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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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A new fire economics evaluation system is being developed at the Pacific Southwest Station. When completed, it will provide fire management planners with a thorough, accurate and honest estimate of the costs, risks and probable outcomes of proposed fire management plans. Details are on page 5.

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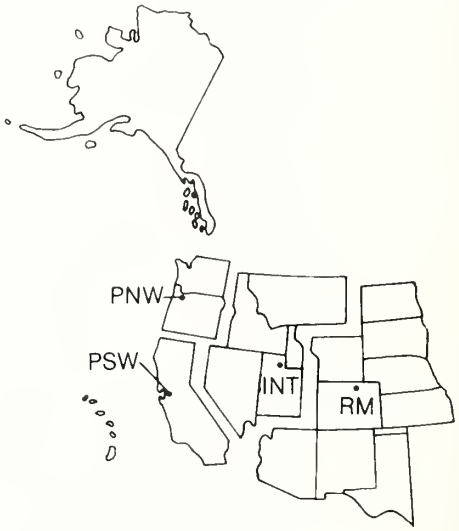
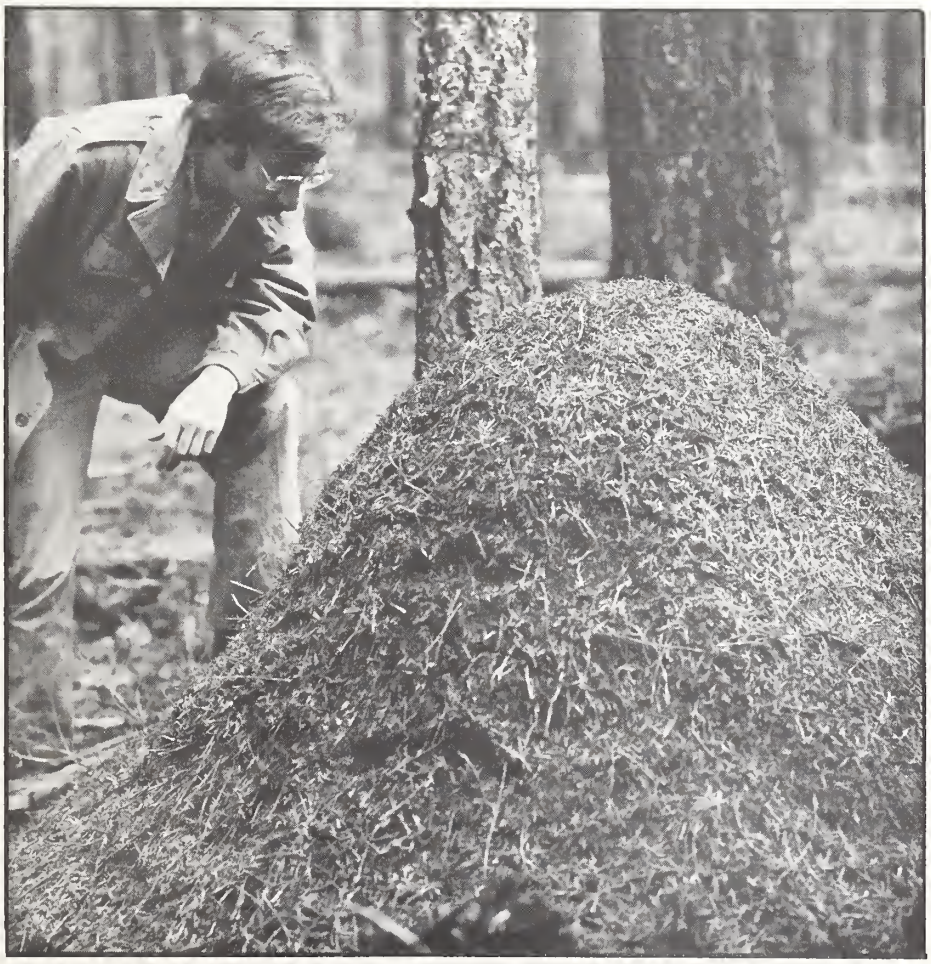


Ants and birds are major predators of western spruce budworm

by Samuel T. Frear
Pacific Northwest Station

When scientists set out to determine the role of birds in keeping populations of the western spruce budworm in check, they came up with an unexpected result: ants, also, are a major predator.

Entomologists Robert W. Campbell and Torolf Torgersen of the Pacific Northwest Station made that discovery in 1979. They had set up exclosures around branches of trees in Oregon and Washington to measure the predation of birds and were surprised to find that budworm pupae disappeared from both unprotected and protected branches. Something other than birds was consuming budworms, and they found evidence that it was ants.



This is a mature mound made by thatching ants of the kind that are predators of the Western spruce budworm.

"Up to that point we were just thinking about birds," Torgersen said. "It was pretty apparent, though, that ants also played a major role as budworm predators."

At the end of the 1979 field season, the two researchers decided they should look more closely at ants as predators and that they needed bigger exclosures to study the effects of both birds and ants.

Budworm is serious forest pest

The western spruce budworm is one of the most serious pests in the forests of North America. In the West it infests more than 5 million acres annually, and damages many different trees: Douglas-fir, true fir, Engelmann spruce, and western larch. Budworm caterpillars feed first on new buds and shoots, later moving on to consume needles. The crowns of trees can become thin and the trees heavily defoliated if the population gets large enough and persists for several years. The ultimate effects of the budworm on the forest are considerable growth losses and some tree mortality.

Integrated pest management is the major thrust of the Canada/U.S. Spruce Budworm Program-West, which funded Campbell's and Torgersen's work. One aspect of such a pest management philosophy is to seek natural ways to reduce budworm damage to trees. If the secrets to natural regulation of the budworm can be learned, the application of this knowledge could reduce dependance on pesticides. The objective is not only to control outbreaks when they occur, but to keep them from occurring in the first place.

Both Campbell and Torgersen are excited about their discoveries of the natural role of birds and ants in consuming budworms. "We are spotting a source of mortality that generally was ignored before," Torgersen said. "The disappearance of pupae, for example, was not noticed by some workers. Others said there was little mortality during this stage. But we found that up to 90 percent of the pupae disappears because of predation. Those numbers are amazing."

Torgersen and Campbell do not find it surprising that budworm predation has not been adequately measured in the past. Although others have suggested the possible role birds might play in predation, few have used exclosures to test the theory. Bird exclosures have seldom been developed because of problems relating to cost, weight, and portability. The two scientists decided to try their hands at designing and building a practical bird exclosure.

Single branch exclosures

They started with a single branch exclosure in the summer of 1979 in central Washington. The exclosure was constructed with plastic pipe, steel rods, garden mesh, and wire bag-ties and was held in place by a wooden support, baling wire guys, and stakes. These devices kept birds away successfully, yet when the researchers examined some of the protected branches, some of the budworms were gone. Suspecting that insects might be the unknown predators, they placed a sticky barrier around the bases of branches to keep walking insects from reaching the pupae.

Nearly all the pupae survived in single-branch exclosures 15 feet off the ground, but some of the pupae were gone from exclosures six feet from the ground. Ants were seen crawling on the trees and tumbling from branches. The scientists believe that ants fell from high branches into lower down cages, but not into higher cages because no branches overtopped these.

During the winter of 1979–80 the scientists worked on designing and building a whole tree exclosure that would help answer some questions arising from their single-branch experiments. In particular, they wanted to know if bird and ant predation was a local phenomenon. Was it related to budworm numbers? What was the pattern over a whole tree?

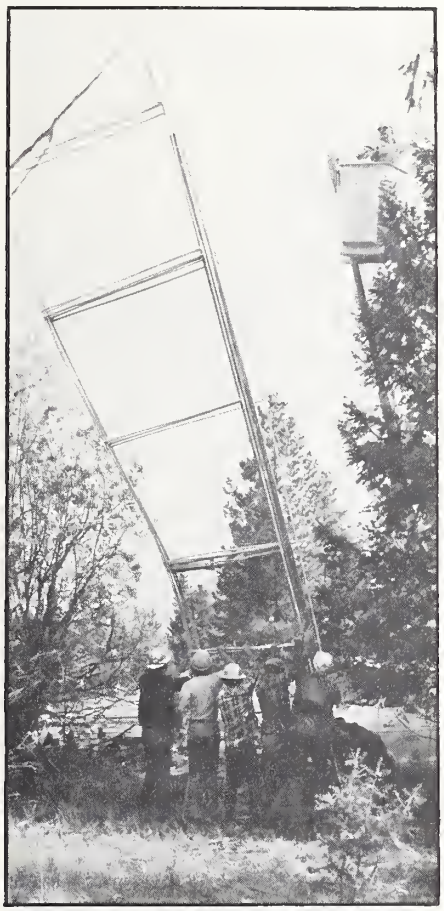
Learning how to construct a 30-foot cage to place around a tree was a trial and error effort. A 30-foot plastic pipe held upright will bend to the ground. To make it more rigid the scientists filled the pipe with sand. "It was like heavy spaghetti," Torgersen recalled. After much experimentation they discovered the right combination of plastic pipe, 2 x 4's, and guy wire.

Whole tree exclosure successful

After several sessions in the parking lot at the Forestry Sciences Laboratory in Corvallis, the scientists put the cage around a live tree on the lawn of the Oregon State University School of Forestry. (A woman passing by asked what they were doing. When they replied they were building a bird exclosure, she commented, "Now you're after birds, too.")

The octagonal exclosure consists of two four-sided sections, built of plastic pipe, wooden supports, and mesh, that fold like an accordian. They can easily be carried by 4 or 5 people. Two aerial ladders on trucks were used to erect the exclosures. It required good coordination between the aerial and ground crews to erect, spread, tie, and guy both of the four-side assemblies. A seven-person crew working with trucks can install four whole-tree exclosures per 8 hour day.

The final job in setting up a tree exclosure is to spread a net topping over the eight-sided structure.



With help from an aerial lift bucket, one of two four-sided assemblies is erected to surround a 30-foot tree.

Torgersen and Campbell believe they have successfully developed a practical tree exclosure that is durable, light, strong, portable, easy to construct, and not too expensive. They estimated that a whole tree exclosure in place costs about $425. In subsequent years this cost will drop because these exclosures can be used for several field seasons.

Their creations were trucked to a site near McCall, Idaho in the spring of 1980 and set up around 32 trees.

In addition to excluding birds with the net-covered exclosure, walking and crawling critters were discouraged by a wide band of sticky material smeared around the base of the tree. The size of the openings in the exclosure mesh is small enough to keep out birds but large enough to allow access to other natural enemies, including parasitic flies and wasps which lay their eggs in budworm larvae. The scientists also are studying how these other natural enemies affect budworm populations, but results so far show their effect to be negligible.

The exclosures were left up during the field season until the normal time of budworm dispersal in late summer. The tree then was dissected branch by branch; every fourth branch was removed and measured, and the pupae removed from it and counted. Thus, an estimate was obtained of the number of pupae per branch in any part of the tree.

Important research results obtained

This research effort paid off. Using the exclosures and sticky barriers, the scientists learned that in a 30-foot tree, birds tend to concentrate in the top one-third, while ants are dominant in the lower two-thirds. Only one of these two predators seems necessary to keep budworms down because when ants tend to lose effectiveness, birds seem to compensate. If you remove both predators, however, there can be spectacular results: budworm mortality without the predators drops to a fraction of that on the check trees.

Since birds and ants have such a dominant role in controlling budworm populations, it might be advantageous for forest managers to encourage them. Flocking species, such as the evening grosbeak, chipping sparrow, and darkeyed junko will concentrate on the budworm when it has a population surge. In other places, where there are no outbreaks, resident species of birds seem adequate for the predation job.

Possible management actions

There are possible management actions that might encourage birds. For example, maintaining several age classes of trees in stands encourages multiple levels of crown, and lush understory vegetation. Not much is known about ants, however. The ant colony, a long-lived organism, is easily damaged, and it may take 30 years for a new mound to develop. The scientists agree that much more information about ants is needed, such as their habitat requirements.

The best management posture may be: if you are not able to enhance bird and ant populations, be sure not to do things that will injure them. Some forest practices like pesticide use or clear-cutting may be detrimental. Thinnings or selective cuts may be advantageous.

Meanwhile, the research on ant and bird predation of the western spruce budworm will continue. In 1982, the exclosures will be set up in Oregon, Montana, New Mexico, and even New York and northern New England, where a closely related budworm occurs. In 1983, the research will be continued in New Mexico.

So far the scientists have worked in stands in Oregon, Washington, Idaho, and Montana with relatively low densities of budworm infestation. While not addressing the problem of what causes outbreaks, their research may provide clues as to what keeps the numbers of budworms low and the factors that regulate them at sparse densities. Their work will lead to the construction of life tables for the spruce budworm: the probability of survival of an individual over a generation, and what causes the demise of those that die.

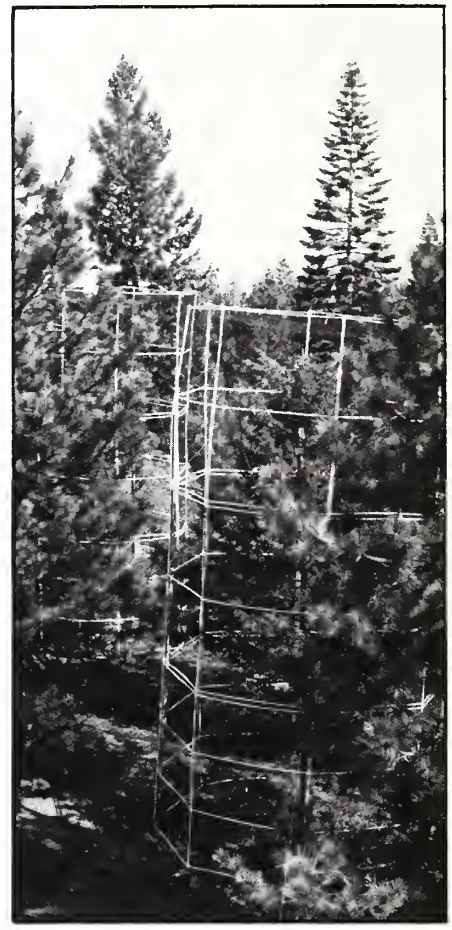
One objective of this research is to learn enough about the two primary predators so that silvicultural practices could be prescribed to encourage colonization or the highest possible densities in forests normally susceptible to the budworm.

For further reading

The following publications are available from the Pacific Northwest Station:

Campbell, Robert W. and Torgersen, Torolf R.; and others, 1981. *Bird exclosures for branches and whole trees.* USDA Forest Service General Technical Report PNW-125. Portland, Ore., Pacific Northwest Forest and Range Experiment Station.

Campbell, Robert W. and Torgersen, Torolf R., 1982. *Some effects of predaceous ants on western spruce budworm pupae in north central Washington.* Environmental Entomology 11(1).



Two completed whole-tree exclosures. These reusable assemblies cost approximately $425 each.

Is your fire management program "economically efficient"?

by Marcia Wood
Pacific Southwest Station

The setting: you work for the Fire Management Staff of a large National Forest. Part of your job is long-term planning: you estimate the kinds of wildfire problems your Forest may face and determine the presuppression budgets you'll need.

These presuppression budgets have to cover a variety of expenses, including those for preventing and detecting fires, and for fuel treatments (cleaning up logging leftovers and other forest debris that could fuel your next fire). The rest of the money goes for "initial attack" forces and for aviation operations. These funds pay for keeping crews, equipment and aircraft on stand-by and for sending them as your initial forces on fires.

Money for putting out fires that escape initial attack (what's referred to as "large fire suppression") comes from a different and separate "emergency" budget. Even though these suppression funds aren't part of your budget, they are a concern, because the way you design your programs for prevention, detection, fuel treatments, initial attack, and aviation may influence suppression costs.

Your decisions about how much money to allot to each area of your program are critical. A mistake in judgment on your part could mean your Forest will put its fire management money in the wrong place and won't get the best possible protection for the budgets you're given.

And, you're limited in spending. Cutbacks in Federal funding mean you're probably not going to get all the money you need.

Sound like a difficult job? It is. It's one that fire management planners on each National Forest face. What's more, their decisions are being challenged. People want to know what they're getting for the millions of dollars ($245 million last year) the National Forest System receives for regular and emergency fire management purposes. The fire management programs of other Federal agencies and of some State organizations as well are facing similar criticism.

Researchers concerned

"The time when Congress would hardly question the amount of money spent for fire management is long past," says Forest Economist Tom Mills of the Pacific Southwest Station in Riverside, California. "Fire management planners now face increasingly sophisticated and rigorous economic reviews of their budgets."

According to Mills, the Fire Management Analysis and Planning Handbook that is now being applied to fire management programs on both State and National Forest lands "addresses the economic question much more thoroughly than any previous analysis procedure." To help fire management planners deal even more completely with the new economic climate, researchers in Mills' Fire Economics Research Unit at Riverside are developing an improved mathematical model that planners can use to prepare economic analyses.

How much will it cost to put out fires during a future fire season? Would this outcome be changed by spending more—or less—money for fuel treatment, aviation, or similar fire management functions? These are questions the new Fire Economics Evaluation System will attempt to answer.

Mills, who is unit leader, says the model promises to "present a more comprehensive approach for economic analysis of long-range fire management program options, and to insure that those program options are thoroughly incorporated into integrated land and resource plans." Further, the model will give planners and administrators some information that they've needed (and—in the past—lacked) about risk.

Called the "Fire Economics Evaluation System," or "FEES," the model will

- screen proposed budgets and options in the most expensive areas of fire management—fuel treatment, initial attack, aviation operations, and large fire suppression
- evaluate the "economic efficiency" of each option
- estimate probabilities of program performance from year-to-year
- predict potential fire-related changes in natural resource outputs

Here's more about each of these features.

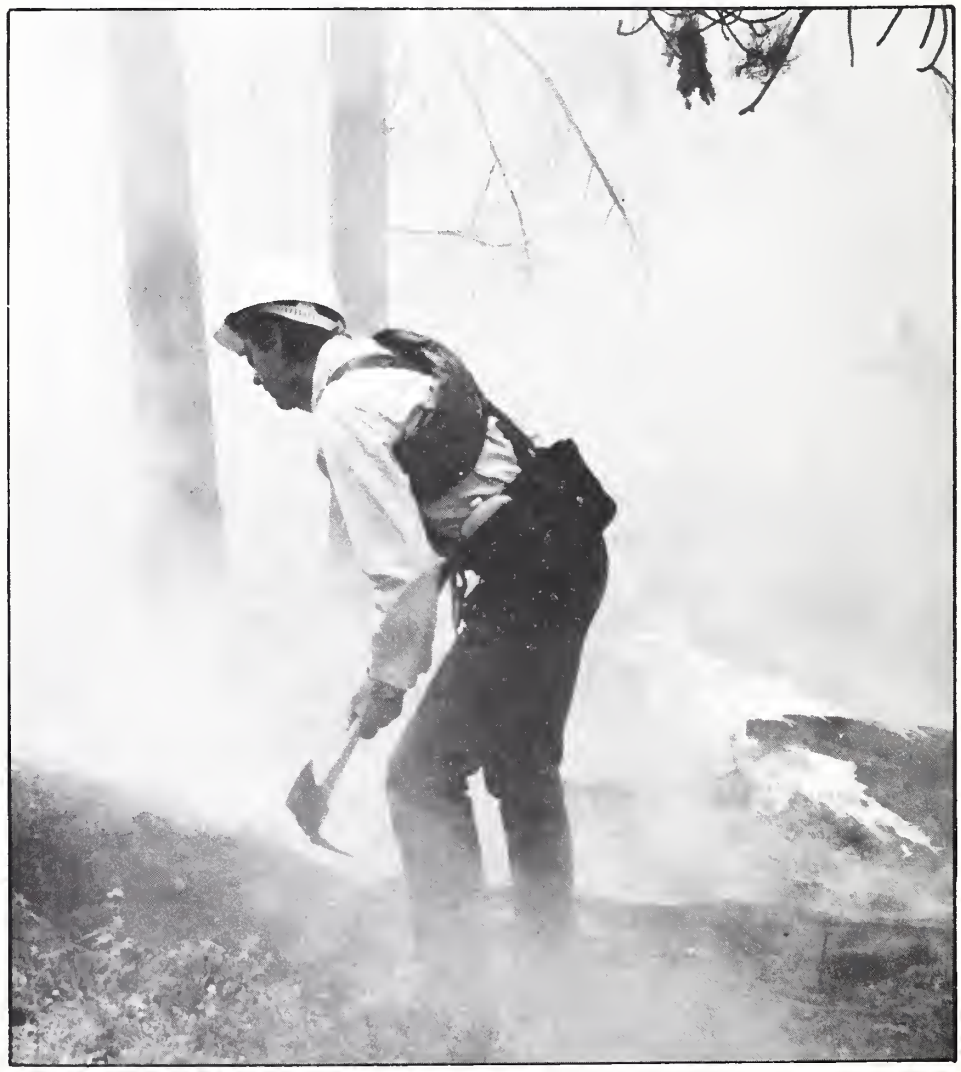
Economic efficiency

A main assumption behind the System is that certain budgets and certain proposed combinations of expenses within these budgets are more economically efficient than others.

What's an "economically efficient" fire management program? The Forest Service defines it as the one that gives the lowest total in the equation "fire program cost plus net value change in resource outputs."

In the equation,

- "fire program cost" includes both presuppression and suppression expenditures. Among them are food and supplies for firefighters as well as their wages (including their overtime, hazard, and holiday pay); maintenance of stations, bases, or camps for crews and equipment; purchase, lease, rental and maintenance of ground tankers, helicopters, and other equipment; and interest and other capital investment costs.
- "net-value change in resource outputs" refers to fire-related changes in the value of natural resources and structures the fire management program was designed to protect. The original value of resources, minus their worth after fire, is the "net value change in resource outputs."
- the budget and combination of planned expenses that give you the lowest "fire program cost plus net value change in resource outputs" is the "economically efficient" choice among the options open to you.



Despite modern technology, hard-working ground crews still are the mainstay of many wildfire attack forces. Wages, food, supplies, and shelter for these crews, as well as other costs, are calculated in the FEES model.

Probability or "risk"

Inherent in each evaluation from the System is a certain amount of probability. This is because some of the information that goes into the System—such as the data about fire weather and fire occurrence—is based on mathematical appraisals of the probability (or likelihood) that these weather and occurrence patterns will happen again. The "risk" section of the model will indicate how much probability is inherent in each cost plus net value change reading produced by the model.

Here's how the model is being built, and where probability enters:

The researchers are tracking the performance of selected fire management program options. Each option is moved through a sequence that mathematically simulates the possible outcomes of each plan.

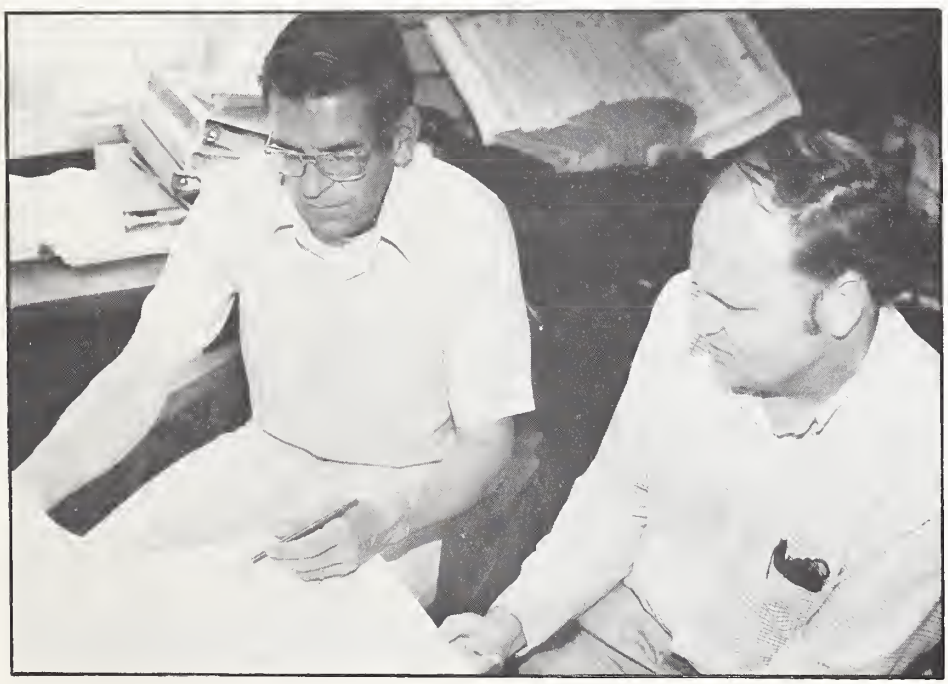
The sequence is shown as separate steps here, but at Riverside the work is going on in all stages at once. The researchers start with a probable budget and different ways to spend it. They analyze forest conditions—slope, aspect, cover type, and other environmental factors that affect the possible size and movement of fires.

Then they estimate how many fires might occur and what the fire weather conditions and size and behavior of the fires might be. (Probability enters the model here, with these estimates of fire weather and occurrence.)

The researchers then evaluate the types of crews and equipment that would be assigned to the fires, and estimate how long it would take to put the fires out. (Again probability enters the picture—these "arrival times" are estimates based on past records.) After that, the scientists figure hour-by-hour costs for the firefighters and equipment.

Next comes a detailed analysis of the possible effects on natural resources and structures (such as houses and other buildings, or dams). From this comes the comparison of before-fire and after-fire values of resources and buildings. This figure is net value change in resource outputs. Add it to your costs and you have fire program cost plus net value change—the accepted criteria for measuring "economic efficiency."

This process is repeated for other proposed budgets and possible ways to spend these budgets. From these repetitions will come a range of suppression costs and net value changes.



FEES is the top priority assignment for researchers in the Pacific Southwest Station's Fire Economics Unit.

Resource changes

The System will estimate before-and after-fire values of all the major forest resources—wood, water, recreation, wildlife, and grazing lands. Different units of measure are used in determining dollar values of these resources. For timber, the unit of measure is cubic feet, and the value of the stand is projected in cubic-foot market prices. Fire-related loss would be an estimate of the future harvest (again measured in cubic feet) lost because of fire.

For water, it's the value per thousand acre-feet (an acre-foot is the amount of water needed to cover one acre one foot deep). For both recreation and wildlife, value is measured in the current worth of recreation visitor-days. (A recreation visitor-day is when one person visits a National Forest for 12 hours, or when 12 people use a Forest for 1 hour.) A decline in the number of visitors—because of fire damage to an area—is counted as a fire-related loss.

For rangelands, the measure is an animal unit month (the amount of forage that will feed one cow for one month). For houses, dams, and similar improvements, the appraisal value is used.

The model is designed to deal with both gains and losses in value. If a fire stimulates production of a forage species of grass, for example, this is counted as an increase in value.

Other values

The "economic efficiency," risk, and resource output change readings the FEES model will produce are important factors in evaluating any fire management program. But, they're not the only factors that have to be considered. Public health and safety, political conditions, and many other criteria—ecological, esthetic, social, technical, and legal—must be taken into account as well, and considered in conjunction with the information produced from the System.

For each fire management option tested, FEES will indicate program cost and possible future losses in resource values.

Target: 1985

The Riverside scientists started working on the System in 1978. They hope to finish a preliminary version of the model this winter. They plan to have tested the prototype in the northern Rocky Mountain-Intermountain Climate Zone by 1985. (FEES will be designed to analyze fire management problems of specific "climate zones." The Rocky Mountain-Intermountain Climate Zone, one of 14 such zones in the U.S., includes all of Idaho and parts of Montana, Wyoming, Oregon, and Washington).

As computerized simulation models go, FEES is large, expensive to build, and complex. However, once completed, FEES will provide more accurate answers on fire management program performance than are currently available. And, FEES will be easier for fire planners on National Forests, or field units of other Federal or State agencies, to use.

To speed up development of the System, the researchers are borrowing from other work that's already been tested and proven. An example is the component that will predict fire behavior. Here, speed of a fire (or rate-of-spread) is a key factor. Rate-of-spread models already developed by researchers at the Forest Service's Northern Forest Fire Laboratory in Montana are perfectly adequate and have fitted neatly into the new System.

But building FEES is not simply a matter of patching together the research of other scientists. Many portions of the model are being built from scratch, using detailed fire records, cost sheets, and other data furnished from National Forests, State agencies, and others.

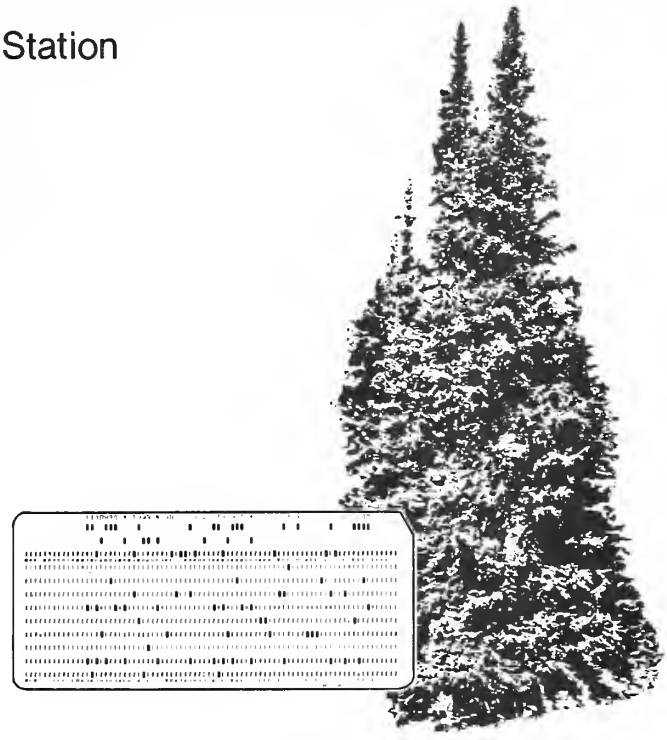
About one-half of the effort that's required to "build" the model goes into creating computer programs the System requires.

When it's completed, the Fire Economics Evaluation System will be the researchers' best effort to give a thorough, accurate, and honest estimate of the costs, risks, and probable outcomes of proposed fire management plans. Although FEES can't take all "unknowns" out of long-range planning, the model will make the fire management planner's best estimate just that much better.

Forestry Research West readers who would like further information about the Fire Economics Evaluation System are invited to phone or write the Fire Economics Unit, Pacific Southwest Station, Forest Fire Laboratory, 4955 Canyon Crest Drive, Riverside, CA 92517, or phone (714) 351-6548 (on FTS: 796-6548).

New timber management series out

by Rick Fletcher
Rocky Mountain Station



More than 10 billion board feet of timber is harvested annually from National Forest Systems lands (1980).

To ensure a continuous supply of timber, while protecting other forest values, land managers and planners need to be aware of the latest timber management techniques and research findings.

Scientists at the Rocky Mountain Station have just finished a series of four timber management publications covering species in the Rocky Mountains and Southwest. These research papers are intended to be companions to the RMYLD computer program, accessed through the USDA Computer Center in Fort Collins, Colorado. (For information on the RMYLD program, write the Rocky Mountain Station and request *RMYLD: Computation of yield tables for even-aged and two-storied stands*, Research Paper RM-199, by Carleton B. Edminster.)

Each publication covers regeneration, precommercial thinning, estimates of growth under intensive management, ways of maximizing board-foot volume yields, and tradeoffs to increase values of other forest resources.

Highlights

The first of the series is titled *Management of Spruce-fir in Even-aged Stands in the Central Rocky Mountains.* These forests are the largest and most productive timber resource in this region. Clearcutting old-growth forests and allowing them to restock naturally was common from the 1950's until recently. Today, however, management intensity has increased, and there's a need for prompt restocking, increasing growth of the new stand by control of stand density, and improving yields by thinning.

The average annual growth for unmanaged, old-growth stands is 80 to 100 fbm (foot board measure) per acre. Research shows that, under even-aged management, annual net growth can be increased to 200 to 650 fbm per acre by controlling stand density.

Bob Alexander, project leader for the Station's Multiresource Management of Montane and Subalpine Zones unit, and senior author of each of the publications in the series, explains, "Old-growth forests with an understory of advanced reproduction can be managed as even-aged by removing the overstory in a simulated shelterwood. In stands without advanced reproduction at harvest, spruce will regenerate from seed, provided (1) there is a dependable seed supply, (2) at least 40 percent of the seedbeds are exposed to mineral soil, and (3) environmental conditions are suitable. Shade is especially important to survival and early growth."

Spruce and fir must have room to grow to reach merchantable sizes in a reasonable amount of time. Scientists suggest precommercial thinning should begin at about age 30 years.

These are the most important water yielding forests in the Rocky Mountains. Because most streamflow comes from snowmelt, scientists have found the best timber harvest pattern is to clearcut 30 to 40 percent of a drainage (1) in small irregular-shaped patches, about 5 to 8 times tree height in diameter, (2) protected from wind, and (3) interspersed with uncut patches of about the same size.

Southwestern ponderosa pine

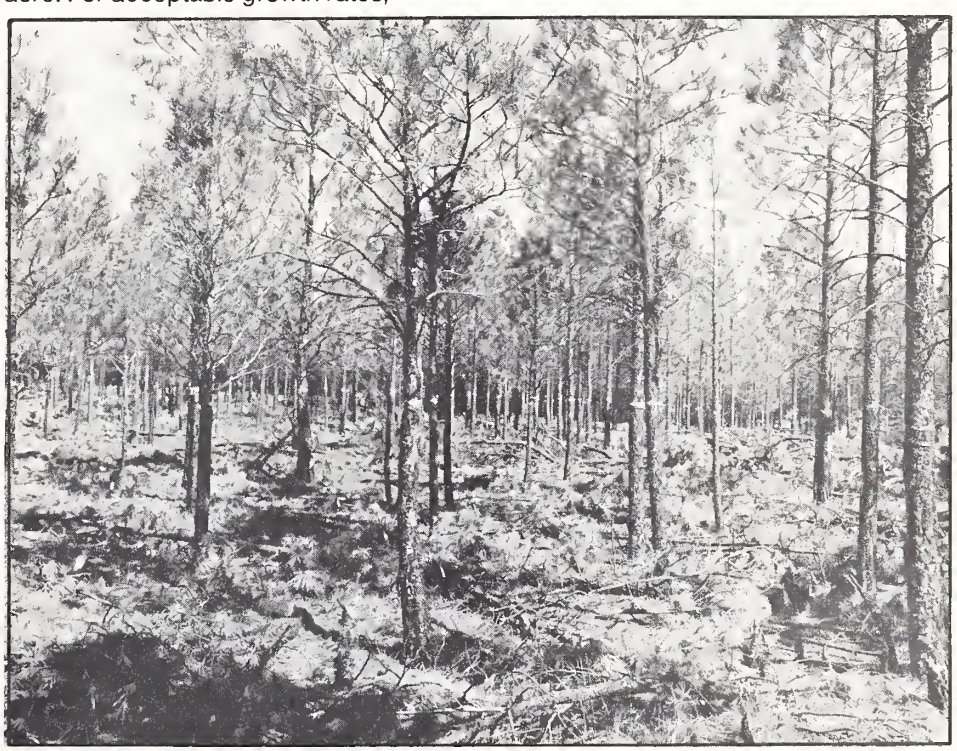
The second paper of the series is titled *Management of Ponderosa Pine in Even-aged Stands in the Southwest.* This publication is of prime importance to resource specialists in the Southwest because ponderosa pine occupies the largest area of commercial forest land in this region.

In old-growth stands, average annual growth varies from 25 to 90 fbm per acre because of understocking, overstocking, and high mortality associated with old-growth timber. Under intensive even-aged management, Station scientists have found that annual net growth can be increased to 100 to 300 fbm per acre.

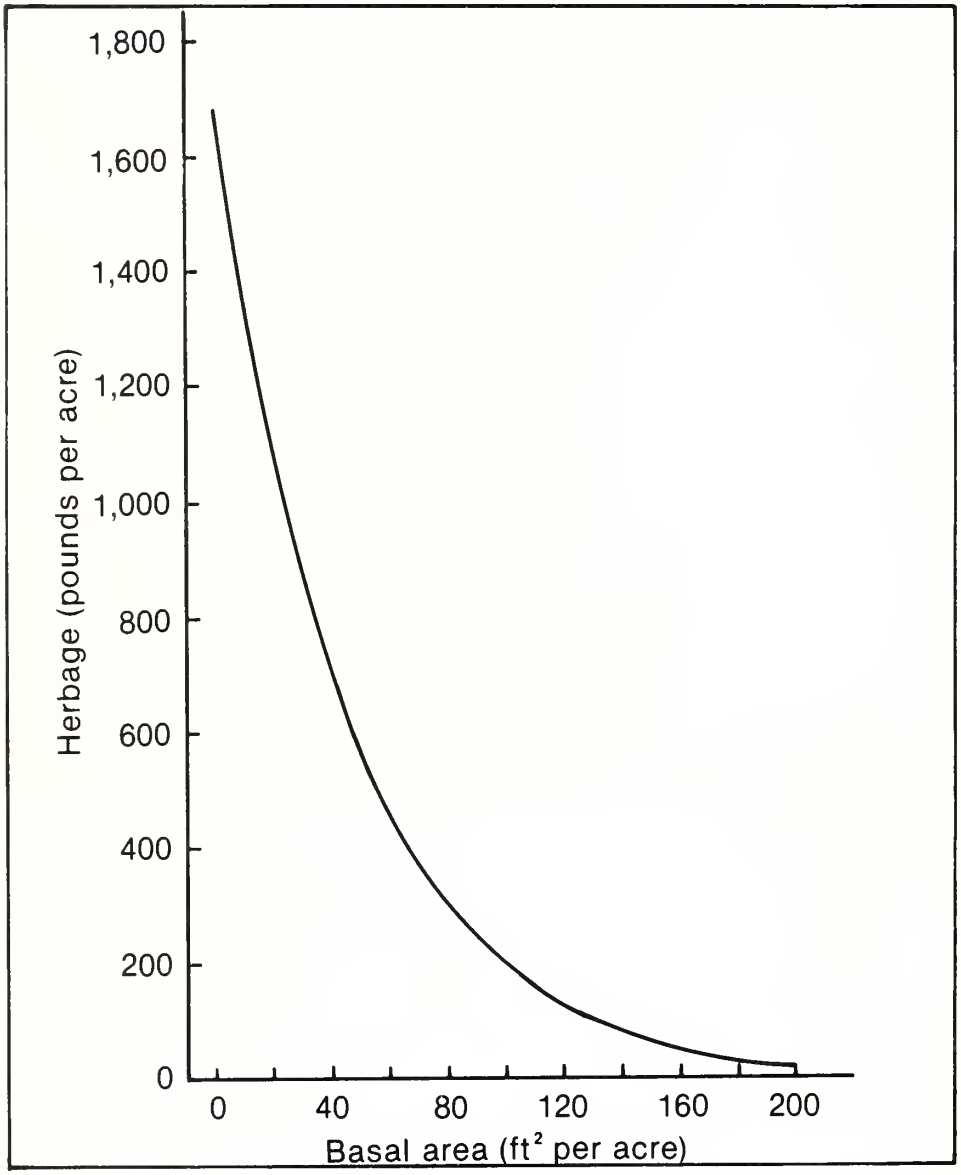
Carleton Edminster, mensurationist with the Fort Collins project, and coauthor of the publication series, says that regeneration is the biggest barrier to ponderosa pine timber management programs in the Southwest. Natural regeneration is slow to establish under the best conditions, and just will not work unless all of the following requirements are met: (1) a large supply of viable seed, (2) a well-prepared seedbed, (3) a site free of competing vegetation, (4) a low population of seed-eating animals, (5) sufficient soil moisture, and (6) protection from trampling and browsing by livestock and big game, and from certain insects. (For more information see "Regeneration in the Southwest - It Can Work!" in the January 1979 issue of *Forestry Research West.*)

However, if conditions are right, reproduction can become overly dense. It is not uncommon for stands to exceed 5,000 or 6,000 stems per acre. For acceptable growth rates, precommercial thinning is recommended to reduce stand density to 1,000 to 1,200 stems per acre at about age 10 years. Thinning is important in achieving the maximum board-foot volume.

The publication also discusses understory herbage production in relation to stand density, and what increases can be expected following thinning and shelterwood cutting.



This second growth southwestern ponderosa pine forest is on site index 60 lands, thinned to growing stock level 120 at age 45 years.



This graph shows a relation of herbage production to basal area of Black Hills ponderosa pine.

Black Hills ponderosa pine

Management of Ponderosa Pine in Even-aged Stands in the Black Hills is the third paper in the series.

While Black Hills ponderosa pine does not occupy a large area—about one million acres in South Dakota and Wyoming—these forests form a unique, isolated segment of the interior ponderosa pine type.

During the past century, virtually all of the area's unreserved forest acres have been cut over once, and many areas have seen multiple cuts. This, combined with losses due to insects, diseases, winds, and fires, has nearly eliminated the original old-growth sawtimber stands on about half of the commercial forests in this region. Surprisingly, however, the residual stands have been left with reasonable stocking.

Under intensive management, annual net growth for ponderosa pine in the Black Hills can be expected to be from 100 to 300 fbm per acre. Controlling stand density offers the greatest opportunity for increasing wood production by increasing growth and reducing mortality.

Alexander says that Black Hills ponderosa pine is most easily maintained as a vigorous, productive forest under even-aged management. The largest volume production per acre can be attained on a 120-year rotation, with either a 20- or 30-year cutting cycle under a two-cut shelterwood alternative. Stands should contain between 60 and 90 trees per acre, with an average diameter of between 15 and 17 d.b.h. at final harvest. Precommercial thinning recommendations are the same as for ponderosa pine in the Southwest.

Black Hills ponderosa pine forests yield more water than those in the Southwest or along the Colorado Front Range. Water yields can be maximized by clearcutting in small, irregular patches. Streamflow increases primarily because removal of trees reduces evapotranspiration. Soil moisture is also fully recharged earlier in the growing season, resulting in more runoff and a longer runoff period than in uncut or partially cut areas.

Lodgepole pine

The final publication in the series, *Management of Lodgepole Pine in Even-aged Stands in the Central Rocky Mountains*, discusses the second largest timber resource in the central Rockies in volume and area of commercial forest.

In old-growth, unmanaged stands average annual growth is 25 to 40 fbm per acre, mainly because of overcrowding, and the debilitating effects of dwarf mistletoe. Alexander says that, under even-aged management with a clearcutting alternative, annual net growth can be increased to 150 to 400 fbm per acre by controlling these two factors. For acceptable growth rates, stands must be thinned to 1,200 to 1,500 stems per acre during the first 10 years.

Understory vegetation in lodgepole pine forests is important forage for big game and livestock. As the amount of overstory decreases, the understory increases proportionately. To increase this vegetation, however, timber production has to be sacrificed.

The changes in production and composition remain for 10 to 20 years before competition from tree reproduction begins to reduce understory vegetation. To maintain forage growth, the manager must be able to make additional cuts in the stand at intervals of at least every 20 years.

Our Nation's forests produce a wide variety of resources. Long-term projections indicate an increased demand for them. Publications such as these will help resource specialists keep up with that demand, while maintaining and improving healthy forest ecosystems.

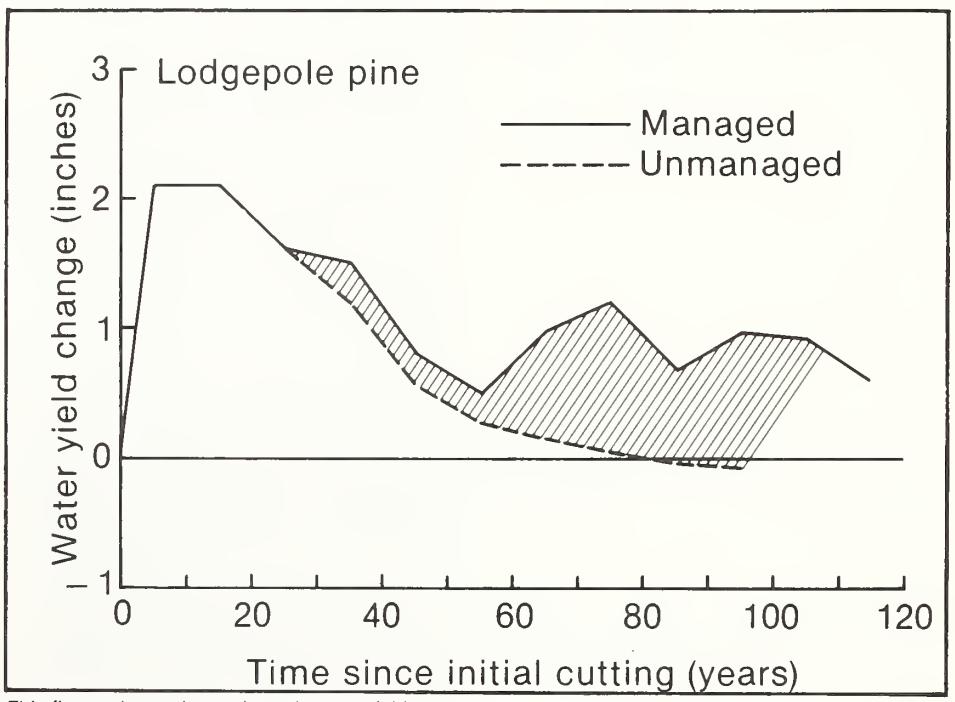
If you would like more details on this research, write for your free copy of any of the publications listed, all authored by Robert R. Alexander and Carleton B. Edminster.

Management of Spruce-fir in Even-aged Stands in the Central Rockies, Research Paper RM-217.

Management of Ponderosa Pine in Even-aged Stands in the Southwest, Research Paper RM-225.

Management of Ponderosa Pine in Even-aged Stands in the Black Hills, Research Paper RM-228.

Management of Lodgepole Pine in Even-aged Stands in the Central Rocky Mountains, Research Paper RM-229.



This figure shows the projected water yield from a central Rockies lodgepole pine forest over a 120-year rotation, on a 30-year cutting cycle.

SEAMPLAN—a computer tool for surface mine reclamation planning

by Edward R. Burroughs Intermountain Station, and M. Douglas Scott Institute of Natural Resources, Montana State University

Today's increased emphasis on coal, phosphate, and hard rock mining in the Northern Great Plains and Rocky Mountain regions requires important decisions by land managers involved with mine reclamation. The complexity and interrelationship of many contributing factors make planning slow, tedious, and costly. To help solve this problem, a team of Intermountain Station researchers and cooperators at Montana State University, Bozeman, developed SEAMPLAN, a computerized mine and reclamation planning system. SEAMPLAN, a minicomputer-based system composed of four main modules, can help mining companies, regulatory agencies, and resource specialists efficiently manage site data in surface mine and reclamation planning.

Data management

The Data Management module contains interactive graphics subroutines that utilize topographic surveys and corehole data to develop contour maps, three-dimensional perspectives, and geologic cross sections. Users can obtain bar chart displays describing the chemical and physical characteristics of overburden and coal. These data files can be built and edited by the land manager.

Production analysis

Production Analysis, of particular interest to the mining engineer, concentrates on the design of surface mines using dragline equipment. The basic objective is to provide tools mining industry planners can use to evaluate the effects of various mine plan decisions on operating costs, required equipment, and production rates. This module can be used at two interrelated design levels:

1. Total mine planning, including the required transportation system; support equipment; and loading and hauling equipment.
2. Pit design for dragline selection and evaluation; boxcut location; optimization of overburden removal, spoils placement and pit geometry; and dragline productivity.

Reclamation analysis

The Reclamation Analysis module can be used by engineers and resource specialists from a wide variety of disciplines. Several misconceptions exist regarding surface mine reclamation. The subject creates a mental picture of seeding, fertilizing, mulching, and transplanting as the major factors in successful surface mine reclamation. These activities, however, are a relatively minor part of the effort. A major initial goal should be to select the most suitable post-mining land use; a second goal should be to determine which reclamation techniques could be used to achieve that land use. The Reclamation Analysis module, a series of programs called CLAIM, addresses these two goals, and can be used independently of other SEAMPLAN modules.

CLAIM programs

The FEASI (land use feasibility) program analyzes at least 80 pre-mining, site-specific data items dealing with mine engineering: climatology; characteristics of topsoil, subsoil, and overburden; surface and ground water hydrology; vegetation; wildlife; socioeconomics; and archaeology. Given the site data, this program compares five general post-mining land uses in terms of their relative feasibility to be successfully reclaimed. These land uses are cropland, native vegetation, wildlife, water-based recreation, and high human use (homes, businesses, etc.). All current Federal land use restrictions are built into the feasibility program so that planned post-mining land uses that conflict with regulations are flagged during the planning process.

TECON, a second program within CLAIM, determines reclamation techniques for the specific site data and calculates the costs of all techniques for each of the five final land use options. TECON analyzes basic environmental data, determines suitable reclamation techniques based on the results of field research and, using unit costs provided by the user, calculates the costs of equipment, supplies, and labor for each technique. The computer then prepares a list of necessary techniques and costs for reclaiming the site for each of the five land uses.

The environmental feasibility ranking is not always the same as the cost ranking for each land use, so another program, OPUSE, combines the results from FEASI and TECON. This analysis produces a listing of the land uses and their costs from the most preferred to the least preferred use.

Many different techniques for efficient surface mine revegetation have been developed over the past several decades. The most sophisticated revegetation plan, however, has little chance of success if the site has not been properly shaped to optimize vegetative production. Over 90 percent of the cost of successful reclamation is in spoils shaping, topsoil salvage, and respreading. One of the most important features of CLAIM is concerned with calculating spoils grading volumes and costs to achieve a final topography, selected by the user, for both dragline and truck-and-shovel mines. Using these programs, known as GRADE, the land manager can interactively plan spoils or highwall geometry so that final-graded slopes, specified by the user, are feasible. Initial benches and/or dragline pit geometry are entered, then the user specifies the final, desired slopes. The computer then draws a cross section of the tentative spoils layout. If the specified final slopes are not compatible with proposed mine geometry, the computer will determine how the post-mining gradients should be changed to accomplish grading objectives. In the case of a truck-and-shovel mine, the computer will calculate how much a spoils bench should be widened to attain the final slope desired by the reclamation planner. After all mine benches and final-graded slopes have been adjusted, the computer draws the final cross section of the spoils layout, complete with grading volumes and costs.

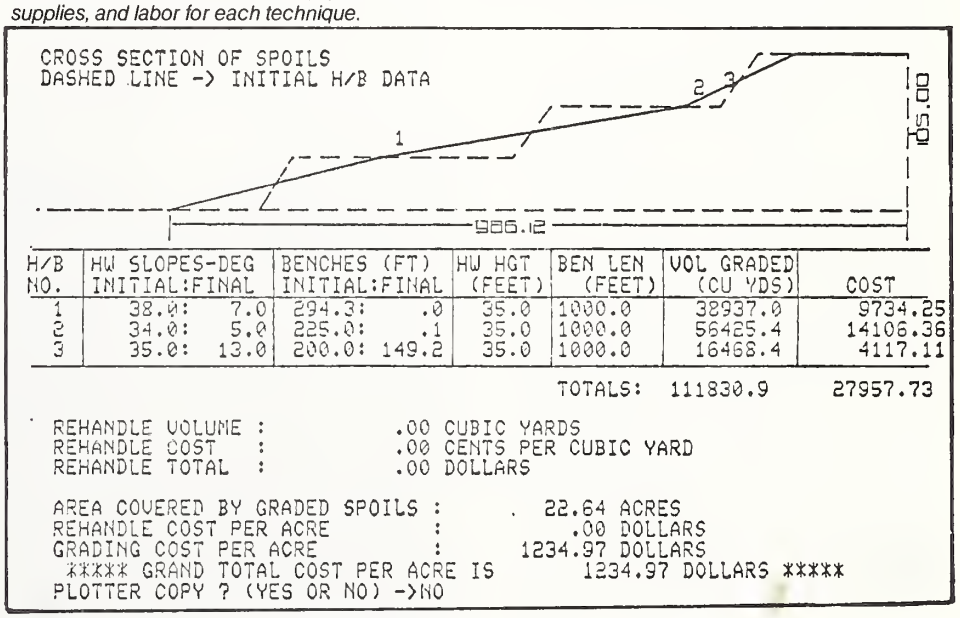
TYPICAL NORTHERN GREAT PLAINS RANGELAND SITE, 1980.

*** WILDLIFE ALTERNATIVE ***

	TECHNIQUE	COST/ACRE
1)	STRIP ALL TOPSOIL	$ 1109.17
2)	RESPREAD ALL TOPSOIL	$ 831.88
3)	STRIP 1 FOOT OF SUBSOIL	$ 1210.00
4)	RESPREAD 1 FOOT OF SUBSOIL	$ 907.50
5)	GRADE SPOIL	$ 1411.11
6)	CHISEL PLOW	$ 9.37
7)	DISC AND HARROW	$ 3.75
8)	CHAINING	$ 3.75
9)	BUY SEED	$ 62.50
10)	DRILL SEED	$ 4.31
11)	BUY FERTILIZER : NITROGEN	$ 10.35
12)	BUY FERTILIZER : PHOSPHATE	$ 11.00
13)	DRILL FERTILIZER	$ .75
14)	BUY HAY MULCH	$ 121.87
15)	APPLY HAY MULCH	$ 24.00
16)	HYDROMULCH SEED AND FERTILIZER	$ 112.50
17)	HAND PLANT SHRUB AND TREE SEEDLINGS	$ 200.00
18)	ERECT ANIMAL FENCING	$ 63.00
19)	STABILIZE TOPSOIL STORAGE PILE	$ 24.79
20)	ADMIN. OF OPERATIONS AND NECESSARY TESTS	$ 918.24
	TOTAL	$ 7039.84

GRAND TOTAL COST FOR 300.0 ACRES IS 2.11 MILLION DOLLARS

TECON calculates the costs of equipment, supplies, and labor for each technique.



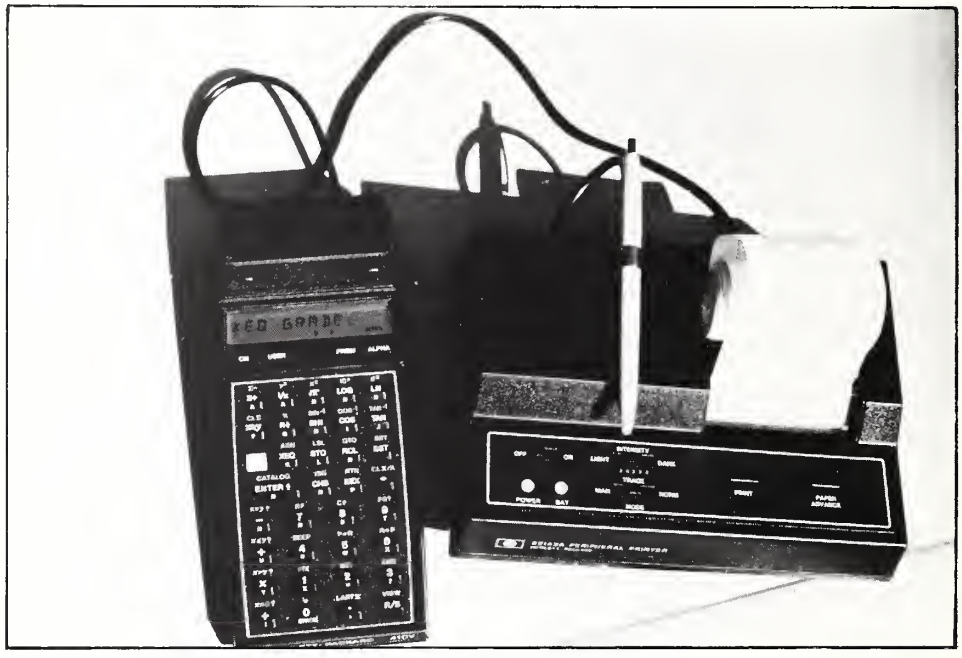
H/B NO.	HW SLOPES-DEG INITIAL:FINAL	BENCHES (FT) INITIAL:FINAL	HW HGT (FEET)	BEN LEN (FEET)	VOL GRADED (CU YDS)	COST
1	38.0: 7.0	294.3: .0	35.0	1000.0	38937.0	9734.25
2	34.0: 5.0	225.0: .1	35.0	1000.0	56425.4	14106.36
3	35.0: 13.0	200.0: 149.2	35.0	1000.0	16468.4	4117.11
				TOTALS:	111830.9	27957.73

REHANDLE VOLUME : .00 CUBIC YARDS
REHANDLE COST : .00 CENTS PER CUBIC YARD
REHANDLE TOTAL : .00 DOLLARS

AREA COVERED BY GRADED SPOILS : 22.64 ACRES
REHANDLE COST PER ACRE : .00 DOLLARS
GRADING COST PER ACRE : 1234.97 DOLLARS
***** GRAND TOTAL COST PER ACRE IS 1234.97 DOLLARS *****
PLOTTER COPY ? (YES OR NO) ->NO

The computer draws the final cross section of the spoils layout, complete with grading volumes and costs.

SEAMPLAN was developed using a relatively costly minicomputer system, including additional disc storage and peripherals such as CRT terminal, plotter, and high speed printer. Recent advances in programmable calculator technology have made it possible to put large portions of the GRADE programs on magnetic cards for the portable, inexpensive Hewlett-Packard 41CV model (41C with quad memory). Complicated graphics features are not possible, but the attached printer provides final reports on grading volumes and costs. Dragline spoils grading routines (DRAG) for this calculator will calculate volumes and costs for the opening cut, mine run, and final cut spoils. Truck-and-shovel spoils grading routines, called TAS, allow the user to interactively lay out the spoils highwalls and benches, and to obtain final reports on grading volumes and costs.



Recent advances in calculator technology have made it possible to put large portions of the GRADE programs on magnetic cards for a portable, inexpensive model.

Impact analysis

Work has not been completed on the computerized impacts analysis module. Results of several studies on surface erosion from mine roads caused by rainfall, dust emission caused by large trucks, and snow accumulation, snowmelt, and associated erosion from phosphate dumps have not yet been incorporated into the planning system. These results are, however, available as individual reports.

Geographic applications of SEAMPLAN programs

The current Data Management programs may be applied to any type of surface mine in the country where ore beds (such as coal or uranium) lie on a relatively uniform, horizontal plane. The Production Analysis module may be used on large, single-seam dragline mines.

Mining operations on National Forests require important decisions by land managers involved with mine reclamation.

The reclamation analysis (CLAIM planning system) is primarily designed for environmental conditions in the Northern Great Plains region of eastern Montana, northeastern Wyoming, and western North Dakota. With slight modification it can be applied to the Rocky Mountain Coal Province, which includes many of the mines being developed on Forest Service lands in southern Wyoming, Utah, and Colorado. The CLAIM system also may be modified for use in the midwestern coalfields of Illinois, Indiana, Missouri, and Ohio. The grading programs, DRAG and TAS, for the programmable calculator may be used for any dragline or truck-and-shovel surface mine in North America.

Reviewing and using computer programs

All SEAMPLAN programs can be reviewed by visiting the Montana State University campus. The appropriate person listed at the end of this article should be contacted 1–2 weeks in advance to reserve a demonstration time. A complete demonstration of any one of the three main systems takes about 3 hours.

If a group of people at the same location would like to review these programs, personnel from Montana State University can provide remote, live demonstrations using a long distance telephone line and a portable graphics computer terminal. A 12-minute slide-tape show is available for use by interested groups. Douglas Scott should be contacted regarding these demonstrations.

If an agency or company wishes to obtain these computer programs for in-house use, the following options are available:

a. Time sharing. If the agency purchases a computer terminal and a telephone acoustic coupler (cost $2000–$6000), they can arrange to operate SEAMPLAN, CLAIM, and GRADE on the Montana State University minicomputer for about $30 per hour plus the phone toll charge.

b. Purchase magnetic tapes and cards. If a user plans to use the programs extensively, he should consider purchasing the software for transfer to his own computer system. Costs for program tapes, cards, and manuals are:

SEAMPLAN Data Management and Production Analysis	$ 90.00
CLAIM and GRADE programs	$295.00
DRAG (HP-41CV cards and manual)	$125.00
TAS (HP-41CV cards and manual)	$125.00

The SEAMPLAN, CLAIM and GRADE programs can be run on a minicomputer or reprogrammed to operate on a large, time-shared computer or a small desktop microcomputer

The following publications describe the development and operation of these programs, and may be obtained by contacting the appropriate sources listed below.

Burroughs, E. R., Jr.; Scott, M. D.; Gibson, D. F. SEAMPLAN. *A computer-based mine and reclamation planning system*. U.S. Department of Agriculture, Forest Service Miscellaneous Publication INT-1. Intermountain Forest and Range Experiment Station, Ogden, Utah.

Green, O. D.; Scott, M. D. *TAS. Truck and shovel spoils grading programs. User's manual for the HP-41C programmable calculator system*. Institute of Natural Resources Systems Publication INRS 1. Montana State University, Bozeman, MT.

Green, O. D.; Scott, M. D. *CLAIM Computerized reclamation planning system for Northern Great Plains surface coal mines. Programmer's Manual*. U.S. Department of Agriculture, Forest Service. Intermountain Forest and Range Experiment Station, Ogden, Utah.

Scott, M. D. *CLAIM: computerized reclamation planning system for Northern Great Plains surface coal mines. User's Databook*. U.S. Department of Agriculture, Forest Service. Intermountain Forest and Range Experiment Station, Ogden, Utah.

Scott, M. D. *CLAIM computerized reclamation planning system for Northern Great Plains Surface Coal Mines. User's Manual*. U.S. Department of Agriculture, Forest Service. Intermountain Forest and Range Experiment Station, Ogden, Utah.

Scott, M. D.; Green, O. D. *DRAG. Dragline spoils grading programs. User's manual for the HP-41C programmable calculator system*. Institute of Natural Resources Systems Publication INRS 2. Montana State University, Bozeman, MT.

Scott, M. D. *Surface coal mine costs in the Northern Great Plains*. P. 301–303 *In* Proceedings 4th annual meeting Canadian Land Reclamation Assoc.

For further information about SEAMPLAN modules, contact:

Data Management and Production Analysis
Dr. David F. Gibson
School of Engineering
Montana State University
Bozeman, Montana 59717

Reclamation Analysis - CLAIM, GRADE, DRAG, TAS
Dr. M. Douglas Scott
Institute of Natural Resources
Montana State University
Bozeman, Montana 59717

Impact Analysis
Dr. Edward R. Burroughs, Jr.
Forestry Sciences Laboratory
Montana State University
Bozeman, Montana 59717

New Publications

Estimating costs of collecting and transporting residues

Large volumes of unused wood are represented by logging residues and standing dead timber. Most of this wood is sound, so why aren't these materials being used?

It's a matter of economics. Collection and transportation costs are often greater than the value of the residues. The costs of harvesting or collecting dead timber and residue materials is extremely variable, depending upon such factors as terrain, volume, piece size, and transport distance. Some of the material is always near the margin or break-even point. A slight increase in the market values of potential products might make it feasible to use that material nearest the margin. When decisions are to be made concerning the possible added use of these residues, it is important that reliable estimates of collection and transportation costs be available. A recent report published by the Intermountain Station provides a method to obtain such estimates.

The report, *Estimating Costs of Collecting and Transporting Forest Residues in the Northern Rocky Mountains,* General Technical Report INT-81-FR30, presents a model that estimates cost per unit of harvesting logging residues or standing dead trees. Harvesting methods include hand or mechanical felling (in the case of standing trees), cable or ground skidding, chipping in woods, or roundwood logging. The model also considers variables such as skidding distance, volume per turn, and piece size. Data are presented in a series of cost tables. Using the proper sequence of tables, a manager can compute costs for a specific situation.

The research leading to the model was conducted by author Richard P. Withycombe, associate professor of management and research associate at the Bureau of Business and Economic Research, School of Business Administration, University of Montana, Missoula. He conducted this research under a cooperative agreement with the Intermountain Station.

Copies are available from the Intermountain Station.

Regional demand for National Forest stumpage

The concept of regional demand for National Forest stumpage, the relationship between price and the maximum quantity of wood products that buyers are willing to purchase, is described in a new publication of the Pacific Northwest Station.

Projections of the Demand for National Forest Stumpage by Region; 1908–2030, describes regional demand and establishes projections of demand curves for each of eight Forest Service regions in the contiguous U.S. The demand relationships can be used in planning at regional and national levels of the Forest Service, such as investigating the effect on price of changing harvest flows from National Forests.

Copies of this publication by Economists Richard W. Haynes and Kent P. Connaughton of the PNW Station and Darius M. Adams of Oregon State University, PNW-282, may be obtained from the Publications Department, Pacific Northwest Station.

Selecting an indicator species

By law, the USDA Forest Service is required to develop forest plans that will maintain viable populations of all existing native vertebrate species. One method used to check how well a land management plan is meeting this goal is by selecting and monitoring an indicator species. This is a plant or animal species that serves as an "early warning system" of habitat changes. Their population changes are indicative of land management effects on a biological community. They are one of the first species to respond to habitat changes.

The Rocky Mountain Station has just published a report that covers the critical factors involved in selecting an indicator species. Scientists say that the ideal species should 1) be sensitive to habitat-induced stress, 2) be conspicuous by sight and sound, 3) be easy to recognize in the field, and 4) operate during the hours when man is active.

Since these attributes are most evident in birds, the report centers on selecting and monitoring of birds as indicator species. It reviews steps used in picking two avian indicator species for a ponderosa pine forest in Arizona—the pygmy nuthatch and violet-green swallow.

For more details, write the Rocky Mountain Station and request *Selection and Monitoring of Avian Indicator Species: An Example from a Ponderosa Pine Forest in the Southwest,* General Technical Report RM-89, by Robert C. Szaro and Russel P. Balda.

Report evaluates fire management programs

The costs and effectiveness of fire management programs on six National Forests are briefly analyzed in a new, 29-page report from the Pacific Southwest Station. *Economic Efficiency of Fire Management Programs at Six National Forests*, Research Paper PSW-157, looks at the costs of initial attack and aviation programs on National Forests in Oregon (the Deschutes and Willamette Forests), in California (the San Bernardino), Arizona (the Tonto), South Carolina (the Francis Marion), and Michigan (the Huron-Manistee).

Forest Economists Dennis L. Schweitzer and Thomas J. Mills, and Forester Ernest V. Andersen, all of the Forest Service, prepared the analysis.

For their study, they used four different budgets for initial attack and air operations. Their intent: to see how variations in funding might affect the success of the firefighting programs. The test involved pitting these programs against a sequence of computer-simulated wildfires, designed to represent two to three "light" through "severe" fire years.

The study focused on two effects: the cost of putting the fires out (fire suppression) and the fire-related changes in the value of the natural resources and structures (such as buildings and dams) that the initial attack and air operations were supposed to protect.

The analysis showed that the lowest funding for the initial attack and air operations program was the most economically efficient on four of the six Forests (for more on the concept of "economic efficiency," see "Is your fire management program 'economically efficient'?" in this issue). Also on four of the Forests, the severity of the fire year didn't affect the economic efficiency of the program. The authors report, "Increased fire year severity may not mean higher program levels are more efficient."

The fire year simulations further showed that fire suppression costs went down as initial attack and aviation funds went up. The authors comment, "This result is in strong contrast to the historical rise in suppression costs that occurred at the same time that presuppression budgets were increasing."

Additional findings are presented in the Research Paper, which is available from the Pacific Southwest Station.

POLO2 expands options of insecticide tests

Thanks to a new computer program, it's now easier and more convenient for scientists to test more variables in experiments with insecticides. Researchers can now efficiently test the significance of as many as nine different variables—each of which might influence how insects respond to test insecticides. These variables could include weight or sex of the insect, time of day the insecticide was applied, or method used in applying the material.

Known as "POLO2", for "Probit Or LOgit Analysis," the new program can easily accommodate results from up to 3,000 different test subjects—more than enough for even the most thorough insecticide study. Using established statistical procedures for two types of analyses—probit or logit—the POLO2 program processes the data and determines whether or not each variable is statistically significant.

For example, at the Pacific Southwest Station, where POLO2 was developed, researchers determined that sex and body weight of western spruce budworms were critical variables affecting response of budworms to a hormone-like chemical. This information—based on response of a laboratory population of budworms—can be used in predicting how a naturally occuring population might react if the chemical were used in the forest.

POLO2 is designed for use on any of the Univac 1100 series computers. The program is versatile—although written especially for evaluating insecticides, it can also be used in research with drugs, or in any other experiments that involve calculations of doses and responses.

POLO2 was written by Computer Programmer Bob Russell and Research Entomologist Jackie Robertson, both of the Pacific Southwest Station, and by Statistician Nick Savin of Cambridge University. "The program is accurate, flexible, and easy to use," says Robertson. "It is also economical: it's tightly written, and uses very little computer time. POLO2 is probably one of the best things we've ever done."

The new manual, *POLO2: User's Guide to Multiple Probit Or LOgit Analysis*, General Technical Report PSW-55, is now available from the Pacific Southwest Station's Publications Distribution Section in Berkeley. To have POLO2 copied onto magnetic tape, send a tape and format instructions to the Station's Computer Services Library, also in Berkeley.

Software package for fuel appraisal process

A new report issued by the Rocky Mountain Station details a computer software package that provides support for the activity fuel appraisal process. This process, developed at the Rocky Mountain Station in 1980, provides a decision framework to help land managers make improved decisions concerning fuels management. It enables the manager to assess the fire hazard changes associated with fuel management actions.

The report, titled *User's Guide to the National Fuel Appraisal Process*, discusses the four ASCII FORTRAN computer programs that make up the software package. These programs are accessed through the USDA Computer Center in Fort Collins, Colorado.

The user's guide covers detailed input instructions, runstreams, example inputs, and example outputs.

Write the Rocky Mountain Station for a copy of the report, authored by David L. Radloff, Richard F. Yancik, and Kenneth G. Walters.

Yield tables for DFSIM are now available

Selected yield tables generated by the Douglas-fir stand simulation program (DFSIM) are now available in a Pacific Northwest Station report.

These include tables for "normal" stands, those planted or precommercially thinned to 300–400 trees per acre, commercially thinned, and fertilized stands. The authors, Robert O. Curtis, Gary W. Clendenen, Donald L. Reukema, and Donald J. DeMars, have selected a limited number of tables representing alternative management regimes and conditions of interest for comparison purposes.

These tables can be used as guides for stocking control, and as aids in choice of management regimes and in estimating probable yields from managed stands. They will be particularly useful to those forest managers who do not have easy access to computer facilities needed to generate their own programs by direct use of the DFSIM program developed in 1981 by the PNW Station and the Weyerhaeuser Company.

Copies of *Yield Tables for Managed Stands of Coast Douglas-fir*, PNW-135 may be obtained from the Publications Department, Pacific Northwest Station.

Book about Oregon coast mammals published

Detailed information about 96 species of mammals of the Oregon coast, with background discussion about the geology, soils, vegetation, and habitat of this area, is contained in a book published by the Bureau of Land Management and the USDA Forest Service.

Natural History of Oregon Coast Mammals is suited for students, educators, planners, resource managers, wildlife biologists, and naturalists. A general description of each of the 65 terrestrial and 31 marine species is provided, with details about the habitat, habits, food, reproduction, predation, and economic importance of each. The authors provide much information about the life history of the mammals through personal observations and anecdotes, as well as with reports from other scientists.

The authors are Chris Maser, wildlife biologist with the BLM; Bruce A. Mate, marine mammalogist with Oregon State University; Jerry F. Franklin, plant ecologist, and C.T. Dyrness, soil scientist, both with the Pacific Northwest Station.

Copies of *Natural History of Oregon Coast Mammals*, General Technical Report PNW-133, may be obtained from the Publications Department, Pacific Northwest Station.

Success with natural regeneration

In the Southwest, planting is the most reliable method of regenerating ponderosa pine. Planting, however, is expensive. A 1978 estimate showed that the cost of planting an acre in the Southwest was over $259.

In 1968, scientists with the Rocky Mountain Station began to devise a method of obtaining natural regeneration. This method has now been proven as over 11,000 acres of ponderosa pine have been successfully established via natural regeneration in central Arizona.

A new report, titled *"Establishing Natural Regeneration of Ponderosa Pine in Central Arizona"*, by L. J. Heidmann, Thomas N. Johnsen, Jr., Quinten W. Cole, and George Cullum, is now available. Published in the February 1982 issue of the *Journal of Forestry*, it discusses some of the problems associated with natural regeneration, specifics of the Arizona studies, and recommended practices for successful natural regeneration. Write the Rocky Mountain Station for your copy.

☆ U.S. GOVERNMENT PRINTING OFFICE: 1982-579-943/354

Looking at wilderness campsites

Managing wilderness areas so that "natural conditions" are preserved is mandated by the Wilderness Act of 1964. Accomplishing that mandate is a concern to land managers faced with continuing increases in recreational use of these areas.

One of the most vexing problems is deciding what to do about degradation of campsites in areas where use is concentrated. A common response to this situation is an attempt to disperse users from the overused areas to less frequently visited parts of the wilderness. Currently, 53 percent of all designated wilderness units in the Forest Service and Park Service attempt to disperse use. But is dispersal a good idea?

To help answer this question, or to develop any other information-based wilderness campsite management policy, managers need information about changes that are taking place. They also need to know the extent to which differences in amounts of use affect campsite condition.

The Intermountain Station has published a report of a study designed to provide such information for campsites in the Eagle Cap Wilderness in northeastern Oregon. Researchers established permanent sampling plots so that long-term changes could be evaluated. The changes which had already occurred were assessed by comparing campsites with undisturbed control plots. *Wilderness Campsite Impacts: Effect of Amount of Use*, Research Paper INT-RP-284-FR30, by Research Ecologist David N. Cole, presents results of the first year of the study. The report describes the changes which have already occurred, and how they relate to the amount of use the site receives.

Monitoring, recently mandated by Congress in the National Forest Management Act, is another of the wilderness manager's responsibilities. In the Eagle Cap study, the researchers evaluated the ability of several individual monitoring methods to predict overall site conditions and amount of change.

If you would like to read more about Cole's study, write to the Intermountain Station for a copy of the report.

Ants may be important predators of western spruce budworm

Ants may play a more important role as predators of the western spruce budworm than has been expected, say two researchers from the Pacific Northwest Station.

Robert W. Campbell and Torolf R. Torgersen found that one trial showed 95 percent of the budworm pupae placed in the Okanagan National Forest in Washington were killed by predators which the researchers believe to be ants.

The research was conducted by wiring twigs containing pupae to branches which either had a sticky barrier applied to prevent access to walking invertebrate predators, or were left untouched. Results at one site indicated that control branches had 85 percent of the pupae removed or reduced to fragments within three days. In contrast, only about eight percent were removed where a sticky barrier was applied around the branch base.

Since the sticky barriers would not deter either flying predators or small mammals, the early results indicate the likely important role by walking invertebrate predators. Evidence of ants in the vicinity was common.

Similar results were obtained at a second trial. A third trial of the experiments showed higher losses on some of the branches protected by sticky barriers, and this may be attributable to ants falling onto them from higher branches, the scientists report. In any case, the two researchers believe there is little doubt that more research is necessary on the role of ants in the population dynamics of the western spruce budworm.

Copies of *Some Effects of Predaceous Ants on Western Spruce Budworm Pupae in North Central Washington* may be obtained from the Publications Department, Pacific Northwest Station.

If you know of someone who would be interested in this publication, he or she can be added to the mailing list by filling out the coupon below and mailing it to us.

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