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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

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Cover

One of the many objectives for scientists at the Pacific Southwest Station is to find ways for controlling major forest insect pests. Here, Entomologist Marion Page examines the needles of a tree seedling for insect damage. Read more about the mission of this research facility, beginning on page 16

To Order Publications

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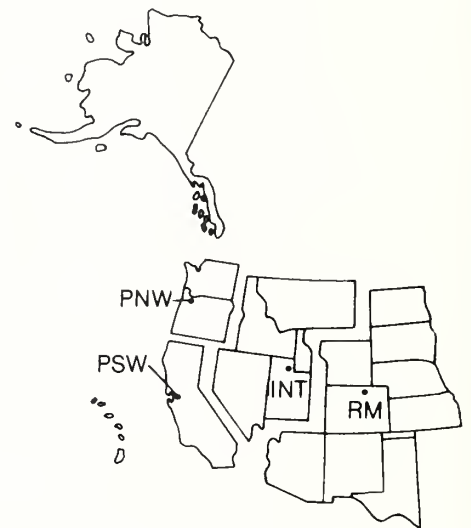
Western Forest Experiment Stations

Pacific Northwest Research Station (PNW)
P.O. Box 3890
Portland, Oregon 97208

Pacific Southwest Forest and Range Experiment Station (PSW)
P.O. Box 245
Berkeley, California 94701

Intermountain Research Station (INT)
324 25th Street
Ogden, Utah 84401

Rocky Mountain Forest and Range Experiment Station (RM)
240 West Prospect Street
Fort Collins, Colorado 80526-2098



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Beavers:
biologists
“rediscover” a
natural resource //

by Dorothy Bergstrom
Pacific Northwest Station



Castor canadensis (Chris Maser photo)

The busy beaver makes little noise as it works the night shift, patrolling and repairing its dams and canals, cutting down trees for food and building materials — keeping its constantly growing incisor teeth worn down. The beaver (*Castor canadensis*) has physical features that equip it for underwater work. Its persistence and constant activity surely qualify it as the workaholic of the animal world. The beaver also has extraordinary engineering skills that allow it to reshape streams to meet its own needs. In improving its own habitat, the beaver initiates ecological changes that affect the habitat of others in its home watershed.

The beaver's “hydrology projects” are not always welcome, especially in parts of the country where farms, ranches, and woodlots dominate the beaver's preferred habitat. When one beaver's decision about where to build a dam, divert an irrigation ditch, or gnaw down a tree conflicts with people's wishes, the reputation of the whole species suffers.

Beavers play pivotal role

In many parts of the West, however, the beaver is becoming appreciated more and more. The beaver is increasingly viewed by researchers and land managers as a skilled, hard-working assistant in the repair and stewardship of riparian ecosystems. In fact, some scientists now regard the beaver as a keystone species — one that plays a pivotal role in regulating entire ecosystems. Beaver dams slow the movement of water, sediment, and streamside vegetation out of watersheds — even small ones. The result is that more water is stored, ground water is recharged, and more diverse vegetation grows along streams. Research is also uncovering information about the effect of beaver activities on another important process: nutrient cycling.

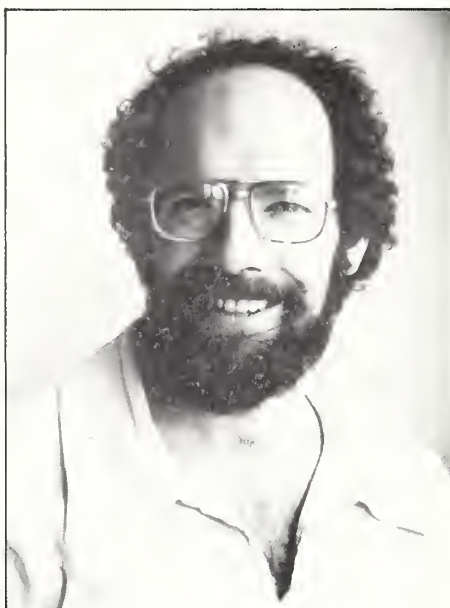
Ecologist Jim Sedell of the Pacific Northwest Station's Forestry Sciences Laboratory in Corvallis, Oregon, thinks that the role of beavers in creating and maintaining the forest environment has been underestimated. He

believes their role in nutrient cycling may be as important as their better-known role in regulating stream flow. Sedell's conviction is based on studies of fish habitat. He and colleague Cliff Dahm (now at the University of New Mexico) have been documenting — for the first time — the chemical processes that link beaver activities and nutrient cycling.

"We're now looking at fish habitat in ways that don't stop at the water's edge," Sedell says. "We're finding that beavers have dramatic effects on streamside vegetation that benefit a whole range of creatures besides fish."

Sedell's interest in beavers dates from a 1981 field trip to investigate fish habitat in a small tributary of a coastal stream in western Oregon. He and a colleague were trying to find out where anadromous fish were rearing and why fewer fish were being produced than in previous years. At one place they saw rocks lined up across a stream, forming a low dam that backed up water several inches deep. There were more coho salmon juveniles in the pool than below the dam, and they were bigger. Although the dam looked like the work of children, it turned out to be a beaver dam built of rocks.

Sedell's interest in beavers was stimulated further when, as a member of an evaluation team, he visited a 300-square mile, unlogged watershed in Quebec Province, Canada. There, at a research facility of the Woods Hole Oceanographic Institution, scientists had concluded that beavers made important contributions to wood decomposition.



Ecologist Jim Sedell.

Sedell decided the possible influence of beavers on fish habitat was too important to ignore. Now, after preliminary results from studies begun in 1982, Sedell sees West-wide implications of the effects of beavers on stream morphology, health of riparian ecosystems, diversity of vegetation, and nutrient cycling on habitat — not only for fish, but for all wildlife and domestic cattle as well.

Fish habitat studies

Sedell began the research by examining fish habitat conditions in six ponds in small streams of the Oregon Coast Range. His current work is done in beaver ponds that have been modified to permit control of conditions. There are four research sites, all in Oregon: Knowles Creek, a tributary of the Siuslaw River in the Coast Range; Fish Creek, a tributary of the Clackamas River in the Cascades; the North Fork of the Willamette River in the Cascades; and Oak Creek, a tributary of the Marys River near Corvallis. In 1982, Sedell

and Dahm (who was then at Oregon State University in Corvallis) began collecting baseline information on spawning the rearing habitat and the distribution and population of spring chinook salmon, coho salmon, winter steelhead trout, and summer steelhead trout. They also began analyzing water samples from above and below the dams.

What they have found so far is that the water in pools and immediately below dams contains more nitrogen and phosphorous than water from other stream reaches and that fish grow faster in the pools. Coho salmon put into the Fish Creek study pond in late November were big enough to go to sea by March. In only 4 months they grew as big as the largest wild smolts found on the West Coast. Sedell says the combination of a rich food base and slightly warmer temperatures in the pond resulted in a 600-percent gain in weight over the winter — about three times the weight gain of juveniles in the main channel of Fish Creek.

"Because larger juvenile salmonids have a better chance of surviving the trip to sea and later returning to their birth streams," Sedell says, "the contribution of beavers to increased fish production seems obvious."

Other fish habitat studies are turning up similar results. In southeast Alaska, for example, Fishery Biologists Mason Bryant and Andy Dolloff, who work out of the Pacific Northwest Station's Forestry Sciences Laboratory in Juneau, have found that beaver ponds provide particularly good winter habitat for coho salmon and that fish in ponds are bigger than fish of the same age that grow in other stream reaches.



A beaver pond on Fish Creek that has less than one-tenth of one percent of the total fish habitat of the Fish Creek basin, produces 6 to 8 percent of the coho salmon.

Bryant attributes part of the increase in numbers of fish in beaver ponds to the increase in water surface area. In one case, he says, a significant amount of habitat was lost when a pond was drained after a dam failed and the stream returned to a free-flowing state. The number of coho salmon in the pond area decreased from about 2,500 to 350.

Results of long-term studies come in slowly, and so far, not much has been published. "Even if we don't have numbers on all the products and processes," Sedell says, "we now have a much better understanding of beaver activities and how they affect ecosystems."

How beavers affect ecosystems

Beaver dams change stream structure by creating pools that alternate with riffles. As water is stored above dams, fluctuations in runoff are reduced. There is less damage from floods, and during dry periods the pools provide important water storage. In late summer and fall, up to 25 percent of the water in small coastal streams in Oregon may be held in beaver pools. Even a few inches of stored water means that more fish survive.

As a greater volume of water is stored, it spreads over more land surface, and the water table rises. Aquatic plants and water-loving shrubs, such as willow and alder, are able to grow in riparian areas. In the pools, juvenile anadromous fish find food and protection from predators while they eat and grow big enough to go to sea.

Beavers also build dens. In part of the country where there are not enough logs for lodges, beavers dig holes in stream banks. During floods these holes provide sanctuary for small fish.



Juvenile coho salmon before and after spending winter in the beaver pond. The weight gain in 4 months was 600 percent, the gain in length was 170 percent.

Beavers bring streamside vegetation into pools. This material, along with vegetation that falls into the water, forms floating mats of twigs and leaves that provide hiding cover for fish and habitat for numerous organisms. By eating about 2,500 pounds of leaves and small branches a year and defecating in pools, each beaver brings considerable organic matter into the stream and provides an important step in nutrient cycling.

To a beaver, the most desirable homesite is a small, low-gradient stream that can be dammed to form a pond. A good swimmer but clumsy out of water, the beaver prefers to swim close to its food supply to avoid the predators it might encounter on land. Beaver food is the cambium layer (inner bark) of streamside vegetation, preferably alder, willow, and aspen. The limbs and branches of trees are used to build dams. If they are not available, stones and gravel may be used along with sticks.

Nutrients recycled in beaver ponds

In the pools, the vegetation in various forms is processed further by aquatic insects that shred and scrape it until it finally sinks and becomes part of the mud at the bottom.

In the mud, under anaerobic conditions (without oxygen), the vegetation breaks down further into basic chemical elements, such as nitrogen, phosphorus, and carbon. This process occurs more slowly than decomposition that uses oxygen, and less nitrogen is utilized. Also in the mud, bacteria ingest metals and transform them into nutrients for other bacteria and algae. The chemical components percolate up into the water and become nutrients for organisms at the beginning of the food chain. The nutrients reach fish a few steps up the food chain in the form of caddisflies, stoneflies, midges, and other insects.

The life cycle of the beaver and its contributions to flood control and good fishing are well known to naturalists and experienced outdoors people, but until recently there had been little or no research to document these contributions. Sedell thinks beavers have been easy for scientists to overlook because they are not very visible (they do most of their work at night).

Historical records help

As part of his research, Sedell has studied the historical record to find out what was known about beavers and what streams in the West were like 100 or more years ago, when fish were plentiful. He found that in prehistoric times, there may have been 400 million beavers distributed from the Arctic

Circle to Mexico, building dams that held back organic sediments that today form the fertile floors of many western valleys. As Sedell puts it: "People today are living on income from the capital laid down by beavers centuries ago."

The recognized role of the beavers during the settlement of North America was economic. "We won the west on beaver pelts," Sedell says. For 200 years beginning in the 17th century, pursuit of beavers by Europeans — and Indians who worked for them — drove the westward expansion of the United States and Canada. The North American beaver was almost extinct by 1900. After State laws were passed to protect it at the turn of the Century, the beaver began a comeback but today there are still less than 9 million.

Sedell found that trapping out the beavers was not the only human activity that affected fish habitat. In the late 1890's the Corps of Engineers spent a great deal of money, effort, and dynamite to remove log jams and big rocks from the larger western streams to channel them and improve conditions for river transportation. But the barriers to human traffic were also the natural features that slowed down the movement of water and nutrients from watersheds and provided habitat for fish and wildlife.

Managers utilize beavers

In his historical review, Sedell also found that beavers have been "rediscovered" by forest managers about every 25 years. In the 1930's and 40's, beavers were put to work in parts of the West to build dams to control stream flow and soil erosion. The Forest Service experimented with packing and parachuting them into remote forest meadows to dam streams and create reservoirs for fighting forest fires — an idea that did not prove cost effective.

The most recent era of beaver rediscovery dates from the late 1970's, when a few resource managers and researchers in the intermountain region independently recruited beavers to repair degraded streams. Conditions in Idaho, Montana, and Wyoming are far more arid than in Oregon and Alaska, and in many areas riparian habitat is important to grazing cattle as well as to fish and wildlife. On much of the range, riparian vegetation had deteriorated badly, partly as a result of continued season-long cattle grazing and loss of stream stability. As deterioration continued, the amount and diversity of riparian vegetation was reduced and there was less food and cover for wildlife, and more soil erosion. During occasional periods of heavy runoff, gullies formed and cut streams deeper. Cattle looking for water got mired in streamside mud and died. Wildlife died or moved away. Once stream channels were degraded, recovery was difficult and often required drastic changes in livestock management.

What was missing was the beaver. Among those who recognized this were Greg Munther, a Forest Service fisheries biologist on the Lolo National Forest, and Researcher Bill Platts of the Intermountain Station in Boise, Idaho. Both have seen good results from using the beaver to improve the quality of riparian zones for wildlife, fisheries, and recreation, and to reduce the impacts of other resource uses such as livestock grazing.

Platts has also documented conditions in the Great Basin and Intermountain Region where beavers have been detrimental to fish habitat. Streambank and channel erosion result when beaver dams built in streams with high flows and high sediment rates wash out. Long-term damage results from the combination of beavers cutting down mature trees, and cattle grazing and eliminating young vegetation. Platts says these detrimental effects can be reduced by proper management of both beavers and cattle. This means keeping beavers out of high-gradient, high-velocity streams, and watersheds where available vegetation does not meet their requirements for dam building.

To reverse the cycle of range degradation in western Wyoming, Wildlife Biologists with the Bureau of Land Management transplanted beavers and also provided cut aspen trees and other reinforcing material for their dams. In short order the beavers built a dam that backed up water and sediment. With stream rehabilitation and revegetation, the fish came back, as did the birds and small mammals. The livestock were better off. And so were the downstream human water users.



Researchers hauled in aspen for transplanted beavers to use in repairing a degraded watershed with no deciduous riparian vegetation. (Bruce Smith photo)

Vegetation studies next

The success of others in using beavers as a management tool on cattle ranges has prompted Sedell to expand his studies of beaver effects. He is now planning long-term, multi-disciplinary research east of the Cascades in Oregon that will include studies of vegetation. He says the next questions are what species of vegetation will best meet the needs of fish, wildlife, and cattle? And what kinds of quantities of vegetation can be produced? The new studies will be done in cooperation with Oregon State University's Sea Grant College Program and the School of Forestry and will include ranchers, forest managers, and fish biologists. Possible study sites are ranches along the John Day and Grand Ronde Rivers in eastern Oregon.

Meanwhile, back in coastal Oregon, studies to better understand the cycling of nutrients are continuing. Technicians are documenting the production of insects and invertebrates in riparian zones influenced by beaver dams. Trials of different species of willow are also planned; it appears that certain species are flexible enough to bend over streams, to shade them in summer, or to accumulate snow in winter and form protective tunnels over streams.

Sedell, the ecologist, combines a scientist's objectivity and curiosity with pragmatism. He thinks enough is known about beavers to put them back to work as partners in land stewardship. He thinks returning them to their historic role in conserving land, water, and vegetation offers the cheapest — and possibly the best — way to improve stream and riparian habitat. "Where else," he asks, "can you get an experienced worker to labor 7 days a week, without pay, on tasks that ultimately benefit entire ecosystem and all their residents?"

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Transpiration
and the forest
water balance

by Rick Fletcher
Rocky Mountain Station

As sunlight filters through the lodgepole pine forest, Merrill Kaufmann works atop a 20-foot tower checking one of his gas exchange chambers. The units, designed and built by him, are being used to measure transpiration rates of trees in subalpine forests.

Kaufmann, Principal Plant Physiologist at the Rocky Mountain Station, is in the midst of a 7-year study to help learn more about forest transpiration (loss of water through leaves or needles), and how it affects the overall water balance.

Throughout the Rockies, precipitation averages 25 inches per year. However, about half is lost to evapotranspiration, reducing the

amount of water available for streamflow. Most of this water is transpired back into the atmosphere through plant leaves.

Interest in transpiration dates back to 1910 when the Wagon Wheel Gap study was initiated in southwestern Colorado. There, the Forest Service undertook studies to learn if differences exist in the consumptive use of water by different types of vegetation. Although some important information was recorded, the limited technology available then restricted the data collected.

Recognizing the ever increasing demand for water in the western U.S., Kaufmann began a renewed effort, in 1978, that has resulted in a computer

Scientists used a helicopter, equipped with an infrared thermometer and video camera, to measure canopy temperatures in different parts of the watersheds





Here, a gas exchange chamber encloses a lodgepole pine branch.

model called RM-CWU (Rocky Mountain-Consumptive Water Use). This model, based on studies that took place on the Fraser Experimental Forest in central Colorado, estimates the annual canopy transpiration for Engelmann spruce, subalpine fir, lodgepole pine, and aspen forests in the Central Rockies.

Stomatal behavior, the plant mechanism for regulating transpiration, was studied intensively, using a series of eight gas exchange chambers. The chambers were placed on platforms on the north and south sides of tree crowns. Each chamber enclosed a branch and measured the water vapor lost throughout the transpiration season (April to October). Measurements were also taken hourly of light intensity, air and leaf temperatures, and humidity. A desktop computer, accompanied by a scanner and switching system, digital voltmeter, and a printer were used to operate the chambers, and collect and analyze the data.

Submodels used

The data were used to develop a series of submodels used in constructing RM-CWU. A stomate submodel provided the means by which transpiration was related to environmental factors such as sunlight and humidity. This new understanding of stomatal behavior guided the selection of measurements needed to estimate transpiration in forest stands.

Another submodel was required for estimating canopy temperature and humidity. In this study, a helicopter equipped with an infrared thermometer was used to collect canopy temperature data. These data were then used to develop a procedure for estimating environmental conditions of forest stands in watersheds.

Using these submodels, RM-CWU was developed and applied at the Fraser Experimental Forest. RM-CWU is a process model, meaning that it focuses on the actual physiological factors affecting transpiration. Because of this, it was possible to develop a model that operates at a much larger scale than used for collecting data on the stomate submodel. Tests of model predictions at the larger scale indicated a high level of accuracy of the transpiration estimate.

The findings

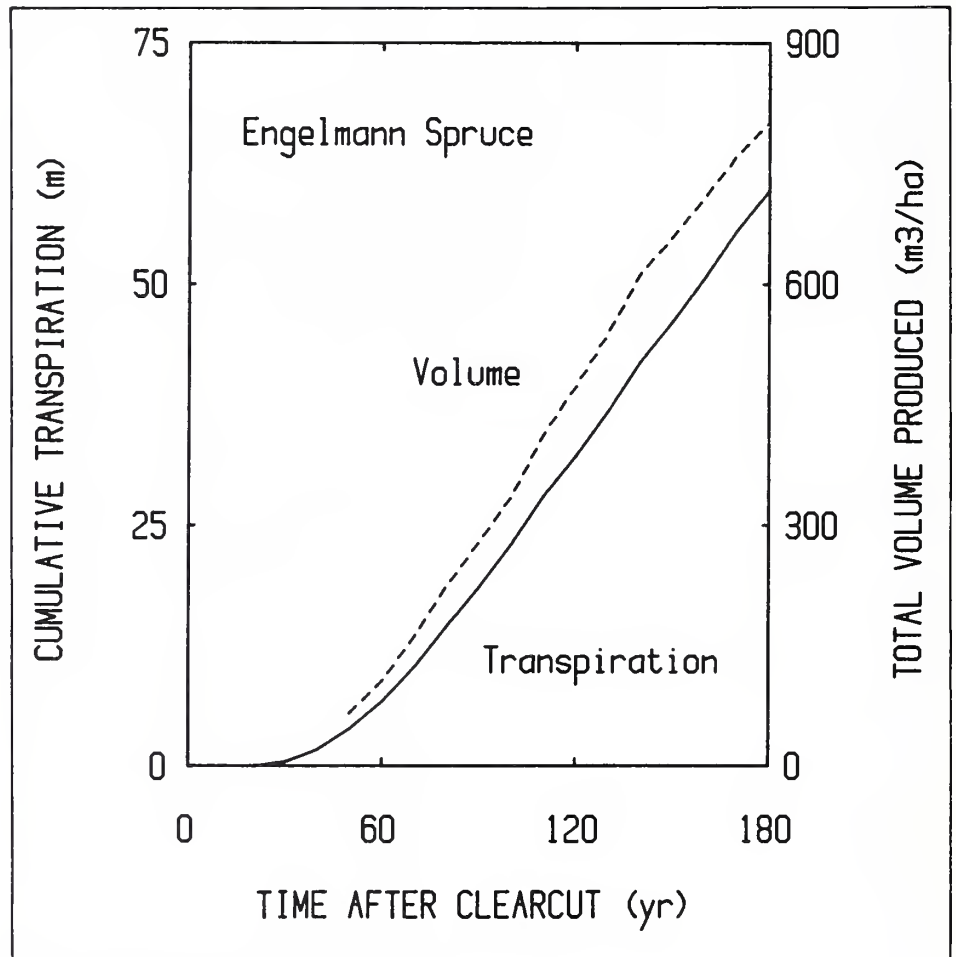
"Part of the results could be predicted," said Kaufmann. "For example, transpiration was higher for stands having higher basal areas, because the leaf transpiring area is directly related to stand basal area. However, I was somewhat surprised at the dramatic differences among tree species," he said. Kaufmann found that Engelmann spruce lost far more water than did the other species. Subalpine fir was second, while lodgepole pine had the lowest transpiration rate among the conifers. While none of the subunits contained aspen, RM-CWU was used to estimate transpiration as if the species occupied the same watersheds. Results showed that the transpiration rate for aspen was about half that of the lodgepole pine, and one third that of the Engelmann spruce.

So why the big difference? Kaufmann found that the dense foliage of spruce and fir had a larger leaf surface area, resulting in a high transpiration rate. Pine, with much less dense foliage and lower leaf surface area, had a lesser rate.

Less dense foliage also explains the transpiration rates for aspen, which does not have as much leaf surface area as the other three species. In addition, because aspen is deciduous, it has foliage for only part of the transpiration season.

"An interesting sidelight came out of this research," said Kaufmann. "Because aspen is often found growing on wet sites, many people believe that the species requires more water than conifers. Our studies indicate that this may not be the case in all situations. Many aspen sites appear to be wetter only because their transpiration rates are low and they

use less water. Consequently, understory vegetation is much more lush in many aspen stands, and probably transpires more water than in conifer stands. Despite this, Kaufmann feels that water loss in the aspen understory is much too low to offset the differences in annual transpiration between aspen and conifer stands.



Using RM-CWU, Kaufmann calculated transpiration for a managed stand of Engelmann spruce following clearcutting.



Much of the research was conducted on the East St. Louis Creek Watershed, Fraser

Experimental Forest.

From his studies, Kaufmann concludes that annual transpiration differs greatly among subalpine tree species. Results suggest that considerable potential exists for influencing long-term water yield by manipulating the composition and density of watershed forests (providing that other factors do not offset the differences in transpiration among the tree species).

"These study results indicate that lodgepole pine watersheds of less than 120 years of age can yield more water than those of spruce-fir, without sacrificing volume production," said Kaufmann. (While annual growth of Engelmann spruce exceeds that of lodgepole pine, volume production is actually less up to 120 years).

Forest transpiration is a major factor affecting mass water balance in subalpine watersheds. These findings should help resource specialists select forest management practices that will augment water yield.

Publications available

If you'd like more information on these studies, write the Rocky Mountain Station and request the reprints, all authored by Merrill R. Kaufmann:

1. *Modelling Transpiration of Subalpine Trees in the Central Rocky Mountains;*
2. *Simulation of Annual Transpiration in Subalpine Forests: Large Differences Among Four Tree Species;*
3. *Species Differences in Stomatal Behavior, Transpiration, and Water Use Efficiency in Subalpine Forests;* and
4. *A Canopy Model (RM-CWU) for Determining Transpiration of Subalpine Forests. I. Model Development, II. Consumptive Water Use in Two Watersheds.*



A computer system was set up on site and used to control the chambers and collect and analyze data.

Wildlife research: separating fact from fiction //

by Mike Prouty
Intermountain Station

An eerie whistle, somewhere between a steamboat calliope and a parade ground bugle, breaks the predawn silence of a mist-shrouded mountain lake, startling a loon into flight from its shoreline retreat. A fainter bugle answers from some forgotten forest valley, echoing away into the endless, forbidding wilds. Huge creatures flit in and out of the deep forest gloom like mysterious shadows.

Perhaps more than any other animal, Rocky Mountain elk have epitomized the majesty and mystery of wild lands in the western United States. To Indian tribes, the "Wapiti" was a mystical, almost sacred animal. These first Americans recognized the power and grace of this animal, and stories about it are deeply intertwined in their legends.

ELK: Is what's best for man best for this animal?

But in this age of widescale utilization of natural resources, and of intensive timber management practices of road-building and clearcutting, and aggressive forest fire suppression, can the elk's noble image survive? Indeed, is the image even accurate? Simply stated, are elk and modern man compatible?

Forest Service Scientist L. Jack Lyon has devoted much of his career to studying elk. The information resulting from his research has shed some light on the habits of this animal, and helped provide an unbiased perspective to the controversy surrounding elk management.

Setting the stage

Lyon didn't begin his research career specifically studying elk, although his



early work laid the groundwork for future elk research. Soon after he arrived at the Intermountain Research Station's Forestry Sciences Laboratory in Missoula, Montana, in 1962, he drafted a research mission statement. Through both basic and applied research, Lyon sought ways to help managers ensure that when the Forest Service manipulated forest vegetation through its multiple-use practices, it would produce positive results for wildlife. He wanted to develop management prescriptions that allowed increases in desired wildlife species through habitat manipulation.

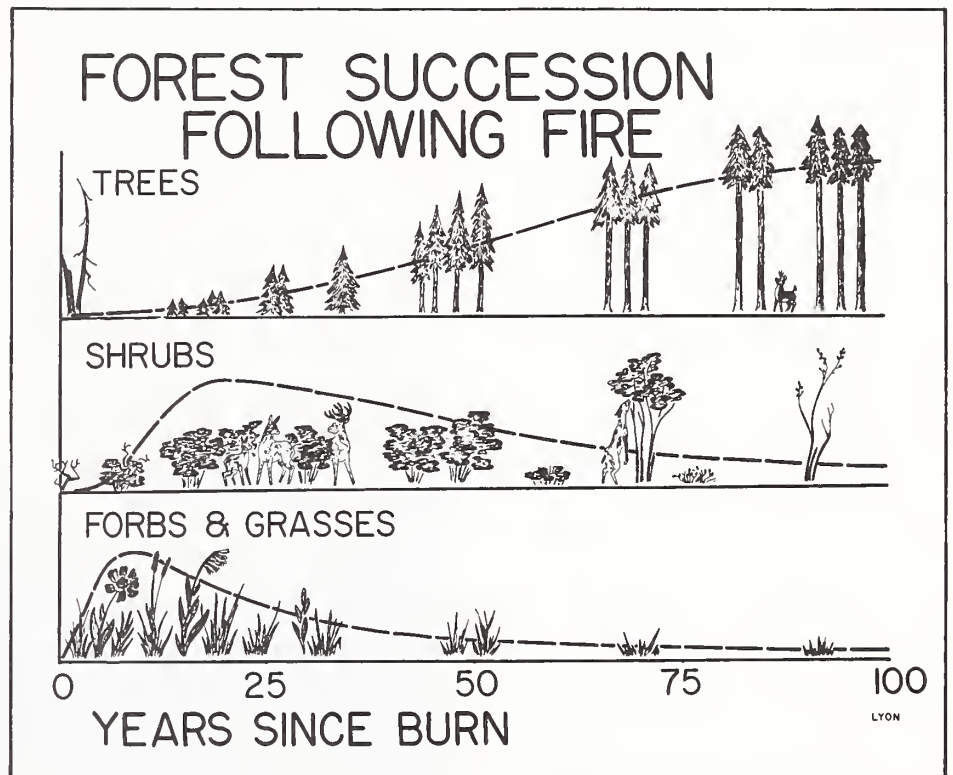
As a first step, Lyon and Plant Ecologist Peter Stickney developed a model to describe how they thought changes in vegetation over time were affecting wildlife habitat in general.

Wildfire and wildlife

Vegetation change existed in the West long before modern human activity occurred. Millions of acres in the West were periodically ravaged by wildfire. Over 2-1/2 million acres burned in 1910. Another 1-1/2 million acres burned in 1919. These conflagrations reduced vast expanses of timberland to ashes, but they also renewed an age-old cycle in which forest plant communities redevelop from the ashes to forbs and grasses, to shrubs, and eventually to trees.

How does this relate to wildlife?

According to the model, the effect of large wildfires created ideal habitat for many wildlife species. The model (see figure 1) projected that as trees mature they shade out and cause a decline of grasses, shrubs, and forbs. As the diversity of plant species declines, so does the diversity of animals that forage, nest, and hide in these shrub, forb, and young forest communities.



Using this postfire forest succession model and knowing the habitat requirements of any wildlife species, a land manager could visualize how well the successional stage of his resource area met the habitat needs of any wildlife species.

The model projected a disturbing trend for elk and deer. With the beginning of an aggressive fire control program in the 1940's, the number and severity of wildfires diminished. And as the young trees that grew after the fires in the early 1900's reached maturity, the abundant forage resource and resulting high numbers of big game began to decline.

Figure 1: Postfire Succession Model.

Lyon recognized that several factors tended to cloud and complicate the projects of the model. There are, for example, very few wildlife species for which a single stage of forest development is adequate habitat. Good elk habitat is a mixture of tree stands and open meadows, blue grouse require open grassy areas and clumps of young trees, warblers nest in shrubs while thrushes nest in dense forests. In short, the homogenous habitat units created by wildfire are not really as good as the model tends to suggest. However, intensive timber harvest activities and subsequent slash burns would also convert vegetation to early successional stages, simulating the effect of wildfire. And, unlike wildfire, timber harvest and broadcast burning can be managed and controlled.

Timing and location of harvest units can be planned to provide the right mix of vegetation to satisfy forage and cover habitat requirements of animals, so Lyon believed managers had the means to manipulate habitat quality.

Yet up to this point, the successional model and its implications to management were only theoretical. How could the model be tested as a predictive tool? Opportunity came, when in the summer of 1961 the Sleeping Child Fire burned over 26,000 acres on the Bitterroot National Forest. Then again in 1967 the Sundance Fire burned 56,000 acres on the Kaniksu Forest. Lyon and Stickney established permanent sampling points on transects across these burned areas, and began to record how species composition, species dominance, production potential, canopy cover, and ground cover changed over time. This long-term analysis has provided baseline information on successional patterns of vegetation and how it affects wildlife diversity and numbers. In addition to these "control" data, Lyon and Stickney have also monitored vegetation changes on over 60 timber harvest areas that were clearcut and burned.

Data from both wildfire and timber harvest areas have confirmed the post-fire succession model, but this hasn't necessarily made absolute predictions any easier. Rates of change, from forbs and grasses to shrubs to trees, vary greatly depending primarily on the species present before the fire. Dominance in the post-fire forest community is generally determined by growth rates of surviving plants rather than replacement by new species. Most important, however, it is beginning to appear that development following logging and development following wildfire are, in fact, quite similar.

Moving from the general to the specific

Although Lyon's research to this point could have been related to any wildlife species, resource managers seemed most concerned about how their activities were affecting deer and elk. The vegetation succession model, supported by years of field data, gave managers a way to predict the effects on wildlife of their management activities. Timber sale planners could visualize and quantify the implications of their actions regarding the wildlife

resource, and there was positive evidence that big game habitat could be improved through timber cutting.

But this research information was only part of the story. While timber harvest, and the increased forage production in early seral plant communities, represented potentially productive habitat, there was mounting evidence that even productive habitat was not always utilized by the animals it was expected to benefit. As more roads were built, the utility of the habitat created by timber harvest seemed actually to be decreasing.



Browse areas, as in this winter range, will gradually become less productive as trees mature.

Research born in controversy

Just as political, social, and biological climates change, so does the mission of research. In the Rocky Mountains before the 1960's, big game populations were expanding, access to forests was poor, and hunter numbers were low. The biggest problem facing State game managers was how to increase the number of animals harvested. Forest Service road construction and timber sales were viewed positively, for they, increased access and facilitated increased harvest of animals.

But as vast acreages of western timberlands matured into climax or near-climax forests in the absence of periodic, severe wildfire in the late 1960's and 1970's, the situation changed. Herds were not increasing as quickly as in the past. Increased logging and road construction had opened vast areas of forest land to anyone with a two-wheel drive pickup and a tank of gas. And increased interest in hunting translated into increases in hunters. State game departments wanted to maintain herds at high levels, but could only do so by shortening hunting seasons and restricting access. The environmental movement in the 60's brought another factor into the picture. Aside from Forest Service timber sales providing too much access for hunters, clearcuts became socially offensive to a very vocal part of the population.

Suddenly State game departments and environmentalists butted heads with the Forest Service over the issue of clearcuts. State agencies urged fewer clearcuts and fewer roads, yet the Forest Service had national timber harvest targets. Like many

controversies, when the smoke and heat of emotions cleared there was an abysmal lack of hard information. How did elk react to roads? How well did elk utilize clearcuts? What was the optimal clearcut size from a wildlife forage perspective?

As a result of this controversy, the mission of the Intermountain Station's forest wildlife habitat research changed. Studies relating forest management practices to changing vegetation succession to changes in general wildlife habitat did not satisfy the need to know how a very few activities associated with timber harvest affect a single species — Rocky Mountain elk.

Cool heads prevail

In 1970 the controversy over logging and its effect on elk peaked. Biologists from the Montana Department of Fish, Wildlife, and Parks (FWP) protested a proposed Forest Service timber sale on the Lost Fork of the Judith River (Lewis and Clark National Forest, Montana), citing expected adverse impact on the local elk herd.

As a result, a meeting was held to discuss the sale and the possibility for cooperative research to study the influence of logging on elk. Almost 30 individuals, representing the Montana FWP, Region 1 and the Intermountain Research Station of the U.S. Forest Service, and the University of Montana's Forestry School met to develop a solution to the problem. The group decided two things, first that the issue of elk and logging greatly exceeded in scope the immediate area of the contested timber sale, and second, all the agencies at the meeting were interested in developing a cooperative research program to resolve the problem. Less than 4 months later, a cooperative research agreement was signed by all agencies. Within a year the Bureau of

Land Management became a full partner, and before the study was completed Plum Creek Lumber Company was also a participant.

A model organization

Cooperative research is not new. But the Montana Elk-Logging Study was unique in several ways. The Cooperative Agreement provided an umbrella research framework for six different organizations. The study was extraordinarily successful in analyzing a significant and controversial resource problem, conducting the necessary research, and translating results into management recommendations.

The structure of the Montana Cooperative Study was responsible in part for the success of the program. A steering committee and a research committee were established. The steering committee was comprised of agency administrators who devoted their energies to program direction and review, and coordination of funding. The research committee was composed of scientists who developed a comprehensive research program, prepared individual study plans, and standardized methods and terminology to increase the credibility and usefulness of program results.

Most important, the structure allowed scientists to do research by keeping the administrative work with administrators. The program also successfully translated the emotional issue of elk and timber management into a pragmatic research problem. Scientists from agencies and organizations with sometimes opposite management missions worked together to find answers to a common problem.

Different views of the problem

Thus began 15 years of cooperative elk research. Each agency pursued individual studies that when combined provided a vast amount of information about elk under a variety of conditions. There were studies of clearcuts, and logging slash and roads, and studies of elk behavior, movements, and response to road closures. The most involved and complicated research involved four different views of elk response to timber sales under different combinations of location and road management.

The University of Montana study in the Sapphire Mountains investigated elk response to a new timber sale in an area with existing roads and old cutting units.

Montana FWP personnel studied the response of elk on the Beaverhead National Forest to a timber sale in a previously unroaded drainage, where the new timber sale road was closed to the public during and after the sale.

Lyon's research work unit studied elk response to a new road and sale in Deer Creek, an area with no previous development. Unlike the Montana FWP study, the road was left open to the public during the logging and closed afterward.

The Bureau of Land Management study in the Garnet Mountains provided information from an unusual set of circumstances. Researchers tracked the movement and behavior of elk in an unroaded drainage for 5 years. Then a road was built, but no associated logging or general traffic was allowed for 1 year. The activities of elk were monitored during this time. For the next 2 years logging occurred but no general traffic was allowed, and the response of elk to this activity was studied.

How were the elk followed in all these studies? A combination of research techniques allowed scientists to observe movement of animals in relation to known disturbances on a daily, seasonal, and yearly basis. In some studies researchers placed radio collars on elk to monitor movement. In other studies, pellets were counted along established transects. Other studies used a combination of these methods.

Getting facts out fast

Perhaps the most important feature of the Montana Elk-Logging Study was the emphasis on transfer of interim research results to the field. The normal research chronology is to develop a study plan, conduct research, analyze data, and finally, publish an article or report (after lengthy review) that documents and explains the study findings.

The Montana Cooperative Elk-Logging Study was an exception to this rule. The steering committee recognized that one important measure of research success is the degree to which research findings are translated into management action.

Thus, throughout the study, emphasis was placed on generalizing research information into management recommendations as quickly as possible. The annual report from the research committee to the steering committee became a vehicle for accomplishing this objective. Each year, copies of this report were widely distributed to managers. In addition, workshops explaining research findings and related management recommendations were presented to agency managers along with informational presentations to civic and community organizations.

Acceptance of the research information was aided by the decision to phrase all management recommendations in the context of "this action will produce this result," rather than the negative "don't do this" approach.

Debate laid to rest

Results and findings from the study are numerous, and provide managers with recommendations for a variety of situations. But the bottom line, contained in over 50 professional journal articles and research papers and 13 graduate theses during 15 years of work, is that elk and timber harvest are not mutually exclusive if carefully managed.

Before the Elk-Logging Study, those debating elk management fell into two camps. Some believed elk were a true wilderness species, intolerant of human activity. Others believed elk could not only exist, but could thrive alongside clearcuts and logging roads. Elk may be viewed as a symbol of pristine wilderness, but the Elk-Logging Study clearly showed that elk habitat is not restricted to such areas. Through careful management and planning, timber sales can increase elk habitat quality, and the negative effects of corresponding road construction can be minimized. The Montana Elk-Logging Study provides 11 specific recommendations to facilitate such planning and management.

Lyon played an integral role in the Cooperative Study — conducting research, serving on the Research Committee, and transferring research results to resource managers. His continual involvement in the Elk-Logging Study provided an important source of continuity as other scientists moved on and funding and active cooperators changed over the years.

But he notes that the most credit for making the program work probably should go to Gene Allen of the Montana FWP. Allen served as Research Committee Coordinator for the first 8 years before the Study had developed the reputation it eventually enjoyed.

Over the years, research findings were often not what managers and interest groups wanted to hear, but they were accepted as a result of respect for the quality and integrity of the program. This is an important attribute, because it enabled the resolution of an emotional resource issued based on facts, and kept this issue out of the courts.

To what does he attribute the degree of trust and respect accorded this research? "Integrity," says Jack. "In any problem involving wildlife, there's a lot of emotion and folklore. Research must remain totally objective. If I'm going to do wildlife research, I want to do it right. I try to investigate problems that are significant to managers, and I don't pretend to know anything I really don't."

New directions

With the recent publication of *Coordinating Elk and Timber Management, Final Report of the Montana Cooperative Elk-Logging Study 1970-1985*, another phase of wildlife research has drawn to a close at the Forestry Sciences Laboratory in Missoula.

Where to now? Lyon isn't quite sure.



He's initiating a study to answer a question that came up during the elk-logging research. On one study area, domestic cattle caused a change in the distribution of elk. So Lyon is beginning a study on elk-cattle relationships, but is not sure where it will take him or how long it will last. He believes the relationship between grazing and wildlife will become more important in the future, especially where grazing is emphasized as a commodity in National Forest Plans.

Permanent transects are used to sample changes in vegetation over time, and elk habitat use.

There are many other controversial issues in habitat management for wildlife that required hard-nosed credible research. Management biologists need good information about wildlife in old growth and riparian habitats. Lyon sees research helping develop ways to monitor wildlife resources as the Forest Service is legislatively mandated to do. There is also considerable interest in the specific habitat requirements of grizzly bears and caribou, and of deer and moose and of nearly 500 other wildlife species found in the forests of the Northern Rockies. Management of big game winter ranges, development and testing of habitat models — the list of wildlife problems is almost endless.

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A brief overview
of the Pacific
Southwest
Station

by John McDonald
Pacific Southwest Station



Extracting pollen from trees in the arboretum at the Institute of Forest Genetics, Placerville, California.

Scientists of the Pacific Southwest Forest and Range Experiment Station conduct research in forestry and forest-related sciences in California, Hawaii, and the Western Pacific. Established in 1926, the Station is one of a network of eight Experiment Stations, and the Forest Products Laboratory, maintained in the United States and Puerto Rico by the Forest Service, U.S. Department of Agriculture.

Researchers work in scientific teams known as Research Work Units. The Station has 20 such teams, specializing in research in such areas as timber management, silviculture, and forest genetics; control of forest insects and diseases; and wildfire management and related fire sciences. Forest fire economics; management of watersheds, range, and wildlife; and landscape and urban forestry are also included.

These research teams are located at the Station headquarters in Berkeley, California and at five other locations: four in California — Arcata, Fresno, Redding, Riverside; and one in Hawaii — Honolulu, with field units at Hilo and Yap.

Results of the Station's research have application not only in California and Hawaii but also throughout the Nation. Research in forest genetics, including pioneering studies in the use of starch gel electrophoresis to measure genetic variation in forest trees, is of not only national but international import. And current work in fire economics on development of mathematical models will help land managers to prepare economic analyses of fire management programs on Federal, State, and private forest lands throughout the United States.

For administrative purposes, the Station's research program is directed as Research in Northern California, and Research in Southern California and Hawaii.

Research in northern California

Seven research units in Berkeley are studying forest genetics, hydrology of the snow zone in the Sierra Nevada, forest disease pests, biology and control of forest insects, technology for management of insects, pest impact assessment, and landscape and urban forestry. A Pioneering Research Unit on hybridization of forest trees, and the Management Sciences Staff (MaSS) are also located in Berkeley.

In addition to the previously cited research, the forest genetics unit is one of three Forest Service research

groups now studying the application of DNA technology to the genetics and genetic engineering of conifers. The unit has also made significant headway in determining the genetic mechanisms that enable sugar pines to resist white pine blister rust and western yellow pine to be resistant to western gall rust. Work on seed source trials of pine and fir and on improved forest nursery practices has contributed significantly to tree improvement programs. Working within guidelines developed for "lifting windows" — the period within which seedlings from a particular seed source can be safely lifted and stored in the nursery — Forest Service nurseries can produce Douglas-fir seedlings with survival rates of 90 to 99 percent in the first year.

Seedbeds and greenhouses at the Institute of Forest Genetics are used by scientists of several research units in Berkeley.



The emphasis on research by the snow zone hydrology unit is on developing better methods for predicting how much water is in the Sierra Nevada snowpack and when the water will be available. The unit has also developed techniques to predict more accurately the water-holding capacity of the snowpack, and the changes that occur in the moisture content of snow zone soils. Data collected by Station scientists at the Central Sierra Snow Laboratory, near Soda Springs, California, are used by reservoir managers and by all of the major suppliers of water and hydroelectric power in California. The unit's scientists, in cooperation with Station scientists in Riverside, are now increasing their emphasis on research on acid rain.

Current emphasis on forest disease research is to develop integrated pest management systems to reduce losses caused by root diseases in forest nursery seedlings, and to develop methods for predicting potential losses from root diseases in young stands. The research unit is also developing information that could lead to the control of the mistletoes that parasitize conifers throughout the West.

The two research units concentrating on biology, control, and management of forest insects have made significant contributions to the westwide program for control of the devastating Douglas-fir tussock moth and to the joint U.S./Canada effort to control the western spruce budworm.

The landscape and urban forestry unit is working to provide more cost-effective techniques for predicting the effects of land management activities on visual aesthetics of forest landscapes and to develop procedures for reducing the costs of managing urban forests.



Horticulturist Philip A. Barker, urban forestry research, checks damage to sidewalk by roots of improperly planted trees.



Research Forester Robert F. Powers, left, and Technician R.A. Cole (deceased) collect soil-solution samples in a thinned and fertilized

stand of ponderosa pine on the Challenge Experiment Forest. The research unit is located in Redding, California.

The two research units at Redding have closely integrated programs, with one concentrating on the regeneration and maintenance of California conifer types, and the other concentrating on growth and yield of those valuable forests. Long-term studies on assessment of the impact of competitive brush on timber growth have produced guidelines for optimum tree densities and brush control strategies that will markedly increase the productivity of ponderosa pine and Douglas-fir on a variety of sites in northern California.

At the Redwood Sciences Laboratory in Arcata, one research unit is concentrating on the management of Pacific Coastal forests on unstable lands, and the second is concentrating on the relationships between timber management practices and wildlife interactions, particularly in old-growth habitat.

The unit concerned with unstable lands has developed guidelines for predicting and monitoring the effects of logging, roadbuilding, and other forest management activities on soil stability and nonpoint source pollution. A major objective is to find ways that these highly productive forests can be managed without impairing slope stability and water quality. Scientists in the unit are also developing guidelines to appraise landslide risk based on an inventory of geologic, climatic, and forest conditions in northwestern California. The results of their research on the contribution of tree roots to soil strength have evoked international interest.



Two research units are located at the Redwood Sciences Laboratory, Humboldt State University campus Arcata, California. One is concerned with management of Pacific Coastal forests on

unstable lands and the other is concerned with timber management/wildlife interactions in northern California and southwestern Oregon.



Researchers at Riverside, California are working to develop better information on fire-behavior prediction that can be used for prescribed burning guides for specific sites in chaparral and related vegetation.

The second research unit is working to develop knowledge on the effects that timber management activities have on plant and animal communities and their habitat. Scientists in the unit are active participants in the Forest Service's Westwide Old-Growth Forest/Wildlife Habitat Research and Development Program.

Research in southern California

Research units in southern California are located in the Forestry Sciences Laboratory, Fresno, and at the Forest Fire Laboratory — one of three such laboratories in the United States — at Riverside.

Two research units are located in Fresno. One is concentrating on range management research, and the other on monitoring wildlife populations.

The range research is aimed at developing ways to determine the timber-range relationships in forests of the west-side Sierra Nevada; the development of guidelines for maintenance of mountain meadows; and the competitive interactions between cattle and deer in the Sierra Nevada. Recent experiments have shown that continuous yearlong grazing has considerable advantages over seasonal grazing, producing increased weight gains in both cows and calves.

The wildlife unit is working to develop safer methods for sampling and monitoring wildlife populations. Some of its current research involves "voiceprinting" bald eagles and peregrine falcons so that their movement and nesting habitats can be studied with minimal disturbance to the birds.

The unit is also developing procedures for monitoring bird populations by the guild concept. The National Forest Management Act requires that all wildlife on National Forests be monitored to assure that no additional species are endangered by forest management activities. Attempting to meet this requirement by classical methods of sampling wildlife populations is prohibitively expensive. So, the Station scientists are using a new approach — inventorying everything in a wildlife guild — as a more efficient and less costly way of evaluating wildlife and wildlife habitat. The concepts are now being tested on National Forests.

Four research units are located at the Forest Fire Laboratory in Riverside. They are concerned with the ecology of chaparral and associated ecosystems; meteorology for forest and brushland management; fire-management planning and economics; and prescribed burning in chaparral and related ecosystems.

Major objectives in research on the ecology of chaparral are to develop an understanding of erosion processes to minimize the hydrologic impacts of land treatments; to determine the dynamics of nitrogen in the chaparral ecosystem; and to determine the processes of deposition and transfer of air pollutants, including acid rain; and to develop an understanding of the ecology of oak woodlands. Using stable isotope tracer techniques, the unit scientists have conclusively demonstrated that nitrifiers can denitrify, and that the nitrification process involves the oxidation of relatively immobile ammonium to highly mobile nitrite and nitrate. The products can leach from soil, causing significant losses in nitrogen and creating water-quality problems.

In other work, scientists sampled vegetation and estimated the hydrocarbons emitted in the Los Angeles Basin. They found that less than 10 percent of the photochemically formed ozone in the Los Angeles Basin can be traced to monoterpene and isoprene emissions from foliage. The results of this research were made available immediately to State and local air pollution authorities.

The meteorologic research is aimed at developing techniques for using meteorological information in predicting fire behavior, determining fire effects, and maintaining air quality. The unit has installed a network of telemetering weather stations that has been used as a model by State agencies for similar installations.

The fire economics research unit is developing FEES (Fire Economics Evaluation System) — a model that will screen budgets and options for fuel treatment, initial attack, aviation operations, and large fire suppression; evaluate the economic efficiency of each option; estimate program performance; and predict potential fire-related changes in natural resource outputs. FEES is now being evaluated and pilot-tested on National Forests and by other Federal and State agencies.

The research unit on prescribed burning has developed guidelines for prescription burning that have been adapted by National Forests in southern California and that have provided a sound technological base for a continuing, multi-million dollar program on prescribed burning recently begun by the California Department of Forestry on both State lands — and cooperatively — on private lands in southern California.



Research in Hawaii

The two research teams in Hawaii work closely with the State's Department of Lands and Natural Resources, Division of Forestry and Wildlife, other State and Federal Agencies, with the University of Hawaii, and with private industry and associations.

The Forest Management Research Unit is working to acquire information on and to develop techniques for reforestation with koa, to determine productivity of biomass in relation to site, and to develop biological controls for noxious weeds.

The second unit is concerned with forestry research in the American Pacific Islands. It has studies established to assess the forest

PSW researchers are assessing the forest resources of the American Pacific Islands.

resource and produce an accurate date base for use in planning land management options, and to enhance forest productivity in the American Pacific Islands.

Station administration

Station administrators are: Roger R. Bay, Station Director; Benjamin Spada, Deputy Station Director; Enoch F. Bell, Assistant Director for Research in Southern California and Hawaii; Ronald E. Stewart, Assistant Director for Research in Northern California; Richard L. Hubbard, Assistant Director for Planning and Application; and Neal B. Smith, Assistant Director for Research Support Services.

The Station's mailing address is: P.O. Box 245, 1960 Addison Street, Berkeley, California 94701. Phone: Director's Office — (415) 486-3292, FTS 449-3292.

New publications

Lumber yield from ponderosa pine

Two reports from the Pacific Northwest Station provide up-dated information on lumber yield from ponderosa pine in South Dakota and California. The last studies on this species in these locations were reported about 20 years ago. The information is likely to be of interest to timber owners, mill managers, loggers, lumber manufacturers, forest administrators and others responsible for making decisions about log allocations and processing, mill design, and timber appraisals.

In California utilization of young growth has increased, and more dimension grades of lumber are being produced. Of the lumber produced in this study, 58 percent was Shop, Moulding, and Select grades, and 24 percent was Standard and Better Dimension. Overrun was estimated separately for old growth and young growth; cubic recovery percent was estimated for all the logs combined. Lumber grade recovery and log value varied by diameter and log grade, except for the grade 1 and grade 2 logs. The study was based on 150 old-growth trees and 60 young-growth trees from the Plumas and Tahoe National Forests.

In South Dakota, the study objective was to determine the lumber volume, value, and grade from sawtimber. About 400 trees from two areas of the Black Hills National Forest were selected to represent diameter classes from 5 to 23 inches. All logs were sawn into 1-inch thick lumber at two sawmills. The data were combined to present overall volume and value recovery relationships for mill-length logs only. Overrun decreased from 151 percent for 5-inch logs to 108 percent for 19-inch logs. Over half the lumber volume recovered was graded No. 3 Common.

Both reports include tables and figures that provide detailed information about board foot and cubic foot volume relationships, lumber grade recovery, and log value. Equations for predicting lumber volume recovery, lumber grade distribution, and value are given, as well as examples of how to estimate recovery of lumber volume and value of logs.

For copies of these reports write to the Pacific Northwest Station: *Lumber Recovery from Ponderosa Pine in the Black Hills, South Dakota*, by Marlin E. Plank, Research Paper PNW-328, and *Lumber Recovery from Ponderosa Pine in Northern California*, by Susan Ernst and W.Y. Pong, Research Paper PNW-333.

Water quality questioned in man-made impoundments

Scientists at the Rocky Mountain Station have just completed a study in water quality in surface mine impoundments.

Mining activity in the Northern High Plains left depressions that have filled with water, and many are being used as livestock watering ponds. Their use represents a real benefit for livestock owners. However, researchers have found that the water in some of these ponds may not be safe because of high concentrations of lead, sulfate, and total dissolved solids.

While they point out that the majority of those studied were deemed safe, these findings indicate a need to test the water prior to use.

Details are available in the reprint *Quality of Water for Livestock in Man-made Impoundments in the Northern High Plains*, available from the Rocky Mountain Station.

Mountain pine beetle guidelines in lodgepole pine

The mountain pine beetle has destroyed an estimated 2 billion board feet of timber each year since 1975. The insect preys most heavily upon lodgepole pine forests of western North America. Forest managers are faced with the challenge of controlling this pest while considering other resources in managing lodgepole pine.

A new report from the Intermountain Research Station offers managers guidelines for suppressing beetle populations in lodgepole stands while considering soil, water, wildlife, timber, and visual resources. Mountain Pine Beetle Guidelines In Lodgepole Pine

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A new report from the Intermountain Research Station offers managers guidelines for suppressing beetle populations in lodgepole stands while considering soil, water, wildlife, timber, and visual resources.

Mark D. McGregor and Dennis M. Cole have collected and summarized state-of-the-art information relating to beetle ecology, host characteristics of lodgepole pine, assessing a stand's risk of attack, and the effect of beetle outbreaks on a variety of ecosystems and forest resources. The resulting guidelines offered in this publication represent an important tool for integrating management of mountain pine beetle populations with multiple resource management.

Request *Integrating Management Strategies for the Mountain Pine Beetle with Multiple-Resource Management of Lodgepole Pine Forests*, General Technical Report INT-174.

Estimating weight from tree crown sections

Estimating the weight of sections of the crowns of large old-growth Douglas-fir and western hemlock trees is now possible, using equations and ratios developed at the Pacific Northwest Station. Previous models only predicted weight of total crowns. Predictions for segments of tree crowns are needed because the amount of crown that remains on logs after trees are felled and bucked varies and because accurate weight estimates are basic to the efficient, effective, and economical operation of airborne and cable logging systems.

Three different approaches were tested for modeling weight of crown segments: a branch method, a ratio method, and a bole section method. The branch method proved less biased and more accurate. It also more easily accommodated the large amount of breakage in crowns of felled old-growth trees.

Equations were based on data from 32 Douglas-fir and 29 western hemlock trees on the Gifford Pinchot National Forest in southwestern Washington. The models were validated by data collected from 49 Douglas-firs and 50 western hemlocks under conditions similar to logging operations.

Although the models were based on limited sampling, the authors believe that results are generally applicable to trees similar in age and size, and grown under similar conditions in the area where data were collected.

Instructions on how to use the models, a description of their development, and advantages and disadvantages of each method are provided in *Estimating the Weight of Crown Segments for Old-Growth Douglas-Fir and Western Hemlock*, by J.A. Kendall Snell and Timothy A. Max, Research Paper PNW-329. Copies are available from the Pacific Northwest Station.

Fire management planning

Fire management planning and fire economics are the general themes of four new publications issued by the Pacific Southwest Station. The four publications involve the use of models or simulation techniques to predict certain aspects of fire behavior and postfire value changes.

Risk in Fire Management Decisionmaking: Techniques and Criteria, General Technical Report, PSW-80, by Gail Blattenberger, William F. Hyde, and Thomas J. Mills presents a method for risk evaluation. Although the model design is admittedly incomplete, its use does make it feasible to make an analytical evaluation of the risks inherent in fire management alternatives.

Fuel Models to Predict Fire Behavior in Untreated Conifer Slash, Research Note PSW-370, by Lucy A. Salazar and Collin D. Bevins presents techniques that are applicable to long-term fire management planning models.

Estimating Postfire Changes in Production and Value of Northern Rocky Mountain-Intermountain Rangelands, Research Paper PSW-173, by David L. Petersen and Patrick J. Flowers presents a simulation model developed to estimate postfire changes in the production and value of grazing lands. The estimates calculated should be useful in land and fire management planning in the Northern Rocky Mountain-Intermountain area.

Changes in Fire Weather Distributions: Effects on Predicted Fire Behavior, Research Paper PSW-174, by Lucy A. Salazar and Larry S. Bradshaw, presents simulation techniques that should be appropriate for use in long-term fire management planning models.

Copies of the four publications are available from the Pacific Southwest Station.

Getting the most from wilderness trail registration stations

Wilderness managers need reliable data that accurately describe wilderness visitors and their patterns of use. Trail registration stations have the potential to provide such information, if a sufficiently high percentage of wilderness users voluntarily supply the requested information at such stations.

In a new report, Margaret E. Petersen, former research forester at the Intermountain Station's Forestry Sciences Laboratory in Missoula, Montana, evaluates factors that influence trail registration compliance. Based on data gathered from an experiment with two different types of registration stations on trails in the Bob Marshall Wilderness, she concludes that location is the most important influence in improving registration rates. Moving the station from the trailhead up the trail dramatically increased the registration rate for both station designs. Sign wording also affected registration rates, especially with some types of visitors.

For more information, including criteria for selecting good station sites, ask for *Improving Voluntary Registration Through Location and Design of Trail Registration Stations*, Research Paper INT-336.

Research at Manitou summarized

In 1936, the Manitou Experimental Forest was established in central Colorado to study natural resource management in the Colorado ponderosa pine zone.

Its location is characteristic of the land area throughout Colorado's Front Range, making it ideally suited for studying:

- the impact of mountain homes and recreation developments on forest resources;
- revegetation of abandoned farmland;
- silviculture of ponderosa pine;
- Douglas-fir and mountain bunchgrass vegetation types;
- erosion control and stream improvement.

A new Rocky Mountain Station report summarizes selected studies conducted at Manitou between 1937 and 1983. It will help land managers, planners, and researchers evaluate the consequences of land management practices in the Colorado Front Range ponderosa pine zone.

Copies of *A Summary of Research at the Manitou Experimental Forest in Colorado, 1937-1983*, General Technical Report RM-116, are available from the Rocky Mountain Station.

Regeneration of Douglas-fir

The Pacific Southwest Station recently issued a General Technical Report that summarizes information about the regeneration of Douglas-fir in the Klamath Mountain Region of northwestern California and southwestern Oregon. The report includes information on research done in the adjacent Coast Ranges of the two States and on relevant studies done elsewhere.

The report covers all aspects of the planting process from seed production to care of young stands. General recommendations are given on seed production, site preparation, natural regeneration, direct seeding, planting, vegetative competition, and animal damage.

By drawing together the findings of many studies — some 175 references are cited — the report should serve as a convenient reference for the forest manager and other practitioners.

Copies of the report, *Regeneration of Douglas-fir in the Klamath Mountains Region, California and Oregon*, General Technical Report PSW-81, are available from the Pacific Southwest Station.

Below-cost timber sales not incompatible with forest management

Should the Forest Service offer below-cost timber sales? Although this is not a new question, recent major reports have criticized below-cost sales, and the issue has attracted additional attention in light of Federal budget deficit concerns.

A new report from the Intermountain Research Station establishes that Forest Service timber sales must be assessed in terms of how they fit into the comprehensive management of National Forests, as mandated by law. Simple comparisons of immediate revenues and costs for a specific sale ignores the role of a single sale in integrated land management objectives over time and space.

In their study, Research Foresters Ervin G. Schuster and J. Greg Jones found that below-cost sales and efficient forest management are not incompatible. In fact, they conclude that below-cost sales may sometimes be essential in the context of long-term production of multiple-use benefits from National Forests.

To obtain a copy of this report, request *Below-Cost Timber Sales: Analysis of a Forest Policy Issue*, General Technical Report INT-183.

Ponderosa pine can outgrow dwarf mistletoe

One of the problems that puzzles forest managers is what to do when all but the smallest trees in a multistory stand are infected with dwarf mistletoe. Because dwarf mistletoe usually responds to increased nutrition and space with accelerated growth — just as trees do — would clearcutting and replanting be best in the long run? Would harvesting the overstory eliminate the mistletoe or would latent infections develop in the understory and retard tree growth? Would thinning the understory saplings help?

The answers to these questions are now available in two reports from the Pacific Northwest Station. The reports are based on 20 years of observation in a thinned, mistletoe-infested stand of ponderosa pine in the Deschutes National Forest near Bend, Oregon. The overstory in the stand was removed and saplings thinned to 250 trees per acre in 1957; a second thinning (1971-1972) reduced trees to 90 per acre and was accompanied by removal of the understory vegetation on half the plots. One report describes stand response in terms of sapling growth; the other provides details on response of the dwarf mistletoe.

The results appear clear. The rate of height growth is a better indicator of future growth than the number of visible dwarf mistletoe plants. If infested saplings can grow 10 inches

or more per year, completing the rotation may be preferable to clearcutting, site preparation, and planting. Trees that maintain healthy upper crowns will continue to grow at an acceptable rate in spite of increased mistletoe in the lower crowns. It is important, however, that saplings be spaced far enough apart so they will grow in height faster than the mistletoe is able to move up in the crowns.

Study results show that good height and diameter growth can be maintained for several decades and that considerable dwarf mistletoe may be tolerated in a managed stand. Controlling understory vegetation augments the effects of thinning.

As for the dwarf mistletoe, its propagation was influenced little by thinning stands to 250 trees per acre. Numerous mistletoe plants developed from latent plants in the suppressed understory and appeared soon after thinning. The mistletoe propagated almost as fast as the tree crowns enlarged but at widely differing rates. The greatest increase was in the lower third of the crown. After tree height growth accelerated in the fifth or sixth year following thinning, proportionally fewer mistletoe plants established higher in the crowns. After 13 years, only 1 percent of all plants were in the upper third of crowns.

Two publications by James W. Barrett and Lewis F. Roth provide details: *Response of Dwarf Mistletoe-Infested Ponderosa Pine to Thinning: 1. Sapling Growth*, Research Paper PNW-330, and *Response of Dwarf Mistletoe-Infested Ponderosa Pine to Thinning: 2. Dwarf Mistletoe Propagation*, Research Paper PNW-331. Copies are available at the Pacific Northwest Station.

Montana succession classified

Successional plant communities will continue to occupy major portions of the forest landscape as a result of fire and logging. A new classification system helps managers predict and treat these important forest communities.

Stephen Arno and Dennis Simmerman of the Intermountain Research Station's Fire Sciences Laboratory, and Research Cooperator Robert Keane have developed classifications of successional community types arising after clearcutting and fire on four major habitat types in western Montana.

In order to facilitate field use of it, the classification system includes diagnostic keys to the community types. For more information request *Forest Succession on Four Habitat Types in Western Montana*, General Technical Report INT-177

To order any of the publications listed in this issue of *Forestry Research West*, use the order cards below. All cards require postage. Please remember to use your Zip Code on the return address.

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- A Summary of Research at the Manitou Experimental Forest in Colorado, 1937-1983, General Technical Report RM-116
- Quality of Water for Livestock in Man-made Impoundments in the Northern High Plains, a reprint
- Effects of Clearcutting a Subalpine Forest in Central Colorado on Wildlife Habitat, Research Paper RM-258
- Modelling Transpiration of Subalpine Trees in the Central Rocky Mountains, a reprint
- Simulation of Annual Transpiration in Subalpine Forests: Large Differences Among Four Tree Species, a reprint
- Species Differences in Stomatal Behavior, Transpiration, and Water Use Efficiency in Subalpine Forests, a reprint
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- Regeneration of Douglas-Fir in the Klamath Mountains Region, California and Oregon, General Technical Report PSW-81
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- Fuel Models to Predict Fire Behavior in Untreated Conifer Slash, Research Note PSW-370
- Estimating Postfire Changes in Production and Value of Northern Rocky Mountain-Intermountain Rangelands, Research Paper PSW-173
- Changes in Fire Weather Distributions: Effects on Predicted Fire Behavior, Research Paper PSW-174
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- Mycorrhiza Management in Bareroot Nurseries, a reprint
- Estimating the Weight of Crown Segments for Old Growth Douglas Fir and Western Hemlock, Research Paper PNW-329
- Lumber Recovery from Ponderosa Pine in the Black Hills, South Dakota, Research Paper PNW-328
- Lumber Recovery from Ponderosa Pine in Northern California, Research Paper PNW-333
- Response of Dwarf Mistletoe-Infested Ponderosa Pine to Thinning: 1. Sapling Growth, Research Paper PNW-330
- Response of Dwarf Mistletoe-Infested Ponderosa Pine to Thinning: 2. Dwarf Mistletoe Propagation, Research Paper PNW-331
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