Oregon's Agricultural PROGRESS

Research With Oregon's "Wild Lands"—

Reports of Five Studies on Resource Management

OREGON STATE UNIVERSITY / CORVALLIS / SUMMER-FALL 1961

Oregon's Agricultural
PROGRESS

Vol. 8 Nos. 3-4

Published by the Agricultural Experiment Station, Oregon State University, Corvallis, F. E. Price, Director; R. G. Mason, Editor; Alice F. Dalbey, Assistant Editor.

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Features:

OREGON'S AGRICULTURAL PROGRESS will be sent free to Oregon residents upon request. Address requests to Bulletin Clerk, Industrial Building, Oregon State University, Corvallis, Oregon, or see your County Extension Agent.

COVER: Old-growth Douglas-fir once covered many parts of the Coast Range. But young hemlock moved in after the fir was logged and took over in thick, dense patches. Proper thinning to increase growth is one of many projects of OSU's Forest Research Laboratory, page 12.

(Photo and story, James Overholser)

THIS ISSUE of *Oregon's Agricultural Progress* reports a sample of research results on improving the management of our "wild land"—our forests and ranges and the fish, wildlife, water, and esthetic resources they encompass. We are increasing our attention in this area of our research program, since these lands must be managed and used more intensively to meet the greatly increasing demands upon them in the years ahead. Research in this area will become even more vital.

Our wild lands—their management and use

Ninety percent of Oregon's land area is wild land. Forty-seven percent of the 61,664,000 total acres of land in our state is classified as forest land. Another 43% is rangeland. Only 8% is tillable farm land. The remaining 2% is cities and roads. With such a high percentage of wild land, research aimed at obtaining best management and most efficient use is of major importance.

Historically, we have been primarily concerned with these wild lands for timber and forage production. The harvesting of these products has been the basis of our lumber and range livestock industries. These industries have been and will continue to be of major significance in our state's economy. Forestry is Oregon's leading industry. It's value exceeds one billion dollars annually. This includes the value of initial processing—putting the timber into lumber, plywood, pulp, and other products. Including value of initial processing, Oregon's range livestock industry produces revenue in excess of 100 million dollars annually.

Expanding population needs "wild lands"

With our rapidly expanding population, wild lands are becoming more important in many other ways. They are the source of our vital water supply. Many sections of our country—including areas in our own state—face critical water shortages. More than 1,000 cities in our country ration water at the present time. Our need for adequate future supplies of pure water means increased attention in our research to such programs as watershed management, pollution abatement, and in-

Better Use of Oregon's "Wild Lands"

by F. E. Price

Dean and Director of Agriculture
Oregon State University

creased efficiency of water use in agriculture and industry.

Another equally pressing demand for use of our wild lands is for living and playing space. Each year more homes are being built in wooded areas away from urban centers. This trend will continue at an expanded rate in the years ahead. Use of our wild lands for outdoor recreation has increased markedly in recent years and will increase many times in the future. Estimates have indicated as much as a 40-fold increase in the next several decades. Not only will we have more people—but these people will have more leisure time, more money to spend on recreation, and vastly improved means of transportation. Primary demands for outdoor recreation in our wild lands will be for hunting, fishing, boating, and other water sports in our streams, lakes, bays, and estuaries; and for camping and outings in our parks and wilderness areas. Maintaining our stock of wildlife and fish for future needs will require expanded research, as well as intensified management by public agencies in cooperation with private landowners.

Multi-use management needed

No longer is it possible for us to consider a single or even a dual use for much of our wild lands. Instead, they must be managed on a multiple-use basis. Fortunately it is technically and economically possible to secure multiple values from wild land management. These same lands serve as watershed, grow timber, produce forage for livestock and wildlife, and in many cases provide recreation areas. Thus the same lands produce multiple values, but they require careful management to do so. Research is necessary to provide the information on which multiple-use management systems are based. Governmental agencies responsible for the management of our federal lands, as well as private companies and individuals owning, using, and managing our wild lands look to Oregon State University and other research agencies to provide needed information and guidance. Our research and educational programs must be geared to meet this need.

Wild land research under way

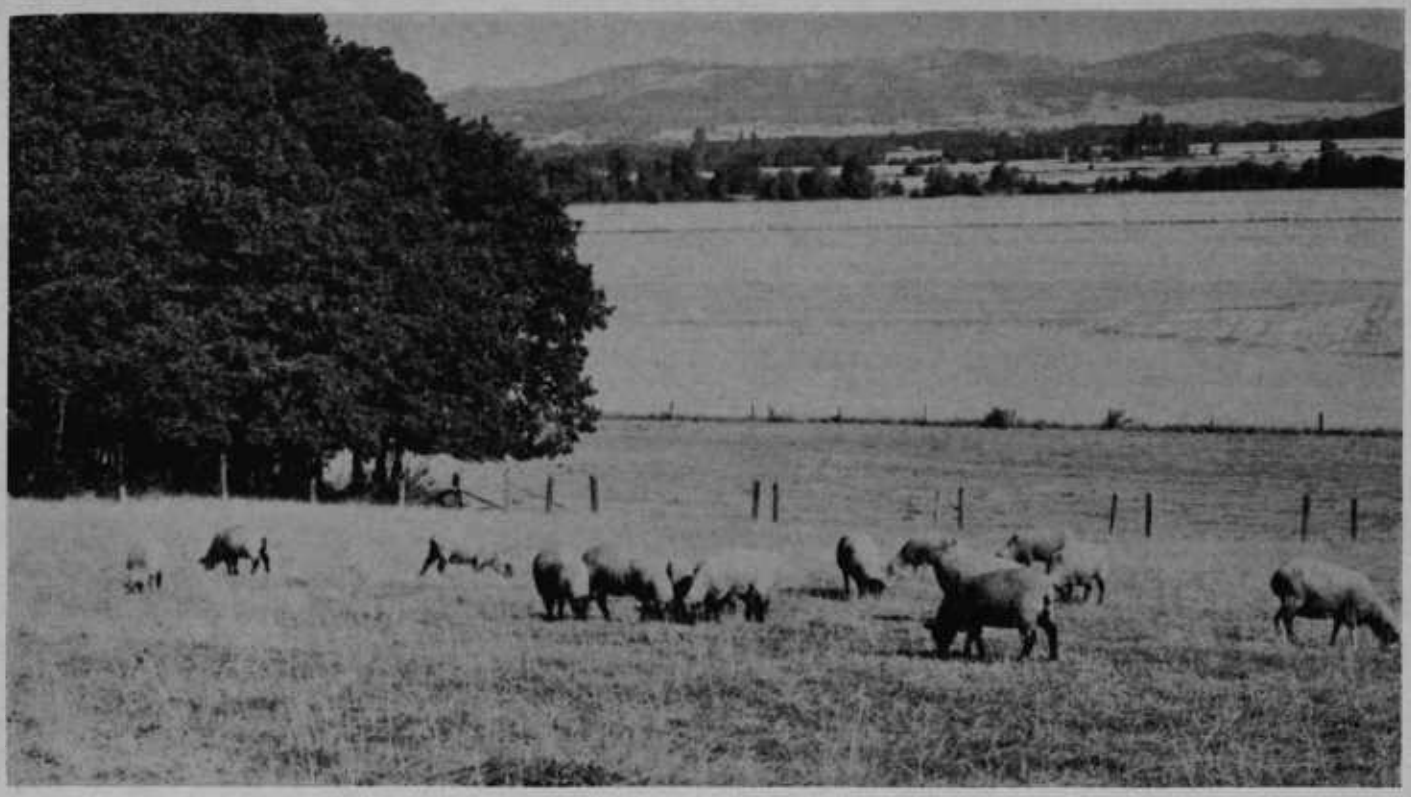
The lead story in this issue of *Oregon's Agricultural Progress* deals with methods of insuring proper inoculation of subterranean clover in seedings in western Oregon ranges and pastures. Extensive plantings of sub clover have been made throughout western Oregon since the introduction of this legume to Oregon from Australia in 1922. Even though sub clover

How to raise sub clover successfully, page 4.

is grown rather widely throughout western Oregon, there are still far too many seeding failures. The research reported in this article indicates that improper inoculation with nitrogen-producing bacteria is one definite source of failure. The article goes on to point out six steps for improving the odds for successful establishment.

Sheep grazing in new plantings of Douglas-fir—if managed properly—greatly increases the growth of these young trees, according to another article. The pros and cons of grazing reseeded forest areas have been debated vigorously for many years. Our research was aimed at establishing some concrete facts on the effect of grazing

(Continued, page 16)



CLOSE grazing of subterranean clover in the summer is a must if this annual legume is to reseed the following fall. Research at OSU indicates that sub clover also must be grazed early in the spring to hold back grasses and weeds. In May, June of first year, remove animals, let clover produce seed.

Let Bacteria "Fix" Sub Clover

That's one way to insure sub clover establishment. But to keep this important legume year after year depends on several key practices.

AGRONOMISTS Frank Crofts, left, and William McGuire check the ability of commercial inoculum to fix nitrogen on sub clover. Such strains should state "for use on subterranean clover" on container.

HAVING TROUBLE getting your sub clover established?

No matter how carefully you have prepared your seedbed nor how much of the right kind of fertilizer you have used, you won't establish this legume successfully until you properly apply the right kind of nitrogen-fixing bacteria, believes William McGuire, OSU agronomist.

Once established and managed properly, sub clover is capable of producing 3 tons of *dry* forage per acre (enough for at least three ewes and their lambs per acre yearly) on western Oregon dryland hill pastures.

But, partial failures in establishing

this legume have dragged out development for two to three years for many farmers, and there have been many complete failures. Research trials at OSU's Camp Adair hill pasture area as well as McGuire's observations of attempts to establish sub clover elsewhere in Oregon indicate much of the poor establishment comes from "ineffective nodulation"—inability to get the right kind of nitrogen-fixing bacteria associated with germinating sub clover.

AGRONOMIST McGuire checks seed "burs" in ungrazed sub clover pasture. He advises close grazing of summer forage to make sure sub clover seeds germinate in fall. Soil surface must be nearly bare.

Nitrogen-fixing bacteria needed

Effective nodulation is the first condition which limits legume establishment. Also, sub clover must have a specific strain of bacteria. Some bacteria will fix more nitrogen than others and if a high-fixing strain is not available, legume seedlings usually turn yellow and grow slowly or not at all—starving from lack of nitrogen. How soon seedlings turn yellow after establishment depends on the amount of nitrogen in the soil. On western Oregon hill soils, this is usually within a few weeks after seeding.

McGuire's research trials point to three important conditions necessary for successful sub clover nodulation by nitrogen-fixing bacteria:

¶ An effective and "invasive" strain of bacteria must be available. By effective, McGuire means it must have a proved high capacity to fix nitrogen when associated with sub clover. By invasive, he refers to the bacteria's ability to enter the legume root early and successfully in competition with native or less effective strains.

¶ Enough bacteria must coat the seed so there is a reasonable chance for the bacteria to invade and inoculate the legume—even after many bacteria have died.

¶ Soil conditions must favor multiplication of root-nodule bacteria so sub clover root hairs can be "infected" when they are ready for inoculation.

Preliminary experiments at Camp Adair in which strains of commercial inoculant have been tested, along with methods of application disclose:

1. Use only a proved strain of bacteria. Commercial strains are available, but they should state on the container, "For use on subterranean clover." Use the inoculant within the date stamped on the label.

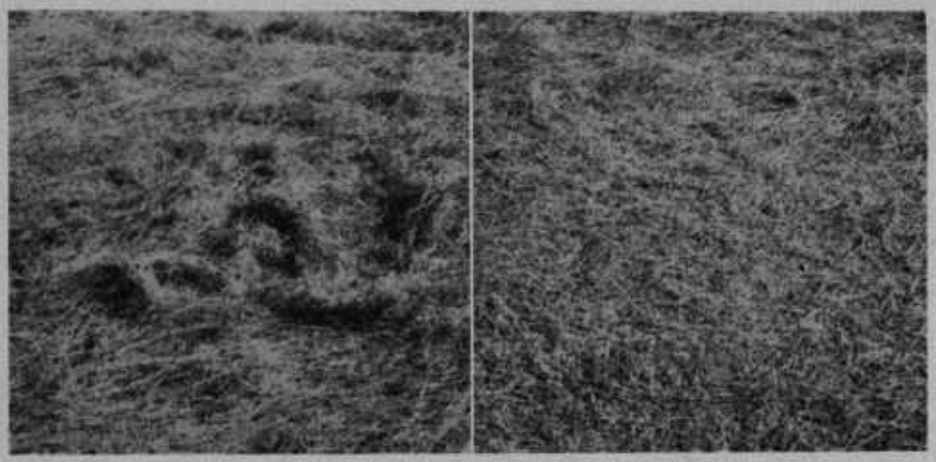
2. Use enough bacteria—at least several thousand per seed. Recommended rates on the container will supply this amount if properly applied.

3. Dampen seed with water or milk and stir until seeds are slightly damp. Then add inoculum and continue stirring until each seed is well coated. Plant as soon as seed will run through drill openings.

4. Inoculate just before seeding. Cover seeds in moist soil. Direct sunlight, heat, and drying kill bacteria. Wait until after the first autumn rain for seeding, even if it is until early October. Late seeding may reduce yields the first year, but soil moisture at planting time will help insure uniform effective nodulation, essential for a good seed crop in future years.

5. Highly-acid fertilizers in contact with inoculated seed kill bacteria. Such fertilizers should be bandseeded.

6. If inoculation fails, reseed. Surface inoculation with pure culture or soil usually is not successful.



SUB CLOVER will not germinate and become established the following year if a mat of forage covers seed, left. Result: grasses will dominate pasture mixture. Seeds will grow in grazed area, right.

Check for nodules

How can you tell if sub clover has been infected with desirable nitrogen-fixing bacteria? McGuire says you can tell quickly by digging a sub clover plant this winter, washing the roots, and checking for "effective" nodules.

These nodules, if formed by commercial inoculum, are about 1-inch from the crown—in the seeding zone

and on the main or primary root. If they were formed by effective soil bacteria, nodules will be on lateral roots at depths greater than 1 inch. In either case, they are about the size of a wooden match head, pinkish on the outside, and if fixing nitrogen, pinkish on the inside. These nodules become much longer by early spring. Ineffective—non-nitrogen fixing—nodules are dull and gray or whitish on the outside, white inside, usually more numerous and smaller than effective nodules. They are found mostly on lateral roots.

McGuire points out that legume seedlings build up resistance to other strains of bacteria once they have been invaded. This means that if a sub clover root is infected first with the improper strain, it is difficult for the proper strain to enter. Also, if the proper strain enters first, invasion by ineffective or parasitic strains is reduced. Thus, it's much easier to nodulate sub clover with an effective strain of bacteria in virgin soil or soil free of other legumes.

INOCULATED sub clover plant, in lower left corner, is healthy and vigorous. Legumes not effectively inoculated are the three stunted plants at upper right, grouped next to the pencil.

Management important

Getting sub clover properly nodulated may be the key so far but after the legume is established, first year management also determines how much forage your sub clover pasture will yield in the years ahead.

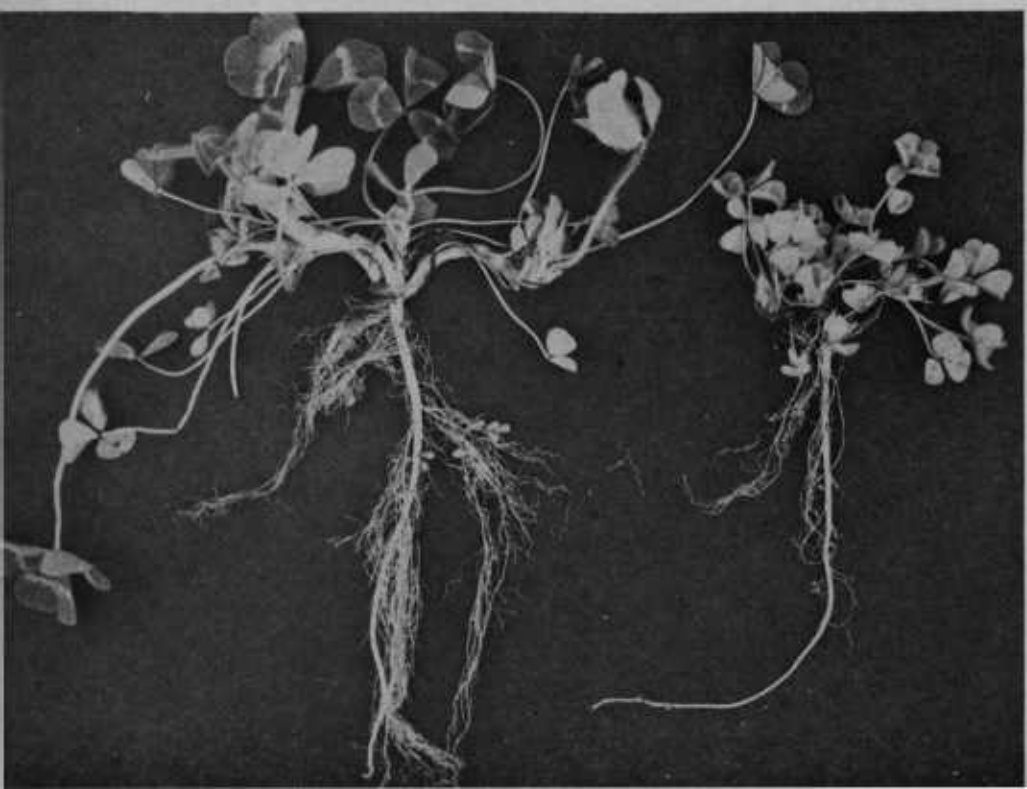
Here are some suggestions:

1. Fertilize on the basis of a soil test. In western Oregon, application of phosphorus probably will be recommended. See your county extension agent.

2. Graze early in the spring to hold back grasses and weeds. Begin grazing with first spring growth or as soon as soil is firm enough to support animals. In May and early June, remove animals and let sub clover produce as much seed as possible. It's important that large amounts of hard seed get into the soil. This insures sub clover survival in the years ahead. *Do not cut sub clover the first year, especially when grass is seeded with sub clover.*

3. Remove as much vegetation as possible during the summer, preferably by grazing, after seeds are mature. Sub clover will not germinate and establish the following autumn where vegetation covers the soil surface. *Soil surface should be bare.* This explains why sub clover often does not re-establish on irrigated pastures. Failure to fully use summer feed means lost feed, loss of clover, and dominance of grass in the pasture mixture.

SUB CLOVER, left, has been effectively nodulated; one at right has not. Note many large nodules along roots of legume at left. Few nodules on plant, right, typify non-effective nodulation.



Whether your sub clover thrives in succeeding years depends on two things, according to McGuire. One is maintenance applications of fertilizer in the fall. Second is removal of all vegetation during the summer to permit reseeding the next year. Sub clover is an annual pasture plant. It develops best under hard grazing and full use. After the establishment year, hay and silage can be cut early so enough seed is produced from regrowth, or cut late so some mature seed is left on the ground.

Sub clover is proving to be one of the most useful legumes for improved hill pastures in western Oregon, McGuire reports. Growth patterns coincide with feed requirements of sheep better than other legumes. Adding cattle keeps the pasture in better condition for sheep. Such pastures can help farmers of western Oregon hill lands increase livestock production.

Leafy Stems From Crested Wheatgrass

You can now control the kind of stems crested wheatgrass produces—coarse seed stalks or leafy shoots. And these leafy shoots can be grazed to produce either once or twice a year, depending on when cattle need feed most.

STUDIES ON HOW crested wheatgrass grows have given Squaw Butte range conservationists some new ideas for better grazing management.

It is now possible to manage crested wheatgrass to produce either one or two crops of stems on one year's moisture supply. The fortunate thing is that the rancher can control the kind of stems produced—either coarse seed stalks or tender, leafy shoots without seed.

Just grazing crested wheatgrass often encourages the kind of stemmy growth cows don't like. Carefully controlled grazing for "one-crop" production yields a high amount of forage and can avoid so-called "wolf plants." "Two-crop" management, however, favors growth of highly palatable, leafy stems. Using both systems, you can take better advantage of the good characteristics of crested wheatgrass, according to Don Hyder and Forrest Sneva, range conservationists at Squaw Butte.

All work reported was completed at the Squaw Butte experiment station west of Burns, where rainfall averaged 12 inches during the study years—1955-1960. The sites used naturally produced vegetation dominated by big sagebrush and bluebunch wheatgrass.

High quality hay provided

Hyder says this new, two-crop management will provide both high quality, late-seeded grazing and excellent May grazing on crested wheatgrass seedings.

Before explaining in detail how these grazing systems work, let's review what research workers found out about the growth habits of crested wheatgrass:

¶ Grass growth began, on the average, late in March, and the growth rate increased in May, was greatest in early June, and stopped in late June or early July. Heads were in the boot in late May, emerged from the leaf sheath in early June, flowered in late June, and seeds were ripe about July 20. Yields and duration of growth depended primarily on amount of precipitation.

¶ Herbage dry matter content increased from 28% in early May to 74% in late August. Crude protein content decreased from 14% in early May to 3% in late August. Protein yield was highest about mid-June, but dropped rapidly after that.

¶ Root growth was most active in April and ended about June 1. Plant food stored in roots accumulated in May, decreased slightly in June, and increased again in July.

It was the effect of clipping time on crested wheatgrass growth that led Hyder to suggest two grazing schemes. One scheme—"one-crop" grazing—provides the highest amount of feed per acre. The other—"two-crop" grazing—insures maximum *early* grazing at a time when it is critically needed, and also provides better quality late summer forage.

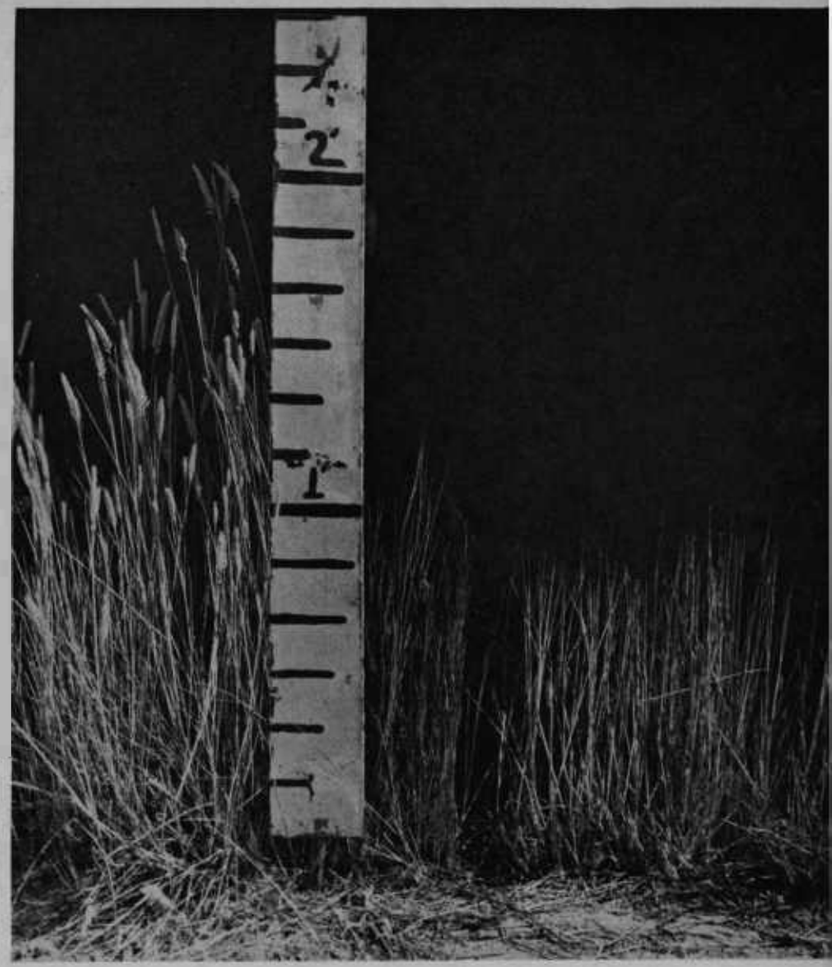
"One-crop" grazing works like this: Begin grazing crested wheatgrass about May 20 (or when seed heads are in the boot). Remove cattle about June 30 (or when seed heads flower). Adjust stocking rates so grazing is close and uniform.

"Two-crop" grazing is handled this way: Graze cattle from about May 1 (when grass is about 6 inches high) until May 20 (when seed heads are in the boot). Hyder emphasized that stocking rates should be adjusted so grazing is close about May 20. This stops further growth of wheatgrass seed stalks. If grazing is close enough and soil moisture is adequate, regrowth will be leafy. Close grazing at the proper time nips seed head development.

This forces the plant to start new growth. Moisture shortages in late June stop growth while it is still leafy—or before stems can be produced.

CATTLE like crested wheatgrass. You can count on good spring gains which last well into the summer when cattle graze this kind of crested wheatgrass. Forage quality doesn't last as long with cheat.

AFTER a long winter on dry hay, cows will like lush green grass. Most would prefer a little green grass than a whole load of hay this time of year. But if new grass is not available with some old growth, cows may lose more weight than they should in adjusting to new green forage. Crested wheatgrass fits this early spring need well. Close grazing is good for this grass then, since it forces leafy regrowth.



COARSE-stemmed crested wheatgrass, left, can be managed to produce either one or two crops of leafy stemmed grass, right. Note how much more tender and palatable grass at right appears.

If soil moisture reserves are adequate and this second crop is produced, the area may be grazed again after leafy regrowth has cured in late July or August and September. Amount of second crop grazing should be moderate.

Advantage of "two-crop" grazing is that it provides badly needed early grazing after root growth is well along and after the plant's food reserves have begun to accumulate. In addition, the second crop of leafy stems will keep the herd going in late summer.

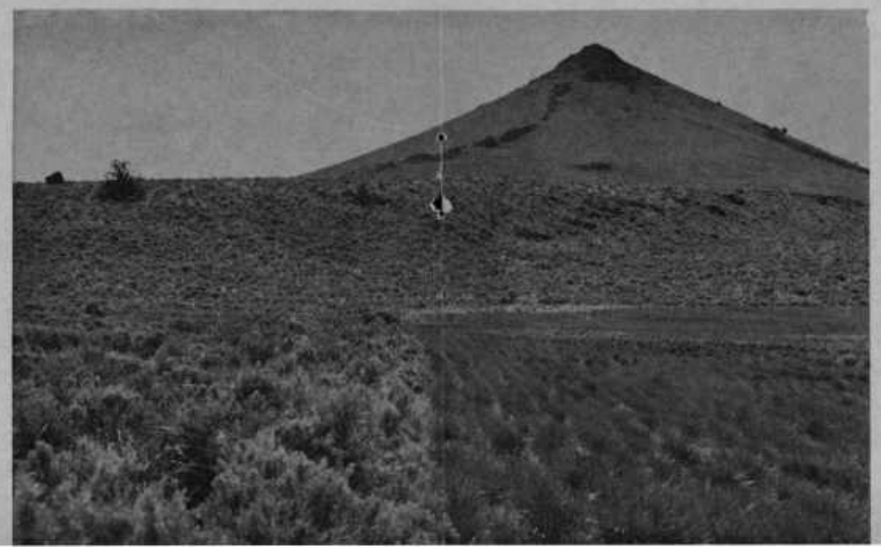
Hyder has proposed a system which combines "one-crop" and "two-crop" grazing. All details for application of the system have not been worked out experimentally. This is largely a matter for each rancher to fit into his own operation. One of the main values, according to Hyder, is using a combination of "one-crop" and "two-crop" grazing on crested wheatgrass seedings as part of an overall range improvement and management program. With a crested wheatgrass seeding fenced into three range units, for example, some ranchers easily could "one-crop" a unit one year, "two-crop" it the next two years, and then "one-crop" it again. By rotating the order of grazing annually each seeded unit would be grazed "two-crop" for two years and "one-crop" for one year, in every three years. Since both cropping systems would be used on different areas in the same year, excellent quality forage would be provided for about three out of the five months cattle are on the range.

Graze bunchgrass range

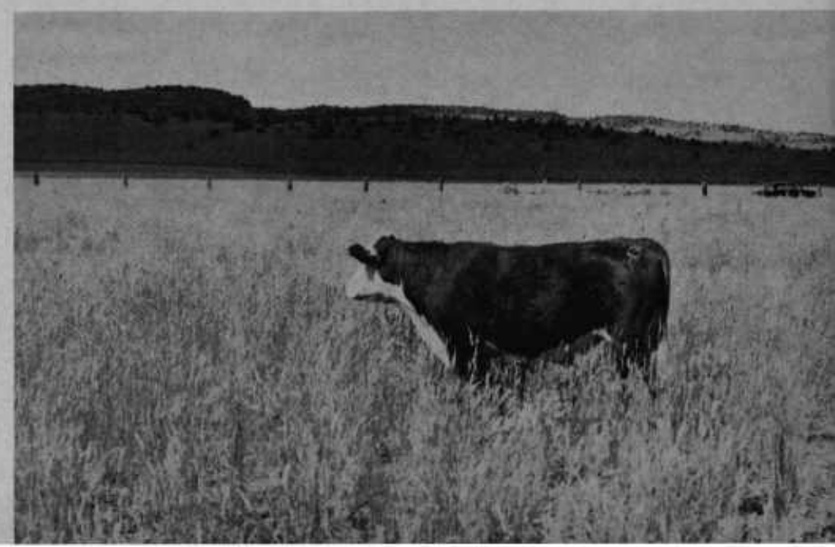
The other two months—July, August, or September—must be made up by grazing native bunchgrass range. This should not only provide high quality forage, but should improve the native range. Application of this system along with good seedings could decrease the grazing load on native range in the early spring. This "rest" is important to the natural improvement of native ranges. Other research at Squaw Butte has shown that such ranges will make phenomenal recovery —tripling beef production per acre, and at the same time growing more and better native forage plants each year.

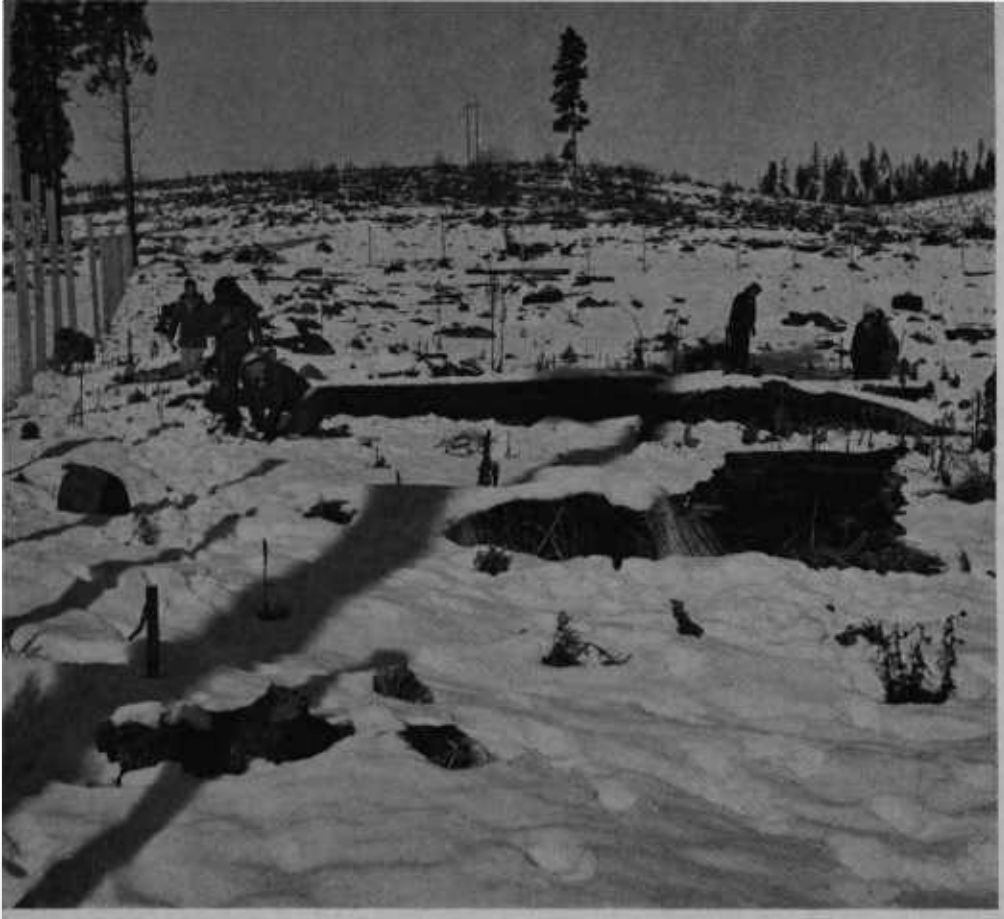
SECOND "stems" of crested wheatgrass look like this. One crop had been grazed when plants were 6 inches high and until heads were in the boot. This photo, showing regrowth, taken in early July.

SAGEBRUSH or grass. Forage yields in brush, left were about 80 pounds per acre, compared to 800 pounds for crested wheatgrass, right. Both cropping systems of crested wheatgrass were developed at Squaw Butte.



A GOOD steer on crested wheatgrass makes a profitable feeder at market time. Photo below gives you an idea of the high grass production you can expect from well-managed crested wheatgrass.





PONDEROSA pine seedlings were planted last fall and spring in mountains between Klamath Falls and Medford. Foresters are studying ways of starting new forests where natural production is lacking.

More Money From Better-Managed Farm Forests

OSU's Forest Research Laboratory reports ways to improve management of Oregon farm forests.

UNCUT young hemlock stand needs thinning to speed growth of better 10-40-year-old trees.

OREGON FARMERS can increase timber yields and farm income by applying research results in forest management, according to Dale Bever, head of research in forest management at OSU's Forest Research Laboratory.

Almost 3 and a half million acres of commercial forest land in Oregon are owned by farmers. This acreage amounts to more than 13% of Oregon's commercial forest land. Farmers can contribute substantially in providing raw materials for the state's largest industry, if farm forests are kept in managed production, continues Bever.

Some large areas present no great problems, because natural reproduction and growth are providing for future harvests. Other areas, however, are difficult to restock, or require treatment to grow good timber rapidly.

Examples of areas where forest scientists are seeking ways to grow new forests are in southeastern Jackson County, where lack of natural seed sources and severe climatic conditions are handicaps, and along the coast where gorse has infested pasture land over thousands of coastal acres.

Pine planted

On Greensprings Mountain between Medford and Klamath Falls, 16,000 ponderosa pine seedlings have been planted to learn effects of various conditions on survival. Conditions studied are exposure to, or protection from deer, cattle, and rabbits; planting in fall or in spring; planting with bar or hoe; planting at two different depths; age and transplanting treatment of seedlings; and origin of seed.

Half of the seedlings were planted late last fall, and the second half were planted as soon as the area was accessible in the spring of 1961.

Plantings are too young to assess effects of most of the variables, but first inspection showed that considerable damage from frost heaving of seedlings planted in the fall was exceeded by mortality among seedlings unable to establish new roots quickly enough to withstand dry summer conditions after spring planting.

Gorse control studied

Study of ways to control gorse along the coast was started several years ago near Port Orford with attempts to find a tree that could compete successfully against this fast-growing weed.

Monterey pine showed promise in early plantings, and a 5-acre plot south of Bandon was selected for further trials with this tree. Early this year, the area was prepared for planting by bulldozing the gorse into piles. Seedlings of Monterey pine then were planted at the rate of 1,000 to an acre. The plot will be observed during the next 30 years to see if the planted seedlings can win in competition with gorse.

Gorse is exceedingly difficult to combat economically. High-value land can be cleared by killing gorse with chemi-

cals, but cost is too great for much of the area now infested.

Gorse can be highly inflammable, but burning it merely provides heat which germinates seeds buried in duff, and a new crop returns. Similarly, removing gorse with tractors is only temporary. Hope is that a fast-growing tree might kill the pest by shading it. Gorse cannot survive shading.

In other areas, crops of timber are established already, and the problem is to treat young stands so that quality is improved and yield is increased. Several young stands are being treated in various ways to learn which is best.

Silviculturists at the Oregon Forest Research Center are studying effects of various methods of thinning young Douglas-fir in five areas near Gates, Wilark, Monmouth, Burnt Woods, and Black Rock. These stands range from 20 to over 50 years in age.

HORSES are excellent for yarding small logs of young (60-70 year) Douglas-fir. Costs are low and horses rarely damage timber. If trees aren't too big, horsepower is efficient for farm woodlots.

Thin young stands

Evidence is accumulating that properly applied cuttings in very young trees will hasten the stand to an economic size and assist in realizing the full timber potential of the site. Methods followed, and costs of making one such thinning in a stand near Burnt Woods will be outlined in a report to be printed soon. Early figures indicate that small sawlogs and pulpwood from the thinning will more than pay for the work, with improvement to the stand an added bonus.

First thinning in a precommercial stand of 17-year-old Douglas-fir on the Jack Stump farm near Monmouth indicated the most economical procedure was to cut trees with a low crown and let them lie where they fell. Falling time amounted to 5½ man-hours an acre, with improvement to the stand as the primary return. Succeeding thinnings in such stands will have increasingly greater returns, study shows.

Cutting in intermediate stands of Douglas-fir was made with horses and rubber-tired farm tractors. Damage to trees left standing was slight. Horses proved economical and dependable.

Various silvicultural treatments also are being tried at four different locations on precommercial stands of western hemlock. Vigorous growth of young remaining trees is expected to result in a stand of improved quality with increased resistance to wind, and wood normally lost through growth suppression will be salvaged.

Immediate economic effects of the various treatments, while important, will not be the only knowledge to be gained from the studies. Studied at the same time are various other things, such as the nutrient cycle in forest trees, interrelationships of stand condition, infestations of insects and fungi, rate and periodicity of seed fall, effect of stand condition on temperature and runoff, and role of microorganisms in the soil.

Other studies under way

Most studies now in progress will continue many years before final results will be possible, but valuable information developed as study proceeds will be published as it comes to light.

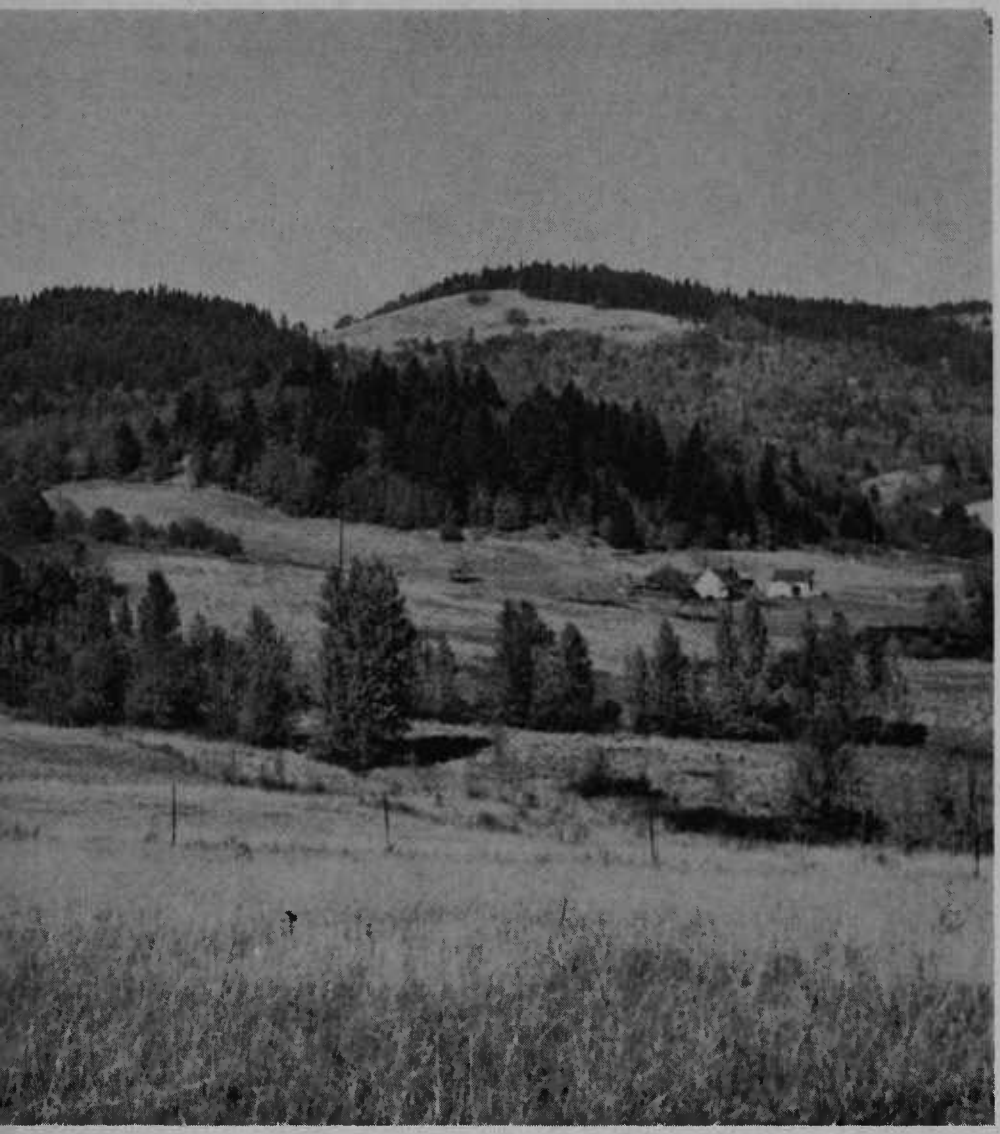
The work described here is only part of the effort being made at the Forest Research Laboratory to achieve full productivity from our forest lands and complete use of the harvest through increased volume and variety of products with improved serviceability and added market value.

RESEARCH Silviculturist Rudolf Kangur checks a stand of thinned hemlock in the Coast Range near Tillamook. More than two-thirds of the dense stand was cut to encourage faster growth of better trees. Poorly-shaped and defective trees were cut. Tags indicate which trees are not to be cut.

Using sheep to remove excess forage releases soil moisture for Douglas-fir seedling growth, report OSU foresters and animal husbandmen. Sheep gains are nil, but tree growth increases are high especially in cleared plots.

Sheep Can Increase Douglas-fir Seedling Growth

FARM forestry can make oak land more productive. Research at OSU shows that careful sheep grazing can speed replacement of oak by Douglas-fir. Much oak land will raise good Christmas trees.



PROPER SHEEP MANAGEMENT can increase the height of planted Douglas-fir seedlings an average of 13 inches—27%—in six years, compared to ungrazed areas.

That's the report from a team of OSU range scientists and foresters. They are testing the long range effects of sheep grazing on Douglas-fir planted in scrub oak areas typical of Willamette Valley foothills.

In fact, height growth during 1960 —the last year of the experiment— averaged 48% more on grazed areas compared to ungrazed plots. Where oak was clear-cut and planted to Douglas-fir, height growth in 1960 was almost doubled—due to properly managed sheep grazing.

The important key, according to range scientists D. W. Hedrick and F. C. Hall, and forester R. F. Keniston, is to use sheep to *remove* only excess, palatable forage. Start grazing only after the leaves of such forage plants are about two-thirds developed. Watch the animals carefully and remove them when they fail to gain.

Sheep gained slightly

After six years, the research workers found that reasonable sheep gains were made only on clear-cut areas and on areas where about half the oak was thinned, then planted to Douglas-fir. Regrowth of oak sprouts and other weedy shrubs reduced available forage after the third year of grazing. Without sprout treatment, further grazing probably would not pay.

Height differences in Douglas-fir

DOUGLAS-fir seedling growth increased tremendously in areas where scrub oak had been clear-cut and where sheep had grazed a few weeks each spring, compared to ungrazed area in photo at right.

DOUGLAS-fir grew fast in cleared and ungrazed plots, but not as fast as in grazed plots at left.

growth were remarkable. Sheep removed enough forage so that young Douglas-fir did not suffer from lack of water. Soil moisture data indicated that grasses and other forages used enough water to limit Douglas-fir growth. By using sheep to remove forage, more soil moisture was diverted for young Douglas-fir growth.

Other pasture needed

Details on sheep management, however, have not been worked out. But research workers have some good leads. Better Douglas-fir growth probably cannot be obtained unless you have some other good pasture to support sheep when they are not on your woodland. In this experiment, sheep were grazed only during the spring growing season. They were removed when about half the forage had been harvested or when sheep failed to maintain their weight. Turn-in date is important. You must have the forage growing rapidly and ahead of the animals or they will browse on Douglas-fir—particularly when new twig growth is just beginning to show. Research workers found only neglible browse damage when sheep were turned in about April 25 (plus or minus a week).

Sheep gained up to 40 pounds per acre in two to three weeks of grazing on the clear-cut but unseeded plot for two to three years after seeding. Gains dropped, however, to less than 10 pounds per acre in five years. In 1960, sheep lost weight in the clear-cut plot because oak sprouts and shrubs crowded out forage. On unseeded, unthinned plots underplanted to Douglas-fir, gains were minor throughout the six-year trial—averaging less than 5 pounds per acre.

On plots thinned of slightly over half the oak, sheep gains were reasonably good for the first two years, averaging about 23 pounds per acre. But recently, they have varied from a low of 2 to a high of 11 pounds per acre, averaging about 5 pounds.

Cutting oak increased fir growth

Thinning and clear-cutting oak also increased Douglas-fir growth. Clearing oak before planting increased the height of Douglas-fir seedlings. Those planted in ungrazed but clear-cut plots were nearly twice as high after six years as seedlings on ungrazed plots in which no oak was cut. Seedlings planted on thinned plots grew about 50% more than fir on unthinned plots.

Where sheep were grazing half of all plots (uncut, thinned, and clear-cut) fir seedlings grew about 25% taller on the grazed than on ungrazed plots in the six-year period. Considering all grazed plots, Douglas-fir seedlings were about 13 inches higher than on all ungrazed plots.

FIR planted on oak-thinned plot did not grow as fast as trees planted in cleared plots.

UNGRAZED oak-thinned plots did not produce as much fir growth as thinned, grazed plot above.

ONE WAY to reduce bark beetle damage is to remove trees already killed by beetles. This reduces exposure of good timber to beetle flights. Foreground and patches of clear-cut areas are examples.

Basic Research Suggests

Bark Beetle Control

Basic information on how water moves up trees as well as the role of resin pressure may provide answers for controlling beetle attacks.

SOME DOUGLAS-FIR and ponderosa pine trees repel bark beetle attacks. Others do not. Why some trees can or cannot withstand such invasions has led a pair of forest entomologists to develop a simple method for predicting which trees are vulnerable and which are not.

The entomologists, J. A. Rudinsky, Oregon State University, and J. P. Vite of the Boyce Thompson Institute for Plant Research, Grass Valley, California, report their use of tree physiology theory can help foresters in their battle to protect our forests from the ravages of beetle attacks.

Forest insects kill or make unusable an amazing amount of timber.

In the United States, forest insects last year killed enough timber to build about 600,000 five-room houses—five or six times as much timber as lost to fire. In Oregon and Washington, bark beetles destroyed over three billion board feet of green Douglas-fir from 1949 to 1954—enough to build more than a half million five-room houses. In Oregon, these beetles killed more than 12 billion board feet of pine from 1921-1937.

Forest insect control is complicated by several things. One is that the Pacific Northwest's great continuous stands of the same kind of trees are highly susceptible to massed insect invasions over tremendous areas.

Basic to control, however, is to find the natural source of resistance. Basic information is also needed about how trees transmit food and water.

Once this research foundation is laid, efficient methods of controlling insect scourges can be developed.

Developing this foundation has received the entomologists' attention. And already it has paid dividends in showing which trees probably are or are not vulnerable.

The method was simple. A small pipe was inserted into the tree's sapwood and a small gauge tightened on the other end. Sapwood resins filled the pipe, and daily and seasonal pressure changes were observed. Field trials showed that trees which could withstand beetle attacks usually maintained at least twice the pressure of trees which succumbed.

This was particularly true when beetle populations were low—where the beetles could "choose."

Why such a simple device works goes back to basic understanding of tree physiology. The entomologists report two reasons why a tree—any tree—tries to repair a sapwood-penetrating wound. One is production of wound-healing resin. The second is the pressure of certain cells which surround resin channels. These cells "push" resin into a wound. When cell tension was high, the researchers reasoned the tree was in good shape to repel attacks simply because sufficient resin could be "pressured" into any wound—such as those bark beetles make. But if pressure was low, an insufficient amount of resin was pushed into the wound. Resins often killed beetles on contact. And, in the case of healthy pines, resin pressure also washed adult beetles from the tree. High oleoresin pressure is the result of balanced water relationship in the tree.

Theory tested

The research job was to test this theory. The simple gauge was developed and tested. Pressure of 424 California ponderosa pine trees was measured. Rudinsky and Vite classed 186 as potentially susceptible to beetle attack, 91 as moderately susceptible, and 147 as potentially resistant. Beetles

successfully attacked 34 susceptible trees (18%) killing 33 of them. They successfully invaded 18 moderately susceptible trees (about 20%) but killed only 6. Beetles invaded only six potentially resistant trees (less than 5%) and killed only one.

The trial was repeated with an 80-200-year old stand of western Oregon Douglas-fir. This stand, however, contained a large proportion of trees infected by fungus. Pressure of these fungus-infected trees at time of beetle flight (April-May) was about half that of healthy trees. Beetle population was low, and infestations were confined to fungus-infected, windthrown, and fire-killed trees—all with low resin pressure.

ENTOMOLOGIST J. R. Rudinsky notes fluctuations of resin pressure of a Douglas-fir. He has found that resin pressure is a good index of how well a tree may or may not resist massed beetle attacks.

Resistance predicted

What researchers have shown to date is that it is possible to predict fairly accurately—by their physiological condition—which fir or pine trees are likely to resist beetle attacks.

Combined with other work on how trees transport water up and send food down to roots for storage, this research can add basic facts necessary for improved chemical insect control.

The entomologists report, for example, that for pine, water ascends in a spiral, moving smoothly from the outer sapwood toward the inner part of the sapwood or xylem tissue. With Douglas-fir, water ascends in a spiral, but zig-zags within a quarter section of the tree.

Other methods of water transport have been noted with other trees, and practical application for insect control with systemic chemicals is apparent: You can predict where these chemicals move in the tree after they are sprayed or injected at the base of the tree, and if they will be located where they can kill feeding insects.

If water rises in a spiral, the whole trunk does not need to be sprayed. A systemic insecticide would move to all sides of the tree crown as it rose up natural water-conducting tissue. But if water goes straight up, more complete root and trunk coverage would be necessary.

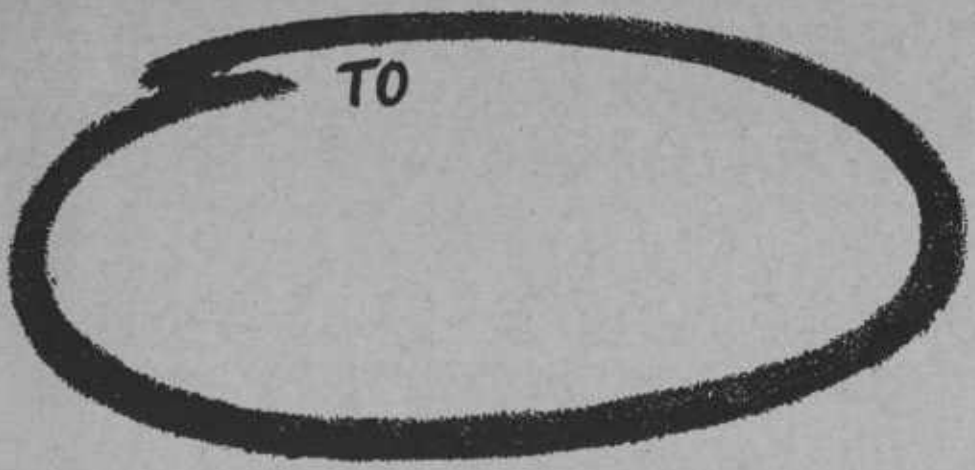
Type of water-conducting system also is important in tree survival. Since most branches are connected with every root in the spiral system, loss of individual roots will not endanger specific parts of the tree and make them susceptible to bark beetles—as it would if water ascended in a straight line.

Possibly more important, however, is finding out what is not yet known: A description of how food moves from a tree's crown down the tree to the roots. This is particularly important because the tissues used for such food movement are located next to the bark. Sapwood tissue is located further in the tree. And most bark beetle larvae kill trees by girdling or gouging out a ring of essential food-transporting tissue.

Once it is known how food is circulated within the crown and transported down the tree, practical suggestions for airplane applications of systemic insecticides, for example, may be made. If food descends in a spiral, the whole crown does not need to be sprayed. A systemic insecticide would move to all sides of the tree as it passed down natural food-conducting tissue. But if food goes straight down, more careful crown coverage would be necessary.

But this research is for the future. The important thing to note, according to the entomologists, is that practical facts usable to others are based on fundamental knowledge which often takes years to accumulate. Theories of how trees resist beetle attacks, and how food and water move up and down trees, for example, are essential before researchers can develop useful guides for better control of forest insects.

ABILITY of natural predators and parasites to kill Douglas-fir bark beetles is tested inside caged sections of this log. Various densities of parasites are being tested. Uncaged sections of log are controls—where no natural parasites are introduced. Predators include Checker, Ostomid beetles.



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Better Use . . .

(Continued from page 3)

Grazing can increase Douglas-fir growth, page 12.

sheep on new Douglas-fir plantings. Our results suggest that sheep are compatible with and actually benefit new trees if grazing is *closely controlled* and the sheep are removed after they have eaten the competing forage plants.

A basic study of how crested wheatgrass grows—how and when it sends up shoots in relation to how it is grazed—sets the stage for new management systems in the range areas of eastern Oregon. This research, as reported in another article, was conducted as a part of the cooperative federal-state Squaw Butte experiment station program.

Get the most from crested wheatgrass, page 7.

The other two major articles deal with forestry research. One reports on research under way in the Forest Management unit—one of two units comprising the OSU Forest Research Laboratory. This Laboratory is the newest unit of the Experiment Station, having joined us in July of this year. Previously this organization had operated as a separate state agency. Needless to say, we were extremely pleased when this Laboratory became part of the Station. It places our research effort in the field of forestry second to none among University programs in the nation. Improving the establishment of new tree plantings, combating gorse with Monterey pines, and management practices to improve tree growth and development are all discussed in this article.

Starting and managing farm forests, page 10.

Control bark beetle via basic research, page 14.

The bark beetle, one of our most destructive forest insects, is the subject of the final article. Why some trees can withstand invasion by these beetles while others cannot has led forest entomologists to search for a simple method of predicting which trees are vulnerable and which are not. Such a tool could be of great value in combating this pest in the future.

These five articles represent only a cross section of the research program under way to improve the management and productivity of our wild land resources. Many other projects are under way in the fields of forestry and range management. Still other projects are concerned with the recreational aspects of our wild lands. Major research effort is devoted to our sport fishery resources and to wildlife management. Much of this research is conducted on a cooperative basis with the Research Division of the Oregon Game Commission. Other research in various basic biological science fields produces results which are applicable to wild land problems.