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PACIFIC SOUTHWEST
Forest and Range
Experiment Station

LOGGING SLASH:

its breakdown and decay at two forests in northern California

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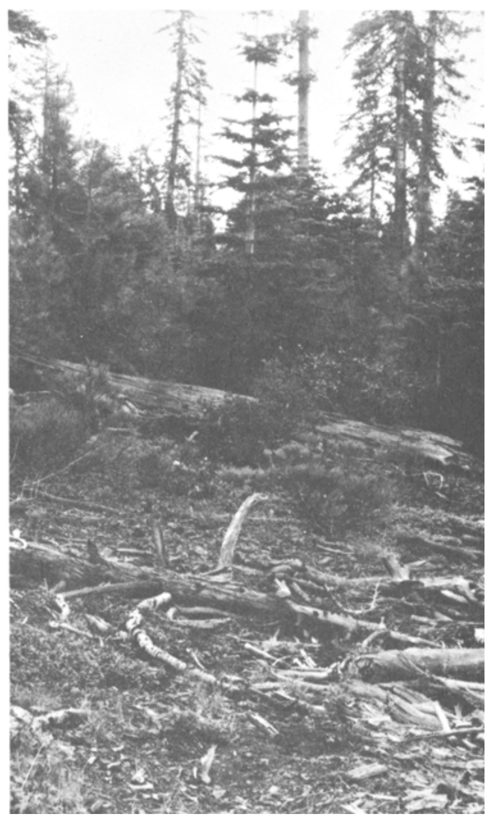

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The Authors

WILLIS W. WAGENER was a forest pathologist at the Berkeley station from 1953 until 1962, when he retired. Thereafter he served as a consultant to the Station until his death in 1969. He was graduated from Stanford University, and earned a doctorate at the Yale University School of Forestry. **HAROLD R. OFFORD** served as chief of the Station's division of forest disease research from 1956 until his retirement in 1965, and since then, has been a consultant to the Station. Native of Toronto, Canada, he earned bachelor's and master's degrees in biochemistry at the University of British Columbia. Much of his career has been devoted to work on methods of controlling forest diseases, with various agencies of the U.S. Department of Agriculture.

The economic disposal of logging slash has long been a problem in fire protection and stand improvement. As Woodbury, Burnett, and Edmonds (1935) point out the problem is particularly acute under critical fire conditions that prevail in California. Decisions about what to do with slash are based in part on information on its rate of breakdown and decay. Slash changes in structure and volume from a complicated interplay of physical and enzymatic agents and the physical and biological characteristics of tree species. Rate of breakdown and decay, therefore, varies widely in major forest types. Rates have been reported for species in the Pacific Northwest (Childs 1939), South (Long 1917; Toole 1965), Northeast (Spaulding 1929; Spaulding and Hansbrough 1944), Midwest (Zon and Cunningham 1931), and Southwest (Gill and Andrews 1956). Kimmey (1955) reported studies of the rate of deterioration of fire-killed timber in California.

In California, a study of unburned logging slash was started in 1923 and concluded in 1957. Over this 34-year period, discrete piles of slash and marked strips of lopped and scattered slash were periodically observed and measured. The influences having the greatest impact on compaction, checking, and decay were assessed. These influences are climatic (precipitation, temperature, insolation, soil moisture) and biologic (characteristics of tree species and decay fungi). Such relatively minor agents of physical breakdown as insects and animals are not quantitatively evaluated in this study.

This paper reports data on slash breakdown and decay for four conifer species under conditions typical at two sites on the Sierra Nevada, northern California, and suggests their implications for forest protection and management. The findings provide a basis for interpreting the records of slash studies in other regions.

EXPERIMENTAL AREAS

Forest pathologists[1] began their studies in Cow Creek drainage, Stanislaus National Forest, in 1923, and near Antelope and Logan Mountains, Lassen National Forest, in 1927.

The Stanislaus plots were on gently sloping ground with a general northwest exposure in Cow Creek, a westward flowing tributary of the Middle Fork of the Stanislaus River. Elevations ranged from 5,300 to 5,700 feet. The soil, with occasional granite outcrops, was a friable loam of granitic origin. On plot sites it averaged 4 feet or more in depth.

A virgin, uneven-aged, mixed-conifer stand averaging 43,000 to 50,000 board feet per acre were present before logging. The area averaged a high Site II, and portions were Site I. The stand consisted of sugar pine *(Pinus lambertiana* Dougl.)-39 percent, by merchantable volume; ponderosa pine *(Pinus ponderosa* Laws.)-24 percent; white fir *(Abies concolor* [Gord. and Glend.] Lindl.) —27 percent; and incense -cedar *(Libocedrus decurrens* Torr.)-10 percent. The litter and duff layer was about 1 to 2 inches deep. Logging was by steam donkey with ground leads.

The stand generally was sound. Many of the older trees were fire-scarred at the base, but the wounds were small, and the butt rot from decay fungi was not extensive. Heart rot from the Indian paint fungus *(Echinodontium tinctorium* Ell. and Ev.) caused occasional cull in white fir trunks, and many of the older incense-cedars were cull because of decay by the pocket dry rot fungus *(Polyporus amarus* Hedgc.). Dead and broken tops were fairly common in white fir from the combined action of the true mistletoe *(Phoradendron bolleanum* ssp. *pauciflorum* [Torr.]) and beetles.

One plot on the Lassen was on the lower eastern slope of Antelope Mountain at 6,000 feet elevation. The remaining 152 plots and sample strips were on moderate southeastern and southwestern slopes of nearby Logan Mountain at elevation ranging from

[1]Studies were started under the general direction of E. P. Meinecke, pathologist in charge. After 1928 they were the responsibility of Willis W. Wagener. Lake S. Gill, Ernest Wright, and James W. Kimmey took major parts in field work. Others who aided in field work were H. N. Hansen, L. W. Musick, James L. Mielke, and Paul C. Lightle.

6,300 to 6,600 feet. The soil is mostly derived from basalts. On the Logan Mountain sites, weathered broken andesite blocks extended to the soil surface with soil pockets interspersed. Soils were relatively fine-grained. On the Antelope Mountain plot, soils were deeper, and basalts were not ordinarily exposed.

The virgin timber stands occupying the areas before logging consisted primarily of ponderosa pine, Jeffrey pine *(Pinus jeffreyi* Grey. and Ball), and white fir, with small admixtures of sugar pine and incense-cedar. Stands were relatively open, averaging slightly more than 22,000 board feet per acre, of which an average of 16,600 board feet were removed in logging. Surface litter and duff were thin, varying from negligible to 1 inch in depth. Site classification varied between a low III and a high IV.

The amount of cull in pine was low on the study area, and few cull logs remained after logging. White fir was much more defective—partly from frost cracks and partly from heart rot of the trunk from the Indian paint fungus. Stem and butt rots, such as *Pholiota adiposa* (Fr.) Quel., and *Polyporus schweinitzii* Fr., were also fairly common. Cull green trees and dead snags, which were felled and left to lie in place, averaged 3.5 per acre. Logging was by crawler tractor.

FIELD PROCEDURES

In both study areas, plots were checked yearly for the first 5 years and then at widening intervals until final checks in 1957. Data were recorded on discrete piles of slash, lopped and scattered slash, and larger wood chunks or logs variously situated on flat or sloping ground of differing aspect. Representative plots were photographed. In the two areas, 324 piles or strips (171 on the Stanislaus and 153 on the Lassen) were established, mapped, and checked. On the Stanislaus, emphasis was on piled slash, and slopes were northwest and northeast. On the Lassen, emphasis was on scattered slash as left after tractor loggings on east, northeast and southwest slopes.

Old dry branches dead before logging were omitted from piles of green slash. Pile composition depended on slash available, but wherever practicable single species piles were erected. On the Stanislaus, 23 percent of the piles were of two or more tree species. On the Lassen, 20 percent of piles had two or more species in the same pile. Of the single species piles 53 percent was ponderosa pine (no attempt was made to distinguish between ponderosa pine and Jeffrey pine); 25 percent, white fir; 15 percent, sugar pine; and 7 percent, incense-cedar.

Experience on the Stanislaus in the first years of the study showed that most piles erected with a loose structure (some of the piles had been formed as compactly as possible) showed little subsidence. On the Lassen, therefore, no attempt was made to achieve a loose pile.

During the early years of the study, physical characteristics of litter and soil, amount of shade and soil moisture, retention or deterioration of foliage and bark, and general condition of sapwood and heartwood were recorded. Later records included the appearance of stain, progress of decay, the nature of the decay fungi, and presence of insects. Except for height measurements of slash piles that were made by yardstick, quantitative data are based on recorded ocular estimates.

Weather records for most of the study period (30 years) were available from the Stanislaus-Tuolumne and Blacks Mountain Experimental Forests. These two Experimental Forests are close enough to the two study areas to provide a reliable basis for evaluating the influence of local weather on slash decay.

PROGRESS OF SLASH BREAKDOWN

Weather Influences

Soil and air moisture and temperature and the characteristics of tree species largely determine how rapidly slash breaks down once the live material has been piled or scattered. Enzymatic organisms that contribute to decay deterioration of slash are omnipresent. High summer temperatures in the absence of rain have long been known to have a limiting if not lethal effect on mycelium of wood-destroying fungi (Loman 1965).

Mean seasonal precipitation at the Stanislaus-Tuolumne Experimental Forest for an 18-year period

(1936-1954) was 38 inches, but only 18.14 inches at Blacks Mountain for that period. *(fig. 1).* Summer dryness is more continuous at Stanislaus-Tuolumne because summer thunderstorms are infrequent. During 19 summers, beginning in 1936, precipitation was under 0.25-inch total for 3 consecutive months in 10 of 19 summers at Stanislaus-Tuolumne and in none at Blacks Mountain.

Snow, which strongly affects compacting of slash, constitutes more than half of the total precipitation at Stanislaus-Tuolumne. Maximum depths seldom exceed *7* feet on cutover areas. In most years snow covers the ground for about 4-1/2 months at an average depth of about 2 feet.

At Blacks Mountain, about half of the total precipitation is snow, and maximum depths seldom exceed 3 feet. For the 3-1/2 months when snow ordinarily persists, it averages about 1 foot deep. Water content of the snowpack runs about 40 percent in both the Lassen and Stanislaus areas.

Summer humidities average low at both locations. Mean moisture for July and August combined, as determined from calibrated moisture sticks, varied from 5 percent in 1959 to 9.4 percent in 1958 near the Stanislaus plots, and from 5 to 7.7 percent between 1956 and 1959 at Bogard Ranger Station, near the Lassen plots. These amounts are all well below the approximate 20 percent moisture content limit at which most decay fungi become inactive.

Mean monthly maximum and minimum temperatures tend to be somewhat higher at Stanislaus-Tuolumne than at Blacks Mountain except in July, when the mean maximum at Blacks Mountain rises slightly above that at Stanislaus-Tuolumne *(fig. 2).* Mean minimum temperatures are above freezing for about 155 days at Stanislaus -Tuolumne and 125 days at Blacks Mountain.

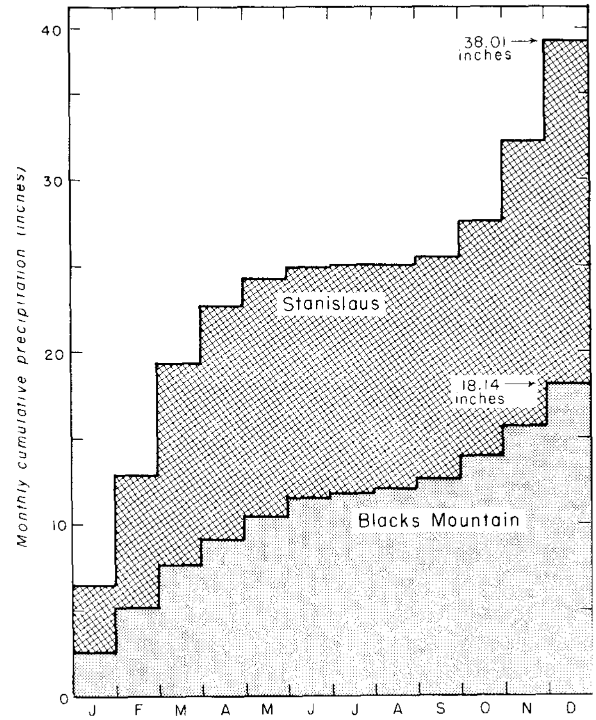

Figure 1—Cumulative mean annual precipitation, by months, from July 1936 to June 1954 at the Stanislaus-Tuolumne and Blacks Mountain Experimental Forests, California.

Processes of Breakdown

The impact of climatic and biologic influences may be traced through observations on compaction, checking, and decay in the piled and scattered slash on the study locations.

Compaction

Compaction was particularly noticeable in slash aggregated in piles or windrows. In the study areas, about 50 percent of the reduction in pile height occurred in the first 5 years after logging *(fig. 3).* Most of the initial subsidence is attributable to the weight of slash itself plus the compressing action of snow.

On both areas, after the first 2 years, the breaking up of twig and branch wood from cross-checking gradually assumed importance. Eventually, in combination with decay fungi, it predominated as the cause of pile height reduction. Slash piles at Stanislaus decreased more quickly in height than those at Lassen for a period of about 15 years *(fig. 3).* Over extended periods, however, the subsidence occurred at rates generally characteristic of a single species pile, such as ponderosa pine *(fig. 4)* and white fir *(fig. 5).* Over a period of 29 years the ponderosa pile *(fig. 4)* subsided from an initial height of 5 feet to 1.5 feet—a 70 percent drop; the white fir pile *(fig. 5)* subsided from 4.8 feet to 0.6 foot—an 87 percent drop. Subsidence of white fir was especially rapid, by comparison with pine during the first 16 years.

In scattered slash no easily replicable measurements of height could be made as a basis for comparison. Apparently, initial subsidence in scattered slash depends much more on breakup from checking alone than on the combined influences of slash weight, snow, and checking which operate on piled slash. The impact of animals is greater on scattered than on piled slash.

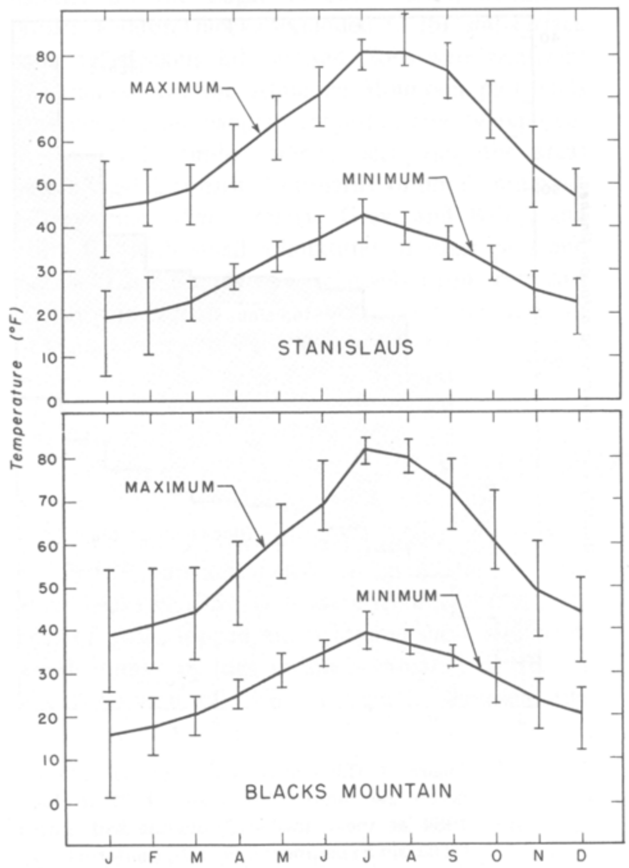

Figure 2—Mean monthly maximum and minimum temperatures and range of deviations at weather station No. 4, Stanislaus-Tuolumne and Blacks Mountain Experimental Forests, California, from 1937 to 1953.

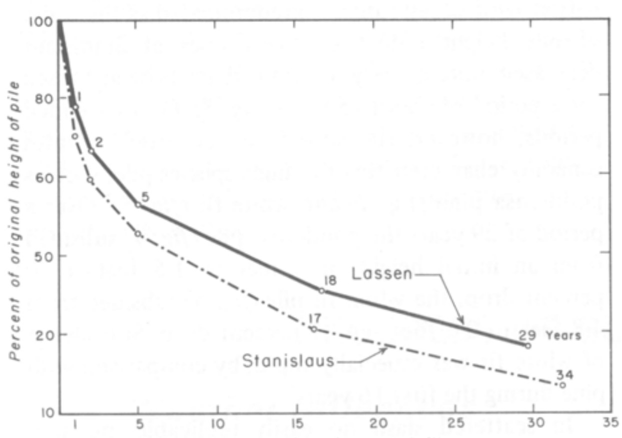

Figure 3—Comparative subsidence in mean height of 83 slash piles on the Lassen National Forest during 29 years, and of 123 piles on the Stanislaus National Forest during 34 years. Data are from all usable piles of single and mixed tree species.

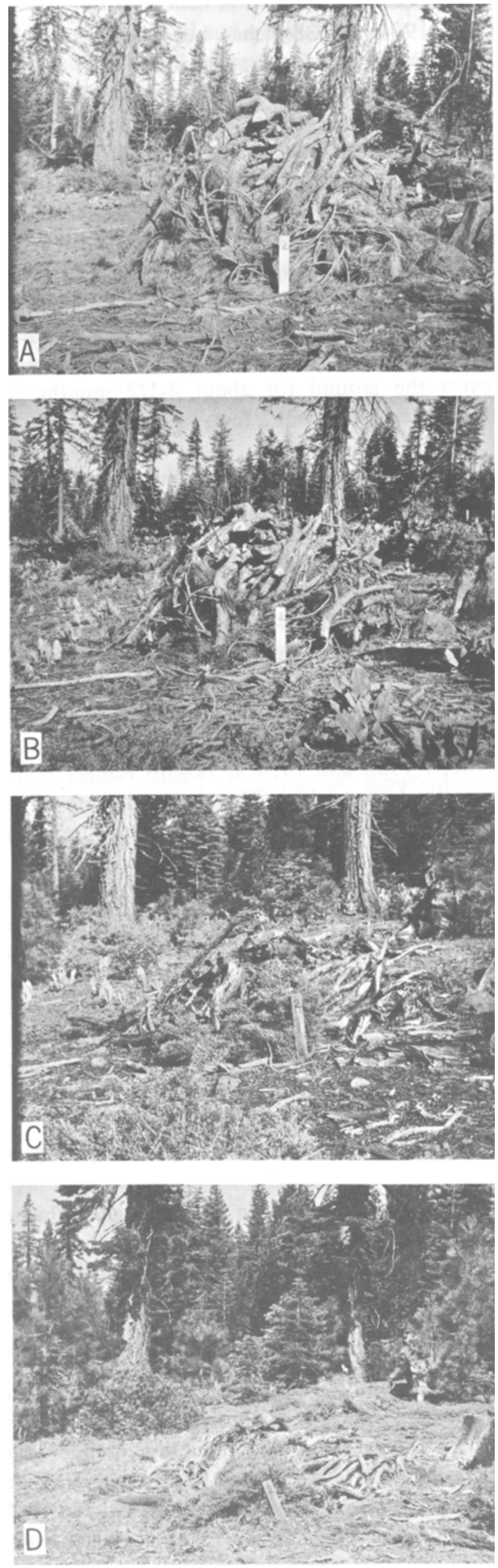

Figure 4—Subsidence of piled ponderosa and Jeffrey pine slash on Plot No. 2, Lassen National Forest, during a 29-year period: **A**, As piled the year of logging (1928), height 5 feet; **B**, 2 years later (1930), height 3.5 feet; **C**, 16 years later (1944), height 2.5 feet; **D**, 29 years later (1957), height 1.5 feet.

Changes occurring over a 29-year period in scattered logging slash, mostly ponderosa pine, on one of the Lassen study strips on Logan Mountain are seen in *figure 6*. By 1957 estimated wood volume, including the larger chunks, had been reduced to about one-third or less of the original volume.

Checking

Shrinkage in twigs and branches from the high temperature and low humidity of summer results in checking. It causes twig and branch wood to break into shorter lengths—notably in slash exposed to full sunlight *(fig. 7)*. Checking is most pronounced in the compression wood at the base of branches—especially in white fir wood. Of the species in these studies, incense-cedar was least affected and white fir the most affected. Breakup from checking appeared to be dominant in the reduction of slash from about the third to the eighth year after logging. In general checking was least rapid on north slopes.

On the Stanislaus plots, 4 years after piling, most twigs and small branches had broken off from main branches. This condition was less marked under shelter of trees or where slash was piled deeply.

Three years after piling, in the Lassen area, white fir showed about 20 percent breakup of small limbs from cross checks. By the sixth and seventh year, nearly all twigs and limbs had broken away from the main stem, leaving scattered limb stubs. Remnants of limbs were most noticeable on pine and incense-cedar.

Checking occurs in bark as well as in wood. Partial loosening of the bark from the wood usually accompanies checking and was noticeable a year after deposition of slash, becoming widespread by the fifth year.

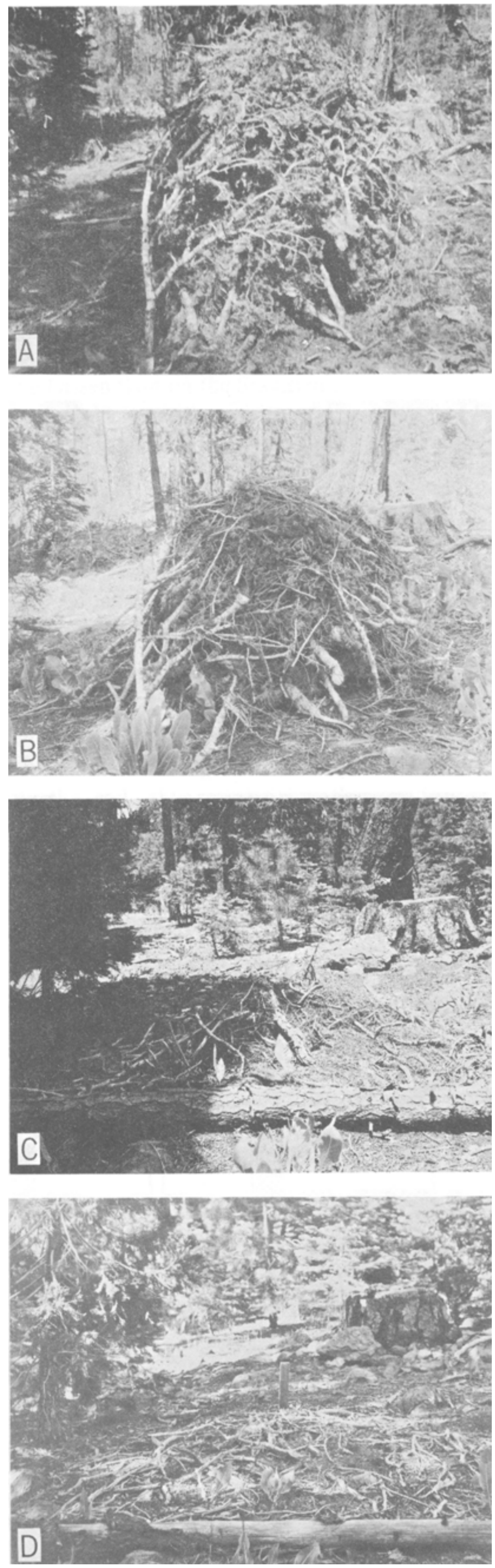

Figure 5—Subsidence of piled white fir slash on strip No. 4, Lassen National Forest, during a 29-year period: **A**, As piled the year of logging (1928), height 4.8 feet; **B**, 2 years later (1930), height 3.5 feet; **C**, 16 years later (1944), height 1.5 feet; **D**, 29 years later (1957), height 0.6 foot.

Figure 6—Changes in scattered logging slash on strip ,No. 4 (Logan Mountain) Lassen National Forest, a gentle southwest slope, during a 29-year period: **A**, Just after logging in 1928; **B,** 4 years later (1932). Foliage had dropped and there was considerable checking in smaller branches; **C,** 16 years later (1944). Decay from *Fomes pinicola* (Fr.) Cke. and *Lentinus lepideus* Fr. has become significant; **D,** 29 years later (1957). Volume is approximately one-third of original.

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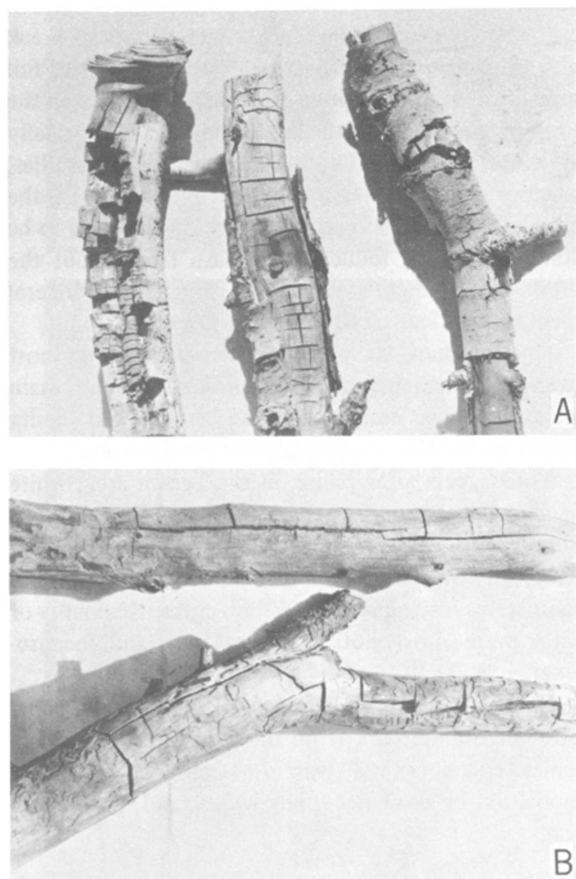

Figure 7—Checking of small branch wood takes place both with and across grain and is usually most pronounced in full sun and in compression wood at the base of branches. It is illustrated in **A**, white fir 6 years after logging; and **B,** sugar pine 7 years after logging.

Within a period of 2 to 4 years after piling of slash, insects accelerate the loosening of bark on both small branches and larger limbs and logs. By tunnels and borings in chunks, tops, and logs they contribute to the breakup of solid wood that takes place over longer periods of time.

In 1930, Willis W. Wagener identified six stages of slash breakdown —all of some significance to fire control and other protection and management problems--from ocular estimates made from 46 plots of piled slash on the Stanislaus (Woodbury, Burnett, and Edmonds 1935). These estimates for the six stages of breakdown for ponderosa pine, sugar pine, white fir, and incense-cedar are summarized in *figure 8.*

Decay

Freezing temperatures in winter, and scarcity of rain in summer and early fall, greatly restrict the activity of wood-rotting fungi in logging slash. Branch wood is usually too dry to permit fungus action except for limited periods in spring and fall. This condition exists in all but large pieces having bark thick enough to retain considerable moisture in the wood. Oleoresins in the bark and wood of twigs and branches of conifers probably further inhibit establishment of decay fungi during the first few years after logging. In the branch wood it is only after 7 to 10 years that fungus action contributes significantly to slash deterioration. Initial major effects of decay fungi were visible after some 15 years, when compaction and breakup from checking had reached peaks and were then diminishing *(figs. 4, 5, 6).*

Other influences on the starting time and progress of decay include the higher minimum temperatures on the Stanislaus *(fig. 2A, 2B)* and the correspondingly longer period when minimum temperatures are above freezing–155 days on the Stanislaus against 125 days on the Lassen. Partly compensating for this difference is greater frequency of summer showers on the Lassen than on the Stanislaus.

The degree to which needles are in contact with the soil influences the start of their decay. By the second year after piling, most of the foliage of white fir had dropped while incense-cedar and ponderosa pine still retained up to 40 percent. This retained foliage tended to be on branches that were bent down, shaded, and close to the ground. Three to 4 years after piling, all needles had fallen from exposed slash; needles on the ground were well matted and partly decayed. Under trees or in the semiprotection of brush a few sugar pine or ponderosa pine needles were still attached to branches even after 4 to 5 years. Rocky soil on the Lassen generally allowed less contact with the soil, thus minimizing the rapid establishment and action of needle-decaying fungi.

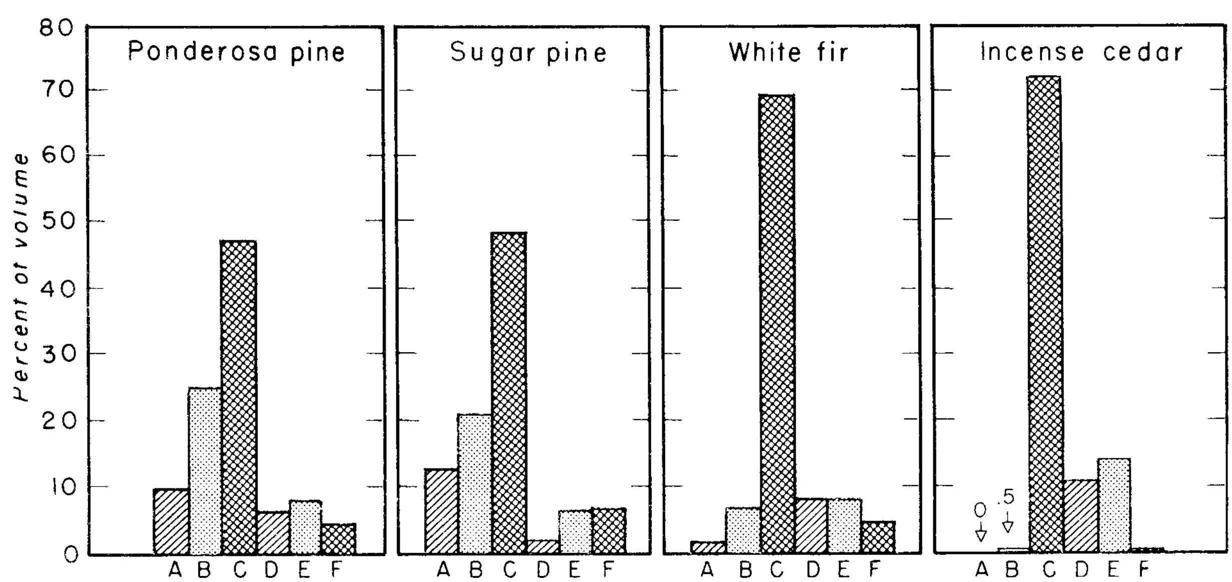

Figure 8—Stages of slash breakdown in four tree species at end of 7 years in 46 plots, Stanislaus National Forest. Key: **A**, bark tight in place; **B**, bark loose and in-place limbs slightly checked; **C**, bark loose and partly sloughed; limbs slightly checked; **D**, bark entirely sloughed, medium checking on all limbs; **E**, bark entirely sloughed, heavy checking; **F**, limbs broken into small cubical sections, some evidence of decay.

Principal Decay Fungi

Two to 3 years after piling, the only notable decay in woody chunks or large pieces was in material lying on the ground or imbedded in it. At the 5-year-interval, some decay from *Polyporus abietinus* (Fr.) Dicks. had started in white fir tops, chunks, or pieces where the bark was thin or cracked *(table 1).*

Table 1 - *Wood decay fungi identified on slash study plots (piles, chunks, and logs), Stanislaus and Lassen National Forests, California*

Fungus[1]	Stanislaus	Lassen	Total
	—*No. of Plots*—		
Polyporus abietinus (Fr.)	9	15	24
Fomes pinicola (Fr.) Cke.	9	14	23
Lenzites saepiaria Fr.	2	10	12
Polyporus volvatus Pk.	8	3	11
Lentinus lepideus Fr.	3	1	4
Poria subacida (Pk.) Sacc.	2	2	4

[1]Excluded as unimportant to decay of slash are the principal heart-rot fungi commonly found in cull logs or large limb chunks: i.e., *Echinodontium tinctorium* in white fir, *Polyporus amarus* Hedgc. in incense-cedar, and *Fomes pini* Fr. (Karst.) in the pines.

During the first 7-year period, only a few instances of fruiting of decay fungi were noted. Of these *Polyporus abietinus* and *Lenzites saepiaria* Fr. were most active in decay of slash. *Fomes pinicola* (Fr.) Cke. is one of the principal fungi rotting white fir and pine logs or chunks, but it does not ordinarily work in material less than 10 inches in diameter. The cubical brown rot *Lentinus lepideus* Fr. occurred throughout the general area, but was recorded on only three of the Stanislaus plots. Sporophores of the pouch fungus *Polyporus volvatus* Pk., which appeared abundantly on tops and on down logs during the second year, probably accelerated subsequent decay of sapwood by the more aggressive *F. pinicola* and *P. abietinus* (Kimmey 1955). Two agarics *(Pholiota* and *Pleurotus* spp.) were often found fruiting on down white fir logs and undoubtedly helped the sapwood to decay.

Stages of Slash Decay

Observations on the presence and the effects of fungi at various intervals were as follows *(table 2):*

Years 1-2–Duff fungi, mostly of the filamentous type, extends to needles and bark of branches on the ground. No decay is noted in twigs or branches except those partly buried in mineral soil. Incipient decay in logs and larger tops of white fir is noticeable during the second year where bark is still retained. In pine, stain and incipient decay is confined to sapwood. *P. volvatus* becomes established in sapwood.

Years 3-5–Foliage in contact with ground is decayed to various degrees. Portions of branches buried or in contact with mineral soil are badly rotted, but decay does not extend appreciably above ground. Rot development in pieces under 10 inches in diameter slows markedly when bark loosens and the wood begins to check, as wood becomes too dry to support fungus growth during summer.

Years 6-7–About half the foliage is disintegrated, the remainder being in various stages of decay *(fig. 8).*

Table 2—*Typical pattern of decay in log, top, or chunk for the four principal tree species during a 32-year period on study plots, Stanislaus National Forest, California*[1]

Species and type	Stage of decay and years after piling
Abies concolor: Top, 10-inches in diameter at large end	Decay 3/4 to 1 inch deep in log face under dirt ____ 2
	Fomes pinicola in sapwood over part of log ____ 3
	Polyporus abietinus in inner bark and wood in part of top ____ 5
	About 6 inches of small end sound; rest of piece decayed, starting to collapse. *Lenzites saepiaria* on part of outer dry shell ____ 16
	Total collapse except small portion of upper sapwood shell ____ 32
Libocedrus decurrens: Broken log, 15-inches average diameter	Surface of wood darkened ____ 2
	Slight stain but no decay found ____ 5
	Slight decay in part of sapwood ____ 16
	Sapwood decayed except for case-hardened shell. Heartwood still mostly sound ____ 32
Pinus ponderosa: Top, 10-inches in diameter at large end	*Polyporus volvatus* superficial in sapwood ____ 2
	Slight amount *P. abietinus* rot in sapwood ____ 3
	F. pinicola in heartwood and under side of top ____ 5
	Interior general decay (heartwood) and some sapwood decay. *Lentinus lepideus* and *F. pinicola* noted ____ 16
	Piece collapsed and decay general throughout piece ____ 32
P. lambertiana: Broken log chunk	*P. volvatus* superficial to ¼ inch sapwood ____ 2
	P. volvatus and *F. pinicola* in heartwood under one side of log ____ 5
	Sapwood mostly decayed; heartwood about 15 percent decayed ____ 16
	Total collapse except for patches of sapwood and heartwood that retain structure ____ 32

[1]Results as recorded at 2-, 12-, 17-, and 30-year intervals for the same species on the Lassen National Forest are substantially the same.

Considerable foliage in the interior of pure pine piles is still well preserved. In most protected spots, a small amount of decay is found in branches off the ground. Logs and tops vary widely in condition; controlling factors are tree species, shade, and degree of bark sloughing.

Years 8-16—Subsidence in small-diameter slash, which made up most of the test piles, during this period is about 16 percent on the Lassen and 18 percent on the Stanislaus. Perhaps half of this reduction represents loss of wood volume through decay and physical breakdown. In the tops and chunks, decay fungi are clearly taking a significant toll of solid wood--especially in white fir *(table 2).*

Years 17-32—Decay is most rapid for white fir and slowest in incense-cedar; the pines were intermediate. Observations of the frequency and effects of the important slash decay fungi during this period highlight the pathological findings of primary concern to forest managers *(tables 1,2).* Of 308 specimens collected from plots, 186 relate to foliage and superficial bark and 122 to wood of twig, branch or log.[2] Among the genera collected from the slash study plots but not otherwise referred to in this paper are *Pholiota, Poria, Corticium, Merulius, Coniophora, Stereum,* and *Pleurotus.*

MANAGEMENT IMPLICATIONS

General observations of the Stanislaus study area in 1957-34 years after logging—showed that it appeared to be approaching pre-logging conditions, although significant residues of the larger pieces of slash were still on the ground. Incense-cedar and large sugar pine limbs had broken up and disappeared the least. Decay was most rapid in dense shade but more rapid in the open than in partial shade. In open areas, breakup by checking was an important factor—more so on level or nearly level ground than on north slopes. Growth of reproduction and consequent shade and increase in thickness of duff played an important part in slash decay.

Final observations on the Lassen 29 years after logging essentially agreed with those on the Stanislaus, but with some differences. Effects of animals on physical breakup of slash were more apparent. And, the occurrence and extent of decay in white fir by *P. abietinus* and in pine and fir by *F. pinicola* and *L. saepiaria* were more notable.

On Logan Mountain (Lassen), a sample strip run in 1958-29 years after logging—showed that about 43 percent of the heavier wood in the original coniferous slash still remained. Lop and scatter plots generally contained log chunks and larger limbs than the slash used in constructing the test piles.

Fire control and forest management personnel might take this 43 percent figure as a rough measure to be applied against published slash and litter weights. Chandler (1960) provides estimates of the dry weight of slash in pounds per tree and pounds per thousand board feet, by species (ponderosa pine, sugar pine, Douglas-fir, white fir, and incense-cedar), for various size classes and crown lengths. Sundahl (1966) reported that for the ponderosa-fir type in 90-year-old stands at the Challenge Experimental Forest in northern California, about 44 tons per acre of coniferous slash after logging could be expected. Hardwoods and litter combined to make an additional 53 tons per acre. An over-all average of 85 percent height reduction for all piles on the Lassen and Stanislaus approximated 60 to 70 percent reduction in volume of branchwood.

Stability of Slash

An objective of the California study was to confirm field observations suggesting that slash in the mixed conifer type of the Sierra Nevada was more stable and persistent than slash in other regions. For example, Spaulding and Hansbrough (1944) reported that the time for breakdown and decay of eastern white pine slash averaged 17 years, and that *Lenzites saepiaria* and *Polyporus abietinus* were primary decay fungi responsible.

In pine forests of the southwest *P. anceps* Pk. was the most abundant and active of the decay fungi, causing breakdown of slash in 8 to 15 years. Of the secondary fungi *P. abietinus* required more outside moisture than *L. saepiaria* and was also more restricted by high temperature. Both of the secondary fungi took about twice as long as *P. anceps* to bring about comparable decay (Gill and Andrews 1956).
Pine slash in California, in the virtual absence of *P. anceps* and under generally dry hot summer conditions, remained in substantial amounts after 15 years.

[2]Notes on this collection are on tile at the Pacific Southwest Forest and Range Experiment Station, Berkeley, California.

In the Pacific Northwest, about 90 percent of wood volume in unburned Douglas-fir slash decayed some 16 to 20 years after logging (Childs 1939). The comparable figure for burned slash was 78 percent. "Wet rots" caused by *Ganoderma oregonense* Murr. and *Fomes applanatus* (Pers. Wally.) were abundant on the spruce hemlock slashings in humid areas of western Washington. The importance of moisture in accelerating the decay of slash was emphasized by Childs (1939) who reported that disintegration of needles and twigs on Douglas-fir and on spruce hemlock sites is usually complete after 10 to 12 years. In contrast, some foliage and much of the small twig material may remain at the end of 10 years on very dry sites in Douglas-fir type. This latter situation is similar to that noted in the dry mixed conifer areas of California.

Fire Hazard Classes

In relating slash deterioration to fire hazard, Spaulding and Hansbrough (1944) identified four classes for softwoods, ranging from *extreme* to *low*. Toole (1965) also proposed four classes for hardwoods. The *extreme* class includes relatively undecomposed slash retaining most of the leaves and small twigs still high in oleoresin; the *low* class represents conditions approaching those before logging when litter was flat on the partially or completely shaded ground. To bring about this change in fire hazard of slash took 17 years for white pine in the Northeast but only 6 years for hardwoods (exclusive of cottonwood) in the South. A similar shift in fire hazard from *extreme* to *low* in mixed conifer Sierra Nevada regions of California would require an estimated 30 years or more. The California study suggests that about one-third of the original volume of wood (exclusive of foliage and small twigs) was still undecayed after a lapse of about 30 years.

Fahnestock and Dieterich (1962) in their studies of flammability of coniferous slash in the northern Rocky Mountain region showed a 56 percent reduction of the original volume of ponderosa pine after 5 years.

The prevalent decay fungi in the California study areas are of the dry, brittle, carbonizing type which induce partially decayed wood having high fire hazard, and not the soft "wet" rots predominant in the Pacific Northwest. Residue of the true firs was notably less durable than that of pine and incense -cedar. On the Sierra Nevada, lopped and scattered slash decays very slowly in all areas exposed to direct sunlight. Compact piles of slash—especially on gentle north and northeast slopes in partial or better shade -decay more rapidly than loosely piled "cordwood" piles in the same or in drier environment.

SUMMARY

Wagener, Willis W., and Harold R. Offord

1972. **Logging slash: its breakdown and decay at two forests in northern California.** Berkeley, Calif., Pacific SW. Forest & Range Exp. Stn. 11 p., illus. (USDA Forest Serv. Res. Paper PSW-83)

Oxford: 332.3--181.9:112.4:111.781.
Retrieval Terms: slash decay; temperature; precipitation; decay rate.

A 34-year study of the condition of unburned logging slash in the mixed conifer type of the Sierra Nevada in northern California showed that breakdown and decay occurred at a much slower rate than has been reported for softwoods or hardwoods in other regions of the United States. Conclusions are based on 324 piles or strips available for part or all of this long-term study on the Stanislaus and Lassen National Forests.

Of primary importance in slash breakdown is the relation of climate to compaction (by winter snows), checking (particularly marked in open sunny spots), and decay by fungi. Secondary and minor elements in the physical breakup of slash, not measured in this study, are insects, cattle, and deer.

Temperature and moisture records from weather stations near the study plots were summarized for an 18-year period to show the significance of summer high temperature and low moisture, which are limiting factors on the spread and growth of the common decay fungi, in retarding decay of coniferous slash.

Incense-cedar had the lowest rate of decay, with sugar pine, ponderosa pine, and white fir next in order. Large limbs or chunks of incense-cedar and sugar pine were especially durable. Most prevalent and most active decay fungi were *Polyporus abietinus, Fomes pinicola,* and *Lenzites saepiaria.* The scarcity of *Polyporus anceps* (in the California areas studied) is a major reason for the slow rate at which pine slash deteriorates.

In California, a span of at least 30 years was needed to lower the fire hazard from extreme (immediately after logging) to a rating generally comparable to that in the prelogging condition.

On the Lassen, 29 years after logging, a sample strip taken in lopped and scattered slash showed that residual wood approximated 43 percent of the original volume of the mixed pine, white fir and incense-cedar slash. Over a similar period of time, all test piles averaged 85 percent reduction in height and an estimated 60 to 70 percent reduction in volume. Pile subsidence was about 10 percent faster on the 123 piles on the Stanislaus than on the 83 Lassen piles, in part because of heavier snowfall in the Stanislaus area. Compact piles of slash –especially on north and northeast slopes in partial or full shade –decayed more rapidly than loosely piled slash in the same or drier environment. On open, sunny areas, breakup of scattered or piled slash by checking is an important factor during the initial 10 years after logging. White fir was most subject to breakup by cross checking, and incense-cedar was least affected over comparable periods of time; sugar pine and ponderosa pine were intermediate.

LITERATURE CITED

Chandler, Craig C.
1960. **Slash weight tables for westside mixed conifers.** U.S. Forest Serv., Pacific SW. Forest & Range Exp. Stn., Tech. Paper 48, 21 p.

Childs, Thomas W.
1939. **Decay of slash on clear-cut areas in the Douglas-fir region.** J. For. 37(12): 955-959.

Fahnestock, George R., and John H. Dieterich
1962. **Logging slash flammability after five years.** U.S. Forest Serv., Intermountain Forest & Range Exp. Stn., Res. Paper 70, 15 p.

Gill, Lake S., and Stuart R. Andrews
1956. **Decay of ponderosa pine slash in the Southwest.** U.S. Forest Serv., Rocky Mtn. Forest & Range Exp. Stn., Res. Note 19, 2 p.

Kimmey, James W.
1955. **Rate of deterioration of fire-killed timber in California.** U.S. Dep. Agric. Circ. 962, 22 p.

Loman, A. A.
1965. **The lethal effects of periodic high temperatures on certain lodgepole pine slash decaying Basidio-mycetes.** Can. J. Bot. 43: 334-338, illus.

Long, W. FL
1917. **Investigations of the rotting of slash in Arkansas.** U.S. Dep. Agric. Bull. 496, 15 p.

Spaulding, Perley
1929. **Decay of slash of northern white pine in southern New England.** U.S. Dep. Agric., Tech. Bull. 132, 20 p.

Spaulding, Perley, and J. R. Hansbrough
1944. **Decay of logging slash in the Northeast.** U.S. Dep. Agric. Tech. Bull. 876, 22 p.

Sundahl, William E.
1966. **Slash and litter weight after clear-cut logging in two young-growth timber stands.** U.S. Forest Serv., Pacific SW. Forest & Range Exp. Stn., Res. Note 124, 5 p.

Toole, E. Richard
1965. **Deterioration of hardwood logging slash in the South.** U.S. Dep. Agric. Tech. Bull. 1328, 27 p., illus.

Woodbury, T. D., Orville P. Burnett, and Marc W. Edmonds
1935. **Progress report on experimental use of fire-breaks within National Forest timber sale areas in the California region.** U.S. Forest Serv. Region 5, 76 p.

Zon, R., and R. N. Cunningham
1931. **Logging slash and forest protection.** Wisconsin Agric. Exp. Stn., Res. Bull. 109, 36 p.

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Disposal of Logging Slash, Thinnings, and Brush by Burying

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ABSTRACT: A feasibility study was conducted on the Stanislaus National Forest to find out if logging slash, thinnings, and brush could be disposed of by burying. This method of slash disposal shows promise and has some distinct advantages over disposal by chipping and burning.

Forest and wildland managers continually seek better logging slash and brush disposal methods. The slash and brush usually cannot b e burned safely in summer because of fire danger. And in winter conditions often are too wet to permit burning. Brush has been disposed of by burying in southern California.

To see if this method would be feasible, we conducted a study on the Stanislaus National Forest in central California. Slash was buried in various types of pits and trenches. The cost of burying slash compared favorably with other methods of slash disposal; it proved cheaper than chipping but somewhat costlier than piling and burning.

Method of Burying Slash

In the fall of 1964, we set out two 1-acre plots in a newly logged 10-acre clearcut block. One plot faced north, the other south. This virgin stand consisted of 75 percent ponderosa pine (*Pinus ponderosa*), 23-percent sugar pine (*P. lambertiana*), and 2 percent incense cedar (*Libocedrus decurrens*). These plots also were covered by a heavy stand of manzanita brush (*Arctostaphylos viscida* Parr y). A total of 35, 990 board feet of merchantable timber was logged from Plot 1 and 44, 490 from Plot 2. The usual procedure after this type of logging operation is to bunch or windrow the undesirable logs, slash, and brush for future burning.

Several types o f pits and trenches were dug in the process of determining which type was most suitable for burying the slash and brush. Same of these were positioned up and down the hill; others were dug on the contour. The trenches averaged 12 to 14 feet wide, 4 to 5 feet deep, and 30 to 60 feet in length. These plots required a pit or trench for each 1/4 acre of slash and brush. Digging larger trenches and moving the slash from areas larger than 1/4 acre slowed the operation. In most cases the trenches were dug first, then the slash and brush were cleared and pushed into them in one operation. It was easier and faster to dig the trenches up and down the hill than on the contour. A tractor-bulldozer could push the slash into the pit from each side. At times slash can be deposited into the heads of draws and ravines and then covered with dirt.

Time Requirement

It took an average of 13 minutes to dig a trench 10 to 12 feet wide, 50 feet long, and 4 to 5 feet deep, and about 26 minutes to clear and push the slash and brush from 1/4 acre into it. An additional 11 minutes were required to cover the trench with dirt. There was enough dirt mixed with the slash to promote decomposition and help reduce settling depressions. The total time to clear and bury the slash on Plot 1 was 3 hours and 20 minutes, and 3 hours and 40 minutes on Plot 2.

Before burying, all slash material was measured and counted and a volume and weight calculation made. Slash weight tables for westside Sierra Nevada conifers[1] were used to determine the amount of slash remaining after the merchantable timber had been removed. The brush weights were determined by weighing numerous sample plants in all sizes obtaining an average weight, and multiplying by the number of plants. The weight of slash and brush buried on the two plots was as follows:

	Plot 1	Plot 2
	- - (tons)- -	
Slash	15	20
Cull logs	6	5
Brush	18	18
Total	39	43

Relative Costs

The costs of burying slash in this feasibility study were as follows:

	Costs[1]	
	Plot 1	Plot 2
	(dollars)	
Unit:		
Per acre	67.16	73.87
Per M bd. ft. of timber cut	1.87	1.66
Per ton of buried slash	1.72	1.72

[1]Based on tractor rental of $17.00 per hour, including operator's wages, maintenance and operation; rates for supervisor-swamper at $3 15 per hour, (GS-7 permanent grade, U. S. Forest Service Calif. Region rates 1964).

[1]Chandler, Craig C. Slash weight tables for westside mixed conifers U S Forest Serv Pacific SW Forest & Range Exp. Sta. Tech. Paper 48, 21 pp. 1960.

If all the buried material on the two plots could have been chipped, the chipping cost would be $108.03 for Plot 1, and $119. 11 for Plot 2.[2] Because much of the material exceeded 4 inches diameter, it was considered too large to chip. All brush could have been chipped.

In 1964, the cost per acre for clearing slash by tractor averaged S42. 70 on the Stanislaus National Forest (contract prices for this work ranged from $32. 50 to $49. 90); for burning slash, $15; or an average total cost of $57.70 per acre.

In addition, some random burying tests were made while constructing fuel-breaks in heavy manzanita brush and in heavy pine reproduction stands which had been thinned by tractors. Costs for burying the brush averaged $102 per acre. The cost for burying the thinned material averaged $103 per acre.

Discussion

There are both advantages and disadvantages in disposing of slash by burying. Some objections to burying slash are:

1. Slash cannot be buried in rocky areas.
2. Slash cannot be buried on steep ground. Generally, though, if the slash can be mechanically cleared, it can be buried.
3. Large cull logs and snags are difficult to bury, primarily because they are too long. They could be cut in two or three lengths and then buried, but often can be left on the ground. Scattered isolated logs are usually not a serious fire hazard nor a deterrent to regeneration.
4. On certain slash projects, such as clearing for road right-of-way, finding room to bury the slash may be difficult.

Among the advantages of burying slash are:

1. Slash can be buried immediately after it has been created. This situation would enable timber sales to be closed sooner.
2. There is no slash burning job to be done, with its inherent problems of planning, patrol, mop-up, and possible fire escape.
3. The ground is immediately available for planting or other purposes.
4. The area looks better because scorched areas and "skeletons" of old burned piles are not present. This advantage is especially important in roadside and recreation zones.
5. Early deep snows often prevent the burning of slash in higher elevation logged areas. Burying the slash in summer eliminates this problem entirely.
6. Burying slash may be desirable on many fuel-break areas where burning would have to be done in confined areas under varied conditions.

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[2] Eased on the cost of $2.77 per ton for chipping green slash. See Schimke, Harry E. Chipping of thinning slash on fuel-breaks. U.S. Forest Serv. Pacific SW Forest & Range Exp. Sta. Res. Note 58. 4 pp, 1964.

7. A combination of burying-burning may be advantageous on many land clearing projects. The control lines could be widened and strengthened by burying the slash in areas difficult to burn. On some disposal jobs the slash could be buried on the better areas and used as control lines; slash on rocky or steep ground could then be burned.

Inasmuch as this was only a feasibility study, it did not cover all conditions normally encountered in logging and fuel-break clearing operations. The study was, however, conducted under most conditions common to these operations. Further study would test slash burying under a wider range of conditions and seek to develop techniques and methods which would promote efficiency and reduced costs.

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