The role of silviculture in the active management of riparian zone vegetation in the Oregon Coast Range: a partnership between researchers and managers

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Abstract. —Riparian plant communities are extremely diverse. Their structure and composition can affect fish and wildlife habitat, while trees and associated vegetation can provide sustainable sources of forest products. Management of riparian vegetation can greatly affect these values. Little information exists however, about the consequences of actively managing riparians to develop desirable habitat characteristics and enhance function versus setting aside areas as passively managed reserves. Management options are limited in riparian areas because of concerns for the protection of values provided by these sensitive areas.

Researchers and managers from multiple disciplines and agencies in partnership through the COPE (Coastal Oregon Productivity Enhancement) program are testing a variety of silvicultural treatment alternatives for active management of riparian areas. The partners collaborate to define needs, identify knowledge gaps, design and implement studies, and facilitate technology transfer. We are learning about the ecological consequences of active management within riparian reserve scenarios by developing and studying a range of active management and reserve options.

The studies provide a reference for managers, researchers, and the interested public to evaluate silvicultural alternatives in riparian areas. We have found in our studies that active management practices such as thinning, vegetation management, and tree regeneration are needed to establish conifers in hardwood and shrub-dominated riparian areas of the Oregon Coast Range. The establishment of conifers along with hardwoods is expected to maintain and enhance riparian structure, function, and productivity. Thinning to create canopy openings that allow 40% or more of full sunlight to penetrate through the overstory and reducing the competition from understory shrubs is necessary to successfully regenerate trees in the hardwood dominated-riparian areas of the Oregon Coast Range. Managers have adapted the findings into both demonstration and on-going operational riparian restoration projects. Cooperation through this partnership has resulted in adaptive learning and better understanding of the options and opportunities for riparian vegetation management, enhancement, and restoration.

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INTRODUCTION

Riparian areas in the Pacific Northwest have traditionally been used for sources of natural resources, settlement, agriculture, transportation corridors and energy (Malanson 1993). Current perspectives of riparian areas focus on the biological and physical functions and processes in riparian areas along with the traditional utilitarian uses. Examples of these functions and processes include habitat for wildlife; nutrient capture; filtering and cycling; the input of woody debris and sediments; provision of favorable microsite and microclimate conditions; and high quality water (Gregory 1997).

Riparian areas are critically important transition zones between the aquatic and upland terrestrial landscape. Frequent disturbances from flooding, landslides, and debris flows have created physically complex environments that are highly productive and capable of supporting a diversity of species. Healthy riparian areas and streams serve as reservoirs of biodiversity, animal habitat, corridors, clean water, wood products, food, special forest products, energy, and recreation. The diversity of riparian outputs often results in conflicts between different interest groups over the use of riparian areas. The biophysical complexity of the riparian landscape and the interactions between the aquatic, streamside, and upslope communities poses a significant management challenge for resource managers (Hayes et al. 1996). The influence of past management practices on aquatic dependent species (especially anadromous fish) have surfaced as one of the most significant challenges currently facing land managers in the Pacific Northwest.

The Northwest Forest Plan (Record of Decision, 1994) amended the Land and Resource Management Plans of federally managed forest lands situated within the range of the northern spotted owl (*Strix occidentalis*) in Washington, Oregon, and northern California. An important component of the Northwest Forest Plan was the Aquatic Conservation Strategy and its emphasis on the importance of riparian areas across this landscape. Riparian Reserves were established to: 1) protect riparian-dependent and aquatic ecosystems and 2) to provide habitat for upslope communities of fauna and flora. Interim widths of the Riparian Reserves designated in the Northwest Forest Plan are determined by "site-potential tree heights". Reserve widths are designated as either one (perennial, nonfish-bearing or intermittent streams) or two (perennial fish-bearing streams) site-potential tree heights. A site-potential tree height is the average maximum tree height that can be attained on a given site at age 200 or older.

Riparian Reserves can encompass over 80% of the coastal forests of the Pacific Northwest. Characteristics that contribute to these extensive reserves include a landscape that is highly dissected by streams, relatively short and steep topography, environmental conditions favorable for the

Figure 1.—Riparian zones are amongst the most ecologically diverse and productive components of the forested landscape in the Pacific Northwest. Diverse riparian vegetation and large woody debris contribute to the habitat and complex functions provided by this coastal Oregon stream.

growth of large and tall tree species and diverse species composition. The Aquatic Conservation Strategy of the Northwest Forest Plan stressed that management activities in Riparian Reserves maintain or improve current riparian habitat conditions, functions, and processes. A watershed analysis process established under the Northwest Forest Plan and variations employed by state agencies and private timber companies are now used for assessing the state of current conditions, the historic conditions, identifying issues and knowledge gaps, and developing management options in riparian areas.

WATERSHED ANALYSIS

A planning process known as watershed analysis is conducted on watersheds to determine current condition of the biotic, abiotic, and social elements within the watersheds (EPA and others, 1995). The watershed analysis process is an important collaboration between land managers, researchers, and private landowners. Analysis of historical conditions and the frequency and impact of natural and human caused disturbances help to establish reference conditions for a watershed. Landscape conditions that influence the function and ability of the watershed to provide the ecosystem values and meet the health and productivity goals are identified. Perhaps most important in the watershed analysis process is determining what is known and unknown about the functions and processes at work. This helps to identify data gaps and define research needs. A listing of the management opportunities that assist in changing the watershed toward a desired future condition is often included at the conclusion of the watershed analysis.

The information from watershed analysis can be used to validate or modify riparian reserve boundaries (widths). Following watershed analysis, management practices on federal lands are designed and implemented to attain the goals of the Northwest Forest Plan's Aquatic Conservation Strategy. These Practices often include silvicultural and instream treatments to enhance terrestrial and aquatic habitat. The outcomes of these practices are monitored for efficacy through an adaptive management learning process.

Land managers need to understand the processes at work within riparian areas and the interrelationship to aquatic and terrestrial species and functions (Figure 1). An understanding of riparian areas begins with an awareness of the geomorphology of the landscape, hence the type and longevity of material within the stream, and mechanisms at work for distributing woody debris, rock, cobble, and sediment throughout the course of the stream. Classifying the width and gradient of the stream reaches assists in identifying various processes at work within the system.

With this information, managers can then determine if the current vegetative composition is appropriate, within the

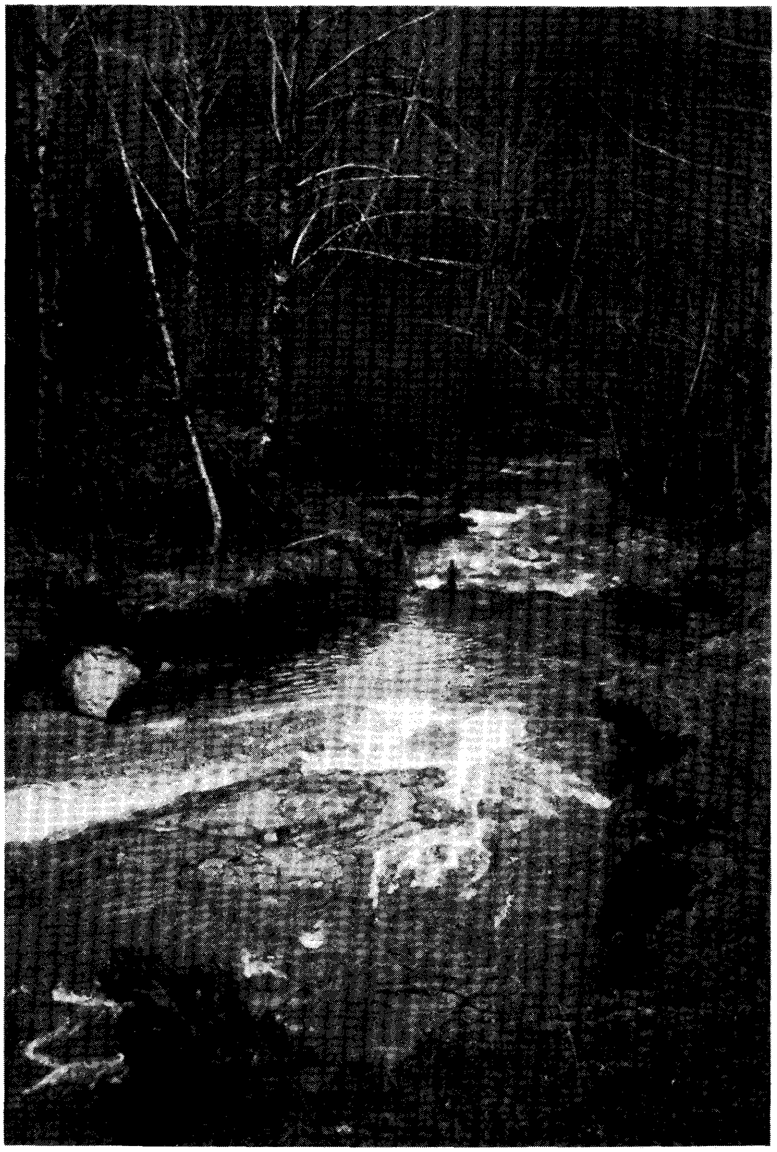

Figure 2.—Past management practices adjacent and within this coastal Oregon stream has contributed to bank erosion, scouring to bedrock, lack of large woody debris, and the dominance of red alder and salmonberry.

context of the entire stream system being considered. Silviculture is often the most appropriate long-term and cost-effective method for enhancing or restoring healthy conditions in riparian areas (Newton et al. 1996). With specific objectives clearly defined, the silviculturist can develop prescriptions that can shift the current riparian forest to a desired future condition.

Silvicultural practices can help grow large conifers within riparian areas that provide shade and wood to streams over long periods of time. Large conifers in the stream (standing or down) are important structural components. When standing, large conifers provide habitat to a wide variety of birds, mammals, insects, and invertebrates. When fallen, large conifers in riparian areas continue to provide habitat to terrestrial wildlife species and often benefit aquatic species as well (Maser and Sedell 1994).

THE HARDWOOD- AND SHRUB-DOMINATED RIPARIAN LANDSCAPE

Previous land-use and harvesting practices have produced a fragmented landscape with isolated patches of older coniferous forests and extensive areas of hardwood-dominated stream reaches. Historic clearing for homesteads, logging, and changes in fire patterns have altered the nature of streamside vegetation. In pre-settlement coastal forests, riparian vegetation often consisted of a mix of deciduous tress such as bigleaf maple (*Acre macrophyllum*) and red alder (*Alnus rubra*) with conifers such as western redcedar (*Thuja plicata*), Douglas-fir (*Pseudotsuga menziessii*), Sitka spruce (*Picea sichensis*), grand fir (*Abies grandis*), or western hemlock (*Tsuga heterophylla*). Due to human influences, many streams (Figure 2) have been degraded and an overstory of red alder and an understory of salmonberry (*Rubus spectabilis*) now heavily dominates these riparian areas.

Riparian areas in the coastal mountains of the Pacific Northwest are physically complex. Microsite variations in soil, drainage, light, geomorphology, and edge occur within short distances. The variations in riparian microsites result in a range of plant growing conditions capable of supporting diverse plant communities. The dense canopies associated with red alder and shrub-dominated riparian areas often mask these complex site characteristics. Large woody debris on the forest floor is often sparse or absent in hardwood- and shrub-dominated riparian areas in the coastal mountains of the Pacific Northwest.

Forest managers, especially fisheries biologists are concerned about the state of vegetation and habitat in these riparian areas. Natural regeneration of both conifer and hardwood trees in red alder- and shrub-dominated riparian areas are extremely sparse (Minore and Weatherly 1994; Hibbs and Giordano 1997). Establishing conifers in these hardwood- and shrub-dominated areas is desirable both for fish and wildlife habitat and for future sources of timber and special forest products. However, restoring or converting these areas to conifer-dominated or mixed stands is often unsuccessful under the heavy shade of red alder. Competition from salmonberry and damage from beaver and animal browsing add to the difficulty. Salmonberry is an extremely aggressive and persistent shrub that occupies highly productive riparian and upslope sites in the Coast Ranges of the Pacific Northwest. The ability of salmonberry to reproduce effectively from rhizomes, seeds, and layering allow it to persist, grow, and invade sites following disturbance (Tappeiner et al. 1991). The multiple mechanisms for salmonberry reproduction often allow it to rapidly occupy sites and effectively exclude tree regeneration.

Red alder is a fast growing, nitrogen-fixing, relatively short-lived, shade-intolerant deciduous tree mainly found on moist, well-drained sites (Harrington et al. 1994, Harrington 1996). At maturity red alder is small in diameter and produces much less wood volume when compared to most conifers (Hibbs 1996). Alder logs decay rapidly and often cannot provide the long-term function of providing large woody debris input into the stream. Large, long lasting logs are an important component of stream channels in the Pacific Northwest (Maser and Sedell 1994). They help create pools and substrate habitat for fish and other aquatic-dependent vertebrates and invertebrates (Bilby and Ward 1991). Many salmon restoration projects have focused on installing logs in stream channels to improve habitat for fish in streams. While this may be a successful short-term solution, these restoration efforts are costly and not self-sustaining. Managing riparian areas for recruitment of large trees from riparian and upslope areas provide a long term and sustainable option for developing and maintaining productive stream and riparian habitat.

A STUDY ON GROWING CONDITIONS, STAND DYNAMICS, AND TREE REGENERATION IN HARDWOOD- AND SHRUB-DOMINATED RIPARIAN AREAS

Opportunities for enhancing riparian habitats desirable for fish and wildlife and tree regeneration in areas dominated by red alder may be forfeited if riparian buffers are not actively managed. Red alder and salmonberry form plant communities that are biologically quite stable and resilient. Understory shrub cover often increases with overstory age. These plant communities create conditions that often exclude tree regeneration, crucial for producing future sources of large wood for fish, wildlife, and timber (Hibbs and Giordano 1996; Nirenburg 1996).

Numerous factors can affect tree regeneration in the Oregon Coast Range. Light availability; soil moisture, rooting substrate; seed source availability; disturbance type, intensity, timing, and frequency; and animals are some the factors that affect tree regeneration. We have found that one of the key elements limiting tree regeneration in the Oregon Coast Range is light (Chan 1990). Light levels under the shade of a red alder canopy are very low. Alder also responds quickly to thinning or gap creation through epicormic and main canopy branch growth. Salmonberry and other associated understory shrubs also compete with tree seedlings for light and water. Competitions from either or both red alder and understory shrubs are major limiting factors for tree regeneration in the Oregon Coast Range.

Scientists and managers of different disciplines from the USDA Forest Service, USDI Bureau of Land Management, Oregon State University , Oregon State Department of Forestry, forest industry, and counties in partnership through the Coastal Oregon Productivity Enhancement Program (COPE) have established studies on the ecology and silviculture of riparian areas in coastal mountains of Oregon. The objectives from one of the studies is to examine: 1) the environmental causes for the scarcity of tree regeneration, and 2) a variety of silvicultural approaches for tree regeneration in hardwood- and shrub-dominated riparian areas. The study focuses on the effects of riparian growing conditions (e.g., light and soil moisture levels and understory shrub and overstory hardwood density and dynamics) on the regeneration of six tree species (Douglas-fir, western redcedar, Sitka spruce, western hemlock, grand fir, and red alder) in the Oregon Coast Range.

Results from the study indicate that growth of the underplanted trees (except red alder and Douglas-fir) in partially thinned riparian alder stands (40-60% of full light penetrating through the canopy) are similar to trees growing in large openings where the canopy was completely removed. However, rapid regrowth of the thinned alder canopy at 8-12% annually may again lead to closed canopy and light-limiting conditions.

Light levels are often low (less than 10% of open conditions) in alder- and shrub- dominated riparian areas (Figure 3a). Light availability is highly correlated with tree regeneration in riparian areas. Light levels above 10-20% of open conditions are necessary for moderate (>60%) long-term survival of six commonly planted conifers and hardwoods. Canopy openings where between 30-70% of full sunlight penetrates are necessary for promoting good tree growth. Between 50-90% of the alder trees in a stand (depending on size, age, and vigor) may have to be thinned to achieve canopy openings of 30-70% (Figure 3b).

Thinning the overstory also favors understory shrub and herb development (Figure 3c). Repeated annual cutting of the understory during the active growing season is effective in preventing the increase in cover and height of most shrubs, and is most effective under a partially or unthinned overstory. Tree regeneration for each of the six tested tree species was enhanced when the understory vegetation was cut at least once a year. However, cutting the understory vegetation more than once a year did not increase the survival and growth of tree regeneration over a single annual cutting. Cutting the understory twice a year shifted the understory composition from a shrub-dominated plant community to an herb- and grass-dominated community. Left undisturbed, the understory shrubs and herbs can have a strong competitive effect on tree regeneration.

Riparian areas are variable: a range of silvicultural treatment options, including choice of planted species can be applied to reach specific goals for fish and amphibian habitat, timber, clean water, and special forest products. Active riparian vegetation management in hardwood- and shrub-dominated riparian areas is often necessary to create growing conditions (i.e., increased light) that favor tree

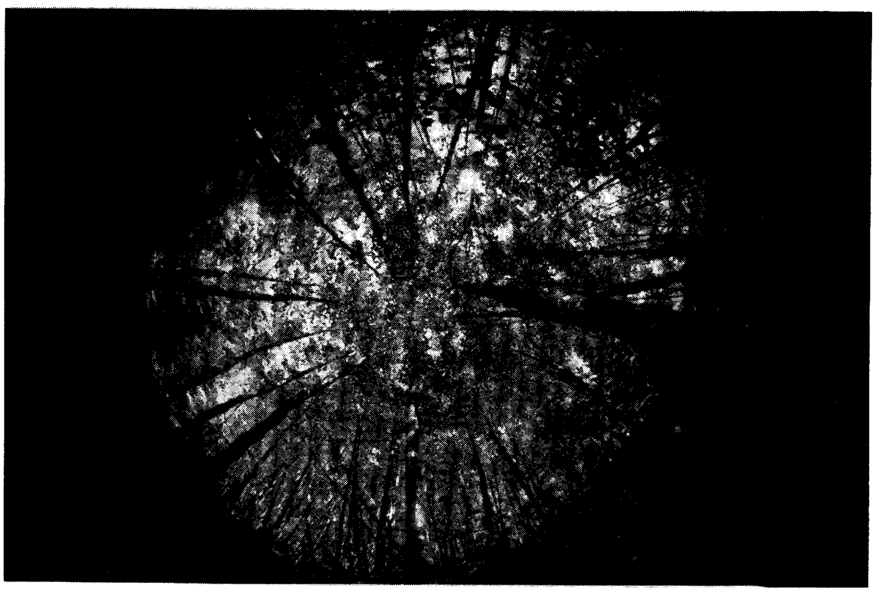

Figure 3a.—Dense plant canopies in riparian areas dominated by red alder and salmonberry effectively exclude tree regeneration. Light levels in this stand are approximately 3 percent of open conditions.

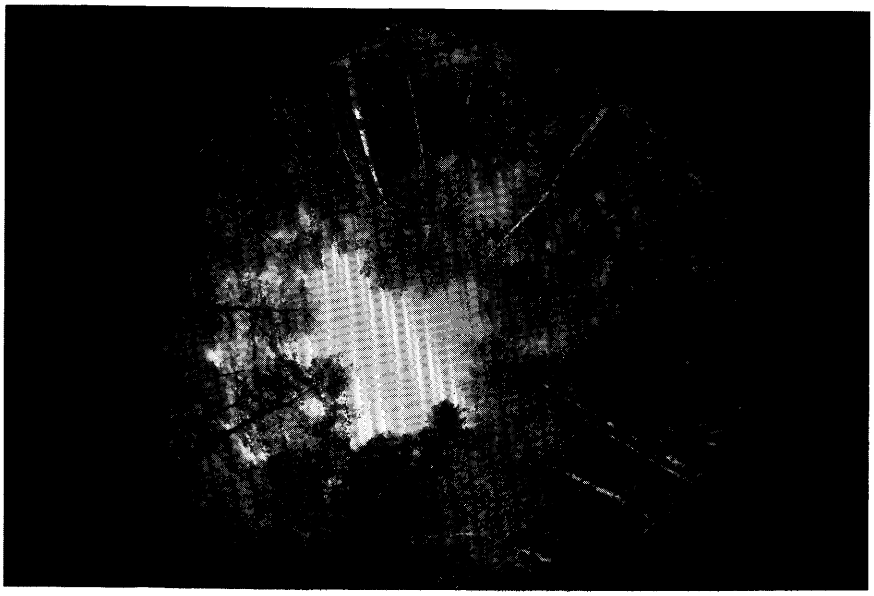

Figure 3b.—A substantial portion of the overstory canopy of red alder must be thinned to create conditions favorable for tree regeneration in riparian areas. The canopy of this thinned 46 year old red alder stand has closed almost 50% five years after thinning.

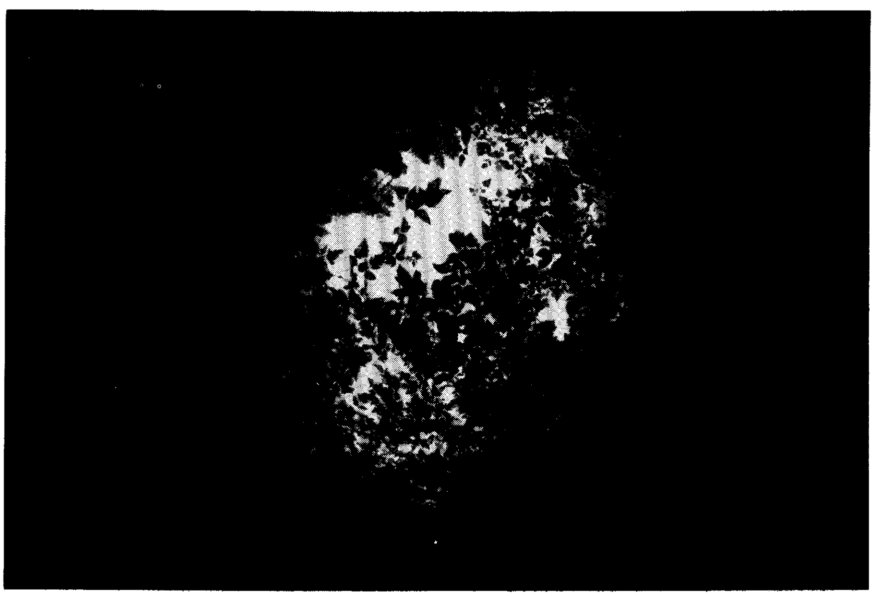

Figure 3c.—Understory shrubs such as salmonberry can quickly fill gaps created in the overstory and exclude tree regeneration.

Figure. 4.—Successful tree regeneration can occur in hardwood and shrub dominated riparian areas of the Oregon Coast Range through active management of riparian vegetation.

regeneration and understory development (Figure 4). Managers should focus on treatments that create adequate tree growing conditions (e.g., light availability) for a particular site versus targeting for a blanket prescription to fit all riparian areas.

Adequate tree regeneration and understory development can serve as the basic structural units for building, sustaining, and optimizing the composition and function of riparian plant communities. Short-term disturbances that promote tree regeneration in previously degraded riparian sites currently dominated by hardwoods and shrubs, are likely necessary to achieve long-term goals for restoring riparian processes and functions.

Emphasis on technology transfer by both researchers and managers through workshops, field trips, publications, and consultations have accelerated adoption of new knowledge and improved techniques for larger scale riparian projects. Ongoing visits and evaluations of the research and demonstration sites by managers, researchers, interested publics, and policy makers have further enhanced the value of this partnership between research and management.

CONCLUSIONS

The application of active management in riparian areas to promote tree regeneration for habitat complexity on a landscape basis should be based on a program of learning through adaptive management (Hayes et al. 1996). We have learned much about silviculture in riparian areas (especially tree regeneration) since our partnership began seven years ago. We realize that there is more to learn, since successful regeneration of trees in riparian areas merely establishes part of the foundation from which managers can build riparian stands and landscapes. We have little information on what is, and how to achieve, the optimal range of riparian disturbances and stand composition and structures. We also lack knowledge on appropriate mixes and distributions of hardwoods and conifers in a watershed. Historical conditions can provide some clues, but do not provide actual evidence of proper function. We continue to learn about how different silvicultural approaches drive stand dynamics and structure, species interactions, and succession in riparian areas. The long-term role and consequences of establishing extensive riparian buffers and their management will also need to be examined. The effects and interactions of riparian silviculture on animal populations remain largely unknown. The role of animals such as beavers on tree regeneration and stand dynamics will need to need to be closely monitored.

The role of silviculture in the active management of riparian areas will continue to gain importance as a long-term solution for enhancing and restoring degraded riparian areas. The effectiveness of silvicultural options in riparian areas will depend on continuing and building the partnership between researchers and managers. Active involvement of specialists (e.g., fisheries and wildlife biologists, botanists, soil scientists, engineers, hydrologists, scientists) in defining objectives and issues with silviculturists is critical.

Elements for Successful Partnerships between Research and Management: a Commentary

The complexity of land management issues has increased, but resources available for addressing these issues have actually decreased for most public agencies. Partnerships between land managers and researchers can be an efficient mechanism for leveraging resources and expertise to focus on important issues. A successful partnership between researchers and resource managers focuses on common issues, problems, and goals. Successful partnerships are especially valuable in studies that are designed for long-term value.

Researchers may propose activities that may be at odds with current best management practices (e.g., cutting all the trees along a section of a stream). Likewise, managers realize that some of our current assumptions might have to be challenged to gain insight on their effectiveness. Thus, a successful partnership may require that managers and researchers assume both traditional and non-traditional approaches.

The traditional roles of land managers in research projects are to: 1) identify issues and problems, 2) work with researchers and stakeholders to implement projects, and 3) alert researchers to potential problems that may affect implementation. Questions that managers might ask researchers include: Is the study pertinent to my needs? What solutions or new knowledge will the study provide? Will the study be well utilized? Is the study visible and supported by stakeholders? A researcher's traditional role is to conduct good science that leads towards a solution or better information. The researcher: 1) develops a problem analysis, 2) packages issues into testable hypotheses, 3) develops an appropriate experimental design, and 4) designs realistic studies that consider site constraints, management concerns, and limitations of resources.

A successful partnership between managers and researchers often dictates procedures that go beyond traditional experimental protocol. A common issue cited by managers is that researchers are often not familiar with the operational details of: 1) environmental laws such as the National Environmental Protection Act and Threatened and Endangered Species Act and the associated consultation and public comment process, 2) project scheduling (it might take two or more years to fully implement a field study), 3) the requirements of the Northwest Forest Plan including watershed analyses, and permitted practices under different land-use designations. Researchers also need to be aware of the manager's funding process and concerns about public perceptions. Researchers can address the needs of land managers by facilitating district and forest involvement in the study. Managers should be provided with progress updates and findings in a timely manner. Researchers should work with managers to interpret and extend research results into operational activities.

Managers must understand a study before they can fully appreciate its value. Understanding a study will often require that managers be aware of the factors that lead to good research such as problem analysis, hypotheses testing, and methods. Managers should work with the researchers in fine-tuning the design and implementation of the study. Managers should be aware of the study design and methods including: the treatments applied, concepts of replication, procedures that may lead to bias, and consistency in which procedures are applied. Managers will likely encounter some procedures in a study that might be contrary to or in addition to what would be done at an operational level. Hopefully, managers will perceive the studies as providing important information leading towards adaptive management. Finally, managers and researchers need to realize the limitations of current and new knowledge and use the information with good common sense. Our partnership has demonstrated an important role for silviculture in the active management of riparian vegetation in the Oregon Coast Range.

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