Proceedings of the

Conference on the Restoration and Management of Coast Redwood Forests: Jackson Demonstration State Forest

College of the Redwoods
Mendocino Coast Campus
Fort Bragg, California
November 4 and 5, 2000

Sponsored by The Mendocino Institute

Proceedings of the

Conference on the Restoration and Management of Coast Redwood Forests: Jackson Demonstration State Forest

College of the Redwoods
Mendocino Coast Campus
Fort Bragg, California
November 4 and 5, 2000

Sponsored by The Mendocino Institute

Russel, William H. and Calvin Winslow (editors). 2000. Conference on the Restoration and Management of Coastal Redwood Forests. Mendocino Institute, Fort Bragg, CA. 64 p.

These proceedings summarize the results of a conference designed to address current issues about restoration and management of public forest lands in the redwood region.

Retrieval Terms: community based forestry, forest ecology, forest management, timber harvest, coho salmon

Conference Sponsor

Mendocino Institute
P.O. Box 1781
Mendocino, CA 95460

Editors

William H. Russell is a Research Associate at the University of California, Berkeley Forest Science Division.
P.O. Box 1690
Mendocino, CA 95460

Calvin Winslow is the Director of the Mendocino Institute and a faculty member of the College of the Redwoods.

Publishers

Dharma Cloud Foundation
P.O. Box 1066
Mendocino, CA 95460
(707) 937-3001

Design and Layout

Persephone Fox
Campaign to Restore Jackson State Redwood Forest
P.O. Box 1789
Fort Bragg, CA 95437
(707) 964-5800

Conference on the Restoration and Management of Coast Redwood Forests: Jackson Demonstration State Forest

November 4 and 5, 2000
College of the Redwoods, Fort Bragg, California
William H. Russell and Calvin Winslow, editors

Contents

Preface

The papers presented here represent the results of the Conference, "Restoration and Management of Coast Redwood Forests." The Conference was held in November 2000 at the College of the Redwoods, Mendocino Coast Campus, and sponsored by the Mendocino Institute.

The Conference was called to develop educational materials concerning the Jackson Demonstration State Forest with the purpose of making a positive contribution to the important discussion, now taking place, concerning the future of this unique, publicly owned forest. It brought together scientists, planners, activists and managers working in the fields of forest and watershed restoration. More than fifty participants, mostly from Northern California, but also from Oregon and Colorado, considered papers and presentations based on original research and firsthand work and experience. There were two full days of intensive discussion and debate.

Jackson Demonstration State Forest is 50,000 acres of redwood timberland in Mendocino County in the rugged Coastal Range. It stretches from just west of the town of Willits nearly to the coast where it joins the Jughandle Reserve and the Russian Gulch State Park, as well as the backyards of residents in the communities of Fort Bragg, Caspar and Mendocino. It is administered by the California Department of Forestry, which oversees commercial timber harvesting by such companies as Mendocino Redwood and the Hawthorne Company.

The Conference was divided into two parts. The first day was devoted to forest ecology and management and watershed restoration. The second day focused on the forest and the communities and included sessions on education, the economy and community forestry.

In addition to the materials presented here, readers are invited to look on-line at the materials which were the basis of visual presentations by Pat Higgins (www.krisweb.com, *KRIS Noyo*), Jim Strittholt (www.consbio.org, *Conservation Focal Areas for the Redwood Region*), and Bill Lemos and Robert Jamgochian (http://musd.mcn.org/~sonar, *A School of Natural Resources*).

I would like to thank the Dharma Cloud Foundation for its generous support in funding the Conference; Barbara Rice, the Campus Vice President of the College of the Redwoods, for opening the College to us; the Thanksgiving Coffee Company and the Harvest Market for donations of coffee and refreshments; Helen Chalfin, the Director of Jughandle Farm for her hospitality; Bill Baxter and Marc Jameson of CDF for participation and helping to provide an early-morning firsthand view of the forest. I must also thank Steve Antler, the Director of the Campaign to Restore Jackson State Redwood Forest, for his enthusiastic support for the project from the beginning.

Special thanks go first to my colleague Dr. William Russell of the University of California, Berkeley, for his splendid paper opening the Conference and also for developing the intellectual framework in which constructive discussion and debate could take place. Finally, Professor Iain Boal of the Geography Department of the University of California, Berkeley, must be thanked first for agreeing to make the trek to the North Coast, then for presenting us with a range of ideas and explanations which placed our issues in a wider context and most importantly were designed to help sustain us in our current occupations and inspire us to future efforts.

Cal Winslow, Ph.D.
Director, The Mendocino Institute
Box 1789
Fort Bragg, CA 95437
707-961-9603

Ecology and Management of Coast Redwood (*Sequoia sempervirens*) Forests

William H. Russell, Ph.D.
Forest Science Division
University of California, Berkeley
P.O. Box 1690
Mendocino, CA 95460
(707) 937-3139
wrussell@mcn.org

Abstract

The past 150 years of management of coast redwood has significantly affected the diversity, structure, and function of the forest. Multilayered uneven-aged structure has been replaced with highly managed even-aged stands. Biological diversity has been reduced through the loss of habitat, and the basic sustaining ecological functions have been altered. The scientific assumptions that drove forest management in the early part of the twentieth century still affect management decisions in the redwood region 100 years later. These assumptions are based on scientific research that was limited by an inability to conceptualize life history strategies that span centuries. Consequently, timber harvest rotations have been too short. In addition, *Sequoia sempervirens* has been misclassified as a shade-intolerant species that requires large canopy gaps for regeneration, resulting in even-aged management for most forests. Through the understanding of current ecological theory within the historical context of forest management in the redwood region, much of the remaining forest can be restored to a healthy functioning system.

Introduction

The coast redwood (*Sequoia sempervirens*) forest is the result of millions of years of adaptation to changing environmental conditions (Raven and Axelrod 1977). From an ancestral range that included much of the Northern Hemisphere this forest type has been reduced, through massive climatological changes, to a narrow strip along the western edge of the North American continent (Peattie 1953). The evidence of this species' long evolutionary history is its extraordinary ability to withstand most natural disturbances (Viers 1996). Fire, flood, and pestilence are practically powerless against these trees (Fritz 1957, Greenlee and Langenheim 1990, Stuart 1987). The resistance of this forest type to human disturbance, however, is not as certain.

For the past 150 years timber harvesting has been occurring in coast redwood forests to the extent that only 5 to 6 percent of the primeval forest remains. What does remain, for the most part, are small isolated groves, surrounded by second-growth stands. With proper management, regenerating stands may once again be comparable to their old-growth counterparts. However, the time investment in growing a five-hundred-year-old tree is often difficult for private timber managers to justify. It is imperative, therefore, that public lands are managed and protected properly.

The redwood forest is more than a collection of trees. It is a complex community of plants, animals, fungi, and microscopic organisms that rely on each other and the ecological processes that sustain them. In order to plot a course toward restoration and sustainable management it is essential to understand both the ecology of the redwood forest as well as its management history. The purpose of this paper is to outline these issues, to point out instances where flawed scientific ideas have led to mismanagement, and to discuss how current ecological theory can be used to improve management and restore the diversity, structure and function of the coast redwood forest.

Land Management History

Prior to European settlement, coast redwood forests were relatively undisturbed by human activity. The native people of the region, who managed other vegetation types aggressively, did not affect redwood forests extensively (Huntsinger et al. 1994, Huntsinger and McCaffrey 1995). Minimal harvesting did occur for the building of dwellings and canoes, and some intentional burning was conducted around the edges of the forest, but it is unlikely that this activity had any measurable effect on the forests' range, composition or structure.

European settlement began in 1769 when the Spanish explorer Portola traveled overland from San Diego to Monterey Bay and eventually to what is now Santa Cruz County (Carranco and Labbe 1975). It was with this expedition that the coast redwood was given its common name "redwood," or "palo colorado" in Spanish. Spanish settlements moved northward to the San Francisco Bay over the next two decades. Missions were built along the California coast using adobe as the preferred building material. Some redwood was probably used as timbers for building framework, but the effect of harvesting on the local forests was negligible.

In 1812 Russians moving south from Alaska built a settlement north of San Francisco Bay known as Fort Ross. The fort was built using lumber harvested from trees growing on site, which included redwood, and some lumber was shipped to northern Russian outposts. As was the case with the Spanish settlements, the Russians exerted little influence on the distribution or structure of the redwood forest

The lumber demand by the Spanish settlements began to increase by the late 1820s. Indian labor used to supply timber in the past was no longer sufficient. Freelance American and British woodsmen began to cut trees and produce lumber using hand tools in the 1830s from Santa Cruz to Marin County in the San Francisco bay area. The first water-powered mills were erected in the redwood region in 1834 on the Russian River, and in 1842 near Mt. Hermon in Santa Cruz County. These mills were of limited productive capacity, however, and generally produced wood for the needs of the immediate area.

With the discovery of gold in the Sierra Nevada foothills in 1848 the demand for lumber increased dramatically (Andrews 1956, Leydet 1969). With fortunes in gold coming out of the placer mines, lumber was needed to provide timbers for mines and ties for the railroads. This boom time in the lumber business was reflected in the names of the communities that grew up around the large new commercial mills. Names like "Fortuna" and "Eureka" hearken to a time when fortunes were made in the woods as well as the gold fields.

Early logging was conducted with hand tools and ox teams. Splash dams were erected on the coastal rivers and creeks to store logs until enough water built up to float them down to the sea. This type of transporting practice is now thought to have been unusually destructive for anadromous fish habitat. Once logs were brought down to the shore they were loaded onto schooners, or bundled together into rafts for transport to southerly ports.

The steam engine was first employed by the logging industry in 1882, first as a means of hauling logs with a steam donkey from where they were cut to a central landing, then as a means of transporting lumber over greater distances with narrow-gauge railroads. These improvements eliminated the need for splash dams but also increased the volume of lumber that could be removed.

With continued advances in technology, and increases in population and prosperity the lumber industry continued to boom in California until the Great Depression. A temporary decline in timber demand was followed by another boom during the Second World War. This boom and bust cycle has repeated several times since, depending primarily on the economic factors that determine home building. The results of this cycle have been a steady decline in the acreage of old-growth redwood and a change in the character of the remaining forest.

The Decline of the Coast Redwood Forest

Prior to European settlement and commercial logging, virgin redwood forests covered roughly two million acres along the coast of northern California from Monterey County in the south to the southwestern corner of Oregon (Fox 1996, Griffin and Critchfield 1972, Olson et al 1990). Extensive logging began in the redwood region approximately 130 years ago and has continued to the present day, greatly reducing the range of the primeval forest. Fox (1996) studied conversion of old-growth redwood stands into second-growth stands and other vegetation types. His results indicate that the acreage of old-growth redwood forest has been reduced to less than 10 percent since the commencement of commercial logging, and continues to decline to this day.

The coast redwood forest type is dominated by a single species (*Sequoia sempervirens*) renowned for its unsurpassed height and its resistance to a variety of destructive agents. This forest type occurs in an irregular belt between 5 and 35 miles wide along the north coast of California and the southern coast of Oregon. Redwoods rarely grow closer than one mile to the coast because of intolerance to ocean winds and salt. In general the redwood forest is limited to mild and relatively wet climates. Fog has often been considered the most important climatic factor in relation to coast redwood distribution. This is supported by its nearly complete restriction to the geographic area influenced by coastal fog.

Redwood forests tend to be arranged vertically in three layers. The overstory layer includes coast redwood (*Sequoia sempervirens*) and to a lesser extent other trees such as Douglas fir (*Pseudotsuga menziesii*), grand fir (*Abies grandis*), and western hemlock (*Tsuga heterophylla*). The subcanopy layer includes hardwood species such as California bay (*Umbellularia californica*) and Tan oak (*Lithocarpus densiflorus*), as well as suppressed conifers. The understory layer contains a variety of species that are often dependent on the low light, high moisture microclimate created by the overstory. Some of the species common in the surface layer include huckleberry (*Vaccinium ovatum*), bilberry (*Vaccinium parviflorum*), redwood sorrel (*Oxalis oregana*), Douglas iris (*Iris douglasii*), salal (*Gaultheria shallom*), and sword fern (*Polystichum munitum*).

Regeneration of coast redwood occurs primarily through clonal sprouting from advantageous (burl) tissue at the base of the tree. A moderate amount of regeneration also occurs through seed. Redwood is a shade-tolerant species, and does not appear to regenerate as easily in dry exposed areas. In addition, redwood has a symbiotic root association with micchorhizal fungi further limiting its ability to survive on highly disturbed sites. The most productive coast redwood stands are located along stream flats and river bottoms where moisture is available in the summer drought months. Because of the predisposition of coast redwood to riparian sites, flood is an important ecological factor. The major impact of flood in this forest type is the deposition of silt. Deposits from a single flood have measured as much as 30 inches. Redwood and several associated understory species (California bay, redwood sorrel) are able to survive this silt deposition because of an ability to rapidly develop aerotopic roots. As most competing species are unable to survive silt deposit, flooding helps to perpetuate the redwood forest type. Fire also tends to favor coast redwood because of the fire resistant properties of its bark and its high crown. Windthrow is the most common agent of mortality in coast redwood, usually affecting single trees, or small groups of trees. Canopy gaps created by windthrow release suppressed subcanopy trees, allowing them to reach the upper canopy layer.

The Value of Old-Growth

Coast redwood forests are unique in their appeal to both foresters and naturalists. Coast redwood is an exceptionally fast-growing species, which can reach stocking volumes as high as 300,000 board feet per acre (Wilcox 1996). In addition, the wood of the coast redwood has pest resistant and rot resistant properties that render it highly valuable as a building material. These resistant properties are greatest in the wood of old-growth trees making them the most valuable and therefore the most sought after specimens.

However great the economic value of old-growth coast redwood forests as a timber source, some argue that the non-commercial values outweigh the commercial. Ancient groves reaching heights exceeding 300 feet are enjoyed by thousands of visitors every year and have been described with such glowing terms as “spiritual” and “cathedral.” In addition to the recreational values, coast redwood forests also provide habitat for a wide variety of wildlife species including a number that have been designated as threatened and endangered by the federal and state governments.

Efforts to protect the remaining groves of virgin redwood began in the late nineteenth century with the establishment of Big Basin State Park, the first park in the California State Park system. Preservation efforts have continued to the present, resulting in the establishment of a variety of redwood parks and preserves including Redwood National Park, and more recently the Headwaters preserve.

Effects of Logging

Results from a study of remote images suggest that 10 percent (or 208,000 acres) of the original old-growth coast redwood forest remained in 1986 (Fox 1996). Of the harvested acres, 63 percent had regenerated into second-growth redwood forests; 21 percent of the forest was converted to other forest types (such as Douglas-fir and oak); 5 percent was converted into shrub and grasslands; and the remaining 1 percent left as bare soil or gravel. Of the remaining 208,000 acres, 114,000 were held publicly in parks and preserves and 94,000 acres were privately owned. Further, estimates of old-growth harvesting between 1986 and 1996 indicate that approximately 40 percent of the volume remaining on private land has been removed. Natural revegetation following timber harvest in coast redwood, in most cases, results in the establishment of a second-growth redwood forest. These forests differ from their old-growth counterparts in a number of ways including stand density, species and habitat diversity, and structural characteristics (Russell et al. 2000, DiGiovanni 1971).

Stand density and canopy cover.

Regenerating redwood stands tend to have high stocking densities and canopy cover. This phenomenon results in lower levels of solar radiation reaching the forest floor (Figure 1), and consequently less developed understory vegetation. High stand density is naturally alleviated through attrition, or through wildlife predation (Russell et. al. 2000b.).

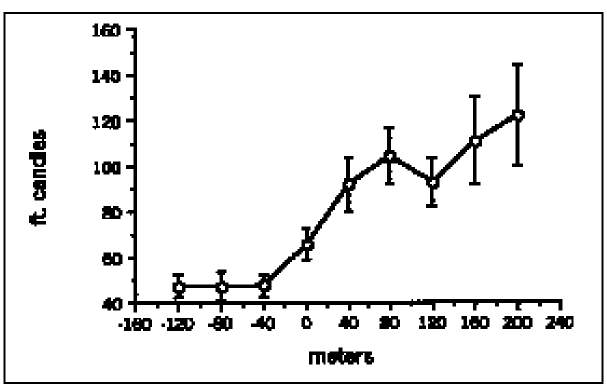


Figure 1. Solar radiation measured across 20-to-50-year-old timber harvest boundaries in Redwood National Park in 1998. Where 0 on the horizontal axis represents the timber harvest boundary: Numbers are positive in the direction of the old-growth, and negative in the direction of the regenerating stand.

Species and habitat diversity.

High-canopy cover in second growth stands has the added effect of reducing species diversity by shading out shrubs and herbaceous species that normally occupy the forest floor (Figure 2). In addition, habitat heterogeneity and habitat diversity is also reduced in regenerating stands. What this means in practical terms is that regenerating stands are more homogenous and uniform than mature stands.

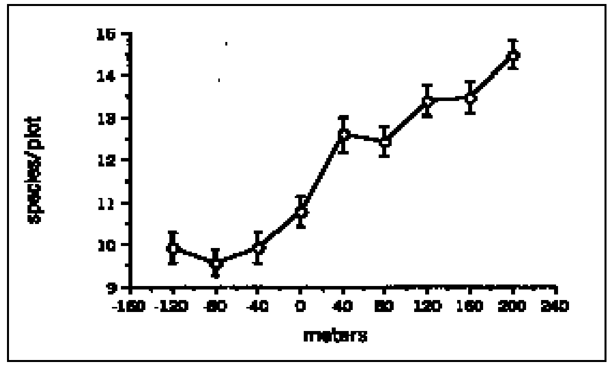


Figure 2. Species diversity measured across 20-to-50-year-old timber harvest boundaries in Redwood National Park in 1998.

Structural characteristics.

The structure of old-growth coast redwood forests is generally composed of several vegetation layers including the canopy layer, which is composed of the tallest trees in a stand, the sub-canopy

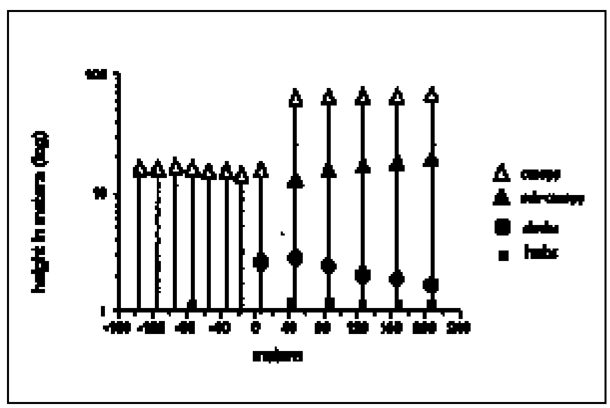


Figure 3. Relative heights and densities of various canopy layers measured across a 20-year-old timber harvest boundaries timber in Redwood National Park in 1998. The vertical axis is in log-scale. The actual canopy heights are approximately 10 times that of the sub-canopy height.

layer defined as a distinct layer of trees which exists below the canopy layer, and an understory layer which can be divided further into a shrub layer and an herbaceous layer. In a second-growth stand this structure is simplified (Figure 3). In many cases solar radiation is so low on the forest floor that the understory layer is nonexistent. In addition, subcanopy does not begin to develop for several decades. Stand structure of regenerating stands is often reduced to a single layer.

The effect of these factors, in combination with habitat fragmentation on a landscape scale, acts to reduce the ability of the forest to support a variety of endemic wildlife species. Eventually second-growth forests may grow to be comparable to their ancient counterparts, but the scale of such a process is in centuries.

In addition to the direct effects of harvesting, there are secondary effects to the adjacent forests (Russell et al. 2000a). Additional secondary effects of harvesting on adjacent stands have been recorded in a number of forest types including coast redwood (Russell 2000, Franklin and Forman 1987, Harris 1984). Timber harvesting can affect adjacent stands in several ways. On a watershed scale logging affects sedimentation of streams, profoundly impacting local fish populations (Dahlgren 1998); in reference to coast redwood forests this includes populations of the once-abundant but now threatened coho salmon. In addition to these broad-scale effects, timber harvesting affects adjacent groves by altering microclimate along the edge of the disturbance (Chen et al 1990), and by exposing trees to the dangers of windthrow and crown dieback.

Ecological Forest Management

The purpose of scientific inquiry is to increase our understanding of the natural world so that we can improve the productivity and reciprocal nature of our relationship with it. Ecology as a science is directed toward the understanding of the relationships between organisms and their environments. It is ecological theory that elucidates the effects of natural and human disturbances on biotic systems and creates models of how individual communities of plants and animals respond to human management. Therefore, the science of ecology is uniquely suited to help us develop sustainable models of forest management. However, as human society is closely linked to the management of natural resources, an understanding of economic theory is also necessary to create plausible management scenarios. Due to the complexity of both the ecological and economic issues involved in the management of coast redwood, or any other large forest system, a truly integrative approach is needed to create a viable management plan.

Ecological and Economic Sustainability in the Coast Redwood Region

In recent decades the term "sustainability" has become a catch phrase in the fields of environmental science and resource management. Consequently the term has held a variety of different meanings depending on the objectives and point of view of the user. In order to discuss how to achieve sustainability we must first determine what sustainable means in terms of forest management.

> Sustained Yield: "… regular periodic output of various renewable resources...." *Multiple Use, Sustained-Yield Act of 1960.*

Traditionally the term sustainable has been used in conjunction with the word "harvest" or "yield," as is the case in the definitions presented in Multiple Use, Sustained-Yield Act of 1960 and the California Forest Practice Rules. These definitions describe an economically prudent rate of extraction for a renewable resource. In the simplest terms, sustained yield means that the rate of harvest does not exceed the rate of growth. If applied properly, a system employing this principle insures the availability of a resource in perpetuity.

> Long Term Sustained Yield: "The average annual growth sustainable by the inventory predicted at the end of a 100 year planning period." *The California Forest Practice Rules 2000.*

There are those who believe that the traditional definition of sustained yield is too narrow in that it does not address the values of the forest beyond timber sales, and that it ignores economic forces that can affect the rate of harvest. Proponents of a broader definition argue that forest management cannot take place in a vacuum but must be integrated with all of the various needs and concerns of the local community and society as a whole. An example of a broader definition can be found in the mission statement of the Institute of Sustainable Forestry.

> Sustainable Forestry: "… forest management that contributes to the long-term ecological and economic well-being of forest-based communities…." *The Institute of Sustainable Forestry, Mission Statement.*

This definition is more complex in nature, and consequently has not generally been adopted by the timber industry. The regulatory agencies of the federal and state governments have implemented a series of regulations in the spirit of this definition such as the Endangered Species Act, the California Environmental Quality Act, and the National Environmental Policy Act. However, this has been done in a piecemeal fashion with no clear philosophical basis for implementation, or the creation of new legislation.

Economic Sustainability.

The Institute of Sustainable Forestry's definition can be broken down into two separate topics: economic and ecological sustainability. Economic sustainability can be defined as the perpetuation of the economic viability and stability of a community. In contrast to the traditional concept of sustained harvest, which allows for the perpetuation of a single industry, economic sustainability considers the viability of the economic community as a whole.

Sustainability of the economy as a whole depends on the sustainability of its components. In the redwood region the economy has historically been dependent on a number of industries including timber, fisheries, recreation and tourism, agriculture, and urban development. This region is fortunate in that most of its economy is based on renewable, potentially sustainable resources with the exception of urban development. Unfortunately, the potential does not necessarily translate into practice. In order to attain economic sustainability in this region, the following goals must be achieved.

1. The practice of sustained yield, as defined above, must be implemented for all renewable resources including timber, fishing, agriculture, and recreation. In order to achieve this goal, the historic "Boom-Town" approach to resource management needs to be abandoned. If this practice is not implemented, the result will be the collapse of one or more of these industries. The collapse of industries leads to a simplification and destabilization of the economic structure of the community and an eventual replacement of sustainable industries such as timber with unsustainable industries such as urban development.

2. The majority of profits from resource extraction and commerce must stay in the community. The current trend of local industries merging with, or being bought out by, national or transnational corporations destabilizes the economies of local communities in two ways. First, absentee ownership leads directly to an extraction of profits from the local economy. Second, the responsibility of large corporations is to their stockholders, not to the economic well-being of a distant rural community or to the economic viability of future generations. For these reasons previously small private companies that have subsequently become controlled by large outside entities are responsible for some of the examples of the least sustainable forestry practices in the industry.

3. The practices of one industry must not prohibit the practice of other industries. In general the more diverse an economy is the more stable it is. A community that is dependent on a single industry is tied to the unpredictable rise and fall of that industry. It is beneficial to the community as a whole to control the expansion of one industry where it threatens the existence of another.

Ecological Sustainability.

Ecological sustainability is achieved when the structure, composition and processes of a community are preserved. As is the case with economics, the ecological sustainability of an area is dependent on the sustainability of its components. Just as when one part of the economy collapses the remainder is weakened, when one portion of the ecological system is disturbed the remainder responds. Within any terrestrial community there are basic processes that affect the whole. These include:

1. Watershed function. A watershed describes a geographic area in which all precipitation flows toward a single point. In such a closed system any activities that occur affect the area as a whole. For example, sediment created through timber harvesting that occurs upslope of a small tributary to a large creek will affect the entire system, including the spawning habitat of anadromous fish. The importance of watershed function is not limited to the life cycle of salmon, however. When properly functioning, forested watersheds provide habitat for a wide variety of riparian species, flood control, erosion control, soil moisture retention for plant growth, and domestic water supply. Hydrology is one of the basic components of an ecological system. When the system is disturbed, drastic and permanent changes can be wrought on a landscape level.

2. Soil structure and function. Soil characteristics, in addition to moisture regime, are often the primary formative factors in the composition and structure of a plant community. It is soil and moisture together that determine what will be a desert and what will be a swamp, what will be a prairie and what will be a forest. Soils can easily be degraded or destroyed by human activity. Removing large areas of vegetation has resulted in historic disasters such as the dust bowl phenomenon of the 1930s. In managed redwood forests, areas that are harvested are susceptible to landslides, which not only result in soil loss but also fill streams with silt.

3. Biological diversity. Diversity leads to stability in ecological systems. The simpler a system in terms of its structure the more susceptible it is to a variety of destructive forces including pathogens, fire, flood, and invasion by exotic species. This can be illustrated by the example of a monocultural cropping system. The close proximity of thousands of individuals with nearly identical genetic makeups increases the susceptibility of a host to attack by pests and parasites. Spatial and temporal diversity within a natural system, such as an old-growth redwood forest, diminishes the impact of destructive agents by allowing distance in time and space between potential hosts.

4. Natural forest processes. The processes that created and sustained forests prior to human intervention are the best models for processes that will create and sustain the same forests into the future. Altering the way in which forests regenerate has been found to greatly affect the character of a forest. A prime example of this phenomenon is the effect of fire suppression on the mixed conifer forests of the Sierra Nevada (Russell et al. 1998). Removal of small fires that were common in these forests was an attempt to protect them but instead resulted in a species shift from pine to fir, and eventually a proliferation of large highly destructive fires. Similar misunderstandings of natural forest processes in coast redwood have resulted in a variety of problems resulting in great expense.

Interaction Between Landscape Components

Modern landscapes exist as a mosaic of various land management types. In the redwood region these types range from urban/industrial, rural/residential, agricultural, industrial forestland, and parks and preserves. Each of these land-use types exerts various pressures on the natural ecological processes of the area. For example, development of forestland into rural/residential areas tends to reduce canopy cover, introduce exotic species (McBride et al. 1996). Neighboring land-use types also affect each other. In Redwood National Park timber harvest activity altered adjacent stand characteristics as much as 200 meters into residual old-growth forests (Russell et al. 2000a). In addition, the activities of one industry may affect the viability of another. In the redwood region the decline of the commercial fishing industry has been tied, in part, to the effects of timber harvesting. Ecological sustainability of a region depends on the ability of managers to consider factors that have no immediate economic value but benefit the long-term health and welfare of the community.

Ecological Theory and Coast Redwood Management

In the early part of the last century, naturalists began to note the steady decline of the nation's virgin forests. What had seemed an inexhaustible resource to the early European settlers on both sides of the continent began to dwindle in the face of agricultural expansion in the east and boom town timber mining in the west. The term "timber famine" became popular in the press, and in the political circles of Washington D.C.. By chance these cries met with a sympathetic ear in the sitting president Theodore Roosevelt and for the first time in the history of the United States the nation began to open its eyes to the consequences of its cavalier use of natural resources. With advice from such visionaries as John Muir and Gifford Pinchot, President Roosevelt redesigned the legal system by which wildlands were managed. The National Park system was created under the department of the interior in order to satisfy those that sought preservation of wilderness, and the National Forest system was created under the Department of Agriculture in order to satisfy the scientifically minded conservationists. The political forces that led to the creation of the Forest Service were accompanied by a new approach to forestry. Prior to the advent of "scientific forestry" as proposed by Gifford Pinchot (the first chief of the Forest Service), forest managers were concerned exclusively with the most efficient ways that timber could be felled and brought to market. With the implementation of scientific forestry, managers began to concern themselves with regeneration of trees following logging.

Silviculture and the Regeneration Fallacy

The tenets of scientific forestry, though new in this country, had been formulated in Germany decades earlier and had been given the name silviculture. The term comes from the Latin "silva" (forest), and "culture" (farm) so that roughly translated silviculture means "forest farm"or "tree farm." The appropriateness of this system as applied to German forestry needs to be understood in the context of the cultural history of Europe. At the same time that Americans were beginning to struggle with how to manage their virgin forests, Europeans were attempting to confront a legacy of timber removal dating back more than a thousand years. The concept of farming trees, though distasteful to many twenty-first century environmentalists, appeared quite progressive when applied to land that had been deforested centuries before. Indeed, the concept of silviculture appeared progressive when brought to the United States, and those that made their living from timber extraction vehemently opposed it.

Silviculture was designed to be applied to regenerating timber stands. This approach was sensible when discussed in the ivy-covered halls of the eastern universities. The cultural history of the forests in the eastern United States was not unlike that of their European counterparts. Though deforestation had occurred only a century or two before, as compared with many centuries before in Europe, the pattern of agricultural fields and small woodlots was familiar to the German-educated foresters. The further the forests diverged from this model, however, the more inappropriate 19th century silviculture became.

The trouble with applying silviculture to the forestlands of the western United States was twofold. The first problem was that much of the forests in the west were as yet unmanaged. As silviculture was designed to be used to manage regenerating stands, the first order of business of the Forest Service was to remove the original forest so that what regenerated would fit into the model better. The second problem was one of scale. Though applying an even-age treatment to a hundred-acre fir forest in the German hinterland may be perfectly sensible, the idea of applying the same treatment to thousands of square miles of inaccessible wilderness is absurd. The strategy of the Forest Service in this case was to break up these large tracts of wilderness into small manageable areas and build millions of miles of roads in order to make the areas accessible. The western forests were corralled into a more orderly state where they have been managed, except in a few cases, by the scientific principles of forestry first proposed by Gifford Pinchot in the early 1900s.

Eventually the concept of silviculture became the standard of forestry in the United States in all public and private forests, including the coast redwood forests of northern California. A great deal of the coast redwood forests had been removed during the latter half of the 19th century in order to fuel lumber for the boom following the gold rush. The principles of silviculture suggest that in order to achieve maximum yield from a stand it should be harvested when its youthful burst of growth begins to taper off and the forest enters its slower growing middle-age stage. For a tree with a maximum life span of 200 years, this point might be somewhere between 50 and 100 years. For a species that lives thousands of years, this point could be 500 years or more. A lack of understanding of the time scale involved, and the economic necessities of war and the post war boom resulted in the next round of coast redwood harvesting beginning in the late 1940s. Several rounds of logging have followed so that some areas have been harvested three or more times since the end of the last century resulting in an average rotation time of 50 to 60 years, or about one tenth of the rotation one would prescribe for maximum yield.

Further problems were caused by miscalculations resulting from scientific misconceptions. Early measurements of regeneration within coast redwood stands indicated that seedling germination was exceedingly low under closed canopy conditions, suggesting that redwood was intolerant of shade (Fritz 1957). These findings led researchers to promote even-age management as a silvicultural prescription in redwood stands in order to increase regeneration and growth. Since that time this prescription has been used almost exclusively and has resulted in practices such as massive herbicide application to newly regenerating stands in order to discourage truly shade intolerant species such as tan oak. These miscalculations were made as a result of a poor understanding of the basic life cycle of coast redwood and because of an inability to conceptualize regeneration over large time scales. The first error was in not recognizing that most regeneration of coast redwood occurs from asexual clonal expansion. When a coast redwood is blown over or dies in place, abundant sprouting occurs as a stress response from cambial tissue present at the base of the tree and in the roots. These sprouts compete as a cohort group, eventually leading to a few survivors that can develop into mature trees. The second error was in not considering the life span of the dominant trees. Where one might be rightly concerned to find only one or two seedlings per acre in a stand of short -ived trees such as bishop pine (*Pinus muricata*), for trees that have life spans of upwards of a thousand years the concern is unwarranted. The regeneration rate is relatively low because the rate of canopy recruitment is exceedingly low. Regeneration at any greater level would be an inefficient use of resources that could be better used for growth.

In summary, the use of silvicultural models developed for forest types that are very unlike the coast redwood type has led to poor management of these forests. Through a better understanding of the biology of the species we are harvesting, more appropriate prescriptions could be implemented.

Natural Regeneration in Coast Redwood

Natural processes created the forests, fisheries, and recreational opportunities that we are currently enjoying. Therefore, mimicking natural processes in our management of these resources allows us the best opportunity for their continued use. An understanding of the natural life cycle of the coast redwood as a species, and the dynamics of redwood stands as a whole, are important in developing management strategies that are sustainable from both an ecological and economic perspective. Stand replacement has historically been used as the standard model for forest regeneration by both foresters and ecologists in virtually all forest types. This model is appropriate for forests that regularly experience catastrophic disturbance such as crown-fire, but does not work well for communities where stand replacement is rare such as the coast redwood forest.

In undisturbed coast redwood forests most regeneration and succession is tied to a process known as gap phase disturbance (Pickett and White 1985). Regeneration occurs in small canopy openings created by tree fall or “chablis” (Halle et al. 1978) resulting in forest stands with complex spatial structures and high species diversity (Sugihara 1992). In contrast, regeneration through stand replacement results in even-aged, low-diversity stands.

Natural regeneration conditions occur in a high moisture, relatively high shade environment. Individual trees that expand to fill canopy gaps were often recruited many years before and have persisted as suppressed sub-canopy trees. In stand replacement events, such as large fires and clearcutting treatments, individual trees must be recruited following the disturbance in a low shade, low moisture environment which is not optimal for the growth of redwoods. Survival of seedlings, naturally recruited or planted, following these events is low, indicating that conditions are not favorable. In addition, the conditions created by complete canopy removal often induce long periods of shrub domination, which is removed at great expense with herbicides or through mechanical means.

Mimicking natural processes through timber harvest with coast redwood suggests the use of single-tree or small-group selection with high canopy retention.

Even-age timber management that mimics the disturbance regime of a forest that experiences stand replacing fires such as bishop pine, or lodgepole pine (*Pinus contorta*) is not appropriate for coast redwood.

Case Study: Jackson Demonstration State Forest

Jackson Demonstration State Forest (JDSF) comprises approximately 50,000 acres of primarily redwood and mixed evergreen forest in western Mendocino County on the north coast of California. The major portion of JDSF was purchased from the Caspar Lumber Company (Founded by Jacob Green Jackson) in 1947. The forest is administered by the California Department of Forestry and Fire Protection (CDF) with the following mandate: 1) Achieve maximum sustained production of timber by applying sound forest management techniques. 2) Conduct innovative demonstrations, experiments, and education in forest management. Extensive timber harvesting had occurred within the forest before the purchase and continues to the present day, resulting in a patchwork of first-, second-, and third-growth forest stands.

JDSF is located between the city of Fort Bragg and the city of Willits with its easternmost boundary on the ridge separating the coastal slopes from the inland valleys. Elevations range from 300 feet near the coast to greater than 2100 feet inland. The forest boundaries encompass extensive portions of two major coastal watersheds including the Noyo River and the Big River. In addition, the majority of the Caspar Creek and Jughandle Creek watersheds are also located within JDSF. Once the spawning grounds for thriving populations of coho salmon and steelhead trout, the productivity of these streams has declined dramatically in recent decades as a result of, at least in part, timber harvest activity (Meehan et al. 1977, Mahoney and Erman 1984, Knight and Bortoff 1984).

In addition to timber harvesting, JDSF is used for a variety of economic and recreational purposes by both local residents and visitors. The forest is popular with hunters, horseback riders, off-road vehicle users, hikers, and campers. Wildcrafting of mushrooms and berries is common in the forest for both personal and economic purposes, and a healthy firewood industry survives on permits issued by CDF to gather within JDSF.

JDSF is diverse both in terms of its natural history and its land-management history. Microclimate, geological activity, and timber management have resulted in a mosaic pattern of various forest types, from isolated multi-layered old-growth stands to young even-aged plantations. Much of the land purchased in 1947 had been managed extensively.

Natural History

The plant and animal communities within JDSF are extremely diverse due to the high variability in elevation and microclimate ranging from the coastal terraces to the mountains 20 miles inland. Understanding this diversity is essential in developing sound management strategies. A lack of understanding of these issues can lead to highly destructive activities.

Vegetation

Though primarily dominated by coast redwood forest, JDSF is actually a mosaic of diverse vegetation types including coastal scrub; bishop pine (*Pinus muricata*) forests that grow in thick stands along the coast; pygmy forests, a rare forest type that is limited to coastal terraces; riparian woodlands found along the larger streams within the forest; oak woodlands and savannas; mixed evergreen forests; and coast redwood stands. Though the focus of this paper is on redwood ecology and management, some attention must be given to each of these vegetation types. In order to restore a natural ecology to Jackson State Forest, one must first understand the importance of each community within the matrix of the forest as a whole.

The Mixed Evergreen Forest—The mixed evergreen forest type is similar in species composition to the coast redwood type, with redwood as a less dominant species. Several additional species reside in the mixed evergreen forest, including pacific madrone (*Arbutus menziesii*), and coast live oak (*Quercus agrifolia*). Some of the moisture-loving species present on the coast redwood type forest floor are absent.

The transition between coast redwood and mixed evergreen forest can generally be attributed to moisture regime. Where redwood dominates in the moist coastal canyons, mixed evergreen forests flourish on the dry upland slopes. These microclimatic conditions also tend to increase fire frequency and intensity, often making fire the most important ecological disturbance agent in this forest type.

Oak Woodlands and Savannas—On hillsides and mountain slopes even dryer than those that support mixed evergreen forests, evergreen oak species such as coast live oak and canyon live oak (*Quercus crysolepis*) are able to persist. Dense stands of oak, referred to as woodlands, typically exhibit a single canopy structure with very little understory. Where oaks are mixed with open grasslands they are referred to as oak savannas. This vegetation type is restricted to very dry sites with poor soils. Fire is quite prevalent in both oak woodlands and oak savannas, and was used by the indigenous inhabitants of the area to promote open grasslands and increase acorn production.

Coastal Scrub and Brushlands—Shrub fields dominated by coyote bush (*Baccharis pilularis*) are common in highly disturbed areas such as road banks and clearcuts and are increasingly populated by exotic species such as broom (*Cytisus* sp.), gorse (*Ulex europaeus*), and pampas grass (*Cortaderia selloana*). Removal of scrub in order to facilitate timber production has been a matter of great expense and debate. Harvesting treatments that are cost efficient in the short term tend to increase shrub domination leading to greater future expense.

Riparian Woodlands—Riparian woodlands in California are generally composed of hardwood species. In the coast redwood forest these woodlands exist as irregular strips of hardwoods, such as red alder (*Alnus rubra*) and various willow species (*Salix* sp.) found in close proximity to watercourses. The riparian zone is less defined in the coast redwood forest than in some other forest types because of the tolerant nature of coast redwood to riparian conditions. Redwood, a relative of bald cypress (*Taxodium distchum*), which inhabits the swamps of the eastern United States, is able to thrive in close proximity to watercourses in moist conditions. The most developed riparian woodlands can be found along the coast in wide river bottoms and in disturbed areas where alder acts as a pioneer species.

Bishop Pine Forest—Bishop pine grows in an irregular band between the coast and the redwood forest and occasionally occurs in small patches on recently burned sites within other forest types in close proximity to the coast. This closed cone species is dependent on fire for reproduction and lives an average of only 80 to 100 years. It is believed by many naturalists that the bishop pine forest acts as a protective screen for the coast redwood forest, which is intolerant of the salty ocean breeze.

Pygmy Forest—The Pygmy forest is a unique vegetation type that developed on the poorly drained acidic soils associated with ancient marine terraces approximately one mile inland from the coast. Though some of the understory species which are common in the coast redwood forest can also be found in the pygmy forest, such as huckleberry, salal (*Gaultheria shallom*), and rhododendron (*Rhododendron macrophyllum*), the trees are unique to the pygmy forest, including pygmy cypress (*Cupressus pygmaea*), and bolander pine (*Pinus contorta var. bolanderii*). Because of the unique nature of this forest type and the absence of any economic value for the trees, the pygmy forest within JDSF has been generally well preserved.

Climate

The climate in JSDF and the redwood region in general can be described as a cool and moist Mediterranean regime. Rain falls generally in the winter months between October and May with an average annual precipitation of 40 to 60 inches. Winter temperatures rarely drop below freezing for extended periods of time. The precipitation is highly variable year to year resulting in periodic floods and droughts. Summer months are generally cool especially near the coast where a marine fog layer keeps temperatures between 50º and 60º F. A significant amount of precipitation is produced by fog drip allowing the drought intolerant redwood to survive through the summer.

Temperatures in the eastern side of JDSF where elevations are higher tend to be hotter in the summer and cooler in the winter. This climatic difference defines the transition for pure coast redwood stands in the west to more mixed stands in the east. Microclimates created by deep canyons and river valleys that allow fog in to moderate temperature complicates the picture by allowing redwood to move further inland in those areas.

Geology

The Franciscan Formation, composed primarily of graywacke sandstone, underlies most of JSDF. The age of the formation increases as one moves away from the coast resulting in higher geologic instability on the eastern side of the forest. As a consequence of this instability landslides are common, and timber harvesting has been limited. In addition soils are much shallower on the east side than on the west, where they can reach depths of 60 inches or more, resulting in poorer forest production.

Wildlife

Jackson Demonstration State Forest supports a variety of wildlife species that are of particular human concern. These species can be delineated into two categories, game animals, and threatened or endangered species.

Several animals are currently hunted in JDSF. The most common of these is the black tailed deer. In smaller quantities game birds such as quail and pheasants are also taken. All of these species are thriving under current conditions, and the California Department of Fish and Game controls harvesting so that there is little concern about their survival under any of the proposed management strategies.

Several endangered species also inhabit the area. The most celebrated of these are the northern spotted owl (*Strix occidentalis*), the marbled murrelet (*Brachyramphus marmoratus*), the coho salmon (*Oncorhynchus kisutch*) and the steelhead (*Oncorhynchus mykiss*). The listing of each of these species under the Endangered Species Act (ESA) has resulted in limitations being placed on forest practices. These limitations, administered by CDF through the California Forest Practice Rules, are intended to meet the specific needs of each individual species, and to make efforts to enhance their habitat wherever possible.

Northern Spotted Owl (*Strix occidentalis*)—The listing of the northern spotted owl as threatened in June 1990 created controversy over timber harvest practices throughout the Pacific Northwest and the Sierra Nevada. As the first in a series of such listings, the spotted owl became a rallying point for conservationists and a sore spot for many in the timber industry. In northern California the spotted owl resides in dense old-growth or late-seral, multi-layered stands of mixed conifer, Douglas-fir, and redwood from sea level to over 7,000 ft in elevation. The owl requires mature forest with permanent water and suitable nesting trees and snags in areas of 100-600 acres or larger in order to survive.

Marbled Murrelet (*Brachyramphus mar-*

moratum)—The marbled murrelet is a small seabird, which nests in the coastal old-growth forests of the Pacific Northwest. Like the spotted owl it is also listed as a threatened species under the Endangered Species Act. The murrelet's dependence on old-growth forests as nesting habitat as well as its use of coastal marine feeding areas have brought its preservation into conflict with human economic interests such as timber harvesting. This is especially true in the northern California coast redwood forests where small, geographically concentrated populations are especially vulnerable to extinction.

Coho salmon and steelhead trout—Coho and steelhead are the most recently listed threatened species to be brought into the timber harvest debate. Both species are anadromous, meaning that they utilize freshwater, nearshore and offshore environments during their lifecycles. Timber harvesting can effect salmonid populations through the destruction of spawning grounds and increasing of stream temperatures. Mortality is especially high during freshwater life stages, often a result of poor forest and agricultural management practices that lead to siltation, which may ruin spawning beds or smother eggs. Migrating salmonids also face physical obstacles and high water temperatures resulting from dams, inadequate water flow due to diversion for irrigation, and impoundment of water for power generation. Once reaching the estuaries, coho salmon fall prey to a number of other species and may be impacted by human changes, such as shoreline development, residential drainage and the filling of marine wetlands. The time spent in their freshwater habitat is critical to development and survival to maturity.

Forest Management in Jackson Demonstration State Forest

The management of the property that eventually became JDSF closely parallels the management history of the coast redwood region as a whole. Very little logging activity occurred in the forest until the Caspar Lumber Company mill was built in the 1860s, at which time heavy logging commenced in and around the Caspar Creek drainage. Initial logging took place using a system of ox teams and splash dams. In the 1890s the steam donkey was introduced, and a system of narrow gauge railroads was built along the stream channels to transport logs. Clear-cut harvesting was the preferred method of extraction during this period because of technological limitations. In the mid 1930s the introduction of tractor logging allowed for more selective logging.

In 1947 the area was purchased by the state and was designated Jackson Demonstration State Forest. At the time of transfer approximately 40,000 of the 47,000 acres had been harvested, leaving approximately 7,000 acres as virgin old-growth. Throughout the 1950s and 1960s even-age selective logging techniques were used to remove 70 percent of the volume of the remaining old-growth stands. The residual old-growth on selectively harvested sites was subsequently harvested in the 1970s and 1980s. In addition to the logging of old-growth, logging of second growth stands has taken place since the 1950s resulting in a forest that is a patchwork of second and third growth stands, with small patches of residual old-growth (Figure 4).

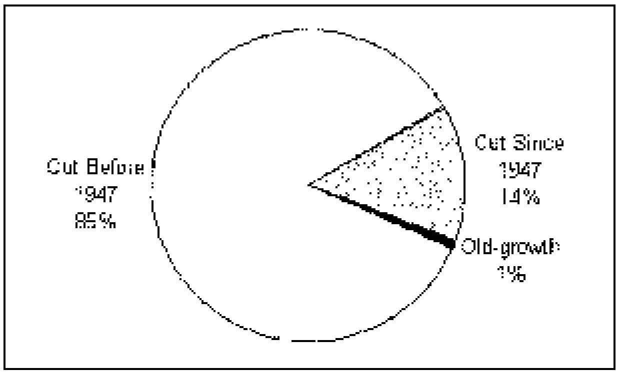


Figure 4. Conversion of old-growth to second growth forests in Jackson State Demonstration Forest.

Current Conditions

Under the current management plan one-third of JDSF is managed under an “even-aged” silviculture system (California Department of Forestry and Fire Protection 2000) including clearcutting and seed tree selection with a proposed rotation of approximately 80 years. Two-thirds of JDSF is managed under an “uneven-aged” silvicultural system including group selection, cluster selection, and single-tree selection with entries between 15 and 20 years. These prescriptions will result in “a patchwork of groups varying in age between zero and

100 years" (California Department of Forestry and Fire Protection 2000). Excluding the residual old-growth, a total of 459 acres (< 1 percent of the total forest area), the entire forest will be held in an early seral successional state. Characteristics inherent in the original forest stands such as habitat diversity will not be able to develop within the proposed rotation period.

Conclusions: A New Management Proposal

The concept of maximum-sustained-yield indicates that in order to reap the greatest commercial benefit from growing timber, trees should be harvested after they reach their maximum growth rate and they begin to reach maturity. Coast redwood, one of the longest lived trees, is known to grow vigorously for centuries, reaching maturity at about 500-600 years, indicating that harvesting of redwood should occur at approximately this point. In contrast, the harvest rotation for this species has generally been applied at 80 to 100 years or less. The consequences of this prescription have been a decline in productivity on redwood lands, a decline in the quality of wood products, and a decline in the natural processes necessary to sustain the forest. In addition, the misconceived idea that coast redwood is a "moderately shade intolerant species" (California Department of Forestry and Fire Protection 2000) has led to even-aged management on nearly all redwood lands. The proposed "uneven-aged" management scenarios mentioned above are inappropriately named, as virtually all trees within JDSF would be in an immature state (0-100 years) under this plan. The concept of uneven-age management is intended to include representatives from all age classes: for coast redwood that would include ages up to 1000-1500 years or more. It is clear that coast redwood has not been managed to its greatest potential and that a shift in the managerial paradigm will be necessary if the coast redwood forest is to endure. In order to begin to restore the coast redwood forest the following management prescription should be adopted.

1. Timber harvesting should be conducted on single-tree or cluster prescription only in order to mimic the natural regeneration of redwood. The overall harvest rotation for any stand of redwood should be approximately 500 years.

2. Unentered old-growth should remain unentered and serve as a model of the ecological processes necessary for a healthy forest.

3. Unentered second growth stands of 80-100 years or greater should be preserved, or managed to promote late seral attributes.

4. The patchwork of multiple entry stands should be employed as an opportunity to apply cutting edge sustainable forestry techniques with a goal of restoration of the structure, diversity, and processes inherent in the original primeval stands.

5. The depletion of soil resources should be slowed by eliminating old road beds. This process has already been initiated by CDF in Jackson State Forest and should be expanded.

These principles of management more closely mimic the natural disturbance regime of a coast redwood forest. Their application will eventually return the forest to a late seral successional state. The inherent qualities of a restored forest include high biotic diversity, habitat and structural complexity, and natural regenerative processes, which have great value ecologically, scientifically, and economically (Peterken 1996).

Diversity of species is ecologically valuable both on a micro and macro scale. At the community level species diversity is an important factor in food web stability. Plants, animals, fungi, and microscopic organisms interact, and in many cases, rely on each other. In addition many species may have scientific or medical value not yet understood. A recent interest in medicinal herbs has led to biomedical research, as well as economically viable community-based wild crafting ventures. Wild crafting has also become popular with non-medicinal species of mushrooms and berries.

Habitat diversity and structural complexity have values that are not as easy to measure, yet are no less important. The clearest benefit of high spatial diversity is for wildlife. A forest that provides the widest variety of habitat types generally supports the widest variety of wildlife species. For example, the marbled murrelet and the giant pacific salamander both rely on late seral forests for different reasons. The murrelet requires tall trees with wide, moss covered, lateral branches for nesting (Miller and 1996). The giant pacific salamander relies on the moist microclimate created by the multi-layered canopy structure. Habitat diversity also leads to ecosystem stability by reducing the impact of pests and invasive species.

Restoring natural regenerative processes has long-term benefits, including more efficient and productive forestry. Coast redwood is a highly prolific species when allowed to grow in its natural conditions. Leaving the majority of the canopy intact would eliminate the shrub domination stage and the overstocked sapling stage, so that trees could develop in the environment of moderate shade and high moisture in which they have evolved and are so well adapted.

Continuation of the current management strategy of forcing forest stands into an early successional state will yield a steadily declining volume and quality of wood products, eventually leading to the collapse of the timber industry in the coast redwood region. Though the application of ecologically passed forest practices will reduce short-term profits, it will allow the survival of the timber industry and the forest itself far into the future.

Literature Cited

Andrews, R. W. 1956. *The Glory Days of Logging.* New York, NY: Bonanza Books.

Carranco, L. and J. T. Labbe. 1975. *Logging the Redwoods.* Caldwell, ID: The Caxton Printers Ltd.. p. 145.

California Department of Forestry and Fire Protection. 2000. *Jackson State Demonstration State Forest: Option A Plan for Achievement of Maximum Sustained Production of High Quality Timber Products*. Fort Bragg, CA: California Department of Forestry and Fire Protection.

California Department of Forestry and Fire Protection. 1991. *Jackson Demonstration State Forest: At a Glance.* California Department of Forestry and Fire Protection. Harold Walt, Director.

Chen, J., J. F. Franklin, and T. A. Spies. 1990. “Microclimate Pattern and Basic Biological Responses at the Clearcut Edges of Old-Growth Douglas Fir Stands.” *The Northwest Environmental Journal* Vol. 6 (2), pp. 424-425.

Dahlgren, R. A. “Effects of Forest Harvest on Stream-Water Quality and Nitrogen Cycling in the Casper Creek Watershed.” 1998, *Proceedings of the Conference on Coastal Watersheds: the Casper Creek Story*. USDA Forest Service Gen. Tech. Rep. PSW-GTR-168, pp. 45-54.

DiGiovanni. 1971. “The Impact of Clearcut Logging on the Reestablishment of the North Coastal Redwood Forest Plant Community.” Thesis, University of California, Davis, CA.

Firestone, D. B. and F. C. Reed. 1983. *Environmental Law for Non-Lawyers.* South Royalton, VT: SoRo Press.

Fox, L. “Current Status and Distribution of Coast Redwood.” 1996, *Proceedings of the Conference on Coast Redwood Forest Ecology and Management.* pp. 18-20.

Franklin, J. J. and R. T. T. Forman. 1987. “Creating Landscape Patterns by Forest Cutting: Ecological Consequences and Principles.” *Landscape Ecology* Vol. 1, pp. 5-18.

Fritz, E. 1957. “The Life and Habits of Redwood the Extraordinary.” *Western Conservation Journal* Vol. 14 (3), pp. 4-7, 38.

Greenlee, J. M. and J. H. Langenheim. 1990. “Historic Fire Regimes and their Relation to Vegetation Patterns in the Monterey Bay Area of California.” *Am. Midl. Nat.* Vol. 124, pp. 239-253.

Griffin, J. R. and W. B. Critchfield. 1972. *The Distribution of Forest Trees in California.* USDA

Forest Service, Res. Paper: PSW-82.

Halle, F. R., A. A. Oldeman, and P. B. Tomlinson. 1978. *Tropical Trees and Forests.* Heidelberg, Germany: Springer-Verlag.

Harris, L. D. 1984. *The Fragmented Forest: Island Biogeography Theory and the Preservation of Biotic Diversity.* Chicago, IL: University of Chicago Press.

Huntsinger, L., S. McCaffrey, L. Watt, and M. Lee. 1994. *A Yurok Forest History.* Report to Bureau of Indian Affairs.

Huntsinger, L. and S. McCaffrey. 1995. "A Forest for the Trees: Forest Management and the Yurok Environment, 1850-1994." *American Indian Culture and Research Journal* Vol. 19 (4), pp. 155-192.

Knight, A. W. and R. L. Bottorf. "The Importance of Riparian Vegetation to Stream Ecosystems." In Warner, Richard E. and Kathleen M. Hendrix (eds.). 1984. *California Riparian Systems: Ecology, Conservation, and Productive Management.* Berkeley, CA: University of California Press, pp. 160-176.

Lydet, F. 1969. *The Last Redwoods and the Parkland of Redwood Creek.*

Mahoney, D. L. and. D. C. Erman. "The Role of Streamside Bufferstrips in the Ecology of Aquatic Biota." In Warner, Richard E., Hendrix, Kathleen M. (eds.). 1984. *California Riparian Systems: Ecology, Conservation, and Productive Management.* Berkeley, CA: University of California Press. pp. 168-176.

McBride, Joe R., William Russell, and Sue Kloss. 1996. "Impacts of Human Settlement on Forest Composition and Structure." In *Sierra Nevada Ecosystem Project: Final Report to Congress, Vol. II, Assessments and Scientific Basis for Management Options.* Davis, CA: University of California, Centers for Water and Wildland Resources.

Meehan, W. R., F. J. Swanson, and J. R. Sedell. "Influence of Riparian Vegetation on Aquatic Ecosystems with Particular Reference to Salminoids and their Food Supply." 1977. *Importance, Preservation and Management of Riparian Habitat: A Symposium.* Fort Collins, CO: U.S. Forest Service, Rocky Mountain Forest and Range Experiment Station.

Miller, S. L. and C. J. Ralph. "Relationship of Marbled Murrelets with Habitat Characteristics in Redwood Forests in Northwestern California." 1996. *Proceedings from the Conference on Coast Redwood Forest Ecology and Management,* pp. 127-130.

Olson, D. F., D. F. Douglas, and G. A. Walters. 1990. "*Sequoia sempervirens*." In Burns, R. M. and B. H. Honkala (eds.). *Silvics of North America, Vol. 1, Conifers.* USDA Forest Service Agriculture Handbook 654, pp. 541-551.

Peattie, D. C. 1953. *A Natural History of Western Trees.* New York, NY: Bonanza Books.

Peterken, G. F. 1996. *Natural Woodland: Ecology and Conservation in Northern Temperate Regions.* Cambridge, UK: Cambridge University Press, p. 522.

Pickett, S. T. A. and P. S. White. 1985. *The Ecology of Natural Disturbance and Patch Dynamics.* San Diego, CA: Academic Press, p. 472.

Ralph, C. J., G. L. Hunt Jr., M. G. Raphael, and J. F. Peat. 1995. *Ecology and Conservation of the Marbled Murrelet.* USDA Forest Service Gen. Tech. Rep. PSW-GTR-152.

Raven, P. H. and D. L. Axelrod. 1977. *Origins and Relationships of the California Flora.* Berkeley, CA: University of California Press.

Russell, William H., Joe R. McBride, and Rowan Rowntree. 1998. "Revegetation after Four Stand-Replacing Fires in the Lake Tahoe Basin." *Madrono* Vol. 45 (1), pp. 40-46.

Russell, William H., K. Carnell, and J. R.

McBride. 2000a. "Edge Effects and the Effective Size of Old-Growth Coast Redwood Preserves." In Cole, David N., and Stephen F. McCool (eds.). 2000. *Proceedings: Wilderness Science in a Time of Change.* Proc. RMRS-P-000. Ogden, UT: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station.

Russell, W. H., J. R. McBride, and K. Carnell. 2000b. "Feeding Damage by Black Bears (*Ursus americanus*) Across Timber Harvest Edges in Northern California Coast Redwood (*Sequoia sempervirens*) Forests (USA)." *Natural Areas Journal* (in review).

Smith, L. G. and C. R. Wheeler. 1992. *A Flora of the Vascular Plants of Mendocino County, California.* San Francisco, CA: The University of San Francisco.

Stuart, J. D. 1987. "Fire History of an Old-Growth Forest of *Sequoia sempervirens* (Taxodiaceae) Forest in Humboldt Redwoods State Park, California." *Madrono* Vol. 34, pp. 128-141.

Sugihara, N. G. 1992. "The Role of Treefall Gaps and Fallen Trees in the Dynamics of Old-growth Coast Redwood (Sequoia sempervirens (D. Don) Endl.) Forests." Dissertation, University of California Berkeley, p. 189.

Viers, S. D. 1996. "Ecology of the Coast Redwood." 1996. *Proceedings from the Conference on Coast Redwood Forest Ecology and Management*, pp. 9-12.

Warrick, S. F., and E. D. Wilcox. 1981. "Big River, The Natural History of an Endangered Northern California Estuary." *Environmental Field Program Publication No. 6.* Santa Cruz, CA: University of California.

Wilcox, W. W. 1996. "Coast redwood as a Future Supplier of Wood Products." 1996. *Proceedings from the Conference on Coast Redwood Forest Ecology and Management,* pp. 48-50.

Defining the Goals: The Role of Management in Restoration

Amy K. Barg
Senior Research Associate
University of California, Berkeley
P.O. Box 1897
Mendocino, CA 95460

Preface

Like many of us, I grew up in these forests of Mendocino. Since my childhood, I have gone away and studied biology, forest ecology and management. I have now returned home and am hoping to do a bit of good here in the forests and community that made me who I am. I have a vested interest in protecting and improving the forests here, and I also see a place for wise management. I ask the question and hope that we can meet the challenge of practicing sustainable forestry. Can we have healthy, productive and diverse forests that provide wildlife habitat, clean water and healthy fish populations, stable soils, and high quality timber?

On to the Presentation:

Restoration and management are words that hold substantial meaning and may be thought of as mutually exclusive. Protection and preservation are similarly packed with meaning, and they are typically thought of as exclusive from management. But is restoration synonymous with protection and preservation? I would like to propose that management, specifically forest management (or silviculture) that is well-founded in ecological principles can play an important, even critical, role in restoration efforts.

First of all, we need to define what we are talking about. What are we trying to restore and to what state? Is the goal to restore Jackson State Demonstration Forest to its prehistoric condition? Or is the goal to have healthy, diverse, and productive forests? If it is the former, then perhaps there is no place for management; if the forests are left to grow as-is for 500 to 1000 years, then they will be “restored” to their original condition. Perhaps. But who can say what will happen in 50 or 100 years from now? Life as we know it will be completely altered. The world's oil supply will be depleted. There will be nearly twice as many people on the planet. Global climate change will be evident, the concomitant shifts in species populations will be occurring, the ocean levels will have risen, and very likely the lay of the land as we know it will be markedly different. Will this building be here? Perhaps it will be at the bottom of the new ocean floor. Will the redwoods be here in a potentially altered climate? We don't know in what state the world will be in fifty years, not to mention 500. So how can we realistically propose to restore the redwood forests to their original condition? In contrast, if we are simply trying to promote forest health, productivity, and diversity, then perhaps both protection and management have a place.

There are many perspectives that can be explored. Clearly, we all want to protect the magnificence of the redwood forest ecosystems for our benefit, for the benefit of all the life forms that exist in and depend upon these forests, and also for our children and children's children. I doubt there is anyone here that would dispute that. But what is an appropriate goal, an achievable goal, in this time and place? The decisions to be made and actions to be taken are in the here and now, not 500 years in the future. So what can we do today, in terms of decisions and actions, to protect and improve the forested landscapes and watersheds in both the present time and the future?

Several words that we are using or may use in these discussions call for definition. I believe that it's important to use a common language, whether the definitions that I offer here are those that we ultimately agree upon or not. At least it's a starting place. For simplicity's sake, I turned to my old standby, the American Heritage Dictionary, to seek the definitions of these words.

1. <u>Preserve</u> verb: To protect from injury, peril, or other adversity; maintain in safety. To keep in perfect or unaltered condition; maintain in an unchanged form. Noun: An area maintained for the protection of wildlife or natural resources. [<u>Preservation</u> is a noun in the dictionary, but we seem to use it as a verb in common

language.]

2. Protection: The act of keeping from harm, attack, or injury; the act of guarding.
3. Rehabilitation: To restore to useful life through education and therapy; to reinstate the good name of; to restore the former rank, privileges, or rights of.
4. Restoration: The act of putting someone or something back into a prior position, place, or condition. The state of being reinstated, reconstructed, or otherwise restored [where restored means to bring back to a previous, normal condition].
5. Management: The act, manner, or practice of managing, handling, or controlling something [where manage means to direct or control the use of; handle, wield, or use; to exert control over.]
6. Silviculture: The care and cultivation of forest trees; forestry.

Way back in college, I learned that forests change. This change is the natural process of succession. We all go through it; it's also called aging. Because change happens, the term *preservation* may be inappropriate when discussing natural living ecosystems. We see an ecosystem like the redwood forest or an incredibly unique place like Yosemite, and we want to keep the living system in its state in perpetuity. We must do so with the awareness that the living system will change, either through the slow process of growth, death, decay, and new growth, or through catastrophic disturbance, such as wildfire, that typically occurs in natural systems. With these basic tenets in mind, I would argue that it is more appropriate to talk about *protection* of ecosystems than preservation. Jams are preserved; not forests.

Given the reality that most of the forestland in the United States, including the northwest coniferous forest ecosystems, has already been harvested at least once, the forests have been dramatically altered by humans. Some of these forests are currently in a degraded state due to past harvesting. Some simply need to grow and recover, and some can benefit from tending in order to more quickly achieve a healthy balance in tree density and species composition. (By health I mean the ability to resist short-term perturbations and be resilient in the face of long-term perturbations.) The idea of tending leads back to management. Forest management, or silviculture, can be put to many uses, not just harvesting in order to generate revenue. (Of course, it is helpful if the forestry operations can pay for themselves.) Forest management interacts directly with the process of succession and can either speed it up or slow it down, depending on the management objectives and practices. In forestlands where tan oak predominates, for example, management may be beneficial in order to restore the previous forest composition of redwood and Douglas fir more quickly than would occur naturally. On the other hand, it may be that the coniferous species slowly reoccupy the site after the tan oak begins to weaken its stronghold. This process takes time and happens during the process of succession.

While we are on the subject of restoration and management of coast forests, using Jackson State Demonstration Forest (JDSF) as a case study, I feel that it is necessary to discuss the current goal of JDSF as managed by CDF. I am aware that the underlying thrust of this conference is to evaluate the possibility of a new strategy for JDSF. I feel that in order to discuss the state forest comprehensively, we should be clear on the current mandates, goals, uses, and benefits of the forest. I present the following information from an email conversation with Marc Jameson. Bill Baxter, the representative from CDF at this conference, can correct or add to any statements that I present below. This quote is from Marc Jameson, forest manager of JDSF:

> The legislative mandate for JDSF is demonstration of forest management, predicated upon dwindling supplies of timber, in order to serve as an example for the 2mm+ acres of privately held timberland within the region, and beyond for that matter. Board of Forestry policies actually mandate that the forest be managed to achieve maximum sustained production of high quality timber products. Policies also mandate contribution to local economy with regular periodic timber sales. Recreation is a secondary, but compatible use. Research, demonstration, and public education are top priority. I am very pleased to be able to say that we have made extensive strides in the past couple of years, with new positions and budget

allocated to demonstration, education, biological sciences, and research.

All revenues generated from the State Forest, except yield and property taxes, are deposited in the Forest Resource Improvement Fund (FRIF). The FRIF fund pays for administration of state forests, research on state forests, urban forestry programs, California Forest Improvement Program (CFIP) projects, and other similar programs. Roughly 4 percent of state forest revenues are returned to counties in the form of taxes to support schools and other local programs. JDSF pays yield and property taxes like any private entity would, so that there is no loss of potential tax revenue as a result of having the State Forest within Mendocino County.

In my opinion, because revenues generated from JDSF support the county, state forestry assistance programs, and the local economy through the wood products industry, some timber production should be allowed on JDSF. I am by no means arguing that the primary focus of CDF's management of JDSF should be timber production. Far from it. I feel that timber can be a by-product of wise and careful management that is conducted for the purposes of forest health, restoration, research, demonstration, and education. I think that we need to leave room for the possibility that we can manage forests in a sustainable manner.

Now is the time to put our wealth of ecological knowledge to good use and incorporate it into sustainable forest management. We have learned a great deal about how ecosystems function in the past few decades, and we still have a tremendous amount to learn. We need to remain humble in the task of applying the knowledge that we have gained, and we need to keep asking questions and seeking answers. The fields of ecosystem management and ecosystem restoration are just beginning. Right here in our community, we have a golden opportunity to pursue meaningful questions to help further our understanding of these fields and their applicability to sustainable ecosystems and communities.

What are the questions that we can ask? There are a myriad. I will pose a few: How do second-growth redwood forests progress toward late successional stages, such as old growth, in the absence of management activities? Can silviculture play a beneficial role in speeding the development of late successional characteristics in second-growth redwood forests? Can we manage forests for many values simultaneously, including wildlife habitat and healthy populations, stable and productive soils, healthy watersheds and streams, and fish populations, non-timber forest products, as well as wood products? Can we restore degraded forestlands through silviculture? Can we maintain productive tree growth as well as diverse stand structures? There are many, many questions that can be asked, and JDSF is an excellent place to pursue such valuable research questions as these. Similarly, JDSF is ideally suited to demonstrate research projects and to educate the community and public on the findings.

Back to what we want: Can we realistically recreate old-growth redwood forests in our time frame? No, I feel that we cannot. Can we protect the remaining old growth? Yes, easily. Can we protect prime examples of second-growth stands that have not been entered with chainsaws since the original harvest? Yes, easily, and at least some of these stands should be protected in perpetuity for research, demonstration and education. These stands, along with the old growth, are synonymous with “key” habitat. Can we restore degraded forestlands, create diverse stand structures, and promote productive tree growth in young redwood stands? That remains to be seen through critical research and evaluation. I feel that there is a valid place for both protection and management on JDSF. We need to keep asking questions and learning along the way, and both protection and management can help us in this process.

I feel that the community needs to be involved in learning about forest ecology and management, as well as defining public values and goals for JDSF in a collaborative way. In order to achieve what we are seeking, we all need to be able to listen to and learn from one another. We all have valuable perspectives and contributions to share.

Off-Channel Winter Rearing for Coho Salmon and Steelhead in Floodplains

Teri J. Barber
Ridge To River
Restoration Hydrologist
P.O. Box 144
Westport, CA 95488
(707) 964-0171
tbarber@mcn.org

Abstract

Floodplains have been used extensively throughout history as fertile farmlands because of their flat, nutrient-rich, tillable soils with nearby access to the water table. Tractors affording greater efficiency converted riparian woodlands and channels into uniformly flat ground. Small tributaries flowed from mountains onto valleys, connecting with their mainstems through floodplain crenulations developed through geologic history, affording widespread migration for fishes until coming under plow. Without the connection, streamflows splay out across the floodplain making soggy wet meadows. Gone are the migration corridors to reach spawning gravel, so are the secondary channels along the hillside so ideal for rearing during bankfull and higher flows. Are these areas important to salmonids? Winter rearing habitat has been found limiting in Oregon salmon streams and is being considered in Northern California. In another vein, conclusions being drawn from hatchery records indicate a correlation between longer smolts and spawning adults drawn from scale samples. That is, a smolt with a short forklength is less fit to survive in the ocean than is a smolt with a longer forklength, perhaps better able to elude predators, consume prey, or both... Survival of the Fittest. Combining the notion of depleted winter rearing habitat with small smolts, I concluded that fishes forced to reside in mainstem habitats during high floods expend excessive energy just to swim against the current while sustained turbidities decrease ability to capture food, producing a small smolt. A juvenile able to escape the high flows in an off-channel velocity refuge will expend far less energy, can afford to wait until waters clear in order to feed, and grows larger. In a pilot test designed to restore the surface water connection of a first-order channel to its mainstem and incorporate slow-water, food-rich refuge in the form of off-channel rearing ponds, I found that if you build ponds, the fish will come. The new channel did enable migration! Of the two ponds constructed, the mountainside pond required more navigation but is surprisingly the pond of choice having a single seine sample numbering 24 steelhead, one coho, and three-spine stickleback too numerous to mention in a roughly circular area of 907 feet. The Fish and Game Biologist present during the seine projected a maximum 30 percent capture rate for steelhead, and far less for coho suggesting the true populations are much higher than that enumerated. Both ponds have several red-legged frogs, newts, bugs, algae, birds, and salamanders besides a surrounding meadow of grass, blackberry, sedge and buttercup.

Lack of Off-Channel Habitats May be a Factor Limiting Salmonid Populations

California Department of Fish and Game hatchery records helped to conclude that smolt length is a significant feature of a smolt, bearing on whether it returns as an adult to spawn by influencing how it fares in the competitive realm of the ocean food web. Large smolts are better able to capture food and elude predators than are smaller, thinner smolts. Freshwater and estuarine habitats available to steelhead and coho are important to fish spending an entire year in the freshwater phase prior to smolt. Modern instream conditions require a winter-rearing juvenile (who is just 5 to 10 centimeters long) to face high streamflow and sustained turbidity for days or sometimes weeks at a time. This is much like an efficient weight-loss regime—the combination of low food intake with frequent aerobic exercise. While healthy for America's human armchair athletes, TV-dinner lovers, and 9 to 5 office dwellers with Safeway and a comfortable couch at hand, meals and comfort are harder to come by for members of the wild community. A low-calorie diet and lots of exercise is what most modern smolts have during the winter. But in order to become successful spawning adults, they require available food and slow water refuge in order to gain weight and transfer that weight gain to forklength. Off-channel habitats provide the slow water, and ponds provide abundant food once the waters clear. When a small tributary is added, the recipe is complete. The tributary provides inflow of cool water year round for those who stay once migration opportunities close.

Disappearance of Tributary Connections and Ponds in Floodplains Over Time

Floodplains hold a place in history frequently used for agriculture. The combination of flat, tillable sands, silts, and gravels, combined with occasional flooding and a nearby water table offer most of what a farmer could want in a quality field. Most of California's most productive farmlands occur in river valleys, like the Napa River Valley, the Russian River Valley, and the Sacramento River valley. While the Wages Creek valley is not nearly so prominent, the locals will tell you what is confirmed by examining the 1952 air photos: that almost every inch of this alluvial floodplain was farmed or ranched in recent history. Tractors converted the floodplain to square plots of managed farm and ranch land and flattened what topographic contours existed there in order to maximize use. In some cases, this practice cutoff surface water to small tributaries from their mainstems. Winter floods washed out of the mountains and spread out on the flattened floodplain. A soft, squishy, wet meadow was created year-round. Plants dotting the topography included rushes and sedges, and all around was buttercup and soggy grass.

Identifying a Restoration Opportunity from Air Photos and Field Reconnaissance

A recent master's thesis by Dave Manning from Humboldt State University, which field-tested an Oregon-based method of inventorying winter rearing habitat, often determined limiting to Oregon salmonids in northern California streams including the Noyo. His results suggested winter rearing was limiting in each of the streams he tested. This means that either the model is oversensitive to winter rearing or northern California streams are winter rearing limited. In any case, I used a simple, much less rigorous method chock-full of assumptions. That is, I assumed that when air photos indicate intense farming or ranching on a flood plain, then the hydrological connections of small tributaries have probably been interrupted and require restoration to relieve the bottleneck in a shortage of winter rearing locations. What often curtails bringing restoration to the ground is land access. Thus, this is a perfect application for JDSF in that it opens up a lot of access and opportunities for restoration planning. When on the ground, look for mouths of small tributaries as they open up onto the flood plain. Is there a visible channel connecting the mainstem to the stream? If not, you've got a winner project. However in order to do it, a signed landowner access agreement is required.

A Successful Off-Channel Rearing Pond Restored in the Wages Creek Floodplain

My pilot project involved planning for two off-channel ponds and a new channel connecting the mountain stream to Wages Creek mainstem across the floodplain. I used two existing willows through which to weave my stream. I designed the lower pond to mimic an oxbow meander cutoff type pond, and the upper pond in a location sometimes occupied by secondary channels, at the base of a mountain where it met the floodplain. These ponds were constructed with an excavator and backhoe in the summer of 1998, as was the channel. Both pools began charging with water following the digging by the alluvial water table and by a first order stream. The channel excavation between the willows was designed as a loose meander, not quite perfect as is often the case in nature. Following excavation, the channel was mulched with local grass hay, seeded with an erosion control mix, and staked with willow. The pools contained a maximum water depth of 2.8 feet in summer. The upper most pool was built large to accommodate sediment deposition from the steep tributary channel it receives. Revegetation on the lower pool included a complete willow fascine along the summer water's edge. The lower and upper pools are located 10 feet and 300 feet off the Wages Creek bank-full channel, respectively. When the winter came, I crossed my fingers and waited. I observed the once dry channel (during the summer) that cut across the flood plain was now bank-full following several days of rain. One late afternoon I was enjoying an unusually warm and quiet view across the pond when a surface strike ejected a fish into midair. Boy, was I surprised! This was followed by another and another until I was sure there were salmonids occupying the upper pond. While this has occurred on numerous occasions in the late afternoon, one can sometimes get them to strike for a piece of bread any time of day to convince friends and other skeptics. Between myself, my 4-year old son, and two fish biologists (Michael Maahs and Steve Cannata of DFG Region 3), we managed to seine net the pond on October 20, 1999 to enumerate the fishes there and to identify their species. Steve remarked that the seine would probably catch approximately 30 percent of the population there because numerous plants and an uneven margin prevented a higher capture rate. Another biologist remarked that 30 percent might be a reasonable catch rate for steelhead but that a far greater proportion of coho would cling to the margins and cover such that their capture rate would reflect perhaps only 10 percent of the number residing there. Twenty four juvenile steelhead were netted with fork lengths ranging from 110 to 166mm. Just one coho was netted with a fork length of 104mm. Zillions of threespine stickleback, a rough-skinned newt, a giant water beetle, and a red legged frog were also netted and released. If 24 steelhead represented 30 percent of the pond population, then there were 80 steelhead there. If one coho represented 10 percent of the pond's coho population, then there were 10 coho there at the time. The area involved is 907 square feet, roughly circular, with a radius of 17 feet and a maximum depth of 2.2 feet. Average depth is about one foot.

Process-Based Woody Material Management at the Basin Scale: Soquel Creek, California

Neil Lassettre
Department of Landscape Architecture and Environmental Planning
University of California
Berkeley, CA 94720
nlass@uclink4.berkeley.edu

Matt Kondolf
Department of Landscape Architecture and Environmental Planning
University of California
Berkeley, CA 94720
kondolf@uclink.berkeley.edu

Abstract

Standard practice involving woody material is to remove wood from channels so it does not catch on bridge piers, deflect flow into banks, or pose hazards to navigation. The loss of wood-related habitats for fish is implicitly recognized by the extensive programs to enhance habitat for salmon and trout by installing artificial habitat structures. Suggestions to permit wood to remain in channels are commonly dismissed by managers because of flood control concerns. Even when channels are spanned by small culverts or bridges with small openings, the "problem" is typically identified as the wood, not the size of the culverts or openings.

In lieu of current policies of debris removal and artificial habitat structures, we explore the potential for basin-scale, process-based wood management, in which wood is allowed to recruit and move downstream through the drainage network, but the current bottlenecks to woody debris transport are addressed. Our model (under development) routes wood of a given size distribution downstream through the network and provides guidance for sizing bridges and culverts to permit wood to pass at various flows. Before recommending culvert and bridge opening sizes, however, new land-use policies in state-owned forests that will increase the size of riparian trees must be taken into account and the model run with a projected future size distribution of wood. Preliminary estimates of marginal costs of building bridges with longer and higher spans (when the bridges are to be replaced anyway) and replacing culverts with summer crossings indicates that these infrastructure improvements, by obviating the cost of wood removal, artificial enhancement projects, and reducing risk of debris jams, would repay the investment in a matter of decades and result in better habitat for anadromous fish.

Introduction

Logs, stumps, and branches that enter and are transported along river and stream channels are important ecological elements within freshwater systems. Large woody debris (LWD) influences channel morphology, contributes to nutrient retention and cycling, provides habitat for aquatic organisms, and contributes to riparian forest formation (Harmon et al. 1986, Fetherston et al. 1995). Despite extensive scientific literature describing the ecological significance of LWD, much in-channel wood is removed or eliminated from stream networks by managers through timber harvest, which alters wood recruitment, flood control practices where wood is removed to maintain conveyance, and road maintenance to keep bridges and culverts clear of water-transported debris. In urbanized and semi-urbanized basins, flood control and road maintenance concerns surrounding in-channel wood typically override ecological concerns (Singer and Swanson 1983). However, wood management programs fail to consider basin-wide processes of LWD recruitment and transport, and are generally unsuccessful in preventing flood and roadway damage. Unfortunately, when management programs are unsuccessful, naturally occurring wood is viewed as the problem, not bridges, culverts, and roadways that impede wood flux and create flood hazard and road failure. In this paper we review the geomorphic and ecological role of LWD, and the current LWD management practices within a study basin and how these practices reduce the abundance of LWD. We will then discuss ongoing research on a process-based basin-

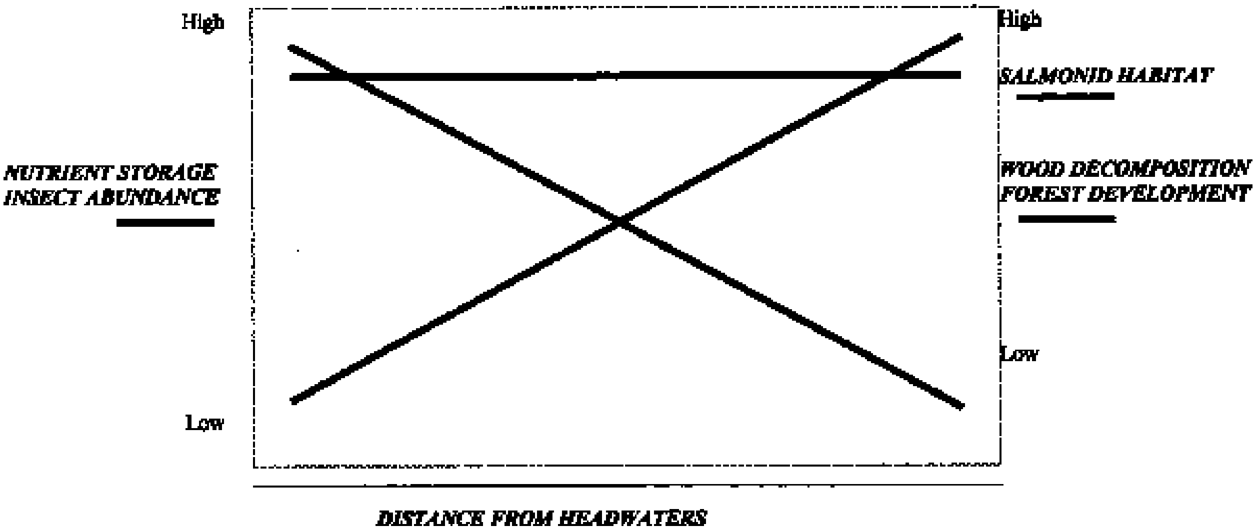


Figure 1. Schematic representation of the general trend of the effects of LWD on channel morphology along the stream network. The sediment storage capacity, influence on channel gradient, and influence on pool formation are greatest in small streams and decreases in higher orders. The influence of LWD on channel width increases along the same gradient, but has a limited effect on the width of large rivers.

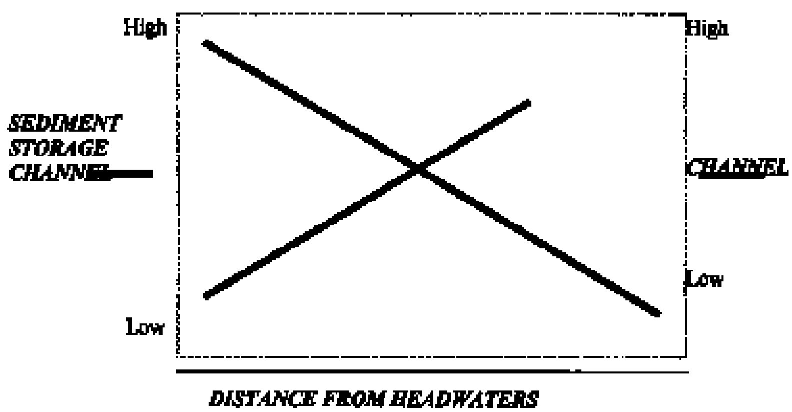


Figure 2. Schematic representation of the general trend of the effects of LWD on stream ecology down channel network. Wood associated nutrient storage and insect abundance is highest in small, low order streams and generally decreases in higher orders. The importance of LWD for salmonid habitat is equally important throughout the basin, although the role of wood varies. Wood decomposes more quickly in the terrestrial environment, and hence more quickly in higher orders where LWD frequently resides partway or completely out of the channel. The influence of LWD on riparian forest development decreases with increasing channel confinement that reduces active floodplain area.

scale approach to managing LWD.

Geomorphic and Ecological Role of LWD

The geomorphic and ecological effects of LWD gradually change downstream through the channel network (Figures 1 and 2). The abundance of wood in a stream or river reflects the balance between wood entering and wood leaving a particular reach (Keller and Swanson 1979). The main controls on the geomorphic effects of LWD are piece size, channel gradient, and channel width. The ecological effect of LWD arises from log characteristics and channel morphology. Logs trap and retain nutrients, create habitat for fish and new riparian growth, and act as a direct nutrient source and attachment site for aquatic insects.

Current LWD Management Approach: An Example

The Soquel Creek basin, Santa Cruz County, California, drains 104 km2 on the central California coast before emptying into the Monterey Bay. The upper portion of the basin is forested with second-growth and old growth conifer species. The lower portion of the basin is semi-urbanized, occupied by the towns of Soquel (pop. 9,188) and Capitola (pop. 10,377).

On eight different occasions over the past 100 years, large storms have formed massive logjams upstream of the Soquel Drive Bridge, diverting flow out of the channel and into the Soquel business district, causing millions of dollars of damage. The county Department of Public Works replaced the bridge in 1890, 1922, and 1956 because of flood damage and plans to replace the current bridge in 2001.

We conducted a preliminary study comparing the size of in-channel wood to the dimensions of bridges and culverts, and found that current structures are too small to allow LWD to pass unimpeded through the basin. All culverts and most bridges are probable bottlenecks to wood movement and are potential flood hazards. The Soquel Creek Storm Damage Recovery Plan (Singer and Swanson 1983) strengthens this assumption by concluding that jams are the main drivers on culvert repair and replacement. The County of Santa Cruz now actively removes LWD from Soquel Creek and basin tributaries during low flow periods to prevent logjams from forming upstream of bridges and culverts.

However, Soquel Creek is a geologically unstable basin, underlain by fine-grained sedimentary rock, and is controlled by the San Andreas Fault intersecting the upper portion of the basin. The greatest source of LWD comes from deep-seated rotational landslides and debris flows, which are common throughout the basin, most occurring during or immediately after intense rainfall. Thus, even if all wood is removed from the channel during low-flow periods, logjam related flooding would still occur, as most wood has not yet entered the system. Removing wood eliminates aquatic habitat that is important in maintaining the health of freshwater ecosystems.

The loss of habitat due to wood removal is implicitly recognized by the installation of habitat enhancement structures that attempt to mimic the physical and ecological effects of LWD. The overall success of these structures in creating and maintaining habitat has been low in Soquel Creek (Lassettre 1997), consistent with observations elsewhere (Frissell and Nawa 1992).

Process-Based Wood Management Approach

The objective of this research is to develop strategies of LWD management that balance ecological objectives and public safety. This study will design a basin-scale wood management plan that allows natural processes of wood recruitment and transport to occur throughout a channel network. The plan will rely on a conceptual model of the downstream flux of LWD that will enable an evaluation of how infrastructural changes, such as modifying bridges and culverts, and how land-use changes, involving timber harvest and residential development, influence LWD flux.

The study will be centered within the Soquel Demonstration State Forest (SDSF), located in the northeast corner of the basin. The California Department of Forestry (CDF) owned forest is the largest piece of property within the basin, and access to this location will enable a detailed study along the east branch of Soquel Creek and adjoining tributaries. The management history of SDSF is well documented and provides an opportunity to examine how various harvest rotations and harvest methods influence LWD flux. The forest is also traversed by the San Andreas fault, the major geologic control within the Soquel Creek basin and possibly a major influence on LWD recruitment. Data will also be collected along selected streams throughout the channel network, depending on access granted by local landowners.

The proposed model will improve the environmental planning of basins subject to increasing urban pressures. The process-based, basin-wide perspective in a planning context will balance ecological health and public safety. We hope to demonstrate that this approach to managing a stream basin, which considers the input and transport of LWD, sustains ecological function and is more economically sustainable than the current approach. As part of the final analysis, we will compare the economic costs of the current approach to my proposed wood-passing approach. Based on current approximations with limited information, it is apparent that the revised approach is a more sustainable long-term solution than the current management style.

Literature Cited

Fetherston, K. L., R. J. Naiman, and R. E. Bilby. 1995. "Large Woody Debris, Physical Process, and Riparian Forest Development in Montane River Networks of the Pacific Northwest." *Geomorphology* Vol. 13, pp. 133-144.

Frissell, C. A. and R. K. Nawa. 1992. "Incidence and causes of physical failure of artificial habitat structures in streams in western Oregon and Washington." *North American Journal of Fisheries Management* Vol. 12, pp. 182-197.

Harmon, M. E., J. F. Franklin, F. J. Swanson, et al. 1986. "Ecology of Coarse Woody Debris in Temperate Ecosystems." In MacFadyen A. and E. D. Ford (eds.). *Advances in Ecological Research.* New York, NY: Harcourt Brace Jovanovich. Vol. 15, pp. 133-302.

Lassettre, N. S. 1997. "Evaluation of Structures to Improve Steelhead Trout (*Oncorhynchus mykiss*) Habitat." Master's thesis, San Jose State University, CA.

Keller, E. A. and F. J. Swanson. 1979. "Effects of Large Organic Material on Channel Form and Fluvial Processes." *Earth Surface Processes and Landforms* Vol. 4, pp. 361-380.

Singer, S. and M. L. Swanson. 1983. *Soquel Creek Storm Damage Recovery Plan.* Aptos, CA: US Soil Conservation Service.

Forest Conservation Planning Using Geographic Information Systems (GIS): Redwoods Case Study

James R. Strittholt
Gerald E. Heilman, Jr.
Conservation Biology Institute
260 SW Madison Ave., Suite 106
Corvallis, OR 97333
stritt@consbio.org

Conservation planning is becoming a common activity among conservationists especially in forested ecosystems. With limited budgets and high costs, however, preparing detailed, comprehensive landscape designs is difficult over large geographic areas. One approach is to identify smaller landscapes (focal areas) within a region that, based on relative ecological attributes and condition, make better candidates for protection or restoration efforts. Once identified, these areas would then be targeted for more rigorous evaluation, including substantial field surveys to develop the best possible ecological assessments and design alternatives.

We developed a GIS-based model for Save-the-Redwoods League. The model was intended to help the organization identify priority areas where they could engage in meaningful proactive planning with their conservation partners. The model considers 10 criteria, organized as patch, neighborhood, or watershed functions that were modeled separately and then compiled by 6th-level watersheds for the entire redwood region. Hence, the model is hierarchical and considers both content and context of forest patches.

Although some model deficiencies became apparent, largely related to variable data quality, the model helped us identify ecologically significant focal areas within each of three recognized redwood subregions.

Since the initial redwood model was constructed, we have worked on developing new techniques to include aquatic considerations in a more integrative fashion. For example, functional connectivity of stream networks throughout the Pacific Northwest is fundamentally important to salmon survival and productivity. The natural dynamic relationship between land and water under which salmon evolved has been significantly altered by urban development, road building, logging, mining, dams, and water diversions, and release of invasive exotic species. Best visualized as a dynamic process rather than a static condition, fragmentation can be described for aquatic systems as well as terrestrial ones with comparable negative ecological. Using a variety of GIS modeling techniques, we have begun developing a conceptual framework that attempts to integrate aquatic and terrestrial considerations by first defining the physical drivers of these dynamic systems over time and space and then predicting the subsequent biological responses to natural and manmade disturbances.

Using KRIS Software to Assimilate Information from the Noyo River Basin: the North Coast Watershed Assessment Pilot Watershed

Pat Higgins
KRIS Project Coordinator
IFR KRIS Office
791 Eighth Street, Suite N
Arcata, CA 95521
(707) 822-9428
phiggins@humboldt1.com

Abstract

The Institute for Fisheries Resources received a grant from the National Fish and Wildlife Foundation and a contract from the California Department of Forestry to produce a CD about the Noyo Basin for use by agencies, private companies and the public using Klamath Resource Information System (KRIS) software. The Noyo River basin is the pilot watershed for the North Coast Watershed Assessment project, a sweeping new effort by the California Resources Agency. From August 1999 to April 2000, IFR contractors gathered information of all types regarding the Noyo River. From April through June, KRIS Noyo underwent peer review and from June to August it was modified to reflect constructive criticism. Map information was also drawn together in ArcView projects.

Information came from state and federal agencies, private companies, consultants, academics and the general public. Data on fisheries, water quality, flows, rainfall, and other relevant topics were included in KRIS. Recent and historical photos illustrate the current health of watersheds and historic land use and changes. Map information includes geology, soil, slope, timber harvests, streams, fish distribution (present and historic), vegetation types, monitoring locations and other useful spatial data.

The California Department of Forestry will be producing and disseminating CDs. Information on the KRIS Noyo project and other KRIS coverages will also be available at the website www.krisweb.com. People actually making changes to KRIS will want to obtain a CD. Bibliographic resources on the CD are much more numerous than on the website also. IFR will be producing CDs for the Big River and Ten Mile Rivers by the end of the year 2000. Phase two of the CDF/IFR KRIS project calls for building KRIS faceplates for all northern California watersheds for which none presently exist. IFR staff will acquire information and data and provide it with the KRIS engine for newly hired State watershed assessment personnel. These folks will actually use the data and KRIS tool in their analysis.

Arcata Community Forest: A Model for Redwood Management

Seth Zuckerman
Arcata Community Forest
736 F. St.
Arcata, CA 95521
Zuckerman@igc.org
(707) 629-3992

Every so often, there comes a time when you decide, an hour or two before your talk, to scrap what you had planned to say because another topic seems more relevant to the situation at hand. I have just had that experience this afternoon, when I realized that what I might convey about the Arcata municipal forest was much more pertinent to this gathering than my intended comments on the limits to regulation as a way of accomplishing environmental progress. So I apologize if my remarks seem hastily thrown together, and I hope you'll bear with me.

Apart from its parks, the City of Arcata owns and manages about 1,200 acres of forestland. Six hundred of that lies just east of the Humboldt State University campus and adjoining the city's Redwood Park. Another 580 acres are located several miles east of the city, on Jacoby Creek. The city acquired this land for $18,000 in 1942, when it was covered in sub-merchantable timber.

These areas have special relevance to Jackson State Demonstration Forest because they contain a stand of publicly owned second-growth redwoods managed for many uses simultaneously on the same terrain: for sustainable timber harvest as well as recreation, wildlife, and fisheries. Some 30 percent of the forest is set aside in reserves, mostly in generous streamside buffers and to avoid cutting on steep slopes. Because the lands are in public ownership, they don't have to yield the highest profit, even though they are still producing some sawlogs. That mix is governed not by regulation, but by the sentiments of the citizenry, conveyed through the political process.

I'm going to focus my remarks mostly on the more westerly of the two tracts, known as the Arcata Community Forest, because it is the tract where the city has logged most recently—just this past summer—and it's the only tract which I have visited. It was clearcut and burned in the 1880s, and served as the watershed for the town's drinking water supply until the 1960s.

After the city shifted its water supply to other sources, it began to log selectively in the community forest. At the time, the second-growth redwood had comparatively little value, because old-growth redwood was still abundant. Instead, the city cut its whitewoods—Douglas fir, Sitka spruce, and grand fir. This commercial thinning increased the growth of the redwoods, but only allowed enough light to the forest floor to promote the regeneration of the most shade-tolerant species: grand fir and Sitka spruce.

The next significant shift in the Arcata forest occurred in 1980, when a citizen initiative passed calling for the purchase of parkland around the city through a bond issue, which was to be repaid through the sustainable harvest of timber from the city's municipally owned woodland. The plan was to cut no more than the forest was growing, by uniformly thinning no more than 30 percent of the stand’s volume. The management of the Arcata forest followed these guidelines through the 1980s.

In retrospect, city forestry staff identifies two problems with this strategy. For one, it tied the rate of harvest to a fixed financial obligation. At the time, interest rates were high and timber prices low, which put a heavy strain on the forest. The city eventually opted to accelerate its logging schedule to pay off the bonds early, saving trees in the long run because the value of the timber was growing more slowly than the interest on the city's debt. It then had to let the forest rest for several years to catch up to the volume it had at the outset.

The city also discovered in the course of its harvest that uniform selective harvest didn't bring about vigorous regeneration of redwood seedlings. As a result, city staff shifted to a system of group selection, opening 1.0- to 2.5-acre patches in the forest that brought more light down to the forest floor, in the hopes of promoting the growth of seedlings. These amounted to small clearcuts, and in subsequent harvests, the city has chosen to keep its openings smaller.

With this experience under its belt, the city charted a new management direction for the forest in 1994, and translated it into a Non-Industrial Timber Management Plan approved by the California Department of Forestry (CDF). This long-term plan allows it to cut when the market is most favorable. In 1995, the city cut half-a-million board feet; in 2000, it took 400,000 board feet, which was about 30 percent of the volume from an eight-acre area. This year's cut amounted to four months' growth on the city's forest, which inventory figures show is increasing at the rate of 1.2 million board feet per year. At a price of $1440 per thousand board feet, the harvest netted the city about half a million dollars, which is being plowed back into the management of the forest for expenses such as wildlife monitoring and trail maintenance. The city also aims to acquire some adjoining parcels of forestland, and could use the proceeds of timber harvest to expand its holdings.

I toured their 2000 logging site at the end of October. Anyone who has ever seen a recently logged area knows to expect a certain amount of slash, ground disturbance, and disruption. This site was actually pretty. The city had brought in a chipper to process the slash and scatter it on the forest floor. The site adjoins one of the main trails leading up from the city's Redwood Park, so there was a premium on maintaining the aesthetic and recreational values.

City Forester Mark André explains the goals behind the city's silviculture. The greatest aim overall is to preserve options for future foresters. The city has a lot of latitude in its management now because of his predecessors' conservative management, he says. As long as he continues in the current style of management, his successors will have even more options for timber harvest and silviculture.

A more specific goal is to break up the even-age structure of the forest.

Just about all of the redwoods sprouted in a short time right after the initial old-growth harvest, meaning that today's forest is composed of uniform-aged 110- to 120-year-old trees. By opening up the canopy a bit, André hopes to stimulate the growth of saplings and stump sprouts, reintroducing a multi-storied canopy structure, and breaking up the homogeneous even-aged quality of the stand. That will improve the forest's value as habitat for birds associated with old-growth forests. When André marks trees for harvest, he considers which leave trees will make good snags. He has also brought in cull logs from a new subdivision nearby to increase large woody debris in streams and on the forest floor.

In fact, biologists from the U.S. Fish and Wildlife Service toured the city's forest and warned André that he was liable to create nesting habitat for the marbled murrelet—a species that is federally listed as endangered—which could complicate the city's future logging plans and restrict it from cutting near the nest sites. The biologists offered the city what is known as a “safe harbor,” a provision in endangered species rules that allows good management to continue uninterrupted if it inadvertently leads to the creation of new habitat for an endangered life-form. The city council declined the offer, saying that if murrelets begin nesting in the forest, they would prefer to protect them.

That choice epitomizes the city's unusual style of forestry: there are few large blocks of mature redwood forest on the North Coast, and even fewer are being managed to develop the characteristics that will attract species associated with old-growth forests. Yet for the landscape and its wildlife populations to recover, every acre is important, including those that are also producing timber. If any forests can be expected to model this kind of stewardship, it is land under public management, such as the Arcata Community Forest or Jackson State Demonstration Forest. Managing second-growth forest to promote the recovery of endangered species alongside the harvest of high-quality, high-value sawlogs—now that would really be something worth demonstrating.

A Framework for Examining the Economic Benefits of Wildland Restoration

Pete Morton, Ph.D.
The Wilderness Society
7475 Dakin St., Suite 410
Denver, CO 80221
pete_morton@tws.org

Introduction

The 1964 Wilderness Act (Section 4b) recognizes the multiple benefits of wilderness areas: "wilderness areas shall be devoted to the public purposes of recreational, scenic, scientific, educational, conservation, and historical uses." While the act provides a basic framework of wilderness uses, it does not begin to enumerate all of the benefits of wilderness areas (Driver and others 1987; Rolston 1986; Reed 1989) or the benefits from restoration of wildlands. This paper attempts to summarize these benefits and uses based on a total economic valuation framework.

Wildland Economic Theory

Wildland ecosystems represent natural capital capable of producing a wide range of goods and services for society. Some of these outputs, such as timber, are freely exchanged in formal markets. Value is determined in these markets through exchange and quantified in terms of price. However, many other outputs—watershed protection, carbon storage, scenic beauty, trophy caliber wildlife and native fish, for example—contribute to our quality of life and support our market economy, but are without formal markets and therefore without prices.

The fact that wildland benefits are not priced does not mean they lack value, only that market indicators of the value do not exist. Economists must estimate the nonmarket benefits of the goods and services jointly produced by wildlands when consumers are unable to express their preferences and willingness to pay via the marketplace. Nonmarket benefits should be included in the economic analysis used to inform public land management decisions. An economic analysis must account for nonpriced benefits and costs, as well as those more readily observed and measured in market prices (Pearse 1990; Loomis and Walsh 1992). An economic analysis is conducted from the viewpoint of society, which should also be the viewpoint of managers of the public estate. In contrast, a financial analysis examines only costs and benefits as measured by market price; it is the viewpoint of private industry and is more concerned with profits or losses.

A Total Economic Valuation Framework

To account for the full array of goods and services generated by wildlands, economists have derived the total economic valuation framework (Randall and Stoll 1983; Peterson and Sorg 1987; Loomis and Walsh 1992). A total economic valuation framework is the appropriate measure when comparing wildland benefits to its opportunity costs (Loomis and Walsh 1992). The total economic benefits generated by wildlands are conceptually summarized in figure 1, based mostly on research by Krutilla (1967), Rolston (1986), Driver and others (1987), Walsh and Loomis (1989), and McCloskey (1990). The seven categories of wildland benefits include direct use, community, scientific, off-site, biodiversity conservation, ecological services and passive use benefits (Morton 1999).

Wildland recreation results in a variety of individual and social benefits including personal development (spiritual growth, improved physical fitness, self-esteem, self-confidence and leadership abilities); social bonding (greater family cohesiveness and higher quality of family life); therapeutic and healing benefits (stress reduction helping to increase worker productivity and reduce illness and absenteeism at work); and social benefits (increased national pride) (Driver 1976; Haas and others 1980; West 1986; Driver and Brown 1986; Williams and others 1989). Wildlands are places for spiritual experiences and have inspired the creation of art, photography, literature, poetry and music. Wildlands also restore mental and physical health, stimulate creativity, achieve self-realization and improve group leadership skills (McCloskey 1990). Wildlands provide current and future gener-

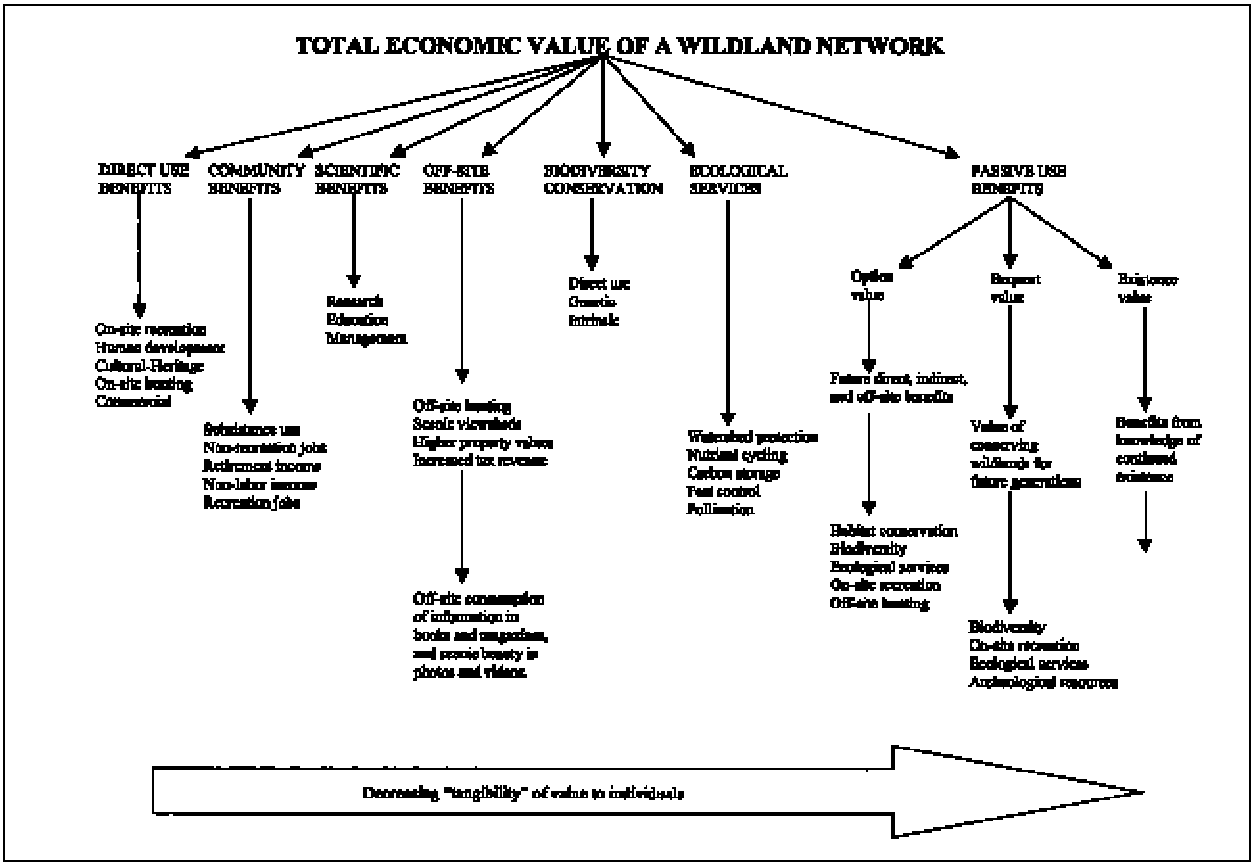


Figure 1. Total economic framework for evaluating wildland benefits.

ations of Americans with a frontier-like environment to reclaim their cultural identity and feed their souls (McCloskey 1989; Reed 1989).

The amenity-based development occurring throughout the American West is partially based on the environmental, recreational and scenic amenity resources generated by public wildlands (Rudzitis and Johansen 1989,1991; Whitelaw and Niemi 1989; Rasker 1994, 1995; Power 1996). Wildlands enhance the quality of life for local residents and indirectly benefit rural communities by attracting and retaining nonrecreation businesses and retirees (Decker and Crompton 1990; Johnson and Rasker 1995; Lorah in press). Hunting and fishing outfitters gain commercial benefits from wildlands by providing a primitive environment for their clients. Wildlands also directly create jobs for wilderness rangers, agency planners and administrators, as well as agency and university researchers (Rudzitis and Johnson in press).

There is also growing recognition of the scientific and management value of a network of wildlands (Stankey 1987). By limiting motorized access, wildlands provide valuable protection of archeological and paleontological resources for future scholars. Wildland vegetation is rich in historical information on disturbance regimes, composition, structure and function of natural communities—information that is prerequisite for successful ecosystem management. Wildlands generate off-site benefits by providing habitat for mountain lion, black bear and other charismatic megafauna that may be hunted or viewed outside wildlands (Loomis 1992). Wildlands also serve as valuable scenic backdrops for resorts and residences on adjacent lands—enhancing property values and tax revenues (Phillips in press).

Wildlands help conserve biological diversity, which includes the full array of native species, the genetic information they contain, the communities they form and the landscapes they inhabit. Genetic diversity allows increases in the productivity and disease resistance of crops and the generation of new medicinal products. Wild plant and animal species are estimated to account for 4.5 percent of the nation's gross domestic product (Prescott-Allen 1986).

Wildlands generate ecological services, including climate moderation, pollination, seed dispersal, watershed protection, natural pest control services and carbon sequestration (Ecological Society of America 1997). Watershed protection protects private property from floods and lowers water treatment and reservoir maintenance costs for downstream communities. Watershed protection is an important role for public lands because wildlands contain the headwaters of many of America's rivers, and controlling development, road construction and hence erosion on private lands is more difficult because of concerns over private property rights.

Sustaining public wildlands with habitat for natural predators is economically rational (Morton and others 1994) as natural predation plays an important role in ending and lengthening the time between pest outbreaks (Ecological Society of America 1997), and natural predation contributes $17 billion per year to the United States economy (Pimental and others 1997). Scientific concerns over atmospheric carbon dioxide levels suggest that the economic benefits of storing carbon in a wildland network could play a significant role in protecting the temperate rain forests—on the Tongass National Forest, for example, where up to 75 percent of forest carbon is stored in the soils (Joyce 1995). Protected by the forest canopy, soil carbon can be stored indefinitely (subject to fluctuations caused by natural disturbances) if these forests are reserved in a wildland network. If the forests are logged, however, the soils can quickly decompose and lose their carbon through exposure to increased sunlight, temperature and wind.

Economists and the courts have also recognized that wildlands generate substantial passive use benefits, including option, existence and bequest values (Clawson and Knetsch 1966; Walsh and Loomis 1989). Option value is like an insurance premium that people are willing to pay over and above their expected recreation benefits to maintain the option, for themselves or for their children, of visiting wildlands in the future (Weisbrod 1964; Krutilla 1967). Existence value is the psychic value a person enjoys from just knowing that wildlands exist—regardless of whether the person will ever visit an area (Krutilla and Fisher 1985). Bequest value represents what the current generation might be willing to pay to bequeath wildlands to future generations. Researchers have found that the passive use benefits of wildlands are typically greater than the other benefits included in the total economic valuation framework (Walsh and others 1984; Walsh and Loomis 1989; Walsh and others 1996).

Conclusion

Opponents of wilderness argue that protecting public lands as wilderness locks up resources, locks out people, and is bad for the economy. However, the facts do not bear out this tired rhetoric. Since passage of the Wilderness Act, economists have expanded and refined their methods for estimating the total economic benefits of wildlands. The total economic valuation framework presented in this paper illustrates that wildlands represent a multiple-use resource that provides a multitude of benefits to the current generation as well as future ones.

References

Clawson, M. and J. Knetsch, 1966. *Economics of Outdoor Recreation.* Baltimore, MD: Johns Hopkins University Press.

Costanza, R., R. d'Arge, R. de Groot, S. Farber, M. Grasso, B. Hannon, K. Limburg, S. Naeem, R. O'Neill, J. Panielo, R. Raskin, P. Sutton, and M. van den Belt. 1997. "The Value of the World's Ecosystem Services and Natural Capital." *Nature* Vol. 387, pp. 253-260.

Decker, J. and J. Crompton, 1990. "Business Location Decisions: The Relative Importance of Quality of Life and Recreation, Park, and Cultural Opportunities." *Journal of Park and Recreation Administration.* Vol. 8 (2).

Driver, B. L. 1976. "Quantification of Outdoor Recreationalists' Preferences." In Smissen, B. et al (eds.). *Research: Camping and Environmental Education.* HPEP Series No. 11. Pennsylvania

State University.

Driver, B. L. and P. Brown. 1986. "Probable Personal Benefits of Outdoor Recreation." *The President's Commission on America Outdoors: A Literature Review.*

Driver, B. L., R. Nash, and G. Haas. 1987. "Wilderness Benefits: a State-of-Knowledge Review." In Lucas, R. C. (ed.). *Proceedings—National Wilderness Research Conference: Issues, State-of-Knowledge, Future Directions.* USDA Forest Service GTR Int-220. Ogden, UT: Rocky Mountain Experiment Station.

Duffield, J. W. 1992. "Total Valuation of Wildlife and Fishery Resources: Applications in the Northern Rockies." In *Proceedings—The Economic Value of Wilderness.* USDA Forest Service GTR SE-78. Asheville, NC: Southeastern Forest Experiment Station.

Ecological Society of America. 1997. *Ecosystem Services: Benefits Supplied to Human Societies by Natural Ecosystems.* Washington, DC.

Gilbert, A., R. Glass, and T. More. 1992. "Valuation of Eastern Wilderness: Extramarket Measures of Public Support." In *Proceedings—The Economic Value of Wilderness.* USDA Forest Service GTR SE-78. Asheville, NC: Southeastern Forest Experiment Station.

Haas, G. E., B. L. Driver, and P. J. Brown. 1980. "Measuring Wilderness Recreation Experience Preferences." In Cannon, L. K. (ed.). *Proceedings of the Wilderness Psychology Group Annual Conference.* Durham, NH: University of New Hampshire. pp. 22-40.

Haynes, R. W. and A. L. Horne. 1997. "Economic Assessment of the Basin." In T. M. Quigley and S.J. Arbelbide (eds.). *An Assessment of Ecosystem Components in the Interior Columbia Basin and Portions of the Klamath and Great Basins*, Vol. IV. 1715-1870. USDA Forest Service, PNW-GTR-405. Portland, OR: Pacific Northwest Research Station.

Johnson, J. and R. Rasker. 1995. "The Role of Economic and Quality of Life Variables in Rural Business Location." *Journal of Rural Studies* Vol. 11 (4), pp. 405-416.

Joyce, L. 1995. *Productivity of America's Forests and Climate Change*. USDA Forest Service GTR RM-27 1. Fort Collins, CO: Rocky Mountain Forest and Range Experiment Station.

Kask, S. and P. Morton. 1998. *Quality of Life and Natural Resource Amenities in Business Location and Retention Decisions.* Paper presented at the Southern Appalachian Man and the Biosphere Conference. Gatlinburg, TN.

Krutilla, J. V. 1967. "Conservation Reconsidered." *American Economic Review* Vol. 57, pp. 777-786.

Krutilla, J. V. and A. C. Fisher. 1985. *The Economics of Natural Environments.* Washington, DC: Resources for the future.

Loomis, J. 1992. "Importance of Joint Benefits of Wilderness in Calculating Wilderness Recreation Benefits." In C. Payne et al (eds.) *The Economic Value of Wilderness.* USDA Forest Service, GTR SE-78. Asheville, NC: Southeastern Forest Experiment Station.

Loomis, J. 1993. *Integrated Public Lands Management.* New York: Columbia University Press.

Loomis, J. B. 1995. "Shifting and Broadening the Economic Paradigm Toward Natural Resources." In Knight, R. L.and S. F. Bates (eds.). *A New Century for Natural Resources Management.* Covelo, CA: Island Press.

Loomis, J. In press. "Economic Values of Wilderness Recreation and Passive Use: What We Think We Know at the Turn of the 21st Century." In Cole, D. N. and S. F. McCool. 2000. *Proceedings—Wilderness Science in a Time of Change.* Proc. RMRS-P-000. U.S. Department of Agriculture, Forest Service. Ogden, UT: Rocky Mountain Research Station.

Loomis, J. and R. Walsh. 1992. "Future Economic Values of Wilderness." In Payne, C. et al (eds.). *The Economic Value of Wilderness.* Southeastern Forest Experiment Station. GTR SE-78.

Lorah, P. In press. "Population Growth, Economic Security and Cultural Change in Wilderness Counties." In Cole, D. N. and S. F. McCool. 2000. *Proceedings—Wilderness Science in a Time of Change.* Proc. RMRS-P-000. U.S. Department of Agriculture, Forest Service. Ogden, UT: Rocky Mountain Research Station.

Manning, R. E. 1989. "Social Research in Wilderness: Man in Nature." In Freilich, H. R. (ed.). *Wilderness Benchmark 1988: Proceedings of the National Wilderness Colloquium.* USDA Forest Service GTR SE-Si. Asheville, NC: Southeastern Forest Experiment Station.

McCloskey, M. 1989. "Understanding the Demand for More Wilderness." In Freilich, H. R. (ed.). *Wilderness Benchmark 1988: Proceedings of the National Wilderness Colloquium.* USDA Forest Service GTR SE-Si. Asheville, NC: Southeastern Forest Experiment Station.

McCloskey, M. 1990. "Evolving Perspectives on Wilderness Values: Putting Wilderness Values in Order." In Reed, P. C. (comp.). *Preparing to Manage Wilderness in the 21st Century: Proceedings of the Conference.* USDA Forest Service, GTR-SE-66. Asheville, NC: Southeastern Forest Experiment Station.

Morton, P. A., D. D. Boone, G. H. Aplet. 1994. "Sustaining Biological Resources on the Southern Appalachian National Forests." In *Proceedings—1994 Southern Forest Economics Workshop.* Savannah, GA: D. B. Warnell School of Forest Resources, University of Georgia.

Morton, P. 1997. "Sustaining Recreation Resources on the Southern Appalachian National Forests." *Journal of Park and Recreation Administration* Vol. 15 (4). pp. 6l-78.

Morton, P. 1999a. "The Economic Benefits of Wilderness: Theory and Practice." *University of Denver Law Review* Vol.76 (2) pp. 465-518.

Pearse, P. H. 1990. *Introduction to Forestry Economics.* Vancouver, BC: University of British Columbia Press.

Peterson, G. L. and T. C. Brown. 1986. "The Economic Benefits of Outdoor Recreation." In *The President's Commission on America Outdoors: A Literature Review.*

Peterson, G. L. and C. F. Sorg. 1987. *Toward the Measurement of Total Economic Value.* USDA Forest Service. GTR RM-148. Fort Collins, CO: Rocky Mountain Forest and Range Experiment Station.

Phillips, S. In press. "Windfalls for Wilderness: Land Protection and Land Value in the Green Mountain National Forest." In Cole, D. N. and S. F. McCool. 2000. *Proceedings: Wilderness Science in a Time of Change.* Proc. RMRS-P-000. U.S. Department of Agriculture, Forest Service. Ogden, UT: Rocky Mountain Research Station.

Pimentel, D., C. Wilson, C. McCullum, R. Huang, P. Dwen, J. Flack, Q. Tran, T. Saltman, and B. Cliff. 1997. "Economic and Environmental Benefits of Biodiversity." *BioScience* Vol. 47 (11).

Power, T. M. 1996. *Lost Landscapes and Failed Economies.* Covelo, CA: Island Press.

Prescott-Allen, C. and R. Prescott-Allen. 1986. *The First Resource: Wild Species in the North American Economy.* New Haven, CT: Yale University Press.

Randall, A. 1983. "The Problem of Market Failure." *Natural Resources Journal* Vol. 23. pp. 131-148.

Randall, A. 1986. "An Economic Perspective of the Value of Biological Diversity." In *Technologies to Maintain Biological Diversity* Vol. 2. Contract Papers. Part E. Valuation of Biological Diversity. Washington, DC: Office of

Technology Assessment.

Randall, A. and J. Stoll. 1983. “Existence Value in a Total Valuation Framework.” In Rowe, R. and L. Chestnut (eds.). *Managing Air Quality and Scenic Resources at the National Parks and Wilderness Areas.* Boulder, CO: Westview Press

Rasker, R. 1994. “A New Look at Old Vistas: The Economic Role of Environmental Quality in Western Public Lands.” *University of Colorado Law Review* Vol. 52 (2), pp. 369-399.

Rasker, R. 1995. *A New Home on the Range: Economic Realities in the Columbia River Basin.* Bozeman, MT: The Wilderness Society.

Reed, P. 1989. “Perspectives on Beginning Research in Nonrecreational Values of National Forest Wilderness.” Paper presented at Soc. of American Foresters Annual Convention. Spokane WA.

Rolston, H. 1986. *Philosophy Gone Wild.* Buffalo, NY: Proetheus Books.

Rudzitis, G. and H. E. Johansen. 1989. *Amenities, Migration, and Nonmetropolitan Regional Development.* Report to Nat. Science Foundation, Dept. of Geography, Univ. of Idaho.

Rudzitis, G. and H. E. Johansen. 1991. “How Important is Wilderness? Results from a United States Survey.” *Environmental Management* Vol. l5 (2), pp. 227-233.

Rudzitis, G. and R. Johnson. In press. “The Impact of Wilderness and Other Wildlands on Local Economies and Regional Development Trends.” In Cole, D. N. and S. F. McCool (eds.). 2000. *Proceedings—Wilderness Science in a Time of Change.* Proc. RMRS-P-000. U.S. Department of Agriculture, Forest Service. Ogden, UT: Rocky Mountain Research Station.

Sorg, C. and J. Loomis. 1984. *Empirical Estimates of Amenity Forest Values: A Comparative Review.* USDA Forest Service GTR RM-107. Fort Collins, CO: Rocky Mountain Forest and Range Experiment Station.

Stankey, G. H. 1987. “Scientific Uses in the Definition of Wilderness.” In *Proceedings of National Wilderness Research Conference: Issues, State-of-Knowledge, Future Direction.* USDA Forest Service, GTR Int-220. Odgen, UT: Rocky Mountain Research Station.

Swanson, C. S. and J. B. Loomis. 1996. *Role of Nonmarket Economic Values in Benefit-Cost Analysis of Public Forest Management.* USDA Forest Service. PNW-GTR-361. Portland, OR: Pacific Northwest Research Station.

U.S. Forest Service. 1982. *National Forest System Land and Resource Planning.* 47 Federal Register, 43, 026-52. Washington, DC: Gov. Printing Office.

U.S. Government Accounting Office. 1991. *Difficult Choices Face the Future of the Recreation Program*. GAO/RCED-91-1 15, Washington, D.C.

Walsh, R.G., J. B. Loomis, and R. Giliman. 1984. “Valuing Option, Existence and Bequest Demands for Wilderness.” *Land Economics* Vol. 60 (1), pp. 14-29.

Walsh, R.G. and J. B. Loomis. 1989. “The Non-Traditional Public Valuation (Option, Bequest, Existence) of Wilderness.” In Freilich, H.R. (ed.). *Wilderness Benchmark 1988: Proceeding of the National Wilderness Colloquium.* USDA Forest Service GTR SE-Si. Asheville, NC: Southeastern Forest Experiment Station.

Walsh, R. G., K. C. Bonetti, and J. M. Bowker. 1996. “Regional Household Preference for Ecosystem Restoration and Sustained Yield Management of Wilderness and Other Natural Areas.” In J. Bergstrom (ed.). *Benefits and Costs Transfer in Natural Resource Planning.* Athens, GA: University of Georgia.

Weisbrod, B. 1964. “Collective Consumption Services of Individual Consumption Goods.” *Quarterly Journal of Economics* Vol. 78, pp.

471-477.

West, P. C. 1986. “Social Benefits of Outdoor Recreation: Sociological Perspectives and Implications for Planning and Policy.” In *President's Commission on America Outdoors: A Literature Review.*

Whitelaw, E. and E. G. Niemi. 1989. “Migration, Economic Growth, and the Quality of Life.” In *Proceedings of the Twenty-Third Annual Pacific Northwest Regional Economic Conference.* pp. 36-38.

Williams, D. R., L. Haggard, and R. Schreyer. 1989. “The Role of Wilderness in Human Development.” In Freilich, H.R. (ed.). *Wilderness Benchmark 1988: Proceeding of the National Wilderness Colloquium.* USDA Forest Service GTR SE-S 1. Asheville, NC: Southeastern Forest Experiment Station.

The Role of Community in Restoration Forestry

Bill Heil
30901 Albion Ridge Road
Albion, CA 95410
707-937-0903

Abstract

The community as it exists today has changed in many important ways. The way the community relates to the forest has also changed. A new model for this relationship is proposed along with a proposal for a demonstration project.

The community of people living on the North Coast is a direct result of logging the forest. Towns were formed around sawmills and the long-time residents of the area are the descendents of mill workers and loggers. The ways these people relate to the forest still in large part determine how the forest is used.

Starting in the 1960s there was a large influx of new residents as well as a large increase of summer recreation visitors. Many of the new residents came here from urban areas as part of a back-to-the-land movement. Learning to live in harmony with the land and building their own homes gave them a new appreciation of wood and the forest. They formed the core of a strong environmental movement and found ways other than resource extraction to support themselves. Some of them became involved in the building trades and have been building homes for the newest influx of residents, older more wealthy people seeking a beautiful place in the country to retire.

In the old days everyone depended on the forest for their living. Over time this has changed to where relatively few people make their living directly from the forest. Despite the large influx of population, large tracts of timberland remain intact and are managed as "industrial forests." The immediate realization of financial gain drives the management, and public trust issues such as clean water and wildlife protection have suffered. In the "industrial model" all of the best material goes directly to the corporation mill. The community is allowed a bit of salvage and maybe firewood.

While no consensus has emerged as to how the forest should be managed, most people do agree on certain items. Foremost is that we enjoy living with the forest and that healthy forests are important to all of us. Most agree that the forests have been abused and overcut and that something should be done to make things better. People from all segments of the community are realizing that the "industrial model" of forest management does not adequately protect public trust resources.

Changing the focus of forestry from resource extraction to restoration will involve a change in the way the forest is used. The changing population is making different demands on the forest, emphasizing recreation and attention to public trust values such as clean air and water and protection of wildlife habitat. In order to ensure that these values are respected the community must also have a part in management of the forest.

A new model of forest management is needed. "Think globally, act locally" could be its motto. The concerns of the whole community, not just those who are directly employed by the timber industry have to be considered. An example of an attempt to involve the community in management was the Jackson State Demonstration Forest Citizens Advisory Committee appointed by then director of CDF Richard Wilson in 1998. It consisted of representatives of timber industry, forestland owners, recreation users and environmentalists. The committee met monthly for over a year and by consensus agreed on a set of recommendations for the management of JDSF that met most of the concerns of the community. Unfortunately most of their recommendations have not yet been given serious consideration by CDF.

The past decade has seen a proliferation of small portable sawmills (micromills) on the North Coast. They are quite versatile and are the means of employment for many people including former timber workers. They fill a niche by providing small landowners a means of turning their trees into lumber they can use. They are also used to saw local hardwoods for furniture workers. If a reliable source of high quality logs were available, micromills could be the basis of many new enterprises, such as custom sawing lumber for the custom homes being built in the area.

One of the concerns of the advisory committee was to find a way to provide logs for local micromills. Jackson Demonstration State Forest is a logical source, but present management practices do not allow for logs to be sorted and sold in small lots. JDSF is managed as though it were "industrial timberland." Timber Harvest Plans are typically several hundred acres. The timber is sold standing to the highest bidder who then contracts the logging to the lowest bidder. Virtually all of the logs are taken to the industrial mills.

Unlike the private industrial timberland, JDSF has not been severely over harvested. The overall inventory is growing and there are still areas of second-growth redwood that have not been reentered. However, the present management practices combined with past practices leave a degraded forest in need of attention. A change of focus from industrial timber production to a restoration model has been proposed.

A Demonstration Restoration Forest would not sell standing timber and leave the logging to the buyer's responsibility. The logging community needs to be educated in the proper way to work in the woods to protect all the values of the forest — not just the most cost-effective way of extracting timber. Ecologically sound logging methods would be a top priority of a Demonstration Restoration Forest.

The kind of timber harvest that would take place in a Restoration Forest would be designed to improve forest health. Methods such as thinning from below to improve the growth of the largest trees would produce logs with few knots and tight grains. They would be ideal for the micromills to process into high quality products such as timbers for the timber framing coming into vogue in custom home building.

Hardwoods, in particular tan oak, have become overabundant because of past practices. At present local residents are permitted to salvage oak for firewood after timber sales are completed. This results in truck traffic on logging roads after they have been waterbarred, damaging trucks and roads. A few of the tan oak logs are taken to Parlin Forks Conservation Camp where a successful milling experiment has been conducted. Most of the tan oak is made into firewood or not used. Micromills were invented for sawing hardwoods and are capable of efficiently sawing tan oak.

I propose a demonstration where a harvest is planned to aid in restoration of the forest. The most progressive capable loggers with the best-suited equipment would do the logging. Costs could be monitored, and training of young people who want to work in the woods could be conducted. The logs, both hardwoods and softwoods, would be sorted and sold in small lots to the highest bidder. I believe such a project would be supported by and benefit both the forest and the community.

Restoration and Management of Jackson Demonstration State Forest

Monroe Robinson
42700 Little River Airport Road
Little River, CA 95456
(707) 937-2825
monroe@mcn.org

The following is my own view of the restoration and management of Jackson Demonstration State Forest (JDSF). I will start with my background as it relates to this issue.

I graduated from Colorado State University with a B.S. in fisheries biology. I worked two summer seasons for the U.S. Fish and Wildlife Service and four summer seasons for the Alaska Department of Fish and Game. All of this work was on research and management projects with Alaskan salmon. Since 1993 I have owned and operated a portable sawmill. From 1994 through 1998 I operated a very environmentally friendly salvage logging operation, working in Jackson Demonstration State Forest (JDSF).

From October 1997 until April 1999 I was a member of the Citizens Advisory Committee to JDSF, created by the California Department of Forestry to give citizens input into the creation of a new management plan for JDSF. During that time I called for and held a citizen-sponsored town hall meeting in Fort Bragg to get public input. The town hall was filled to standing room only. If there is any interest, I have a copy of the video of that very powerful evening of people speaking of their priorities. Most people present demanded that JDSF stop using herbicides in their forest management, feeling that the herbicides are related to the very high rate of cancer and other health issues locally. Next to that, people felt that clear cutting should stop in all forms, cutting the remaining old-growth trees should stop, and stream protection necessary to restore salmon and steelhead populations should be provided.

I want to see JDSF demonstrate forestry restoration and management that does not rely on the use of herbicides. I find pampas grass, French broom, and eucalyptus growing where logging has taken place too frequently in a particular area. None of these species germinate easily under a canopy of shade, and if they do, they do not live long. Evidence of this is obvious in the forest, so a forest with these undesirable species should not be reentered until the unwanted species have died out. Large eucalyptus trees already in the forest can be carefully removed while allowing the forest to grow a canopy of desired trees.

There are thousands of old-growth trees within JDSF. Very few of them are over four feet in diameter where JDSF currently leaves them. These trees belong to the people of California. I am sure that, with few exceptions, almost every citizen would feel the time has come to stop cutting the last standing trees that are many hundreds of years old on state forest lands. Every one of these trees should be left standing and a buffer of other retained trees should be left around them.

JDSF is not just a forest to harvest trees. It is a forest that is habitat for salmon and steelhead. JDSF maintains that they are doing a good job of providing habitat for salmon. I maintain that they are doing a dismal job of that even on their special demonstration areas like Caspar Creek and Parlin Fork where they have added large woody debris. There will never be salmon and steelhead habitat until adequate stream buffers are provided, and these buffers mean no logging.

Large woody material will never accumulate if large trees near the streams are removed. Some of the trees that are currently removed could be felled into the waterways to speed up the accumulation of large woody material.

The salmon from the rivers along our coast live most of their life in the Pacific Ocean, the same ocean that salmon from Alaska live in. They are affected to the same degree as Alaskan salmon by such things as high seas fishing, the effects of "El Nino" and by natural predation. Most of the Alaskan salmon stocks are in a healthy state today except for those in the streams where logging has been heavy, and where there has been some local over-harvesting. JDSF should actively restore the condition of the rivers and steams within its boundaries and demonstrate the process. Great gains could be made by small timber owners from seeing this demonstrated.

Contracts today are sold to the highest bidder. The successful bidder then contracts to the lowest bidder to do the logging. The result is that logging is frequently done with less care for the land and environment on JDSF property than on industrial timberlands. This is a very bad deal for JDSF. It does not matter what silviculture method is used; the result is a disaster to the forest. What is needed is for JDSF to contract and supervise the logging and not give the bid to the highest bidder, but have a policy of giving the bid to the company who will log in a careful manner. Then sell the logs. Firewood logs should be made available to the local community. The State of California is subsidizing and funding an effort to have hardwood logs sawn, to help start a hardwood industry. JDSF should assist this effort, rather than ship hardwood logs to be chipped as is done today. The best hardwood logs should be made available to be sawn by micromills. This would help the local economy.

It is well documented that redwood trees put on almost no board feet to volume the first 30 to 40 years of a tree's life. Then they start to put more and more board feet of lumber on each year to where they are really adding a lot of volume per year by the time they are 60 to 80 years old. This very rapid rate of growth does not start to decline hardly at all until the tree is 150 to 200 years old and even then the decline is very slow in growth rate. Just thinking in terms of maximizing growth within the forest, JDSF should be letting trees grow much longer instead of cutting them when they are just starting to grow. Thinning as a type of logging at an early age makes sense in forest restoration. Letting the trees grow to an older age will result in a more restored forest ecosystem in every respect.

My salvage logging and sawmill operations centered on high quality logs and clear and select lumber and timbers. This high grade of lumber commands many times the price of lumber from young trees with an abundance of knots and almost no rot resistance. JDSF has several areas of older unentered second-growth forest that they are currently trying to log as rapidly as possible. This is just exactly the wrong thing to be doing. These trees are still growing rapidly. If they are logged, that land will produce virtually no volume of lumber for another 30 to 40 years, and then it will be knot-filled wood. The growth that these mature second-growth forest are adding is very high quality, a large portion free of knots. These trees should be allowed to grow. If harvesting must take place it should be years from now and at a very slow rate of harvest. This could provide a very high quality lumber and a very high sale price for the logs if JDSF contracts the logging and then sells the logs as I have previously suggested.

The mandate that guides the operation of JDSF needs to be changed at a legislative level. The new mandate should have as the top priority to restore the forest, including the river and streams. This can be the demonstration of restoration of habitat for all the diversified plant and animal life that was here before logging began. Next to that should be recreation. This new mandate can include logging within the forest to fund and demonstrate restoration.

Economic Effects of Restoring Jackson State Redwood Forest: Dispelling the Myths

Vince Taylor
Campaign to Restore Jackson Forest
P.O. Box 1066
Mendocino, CA 95460
707-937-3001
vtaylor@mcn.org

Summary

Although Jackson State Forest now accounts for from 10 to 15 percent of timber production in Mendocino County, the effects of halting all logging there would be quite small and short-lived. Only about 140 timber-related jobs would be lost, and most of the people affected would soon find jobs in the growing sectors of the county economy. Because timber and wood products have become such a small part of the county economy, and even of the Fort Bragg economy, the effects on the overall employment and economic activity in the county would be difficult to notice.

Introduction

When considering policy changes that would reduce the amount of logging, conventional wisdom focuses almost exclusively on the jobs that would be lost. Such a narrow focus misses the forest for the trees. A number of economic analyses have shown that many positive economic benefits result from reducing logging. These benefits generally flow from the enhanced natural environment that occurs when logging is reduced. People value living near and visiting a more beautiful environment. This “value” is an economic benefit. People are attracted to moving to a place where natural beauty is protected, creating additional demands for services and facilities in the area—a direct economic benefit. Recreation opportunities are created, attracting visitors who also add to the local economy.

A number of studies of specific instances where major reductions in logging occurred have concluded that the benefits outweighed the losses. The major foundation for this conclusion was the observation that local economies prospered and grew even when logging was dropping precipitously. If the direct economic losses are small or quickly reversed by other forces, there can be little argument with the conclusion that the benefits outweigh the losses—for the environmental benefits of reduced logging are manifold and continuing.

This paper focuses on the question: What would happen to the economies of Fort Bragg and Mendocino County if logging were halted in Jackson State Forest? Total cessation of logging is assumed, not because it is a likely consequence of making restoration the priority for the forest, but because it provides a “worst case” estimate. At this point, the Campaign to Restore Jackson State Forest has not researched the issue sufficiently to have a position on the kind and extent of logging that would be compatible with the goals of the Campaign.

Jackson State Forest's Contribution to Mendocino County Timber Production

First, let us look at the contribution Jackson State has made to the timber industry in Mendocino County. Charts 1-3 provide several views of logging history in Mendocino County. Chart 1 gives a long-term perspective. County timber production peaked at over one billion board feet in 1955. It has been in a long-term decline ever since. People familiar with logging in Mendocino County know that the last sharp drop, from about 400 to 200 million board feet in the early 1990s primarily reflected the virtual exhaustion of the industrial forest base by the two major owners, Georgia Pacific and Louisiana Pacific, together with decreased production from federal forestland. These two giant corporations have now sold off their lands to new owners and departed.

The contribution of Jackson State Forest to total production is barely visible at the top of the chart area displayed in Chart 1. Chart 2 shows more recent history, allowing the scale to be adjusted so that changes in Jackson State production can better be seen. Still, though, Jackson State appears to make an almost imperceptible contribution to total production. In physical terms, this is true, but not so in terms of Jackson State's percentage contribution to the shrinking total.

Chart 3 shows that the percentage contribution of Jackson State to timber production has stepped upward over time. This is primarily due to declining total production, but as Chart 4 shows, Jackson State production increased fairly steadily until 1965 and spiked upward to unprecedented levels of 42 and 47 million board feet in 1996 and 1997. The production in these two years was far above Jackson State's “allowable cut” of 29.5 million board feet. Production in the following two years returned to more “normal” levels.

Even though the physical volume of Jackson State production does not seem large in the context of Mendocino County's overall timber production, Jackson State is now contributing between 15 and 20 percent of the logs being delivered to mill. The management of Jackson State has said it has the ability to maintain or even increase timber production for the foreseeable future. For mill owners and timber cutters, Jackson State has become an important source of logs. Because production on industrial timberlands seems likely to fall even further, any movement to emphasize restoration over logging in Jackson Forest will alarm mills and timber cutters.

Economic Effects of Cutting Timber Production in Jackson State Forest

The government appropriately should be concerned that its actions not harm businesses and individuals. Thus, the impact of reduced timber production on local mills and employment needs to be considered in evaluating a change in state policy toward Jackson State.

It needs to be recognized that national and local economies are constantly changing. For many decades our economy has been shifting away from natural resource production towards services and distribution of goods. A reduction in timber production in the state forest would mirror the major declines that have taken place in federal and industrial forests. The shift of resources from timber production to other, growing areas of the economy is necessary and desirable for economic health and long-term prosperity. Having said all of this, though, there is no denying that any reductions in log production will cause hardships for businesses and workers.

For forming policy, it is certainly important to have an idea of the magnitude of the changes that would flow from cutting timber production in Jackson State Forest. First, let us look at the total role of timber production in Mendocino County. How great would be the impact on jobs and the economy of halting timber production in Mendocino County? An historical perspective can help to answer this question.

Employment declined less than timber production.

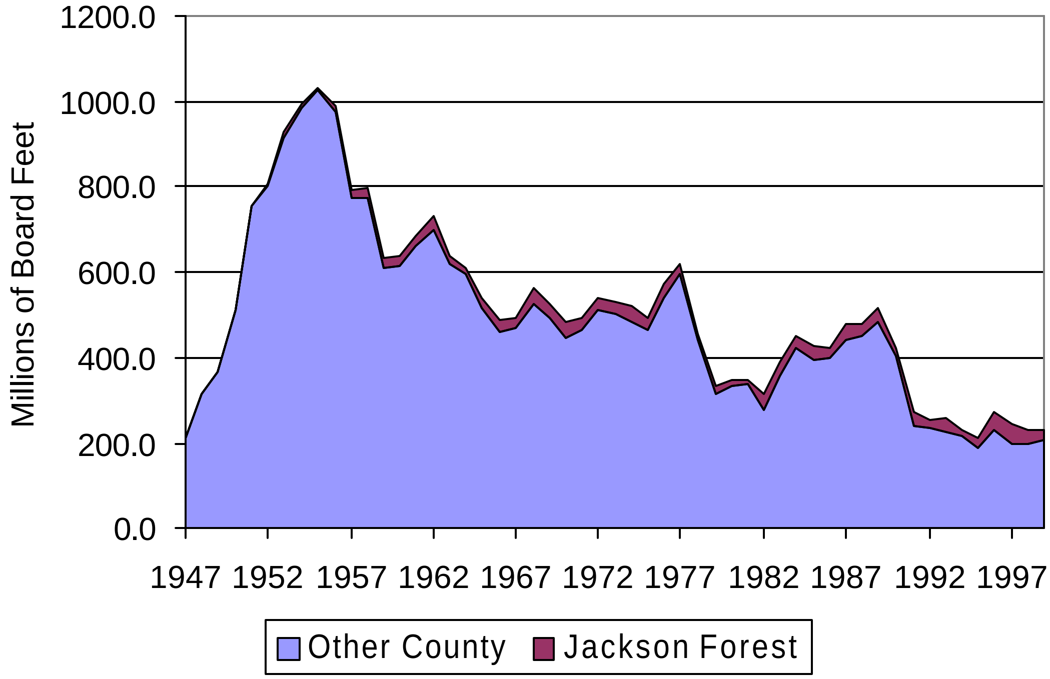
Chart 5 shows employment and an index of production for the timber industry in Mendocino County since 1972. Surprisingly, employment in the timber industry fell significantly less than timber production between 1972 and 1999. While production declined by 58 percent in this period, employment declined by only 34 percent. Thus, for every 10 percent decline in production, employment fell by only 6 percent. Because almost all industries made significant innovations and substituted equipment for labor during this time, increasing output per worker, the expectation is that employment would have declined by more than production, not vice versa.

Several reasons appear to account for the less than proportional decline in employment relative to timber production:

1. **Logging only a part of the timber industry:** Only about 30 percent of the jobs in the timber industry were in logging in 1999. The rest of them are at mills and other wood-processing plants. Only the logging jobs are tied directly to the level of country timber production.
2. **More loggers per board foot:** From 1992 to 1999, the only period for which data on jobs in the logging sector were available, there was a steady trend toward greater use of labor per board foot of lumber logged, as seen in Chart 5A. While timber production in the period decreased by 9 percent, logging jobs increased by 57 percent.

Chart 1

Mendocino County Timber Harvests



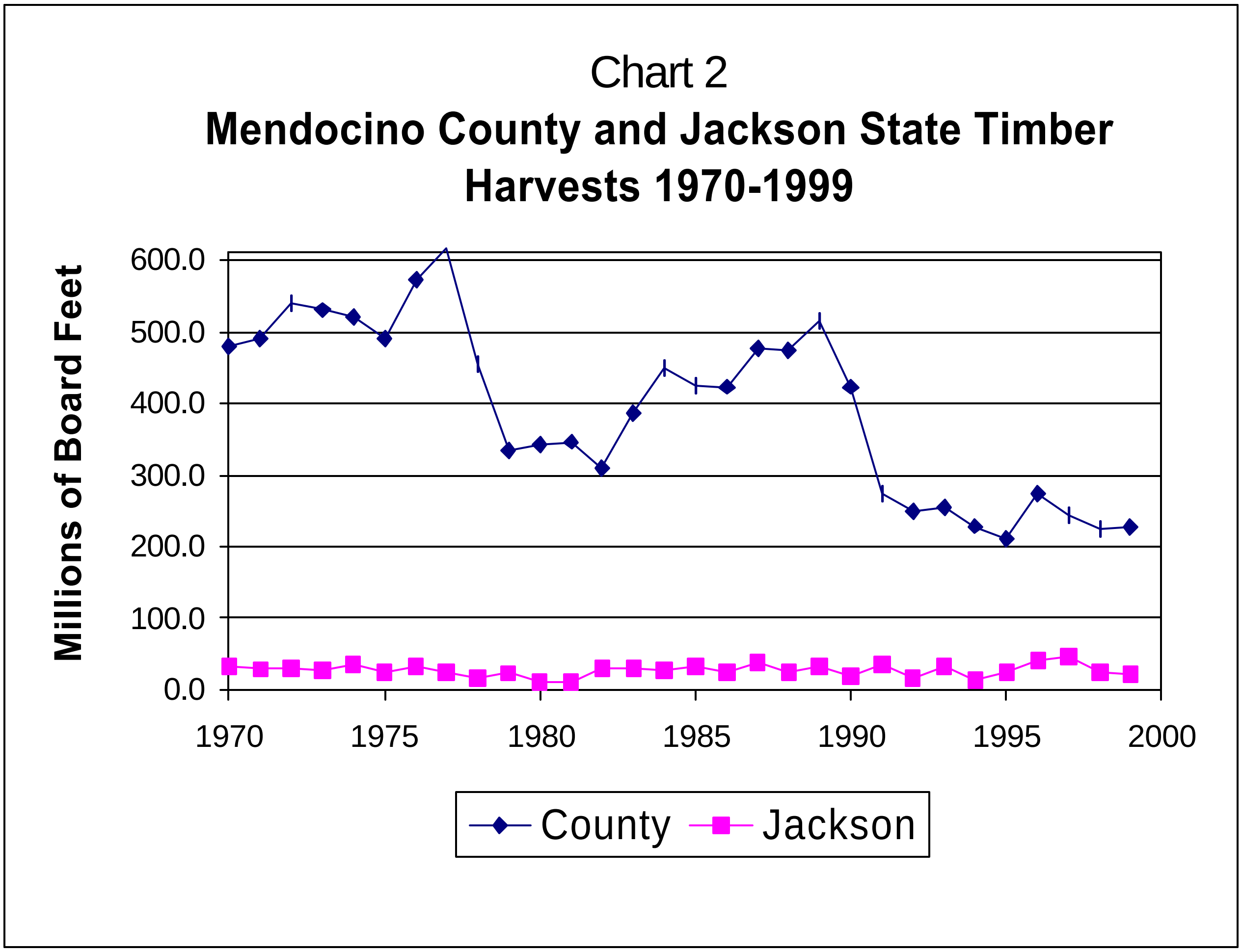


Chart 2
Mendocino County and Jackson State Timber Harvests 1970-1999
Millions of Board Feet
600.0
500.0
400.0
300.0
200.0
100.0
0.0
1970
1975
1980
1985
1990
1995
2000
County
Jackson

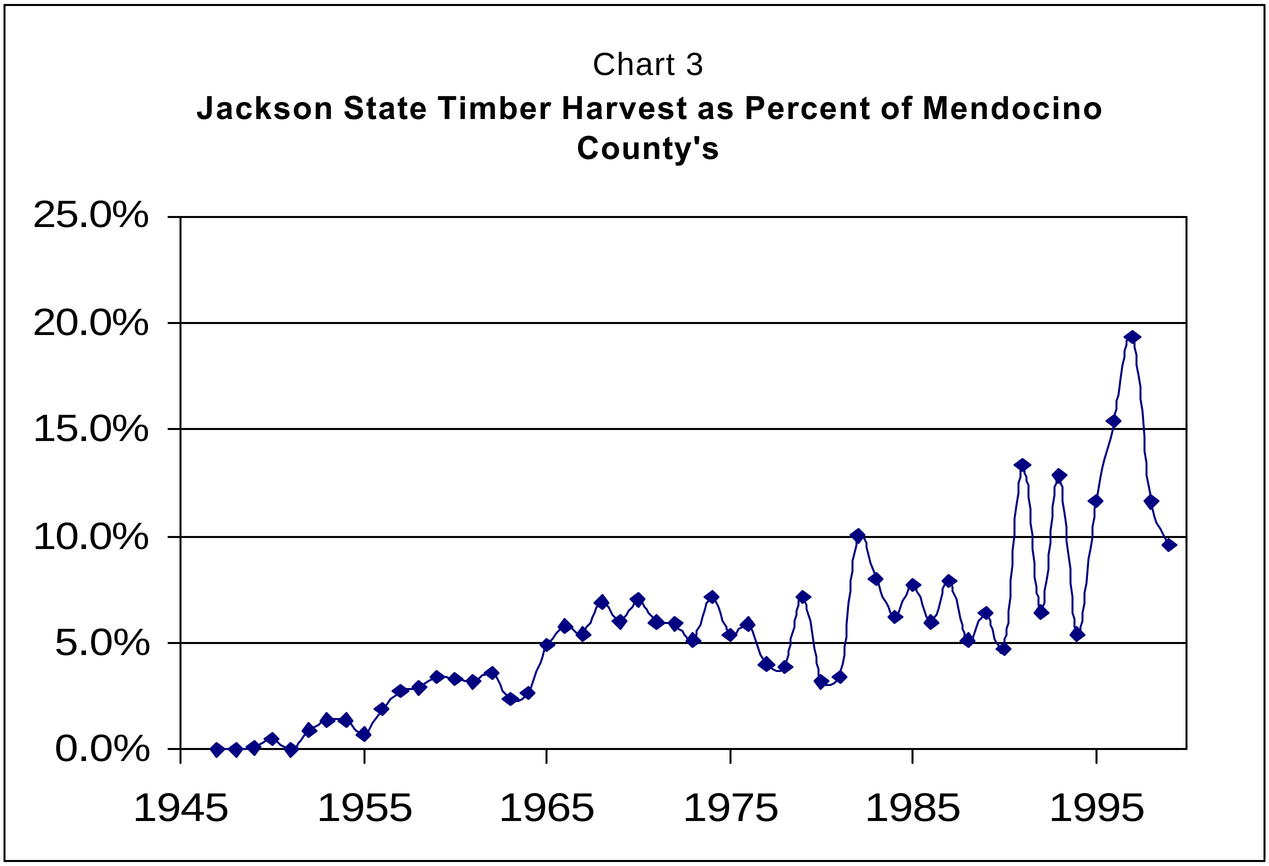


Chart 3
Jackson State Timber Harvest as Percent of Mendocino County's
25.0%
20.0%
15.0%
10.0%
5.0%
0.0%
1945
1955
1965
1975
1985
1995

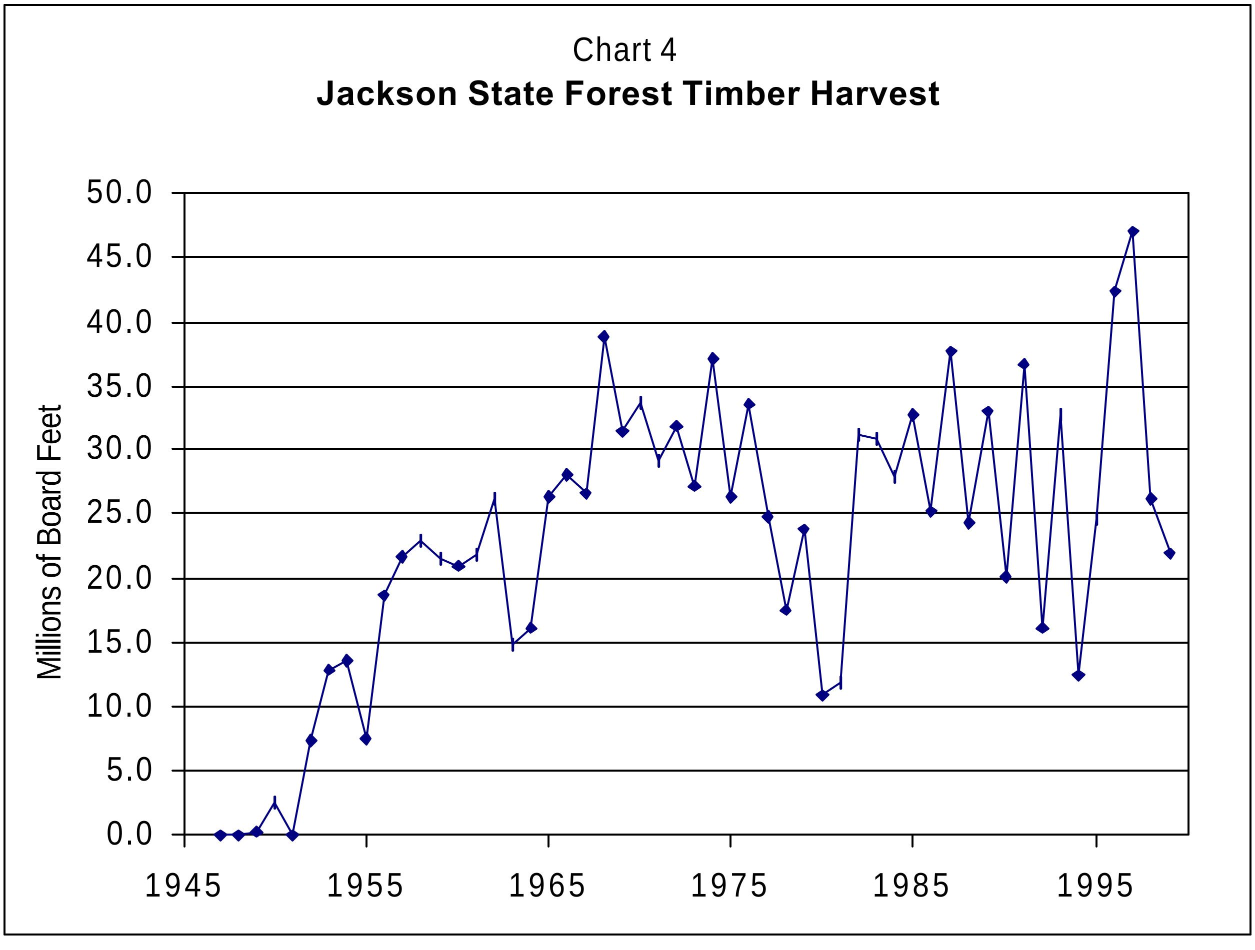


Chart 4
Jackson State Forest Timber Harvest
Millions of Board Feet
50.0
45.0
40.0
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
1945
1955
1965
1975
1985
1995

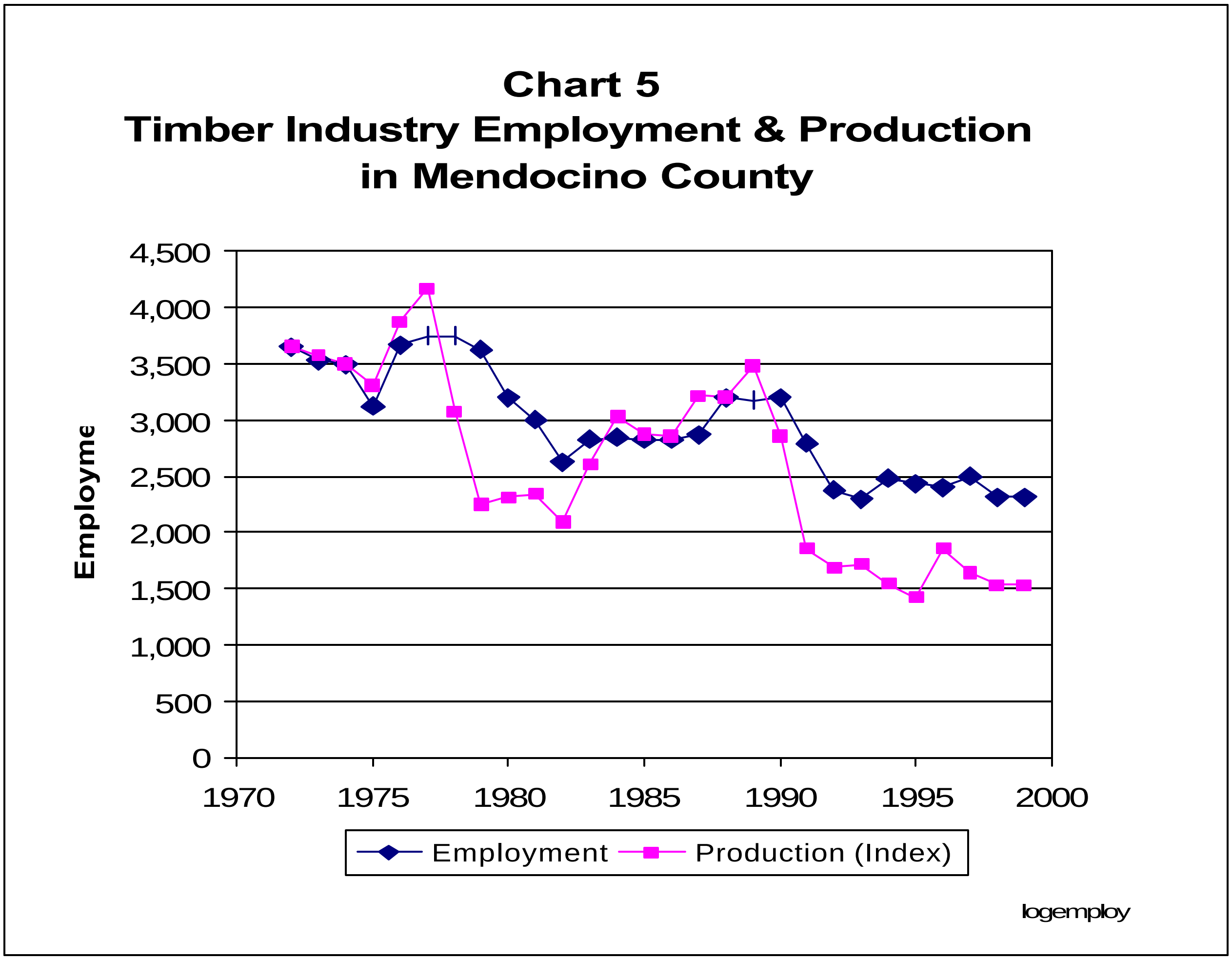


Chart 5
Timber Industry Employment & Production
in Mendocino County
Employme
4,500
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
1970
1975
1980
1985
1990
1995
2000
Employment
Production (Index)
logemploy

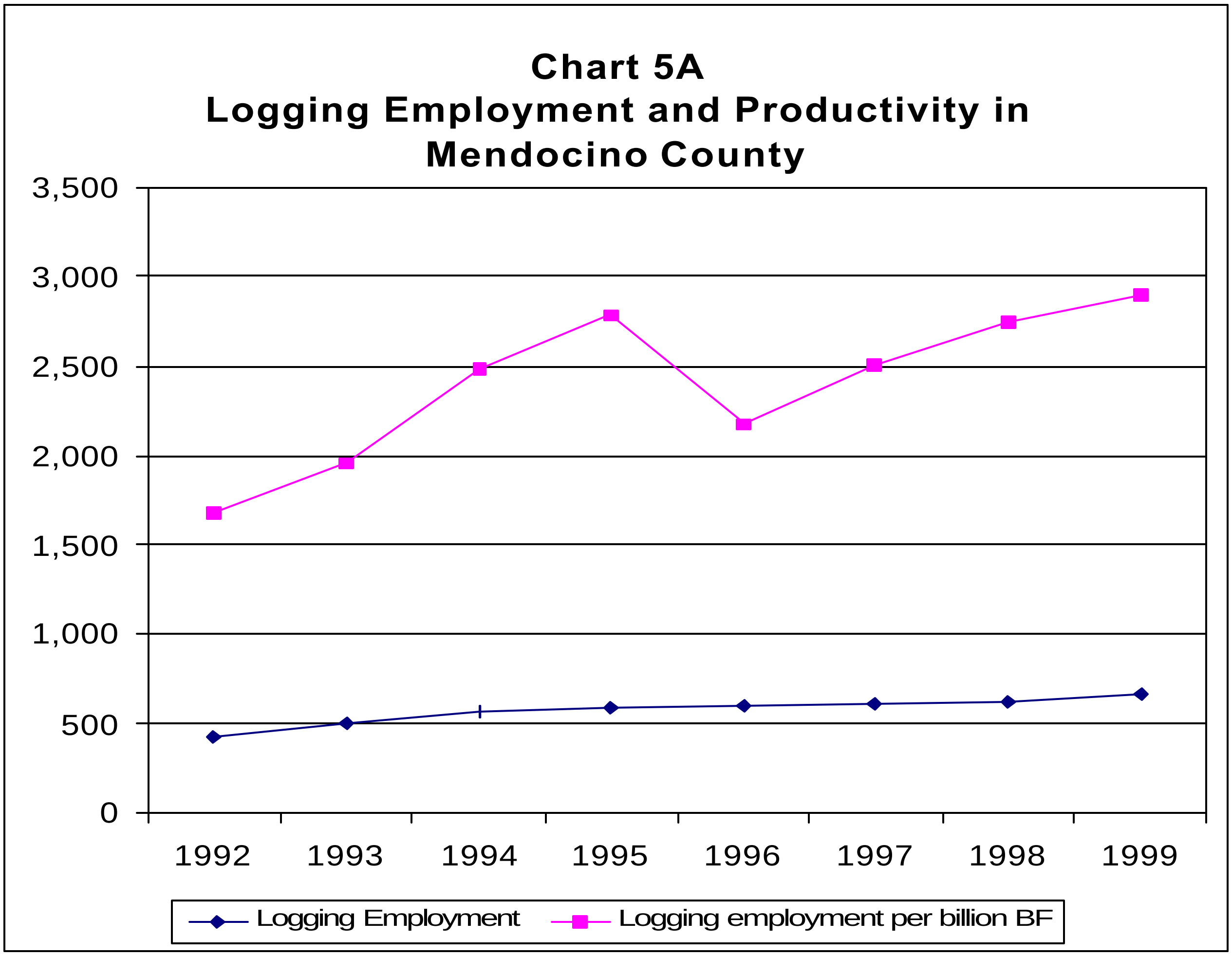


Chart 5A
Logging Employment and Productivity in Mendocino County
3,500
3,000
2,500
2,000
1,500
1,000
500
0
1992
1993
1994
1995
1996
1997
1998
1999
Logging Employment
Logging employment per billion BF

Some possible reasons for this increase are smaller trees being cut, more care taken to avoid environmental damage, more cable as opposed to tractor logging, and more logging being done on small, non-industrial parcels.

3. **Mills import logs to meet needs:** Mills don't merely take logs that are cut locally, passively reducing production in line with county log production. When local supplies are insufficient to keep the mills fully supplied, they strive to keep up production by importing logs from elsewhere. Over time, as local supplies have dropped sharply, mills have reached further and further afield. Mills are reaching out beyond adjacent counties. Santa Cruz has become a source of logs for Mendocino mills. In 2000, at least one mill in Mendocino County, Harwood Products, was obtaining about one-half of its logs from Washington State and British Columbia!
4. **Increased processing of raw materials:** Over time, mills have done more processing of the logs they obtain, adding more value to the raw logs and increasing the labor per log processed. Harwood Products went from three to two shifts at its mill during the 1990s, while processing about the same amount of timber. Yet employment remained approximately the same because of the increased amount of processing done on the raw materials.

In the last ten years, the timber industry has improved its ability to maintain mill output and timber employment in the face of declining county timber production. From 1989 to 1999, timber production decreased by 56 percent, while timber-related employment decreased by 28 percent, only one half as much. In making a quantitative estimate of the effects of a decrease in county timber production on county timber employment, it seems reasonable to use the experience of the last decade, that is, a 10 percent decrease in timber production will lead to a 5 percent decrease in timber employment.

Decreases in Industrial Timber Production Offset by Increases in Non-industrial Timber Production

As timber production from the major industrial companies has fallen, mills have not only imported more logs from outside of the county, but they have successfully sought out timber from non-industrial landowners. The data needs to be gathered to determine the extent of this effect. At this time the amount of substitution is not known, but it will be determined in the future.

The Economy of Mendocino County Has Prospered While Timber Production Declined

The sharp fall in logging employment from 1970 to 1999 did not cause a depression in Mendocino County. Chart 6 shows that total employment in the county climbed steadily, except for the two periods when the entire economy of California experienced recessions. The main consequence of the falloff in timber employment was to reduce the timber sector to only 7 percent of total employment.

Employment Effects of Halting Logging in Jackson State

Because the timber sector has become a small factor in total employment, and because Jackson State accounts for only 10 to 15 percent of timber sector employment, if all logging were halted in Jackson State, it would have a minor impact on county employment. If we take 12 percent of production as a middle estimate, the proportionate percentage of timber and wood products employment would be 277 jobs. As we have seen, though, a given percentage decrease in timber production leads to only half as great a reduction in employment—or about 140 jobs. There would undoubtedly be some offsetting increase in production from non-industrial timber owners; thus the loss of jobs would be less that 140 jobs.

The 140 jobs that might be lost if all timber production from Jackson Forest were halted amounts to a tiny fraction of total county civilian employment in 1999 of 39,000 persons, less than four-tenths of one percent. Such a small percentage

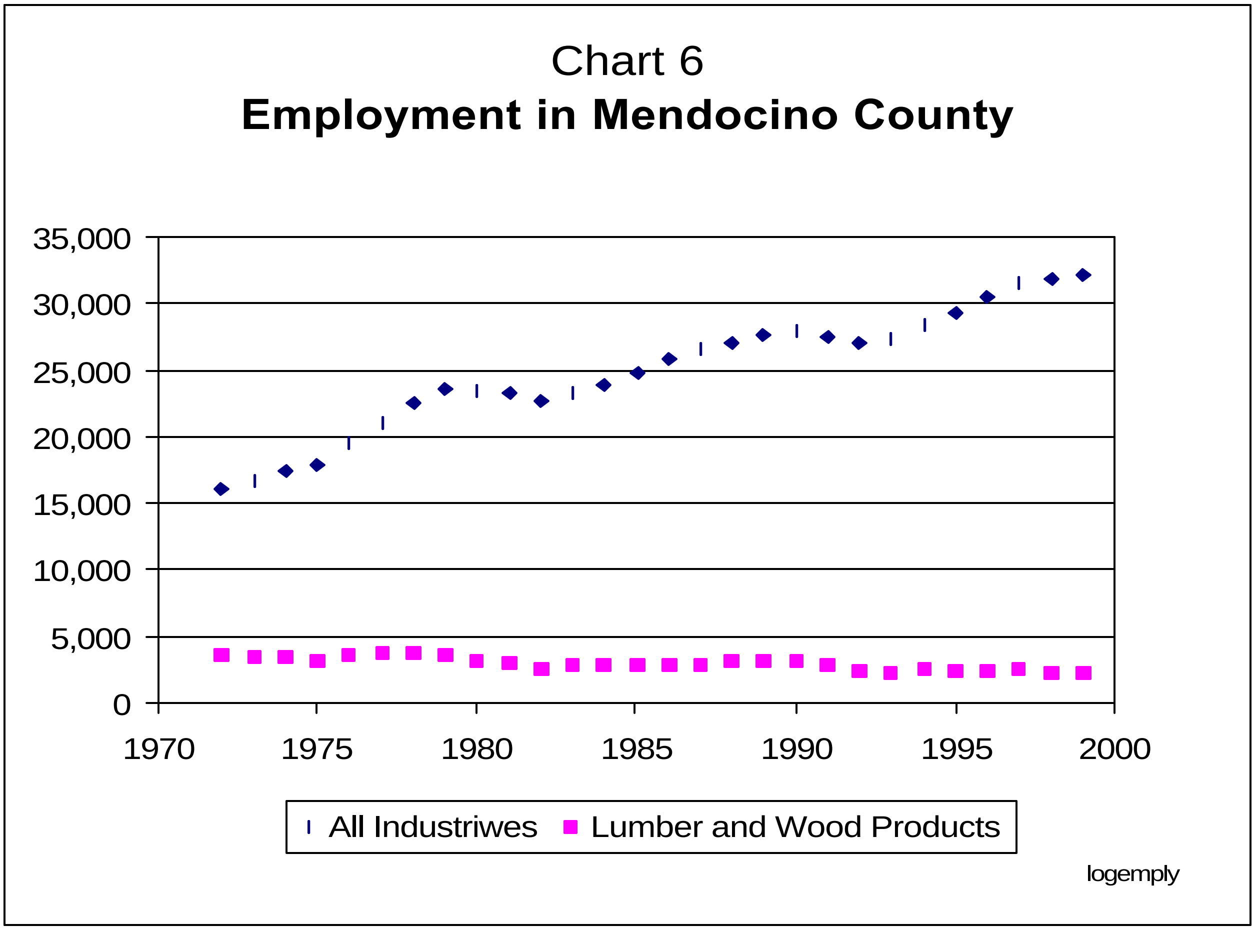


Chart 6
Employment in Mendocino County
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
1970
1975
1980
1985
1990
1995
2000
All Industriwes
Lumber and Wood Products
logemply

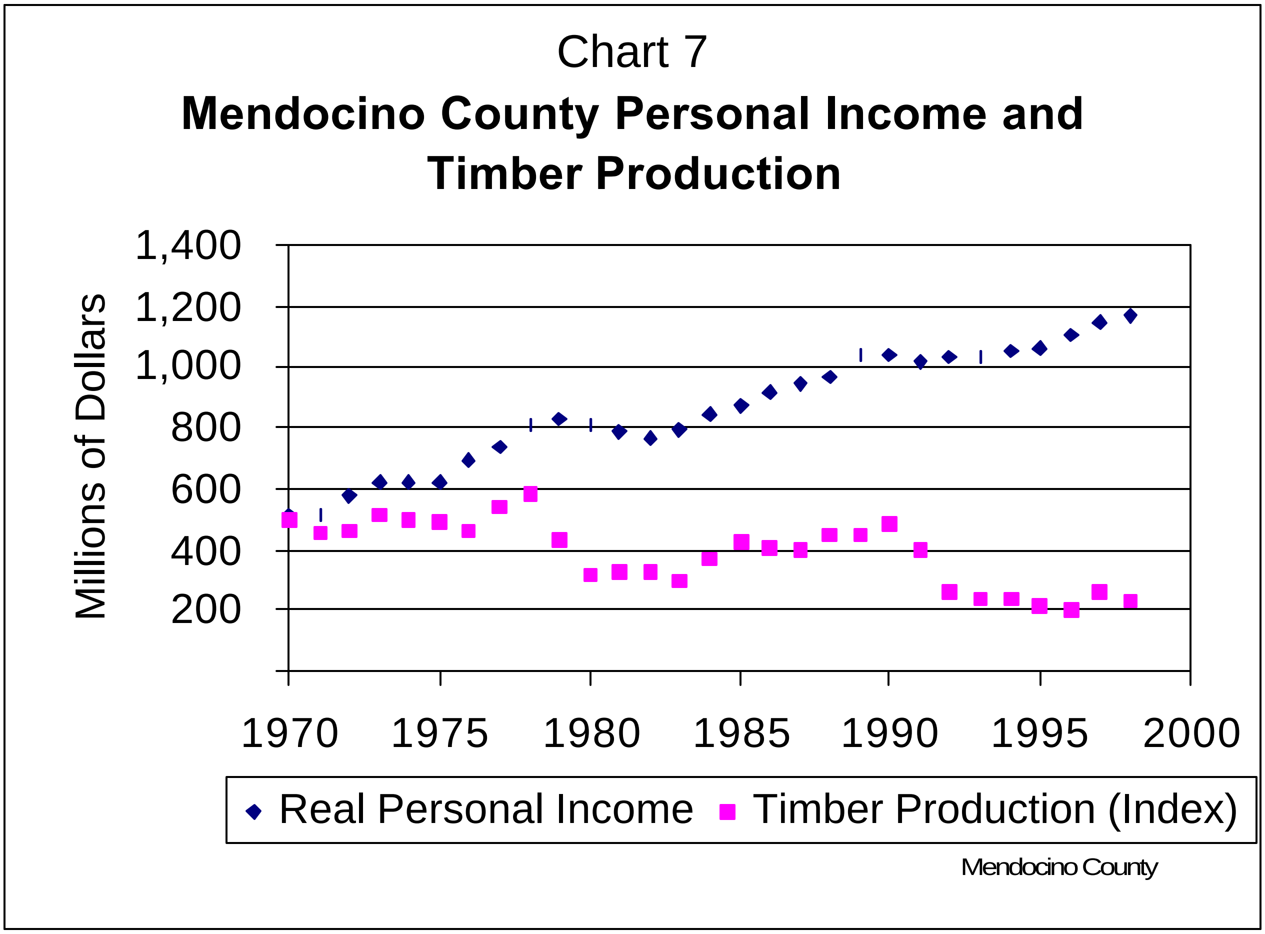


Chart 7
Mendocino County Personal Income and Timber Production
Millions of Dollars
1,400
1,200
1,000
800
600
400
200
1970
1975
1980
1985
1990
1995
2000
Real Personal Income
Timber Production (Index)
Mendocino County

decrease in jobs is not going to significantly impact the employment situation in Mendocino County.

Although the loss of 140 jobs would not have a significant impact on the economy, the loss of jobs would be painful and disruptive to those involved. While this human dimension cannot and should not be ignored, it needs to be acknowledged that changing jobs is a standard event in our dynamic economy. The average job tenure in the United States is less than five years, meaning that almost 20 percent of the labor force changes jobs in any given year. This implies that 6,000 people change jobs each year in Mendocino County, 42 times the number of people that might lose their jobs if logging halted in Jackson State Forest.

Of course, many of those who change jobs do so without entering the ranks of the unemployed, but many do. Losing a job is a fairly common experience. For most people, it an unpleasant, temporary experience, but hardly devastating. Unemployment in Mendocino County in 1999 was about 7 percent, with people entering and leaving the pool of unemployed quite quickly. If Mendocino County mirrors the country, seven out of ten unemployed people find a job within three months, nine out of ten within a year. During the period when people are out of work, unemployment insurance, savings, and assistance from other family members help to cushion the financial impact.

The loss of jobs caused by shifting Jackson State to restoration would be part of a major shift in the economy that has been going on for a long time and that has affected almost everyone: the shift from extraction, farming, and manufacturing industries to "service" industries, such as entertainment, retail and wholesale trade, banking and finance, government, and transportation. As this shift takes place, economic health requires that people move from the declining industries into the expanding ones. A more realistic image than "job loss" is "job shifting."

Effects on the County Economy of Halting Logging in Jackson State

Looking at the general economy, rather than jobs, the role of timber production is still smaller and the effects of halting logging in Jackson State would be even smaller. Chart 7 shows the course of real (inflation-adjusted) income since 1970, along with an index of timber production. During this period, while timber production declined by 58 percent and timber jobs decreased by one-third, personal income more than doubled. In 1998, timber-related jobs produced only about 5 percent of personal income in Mendocino County. If halting logging in Jackson Forest reduced these earning by 6 percent (one-half of 12 percent), it would reduce county personal income by three-tenths of one percent—until the people released from forestry jobs found work elsewhere.

Effects on the Fort Bragg Economy of Halting Logging in Jackson State

But, while the economy of Mendocino County may have become virtually independent of the timber industry, what about our local community of Fort Bragg? How would it fare if Jackson State were shifted to restoration? The evidence shows that Fort Bragg, too, has grown as the timber industry has declined and that its growth has been relatively unaffected by the fluctuations in the timber industry.

Chart 8 compares Fort Bragg taxable retail sales and taxable lodging sales, adjusted for inflation, with county timber production over the period 1972 to 1999. While timber production fell by almost two-thirds, retail sales tripled. Lodging grew far faster, quadrupling in the seventeen years between 1982 and 1999.

Chart 9 shows that Fort Bragg has been able to expand over the long run as logging declined. But, what about the short run? Is the economy of Fort Bragg sensitive in the short run to shifts in the rate of logging? Chart 9 answers this question. This chart plots annual changes in real (inflation-adjusted) retail sales versus annual changes in county timber production. If timber production had a significant effect on the Fort Bragg economy, the plots would show a strong upward slope from left to right. In fact, except for the one point in the far lower left quadrant, there is no evidence that timber production affected retail sales in Fort Bragg. Even giving weight to the one outlying point, the

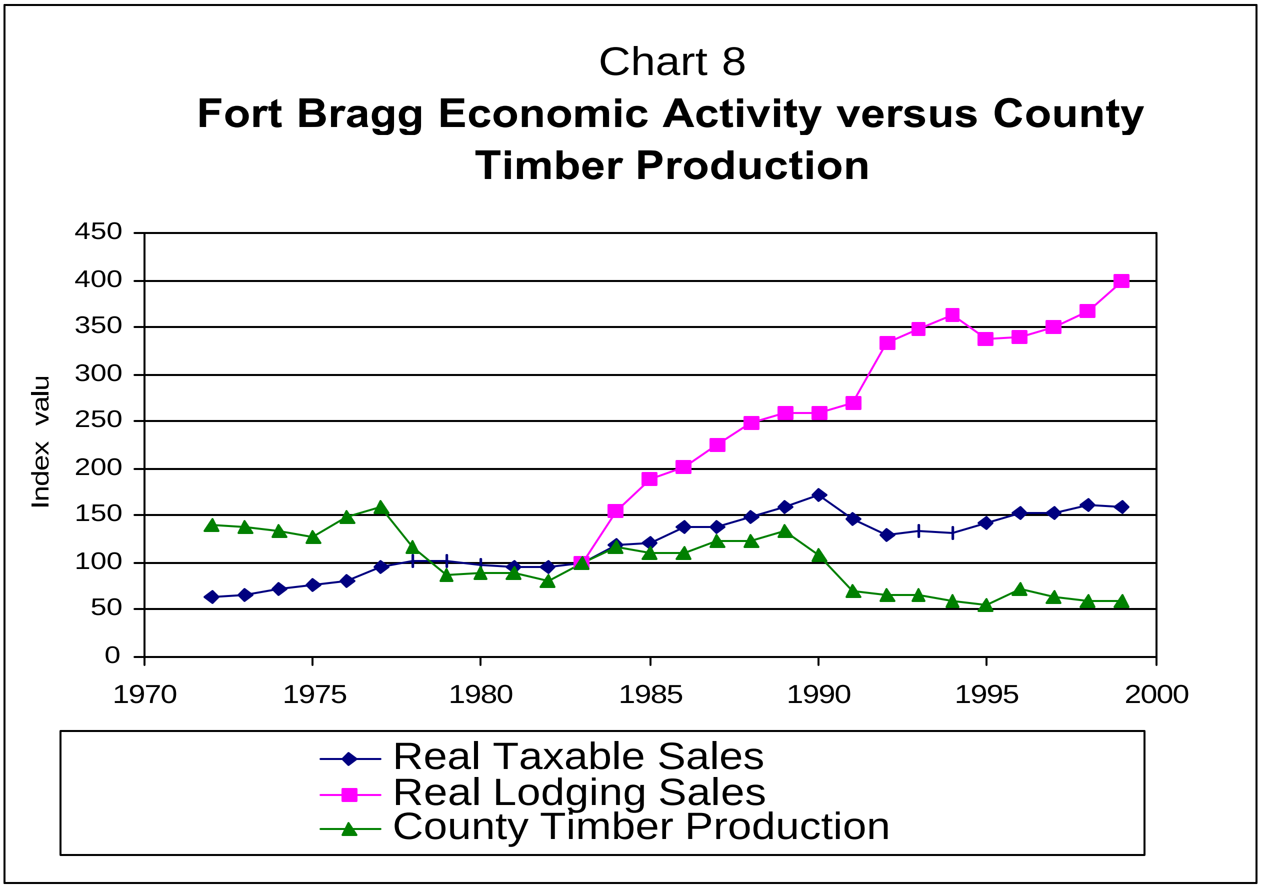


Chart 8
Fort Bragg Economic Activity versus County Timber Production
Index valu
450
400
350
300
250
200
150
100
50
0
1970
1975
1980
1985
1990
1995
2000
Real Taxable Sales
Real Lodging Sales
County Timber Production

line drawn in on Chart 9 implies that a 10 percent decrease in timber production would reduce retail sales by only one-half of one percent.

Conclusion

Although Jackson State Forest now accounts for from 10 to 15 percent of timber production in Mendocino County, the effects of halting all logging there would be quite small and short-lived. Only about 140 timber-related jobs would be lost, and most of the people affected would soon find jobs in the growing sectors of the county economy. Because timber and wood products have become such a small part of the county, and even the Fort Bragg economy, the effects on the overall employment and economic activity in the county would be difficult to notice.

In reality, of course, not all of these jobs would be lost by changing the mission of Jackson State Forest. Recreation, restoration, education, and research activities in the forest would create jobs. Possibly some significant amount of logging will be found to be compatible with restoring the forest to old-growth. The increased tourism created by a restoration forest might well add more jobs than are lost. But, by any calculation, the benefits to the population at large of the county and the state far outweigh the temporary job dislocations that would occur with changing the mission of the Forest.

Chart 9

Fort Bragg Annual Changes in Real Retail Sales versus Changes in Real County Timber Production