelerated erosion in the region has loaded the floods with gravel instead of silt, and large jams of small trees can divert channels across floodplains with impunity. Increased sediment loads force channels to aggrade with excess sediment, and channel gravels are now increasingly deposited on floodplains in place of silt. At the same time, the size of the floods may have increased due to an increased severity of rain-on-snow floods associated with widespread clearcutting (Christner and Harr 1982). Here is a case, then, where the character of riparian stands will change inevitably due to an anthropogenic shift in the disturbance regime.

Floods occur frequently enough and the 1964 flood occurred recently enough that floods are widely accepted as “normal.” Drought and fire, however, fall into a different physiological category of disturbance. Drought, for example, is rarely recognized as a natural agent that influences stand structure. The drought of the 1980s was a natural event in the Sierra Nevada, yet many bemoaned the drought-induced mortality in Sierran forests as a disaster that was destroying the character of the forests. Similarly, mortality of red fir stands in northwest California was

interpreted as a disease problem that had to be remedied rather than as a natural adjustment to prolonged dry conditions.

Now consider the effects of a drought from the point of view of old-growth forests. One of the characteristics of old-growth stands is a relatively low stocking density of large trees. Today's younger stands, in comparison, are heavily over-stocked. The old-growth forests have experienced several droughts of far greater severity and duration as the recent one; the young stands have not. The drought affected young stands by increasing the susceptibility of the more poorly adapted or disadvantageously sited trees to attack by insects or disease, and the resulting mortality reduced stocking densities toward those more characteristic of old-growth forests. The loss of the "cull" trees then increased the soil moisture available to the survivors by reducing the competition; the stands thus became better adapted to survive drought conditions, as, in a very small way, did the gene-pool of the species as a whole. The key idea here is that droughts are a normal, repeated event on the scale of a tree's lifespan, and the character of old-growth stands may very well reflect the influences of a few past droughts more strongly than it reflects the intervening decades of average conditions. If one were reconstructing climate from stand characteristics, one might infer that drought is more "normal" than average is.

Fires fall into a similar category as drought in that they are rare enough and spectacular enough to be considered catastrophic, yet they are frequent enough to have strongly influenced the character of old-growth forests. The normalness of fires, however, is increasingly being recognized, and forest managers now include prescribed burning as a management tool. But unlike drought—and like flooding—the fire regime is one that has been strongly affected by human endeavors. Recent studies in the Sierra Nevada show that the average annual area burned has decreased in the face of fire-control efforts, but that the average fire intensity has increased. The low-intensity fires are the easiest to control, so they have largely disappeared from the landscape (McKelvey et al. in press). This change in fire character will influence forest stand structures, overland-flow runoff volumes, surface erosion rates, soil characteristics, predation rates, forage availability, and so on. Characteristics of even the remaining old-growth stands are not the same as they were, under the pre-Euro-American fire regime.

The relation between management and natural catastrophe has been an odd one, quite apart from the influence of management on catastrophe. Managers are well-accustomed to managing for extreme events when it comes to flooding. Road culverts, for example, must be built to accommodate floods of specified sizes, and zoning recognizes the boundary of the 100-year floodplain. When it comes to drought, fire, or landslide, however, the rules are different. When one of these events occurs naturally, it

is considered an act of God which could not possibly have been foreseen. If management practices conspired to aggravate the natural effects, that's too bad; the damage was still due to the capriciousness of Mother Nature rather than to the influence of humans. Thus the suitability of salmon habitat is judged according to what is present in average streams under the conditions that were present when they were surveyed, and the ability of the channel to provide refuge during drought is not considered. Similarly, water rights are usually based on average flows, and riparian shade requirements do not provide for worst-case (read, "normal") conditions during which parts of the buffers are downed by wind or fire. For anything but floods, forests are managed under the assumption that average conditions are the ones that are to be expected.

However, interviews conducted soon after the 1980s drought suggest that the populace is developing a different view of "normal" and of the responsibilities of land management (Reid, in review). In one case, aggradation had prevented chinook from returning to a drought-stricken channel; a channel passable under average flow conditions had been widened by human activities until it was too shallow for passage during the dry years. One respondent described the role of the drought as "developing the film that had been exposed by land management." In other words, the impacts of management simply had not been apparent before the drought, and it was the responsibility of the land managers to ensure that their activities were not altering the ecoscape in such a way that it could not cope with the very natural occurrence of a drought. The drought was an act of God, but the impacts were caused by human activities. This is the standard applied in the case of flooding, and it appears likely that it will be increasingly applied to management in the face of other foreseeable disturbances.

We, thus, cannot manage for average conditions but must manage for the extremes. This is hard to do if our management history is so short that it has not yet been tested by extremes. Adapting management practices to allow for such disturbances will require an increased understanding of what those disturbances are, how frequently they occur, what their influences on the ecoscape are, and how they interact with management practices. In particular, their influence over long time spans must be understood, as must the potential for future changes. Global climatic changes, for example, may now be influencing the severity and duration of droughts.

The Interdisciplinary World

The third difficult concept is one that unites the two discussed above: both require an interdisciplinary perspective if they are to be dealt with. The interdisciplinary perspective is surprisingly difficult to

develop both because of societal pressures and because of individuals' propensities.

The division between disciplines is capricious. A botanist cannot explain why a particular floodplain supports big trees any more than a geomorphologist or a hydrologist can, but together, they can do a very good job of it. The nature of the question determines the information needed to answer it, and more and more often, the questions are demanding interdisciplinary answers. Everything is connected, both physically and conceptually. To understand the habitat use of fish in redwood streams, for example, we must understand the habitats those streams provide, and to understand those habitats, we must know something about the large woody debris inputs to the stream system. We thus must understand the demographics of and nature of disturbance in riparian stands, which means we must know something about the flood regime, climatic extremes, and landsliding patterns. It sounds complicated only because we are not used to thinking this way. We are not used to designing strategies to answer questions for which answers require information from more than one discipline.

But consider the issues of importance in Redwood Country: How can we best protect the remaining coho? What strategy for commodity production will best sustain jobs in northwest California? What will happen to the redwoods when the climate changes? What rate of gravel extraction is appropriate? How should we manage estuaries? Every one of these is an inherently interdisciplinary question, yet each has been seized by a different discipline, largely to the exclusion of the others. And, historically, each time a particular discipline has come up with a solution to problems like these, the solution has been shown to be unworkable when it is

finally exposed to the broader reality represented by the previously excluded disciplines. Unless we develop the facility for answering interdisciplinary questions, we are doomed to keep producing irrelevant solutions.

Literature Cited

- Campbell, R.K. 1979. Genecology of Douglas-fir in a watershed in the Oregon Cascades. *Ecology* 60: 1036-1050.
- Christner, J., and R.D. Harr. 1982. Peak streamflows from the transient snow zone, Eastern Cascades, Oregon. *Proceedings of the 50th Annual Western Snow Conference*. Pp. 27-38.
- McKelvey, K.S., C.N. Skinner, C.P. Weatherspoon, D.J. Parsons, D.C. Erman, J.W. van Wagtendonk, S.J. Husari, and C. Chang. In press. Fire in the Sierra Nevada, an overview. In: *Status of the Sierra Nevada, Volume 2*. University of California Wildland Resources Center Report.
- Reid, L.M. In review. Evaluating timber management effects on beneficial water uses in northwest California. Report to the California Department of Forestry and Fire Protection.
- United States Department of Agriculture and United States Department of the Interior. 1994. Record of Decision for amendments to Forest Service and Bureau of Land Management planning documents within the range of the northern spotted owl; Standards and Guidelines for management of habitat for late-successional and old-growth forest related species within the range of the northern spotted owl. U.S. Government Printing Office 1994 - 589-111/00001 Region no. 10.
- Washington Forest Practices Board. 1993. Standard methodology for conducting watershed analysis under Chapter 222-22 WAC. Version 2.0. Department of Natural Resources Forest Practices Division, Olympia, WA.