USDA Forest Service
Research Paper INT-104
1971

PONDEROSA PINE PLANTING TECHNIQUES, SURVIVAL, AND HEIGHT GROWTH IN THE IDAHO BATHOLITH

Dale O. Hall

INTERMOUNTAIN FOREST AND RANGE EXPERIMENT STATION
Ogden, Utah 84401

THE AUTHOR

Dale O. Hall is presently the Silviculturist and Project Leader for Silviculture of Ponderosa Pine and Interior Douglas-fir, Intermountain Station, Boise, Idaho. He obtained B.S. and M.F. degrees from the University of California at Berkeley. Prior to the Boise assignment, from 1960 to 1966, he was an Associate Silviculturist, Pacific Southwest Station, at Challenge, California. From 1956 to 1960, he was Resident Forest Manager of Blodgett Forest, University of California. He has been employed in the timber industry as a Logging Engineer and as a Forestry Consultant.

ACKNOWLEDGMENT

Many people have contributed to this study during the 8 years of its duration. James D. Curtis prepared the study plans, installed the studies, and made the first analyses. Marvin W. Foiles worked closely with Curtis until Curtis retired in 1966. Foiles transferred in mid-1967. Dale Potter and Gary G. Baertsch, Forestry Technicians, successively assisted with the field installations and measurements. Krassel District Ranger Howbert W. Bonnett and his successor Edwin A. Heikkenen coordinated the logging operations at Zena Creek with plot treatment needs. Project Sales Officer Larry Finn helped locate suitable plot areas and supervised the planting crews.

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PESTICIDE PRECAUTIONARY STATEMENT

Pesticides used improperly can be injurious to man, animals, and plants. Follow the directions and heed all precautions on the labels.

Store pesticides in original containers--out of reach of children and pets--and away from foodstuff.

Apply pesticides selectively and carefully. Do not apply a pesticide when there is danger of drift to other areas. Avoid prolonged inhalation of a pesticide spray or dust. When applying a pesticide it is advisable that you be fully clothed.

After handling a pesticide, do not eat, drink, or smoke until you have washed. In case a pesticide is swallowed or gets in the eyes, follow the first-aid treatment given on the label, and get prompt medical attention. If the pesticide is spilled on your skin or clothing, remove clothing immediately and wash skin thoroughly.

Dispose of empty pesticide containers by wrapping them in several layers of newspaper and placing them in your trash can.

It is difficult to remove all traces of a herbicide (weed killer) from equipment. Therefore, to prevent injury to desirable plants do not use the same equipment for insecticides and fungicides that you use for a herbicide.

NOTE: Registrations of pesticides are under constant review by the U. S. Department of Agriculture. Use only pesticides that bear the USDA registration number and carry directions for home and garden use.

CONTENTS

ABSTRACT

Site preparation and mulching tests were carried out on some steep slopes having shallow soils in the Douglas-fir—Ninebark habitat type on the Boise and Payette National Forests. Treatments included: (1) hand scalping; (2) a herbicide; (3) spot burning; (4) periodic hand weeding; (5) straw mulch; (6) black plastic film mulch; and (7) glass fiber mulch. Other natural variables recognized were: (a) aspects; (b) soil depth; (c) moisture relations; (d) summer rainfall; (e) temperatures above undisturbed vegetation and above surfaces of treatments (4), (6) and (7). Survival and 5-year height growth of the outplanted 2-0 nursery stock were measured. Extensive mammal damage was noted and appeared to be indirectly correlated with soil depth. All treatments increased seedling survival. Observations suggest that combining hand scalping and herbicide is most promising in terms of cost and effectiveness. Height growth was positively correlated with plot survival percent and soil depth. Trees were tallest where black plastic film was used and on SE aspects; such growth was probably related to the influence of warmer temperatures.

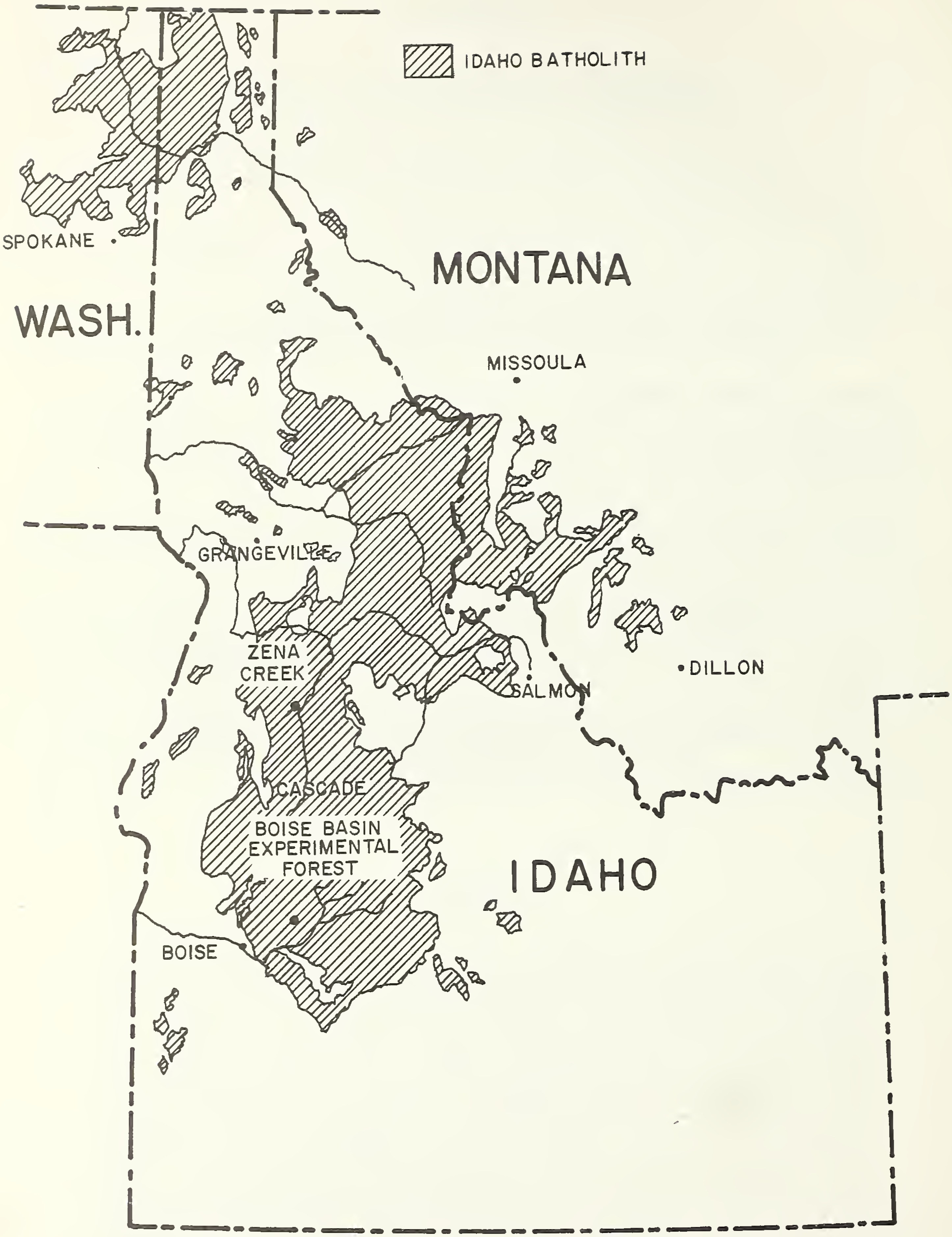

Figure 1.--Map of the Idaho Batholith. (From USGS Map.)

Introduction

The Idaho Batholith (fig. 1) has some prominent characteristics which are serious obstacles to forest management and regeneration. The shallow, granitic soils are notably coarse grained and provide severely limited moisture storage and a high evaporative potential.[1] [2] On steep slopes these soils have a high inherent erosion potential (Megahan and Kidd).[3] High intensity rains (Kidd 1961; 1964) from frequent and unpredictable summer convectional storms further aggravate erosion potentials. These storms also provide some relief from soil moisture deficits. Established vegetation makes almost full use of available soil moisture but stabilizes soil in the process.

The land manager faces a dilemma. If trees are to be harvested, he must find ways to maintain a vegetative cover to control erosion yet reduce vegetative competition so that replacement seedlings have enough soil moisture to survive and grow. Furthermore, his harvesting methods will be severely limited by the steep slopes.

A series of ponderosa pine (*Pinus ponderosa* Laws) planting tests in the Idaho Batholith (1961 to 1964) were primarily concerned with controlling vegetative competition at the time the seedlings were planted and for several years thereafter.[4]

We evaluated hand scalping, a pre-emergence herbicide (simazine),[5] spot burning, and periodic weeding techniques, mulches of straw, plastic film, and glass fiber (table 1). Slope aspects and soil depths were other variables considered. Highly variable climatic factors occurring from year to year were a confounding influence.

Four tests were installed on the Zena Creek logging study area, Payette National Forest, and one test at the Boise Basin Experimental Forest on the Boise National Forest (fig. 1).

Tests were installed in habitat types (h.ts.) that closely resemble, and probably are, the Daubenmires' (1968) *Pseudotsuga menziesii - Physocarpus malvaceus* (The Douglas-fir--Ninebark h.t.). Our results specifically apply to this presumed h.t. and should only be extended to other h.ts. with reservations. The seral nature of ponderosa pine occurrence in this h.t. is important in any consideration of regeneration.

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[1]Richard Alvis, John Arnold, and others. Soils of the Zena Creek Logging Study, Payette National Forest. 1960. (Unpublished report on file (2510) at USDA Forest Serv., Region 4, Ogden, Utah.)

[2]O. C. Olson. A soil survey report of the Boise Basin Experimental Forest. 1965. (Unpublished report on file (2510) at USDA Forest Serv., Region 4, Ogden, Utah.)

[3]Walter F. Megahan and W. J. Kidd, Jr. Effects of logging and logging roads on erosion and sediment deposition from steep terrain. In preparation. USDA Forest Serv., Intermountain Forest and Range Exp. Sta., Ogden, Utah.

[4]Dale O. Hall. Conifer planting techniques, survival and height growth in the central Idaho batholith. 1969. (Unpublished final report for Study FS-INT-1202-494 on file at USDA Forest Serv., Intermountain Forest & Range Exp. Sta., Ogden, Utah.)

[5]Simazine is the common name for 2-chloro-4, 6-bisethylamino-1, 3,5-triazine.

Table 1.--*Planting test constants and variables*[1]

Test number	Year	Aspect	Average soil depths	Treatments: Site preparation	Treatments: Mulch
			Inches		
			ZENA CREEK LOGGING STUDY AREA		
I	1962	SW	17 -24	Scalps Pits Furrows	Straw None
II	1962	SE to W	--	2' scalp 4' scalp 6' scalp Burned spot	None
III	1963	East (SSE to E) West (SW to NNW)	16 -31	Pits	Glass fiber Black polyethylene None
IV	1964	ESE	24 -31 +	Pits	Glass fiber Black polyethylene Simazine None
			BOISE BASIN EXPERIMENTAL FOREST		
V	1964	SSW	20 +	Scalps	Glass fiber Black polyethylene Weeded None

[1]A single column item listed for a test number represents a constant, multiple items, the test variables.

Some of the wildlife species that browsed and foraged on test seedlings have been tentatively identified as:

Rocky Mountain mule deer--*Odocoileus hemionus hemionus*

Rocky Mountain elk--*Cervus canadensis nelsoni*

Snowshoe hare--*Lepus americanus*

Northern pocket gopher--*Thomomys talpoides*

Porcupine--*Erithizon dorsatum*

Harvesting limitations dictated patch cuts of one to several acres. Logging generally took place the year before the study areas were planted. All planting was done by hand with a shovel using 2-0 nursery stock from the Lucky Peak Forest Service nursery near Boise.

For the sake of brevity, these five tests will be outlined briefly and only the specific results indicated.

Site Preparation, Mulching, and Aspect Tests (Zena Creek)

Test 1: Pits, Furrows, and Scalps, With and Without Straw Mulch, 1962

This first experiment at Zena Creek included tests of three site preparation methods. The three methods were: (a) a shallow hand-dug pit (3 by 3 feet with a horizontal bottom surface for planting); (b) a shallow V-trench or furrow made with a rotocat machine (about 4 feet along the contour); and (c) a scalp (3 by 3 feet). The sites were prepared in the fall of 1961. The 2-0 ponderosa pine seedlings were planted in May 1962. A straw mulch (3 by 3 feet) was placed around half of these seedlings to stabilize soil and conserve moisture; the remaining seedlings were left as planted.

The two test areas were selected to provide a range in soil depths. Both areas were at about a 5,000-foot elevation, on southwest aspects, with slopes averaging 70 percent.

Soil depths were quite variable in each area. Thirty-three soil pits (table 2 and Appendix I) showed a range in depths to bedrock of 7 to 24 inches for Area 1 and 14 to 38 inches for Area 2. Three blocks were established in each area to reduce the influence of this variability on the statistical analysis of survival.

Seedling survival counts on the two test areas were made each fall from 1962 to 1966 (Appendix II). In the analysis of variance of seedling survival, after the 1962 growing season, 48.5 percent of the total variation was due to block differences in areas.

Table 2.--*Average soil depths (inches) to bedrock, Test 1 (Zena Creek)*

Site preparation	Test area 1	Test area 2	Combined areas
	STRAW MULCH		
	Inches		
Scalps	13.7	25.3	19.5
Pits	11.0	22.3	16.7
Furrows	16.0	25.7	21.8
	NO MULCH		
	Inches		
Scalps	19.3	29.3	24.3
Pits	18.8	25.2	22.0
Furrows	20.0	19.7	19.9

The mulch/area interaction was highly significant (p = .01) in 1962 (fig. 2). Although seedling survival on Area 2 was higher under a straw mulch than under no mulch, the situation was reversed on Area 1. A tentative inference is that mulching on the deeper soils helps conserve enough moisture to improve survival. It doesn't help on shallower soils because the reservoir of moisture just isn't large enough to meet normal evapotranspiration demands and new seedling demands too. By 1966 this mulch/area interaction had decreased but was still significant (p = .05).

A highly significant mulch/site-preparation/area (3-way) interaction was present in 1962 (fig. 2). By 1966 this 3-way interaction had lost all significance.

The extent of terminal damage over the $6\frac{1}{2}$ years became evident when the seedling heights were measured in October 1968, seven growing seasons after planting (Appendix III). On Test Area 2, 82 percent of the seedlings alive at the time of height measurements showed terminal damage; on Test Area 1, 58 percent showed terminal damage. The damage to most stems was of the type ascribed to hares (Lawrence, Kverno, and Hartwell 1961). Deer and elk were probably the next most important causes of damage. Such depredations were probably responsible for some seedling mortality as well. There did appear to be a correlation of soil depth with percent of seedling damage (fig. 3). Seedlings on deeper soils, growing more vigorously, may have had tissue that was more succulent, or less resinous, or perhaps they were associated with a greater quantity of edible plants tending to concentrate animals and giving an increased probability for browse damage.

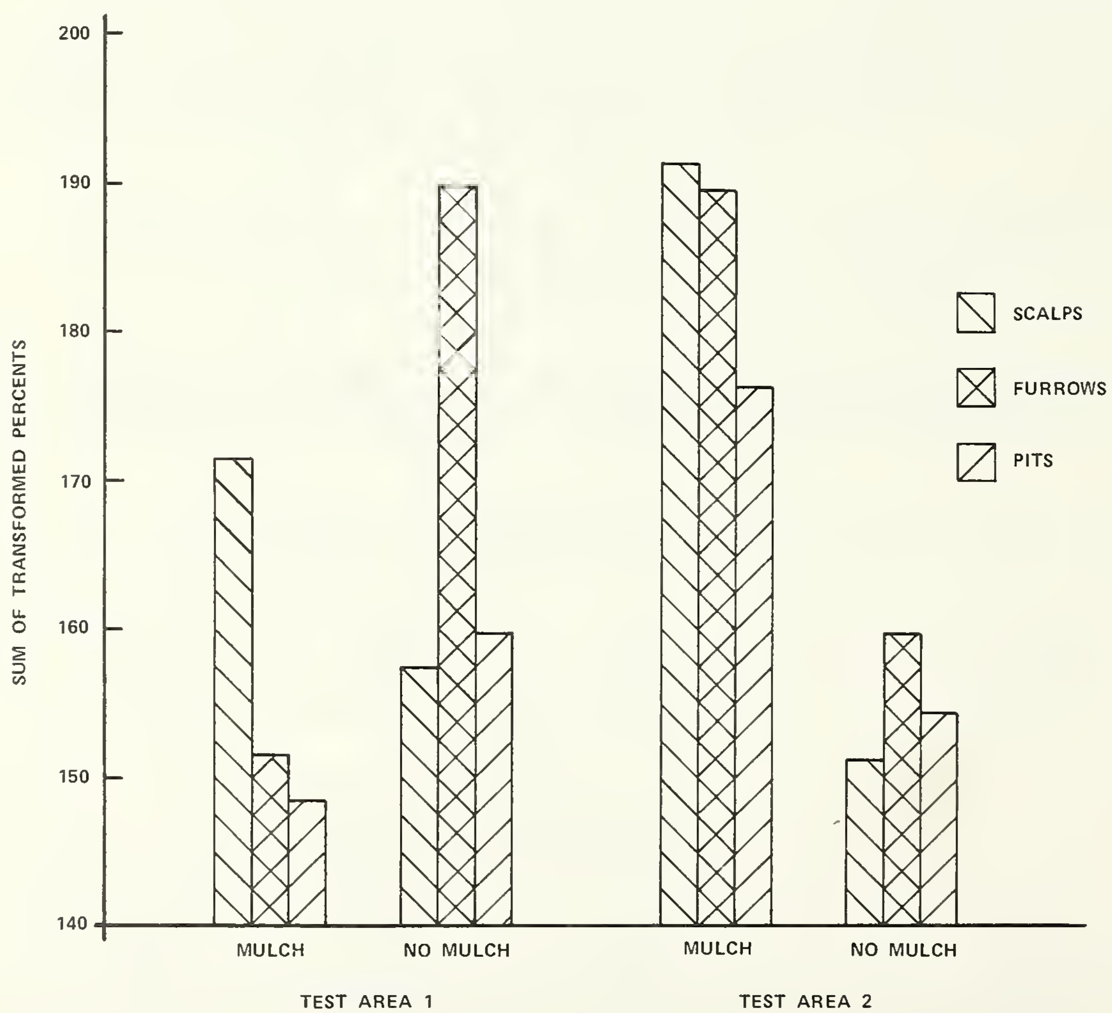
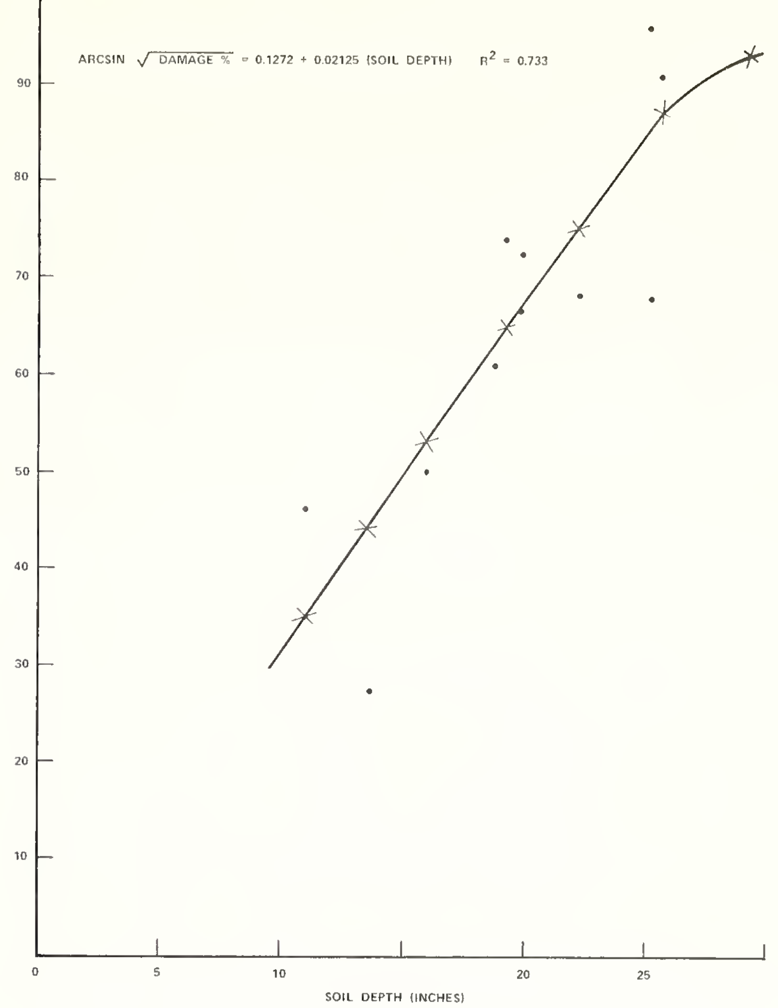


Figure 2.--Interactions between mulches, site preparation, and areas, 1962.

Figure 3.--Soil depth and seedling damage percent (1968) by areas and treatments.



Treatment differences were not apparent in seedling heights. The average heights for 1966 and 1968, for seedlings alive in 1968, were:

	Soil depth - - - *(Inches)* - - - -	
	8-16	*20-40*
	Normal seedling height - - - - -*(Feet)*- - - -	
1966	0.83	1.01
1968	1.24	1.72
	Damaged seedling height - - - - -*(Feet)*- - - -	
1966	0.77	0.94
1968	1.10	1.44

Average annual height growth (1966 to 1968) for normal seedlings on the shallow soil was 0.20 foot per year; on the deeper soil (Area 2), it was 0.30 foot per year.

Test 2: Burned Spots and 2-, 4- and 6-Foot Scalps on Two Aspects, 1962

In 1961 some ponderosa pine seedlings had been planted on burned-out slash piles. Random field observations suggested that better survival and growth occurred on these burns. Thus, it was assumed that an alternative, a scalped planting site, would hold promise for a similar reduction in competition.

In this test, survival levels were compared on three sizes of scalps (2, 4, and 6 feet in diameter) and on burned spots. Three areas were selected, all on the same soil type. Two areas had westerly aspects (A and B), the third faced easterly. All vegetation and the top 4 inches of mineral soil were removed by scalping. On the other hand, the direct effects of spot burning probably did not exceed 1 inch in depth. There were 287 ponderosa pine 2-0 seedlings planted in May 1962, of which 40 were on the east aspect. Survival counts were made each fall for 5 years (Appendix II). The percent of survival in the fifth year was as follows:

Treatment	*Aspect*		
	East	*West "A"*	*West "B"*
	- - - - - - -	*Percent*	- - - - - -
Scalps:			
2-foot	27.3	42.6	36.4
4-foot	60.0	46.3	72.7
6-foot	33.3	35.4	63.6
Burned spots	55.6	55.8	69.2

A chi-square test of the independence of the four treatments (testing the supposition that survival was not independent of site preparation) was not significant (p = .05). However, a trend in the chi-square value, over the 5-year test period, was apparent:

Year	*Chi-square value*
1962	2.15
1963	2.36
1964	6.76
1965	5.41
1966	7.36

p .05 = 7.81

This trend suggests that if measurements had been continued for 1 or 2 years a significant difference would have resulted. The burned spots and 4-foot scalps maintained the greatest survival percentage after 1964.

The effects from burning were not readily apparent; however, the size of the burned spots which were about 4 feet across may have been as great an influence as the burning treatment itself.

In support of the idea that size of treated area is important, it does appear that a 4-foot scalp gave better survival than either a 2- or a 6-foot scalp. Perhaps the 2-foot scalp (3.1 sq.ft.) was not as effective in preventing or retarding competition as the 4-foot scalp (12.6 sq.ft.) which had four times the cleared surface area. The reasons for the decrease in survival on the 6-foot scalp (28.3 sq.ft.) are not apparent.

Test 3: Pits and Synthetic Mulches on Two Aspects, 1963

The straw mulch used in 1962 seemed to have a slight, beneficial effect on seedling survival. Thus, the use of cheap effective mulches to reduce competition and increase soil moisture in the vicinity of planted seedlings looked promising. Accordingly, two new mulching materials (black polyethylene film and a light-colored glass fiber blanket) were chosen for testing and comparison with a no-mulch (control) condition.

The two synthetic mulch materials were in sheet form, rolled for shipment. The polyethylene was 4 mils thick, 36 inches wide and 150 feet long and was perforated every 3 feet to facilitate separation. The glass fiber blanket was 1/4 inch thick, 6 feet wide, and 150 feet long and had to be cut into 3- by 3-foot pieces.

East and west aspects were compared. All six plots were located on soils that averaged 20 to 40 inches deep. Sample soil depths, from surface to bedrock, ranged from 12 to 43 inches.

In the fall of 1962, 900 spots 36 inches square were first scalped and then dug out to form a pit of sorts. The pits were allowed to settle during the winter. In early April, 1963, the 150 pits in each of the six plots were planted with a 2-0 ponderosa pine seedling (fig. 4). The three treatments were randomly assigned within groups of three adjacent seedlings. Late in May the two kinds of mulch sheets were spread around designated seedlings and held in place with three to five wire pins (fig. 5). For a total of 50 trees the cost per tree for mulch and installation was: polyethylene-42 cents; glass fiber-66 cents.

Temperatures were measured in early August 1963, at the mulch surface and at the soil surface under the mulch (table 3). The dates and time of day were selected to provide the highest temperature readings for each aspect. Surface temperatures were generally the highest on the black polyethylene; temperatures on the glass fiber surface were consistently the lowest. Soil temperatures beneath mulches were 13 to 18 degrees less than on the mulch surface, and 14 to 24 degrees less than at the exposed soil surface. No heat lesions were found on seedling stems in contact with mulches.

Mulch differences were highly significant in the analysis of variance for survival for 1963 through 1967. Survival was best with a glass fiber mulch (Appendix II). It seems that competition on the "check" plots increased in this 3-year period while with black polyethylene the competition was maintained at a reduced level. Some increased first-year transpirational stresses over the warmer black polyethylene may have caused the initial high mortality. With increasing age and height this factor would have less influence and competition factors would become more important. Fifth-year survival percentages were:

Treatment	*East*	*West*
	(Percent)	
Control (no mulch)	16.1	31.1
Glass fiber mulch	43.3	47.9
Polyethylene mulch	22.0	30.1

The aspects tested (west and east) did not have a significant effect on survival rate. Survival on individual plots during the first year ranged from 98 percent for seedlings mulched with glass fiber on the east aspect to 24 percent on the same aspect with black polyethylene. Furthermore, the interaction between aspect and mulch was not significant.

Although mulch materials did not completely eliminate vegetative competition, they did slow it down, and at many of the installations the effect continued into 1969.

Figure 4.--Soil pit with planted ponderosa pine seedling.

Figure 5.--Glass fiber blanket serves as mulch and is held in place with wire pins.

Table 3.--*Mean maximum recorded temperatures (°F.) at mulch surface and beneath mulch, 8/5/63 and 8/7/63*

Mulch	East (11 to 12 a.m.)		West (2 to 3 p.m.)	
	Mulch surface	Soil beneath mulch	Mulch surface	Soil beneath mulch
	- - - - - - *Degrees*	*Fahrenheit*- - - - - -		
Glass fiber	141.8	123.7	133.8	115.8
Polyethylene	149.7	131.2	141.6	128.4
None (soil surface)	147.8	--	142.0	--

Animals interfered with the mulch materials, but no mulches were completely removed. Deer, elk, and squirrels were the presumed culprits. In other tests, no mulch/terminal damage relationship was evident. This leads one to believe that there is a low probability for such a bias in this test. I can only guess at the animal/vegetative cover/damage relationship.

Seedling heights were measured in 1967 at the end of five growing seasons after planting. Some of the seedlings had damaged terminals and were excluded from the analysis. Twenty-eight of the 31 damaged seedlings were on one plot which had grass cover but little brush. Other plots had predominantly brush cover. The number of undamaged seedlings and average heights for each treatment, both east and west aspects combined, were:

Treatment	*Seedlings (Number)*	*Height*[6] *(Feet)*
Glass fiber mulch	107	0.93
Polyethylene mulch	67	1.10
Control (no mulch)	52	.86

Test 4: Pits, Synthetic Mulches, and Simazine on Two Aspects, 1964

A second test of the glass fiber and polyethylene mulches was made at Zena Creek in 1964. It was believed that relative effects of the mulches, the weather and, perhaps, the interactions, could be gaged by using something other than a mechanical mulch to eliminate competing vegetation. The pre-emergence herbicide simazine was selected to provide this weed-free condition; it was assumed that simazine would not directly affect seedling growth. Thus, the four treatments were: (1) black polyethylene mulch; (2) glass fiber blanket mulch; (3) simazine herbicide application; and (4) control (no treatment other than the pit).

East and west aspects were again compared by using four replications on each aspect. Average soil depths on the eight plots ranged from 21 to 31 inches to bedrock. Two hundred seedlings were planted in each of the eight plots, 50 seedlings per treatment (total of 1,600 seedlings).

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[6] "t" tests of mean heights showed no significant differences.

The hillside pits, 3 by 3 feet and about 6 inches deep in the center, were prepared shortly before the seedlings were planted in early June 1964. The glass fiber mats and polyethylene sheets were held in place by three, or more, 1-foot-long wire pins. Simazine pellets were scattered evenly at a rate of 5.67 grams per pit; the cost of herbicide per seedling was 3.2 cents. As a followup, live seedling tallies were made each fall through 1968.

Rainfall at the Zena Creek study area, June to September 1964, was 175 percent of normal (table 4). This exceptionally wet summer undoubtedly had a bearing on seedling survival patterns.

First-year survival was the highest of any comparable plantings at Zena Creek. Aspect differences were significant but treatment differences were not. Survival was greatest on the west aspect (Appendix II). Probably the generous recharging of soil moisture during the summer was a big factor in the relatively high survival when using black polyethylene mulch. This lateral recharging, coupled with the relatively cool summer of 1964, probably reduced the high temperature-moisture deficit impact of the black polyethylene, giving a slightly greater survival level than was found in the 1963 tests.

Black polyethylene improved survival on both aspects (fig. 6), but was the best treatment on the east aspect. Simazine also improved survival on both aspects; it was best on the west, more moist aspect. By 1968 all treatments on the east aspect appeared to be much more effective than those on the west aspect when measured against the no-mulch treatment. In 1968, however, treatments differed significantly ($p = 0.01$), as reflected by the following tabulation:

Treatment	*East*	*West*
	(Percent of survival)	
Control (no mulch)	28	61
Glass fiber mulch	42	60
Polyethylene mulch	55	66
Simazine	44	70

The range in treatment effects increases with time for both aspects, i.e., differences became more prominent with time (fig. 6). This fact underscores the cumulative effect of less advantageous conditions. The large increase in the range between 1965 and 1966 may be attributed to a dearth of rainfall between June and September (table 4). Total precipitation in these months was only 33 percent of normal.

Seedling heights were recorded in 1968, five growing seasons after planting. As previously mentioned, there were seedlings with damaged terminals on every plot, but one plot that was covered by grass on a warm southeast slope was especially hard hit and about 50 percent of the live seedling terminals were clipped, nipped or cut. On other plots where brush species predominated there were fewer damaged terminals. It seems that either the deer or elk, or both, may congregate in these warm, open areas where the snow is sometimes absent through the winter, or maybe it is shallower and melts earlier in the spring. Only a small amount of damage on the plots of Test 4 was attributed to rabbits and hares.

Table 4.--*Precipitation records*

Month	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	10-year average
					Zena Creek, 5,000',[1] Payette National Forest (INT-WMR Gage)						
June	0.81	0.33	0.77	1.61	4.76	5.03	1.80	1.66	2.29	0.86	1.99
July	.20	.27	.07	.66	.18	1.15	.70	.03	.50	.30	.41
August	.94	.77	.83	.85	.34	1.73	1.74	.28	.10	2.12	.97
September	3.77	.94	.95	1.12	1.85	.86	2.14	1.63	1.71	.76	1.57
Totals	5.72	2.31	2.62	4.24	7.13	8.77	6.38	3.60	4.60	4.04	4.94
					Idaho City, 4,000',[2] Boise National Forest (WB Gage)						
											WB Normal
June						2.93	1.58	0.22	1.83	1.70	1.38
July						.37	.14	.02	.05	T	.34
August						.82	1.78	T	T	4.89	.29
September						.57	1.66	.62	1.00	.33	.57
Totals						4.69	5.16	.86	2.88	6.92	2.58

[1]A standard U.S. Weather Bureau gage monitored by the Intermountain Forest and Range Exp. Station, Watershed Management Research work unit, Boise, Idaho.

[2]A U.S. Weather Bureau climatological station.

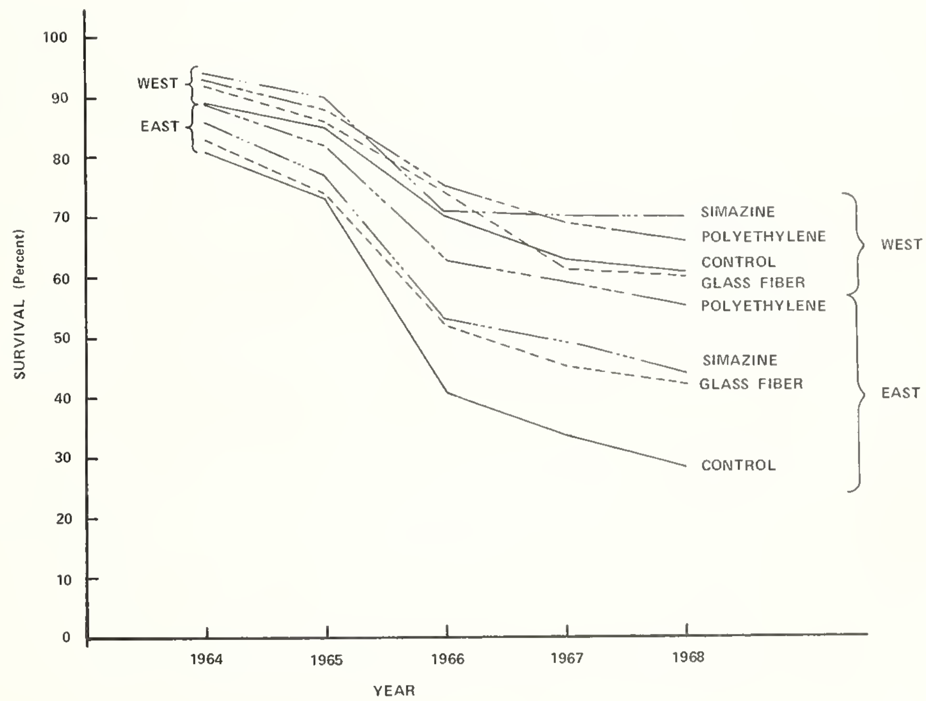

Figure 6.--Seedling survival by aspects and treatments, 1964 to 1968.

Average tree heights at the Zena Creek study area were greater for all treatments on the east aspect:

Treatment	*Tree heights*	
	East	*West*
	- - -(*Feet*)- - -	
Control (no mulch)	1.3	1.3
Glass fiber mulch	1.1	1.0
Polyethylene mulch	1.5	1.2
Simazine	1.3	1.1

Seedlings that received the black polyethylene mulch on the warmer aspect were consistently the tallest. Romberger (1963) has suggested that a threshold spring temperature triggers height growth. This increased height can be expected because higher temperatures occur over black surfaces and the threshold temperature is reached earlier in the spring when moisture is readily available.

Soil Moisture and Temperature Relations (Boise Basin)

Test 5: Soil Moisture and Temperatures Associated With Undisturbed Spots and Pits, With and Without Synthetic Mulches, 1964

These tests at the Boise Basin Experimental Forest attempted to accomplish the following.

(1) Trace the seasonal soil moisture depletion cycle under: (a) two kinds of mulch--black polyethylene, and glass fiber blanket; (b) weeded mineral soil; and (c) an undisturbed condition (control).

(2) Measure the summer temperature gradients on a given day above each of the four treatments on both level and sloping ground.

(3) Measure the seedling survival associated with the treatments, soil moisture, and the air temperature regime.

Survival results were analyzed for two test areas: (a) An aspect having an azimuth of 185° and a slope of 35 percent; and (b) an aspect at 223° with a slope of 32 percent.

Undamaged, 2-0, ponderosa pine planting stock with a top:root ratio of 1:2, or better, was planted in mid-May 1964. The mulches were put in place several days later. First-year survival was recorded at 2-week intervals from June 1 to October 15. The weeding treatment was repeated at each of the first five semimonthly survival counts. Annual survival counts were made each fall until 1968.

Precipitation at Idaho City in June and August of 1964 was more than twice the normal amount; July and September were very close to normal (table 4).

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Site preparation and mulching tests were carried out on some steep slopes with shallow soils in the Douglas-fir--Ninebark habitat type. Five-year survival and height growth were measured. All treatments increased seedling survival. Height growth was positively correlated with plot survival percent and soil depth. Extensive mammal damage was noted.

On July 1, 1964, 45 days after planting of seedlings, the soil moisture percent (dry weight) generally exceeded "field capacity" as estimated from 1/3 atmosphere tests in the laboratory (figs. 7 and 8; Appendices IV and V). Moisture contents were well above "field capacity" in the second area (B) and near "field capacity" in the first area (A). Soil moisture was determined at three levels below the surface: 3 to 6 inches, 9 to 12 inches, and 15 to 18 inches. In all samples, the hand-weeded plots appeared to show the greatest moisture recharge on September 1. Recharge was considerably less (or slower) under both polyethylene and glass fiber mulches. In some cases a recharge was not evident until the measurement of October 1. Such a recharge undoubtedly stemmed from lateral movement of soil water under the mulches.

Temperature profiles (°F.) at the Boise Basin study area were determined on August 4, 1964. Maximum air temperature recorded at the Weather Bureau Station at Idaho City on this date was 91°; the minimum was 40°. The sun was at its zenith between 12:40 and 12:45 p.m., m.s.t. Relative humidities ranged from a high of 84 percent to a low of 18 percent. The wind had an average velocity of 10 miles per hour and was out of the west. There were no clouds that day.

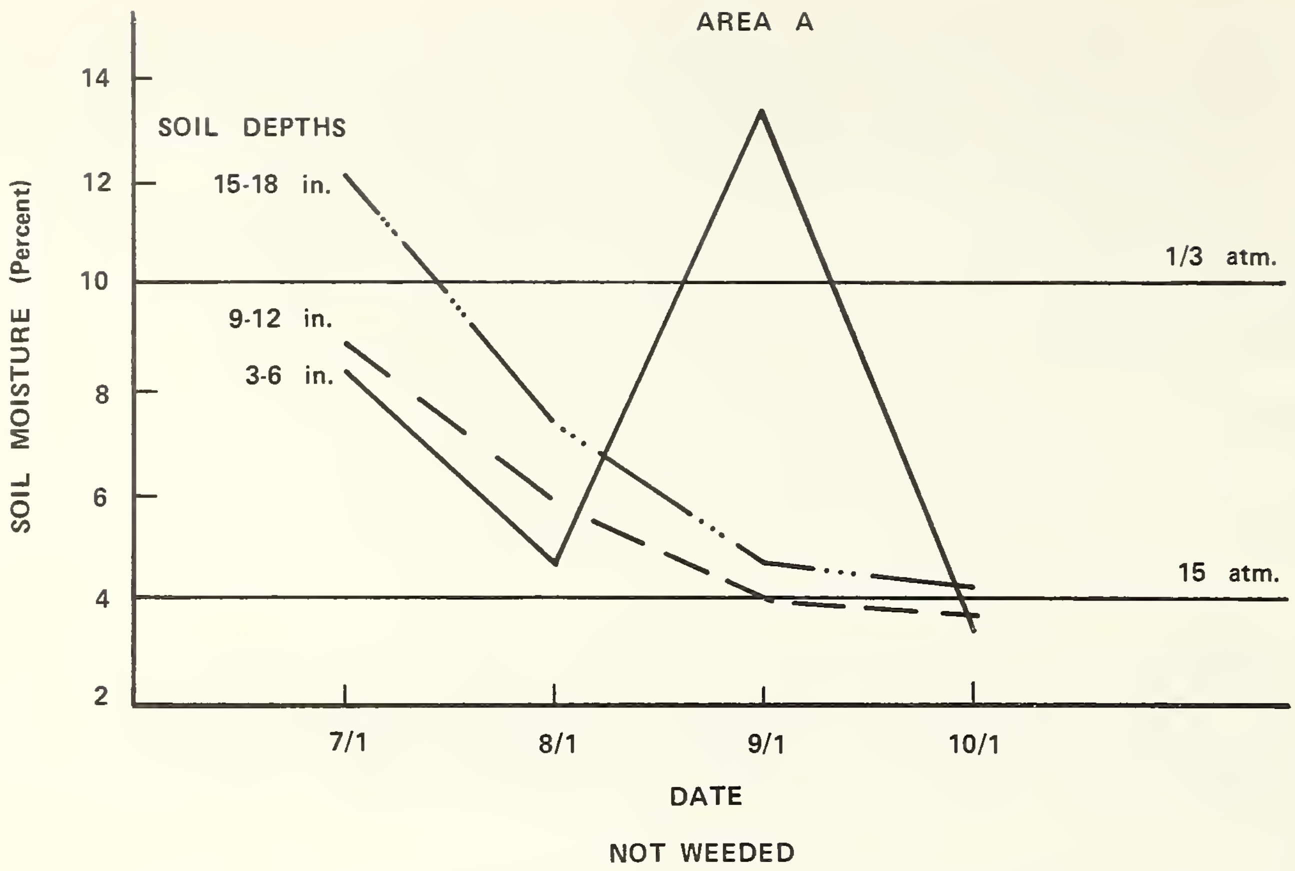
Temperatures were slightly higher on the slopes that were most nearly at right angles to the sun. Highest temperatures occurred at the soil surfaces (100.8° to 149.5° F.). Temperatures between the surface and 0.5 foot above the surface were highest over black polyethylene (149.5° to 96.5° F.). Glass fiber had the lowest maximum surface temperatures. Highest temperatures were reached sooner on the surfaces than above them.

Live seedling tallies were made on the 1st and 15th of each month from June to October 1964. The first mortality was noted July 15 (table 5). Fall tallies were continued annually until 1968 (Appendix II). The variation in survival of seedlings due to areas was amazingly low (Appendix VI). Treatments differed significantly (p = .95) in 1964 and 1965, but not in the remaining years. The undisturbed treatment had the poorest rate of seedling survival in all years. Through 1965, the other three treatments showed some differences as to seedling survival. In 1966, and later, the yearly differences in survival were slight; this apparently was the reason for a lack of significance in the treatments during these years.

Table 5.--*Seedling survival (percent) by treatments, July to October 1964, Test 5*

Treatment	Date of seedling tally					
	7/15[1]	8/1	8/15	9/1	9/15	10/1
Glass fiber mulch	100	100	100	100	100	100
Polyethylene mulch	100	100	100	96	94	92
Hand weeded	100	100	96	92	90	86
Control (no mulch)	98	98	92	86	82	82

[1]25 seedlings planted in each cell.



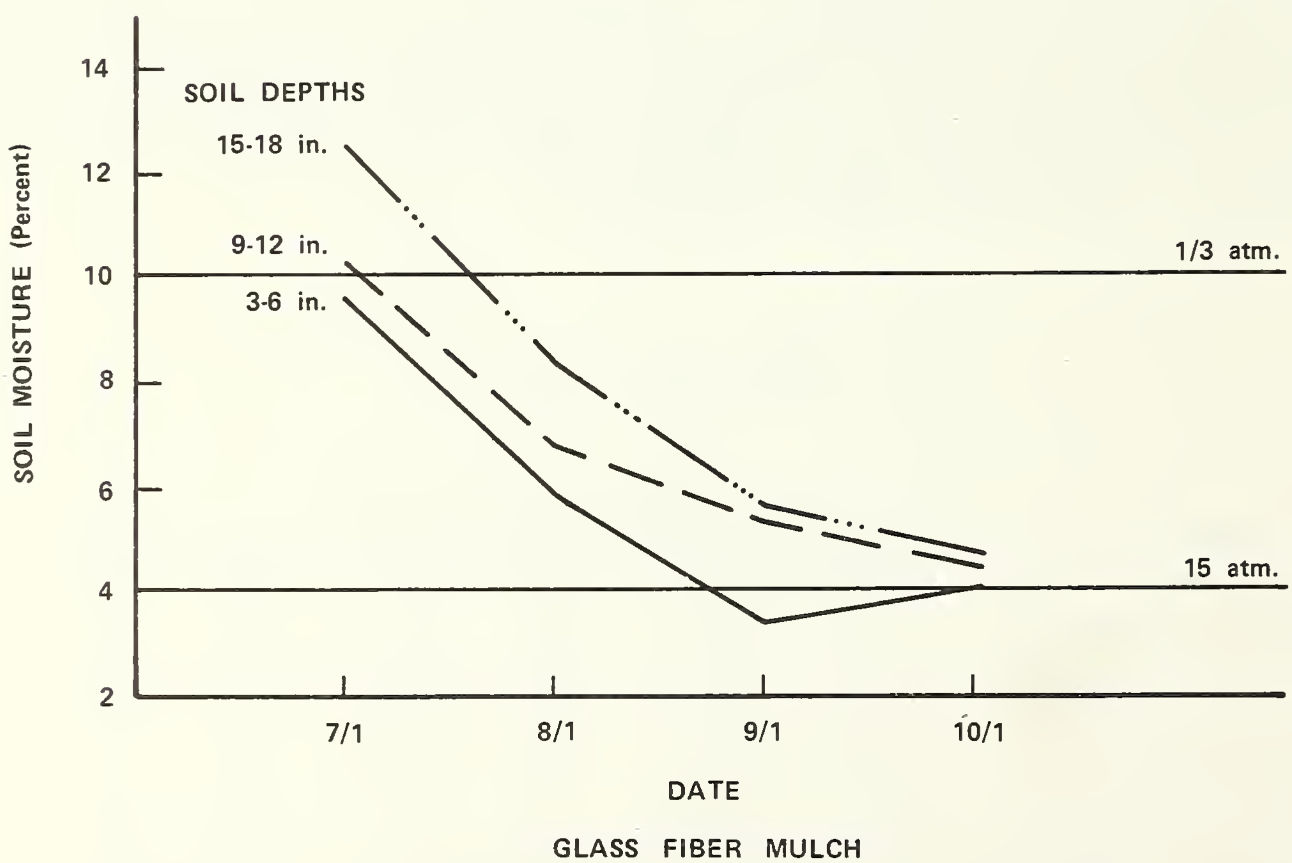
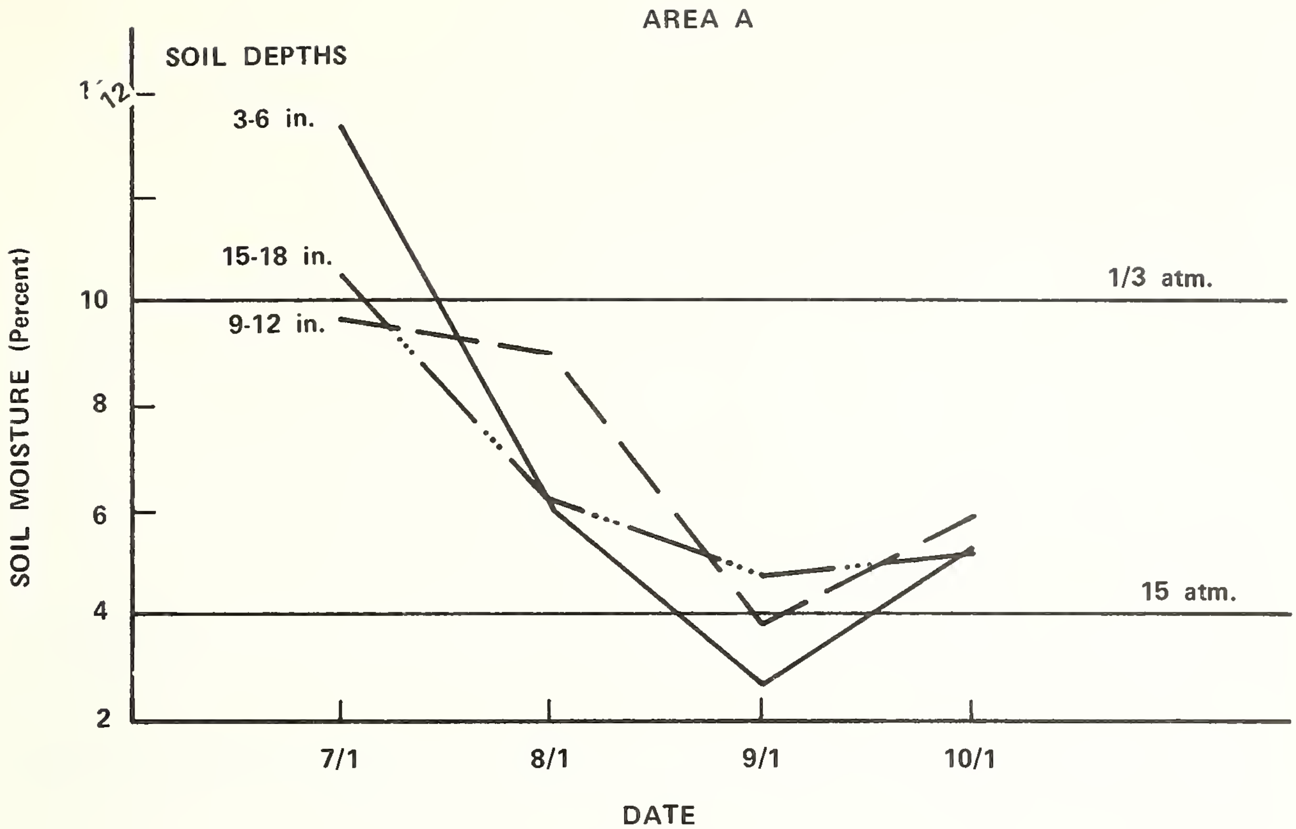
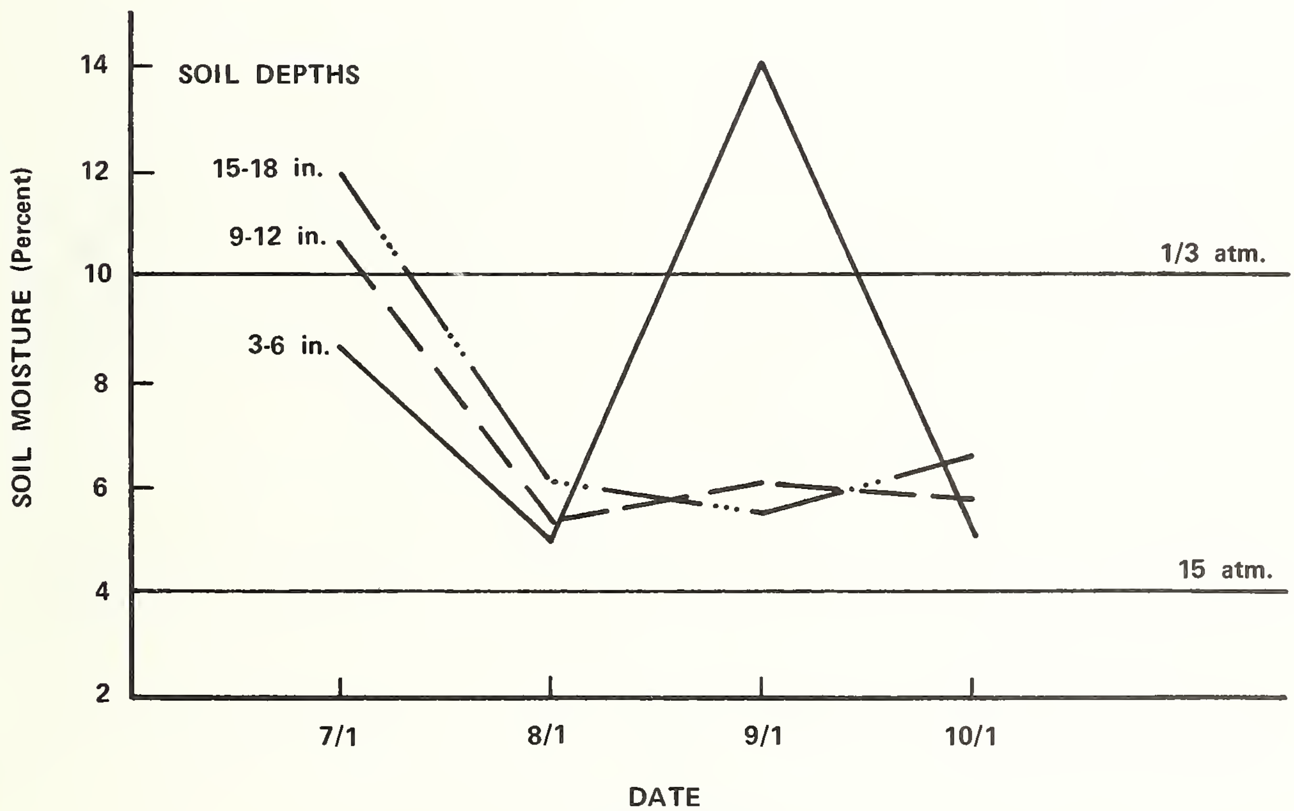


Figure 7A.--Periodic monthly soil moisture levels under two treatments.



POLYETHYLENE MULCH



HAND WEEDED

Figure 7B.--Periodic monthly soil moisture levels under two treatments.

AREA B

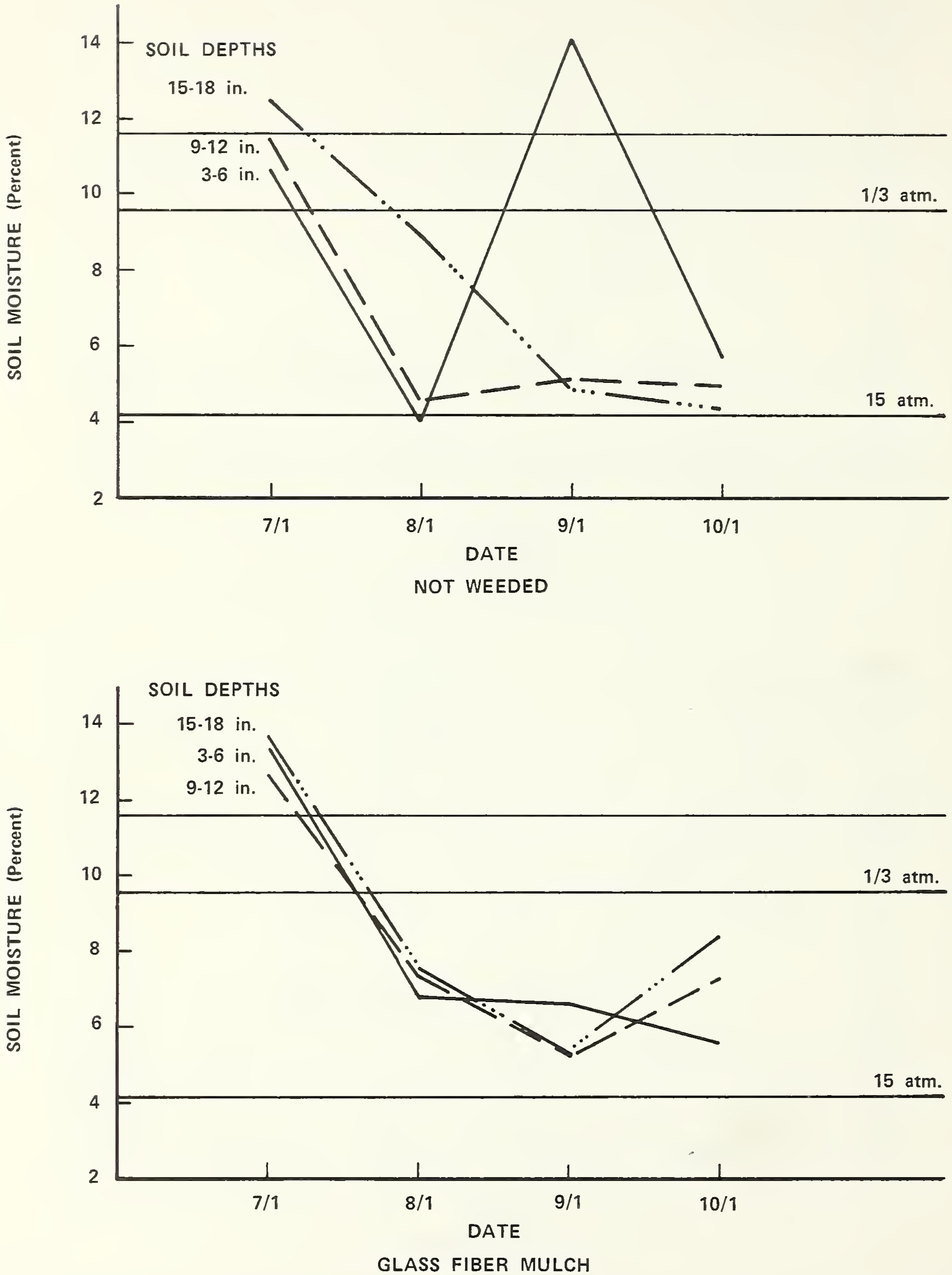


Figure 8A.--Periodic monthly soil moisture levels under two treatments.

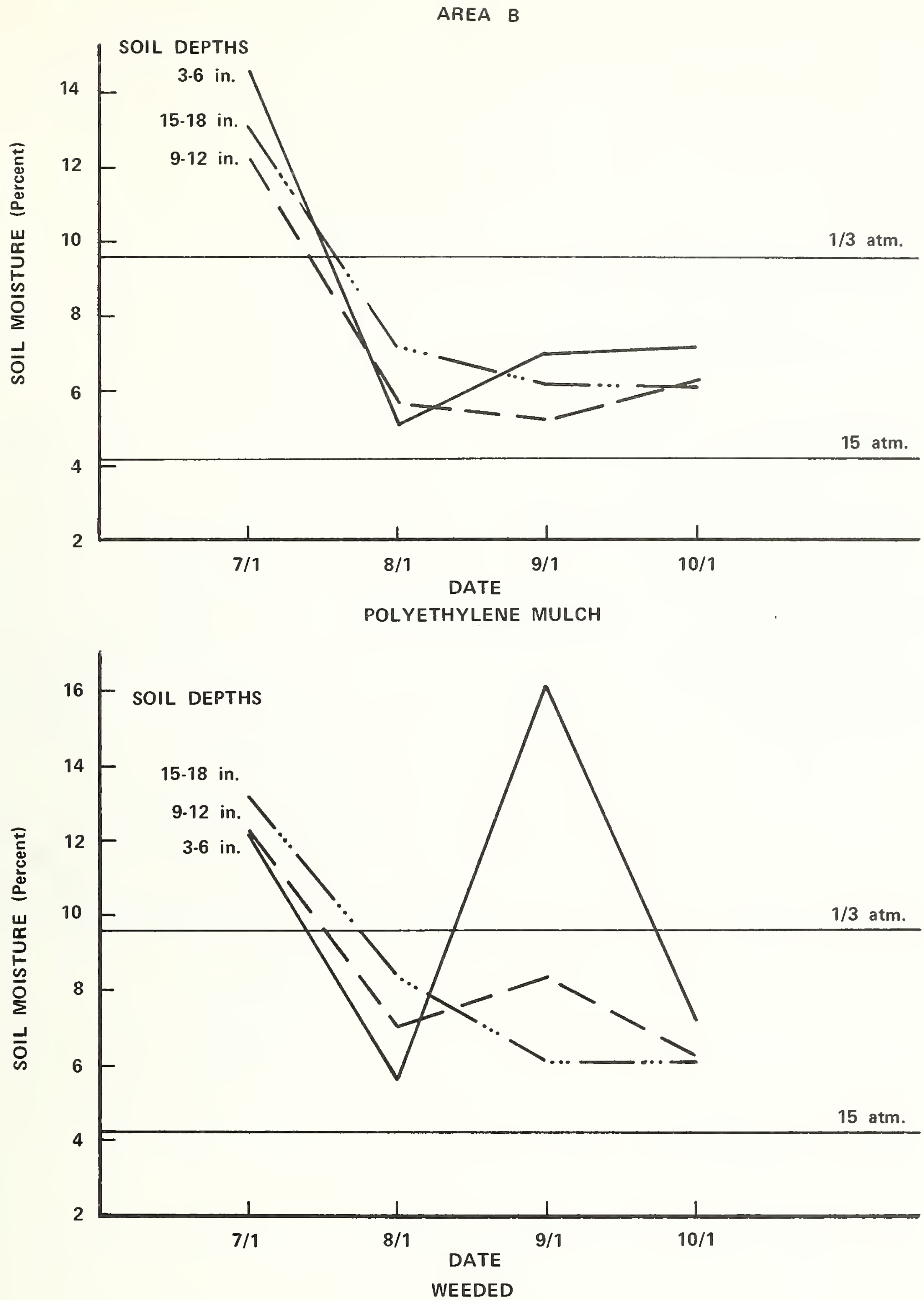


Figure 8B.--Periodic monthly soil moisture levels under two treatments.

This trend of diminishing significance at the Boise Basin study area is in direct contrast to the increasing significance for the 1964 plantings at Zena Creek. Approximately one-third of the total variation in this Boise Basin test was caused by sampling error, and only a negligible variation existed between experimental units (Areas). This originally negligible variation increased with time, at a faster rate than treatment variation, thus giving the opposite trend in "F" values.

The interrelationships between the mulch temperatures on a day in August and soil moisture relationships are not easily identified. The high temperatures that occurred over the polyethylene apparently did not reduce seedling survival to any great extent in this summer of abundant rainfall. Likewise, the slower recharge rate under this mulch was not limiting to any noticeable degree. More moderate conditions associated with the glass fiber blanket did not provide significantly better survival during the 5-year period.

Indicating the advantages of less competition and earlier spring height growth initiation, seedlings mulched with black polyethylene film were taller. As mentioned earlier, significant numbers of the seedlings alive in 1968 had terminal damage (table 6).

The impact of vegetative competition was evident and seedlings that received the control treatment were the shortest in both terminal damage classes (fig. 9). A comparison of the means within damage classes showed a significant difference (p = .05, "t" test) only between the polyethylene and control treatments, and this difference was in the "damaged" terminal class. Although the mean for the weeded treatment was the same as the mean for the polyethylene the greater variation about the former made the comparison with the control treatment insignificant (p = .05). These results imply that the use of mulch to reduce competition does provide some increased height growth.

Table 6.--*Proportion (percent) of seedling terminals damaged, 1964 to 1968*

Treatment	Area "A"	Area "B"	Average
		Percent	
Polyethylene mulch	37	18	28
Glass fiber mulch	20	32	26
Hand weeded	26	37	32
Control (no mulch)	35	60	47

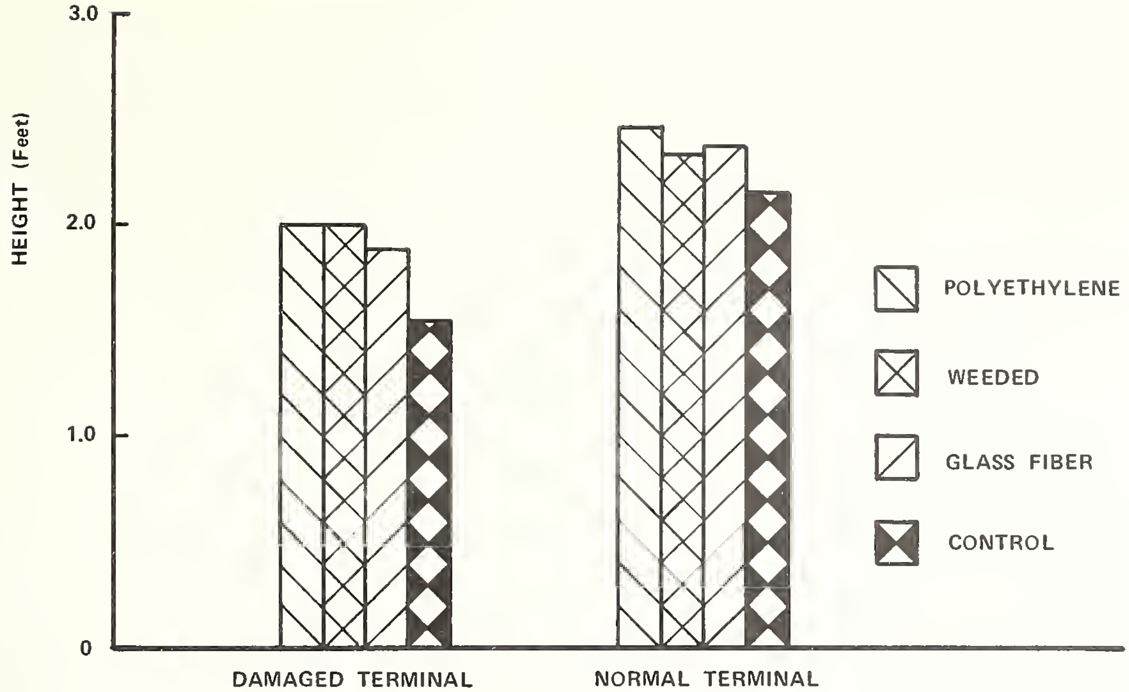


Figure 9.--Mean fifth-year heights of seedlings by treatment and terminal damage classes.

Summary and Conclusions

During the period from 1962 to 1964, ponderosa pine seedlings were outplanted in four different tests at Zena Creek, Payette National Forest and one test (1964) at Boise Basin Experimental Forest, Boise National Forest. All tests appear to have been in the Daubenmires' (1968) Douglas-fir--Ninebark h.t. A variety of techniques to reduce or eliminate competition were tested. Site preparation tests included scalps (from 2 to 6 feet wide), pits, furrows, burning, and natural undisturbed areas. For the mulch tests, black polyethylene film, glass fiber blankets, and straw were used. Simazine, a pre-emergence herbicide, was also tested. Some limited attempts were made to characterize the site conditions and evaluate seedling responses to: aspect; soil depth and moisture content; and summer precipitation and temperature. Seedling survival tallies were made throughout a 5-year period after each planting (Appendix II). Fifth-year height measurements were made on a number of plots. Some general conclusions are warranted:

1. All the practices which reduce vegetative competition improved survival. The relative improvement increased with time.

2. The better the survival the taller the trees in the fifth year when other factors are held constant.

3. The greater the summer precipitation (with good distribution over a period of time), the better the survival.

Some additional conclusions were made as a result of individual tests. Naturally, these conclusions are limited to the Douglas-fir--Ninebark h.t. in the Idaho Batholith. The tests were not specifically designed to obtain some of the conclusions, but the observations and results from the series seem to support them. Confidence in these conclusions is indicated as follows: * = statistically significant test assuming that p = .95; trends = one or more tests appear to support conclusions, but because of time limits, confounding variables, or design limitations, no statistical significance was obtained; observed = no measurements were made but the relationship seemed apparent during field observations. The latter two classes should be accepted cautiously until proper testing or extensive experience validates them. The conclusions are as follows:

1. Seedling survival and height growth is positively correlated with soil depth (Tests I, III, V: trends).

2. Animal damage is extensive (up to 82 percent) and affects both survival and height attainment (I, III to V: trends).

3. Hand scalping with an application of simazine provided the least expensive control of competition in a moist summer--1964 (IV: trends).

4. Northwest aspects have better survival (IV: *; III: trends), but fifth-year heights are greater on warmer southeast aspects (III, IV: trends).

5. Treatments have less influence on survival in the more moist seasons and sites (III to V: trends).

6. Native grass competition (moderate density levels) seem less severe on seedling survival than brush species in this h.t. (III, IV: observed).

7. Animal damage did not appear to be influenced by mulch materials (I, III to V: trends).

8. Mean fifth-year heights for undamaged seedlings ranged from 0.86 to 2.50 feet. Heights appeared to be positively correlated with survival, soil depth, and relative temperatures (I, III to V: trends).

9. Five-year heights were greater when black polyethylene was used (III to V: trends).

10. On granitic soils in central Idaho the surface 12 inches of soil reaches the "wilting point" (15 atmospheres determination) during the summer unless additional moisture comes from summer storms (V: trends).

Recommendations

As a result of these studies, the following two recommendations seem appropriate.

1. Initial seedling stocking standards should take into account the onsite differences and be adjusted as to the planting area to insure adequate stocking at some target date after planting, for example, 3, 4, or 5 years. The survival rates vary greatly with the onsite environment, i.e., specific cover species, aspect, soil depth, animal populations, and summer precipitation. The probabilities of abnormal summer precipitation levels should be used to weight the initial standard. Sites similar to those in these studies may require planting 600 seedlings, or more, to have 300 live seedlings after 3 years.

2. Site preparation and vegetation control should be used to improve ponderosa pine seedling survival and growth. On steep slopes in habitat types similar to this study, 3- to 4-foot-wide scalps (hand-made) with a simazine herbicide treatment (6 grams/10 sq.ft. for simazine 4G) in the fall should lead to reasonable survival levels. Planting unprepared sites would require 3 to 4 times as many seedlings, and a corresponding cost increase, to reach a 3-year stocking standard.

Natural regeneration was not considered in these tests. Because of the inherent problems of planting seedlings in the shallow soil of these steep slopes, and because of the high costs, a third recommendation is advisable, as follows:

3. Further study should include comparisons with natural regeneration systems.

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Appendix I

Soil Depths on Regeneration Plots, Test 1

Area summary

Test area		Block number	Number of soil pits		Soil depth to bedrock, average	
					(*Inches*)	
1		1	3		12.3	
		2	7		16.4	
		3	6		20.1	
	Total			16		[1] 17.0
2		4	6		19.8	
		5	5		28.8	
		6	6		23.2	
	Total			17		23.6
Combined 1 and 2				33		20.4

Treatment summary

Treatment		Test area number	Number of soil pits		Soil depth to bedrock, average	
					(*Inches*)	
		STRAW MULCH				
Scalp		1	3		24.3	
		2	3		25.3	
	Total			6		24.8
Pit		1	3		11.0	
		2	3		22.3	
	Total			6		16.7
Furrow		1	2		16.0	
		2	3		25.7	
	Total			5		21.8
		NO MULCH				
Scalp		1	3		19.3	
		2	3		29.3	
	Total			6		24.3
Pit		1	4		18.8	
		2	4		25.2	
	Total			8		22.0
Furrow		1	5		20.0	
		2	3		19.7	
	Total			8		19.9
Treatments		1	[2] 20		18.6	
		2	[2] 19		24.6	
	Total			[2] 39		21.5

[1] This column consists of weighted averages.

[2] Some borderline pits used for two treatments so number of pits will not agree with total in block summary.

Appendix II

Survival (Percent), Tests 1 through 5[1]

	1962	1963	1964	1965	1966	1967	1968
-TEST 1-							
Test area I				*Percent*			
No mulch							
Scalps	62.3	50.7	46.4	43.5	36.2	--	--
Pits	64.0	52.0	45.3	36.0	25.3	--	--
Furrows	77.3	66.7	56.0	45.3	20.0	--	--
Straw mulch							
Scalps	69.3	57.3	52.0	48.0	22.7	--	--
Pits	57.5	42.5	39.7	32.9	27.4	--	--
Furrows	59.3	42.9	30.0	22.9	21.4	--	--
Test area II							
No mulch							
Scalps	58.6	47.1	38.6	34.3	30.0	--	--
Pits	61.3	52.0	36.0	22.7	16.0	--	--
Furrows	64.0	46.7	32.0	24.0	20.0	--	--
Straw mulch							
Scalps	78.3	68.9	48.6	41.9	37.8	--	--
Pits	70.4	57.7	54.9	50.7	36.6	--	--
Furrows	77.3	69.3	53.3	42.7	34.7	--	--
-TEST 2-							
East				*Percent*			
2' Scalps	63.6	63.5	54.5	45.5	27.3	--	--
4' Scalps	100.0	80.0	80.0	80.0	60.0	--	--
6' Scalps	66.7	50.0	33.3	33.3	33.3	--	--
Burned spots	83.4	83.4	83.4	83.4	55.6	--	--
West							
2' Scalps	67.2	57.0	53.5	50.0	41.4	--	--
4' Scalps	75.5	67.6	63.1	60.0	50.8	--	--
6' Scalps	76.2	67.7	52.5	52.5	40.7	--	--
Burned	66.2	63.1	61.5	61.5	58.5	--	--
TEST 3-							
East				*Percent*			
Scalped	61.3	38.9	31.5	20.1	116.1	--	--
Glass fiber	76.0	64.0	57.3	48.0	43.3	--	--
Polyethylene	34.7	29.3	27.3	23.3	22.0	--	--
West							
Scalped	60.7	53.3	47.3	33.8	31.1	--	--
Glass fiber	85.3	74.7	69.4	54.2	47.9	--	--
Polyethylene	50.7	43.0	37.8	31.5	30.1	--	--

(Con. next page)

	1962	1963	1964	1965	1966	1967	1968
-TEST 4-							
East				*Percent*			
Scalped	--	--	81.5	73.0	41.0	33.5	27.5
Glass fiber	--	--	83.0	73.5	51.5	45.0	41.5
Polyethylene	--	--	89.0	83.0	63.0	58.5	54.5
Simazine	--	--	86.0	77.5	53.0	48.5	43.5
West							
Scalped	--	--	89.5	85.0	69.5	63.0	61.0
Glass fiber	--	--	92.0	81.5	70.5	61.0	60.0
Polyethylene	--	--	93.5	88.5	73.5	68.5	66.0
Simazine	--	--	94.0	90.0	75.0	70.0	70.0
-TEST 5-							
Test area I				*Percent*			
Weeded	--	--	84	80	80	76	76
Glass fiber	--	--	100	84	84	80	80
Polyethylene	--	--	92	83	88	80	76
Undisturbed	--	--	80	68	64	64	64
Test area II							
Weeded	--	--	88	84	76	76	76
Glass fiber	--	--	100	92	76	76	76
Polyethylene	--	--	92	84	76	76	68
Undisturbed	--	--	84	72	64	60	60

[1]Highest values underlined.

Appendix III

Mean Heights of Seedlings by Terminal Condition Class, 1968, Test 1

Test area	No mulch: Scalps Height	No.	Pits Height	No.	Furrows Height	No.	Straw mulch: Scalps Height	No.	Pits Height	No.	Furrows Height	No.	Means Height	No.
	Feet													
							NORMAL TERMINAL							
1	1.60	5	1.27	7	1.23	3	1.15	8	1.21	7	.90	3	1.24	33
2	1.40	2	1.40	3	2.00	4	1.30	1	2.08	8	.75	2	1.72	20
Mean	1.54	7	1.31	10	1.67	7	1.17	9	1.67	15	.84	5	1.42	53
							DAMAGED TERMINAL							
1	1.22	14	1.14	11	.81	8	.90	3	1.32	6	1.00	3	1.10	45
2	1.29	17	1.42	6	1.43	8	1.58	25	1.34	17	1.49	20	1.44	93
Mean	1.26	31	1.24	17	1.13	16	1.51	28	1.33	23	1.43	23	1.33	138
											G Mean		1.35	191
											Area 1		1.16	78
											Area 2		1.49	113

Appendix IV

Soil Moisture Content (Percent) at 1/3 and 15 Atmospheres, Test 5

Area	Area "A"		Area "B"	
	Upper slope	Lower slope	Upper slope	Lower slope
15-ATMOSPHERE TEST				
Inches	*Percent*			
3-6	3.85	3.78	4.99	4.83
9-12	4.36	3.61	3.89	4.34
15-18	4.46	4.21	3.60	3.92
Mean	4.05		4.26	
1/3-ATMOSPHERE TEST				
3-6	10.34	9.94	9.93	11.49
9-2	9.36	9.62	8.26	10.18
15-18	10.32	10.74	8.01	9.85
Mean	10.05		9.62	

Appendix V

Periodic Monthly Soil Moisture Content Under Four Mulch Treatments at Three Depths, Test 5

Treatment	Depth	Date							
		7/1	8/1	9/1	10/1	7/1	8/1	9/1	10/1
	Inches	Percent							
Black poly-ethylene	3-6	13.4	6.1	2.7	5.3*	14.6	5.1	7.0	7.2*
	9-12	9.7	7.0	3.9	5.4*	12.3	5.7	5.3	6.3*
	15-18	10.5	6.2	4.8	5.1*	13.1	7.2	6.2	6.1
Glass fiber	3-6	9.6	5.8	3.4	4.1*	13.4	6.8	6.7	5.6
	9-12	10.3	6.8	5.3	4.5	12.7	7.4	5.3	7.4*
	15-18	12.5	8.4	5.7	4.8	13.7	7.6	5.4	8.5*
Hand weeded	3-6	8.7	5.0	14.1*	5.1	12.1	5.7	16.1*	7.2
	9-12	10.6	5.4	6.1*	5.8	12.3	7.0	8.3*	6.2
	15-18	12.0	6.1	5.5	6.6*	13.2	8.4	6.1	6.1*
Not weeded	3-6	8.4	4.7	13.4*	3.5	10.7	4.0	14.2*	5.7
	9-12	8.7	5.9	4.0	3.7	11.5	4.6	5.2*	5.0
	15-18	12.1	7.3	4.7	4.2	12.5	7.0	4.9	4.4

* Indicates some recharge since last date.

Appendix VI

Analysis of Variance Table for Seedling Survival, 1964-1968, Test 5

Component	d.f.	1964			1965			1966			1967			1968		
		SS	MS	F	SS	MS	F	SS	MS	F	SS	MS	F	SS	MS	F
Area	1	0.00	0.00	0.00 NS	0.02	0.02	0.10 NS	0.24	0.24	1.00 NS	0.04	0.04	0.10 NS	0.08	0.08	0.03 NS
Location	48	4.44	.09		10.00	.20		11.96	.24		13.66	.28		12.73	.26	
Treatment	3	.77	.25	3.12*	1.12	.37	3.08*	1.09	.36	2.40 NS	1.25	.41	2.56 NS	1.12	.37	2.11 NS
T x A	3	.01	.00	.00 NS	.06	.01	.08 NS	.13	.04	.27 NS	.05	.01	.16 NS	.08	.02	.11 NS
Error	144	11.96	.08		18.31	.12		22.52	.15		23.94	.16		26.29	.18	
Total	199	17.19			29.51			35.95			38.95			40.31		

Headquarters for the Intermountain Forest and Range Experiment Station are in Ogden, Utah. Field Research Work Units are maintained in:

- Boise, Idaho
- Bozeman, Montana (in cooperation with Montana State University)
- Logan, Utah (in cooperation with Utah State University)
- Missoula, Montana (in cooperation with University of Montana)
- Moscow, Idaho (in cooperation with the University of Idaho)
- Provo, Utah (in cooperation with Brigham Young University)