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Forestry Research West

A report for land managers on recent developments in forestry research at the four western Experiment Stations of the Forest Service, U.S. Department of Agriculture.

Forestry Research West

In This Issue

Cover

Researchers at the Intermountain Station are studying Research Natural Areas (RNA)—a national network of unique ecological areas designated for research, education, and maintenance of biological diversity on National Forest System lands. They are focusing on the value and importance of these areas, and the need for long-range management plans. Here, scientist Chuck Wellner examines old-growth Engelmann spruce in the Pony Meadows RNA in Idaho. Read more about it beginning on page 10.

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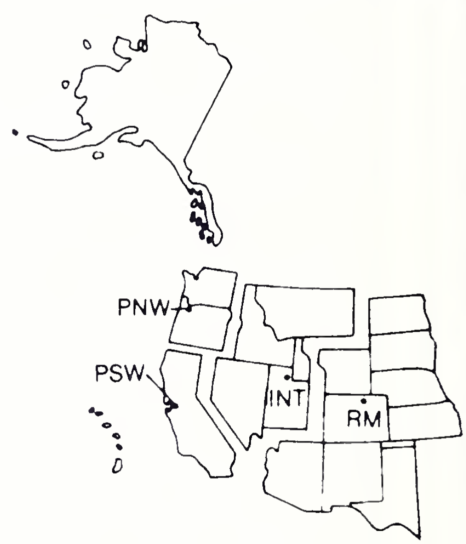


Changing times for hardwoods

by Cynthia L. Miner
Pacific Northwest Station

Forestry in the Pacific Northwest conjures up images of conifers, which indeed dominate the landscape. But hardwoods in the region provide for traditional and not-so traditional values, including forest products, site productivity, biological diversity, wildlife and fish habitat, water quality improvement, and aesthetics. With growing recognition of these values, hardwood management is an emerging science and art in the region.

Times change for hardwoods

Managing hardwoods is not entirely new to the Pacific Northwest. Hardwood reforestation predates conifer reforestation in the region. In the 1890s, some of the first reforestation in the United States was the planting of black cottonwood in Oregon by a pulp and paper company. Before it discontinued the plantings 20 years later, the company planted more than 1,000 acres of river bottomland with black cottonwood.

Since the 1950s, foresters have attempted to suppress and eliminate hardwoods in favor of conifers. Hardwoods compete with Douglas-fir and other conifers that have brought higher prices. Red alder, nonetheless, has been the subject of study for more than 30 years because of its symbiotic relation with an actinomycete, which resembles bacteria. In this relation, otherwise unavailable nitrogen in the air is fixed into biological components that alder can use.

Hybrid cottonwood is being grown for fiber at rotations of less than 10 years in the Pacific Northwest.

Symposia have been held on the biology, use, and management of red alder; and an annotated bibliography on the species was published. In the proceedings of the 1967 symposium on red alder biology, the foreword prophetically states, "Soon foresters may find it economically and biologically desirable to manage for alder on selected sites or in selected situations."

The time has come for alder and for other hardwood species. Cottonwoods are once again being planted along river bottoms—this time hybrids of black cottonwood and eastern cottonwood at rotations of less than 10 years. On public lands, foresters are cultivating and managing red alder with practices such as planting and precommercial thinning. Private companies are experimenting with red alder plantings on highly productive sites. Researchers and managers are examining the potential roles species such as Pacific madrone, big-leaf maple, and Sitka alder have in managed forests.

Economics peak interest

Alder and cottonwood have received the most attention in the Pacific Northwest, largely because of their growing economic value. Furniture makers who once used red alder as interior pieces in furniture now stain the wood or let it stand on its own beauty as finished wood. Supermarkets and business suppliers carry paper products made of hardwood fiber from the Pacific Northwest. Ships are loaded with red alder logs and particularly red alder chips for export worldwide.

The economic value of alder has caught up to that of Douglas-fir.

Volume recovered from alder is less than that from Douglas-fir, but lumber value of alder is high enough so the value of alder logs compares to the value of Douglas-fir logs.

When Douglas-fir and alder prices for select and better grades of lumber are compared for 1986, 1987, and 1988, alder has the higher prices per thousand board feet. Alder pallet prices were comparable in those years to Douglas-fir utility prices. Recovery and harvesting efficiency are often mentioned as offsets of the price of alder.

In a recent recovery study, research forest products technologists, Marlin Plank, Forestry Sciences Laboratory, Portland, Oregon; Thomas Snellgrove, Forest Service, Washington, DC; and Susan Willits, Forestry Sciences Laboratory, Portland, found that, indeed, volume recovered from alder logs is consistently less than that for softwood logs. Lumber value for red alder is higher, however, than for Douglas-fir, and increases more rapidly as log diameter increases. The increase is so dramatic that despite the lower amount of lumber volume recovered, the value of alder logs can compare to second-growth logs of Douglas-fir.

About 5 years ago, as forest managers began to realize the value of alder, they became concerned about supply. It was then that inventory data showed most red alder was 30 years old or older. Because alder and other hardwoods often grow in mixed stands, inventory of these species is not exact. In Oregon and Washington, west of the Cascade Range, inventories show red alder occupies about 13 percent of commercial forest land. On this land, the growth of red alder now exceeds harvest, but in 10 to 20 years sawtimber may be in short supply. "Present demands are being met with trees established

The ability of alder to fix atmospheric nitrogen makes it desirable in crop rotation and in mixture with other species, here with Douglas-fir.

naturally 40 or more years ago before the widespread use of herbicides and other techniques of controlling alder," says Dean DeBell, principal silviculturist, Forestry Sciences Laboratory, Olympia, Washington. "Young alder stands are scarce, and considerable concern exists about future availability of adequate supplies.

"Companies that had alder mills in the past did not have control of much land," DeBell explains. "Because stumpage prices were low, people did not plant alder. Most of the value was added on in manufacturing. Now companies that mill and manufacture products from hardwoods are beginning to control their supply. This includes paper manufacturers that are establishing plantations to help meet the need for short-fibered (hardwood) pulp." Hardwoods provide the qualities of smoothness and softness to paper. Tissues and computer papers need up to 30 percent hardwood component mixed with softwood.

To ensure a supply of hardwood pulp, one paper manufacturer has planted over 8,000 acres of mostly abandoned agricultural sites with hybrid cottonwood in Oregon and Washington in the past several years. Other companies are also planting cottonwood. This species grows faster than any other tree species in the Pacific Northwest. Whereas red alder is a generalist that adapts to most sites, cottonwood is a specialist. The fast growth rates of cottonwood are confined to sites where soil moisture is abundant, aeration adequate, and nutrients plentiful.

Cottonwood has extremely rapid juvenile growth and responds very well to intensive growing practices.

Biological goals

Although demand and supply have put hardwoods in the limelight in the past few years, biological goals may sustain interest. Resource managers in the Pacific Northwest increasingly use hardwoods to improve site productivity, control phellinus root disease, improve riparian areas, and improve wildlife diversity. The forest landscape of the coastal Pacific Northwest will remain one of conifers, but the role of hardwoods in managed forests will undoubtedly expand.

Resource managers now plant, manage, and experiment with hardwoods. In the last three years, the demand for red alder seedlings for outplanting has risen from 100,000 to 500,000 seedlings in National Forests of Washington and Oregon. A demand for cottonwood seedlings has also developed in those States. About 100,000 cottonwood have been requested for plantations and stream improvement for 1991.

Reasons for planting are diverse. In 1989, Tom Turpin, forest silviculturist, reported the Siuslaw National Forest planted 100–150 acres of alder and several acres of experimental plantings of cottonwood and eucalyptus. "When we precommercially thin our Douglas-fir plantations, if the site has soil low in nitrogen, we will leave up to 40 alder per acre for increasing nitrogen and diversity in the stand," Turpin says. "We are also planting alder in known phellinus areas. If the disease is severe enough, we're planting all alder. We're also using alder in riparian areas and for managing wildlife diversity."

About 70 percent of the Douglas-fir sites in the Pacific Northwest are limited by low levels of soil nitrogen, an element crucial to tree growth. The ability of alder to fix atmospheric nitrogen makes the species desirable in crop rotation and in mixture with other species such as Douglas-fir. Nearby plants benefit from the high nitrogen levels in alder plants when leaves or other plant parts fall and decompose. Alder root turnover and root exudation also serve as sources of nitrogen for other plants.

Another biological advantage of hardwoods is their resistance to phellinus root disease, commonly called laminated root rot. *Phellinus weirii* is a fungus that destroys the roots of conifers, thereby slowing growth and eventually killing the tree. After a tree is cut, the fungus remains in the roots and will infect conifers later planted or regenerated naturally. Five to ten percent of the area of Douglas-fir types west of the Cascades are affected by the disease. As resource managers become more aware of the impact of phellinus, they are planting hardwoods as well as less susceptible conifer species, such as western white pine and western redcedar, on infested sites.

Hardwoods add structural and plant species diversity to the conifer-dominated landscape. Alder, Pacific madrone, tanoak, cottonwood, and other hardwoods provide habitat and food for wildlife including deer, northern flying squirrels, varied thrushes, bushy-tailed woodrats, and many others. Breeding birds that migrate from the tropics tend to be associated with hardwoods.

New uses

As knowledge of hardwoods increases, so does innovation in their use. Researchers at the Olympia Forestry Sciences Lab have been examining red alder and cottonwood as cost-effective fiber and bioenergy crops for 9 years. Their research complements work underway at Washington State University, University of Washington, and the James River Corporation. Since this research began, growing hybrid cottonwood for fiber has become viable, and plantations have been established as a fiber source.

Bioenergy plantations may also become a reality with recent developments in converting biomass, the combined material of a plant including leaves and bark, to liquid fuel. Biomass fuel is the only renewable alternative to fossil fuels for powering engines. Plantations on farmland no longer in crop production may also pull carbon dioxide out of the atmosphere and lessen the greenhouse effect. Such plantations would stabilize soil, require less fertilizer and pesticides than used for most crops, and open up a new market for farmers.

In a related effort, researchers at the Corvallis Forestry Sciences Lab and Oregon State University are developing demonstration and research areas where cottonwood is grown for both fiber production and groundwater scrubbing along streams in pastures. In other countries, such as France, and in the eastern United States, cottonwoods are planted along streambanks to help reduce water pollution from pastures.

"Banks with a root mass of cottonwood can prevent erosion and pollution by trapping clays and fine sediments," says Jim Sedell, research ecologist, Forestry Sciences Laboratory, Corvallis, Oregon. The trees keep excess nitrates and phosphates from entering the stream and provide shade and other conditions important to fish that were found along natural streams before conversion to pasture. The demonstration cottonwood plantings will also provide a variety of strata for wildlife. "Land ownership is mixed along rivers," Sedell says. "This mixture can provide a rich array of vegetation patches along the river, improving wildlife diversity."

Although red alder has been the subject of most alder research, scientists at the Wenatchee Forestry Sciences Lab are examining sitka alder and thinleaf alder. In one study, Sitka alder is being planted in microdrainages of clearcuttings. The shrub, like red alder, will fix nitrogen. After several years of adding nitrogen to the site, the shrub will be overtopped by conifers that have benefited from the nutrient. The researchers expect the planting will make clearcuttings more attractive to wildlife.

The Wenatchee research team is also investigating the role alder shrubs might play in western redcedar regeneration. High water tables result in some poorly drained areas where redcedar has been cut. Because the large trees no longer take up water, the site can become too wet for redcedar seedlings. The alder shrubs can tolerate the wet site. The shrubs are expected to dry the soil enough to improve survival and growth of redcedar.

Researchers have planted Sitka alder to see if this shrub can dry out sites too wet for survival and growth of redcedar seedlings.

Know-how

Although complete guidelines for managing hardwoods are lacking, red alder and cottonwood guidelines are becoming available. Site index curves and site evaluation guides for red alder were published by the Pacific Northwest Research Station in 1986. In *Control of Red Alder by Cutting*, DeBell and Turpin provide information managers can use in retaining selected alders in a stand. Guidelines have been developed by M.A. Radwan, Forestry Sciences Laboratory, Olympia, and others for rooting cuttings of red alder; these allow selected genotypes to be propagated. In another effort, Radwan and W.V. Fangen, Washington State Webster Nursery, Olympia, have developed quality alder planting stock by direct seeding into styroblocks and transplanting to a nursery bed.

David Hibbs, leader of the Hardwood Silviculture Cooperative at Oregon State University, and Alan Ager, Operations Resource Analyst, Umatilla National Forest, recently published guidelines for alder seed collection, handling, and storage. Hibbs and others have also published information on thinning of red alder. The Hardwood Silviculture Cooperative was created to improve the information base for hardwood silviculture. Presently the cooperative focuses on alder.

Cottonwood plantations are often established from stem cuttings. Although cottonwood is considered to be an easy species to propagate vegetatively, there are differences between sources that markedly influence establishment. In *Bud Characteristics of Unrooted Cuttings Affect Establishment Success of Cottonwood*, Radwan, Joseph Kraft, and DeBell provide recommendations for selecting cutting materials to ensure uniformity of stock and early growth.

In addition to providing management guidelines for alder and cottonwood, the Olympia research team is working for genetic improvement of these species. The team has made several selections of red alder and black cottonwood clones. The team is now testing new and previously available genotypes for response to spacing, irrigation, and fertilizer. Although hybrid cottonwoods have attracted considerable attention, the Olympia team is also evaluating clones of native black cottonwood, including "Capital Lake," an apparently superior clone with unusual leaf characteristics, located by Radwan near Olympia.

For more information about hardwood research at PNW Research Station, request *Red Alder Harvesting Opportunities in Western Oregon*, Resource Bulletin PNW-173; *Control of Red Alder by Cutting*, Research Paper PNW-414; *Geographic Variation in Red Alder*, Research Paper PNW-409; and *Bud Characteristics of Unrooted Stem Cuttings Affect Establishment Success of Cottonwood*, Research Note PNW-461.

Copies of the 1977 symposium on *Utilization and Management of Alder*, General Technical Report PNW-70 are still available from the Forestry Sciences Laboratory, 3625 93rd Avenue, S.W., Olympia, WA 98502. Requests for older publications about red alder including height and site index curves and site quality estimation, and questions about alder and cottonwood can also be sent to this address. Also look for information in the coming months on alder seedling production and a 1991 symposium on hardwood management and use.

Lessons from the lysimeters

by J. Louise Mastrantonio
for Pacific Southwest Station

Steep and rugged watershed of the San Gabriel Mountains, part of the San Dimas Experimental Forest. Mt. Baldy is in the background.

LYSIMETER: A device for measuring water percolation through soil...something like a "flower pot" that is buried and filled with soil.

It takes four hundred years or more for an argillic horizon to form in soil. True or false? Until very recently, "true" would have been the correct answer. In fact, textbooks still claim it takes 3–4,000 years to form an argillic horizon...a layer of clay that has moved down and accumulated in the soil.

Recent research, however, indicates that an argillic horizon may develop rather rapidly—on the order of decades rather than hundreds or thousands of years. Furthermore, its formation may be more a function of overlying vegetation than of time itself.

This new information comes, not from expensive and time-consuming research, but by, quite literally, digging into the past. And it is one of several important findings from a study conducted recently at Tanbark Flats in the San Dimas Experimental Forest, a U.S. Forest Service research site in the Angeles National Forest east of Los Angeles. The scientists are: Hulton B. "Hutch" Wood, a research forester with the Pacific Southwest Station at Riverside, California; Robert C. Graham, Assistant professor of Soil Mineralogy and Genesis at the University of California, Riverside; and Mary A. Lueking, a soil scientist then with Oregon State University and now with ALPKEM in Clackamas, Oregon.

History

But we're getting ahead of the story. It actually begins more than fifty years ago. In the 1930's, a major research project was initiated at Tanbark Flats to determine how different species of plants affect water yield. Even back then, people were concerned about the availability of water in southern California. Scientists thought maybe some plants would use less water than others and might be used on hillsides to increase water runoff into storage basins.

Researchers, including engineers, hydrologists, plant physiologists, research foresters, and soils experts, spent several years devising an experiment—a study so elaborate and labor intensive there is no way it could be duplicated today. But labor was cheap then, what with a depression going on, and dozens of laborers from work programs such as the Civilian Conservation Corps were put to work—digging holes. These were no ordinary holes. They were lysimeters—devices for measuring the movement of water through soil.

First a large trench was dug, the soil removed and stockpiled. Then lysimeter holes were dug. Some were encased in concrete or metal casings ("confined lysimeters"). Others were left "unconfined."

Then devices were installed to collect and measure water that flowed through the soil or ran off the surface. The excavated soil was then sieved, mixed, and returned to the lysimeter holes. Thus, each lysimeter contained identical and homogeneous soil samples. In addition, samples of this soil were "archived"—stored away in glass jars for future reference.

The lysimeters were completed in 1937 and baseline monitoring was begun soon after. Nine years later, five different types of vegetation were planted over the lysimeters: scrub oak (*Quercus dumosa*), ceanothus (*Ceanothus crassifolia*), Coulter pine (*Pinus coulteri*), buckwheat (*Fasciculatum eriogonum*) and chamise—(*Adenostoma fasiculatum*). Data collection continued until 1960 when a major fire burned through the Experimental Forest, and provided a convenient stopping point for the research. A report summarizing the research results was published and, for all practical purposes, the study was abandoned.

Today, Tanbark Flats is far quieter. The Experimental Forest is closed to the public because of fire hazard, but the area is visited frequently by scientists working on different research projects—and by forestry professionals as part of field tours.

Comparing soils

Wood, who confesses to being something of a junk collector, became intrigued with the old lysimeter study after transferring from Hawaii to Riverside in 1982. It was the archived soils that fascinated him. They had been stored all these years in a shed downhill from the lysimeter plots. "When I saw all those 'antique' soils in there—uncontaminated—it started my wheels spinning. Here was a beautiful treasure trove of soils that had been put away for fifty years." What Wood proposed to do was to compare the archived soils with present-day soils that have been exposed to high levels of atmospheric pollution. Because the original samples had been saved, the old lysimeter study offered a unique opportunity to study the effects of air pollution on soils in the watershed—something no one had looked at previously.

More specifically, the study would:

1. Determine the presence of toxic metals (lead, copper, cadmium, arsenic; and mercury) and basic chemical characteristics of lysimeter soils developed under four different plant species: ceanothus, scrub oak, Coulter pine, and chamise. The buckwheat plots were not used because, over the years, they had been invaded by other species.

2. Compare sulfate concentrations and sulfate adsorption capacities for archived and lysimeter soils.

Soil Scientist Bob Graham holds soil formed under scrub oak. He's pointing out the boundary between organic material and mineral soil.

Sulfates are common in smog. As excess sulfate is leached from the soil it may be accompanied by losses of cation nutrients.

3. Determine the effect of different plant species on nitrogen cycling in the lysimeters.

4. Assess the degree of soil development achieved after fifty years of soil formation.

The study was proposed in 1987 under a system of competitive grants at the Pacific Southwest Station in which scientists must compete for discretionary dollars. Research administrators were intrigued and the study was funded.

Wood located the study in the "unconfined" lysimeters because vegetation growth had been inhibited by the containers of the confined lysimeters. Soil pits were dug to a depth of 30 and 100 centimeters and soil samples taken. Observations were made of their morphological properties and later, in the laboratory, the soils were analyzed for soil chemicals, nitrogen, and toxic metals.

Research Forester Hutch Wood holds soil formed under a Coulter pine. Needles at the surface have not been incorporated into the soil.

Findings

Excessive amounts of toxic metals were found, particularly zinc and lead. This was high "but not extraordinarily high" when compared to some industrial sites, according to Wood. Differences were also found in soil nitrogen under the different plant covers. For example, ceanothus helped fix nitrogen in the soil while chamise inhibited nitrification.

But what has researchers most intrigued is the difference in the way soils develop under different plant species. Under scrub oak, earthworm activity promoted thickening of the "A" (or upper) horizon—to about seven centimeters. The leafy matter of scrub oak is apparently very palatable to earthworms. In eating the leaf litter, they also ingest clay particles, and move them up to the surface.

Under pine, however, something totally different happened. All the needles accumulated on the surface. There were no earthworms at all and only a very thin "A" horizon—one centimeter thick. Below this, however, scientists detected a weak argillic (Bt) horizon in the subsoil.

"The interesting thing," according to Graham, "is that the soil processes are completely reversed. In one, clay is being moved to the surface and accumulating. In the other, clay is being leached down in the soil profile and accumulating in the subsoil."

What may be even more startling is that the soil under the pine actually meets requirements for an argillic horizon. Argillic horizons are subsoils that have been enriched with clay that has moved from the surface down into the soil. Their presence is commonly used as an indicator of soil stability. If an argillic horizon is present, builders and engineers consider it safe to locate buildings and other structures—even nuclear power plants. The more well developed the soil, the more stable—long existing—the site is believed to be.

But at Tanbark Flats, an argillic horizon had formed in only about forty years—certainly not a time frame that any builder would be comfortable with. Thus, depending on the conditions under which it was formed, the argillic horizon may not always be a good indicator of site stability.

"The lysimeter study was inadvertently an experiment in soil genesis," Graham says, adding that soil forms as a function of five factors—climate, organisms (dominantly plants), topography, parent material, and time. "Usually when people study soil formation, they try to find situations where all those factors are constant except one," he adds. "In nature, that's hard to do. But here everything was the same—except the vegetation."

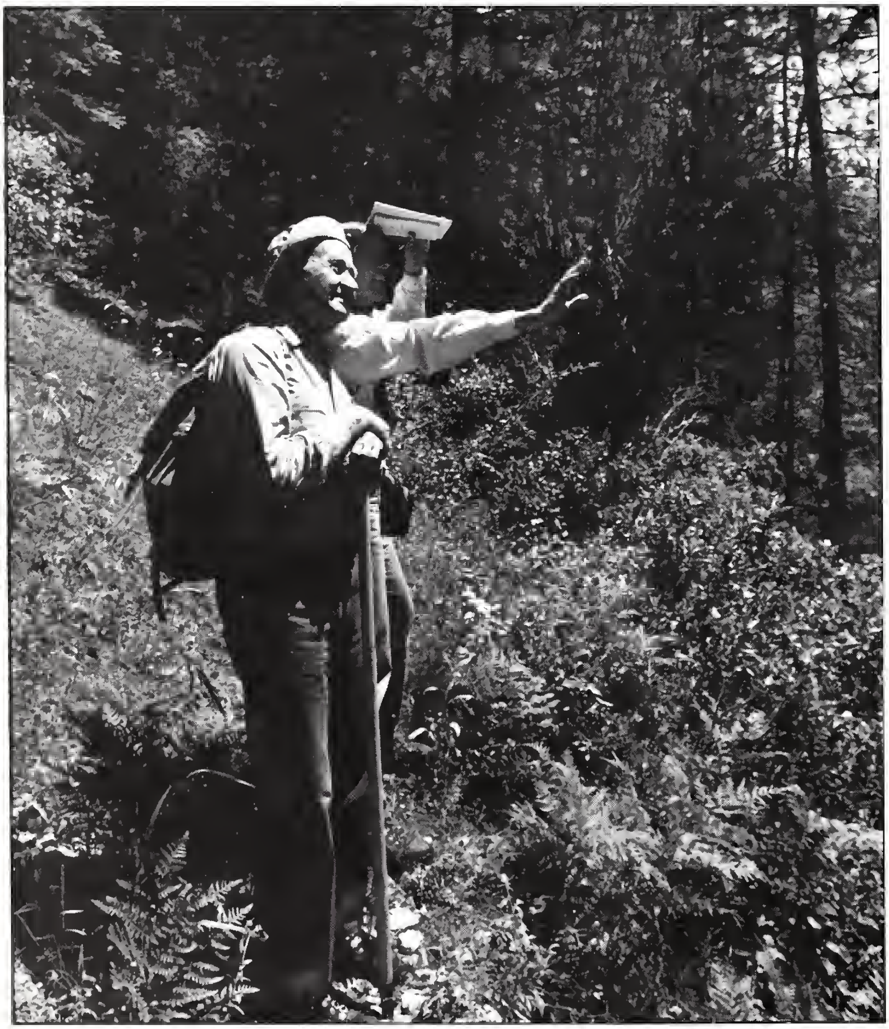
It was, inadvertently, a perfect experiment in soil genesis. Researchers who spent so many years designing and carrying out the original study could not possibly have known their work would produce useful results long after the study was abandoned. And who knows what scientists may learn in the future from the old lysimeter study?

Preserving Research Natural Areas

by David Tippets
Intermountain Station

Preserving Research Natural Areas (RNA's) provides National Forest managers and scientists with a true test of management maturity. Like growing from child to adult, it presents the challenge of delaying gratification to meet tomorrow's needs by subduing the temptation to satisfy today's appetites.

Like sticky-handed children looking through the candy store window, the public stands before the National Forests, pleading for more—more water, more wilderness, more recreation, more timber, more minerals, and more grazing. Few ask to have their resources invested to collect the interest of knowledge so they can reap greater benefits at maturity in clean air and water, and the ability to inherit the land at its greatest potential. Like the last piece of candy on the shelf, pristine ecosystems are threatened by the ravenous appetite of a population struggling to learn to conserve for the future.



Chuck Wellner and Susan Bernatas exemplify the partnership and spirit of cooperation that has been essential to establishing RNAs.

"When the well's dry, we know the worth of water," Benjamin Franklin said. Although most scientists and land managers today agree that intact ecosystems, complete with all their parts and natural processes, hold the keys for learning about the operation of spaceship earth, their worth is often undervalued when balancing the tradeoffs between tomorrow's discovery and today's thirst. Wise managers and scientists struggle to articulate their worth, and like loving parents hope to teach the value of water before the well's dry.

Unlike wilderness, natural areas claim no throng of passionate supporters. They offer no hope of great outdoor adventure and seldom provide scenic vistas. And for most of the public they offer no personal use.

"Research Natural Areas are part of a national network of ecological areas designated in perpetuity for research and education and/or to maintain biological diversity on National Forest System lands," states the Forest Service manual. "Research Natural Areas are for nonmanipulative research, observation, and study."

RNA's fall under the more generic classification of "natural areas" that includes Areas of Critical Environmental Concern managed by the Bureau of Land Management, as well as other specially managed public and private lands.

In 1977 the Federal Committee on Ecological Reserves defined an RNA as: "A physical or biological unit in which current natural conditions are maintained...allowing natural physical and biological processes to prevail...under unusual circumstances, deliberate manipulation may be utilized to maintain the unique feature that the Research Natural Area was established to protect."

Ecologists propose a national network of natural areas that represents all important ecological types. For some types only relatively small areas remain, resulting in RNA's that are much smaller than typical wilderness areas.

Because too much concentrated recreational use could damage natural features or disrupt natural process, RNA locations are not marked on public maps and visitation is promoted only for education and research. A natural area's constituency will likely always be the small group that looks past the landscape to discover the mysteries that bind the pieces of the landscape together into the living whole.

In the beginning

The movement to preserve natural areas as living laboratories began early in the century during the same era that the science of forestry began to take root in America. The Organic Administration Act of 1897 that created the National Forests authorized the Secretary of Agriculture to designate Research Natural Areas. The Ecological Society of America recognized the need to preserve natural areas in 1917 when it established a committee to tackle the challenge. In 1922, W. W. Ashe wrote in the *Journal of Forestry* about the need to preserve representative forest types to serve as guides for silviculture. The Forest Service created its first Research Natural Area, Santa Catalina, in 1927 in the Coronado National Forest in Arizona. The Coram RNA was established in the Flathead National Forest in Montana in 1937.

The Nature Conservancy, founded in 1951, and professional organizations including the Society of American Foresters, the American Association for the Advancement of Science, the Society for Range Management, and the Soil Conservation Society all took an active interest in natural areas. But formal establishment of National Forest RNA's proceeded slowly until after Congress passed the National Forest Management Act of 1976 (NFMA).

"Without the added boost of NFMA we got little accomplished even though the idea has been around a long time," Chuck Wellner, an early pioneer in RNA establishment, said recently. While a Forest Service scientist, Wellner successfully proposed the first three RNA's established in the Northern Region in the 1930's—all in experimental forests. According to Wellner, he was unsuccessful in establishing others because the "very practical minded" Regional Forester didn't believe that RNA's were a high enough priority to "bother the Chief about."

NFMA brought the schedule for identifying and proposing natural areas into line with Forest planning. "Forest planning shall provide for the establishment of Research Natural Areas ... for the identification of examples of important forest, shrubland, grassland, alpine, aquatic, and geologic types that have special or unique characteristics of scientific interest and importance..." states the regulation based on NFMA.

By 1990, at the end of the first round of Forest planning, Forests nationwide identified and proposed 450 RNA's. The area of the Intermountain Research Station, encompassing both the Intermountain and Northern Regions of the Forest Service, has led the nation in the rate of establishment of RNA's during the last 2 to 3 years. But even at the Intermountain Research Station's accelerated rate, it would take 20 years to evaluate all 450 areas currently proposed in the National Forest System. And many important types have yet to be identified and proposed.

Problem of priority

"It's always the job that goes to the bottom of the inbox," Wellner said, telling the story of one District Ranger in Idaho who carried an RNA establishment proposal in his briefcase for 2 years before he took time to review it. Wellner, who retired as Assistant Director of the Intermountain Station in 1973, devoted the past 17 years of his retirement to identifying and proposing natural areas. "It's not how I planned to spend my retirement," he recalled, "but I'm afraid if I don't do it it won't get done."

"Nobody has a lot of time, so everyone is frustrated," current Assistant Director Dick Krebill said when asked about the rate of establishment. Krebill coordinates RNA activity between the Intermountain Station and the Northern Region.

"Unless people feel there is a value in RNA's, it's a negative thing to make an area an RNA," Krebill said, explaining that too often RNA's are promoted as areas that have value only to research.

The proposed Aquarius RNA is divided by the North Fork of the Clearwater River in the Clearwater National Forest in Idaho.

Angela Evenden inspects a phantom-orchid, classified as sensitive in the Northern Region, under the redcedar overstory of Aquarius.

Wellner agrees in concept and laments that "research" was included as part of the name because so few understand the practical value of knowledge contained in natural areas. Establishing Research Natural Areas is "maintenance of natural diversity in a multiple-use framework," he said, emphasizing the relationship of preservation to the utilization of natural resources.

Many RNA proponents see the areas with the vision of silviculturalists, practitioners in the art of growing forests. They study natural areas to learn how to better grow managed forests, viewing RNA's for their value to understanding how to wisely use forests—not just preservation only for the sake of preservation. For this reason many people in industry support the preservation of Research Natural Areas.

"The first prerequisite to intelligent tinkering," Aldo Leopold said, "is to save all the pieces."

Lessons from the land

Wellner cites the mistakes of European forestry, where after years of intensively managing coniferous forests, managers recognized that they had lost the productivity of forest soils and had few natural productive sites left to learn from. But eventually they discovered that a natural forest's conifers were mixed with hardwoods, which helped buffer the acid produced by the conifers and kept the soils from becoming too acidic.

Assistant Station Director Keith Evans looks for signs of hybridization in single-leaf pinyon pine in the Mollens Hollow RNA on the Wasatch-Cache National Forest in Utah.

"We haven't paid enough attention to effects of practices (roading and logging) on soils," Wellner said. We know almost nothing about the microinvertebrates and their role in the soil. And where are we going to go to learn if we don't have undisturbed areas?" He points out that because of the great differences in soil, managers must consider not only kinds of vegetative cover, but also the kinds of soil when establishing a network of representative natural areas.

"The most productive thing that we have coming from wildlands is water," Wellner added, emphasizing the need to encompass complete drainage basins within natural area boundaries whenever possible, enabling scientists to study the hydrology along with the soils fauna and flora in a complete ecosystem approach.

During a recent visit to Mollens Hollow RNA in Utah, Intermountain Station Assistant Director Keith Evans, coordinator for RNA activity between the Station and the Intermountain Region, pointed out the value of RNA's to learning about less mobile small mammals, reptiles, and invertebrates. An ornithologist, Evans also identified opportunities to study the unique structure of undisturbed vegetation, and use by birds, compared to structure and use in disturbed plant communities.

Wellner emphasized the potential for learning about small animals in natural areas, telling the story about a University of Idaho entomologist who, on his first visit to the proposed Aquarius RNA in the Clearwater National Forest of Idaho, discovered an insect never recorded before and soon after found a rare salamander.

To date, RNA's seem valued mostly for the preservation of representative vegetation or habitat types used to judge the production potential of different kinds of land if undisturbed. To many this means "old growth" forest, but it also includes grasslands and shrublands. Using pristine types as a standard of comparison helps give managers the ability to judge the ecological status of managed lands. In the Pony Creek RNA in the Payette National Forest of Idaho, 14 forest habitat types occur as well as additional riparian habitat types not yet classified. As you cross from the adjacent logged drainage into Pony Creek, the value of the RNA, as a standard of comparison, jumps at you fast and hard—as though crossing from the Arctic to the Sahara. But for many species and habitat types there is no standard of comparison; for them the conservation movement came too late. Particularly rare are low-elevation primary timber and riparian types.

RNA's also preserve habitat for threatened, endangered, and sensitive plant species. Sixteen occur in Aquarius alone. In these cases natural areas preserve the biodiversity of the rare and unusual as well as the more common.

Living on the edge

Species living on the edge of existence, like aging patriarchs, may in the long run teach us the most about keys to adaptation and survival. Natural areas provide us with our last chance to learn from these ancients who evolved to their glory in another place or another time.

As concern heightens about global climate change from deterioration of the ozone layer and destruction of the rain forests, and as people speculate about how the earth's surface might change when subjected to more intense solar radiation, RNA's that harbor relict populations of vegetation that thrived before the Ice Age give hope for the discovery of clues to the earth's future. In some regions these survivors of the Ice Age tell us that the earth was once warmer and drier, and in other regions relicts reveal a past that was warmer and wetter. In both cases RNA's give scientists hope of better predicting the trends in vegetation change that might follow global warming.

Mollens Hollow RNA harbors a relict stand of reproducing singleleaf pinyon, living on the extreme of its range on south-facing mountain slopes, surviving since the Tertiary period over 2 million years ago. Not far away, a few individual two-leaf pinyons and white fir provide additional evidence of a once warmer and drier climate.

Dendrologist Ronald Lanner, from Utah State University in Logan, points out that these populations on the extreme of their range may be "genetically pre-adapted to global climate change."

"Anything that's unusual and unique can teach us something, and the more we know the better off society is," Lanner said about Mollens Hollow RNA. "You can't see cause and effect relationship unless you have examples of undisturbed areas," he added, stressing the value of natural areas for identifying the cause of changes.

Still going strong at 80, Chuck Wellner demonstrates Franklin's "philanthropy in the best sense of the word," as he devotes the 17th consecutive year since retirement to the preservation of natural areas.

In the Clearwater National Forest in Idaho, the Lochsa RNA and the proposed Aquarius RNA contrast by showing relicts of a warmer, moister climate that existed before uplifting created the Cascade Mountains, which in turn created a rain shadow to the east. Giant stands of old-growth western redcedar in Aquarius tower over an association of ferns and forbs found nowhere else except on the wet western side of the Cascades.

Research natural areas include pristine grasslands as seen mixed with a rich mosaic of aspen and conifers in the Cliff Lake RNA in the Beaverhead National Forest in Montana.

Pacific dogwood teeters on the edge of adaptation in the Lochsa RNA, the only inland location where the species occurs. But heavily diseased in recent years, the hardwood seems threatened and scientists are concerned that it may disappear before they can learn why.

Silviculturalist Fred Johnson of the University of Idaho started monitoring the dogwood in 1960. In 1988, he studied mortality in this isolated population and documented 50 percent mortality and 48 percent infection in surviving plants.

In 1990, Northern Region botanist and RNA coordinator Angela Evenden observed that individual plants that appeared almost dead the previous year seemed to be regaining vigor—but as is the unfortunate case with many RNA's, no one seems to have the time to study the phenomenon in enough detail to understand the changes. Evenden pointed to the urgent need to establish baseline data for monitoring in all RNA's and to begin gathering important information before the opportunity is lost.

New age of natural areas

Keith Evans stresses the same point made by Evenden, that with many areas now identified and a process of establishment started, the new critical need for Research Natural Areas is education, preservation, management, and research. Evans points to the tragedy of a RNA established 30 years ago in Nevada that was recently proposed for disestablishment because lack of management had allowed mining, grazing, and firewood cutting to destroy the value of the area for research.

District Ranger Jon Bledsoe, who manages the Lochsa RNA, stresses the same point from the perspective of a manager, saying that the research branch of the Forest Service needs to give managers a plan clearly stating the kind of management needed to maintain the values of RNA's. Bledsoe suggests that fire prescriptions and

strategies for noxious weeds management need to be addressed in RNA management plans.

Even though the rate of establishment seems painfully slow to advocates such as Wellner, he agrees that it's time to start directing some of the scarce resources available for RNA's to new priorities of protection, management, and baseline data collection.

Home stretch effort

The Forest planning effort seems to have put RNA establishment on the home stretch, but many races are lost on the last leg. "The areas that are undisturbed get scarcer and scarcer, and old-growth areas become more valuable and harder to pry away from

Angela Evenden shows the fruit of the coastal disjunct, Pacific dogwood, that occurs in the Lochsa RNA.

the economic base," Krebill said, pointing to the conflict of preserving some of the most valuable areas.

Using the proposed Aquarius area as an example, Wellner recounts a history of establishment success proportional to the lack of conflict over commodity production, rather than the potential wealth of scientific discovery. "Timber and grazing interests have always had veto power over natural areas. Aquarius should be the premier natural area in Idaho," he said, telling the story about how timber industry influence brought the governor and congressional delegation into the debate over the management of Aquarius. With a road proposed through its middle and new campgrounds proposed on two sides, the future of Aquarius remains in question. Some of the last battles for establishment may be the most important ever fought to preserve a complete knowledge of natural history.

Pacific Northwest Research Station scientist and RNA establishment leader Jerry Franklin identifies three home stretch threats to natural areas: lack of scientific use, inadequate documentation of research and marking in the field, and inadequate management.

"We must never forget that creating the system is only the first step: eternal vigilance is, unfortunately, essential for a permanent system," wrote Franklin in 1984. "For each of us, a professional commitment above and beyond the scope of anyone's current job description is required—the future of our natural area system relies on philanthropy in the best sense of the word."

Fire impacts on S.W. habitat diversity

by Rick Fletcher
Rocky Mountain Station

Fire occurs in most, if not all, of the vegetation types in the Southwest. In concert with climate and soils, it is responsible for development of existing biotic communities. But the importance of fire in shaping these communities varies.

A group of Rocky Mountain Station scientists is studying the effects of fire on Southwestern ecosystems—specifically the influences of prescribed fires on wildlife and their habitat. Kieth Severson, Project Leader for the Station's wildlife project in Tempe, Arizona, said in a recent review of research results on the effects of fire on wildlife, "fire influences wild animals in two general ways: by killing directly, and by altering their habitat. Most animals have the ability to escape by moving or burrowing. Where mortality does occur, areas are often rapidly recolonized by immigration or by an animal's innate ability to reproduce rapidly. Generally, the beneficial effects of fire on wildlife, especially in habitats where fire commonly occurs, offset potential losses."

Prescribed fire can improve habitat for wild animals primarily by increasing diversity in the shrub and herb layers. Fire can alter both the relative abundance of forage plants and their nutritive contents. It also can be used to augment diversity in habitat structure by breaking up homogeneous cover types.

Greater Basin Conifer Woodlands. Note the lack of understory vegetation between trees. While 'broadcast' burning can be difficult under these conditions, the small, dense thickets such as those on the left can be burned which result in the creation of small, forage producing, openings.

Station scientists are looking at three strategies for increasing habitat diversity in the major woodland and forest types in the Southwest via prescribed fire: (1) altering forage composition, (2) increasing nutritive content of forages, and (3) diversifying habitat structure.

Pinyon-juniper woodlands

Pinyon-juniper woodlands, distributed throughout the northern two-thirds of Arizona and nearly all of New Mexico, are important habitat for a variety of wildlife. A primary objective of land managers in burning pinyon-juniper is to improve wildlife habitat by increasing diversity of vegetation. It is difficult to predict early plant succession on pinyon-juniper burns because it depends on (1) where the burn leaves the site within the successional framework, (2) the response from soil seed reserves, (3) postfire weather, and (4) the availability of plants adapted to postfire conditions. Studies do show, however, that diversity of species increases as preburn species return to the site.

Unburned sites are important cover for large ungulates as well as habitat for tree nesting birds, and function as wintering areas for a multitude of nongame birds.

No information is available on effects of burning on bird habitat in this type. Trees in closed stands of pinyon-juniper with no significant understory can be very difficult to kill because such stands do not carry fires well. Prescribed fires have succeeded in parts of the Southwest by using drip torches, igniting only those areas that have the proper overstory-understory conditions for small (2-4 acre) spot burns.

Other studies have compared populations on chained areas with those in untreated pinyon-juniper stands. Total number of birds and number of species were consistently higher on untreated plots. In the chained plots, the species dependent on foliage and live trees for nesting or foraging declined. Removing snags eliminated cavity nesters such as the hairy woodpecker. Researchers recommend that chainings should be no wider than 600 ft. If treated areas are large, whether chained or burned, the impacts on birds appears to be significant.

Another way to manage pinyon-juniper overstory is to integrate burning with fuelwood harvesting or, in certain circumstances, mechanical methods such as bulldozing and cabling.

Southwestern Ponderosa Pine. Fire in ponderosa pine can increase understory production by reducing the number of small, live competing trees, the amount of litter, and depth of duff. Burning under these conditions often results in temporary increases in forage quality.

Ponderosa pine forests

Fire has probably received more attention in the ponderosa pine series than in any other biotic community in Arizona and New Mexico. Both in research and application, most emphasis has been on the use of prescribed fire as a tool to remove excessive fuel accumulations. The primary benefits to wildlife are increases in understory production and temporary increases in nutritive content of forage plants.

"Perhaps the first thing that piqued managers' interest in the relationship between fire and wild animals is the way that fire alters the distribution of animals, particularly ungulates," said Severson. "Animals are often attracted to a burned area immediately after a fire, sometimes gathering on the black surface—presumably consuming ash for nutrients." Severson notes, however, that the strongest attraction appears to be the greening stage after the burn.

Scientists have found that the first point to consider when using prescribed burns to achieve this "nutrient flush" is that such responses are short-lived. "The nutrient content of plants growing on burned areas is higher than that of plants growing on preburn or control areas," says Severson. Studies show, however, that nutrient contents of forage plants tend to revert to control or preburn status in two years or less.

The other point warranting attention is that relatively "warm" fires apparently have to be used to achieve these goals. Light fires (soil surface temperatures of less than 150 degrees F) were not suitable for improving the quantity or quality of browse plants. Soil surface temperatures of around 572 degrees are necessary to obtain significant increases in foliar nutrient concentrations. However, if soil temperatures are allowed to become too hot (over 600 degrees F), nutrient losses will occur including nitrogen, the key constituent in protein.

Small bird responses to fire in ponderosa pine forests demonstrate the potential effectiveness of habitat diversity on breeding populations. Species that forage among needles of living conifers are more common in unburned forests, while those characteristic of low brush and open ground are more predominant on the burn. Studies in California show that bird numbers change on the burned sites, but remain relatively stable on unburned sites. Differences are attributed to changes in the vegetation on the burned areas: (1) standing dead trees which served as foraging and nesting sites declined to about 20 percent of the postfire density, (2) shrub cover increased twofold, and (3) density of live overstory trees increased by 50 percent. As a result, birds dependent on snags decreased, those that nested or fed in shrubs increased, and those that nested or fed in the canopies of overstory trees increased.

A decadent aspen stand. Aspen stands are important to wildlife because the understory is more productive and diverse than that in adjacent coniferous stands and because aspen itself is an important browse species for native ungulates. Sprouting in such stands can be encouraged by a combination of cutting and burning.

"As a result of these studies," says Severson, "we find that fire can be used in ponderosa pine to benefit small birds as well as the larger herbivores. Relatively cool fires, burning 25 to 33 percent of the forest floor in irregular patches in a 3- to 4-year rotation, can create understory mosaics that vary in production, composition, and nutritional value."

Mixed conifer and subalpine forests

The response of these two biotic communities to fire, and the way fire can be used within each to improve wildlife habitat, are similar. Wildfire is far less frequent in these types than in ponderosa pine because of the wetter nature of the habitat. Because quaking aspen is one of the major tree species in these forests, and a vital species to wildlife habitat, scientists have turned much of their focus to this tree type.

Quaking aspen is the principal successional species after fire. Fire suppression over the years, however, has resulted in large, overmature stands, with aspens often being overtopped by conifers. Rejuvenation of these stands is critical, because only 7 percent of the estimated 480,000 acres of aspen in Arizona and New Mexico are in the seedling and sapling stage; the rest are mature or overmature. Scientists point out that without management intervention, seral aspen stands will probably be replaced by conifers, and stable ones may become all-aged and less productive.

Aspen stands have three characteristics that make them important components of wildlife habitat. First, the herbaceous understory is more productive and diverse than in adjacent conifer stands. Second, aspens are the only deciduous trees at higher elevations in the Southwest, and contribute significantly to the enhancement of diversity and creation of "edge". Finally, aspen itself is a palatable and nutritious browse consumed by elk, deer, and cattle.

In two separate studies, one on birds, the other on elk, scientists found that clearcutting aspen in small blocks on an 80-year rotation can increase "edge", species diversity, and even total number of birds. In the elk study they found no dietary nutritional differences between burned and unburned aspen stands, but did note that time spent feeding was substantially greater on burned aspen sites, probably because preferred forages were consistently available. Aspens in a forest landscape benefit not only wildlife, they also furnish significant forage for livestock. Aspens provide excellent watershed protection and are aesthetically desirable. They can even be managed as fuel breaks because of low ignition rates, low burning index, and lack of ability to carry a crown fire.

Recommendations for managing aspen in the Southwest conclude that, although cutting may create uneven-aged patches in young and mature stands, it alone may not result in significant sprouting in overmature stands. Intense wildfires have been shown to promote sprouting under these circumstances, however. Therefore, clearcutting, followed by broadcast burning of slash, may yield better results. Severson explains that as apsen stands pass maturity, higher intensity fires may be necessary to stimulate adequate sprouting because increased root temperature, caused by exposure of soil to sunlight, is the cardinal factor in stimulating suckering. In younger stands, increased soil temperature resulting from clearcutting and light burning, which creates a blackened surface, also has resulted in sprouting. A moderate- to high-intensity burn creates higher soil temperatures in two ways; directly, by heating the mineral soil, and indirectly, by removing all litter and duff and by creating a blackened surface. Studies show that there is apparently no danger of too much heat—it appears impossible to prevent root sprouting by intense burning.

Because of active fire suppression efforts, succession in many stands has progressed to the point where conifers are codominant. In stands where the coniferous component is significant, prescribed fire could be used in conjunction with timber harvesting.

The optimum size of individual areas to be burned depends on several factors including management objectives, size of the original stand, and other constraints. Treated areas that are too small may result in concentrating browsing animals to the point where aspen regeneration is eliminated. Without control of ungulate use, clearcutting or burning less than 12 acres might be futile. Several such areas should be treated in the same general area to distribute browsing pressure as much as possible.

Low elevation riparian habitats in the Southwest are very fragile. Because of their rarity and valuable nature, these habitats should not be burned. Research has yet to identify the role of natural fire in such riparian systems. Information will become available as research opportunities arise to study wildfire events that directly and indirectly affect these systems.

Riparian-stream ecosystems

Little information is available on the specific effects of fire on riparian-stream ecosystems. Several studies have been done, however, on the effects of fire on fishes. Findings show that fire can increase streamside deciduous vegetation, and cover and food supplies for fish. Scientists often dismiss water quality changes and increased nutrient inputs to streams caused by prescribed fires as having little effect on fish.

"We agree generically, however, that large fires have the greatest potential for causing damage to water and its inhabitants," says Severson. "A large, hot wildfire, as a result of convectional heating and input of burning debris and ash, could conceivably increase stream water temperatures to a lethal level for trout," he says. Severson also suggests that in-stream and streambank sedimentation and hydrological response, singularly or in combination, are two primary factors that may be altered by either wild or prescribed fire.

Currently, the effects of fine sediment on fishes and their habitat is a proposed priority research emphasis for the USDA Forest Service.

If you would like further details on this research, they are available in a new report titled *Effects of Fire in Management of Southwestern Natural Resources*, General Technical Report RM-191. The report is a proceedings of a symposium held in 1988 in Tucson, Arizona. It is a compilation of 36 papers and a listing of selected literature references on fire effects in the Southwest. Topics include: Fire History and Climate in the Southwestern United States; Fire Effects on Vegetation and Succession; Using Fire as a Management Tool in Southwestern Ponderosa Pine; Obstacles and Opportunities in Prescribed Fire Management; Smoke Management; Prescribed Fire Monitoring and Evaluation Activities; FIREMAP - a GIS Supported System; Fire and Forest Insect Pests; and several others. The Rocky Mountain Station has copies.

New from research

Grazing, grasses, and tree regeneration

Timber, domestic livestock, and wildlife are important to the local economies of eastern Oregon. To manage a mix of these values, land managers need an understanding of how timber and range management affect tree regeneration and understory vegetation. Toward such an understanding researchers have been studying effects of cattle grazing and grass seeding in the mixed conifer forests of the Blue Mountains in eastern Oregon since 1974.

Because the shelterwood system is commonly used in mixed conifer stands, researchers focused on this system. They determined the effects of cattle grazing, grass seeding, shelterwood cutting, and slash disposal on (1) tree seed production and viability; (2) tree seedling recruitment, distribution, and mortality; (3) tree seedling growth; and (4) seedbed condition.

Researchers found natural regeneration of trees was abundant after shelterwood cutting to three overstory densities regardless of grazing and grass seeding treatments. Neither grazing nor seeded grasses decreased seedling establishment, but the grass did retard seedling height growth. A residual overstory of about 30–40 square feet of basal area appeared adequate for natural regeneration in 5 years. Seeding 4–5 pounds of less competitive grasses and grazing up to 60 percent of the current years growth were compatible with tree seedling establishment.

Request *The Influence of Cattle Grazing and Grass Seeding on Coniferous Regeneration After Shelterwood Cutting in Eastern Oregon*, Research Paper PNW-417.

The use of volume tables for timber inventory

Intensive forestry requires that foresters be able to estimate tree volume accurately for such phases of timber management as timber sales, forest surveys, appraisals for land exchanges, evaluations of damage, advance planning, and growth and yield studies.

To be of value, estimates of tree volume should be expressed in units of measure that relate to the products derived from the tree, and in terms familiar to the user.

This Research Note explains the use and benefits of using volume tables to display important data critical in the management of any timber stand.

Request *Local Volume Tables for Young-Growth Conifers on a High Quality Site in the Northern Sierra Nevada*, Research Note PSW-404.

Analysis of outdoor recreation and wilderness presented

Every 10 years, forest and rangeland resources are assessed as directed by the Forest and Rangeland Renewable Resources Planning Act (RPA) of 1974. Many volumes have been compiled for the 1989 RPA Assessment. The Rocky Mountain Station has issued a report that forecasts information on the outdoor recreation and wilderness situation in the United States from 1989 to 2040.

The bulletin is one of a series of seven, assessing such resources as land base, wildlife and fish, forest-range grazing, minerals, timber, and water. The outdoor recreation and wildlife bulletin covers topics such as the demand for, and supply of outdoor recreation and wildlife; the social, economical, and environmental implications of demand-supply of such Forest Service lands; and the opportunities and obstacles facing forest managers working to improve such lands.

For a copy of *An Analysis of the Outdoor Recreation and Wilderness Situation in the United States: 1989–2040*, request General Technical Report RM-189 from the Rocky Mountain Station.

United States Department of Agriculture

Forest Service

Intermountain Research Station

General Technical Report INT-270

June 1990

Proceedings—Symposium on Whitebark Pine Ecosystems: Ecology and Management of a High-Mountain Resource

Proceedings—symposium on whitebark pine ecosystems: ecology and management of a high-mountain resource

Current whitebark pine research, as described in a new proceedings, is particularly ecosystem oriented, showing relationships between the tree and insects, disease, fire, birds, rodents, and even the grizzly bear reigning at the top of the food chain. Ecological relationships are hard to illustrate more dramatically than described here for high-elevation whitebark pine forests.

Long ignored by researchers because of its low value as a commercial species, whitebark pine's recently recognized ecological significance has stimulated new and abundant interest. The proceedings includes 52 papers and 14 poster synopses, summarizing most of the current knowledge available to managers who care for the high-elevation whitebark pine ecosystems. This volume is likely to become a frequently consulted reference in the Northern Rockies and Cascades.

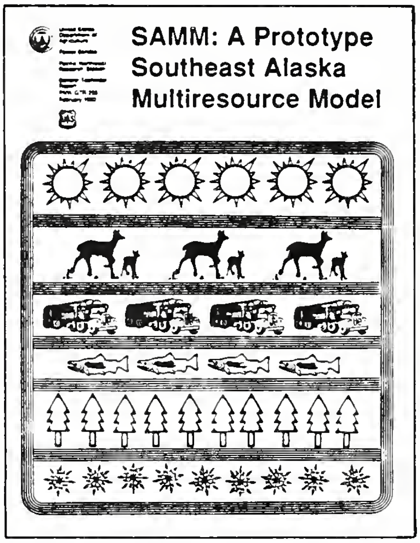
Request *Proceedings—Symposium on Whitebark Pine Ecosystems: Ecology and Management of a High-Mountain Resource*, General Technical Report INT-270.

Computer model projects multiresource interactions

This publication describes the prototype model of SAMM (Southeast Alaska Multiresource Model). The model is being developed to project multiresource interactions in the spruce and hemlock forest of southeast Alaska. A forest multiresource projection model, SAMM is capable of characterizing and displaying interactions of four major resources for a 150-year rotation. These resources are timber, Sitka black-tailed deer, streams, and anadromous fisheries. The model is for application in watersheds of 5,000 to 20,000 acres.

Final testing is needed before SAMM can be used for quantitative analysis, but the model has been developed and evaluated sufficiently for use in qualitative planning. The model can thus be used to characterize relative change in resource outputs from management action. This publication discusses model objectives, assumptions, specifications, submodels, and management implications.

Input for SAMM includes data on physical and biological resources, management actions, and economic and social characteristics. The model is programmed for IBM PC/ATs or full compatibles. A users guide is under preparation.



Request *SAMM: A Prototype Southeast Alaska Multiresource Model*, General Technical Report, PNW-255.

Effects of global warming on American forests

As directed by the Forest and Rangeland Renewable Resources Planning Act (RPA) of 1974, forest and rangeland resources must be assessed every 10 years. Climate, and how it changes, is one of the many resources being assessed.

Since the beginning of the industrial revolution, the chemistry of the atmosphere has been altered by increases in greenhouse gases such as carbon dioxide, methane, nitrous oxides, and others. These gases trap a portion of the earth's infrared radiation and warm the planet. Current projections indicate that with present technology and population growth, the concentration of greenhouse gases will double by the year 2030.

Changes in the location and abundance of North American tree species are associated with a 5 degree celsius warming that occurred over a period of 8,000 years between 15,000 and 7,000 years ago. Again a 5 degree celsius warming is predicted, but this current change is expected to occur much more rapidly—over just 100 years.

The impact of this potential climate change on North American ecosystems, and particularly on forest resources, needs to be determined. A recent document, one of 13 included in the 1989 RPA Assessment publications, summarizes current research on the impacts of climate change on America's forests. It defines the greenhouse effect, quantifies atmospheric and ecological responses, and gives options for future forest management techniques in a changing climate.

For a copy of *Climate Change on America's Forests*, request General Technical Report RM-187 from the Rocky Mountain Station.

Influence of nontimber resources on timber sale characteristics in the Intermountain West

Economists Niccolucci and Schuster recently assessed the dollar cost of managerial discretion in timber sale design for both the Northern and Intermountain Regions of the Forest Service. They looked at the added costs of mitigating adverse effects of timber sales, and evaluated the cost of voluntary modifications compared to modifications mandated by policy.

The added cost to stumpage for the Intermountain Region was $13/M bd ft and $21/M bd ft for the Northern Region. Translated into the cost per acre for considering nontimber resources, the Intermountain Region's mitigation costs equal 9 percent of the total logging costs compared to 14 percent of logging costs in the Northern Region.

The difference between the Regions narrows when looking at the mandatory policy costs alone, but widens after adding in the greater voluntary costs of managerial discretion used in the Northern Region. The authors observed that "timber sale modifications made voluntarily were less expensive than the required modifications."

"If not required to modify the sale characteristics, did the benefits generated by the voluntary modified sale characteristics equal or exceed the costs?" they ask, suggesting that knowledge of the costs and benefits of voluntary actions will lead to sound economic decisions.

Request *Influence of Nontimber Resources on Timber Sale Characteristics in the Intermountain West*, Research Paper INT-422.

Estimating postfire water yield

Wildfire annually burns thousands of acres of Pacific Northwest watersheds and can affect the quantity and quality of water resources. Fire often produces an increase in water yield which may persist for many years.

A methodology is presented here in which site-specific hydrologic models were adapted to provide the estimates of postfire water yield for fire management planning.

Request *Estimating Postfire Water Production in the Pacific Northwest*, Research Paper PSW-197.

Piecewise SALT sampling

Forest activities such as logging, road building, and mining can reduce water quality in streams and rivers. Increased sediment delivery is a possible result of such activities. Increased sediment production can have direct effects on sedimentation and fisheries, or indirect effects by acting as a vehicle for chemical pollutants.

Piecewise SALT is a modification of the original SALT procedure. It allows the user to adjust sampling to special needs such as measuring smaller storms, and to limit sample collection to logistically possible regimes.

Piecewise SALT also provides estimators for periods essentially disconnected from the times of station visits.

Request *Piecewise SALT Sampling for Estimating Suspended Sediment Yields*, General Technical Report PSW-114.

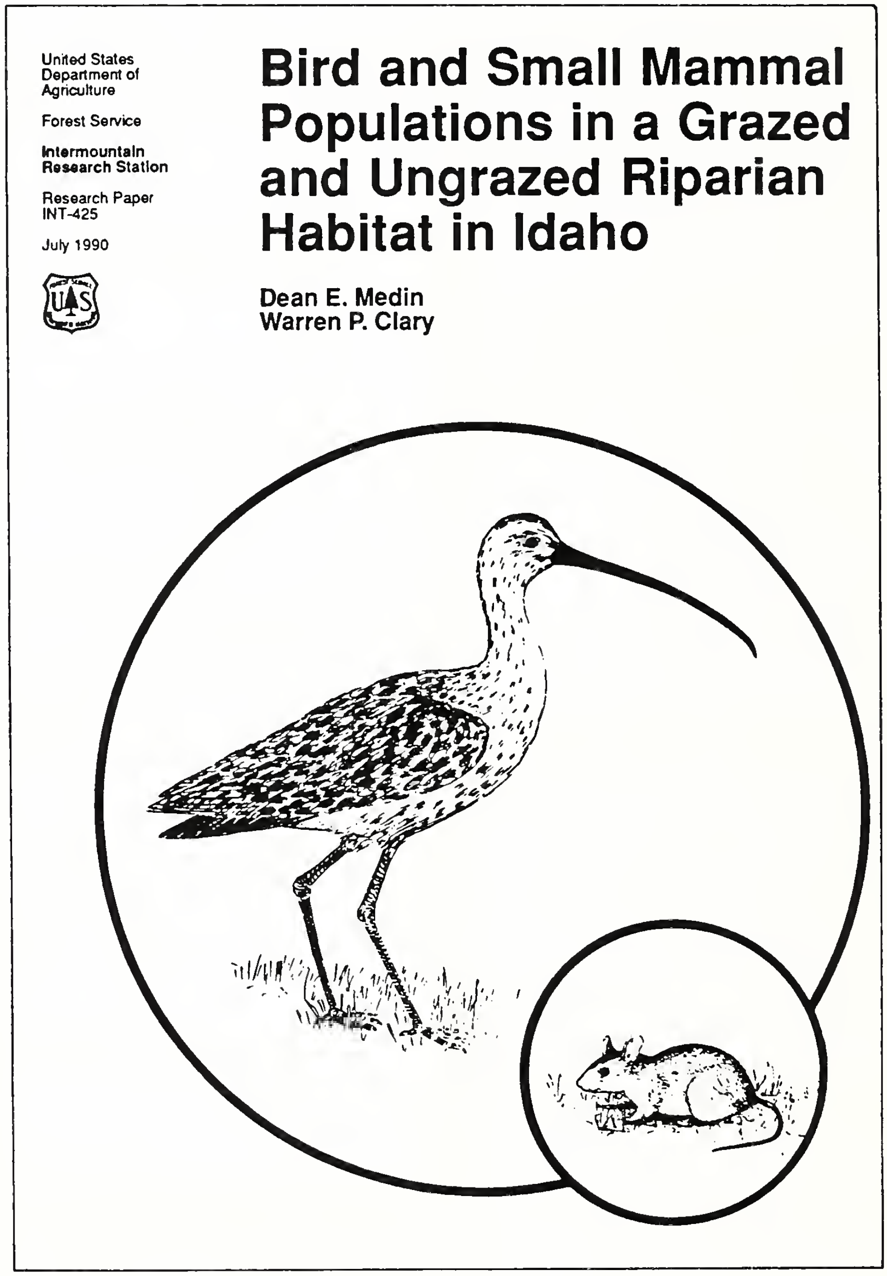
Bird and small mammal populations in a grazed and ungrazed riparian habitat in Idaho

Some birds and small mammals prefer the structure of grazed over ungrazed habitat, Dean Medin and Warren Clary report, concluding research in an east-central Idaho study.

"There was little difference between grazed and ungrazed habitats in total breeding bird density," they said. "But total bird biomass, bird species richness, and bird species diversity were higher in grazed habitats. Shorebirds—killdeer, willets, and long-billed curlews—preferred the grazed areas with lower vegetation. Other species, such as savannah sparrows and red-winged blackbirds were more common in the ungrazed area."

Small mammal populations were a third higher in the grazed areas, but unlike with birds, species richness and diversity were greater in the ungrazed area. Deer mice, the most abundant mammal species, increased after grazing, but conversely montane voles demonstrated a preference for the ungrazed habitat.

Request *Bird and Small Mammal Populations in a Grazed and Ungrazed Riparian Habitat in Idaho*, Research Paper INT-425.


United States Department of Agriculture

Forest Service

Intermountain Research Station

Research Paper INT-425

July 1990

Bird and Small Mammal Populations in a Grazed and Ungrazed Riparian Habitat in Idaho

Dean E. Medin
Warren P. Clary

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3. (89–101) *Statistical Estimators for Monitoring Spotted Owls in Oregon and Washington in 1987*, Research Paper PNW-420.
4. (89–178) *Red Alder Harvesting Opportunities in Western Oregon*, Resource Bulletin PNW-173.
5. (88–215) *Control of Red Alder by Cutting*, Research Paper PNW-414.
6. (88–110) *Geographic Variation in Red Alder*, Research Paper PNW-409.
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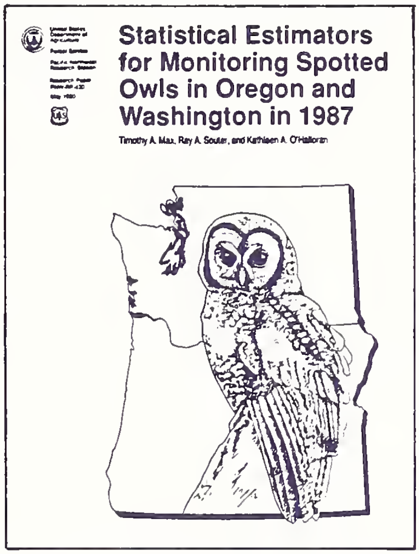
Sampling framework for spotted owls

This publication presents the statistical framework for spotted owl monitoring on 11 National Forests in 1987. The spotted owls were monitored for estimates of occupancy and reproduction rates for pairs of spotted owls. The estimates from 1987 will be used with later estimates to establish trends. Although technical, the publication allows an understanding of the sampling framework.

The authors document the technical details of the statistical estimation procedures used to summarize the data obtained from sampling. All relevant formulae and decisions about collapsing strata to estimate variances are presented. Two sources of potential bias are also thoroughly discussed in the publication.



Request *Statistical Estimators for Monitoring Spotted Owls in Oregon and Washington in 1987*, Research Paper, PNW-420.

Economics and risk of fire management programs

In a time where forest budgets are strained and funding for fire is tight, current research will help fire managers to better understand the economic effects of fire management programs.

Because of the fire system's highly stochastic and complex nature, there is relatively little information on the economic efficiency of alternative fire management programs and even less on the tradeoffs between efficiency and risk.

Thomas Mills and Frederick Bratten set out to address these concerns. As a result they formulated three hypotheses about fire system performance to guide analysis into these dimensions:

1) Economic efficiency.
2) Risk in the fire management system.
3) Efficient funding level.

Request *The Economic Efficiency and Risk Character of Fire Management Programs*, Northern Rocky Mountains, Research Paper PSW-192.

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