L. A. CARTER file

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FIRE CONTROL NOTES

A PERIODICAL DEVOTED TO THE TECHNIQUE OF FOREST FIRE CONTROL

FOREST SERVICE • U. S. DEPARTMENT OF AGRICULTURE

FORESTRY cannot restore the American heritage of natural resources if the appalling wastage by fire continues. This publication will serve as a channel through which creative developments in management and techniques may be communicated to and from every worker in the field of forest fire control.

Volume 19 Number 4

FIRE CONTROL NOTES

A Quarterly Periodical Devoted to the

TECHNIQUE OF FOREST FIRE CONTROL

The value of this publication will be determined by what Federal, State, and other public agencies, and private companies and individuals contribute out of their experience and research. The types of articles and notes that will be published will deal with fire research or fire control management: Theory, relationships, prevention, equipment, detection, communication, transportation, cooperation, planning, organization, training, fire fighting, methods of reporting, and statistical systems. Space limitations require that articles be kept as brief as the nature of the subject matter will permit.

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Forest Service, Washington, D. C.

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NOTE: The April 1959 Fire Control Notes will emphasize Fire Control Training. Special assignments of certain articles have been made but the editor would welcome additional items on this general subject. These must reach the Washington office by January 15.

EQUIPMENT DEVELOPMENT AND FIRE RESEARCH[1]

MERLE S. LOWDEN
Director, Division of Fire Control, U. S. Forest Service

People look at equipment development in a variety of ways. Some think of it as a mechanic with a monkey wrench tinkering with a machine that never works when you most want it. Others think of it as scientific research with complicated chemicals, formulas, and machines. Somewhere between these two extremes lies equipment development as we are trying to approach it in the Forest Service and as I see it in relation to the fire control job. Surely it has a very close tie to research, but there is a difference. Working as a team we must depend upon research to find the fundamental facts and to determine relationships between cause and effect.

Equipment development takes the results of research and tries to find a way to do it with machines. Let me take an example to illustrate this point. We are hearing a lot these days about aerial attack on fires with fire retardants. Research, development, and trial use were combined in the Operation Firestop project several years ago in California. One of the basic research studies at that time was to try many chemicals and compounds to test their value as wildfire suppressants and retardants. The most successful found by those tests was sodium calcium borate which is now becoming widely used. Also a part of the Firestop operation was the study of cascading water from an airplane from various heights to determine distribution and effectiveness on the ground. It was a logical step to mix water with the successful retardant and to apply the mixture from the air.

Actually doing the job, of course, is much more complicated than thinking about it. This took a great deal of analytical calculation and study, adventuresome imagination on the part of the field men in testing, good engineering in figuring the types of gates and openings to use for tanks, and the combining of many skills. The operation, while successful, is still in its infancy. However, this year there are 70 planes in this country available and equipped to attack fires from the air. Progress from an idea to a successful operation required a continuously working team of research, equipment development, and the actual users (or fire fighting organizations).

Most of our equipment development requires this same type of teamwork. Somebody must take an idea or research result and build or adapt a machine to it that is successful in field operation.

[1]Taken from a paper presented at the Region 9 Fire Committee Meeting, Grand Rapids, Minn., June 12, 1958.

In its application to the field there is another highly important task for research. This is in setting up procedures and methods for evaluation and in giving technical advice on the evaluation and analysis of results as they come from the tests.

There are many supplemental features or accompanying steps in equipment development. Often times we can get results by having industry do the job without any immediate cost to the Government. This we try to do as often as we can. In many cases after an article shows wide application with sufficient opportunity for profit in its manufacture, the development will be carried forward by some manufacturer. Field radios are a good example of this. The Forest Service did the early development work and made the first sets. They continued for a time to develop and make pilot models. Later manufacture of these models was contracted. As this business expanded to many agencies and small radios had widespread use, leading manufacturers began their own development program. At present the Forest Service mainly carries its needs to the manufacturers, checks and works with them in development, and tests results. Practically the entire job is done by private industry.

Another supplement to development is to take a product used for one purpose and adapt it to another. Through such trial use we may discover an article that fits our fire needs. A good example of this is the use of the railroad fusee for backfiring.

Equipment development frequently leads to standardization and ties in with specifications for manufacture. It is hard to separate these parts of the total job.

Another task that goes with development is getting people to use the new article. Regardless of how good a "mousetrap" we develop, it doesn't amount to much if nobody uses it. We have some glaring examples where we have spent much money and developed a fairly good product but have done a poor job of selling it for field use. Our fireline trenchers are somewhat in this status.

We have many methods of selling ideas. Written material, such as technical bulletins, progress reports, magazine articles, and handbooks, has its value. Demonstrations are a tested method and have been used a great deal by your group. "Chautauqua" tours are not as common but have been used with good success. Those developing trail-building equipment in the West have had outstanding success with demonstration tours. In the Forest Service we often use the free sample method; that is, we fully or partially finance from the Washington Office an early model. Regions or forests may be reluctant to spend their money on a new item, but once they try it and it is successful they are very willing to use their funds to buy more. It is always possible, of course, to issue orders to use new equipment but if this is necessary we have failed somewhere in the selling job.

I might say something about the Technical Equipment Board system in use in the Forest Service. We have a rather large board in the Washington Office appointed by the Chief and drawn from various units which have an interest in equipment development. Many of the regions have smaller but similar groups. Field units make proposals through the regional boards in a prescribed manner. Field folks at all levels are encouraged to suggest projects to be included in the equipment development program.

Proposals are reviewed within each region and those which find favor are recommended to the Chief's office for further consideration. There they are reviewed by the functional division that has the greatest interest in the project. For fire equipment this would be in the Division of Fire Control. The functional division reviews and recommends projects for coordination by the equipment board. This board prevents overlapping or duplication and arranges joint financing where several functions are interested. It brings together many interests and often a new machine or idea is found to have many applications in different forestry functions. Some modification may make a machine useful for many jobs. Each functional division thus can plan its program, and carry through on the introduction to field units. The equipment development program for the Forest Service is coordinated by the Technical Equipment Board and the action plan issued for each fiscal year.

Actual development work is done in many locations throughout the country but our main efforts have been concentrated in a few equipment centers. At Arcadia, Calif., we are concentrating on pumps and tankers, small mechanized handtools, helicopter accessories, aerial tankers, spark arrestors, and machines for testing other machines and apparatus. At Missoula, Mont., work connected with smokejumping and air cargo transportation is underway. This includes new and different parachutes, cargo packaging, protective clothing, letdown equipment, and other aerial items. We have also done most of the fireline trencher work there. A development center somewhere east of the Mississippi River has been under consideration for some time.

Radio and electronic work is now concentrated at the Beltsville Radio Laboratory outside of Washington and we have recently strengthened and broadened the work there.

Some projects are done at the experiment stations and in the regions. Methods of air cargo delivery and water transportation by plane have been worked on for several years by the Superior Forest at Ely. The Forest Service for many years carried on joint work with the State of Michigan at Roscommon. After a lapse of a few years we again have an agreement and are working with them on development of a sandthrowing machine.

Equipment development work in fire control may be classed in various ways. I like to think of it as falling into two main groups. The first is that in which known and tried items are improved or further developed. Many of these are continuing jobs such as those in our smokejumper project where we are continually improving parachutes, rigging, protective clothes, and similar items. The second is the pioneer type in which we explore new fields and new ideas, such as large-tire carriers and fire suppression rockets.

FIRELINE TRENCHER ATTACHMENT FOR POWER SAWS

RAYMOND M. WEST, *Anaconda Forest Protection Service,* and ROBERT W. STEELE, *School of Forestry, Montana State University*

The power saw trencher is a lightweight combination trenching and cutting machine for fireline construction. It consists of two spiral augers mounted on a shaft at the end of a standard chain saw blade (fig. 1). The teeth of the cutting chain turn the augers by means of a sprocket in the center of the shaft.

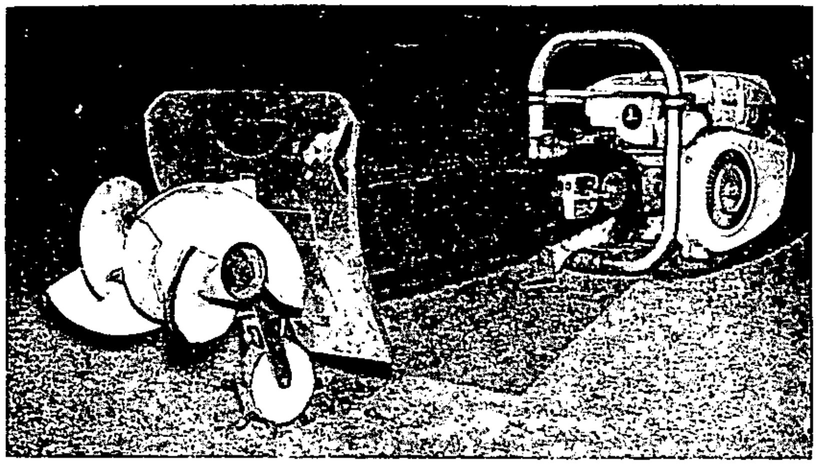

FIGURE 1.—Powered lightweight trencher. Note two-way spiral augers and the small support wheel.

The two-way spiral augers are 7 inches in diameter. Each is 6 inches wide so that a trench a foot wide can be constructed (fig. 2). The augers are made of abrasion resistant steel and are keyed to a shaft which is mounted in bearings on the sides of the blade.

Power from the saw motor is supplied to turn the augers through the cutting chain as the chain moves along the blade and engages the sprocket. The rotating augers throw dirt to both sides, making a clean trench.

In operation, the machine is held at a steep angle while resting on a small support wheel (fig. 1) mounted directly below the blade. The depth of trench can be varied by raising or lowering the handle of the power saw motor to engage the rotating augers in the soil. A guard protects the operator from flying dirt and stones. The suggested method of use is with a 3-man crew, one with the trencher, one with a pulaski for heavy cutting and digging, and one with a shovel for line cleanup.

FIGURE 2.—A foot-wide trench can be cut.

The machine digs readily through sod and duff to mineral soil. It throws needles and other forest litter out of the trench, and is easily moved along the fireline. It can be operated both forward and backward on slopes or level ground. When necessary to cut a windfall or snag during the construction of a fireline, the machine is used as a conventional power saw, there being sufficient length of cutting blade back of the protective guard (fig. 3).

The advantages of this combination cutting and digging power tool are—

It is small and light, and can be transported anywhere about a fire.

It can be packaged for aerial delivery.

The unit complete with blade, chain, and augers weighs approximately 10 pounds.

FIGURE 3.—Machine used as a conventional power saw on a windfall.

It can be used on most standard chain saw motors and is easily attached by simply removing the original blade and chain.

No special training is needed to operate it.

It can produce an effective fire trench rapidly by mechanical means.

TRACTOR HEADLIGHTS

A. B. Everts
Equipment Engineer, Division of Fire Control, Region 6, U. S. Forest Service

Region 6 was asked to develop a lighting outfit for tractors. This outfit was to fit on any tractor rented for fireline construction. Field sampling of opinion indicated that there should be three lights, two forward and one backup, and that the direction of each beam be adjustable.

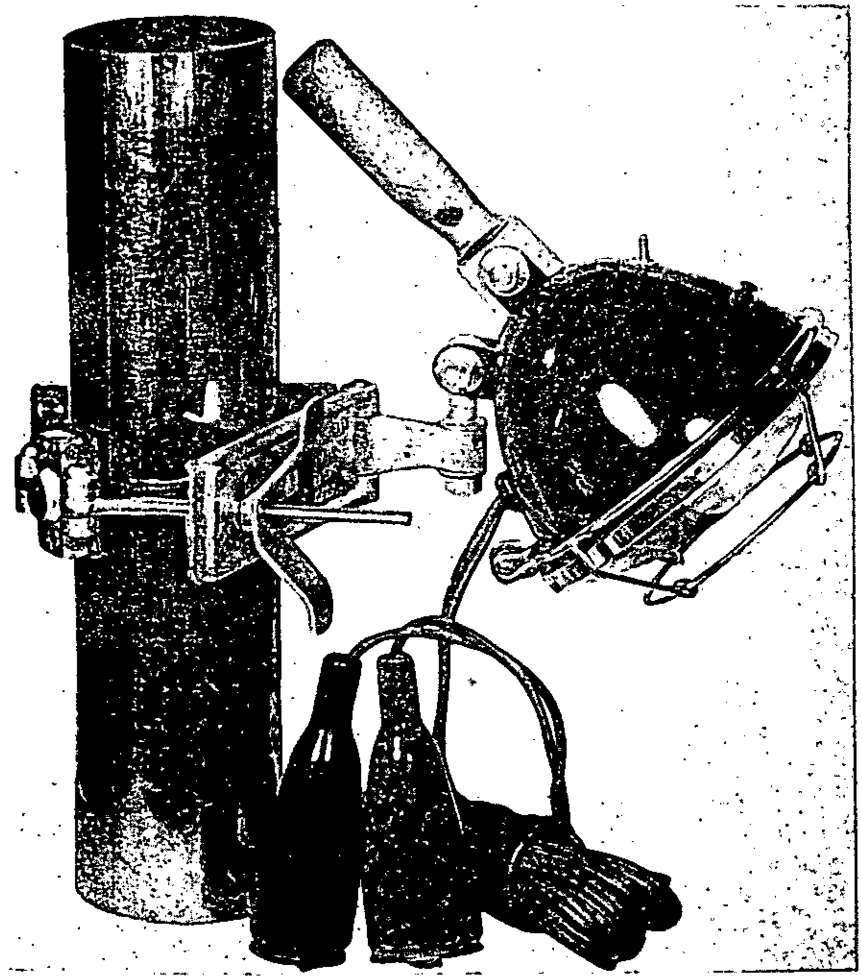

FIGURE 1.—Universal clamp will fit either round or square canopy supports. Clamp is lined with brakeshoe material to provide a sure grip.

The first problem to solve was how and where the lights should be attached to the tractor. Most logging tractors are equipped with canopies. In many States the law requires that they be so equipped. These canopies, however, are not all of the same design. Some of the supports are round, and some of them are square. The clamp designed will fit either type (fig. 1).

Some tractors are equipped with batteries. These may be either 6 or 12 volt. The kit, therefore, contains both 6- and 12-volt light bulbs. Alligator clip quick connectors provide a means of clamping the headlight wires to the wet battery. If the rented tractor has no battery, then 12 No. 2 dry cells can be used. These are connected in groups of 4 each.

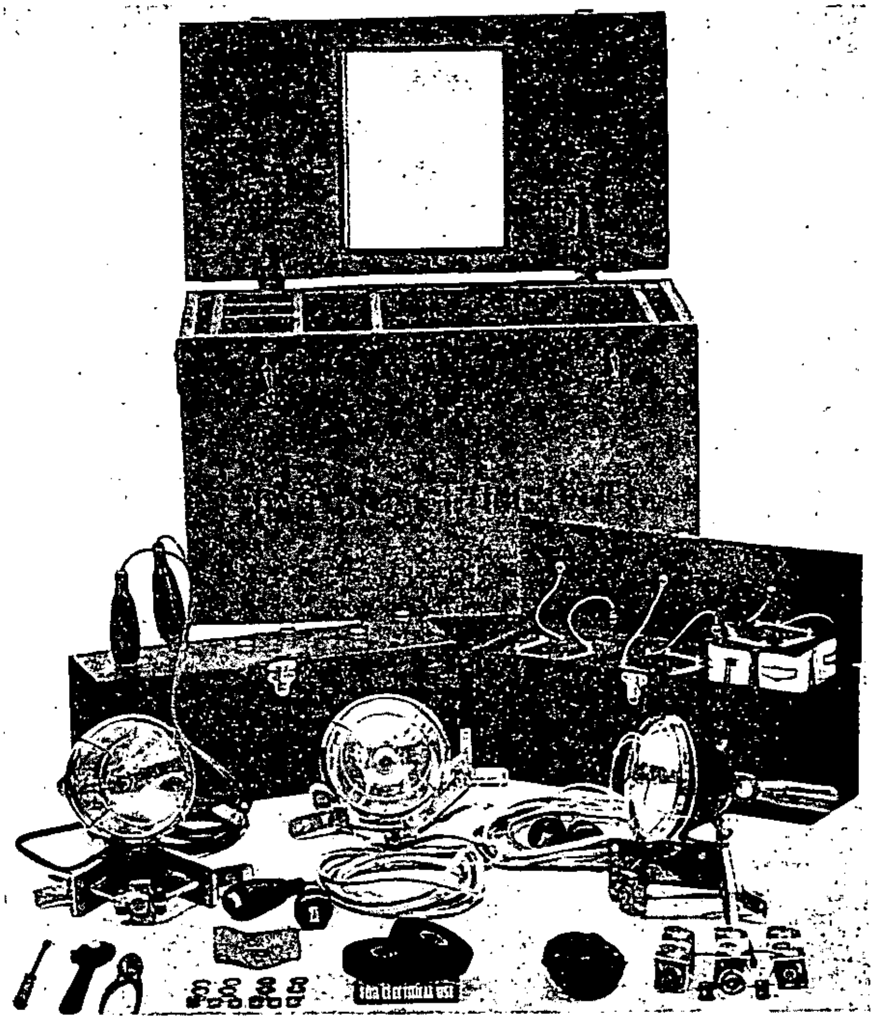

FIGURE 2.—Complete tractor-lighting outfit.

The complete kit, developed to meet forest fire fighting needs (fig. 2), is now available commercially. The lights and clamps can be purchased separately where it is known that the tractor on which they will be used is battery equipped.

The standard contents for the kit are as follows:

3 Tractor lights with 15-foot twin wire cords equipped with positive and negative insulated quick clamps and 6-volt lamps.
3 Wire lens guards for lights.
3 Universal adjustable clamps for canopy stanchions.
2 Battery boxes with terminals, each to accommodate 12 No. 6 dry cell 1½-volt batteries.
6 Dry cell connector plates.
24 No. 6 1½-volt dry cell batteries.
3 Lamps, 6-volt G.E. No. 1021.
6 Lamps, 12-volt G.E. No. 1327.
20 feet of twin wire cord.
2 Rolls 4-inch insulated tape.
1 8-inch crescent wrench.
1 6-inch pliers.
1 6-inch screwdriver.
2 Spare wingnuts for clamps.
6 Spare washers for clamps.
6 Spare hex nuts for lamps.
6 Spare lockwashers for lamps.
3 Spare battery box wires.

The kit, complete without batteries, weighs 85 pounds. Its dimensions are 15 by 16 inches, 28 inches long. Further information can be obtained from the Division of Fire Control, U. S. Forest Service, 729 N. E. Oregon St., Portland 8, Oregon.

FAN PSYCHROMETER

ROBERT M. LOOMIS, *Forester, Columbia Forest Research Center, Central States Forest Experiment Station,* and
VIRGIL STEPHENS, *Fire Control Officer, Missouri National Forests*

Battery-operated fan psychrometers have been widely used to measure relative humidity at fire-danger stations. With electricity now available at many stations, a unit using this current is practical. A fan psychrometer suitable for locations where 110- to 120-volt, 60-cycle alternating current is available was assembled

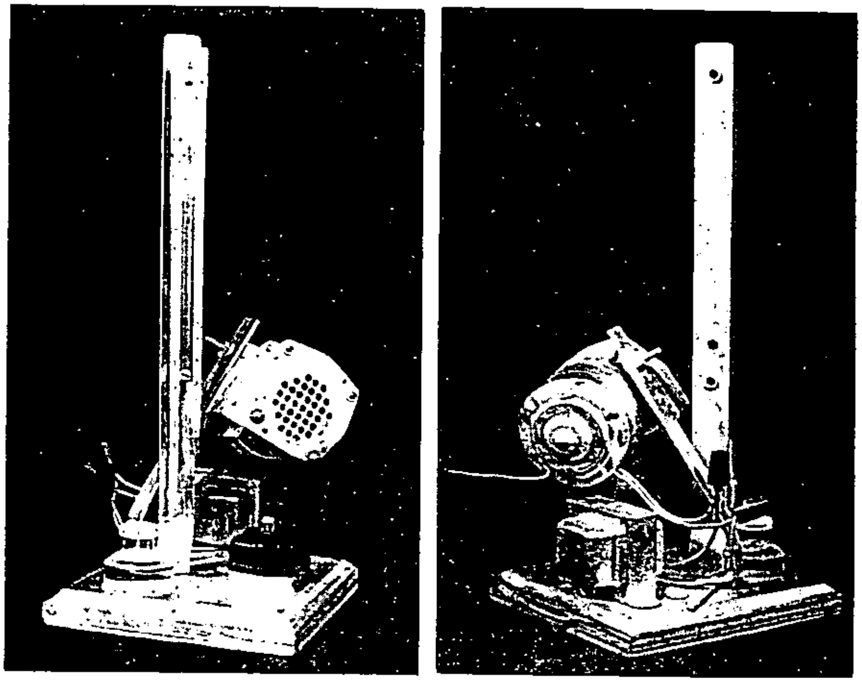

FIGURE 1.—Fan psychrometer: *Left,* Front view showing arrangement of wet and dry bulb thermometers, motor and fan, transformer, switch, and water container; *Right,* rear view showing assembly of motor and psychrometer, electrical wire connecting to 110-v. outlet entering base, cover for bottom of base, and ground wire from motor.

by Central States fire research personnel.[1] The 6,000-r. p. m. blower, 24-volt d. c. motor, and transformer were obtained as a unit through a radio-TV supplier for $4.00.

This instrument is efficient and compact, and simple to operate. The high-speed blower draws air from the side away from the motor, eliminating the possibility of motor heat influencing the reading.

[1] J. Allen Jackson, R-9 Training Officer, formerly Assistant Supervisor, Missouri National Forests, suggested this instrument.

The assembly shown in figure 1 is an example of a workable arrangement of the wood base, motor, transformer, blower-type fan, two strap-iron supports, switch, water bottle, and psychrometer. The wood base is ¾ by 7 by 7 inches, and is grooved on the bottom to carry the electrical wires. Holes are drilled to carry the wires through the base to the switch and transformer. Enclosing the electrical wires in the base is a piece of ⅛-inch Masonite attached to the bottom with countersunk flathead screws. A circular hole, 1⅞ inches in diameter and ⅜ inch deep, is cut into the base to hold the water container, which is an India ink bottle with plastic cover.

Two supports, one for the motor and one for the psychrometer, are bent from ⅛-inch by 1-inch strap iron, 10½ and 17 inches long. Supports, transformer, and switch are held to the base with roundhead screws. The motor and psychrometer are attached to the supports with stove bolts. The psychrometer is kept from direct contact with the strap iron by tubular metal sleeves ½ inch long. Blower and thermometers are arranged so that the air blows across the dry bulb first. For safety the motor is grounded with the wire from the rear of the motor.

This type of instrument is now in use on the Missouri National Forests and is proving satisfactory.

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Inexpensive Scanning Stereoscope

In office stereoscopic delineation of types, photo measurements, or dot counts on aerial photographs, nothing is more aggravating than to be hampered by the legs of a pocket stereoscope.

Freedom of hand movement can be obtained by rigidly mounting a stereoscope to a bar from an upright at the proper focusing height. However, this method requires that the photos be moved beneath the stereoscope for complete stereoscopic coverage, which is rather unhandy.

Commercial scanning-type stereoscopes are excellent and eliminate both of these disadvantages. Most of them, however, are too expensive for the average person engaged in photointerpretation.

A practical yet inexpensive scanner can readily be made by attaching a common magnifying stereoscope to a storm sash friction-type adjuster. The adjuster is screw-fastened to a short length of 2" x 2". The 2" x 2", in turn, is attached with screws to the left edge of a plywood base on which the photographs are placed. This viewing surface can be tilted toward the photointerpreter by raising the back edge to the desired height with legs or a wooden strip.

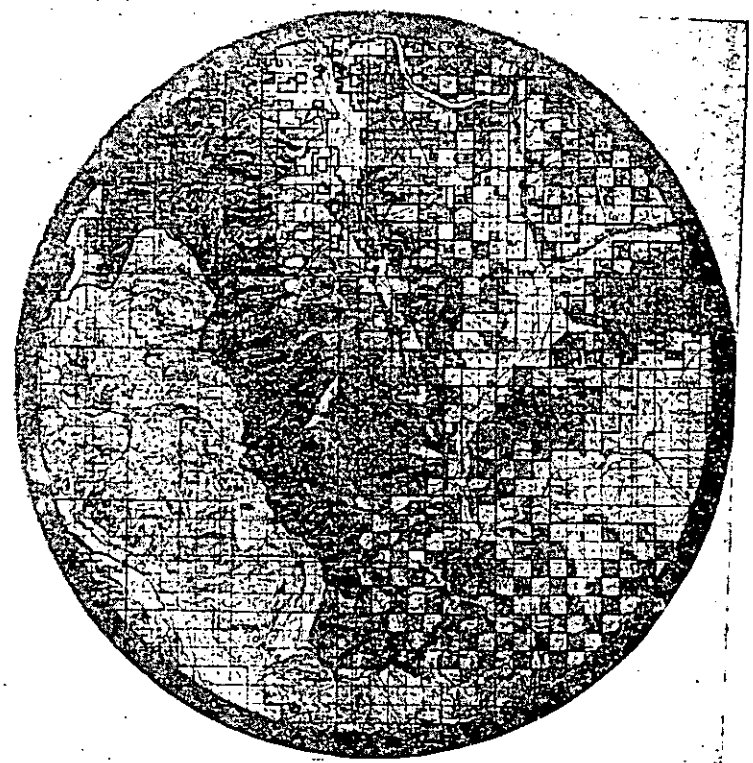
The friction disks at the three hinge points of the adjuster eliminate wobble but allow free roving of the stereoscope in a horizontal plane to any desired stereoscopic position over the aerial photographs. Smoother movement of the arms is accomplished by lubricating each joint and adjusting the locknuts. A hacksaw is used to notch the end normally fastened to the sash before bolting the stereoscope to it. One stereoscope in use has the standard 2X lenses mounted with an interpupillary distance of 63 mm. in an eyepiece made of ¼" hardboard.

Certainly a more refined unit can be made by variations of the above. However, the point is that a stereoscope can be successfully adapted for scanning for about $1.00—PAUL M. HAACK, JR., Technical Note 40, *Alaska Forest Research Center, U. S. Forest Service.*

Lightning-Strike Recorder Rings for Lookout Firefinder Maps

Since 1954 Region 1 has been experimenting with aluminum rings of different sizes placed over the map disks on firefinders. Lightning strikes were recorded on the aluminum with pencil as they occurred. When the temporary record was no longer needed it was easily erased. These experiments have led to a new method which appears to be very satisfactory. All firefinder maps in Region 1 will be mounted as follows:

1. The maps are cut 1¼ inches in diameter smaller than the metal required, leaving a ⅝-inch margin of bare metal.



2. 3S aluminum sheets .018 grained on one side, are used. Grained aluminum is ideal for pencil marking and the marks are easily removed.
3. The map is bonded to the grained side with dry-mounting tissue. A large electric dry-mounting press is heated to 230 degrees and approximately 10 pounds of pressure per square inch is applied. After 45 seconds the pressure is released and the map is turned 90 degrees. Pressure is again applied for another 45 seconds.
4. The mounted maps are made water repellent by spraying with aircraft industrial lacquer.

On some makes of firefinders (old-style Bosworths) the metal azimuth circle covers the perimeter of the map. If this is the case, allowance must be made by cutting the map smaller before mounting and spraying.—A. R. FINK, *Missoula Equipment Development Center, U. S. Forest Service.*

HOW EASTERN REGION FIRE TRAINING COMMITTEE FUNCTIONS

A. R. COCHRAN
Former Fire Chief, Section of Fire Control, Region 7, U. S. Forest Service

A public awakening to the strategic place of resources in national existence came out of the world war experience. Old standards of protection were recognized as inadequate. New higher standards were required. Protection agencies faced a changed situation. Disastrous fires over widely separated areas of the country gave a sense of urgency to the situation. Losses formerly tolerated were no longer acceptable. Resource managers needed answers to the problems of resource protection. They needed to be equipped and trained for a job always different, but which now required much more exacting standards.

Training seemed to offer one of the most promising opportunities for strengthening fire control rapidly. This Region sought to meet the urgent training requirements through a task force approach. A Regional Training Committee was activated to analyze training needs, develop a training program, and apply it in the Region. Membership of the five-man committee consisted of three qualified firemen from the forests, the regional fire specialist on fire studies, and the regional fire staff officer.

The first work of the committee consisted of assembling information on fire control subjects as complete and authoritative as possible. The findings of research, the well-established standards and techniques of fire control, and the experience of fire control people were brought together. Fire weather and fire behavior studies furnished an important part of the information assembled.

The committee decided that in preparing a program emphasis should be on principles. The reason for adopting such a guide was to equip the administrative officer with principles and natural laws as the tools required for solving the multiplicity of situations which he will face in resource protection. Fire control subjects treated in this way attained a scientific stature as against a system of dogma, rule of thumb, and special problem solving which at best could be applied rigidly and often crudely, never quite fitting the problem on the ground.

The first step in developing an overall training program was to prepare an outline of subjects important to fire control and related to training needs of the Region. These subjects were apportioned into yearly training programs representing priority of subject matter and limited to what could be covered reasonably in the time available during any one year.

After the subject matter for a year's program was selected, the committee made an exhaustive analysis of each subject and arranged material in logical sequence. They limited subjects to those bearing on principles. This assisted the committee in sorting the pertinent from the nonrelevant. This phase required about one week of committee work for each year's training program.

Each subject was defined, and assigned its proper place in the training outline.

Each major subject is broken down into instructional units which the following illustrates:

What: Define subject.

Why: State the specific function or place of the subject and the reason why it is included.

The subject is broken into teaching units:

Lesson plan No.	*Instructional units*	*Scope of instruction*
1	Name of instructional	Define the limits or
2	unit for each lesson	bounds of instruction,
3	plan.	giving specifically
4		the area to be included in each lesson plan.

This process of stating the what and the why of each subject requires clear thinking and is the means of separating principles from nonessentials.

Because this outline information provided insufficient guide for the actual training job, a text was prepared. This gave fluency to the subject matter and provided a flexibility that paid off well for the time and effort required to make the writeup.

Lesson plan development was in accordance with professional standards; used as a reference was "Techniques of Military Instruction," FM 21-6, Department of the Army Field Manual, May 1954. The committee's big responsibility in lesson plan development was to find training techniques that carried an impact for fire control subjects. This is a fertile field for attention. In addition the committee had to adapt training techniques to the resources available on a forest.

Lesson plans, however carefully prepared, should not be released for general use until they have been proved in a training session. The experience of the training committee has been that some very worthwhile and needed adjustments have been made through the regional test training session. The trainees in the regional training session are responsible for forest training in these subjects and are naturally keen and alert. They are quick to detect weaknesses and ready to make changes that show they are needed.

A considerable amount of time must be spent by the fire specialist and regional fire staff man in preliminary work on a training session. This includes time for consultation with fire research people.

The training committee has used 5 to 6 weeks in session to produce a training program for a given year. In addition to the time in consultation, members spend whatever time is required, individually, on the subjects for which they are assigned responsibility for teaching in the regional training session. Because they have individual responsibilities for producing results, each is inclined to take his "homework" very seriously. Although committee members had to devote a significant amount of time, their efforts were justified by the results obtained. Attention to the technical soundness of the training material developed and to training techniques has paid off in effective fire control training.

SLASH DISPOSAL BY BURNING ON THE KLAMATH

Lee Morford
Forest Dispatcher, Klamath National Forest

Beginning with the World War II years, the cost of slash disposal increased to such an extent that disposal and hazard reduction became less common on forest lands. Personnel on the national forests of California began searching for a cheaper method to accomplish the desired results from both a fire hazard and silvicultural standpoint. When the logging industry moved into the Douglas-fir area of northwestern California a new fire problem faced the protection agencies. In the Douglas-fir timber a cull volume ranging from 20 to 50 percent of the total volume was left on the ground following logging. This created a very heavy accumulation of both large and small fuels. Fires occurring in these fuels were extremely difficult to control, particularly when fire dangers were above the low range.

Late in 1952 a study was made of the fires occurring in the Douglas-fir type slash areas of northern California. This study indicated that, if protection goals were to be met, some method of slash disposal would have to be instituted in spite of the heavy costs.

The Klamath National Forest took the lead in attempting to devise ways of disposing of the heavy accumulation of fuel so that fires in the slash areas could be controlled. The Happy Camp District was designated as an experimental area. Fred Wilder, who has an excellent knowledge of fire behavior, was assigned to the project. He treated the areas in several different ways and kept cost records on the treatments. It soon became apparent that if slash burning was to be done safely and economically, all district managers would need established guidelines. The costs could be prohibitive if burning was tried when fuels were too wet; burning was unsafe when fuels were too dry.

The problem had been discussed with the California Forest and Range Experiment Station at Berkeley and the fire weather section of the Weather Bureau. It was decided to set up a series of weather observation stations to get a representative measure of weather conditions in the timbered belt. By correlating their observations with the burning being done under the supervision of Fred Wilder, and through trial and error in other slash burning projects, it was possible to establish a set of preliminary guidelines to slash burning for use by all districts on the forest.

During the fall of 1956 the new guidelines were put into full use forest-wide. Weather observations were taken at the Humbug Fireman Station and Scott Bar Mountain, Slater Butte, and Blue Ridge Lookouts. The lookout stations were at the upper edge of the timbered areas in which the slash was being burned and the Humbug Fireman Station at the lower edge.

These observations were correlated with the burning projects on the Happy Camp District, to serve as a basis for revising and improving the preliminary guidelines, for which burning indexes had been computed from our Fire Danger Rating System. The revised system was used again in 1957 and a record was kept of the intensity with which the slash burned. Using this record and correlating it with the observed weather conditions and the previously established indexes, we again broadened and improved the guidelines.

The procedure under the guidelines is as follows: Observations are taken from selected stations prior to the beginning of the slash burning. Weather forecasts are received twice daily during the month of October and once each day thereafter. From these weather forecasts and from the computed indexes of the day before, the burning index is predicted for the next day. This predicted index is then given to all districts engaged in or planning slash burning.

No burning is done prior to October 1, and then not until at least ½ inch of rain has fallen. The guidelines and the indexes are used to determine where and when the slash can be burned safely and where and when the slash can be burned without too great a cost. In other words, when the burning index is zero, it is a waste of manpower and money to try to burn the lighter fuels. Heavy fuels that have been piled with some type of protection from weather can be burned at any time when there is no danger of spread.

To take advantage of every day of good burning conditions, it is advisable that work crews have a staggered tour of duty. It is also best to have men available to check areas that have been previously burned under favorable conditions whenever the increasing burning indexes indicate that there is danger of spread.

This system does not entirely eliminate all risk in burning slash since weather predictions are not always dependable and very often the weather prediction is not representative of small isolated areas. Either one of two methods is recommended for overcoming these deficiences. (1) Place a person in charge of the burning operations who has a good understanding of fire behavior and a background of experience in slash burning, or (2) have a portable weather station available at a selected site near the burning project where observations may be taken during selected periods throughout the day. Either of these two methods work satisfactorily and prevent unpredicted severe burning conditions from trapping the burning crews or catching them with fires that they may be unable to contain and that may become costly.

TYPICAL SLASH BURNING GUIDELINES

1. Slash burning will not be permitted until after October 1, and then not until the following conditions are present and requirements met.
2. Trends of the fire danger for Area 8 must be available for at least 5 days prior to burning, except that burning may be started immediately after at least ½ inch of rain has fallen.

3. Slash may be burned in these situations after ½ inch of rain and the Area 8 index trends are as indicated.
   a. In shaded canyon bottom; index below 17.
   b. North exposure, about 6,000 feet elevation; index below 15.
   c. North exposure, fir type, 3,500 to 6,000 elevation; index below 12.
   d. North exposure, pine or mixed conifer type, 3,500 to 5,000 elevation; index below 10.
   e. Piled slash along lower side of roadbed, or slash piled and lined with firebreaks, fir and Douglas-fir types; index below 10.
   f. East, south, and west exposures, Douglas-fir slash, 2,500 to 6,000 elevation; index below 10.
   g. East, south, and west exposures, mixed conifer and pine, below 5,000 feet; index below 7.
   h. Ridgetops and exposed points, pine and mixed conifer, index 3; Douglas-fir and fir, index 5.

CONCLUSIONS

The hazard reduction done on the Klamath since 1950 has not been fully evaluated. However, in 1955 during one of the most severe fire seasons in the history of the forest, an incendiary fire was started in unburned slash. It spread to an area in which the slash had been burned. This fire was controlled during the first burning period after spreading over approximately 800 acres. The fire overhead stated that only because of the previously burned slash were they able to construct and hold firelines. This fire was one of 28 that started on the forest between September 1 and September 5. Several of these 28 fires were disastrous, and a total of approximately 64,000 acres of timberland were burned over in the first 10 days of September.

The Klamath is crossed by a very large lightning belt and no part of the entire forest is exempt from lightning storms. It is not uncommon for 30 to 70 fires to be started from a single thunderstorm. With the cutover area increasing at the rate of 5,000 to 10,000 acres a year, the risk of lightning fires and the potential disaster resulting from them is continually increasing. This situation alone makes it imperative that adequate hazard reduction be employed. We believe that, by using these guidelines for reduction of hazard, we will be able to meet the objective of both fire protection and silvicultural management of cutover areas.

SLASH DISPOSAL BY DOZER, NORTHERN ROCKY MOUNTAINS[1]

In 1952 the U. S. Forest Service started a project that included an analysis of dozer-piling methods for slash disposal in the clear-cut lodgepole pine type, with attention to effects on regeneration. Advantages and limitations of dozer piling were to be determined and a comparison of machine sizes (dozers), production, and cost made. In 1953 the larch-Douglas-fir and ponderosa pine types were included.

During 1954 and 1955, dozer bunching or piling of slash was used on approximately 33 percent of the acreage and 40 percent of the volume prepared for disposal in the Northern Region (Region 1) of the U. S. Forest Service. It is entirely possible that at least 50 percent of the volume will be handled by this means within the near future.

Specific cost data were particularly difficult to obtain because of many variables such as type of blade, volume, slope, ground condition, experience and skill of operators, and contract rate. It was also extremely difficult to measure results of slash disposal proper against incidental stand-improvement and other work. It was not possible to establish the necessary controls for absolute accuracy in cost and production analysis. This report, however, is prepared from such figures as we could get and have analyzed by the most experienced men available. Although it falls far short of the desirable, it should be helpful in planning machine operations.

MACHINE SIZE

In general, men experienced in machine slash disposal favor the larger machines, such as the crawler type D-7 or D-8 (fig. 1). Dozers comparable in size and power to the D-7 or D-8 have been most widely used; however, machines comparable to the D-6 have also been satisfactory from the cost and production standpoint. Many men who formerly considered only the larger machines have been swinging to the D-6 size class because of transportation, availability, and other advantages attributable perhaps to local considerations or conditions.

The production of a D-4 size machine was analyzed for only one job. Results were not considered favorable to general use of the smaller dozers. These small machines have trouble in handling slash where stumps are present in any quantity or where there is extensive windfall. Although the general use of dozers in the D-4 size class is not recommended, they have unexplored possibilities where cut per acre is light and other factors are ideal. On good ground they are highly maneuverable and may have a place when compared to the alternative of hand piling.

Contract dozers in the D-6 class have been available for $9.75 an hour; dozers in the D-7 class for $11.75; and dozers in the

[1]A somewhat shortened version from *Mechanized Slash Disposal*, compiled by H. K. Harris. U. S. Forest Service Equip. Devlpmt. Rpt. No. 43, 27 pp., illus. 1956.

FIGURE 1.—Slash disposal dozer. Note heavy armor and cab protection.

D-8 class for $12.50. These rates include operators. They vary somewhat by areas and according to the availability of other work.

RATING AN AREA FOR DOZER WORK

Because cost and results vary according to the difficulty of a slash-disposal job, the relation between obstacles and ease of production are of importance in planning. Therefore, the following factors must be considered:

Slope.—Although dozers can operate on slopes steeper than 35 percent, production falls off so rapidly that costs become prohibitive.

Windfall.—Some areas contain sufficient windfall to definitely hinder the slash-piling effort, particularly if long and large stems are involved.

Snags.—Standing snags represent a considerable hazard to the operation; the number per acre is important in any attempt.

Rock outcrops.—Rock slows down tractor maneuverability and handling of the blade.

Reserve stand.—Reproduction and larger trees that must be saved influence rate of production. This factor is also a consideration in the selection of slash-disposal methods.

Boggy ground.—Soft ground not only limits tractive effort but can tie up a dozer team for long periods. It is often a consideration in selecting the time or season of operation.

Soil characteristics.—Light soil types, such as those common to true white pine types, provide poor traction even under ideal condition.

Slope should probably be the major consideration in rating an area for ease of production with dozers. In one study where slash was bunched on 69.8 acres by a TD-18 dozer equipped with an Isaacson brush blade and operated by a skilled operator, the time required per acre almost doubled when slope increased from 20 to 35 percent.

The following tabulation, based on observation of dozers at work and discussions with field men, can be used to rate an area in respect to the possibilities of dozer slash piling.

Factor:		Ease-of-production classification		
		Easy	*Average*	*Difficult*
Slope	percent	Less than 15	15-30	More than 30
Windfalls per acre	number	0	1-10	More than 10
Reserve stand, stems per acre	do	Less than 5	5-10	More than 10
Snags[1] per acre	do	Less than 3	3-10	More than 10
Rock outcrops, area	percent	Less than 3	3-10	More than 10
Boggy ground, area	do	0	1-10	More than 10
Very loose soils, reduce slope factor	do	0	5-10	More than 10
Reproduction stocking[2]	do	Less than 15	15-50	More than 50

[1]General definition given by field men, "Any dead stem left standing, following logging, over 6 inches d.b.h. and 10 feet in height."

[2]Percent stocking based on 4-milacre units.

PRODUCTION AND COST

An analysis of production showed that dozers in the D-7 or D-8 size class, properly equipped, and operated by experienced men, can be expected to average 2 acres an hour in areas rated "easy"; 1.2 acres per hour in areas rated as "average"; and .67 acres per hour in areas rated as "difficult."

For each thousand board-feet of timber logged, cost of machine piling slash averaged less than a dollar on easy areas, $1.25 on average areas, and $2.35 on difficult areas.

The following factors in addition to those determining ease of production also influence cost:

Volume of slash handled.

Acreage or size of operation.

Transportation and nonproductive machines and labor.

Size, condition, and number of machines.

Skill of operators.

Field supervision.

Amount and kind of stand-improvement or other work done in conjunction with slash bunching.

Time and season.

Contract or Government-owned dozers.

The species handled in a dozer operation may also have some influence upon cost. Studies are under way to determine the volume of slash to be expected in various timber types and its relation to sawtimber volume. It is known that the volume of slash per thousand board-feet of timber logged is much greater in young stands than in mature stands. Six trees 12 inches d.b.h. produce approximately the same scale as one tree measuring 24 inches d.b.h., but the large tree produces only about half as much slash as the 6 smaller ones.

In the study reported here, slash accumulations were not measured for volume. However, the extent to which volume of slash influences cost is reflected in the cost of dozer operation, not including overhead, according to the volume of timber logged per acre as follows:

Volume logged per acre (M board-feet)	*Cost of dozer piling per acre (dollars)*
5	10
10	14
15	19
20	23
25	27
30	31

Note that an increase in volume of timber logged per acre will, in general, result in a reduced cost per thousand board-feet for the dozer operation. The reason for this is obvious. Noneffective dozer operations, such as backing and turning, are reduced as the volume logged per acre, and hence slash, increases.

Small, isolated areas with light volumes of slash may be more economically handled by hand-piling than by dozers, since contract rates or transportation costs for dozers raise cost considerably. On the other hand, relatively small areas with heavy volumes of slash may be more economically handled by dozers. The deciding factor may be site ease-of-production classification ("easy" or possibly "average"), the amount of stand improvement, or possibly benefits from dozer bunching such as scarification and seed distribution.

OPERATIONAL TECHNIQUES

Carefully planned and executed operational techniques may make the difference between an economical operation or one that is costly. For example, in the investigation reported here, time studies were made to establish a "pattern of operation" for dozer piling slash on a clear-cut lodgepole area which included considerable stand-improvement work. The time studies took into account (a) distance of drift slash, (b) effect of standing trees and stumps, (c) blade capacity and allowable loss of slash from blade, (d) pattern of dozer movement, and (e) windrowing of slash vs. bunching or piling.

As a result of the time studies, production for the particular situation considered was increased from approximately 1 acre per machine-hour to 2.25 acres. This was accomplished by—

Increasing distance of each swipe to approximately 2 chains Although some sloughing was experienced, it consisted principally of slick stubs and poles with only a few branches which are not a serious fire hazard when left on an area.

Reducing the noneffective time spent in maneuvering the tractor by backing through finished area and crowding new slash when moving forward.

Windrowing slash instead of piling. In this instance, the windrows required less nonproductive maneuvering of the tractor.

The pattern of operation may require considerable variation to fit conditions. The training of operators, particularly with respect to pattern of operation and degree of cleanup required, is essential to the success of every job. The following matters should also be considered by supervisors in planning slash disposal:

1. Avoid machine piling in areas too steep for economical operation. Weigh production against operating time as a check.

2. On some sites, machines are not practical because of the volume and spacing of reproduction or seed trees that must be left. The big machines, with wide blades, cannot operate without pushing many trees down and damaging considerable reproduction.

3. On sites where soils are easily eroded and steep slopes predominate, dozer operations may not be desirable. Use of dozers may contribute to the erosion problems created by the logging operation.

4. The amount and kind of stand-improvement work should be considered. Dozers can push over residual trees in many stands better, faster, and cheaper than hand labor can. When both stand improvement and slash disposal are done concurrently, the overall job is simplified.

5. Select the proper season for dozer operations. Some areas do not dry out until late summer and much trouble will be experienced if machine piling is started too early. Dozers cannot operate successfully on steep ground (20 to 35 percent) when it is frozen. Sometimes the difference between morning and afternoon frost conditions, particularly on north-facing slopes, is a factor.

6. Slash is more easily handled if it has had a month of drying weather. Where maximum seed distribution is desired, the cones from dried slash are easily shaken from the branches and scattered throughout the operating area. In some timber types, however, excessive scatter of cones and seed from dry slash may result in undesirable, overdense stands; it may be advantageous to bunch such slash as soon after cutting as possible.

7. Select the proper size dozers. In lodgepole clear cuttings for example, the stumps are too numerous to avoid and must often be pushed out by the blade for maximum production. Small dozers have not proved practical.

8. Whether contract or Government-owned dozers are used, give particular attention to service and repair. Fuel barrels are a poor substitute for a tank wagon because of lost handling and fueling time. If barrels are used, they must be kept clean and free of rust and scale. A 15-gallon drum should be available for oil changes. Each dozer should carry an extra hoist cable, and other cable should be kept on hand. There should be extra grouse plates (with bolts) for tracks. A supply of extra filters for oil changes should be available.

9. All dozers must be equipped with substantial cabs. All men must wear hard hats. Ground workers should be kept at least 200 feet from dozers at work. Special and detailed safety plans, instruction, and inspection are necessary.

10. Use dozers in pairs if the job is large enough. This will reduce lost time on soft ground or when the dozer gets "high-centered."

11. In heavy windfall or snag areas, use a helper with a power chain saw, especially with machines of the D-4 or D-6 size class.

12. It is important that the cleanup around the perimeter of each unit be better than average. This will provide a safety factor if burning operations are conducted during windy or dry weather, a condition that often occurs during the early fall. The pattern of cleanup may often be arranged to provide additional safety by means of separator strips, where the slash piling is given special attention.

13. Keep a qualified foreman on the job. It should be his responsibility to—

a. Do the current planning on an operation; i.e., where to use dozers or hand piling on an area; where slash should be left to prevent erosion; and other necessary details. Conduct time studies, as necessary, in order to reduce noneffective maneuvering of machines to a minimum in establishing a pattern of operation.

b. Direct operations when windrowing, piling, scarification, and stand-improvement work are done concurrently.

c. Keep dozers spaced for safety of operation but close enough that they can assist each other when necessary. Check work of operators frequently to prevent unnecessary "polish" as well as inadequate cleanup.

d. Avoid working dozers in smoke and under conditions of reduced visibility when burning is done in connection with piling.

e. Check operators on proper maintenance of Government-owned equipment. (Operators should follow manuals carefully regarding service periods; brush blades are heavier than regular blades and front idlers require extra attention. Fuel tanks should be filled each night to avoid condensation, and the last hour of a shift should be used to grease, fuel, and tighten bolts.)

f. Keep a daily record of running hours for each dozer. Settle with dozer operators (contract equipment) on actual running time each day. Prepare accurate progress maps and cost data necessary to report and analyze accomplishments.

EFFECTS OF BUNCHING ON REGENERATION

Prompt restocking to the right density and with the most desirable species is at least as important a management objective as harvesting the timber stand. The problems of regeneration differ with areas, timber types, and methods of logging and slash disposal. In discussing the effects of dozer bunching on regeneration, it must be recognized that the acceptance of a single method of slash disposal is not recommended. Each slash-disposal method possesses certain advantages and disadvantages that must be weighed carefully before selecting one to apply to a given stand or condition.

Lodgepole pine type.—Clear cutting in blocks of various sizes, depending upon conditions of topography, wind, and other factors, is the common practice in pulpwood cuttings in the lodgepole pine type of Montana. After pulpwood clear cuttings, only small or occasionally large defective trees remain. Therefore, trees that occupied the area before cutting and the trees in the surrounding uncut timber furnish the principle source of seed. Seed dispersed from surrounding timber is chiefly limited to the margins of the cutting area, and the small amount of seed dispersed beyond 3 chains is inadequate and undependable for reproducing a stand. Therefore, seed dispersed before cutting and seed on cones attached to slash and in individual cones scattered over the ground undoubtedly accounts for most of the supply for regeneration.

Since some slash disposal is usually necessary to reduce the danger of fires in logging debris, an understanding of the effects of disposal on natural regeneration is important for planning successful renewal. Most publications concerning lodgepole pine regeneration place considerable emphasis on slash-disposal methods; however, they differ widely in conclusions and recommendations.

The White Sulphur Springs area, where most of the information for this discussion was collected, contains pure, even-aged, overmature stands growing at elevations of 6,500 to 7,500 feet. Soils are generally clay and silt-clay loam composition. The results reported here should be applicable to similar stands in Montana and elsewhere.

Preliminary observations of broadcast-burned and unburned clear cuttings indicated that effects of slash disposal were closely associated with the available seed supply. Sparse reproduction was found on burned seedbeds created either by broadcast burning or burning of piled slash. Abundant reproduction was found on unburned seedbeds. Much of the seed and cones were destroyed by the fire which accounted for this difference. If the fire from broadcast burning covers the major part of an area, average reproduction will be exceedingly low.

The amount of regeneration observed in a stand of lodgepole pine, according to seedbed, is given in the tabulation that follows.

	Seedling distribution, stocked milacre quadrants			*Density of trees per acre,*
	1950 (percent)	*1951 (percent)*	*1954 (percent)*	*1954 (number)*
Seedbed:				
Burned, piled slash	15	15	28	860
Burned, windrows	24	18	28	720
Slash, windrows and concentrations	38	28	45	1,880
Forest floor	78	74	80	7,010
Skidroad	95	88	96	10,380
Scarified	83	81	88	10,730
Slash, lopped and scattered	83	76	82	9,910

Since the regeneration on undisturbed forest floor exceeds the present concept of optimum stocking and number of seedlings per acre, scarification or scattering of seed as a result of dozer piling cannot be considered an advantage (fig. 2). If fire-hazard reduction were not required, the best treatment would be to leave the slash in place. Future stocking in the stand will presumably level off or increase very slowly. Viable seed has been found in cones attached to 6-year-old slash.

FIGURE 2.—Lodgepole reproduction in scarified ground 5 years after slash was piled.

Dozer piling in the lodgepole type is advantageous in that it permits controlled burning of slash, thus limiting the total burned area; it also permits the economical destruction of defective and diseased trees (fig. 3).

Research was begun in 1955 to determine the value of dozer bunching as a control of regeneration in areas where distribution and supply of seed are overabundant. It may be possible to bunch cone-bearing slash before it dries and the seed is easily shed. This would not only reduce the seed in scarified areas between

FIGURE 3.—*Top,* Machine-piled slash in lodgepole clear-cutting area. *Bottom,* Slash disposal and stand-improvement work combined on clear-cut lodgepole pulpwood sale.

windrows or piles, but more cones would be consumed by the burning operation. First results of the study have produced some leads as to when the slash might have to be removed in order for the control to be effective.

Also important to the slash problem, but not necessarily directly related to machine slash disposal, are observations regarding the fire hazard of undisposed slash in the lodgepole type. In areas where no slash-disposal treatment was undertaken, and in areas where lopping and scattering was done (fig. 4), the fire hazard remained at a level higher than was acceptable to fire control men 4 years after needle fall. Needle fall, which took place within two growing seasons after logging and one growing season after disposal, was assessed as having dropped the rate of spread one class.[2]

Larch-Douglas-fir type.—Dozer piling is generally regarded as conducive to good regeneration in the larch-Douglas-fir type in Montana. In the average logged-over larch-fir stand, only 10 to 20 percent of the area is disturbed sufficiently by logging to provide favorable seedbed conditions. Dozer bunching provides additional favorable seedbed where slopes are not too steep and dozers can be economically used.

One study of cutting practices in Montana larch-fir type revealed that stocking was generally adequate in the three cutting methods used where the slash was piled by bulldozer and brush blade and/or burned. The results are shown in the following tabulation:

Cutting method and slash-disposal treatment	First-year seedlings per acre	
	Western larch (number)	Other species (number)
Seed tree:		
Hand pile and burn	259	247
Dozer pile and burn	4,598	2,725
Spot burn	1,799	464
Shelterwood (economic selection):		
Hand pile and burn	545	545
Dozer pile and burn	5,692	331
Spot burn	6,228	703
Shelterwood (vigor selection):		
Hand pile and burn	1,144	1,468
Dozer pile and burn	9,509	2,204
Spot burn	10,592	1,941

As a result of slash-disposal treatment, favorable seedbed area ranged from 35 to as much as 80 percent. The hand-pile and burn treatment, for the three methods of cutting, resulted in the lowest stocking because of the lack of favorable seedbed.

In some areas the use of bulldozers on slopes of 30 to 35 percent, and even on gentler slopes in some soils, may induce soil erosion and hasten runoff to an undesirable extent. Because of the importance of soil scarification and removal of intermediate and low vegetation, this aspect of the problem needs more study.

Prescribed burning is the only known method for preparing seedbeds on slopes greater than 35 percent. It is risky and difficult. All indications point, however, to the superiority of mineral soil as produced by scarification and burned forest floor for germination and establishment of larch reproduction.

[2]Fuel classification currently in use in Region 1 divides fuels into 5 rate-of-spread classes known as low, medium, high, extreme, and flash.

FIGURE 4.—Lodgepole clear-cut area 5 years after slash was lopped and scattered.

Ponderosa pine type.—Studies show that mineral soil will produce approximately eight times as many seedlings per acre as natural duff under similar conditions. A mineral-soil seedbed can be obtained either through burning or scarification. Where rodents are a problem, the scarification produced by logging and supplemental machine slash piling, and the exposed soil resulting from burning, may make the difference between satisfactory and unsatisfactory restocking. In one instance, rodents destroyed 92 percent of the seed.

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INFORMATION FOR CONTRIBUTORS

It is requested that all contributions be submitted in duplicate, typed double space, and with no paragraphs breaking over to the next page.

The title of the article should be typed in capitals at the top of the first page, and immediately underneath it should appear the author's name, position, and unit.

Any introductory or explanatory information should not be included in the body of the article, but should be stated in the letter of transmittal.

Illustrations, whether drawings or photographs, should have clear detail and tell a story. Only glossy prints are acceptable. Legends for illustrations should be typed in the manuscript immediately following the paragraph in which the illustration is first mentioned, the legend being separated from the text by lines both above and below. Illustrations should be labeled "figures" and numbered consecutively. All diagrams should be drawn with the type page proportions in mind, and lettered so as to permit reduction. In mailing, illustrations should be placed between cardboards held together with rubber bands. *Paper clips should never be used.*

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Smokey's Commandments
BREAK MATCHES
CRUSH SMOKES
BE SURE ALL
FIRES ARE OUT!
SMOKEY
Remember-
Only you can
PREVENT FOREST FIRES!