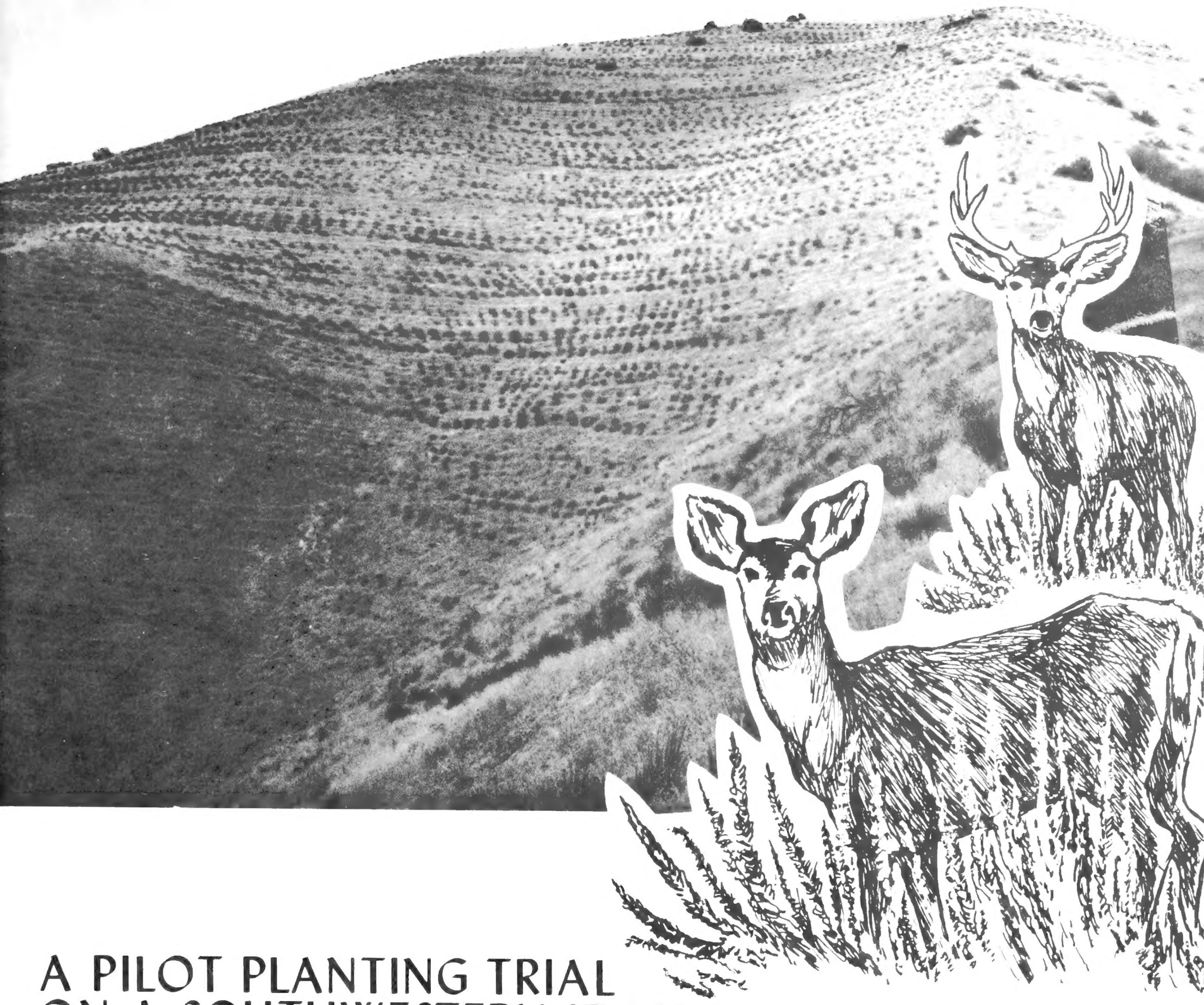

A PILOT PLANTING TRIAL ON A SOUTHWESTERN IDAHO DEER WINTER RANGE

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RESEARCH SUMMARY

The 30-acre (12-ha) planting was designed to test the applicability of procedures recommended for improving deteriorated deer winter ranges in southwestern Idaho by artificial revegetation. Secondary objectives were to compare: (1) two planting methods--direct seeding and transplanting; (2) two browse species--antelope bitterbrush (*Purshia tridentata* [Pursh] DC.) and wedgeleaf ceanothus (*Ceanothus cuneatus* [Hook.] Nutt.); and (3) two bitterbrush seed sources--southwestern Idaho and northwestern Nevada--for both the seeding and transplanting methods.

Competing vegetation was reduced by preparing scalps about 3-ft (1-m) square with hoes made from square-nosed shovels. About 1,200 scalps per acre (3 000 per hectare) were prepared on a spaced grid pattern of 6 ft (2 m) from center to center. Seeding was done in late October and early November using hand-operated seeders. Three spots were seeded near the center of each scalp at a rate of 12 to 16 seeds per spot. Transplanting of bare-root nursery stock (1-0) was done in April using planting spades. One transplant was placed near the center of each scalp.

Overall, the seeding treatments had a sixth-year survival of 80 percent; transplanting treatments had a sixth-year survival of 62 percent. Survival was calculated as the percentage of scalps with surviving plants. Seeded bitterbrush had better survival than bitterbrush transplants. The converse was true for wedgeleaf ceanothus. Bitterbrush from local seed sources, whether seeded or transplanted, outperformed other plants significantly in survival and nonsignificantly in height growth.

The findings support the notion that adequate technology is generally available for revegetating southwestern Idaho deer winter ranges, and that inconsistent results are at least partly due to improper application of recommended procedures.

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INTRODUCTION

Large areas of southwestern Idaho deer winter ranges have declined in both acreage and forage productivity (Holmgren and Basile 1959). Many factors have contributed to the decline. Wildfire, insect infestations, rodents, overuse by livestock and big game, urban expansion, agricultural development, road and highway construction, and water storage projects have been among the most damaging impacts (Klemmedson 1967). Effectively improving the forage productivity of these winter ranges is a major challenge.

One way to improve winter ranges is through artifical revegetation--the direct establishment of food and cover plants. Seeding or planting often is the only practical means of restoring productivity where essential food and cover plants are lacking or sparse. Early attempts to directly improve southwestern Idaho deer winter ranges through shrub planting programs were mostly unsuccessful (Holmgren 1956). As a result, studies began for developing the knowledge required for effective range restoration.

Holmgren (1954) evaluated 50 native and exotic browse species for their potential suitability for artificial revegetation. Of those species, only four indicated promise, and only antelope bitterbrush (*Purshia tridentata* [Pursh] DC.) was outstanding. Consequently, many later studies dealt almost exclusively with bitterbrush.

These studies included methods of collecting and cleaning seeds, preplanting treatment of seeds (Casebeer 1954), season of seeding, seeding rates, depth of seeding (Basile and Holmgren 1957), seeding methods and equipment, site preparation techniques, effects of plant competition, influences of small mammals and insects, and effects of trampling and browsing. Holmgren and Basile (1959) summarized these investigations and recommended species to be planted, planting methods, planting locations, and methods of protecting and managing planted areas.

Yet, shrub planting programs failed to achieve consistent results. Small experimental plantings became well-established stands. Successes were uncommon on large plantings. Operational projects were scaled back to minor trials on limited areas.

Causes of failure are conjectural in most cases. Holmgren (1956) provided evidence that competition for soil moisture from cheatgrass (*Bromus tectorum* L.) and other annuals was particularly damaging. Poor quality seed, improper planting technique, high rodent and rabbit populations, disease, insect depredation, frost injury, frost heaving, summer drought, and trampling and browsing by hoofed mammals have been advanced as associated or additional causes of poor stand establishment. Also, environmental conditions for shrub establishment on southwestern Idaho winter ranges are harsh, particularly southern exposures.

We wondered whether knowledge was in fact adequate for the task of revegetating those winter range problem areas most in need of restoration. Our observations suggested that research-tested and recommended procedures were adequate, and that inconsistent results were at least partly due to improper application. To examine this, we established a carefully controlled and supervised pilot planting on a representative area of deer winter range in poor condition. We designed the planting to serve as a full scale test of the applicability of recommended procedures, to help define problems yet unsolved, and to provide the basis for additional experimentation. For the experimental function, we defined three specific objectives: (1) to compare two planting methods--direct seeding and transplanting; (2) to compare two browse species--antelope bitterbrush and wedgeleaf ceanothus (*Ceanothus cuneatus* [Hook.] Nutt.); and (3) to compare two bitterbrush seed sources--southwestern Idaho and northwestern Nevada--for both the seeding and transplanting treatments.

THE STUDY AREA

The planting was done on a deteriorated segment of potentially productive deer winter range. This range once supported large stands of shrubs, mostly bitterbrush, that are now gone from many parts of the area (Holmgren and Basile 1956). The 30-acre (12-ha) test area is a topographic unit varying from lower toe slopes to a major ridge at the top (fig. 1) and located between Nelson and Carpenter Creeks on the South Fork of the Payette River in Boise County.

Figure 1.--Pilot planting area between Nelson and Carpenter Creeks on the South Fork of the Payette River, Boise National Forest (photo taken October 1968).

Topography is typically steep and dissected. Slope gradients are between 25 and 80 percent with generally south facing exposures. The elevation is from about 3,300 ft (1 010 m) to 3,800 ft (1 150 m). Soils are of granitic origin, coarse textured and loose, with low water-holding capacity. Average annual precipitation is about 23 inches (60 cm), most of which falls as snow in the winter. Summer rains generally occur as infrequent, scattered, high-intensity thundershowers. Soil surface temperatures in the summer are high, with 140° to 158° F (60 to 70° C) common and maximums reaching 168° F (76° C) (Ferguson 1972).

Vegetation is dominantly annual with cheatgrass the most abundant component. Broad-leaved annuals include storksbill (*Erodium cicutarium* [L.] L'Her.), ground smoke (*Gayophytum diffusum* Torr. and Gray), prickly lettuce (*Lactuca serriola* L.), and Douglas knotweed (*Polygonum douglasii* Greene). Bluebunch wheatgrass (*Agropyron spicatum* [Pursh] Scribn. and Smith) and arrowleaf balsamroot (*Balsamorhiza sagittata* [Pursh] Nutt.) are the most common perennials.

Although deer had yearlong access to the planting area, few were present during the summer and early fall. Livestock grazing was not permitted.

Treatments, listed in top-to-bottom order of establishment within planting blocks, were as follows:

1. Bitterbrush, direct seeding, southwestern Idaho seed source.

2. Bitterbrush, transplants, northwestern Nevada seed source.

3. Bitterbrush, transplants, southwestern Idaho seed source.

4. Wedgeleaf ceanothus, direct seeding, north-central California seed source.

5. Bitterbrush, direct seeding, northwestern Nevada seed source.

6. Wedgeleaf ceanothus, transplants, north-central California seed source.

Starting at the lower edge of the tract, treatments were applied sequentially to two rows of scalped planting spots each, covering the width of the tract on east-west contours. The fixed arrays of six treatments (12 rows) were repeated contiguously up the slope until the entire tract was planted.

Twelve well-distributed blocks, approximately 75-by-150 feet (23-by-46 meters) wide and encompassing one set of six treatments each, were subsequently marked off for observation of plant response. But the consistent arrangement of treatments for all blocks gave no design protection against response bias that could result from top-to-bottom nutrient or moisture gradients in the sloped blocks. Such gradients were expected to have a minimal effect, however, within the rather short length of slope for each block. Also, this judgment appeared to be supported by the data. Response magnitudes were generally inverse to the direction of expected bias effect associated with treatment location. Thus, within-block bias effects were assumed to be negligible and the data were analyzed as for a conventional randomized block design.

PLANTING METHODS

Direct Seeding

Seeding methods were essentially those recommended for bitterbrush by Holmgren and Basile (1959). There were minor modifications based on recent findings.

Seed source.--Bitterbrush seeds were collected from Ada and Boise Counties in southwestern Idaho, and from Washoe County in northwestern Nevada. Wedgeleaf ceanothus seeds were collected from Shasta County in north-central California.

Seed treatment.--Bitterbrush seeds were treated with a mixture of Endrin (50 percent wettable powder) and liquid Arasan 42-S (thiram fungicide). Endrin was applied at a rate of 1 percent by weight and Arasan at a rate of 4 percent by weight. Both chemicals were mixed with diluted (9:1) Dow Latex 512R adhesive before application. Aluminum powder was used as a coating to prevent caking. Wedgeleaf ceanothus seeds were soaked in water heated to 176° F (80° C) to reduce hard seed coats (Grisez and Hardin 1967) and planted without Endrin-Arasan treatment.

Seeding season.--Both species were seeded in late October and early November 1968.

Site preparation.--Competing vegetation was reduced by preparing scalps about 3-ft (1-m) square and 2 inches (5 cm) deep with hoes made from square-nosed shovels.

Seeding depth.--Both bitterbrush and wedgeleaf ceanothus were seeded at a depth of 1 to 1.5 inches (2.5 to 3.5 cm) (Basile and Holmgren 1957; Adams 1962).

Seeding rate.--Three spots were seeded near the center of each scalp at a rate of 12 to 16 seeds per spot (Ferguson and Basile 1967). Schussler hand-operated seeders were used to dispense seed and control planting depth.

Spacing.--About 1,200 scalps per acre (3 000 per ha) were prepared on a spaced grid pattern of 6 ft (2 m) from center to center.

Transplanting

Bare-root planting stock (1-0) of both bitterbrush and wedgeleaf ceanothus was obtained from the Lucky Peak Forest Nursery, located near Boise, Idaho. Plants were lifted in early April, sorted, and graded for an undamaged root system, undamaged tops, and adequate root length and root:shoot balance. Polyethylene-lined kraft paper bags were used for cold storage and transport.

Field planting was done in mid-April 1969 by experienced planting crews from the Garden Valley Ranger District, Boise National Forest. Planting spades were used. Site preparation and spacing were as described above for direct seeding.

DATA COLLECTION

Seedling emergence, survival, and height growth were recorded on each sample scalp and tabulated separately for each plot (treatment), block (replicate), and site characteristic (aspect, slope position, slope gradient, slope shape, nature of competing vegetation). Survival during the first year (1969) was assessed at 2- to 3-week intervals from May 1 to September 10. Second-, third-, and sixth-year survival was assessed in September each year. Emergence percentage values were calculated on a per-scalp basis. Survival was based on the total number of scalps with emergent seedlings. The height of the tallest surviving seedling or transplant on each scalp was measured in September each year.

Probable causes of mortality were assigned for each seedspot or transplant. Criteria used to identify the causes were similar to those of Gashwiler's (1971).

In the first-year survival assessment, soil samples were collected from six sites distributed throughout the planting area. Samples were taken at depths of 6, 12, and 24 inches (15, 30, and 60 cm) on paired scalped and unscalped areas. Percent soil moisture was measured gravimetrically. Maximum soil surface temperatures on each soil sampling site were recorded using thermopapers.

Weather data were summarized from U.S. Weather Service records at Garden Valley Ranger Station, located 2.5 mi (4 km) from the planting site and at about the same elevation.

RESULTS AND DISCUSSION

Emergence

Emergence of bitterbrush from both the Idaho and Nevada seed sources occurred from the second week of March until mid-April. Wedgeleaf ceanothus emerged from late March until the end of April. Most of the bitterbrush seedlings emerged during the last week of March and the first week of April. Wedgeleaf ceanothus emergence peaked about mid-April. Emergence counts were made May 1.

Bitterbrush emergence averaged 99 percent for the Nevada seed source and 97 percent for the Idaho seed source (table 1). Most of the seed spots had clusters of emergent seedlings. There was little site variation in bitterbrush seedling emergence; lower slope sites had slightly lower emergence values.

Wedgeleaf ceanothus emergence averaged 36 percent, significantly lower ($P<0.05$) than bitterbrush (table 1). Many seed spots had a single emergent seedling. Emergence was highest (66 percent) on lower slope sites and lowest (13 percent) on upper slope sites. We were unable to identify the reason for the poor emergence of wedgeleaf ceanothus. A 600-seed sample from each seed lot used in the planting was hand sown on a nearby site at the time of the pilot planting. Two-thirds of the seeds were protected by a rodent-proof screen. Sixty percent of wedgeleaf ceanothus produced emergent seedlings in both the protected and unprotected plots. This was better than that exhibited by bitterbrush from either seed source (20 to 40 percent emergence).

Table 1.--*Average emergence (percent), survival (percent), and height (cm) of antelope bitterbrush and wedgeleaf ceanothus seedlings and transplants*[1]

Species	Seed source	Planting method	Emergence[2]	Survival[3] Year 1	Year 2	Year 3	Year 6	Height Year 1	Year 2	Year 3	Year 6
Bitterbrush	Idaho	Seedling	97a	99	98	96	94a	11	24	26	55a
Bitterbrush	Nev.	Transplant	--	87	70	56	39c	16	31	23	53a
Bitterbrush	Idaho	Transplant	--	94	90	88	86b	16	32	28	57a
Wedgeleaf ceanothus	Calif.	Seeding	36b	79	59	53	47c	4	10	16	32b
Bitterbrush	Nev.	Seeding	99a	98	94	88	78b	10	23	19	54a
Wedgeleaf ceanothus	Calif.	Transplant	--	92	86	76	61d	19	24	26	37b

[1]Column values not having the same letter are significantly different ($P<0.05$). Comparison of treatment means followed Snedecor (1956, p. 253). Arcsin transformation was used for percentages.
[2]Emergence percentage values based upon the number of scalps that had at least one emergent seedling.
[3]Survival percentage values for seeded scalps based upon the number of scalps that had emergent seedlings; survival was calculated as the percentage of scalps with surviving plants.

Survival

With two exceptions, survival during the critical first-year growing season exceeded 90 percent (table 1). Seeded wedgeleaf ceanothus averaged 79 percent survival; bitterbrush transplants from the Nevada seed source averaged 87 percent survival. First-year precipitation, soil moisture, and survival trends are shown in figure 2. Monthly means of precipitation and temperature immediately preceding and during the growing season are compared with long-term records in table 2. Growing-season precipitation was below normal except for the month of June, during which rainfall was more than double the long-term average. July and August were almost without rainfall. April-to-September temperatures were generally above normal. Soil surface temperatures measured on the planting site were commonly above 150° F (66° C) in July and August.

Table 2.--*Comparison of 1968 and 1969 weather data with long-term records, Garden Valley Ranger Station, Idaho*

Month	Precipitation Total	Precipitation Departure from normal	Temperature Mean	Temperature Departure from normal
	cm	*cm*	*°C*	*°C*
October	3.9	-0.4	8.8	-0.7
November	9.0	+1.7	2.6	+1.0
December	12.1	+2.6	-2.3	+ .2
January	18.9	+10.3	-2.3	+2.0
February	4.7	-3.0	- .9	+ .1
March	1.4	-5.3	2.2	- .8
April	1.5	-3.0	8.8	+ .4
May	1.9	-2.6	14.3	+1.6
June	8.7	+5.2	16.8	+ .3
July	.1	- .7	20.9	- .7
August	.0	-1.0	21.9	+1.6
September	2.0	+ .2	17.4	+1.6
Year	64.2	+4.0	9.0	+0.6

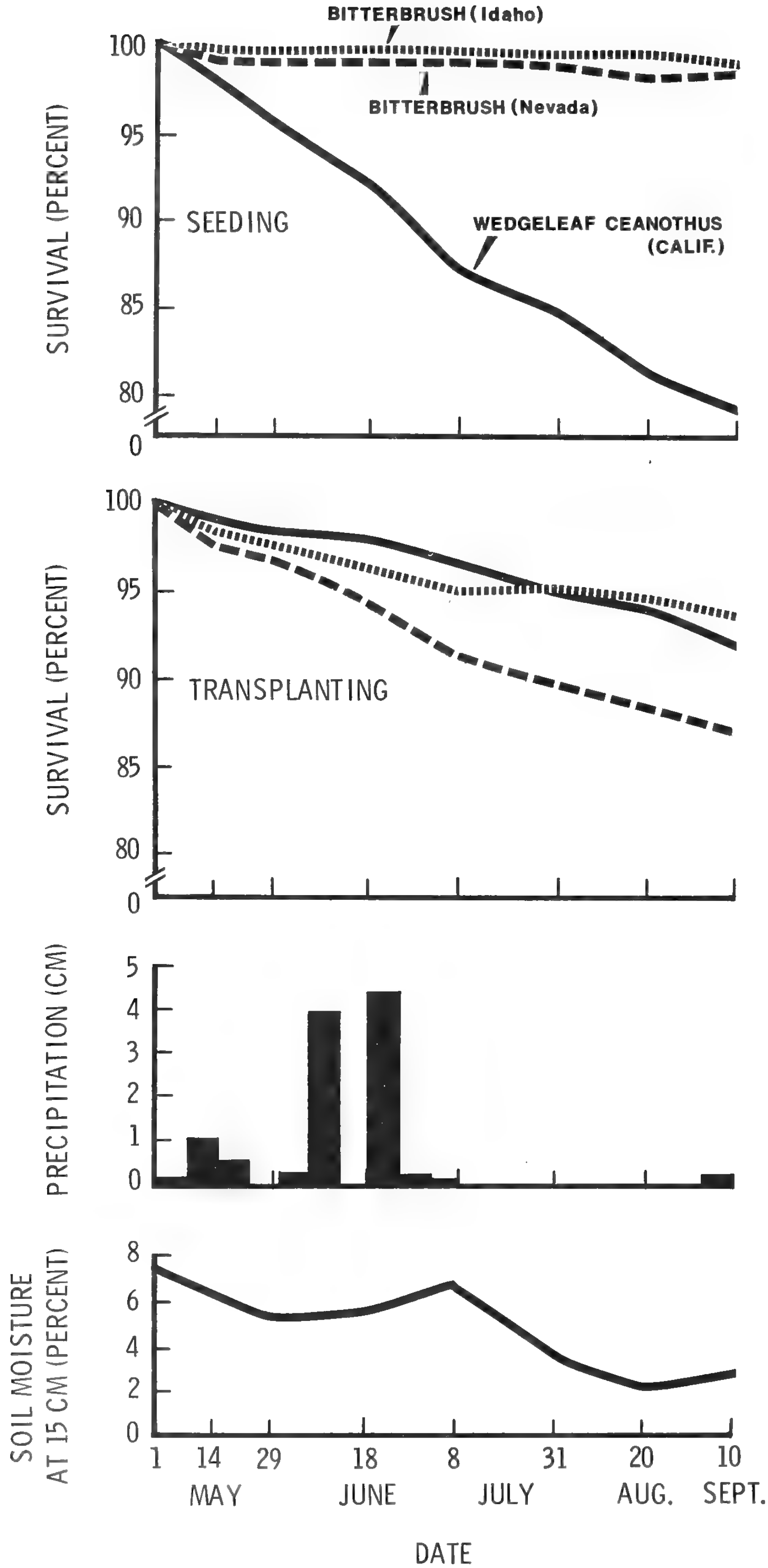

Figure 2.--Trends in first-year survival, precipitation, and soil moisture from May 1 to September 10, 1969.

Rapid desiccation of soils with the onset of the dry season is characteristic of many rangeland sites in southwestern Idaho. Soil moisture, after being recharged in June, dropped to a season minimum of about 2 percent at the 6-inch (15-cm) depth in mid-August (fig. 2). Soil moisture percentages were markedly higher under scalps than under unscalped areas (table 3). First-year survival trends appear weakly correlated with soil moisture trends. The soil moisture recharge in June may have prevented more steeply declining survival curves.

Table 3.--*Average soil moisture content (percent) at three depths (cm) on scalped and unscalped areas, 1969*[1]

Treatment	Depth	Date							
		5/1	5/14	5/27	6/18	7/8	7/31	8/20	9/10
Scalped	15	7.5	6.4	5.5	5.6	6.8	3.8	2.2	2.7
	30	7.7	6.8	5.9	5.6	7.3	4.4	3.4	3.7
	60	8.0	8.0	7.1	5.5	7.7	4.6	4.2	4.8
Unscalped	15	4.3	2.8	2.7	4.3	6.2	3.2	1.5	1.4
	30	5.8	3.9	3.6	3.2	7.3	4.0	3.0	3.3
	60	7.1	6.0	5.3	4.0	6.4	4.4	3.6	3.7

[1]Each soil moisture value is the average of six sampling sites distributed throughout the planting area.

Sixth-year survival differed markedly between species, seed source, and planting method (table 1). Seeded bitterbrush had better survival than bitterbrush transplants. The converse was true for wedgeleaf ceanothus. Overall, seeding treatments averaged 80 percent survival; transplant survival averaged 62 percent. Bitterbrush seeded from local seed sources had a sixth-year survival of 94 percent, higher ($P<0.05$) than any other treatment. Bitterbrush from local seed sources, whether seeded or transplanted, outperformed other plants significantly in survival and nonsignificantly in height growth. Although rating standards for shrub plantings are nonexistent, we suspect that few would be dissatisified with sixth-year survival rates from 60 to 80 percent (compare fig. 3 and 4).

Figure 3.--A pilot planting area before planting (photo taken October 1968).

Figure 4.--The same area six growing seasons after planting (photo taken October 1974).

Substantial differences occurred in average height growth between species at the end of the sixth growing season. Bitterbrush, regardless of seed source, had better ($P<0.05$) height growth than wedgeleaf ceanothus. There were no differences ($P>0.05$) in sixth-year heights between the seeding and transplanting treatments of either bitterbrush or ceanothus.

Sixth-year survival and height of bitterbrush planted from local seed sources varied by site (table 4). Survival was strongly related to topographic influences. Generally, the higher survival rates were on lower and upper slope positions. This was true for both the seeding and transplant treatments. Height growth followed a similar pattern except for a slower growth rate on the extreme upper slope position. Season-long soil moisture trends measured during the first year were highest on the lower slope sites.

Plants on slopes that were either horizontally or vertically concave or convex had higher survival. Those slope shapes were generally associated with the upper and lower slope positions. Lower survival rates were found on vertically and horizontally straight mid-slopes. Slope gradients under 65 percent and those with southeast aspects generally had better bitterbrush survival than steeper slopes and those facing south or southwest. There are exceptions to these generalities and there is probably some confounding among the topographic variables.

Each scalp on each of the 12 sample blocks was classified as to the nature (annual, perennial) of the proximate competing vegetation. There was a tendency toward lower bitterbrush survival on those blocks having the largest percentage of scalps with predominantly perennial competing vegetation (fig. 5). Most of the perennial competition was from bluebunch wheatgrass and arrowleaf balsamroot. Holmgren (1956) documented the competitive effect of cheatgrass and other annual vegetation on the survival of seedling bitterbrush. Our study was not designed to directly evaluate the effects of plant competition. Nevertheless, the data at least suggest that perennial vegetation may have a stronger competitive influence on bitterbrush seedling survival than annual vegetation. Apparently, scalping effectively reduces competition from annuals. But perennial plants near the perimeter of the scalp may extend their roots farther laterally and deplete soil moisture throughout the growing season.

Causes of Mortality

Each time survival counts were made, we recorded the apparent causes of mortality that had occurred since the previous observation, relying heavily on personal judgment. Because survival counts began on May 1, we probably missed early postemergence mortality.

Drought accounted for 36 percent of 3-year seedling mortality and 29 percent of 3-year transplant mortality (table 5). Heat and frost heaving caused minor mortality.

Table 4.--*Sixth-year survival (percent) and height (cm) of antelope bitterbrush seedlings and transplants related to site characteristics*[1]

	Site characteristics				Survival		Height	
Block	Slope position	Aspect	Percent gradient	Slope shape	Seedling	Transplant	Seedling	Transplant
1	Lower	SSE	48	Horizontal straight, vertical concave	96	98	68	73
2	Lower	SW	64	Horizontal straight, vertical concave	100	94	55	54
3	Lower	SE	71	Horizontal straight, vertical straight	96	94	61	60
4	Middle	S	69	Horizontal straight, vertical straight	92	88	42	53
5	Middle	W	77	Horizontal straight, vertical straight	72	68	25	28
6	Middle	S	66	Horizontal straight, vertical straight	86	76	52	57
7	Middle	S	75	Horizontal straight, vertical straight	91	78	56	53
8	Middle	SSW	65	Horizontal concave, vertical concave	98	88	64	62
9	Middle	S	57	Horizontal straight, vertical concave	98	82	70	65
10	Upper	S	62	Horizontal convex, vertical convex	100	86	62	66
11	Upper	S	67	Horizontal concave, vertical straight	100	92	59	59
12	Upper	ESE	54	Horizontal concave, vertical concave	98	86	36	43

[1]Bitterbrush established from southwestern Idaho seed sources.

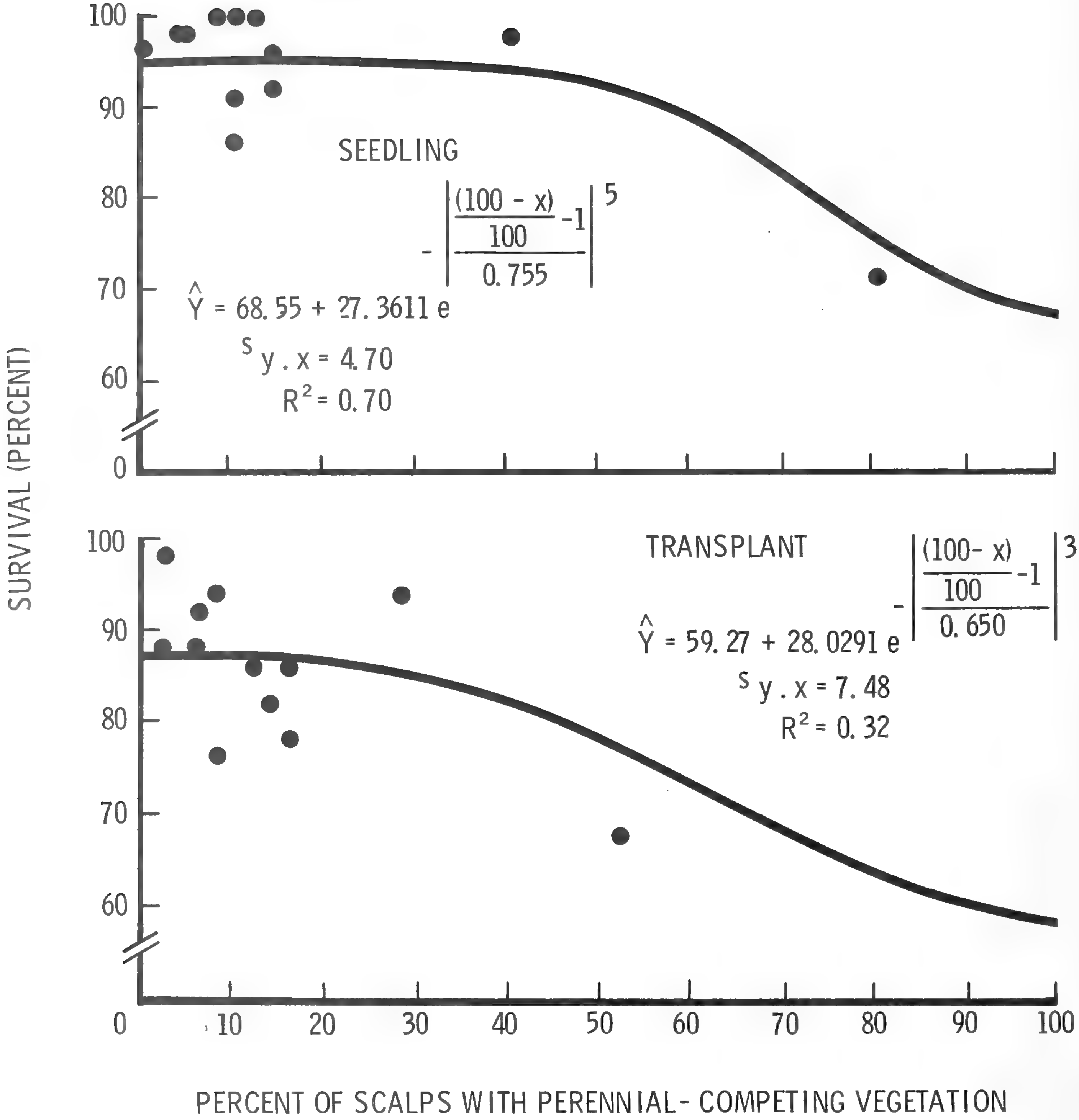

Figure 5.--Sixth-year survival of bitterbrush seedlings and transplants (southwestern Idaho seed source) in relation to percentage of scalps with perennial competing vegetation.

Table 5.--*Percentage of 3-year seedling and transplant mortality attributable to specific causes*[1]

Cause	Seedling				Transplant			
	Bitterbrush, Idaho N=159	Bitterbrush, Nevada N=307	Wedgeleaf ceanothus, California N=140	Average N=606	Bitterbrush, Idaho N=90	Bitterbrush, Nevada N=284	Wedgeleaf ceanothus, California N=151	Average N=525
Weather								
Drought	42	35	32	36	38	29	25	29
Heat	1	0	0	1	0	0	0	0
Frost heave	0	0	0	0	1	1	2	1
Animal								
Small mammal	7	7	7	7	7	5	18	9
Insect	4	2	6	3	2	0	0	1
Trampling	14	10	8	11	3	1	3	2
Browsing	2	7	1	4	1	2	8	3
Disease (damping-off)	3	2	0	2	0	0	0	0
Soil movement	1	1	0	1	0	0	0	0
Planting technique	0	1	0	1	9	4	2	4
Unidentified	26	34	46	35	39	58	43	51

[1]Seedling N is the number of seed spots to which a cause of mortality was assigned; transplant N is the number of transplants to which a cause of mortality was assigned.

About 25 percent of seedling losses and 15 percent of transplant losses were caused by animal activity. Trampling by deer and clipping, root cutting, and mound building by pocket gophers (*Thomomys talpoides* Merriam) were mainly responsible. Wedgeleaf ceanothus transplants were particularly susceptible to root cutting by pocket gophers. Trampling killed 11 percent of the seedlings and 2 percent of the transplants. This difference was the largest of any single cause of mortality between seedlings and transplants. Insects (mostly grasshoppers, webworms, and cutworms) also killed more seedlings than transplants. The planting was aerially sprayed (Malathion) in mid-July of the first growing season as part of an area-wide grasshopper control program.

Browsing by deer killed 4 percent of the seedlings and 3 percent of the transplants. Most of the browsing mortality occurred between the second and third growing seasons, a period separated by a severe winter. A decrease in average shrub height for some treatments the following year (year 3 in table 1) probably reflected the heavy browsing of that winter.

Damping-off fungi and soil movement accounted for 3 percent of seedling mortality. Four percent of transplant mortality was attributed to poor planting technique; most of this was from doubled-up root systems.

Although not reflected in table 5, we later observed winter injury and winter kill of wedgeleaf ceanothus.

Costs

Costs of seeding and transplanting are compared in table 6. Total seeding cost per acre was $204.75 ($505.92 per hectare). Total transplanting cost per acre was $232.56 ($574.65 per hectare). Costs are expressed at approximate 1979 prices. Labor costs were computed on a $5.00 per hour wage scale. Costs for tools, and travel and lodging for planting crews are not included.

Table 6.--*Estimated costs of seeding and transplanting treatments, 1979*

Planting method		Cost per acre	Cost per hectare
Seeding			
Seedbed preparation (scalping hoe)		$ 120.00	$ 296.50
Seeding (hand-operated seeder)		45.00	111.20
Seed (cleaned)			
Bitterbrush		28.60	70.67
Wedgeleaf ceanothus		9.40	23.23
Preplanting seed treatment[1]		1.45	4.32
	Total	$ 204.75	$ 505.92
Transplanting			
Seedbed preparation (scalping hoe)		108.00	266.86
Handplanting (planting spade)		68.00	168.03
Planting stock (1-0 transplant)		56.56	139.76
	Total	$ 232.56	$ 574.65

[1]Rodent repellent treatment of bitterbrush and hot water treatment of wedgeleaf ceanothus.

Seedbed preparation (scalping) was the largest single investment item, accounting for 59 percent of total seeding cost and 46 percent of total transplanting cost. Seeding was about 12 percent less costly than transplanting. The cost of seed was about two-thirds that of nursery planting stock. Seed prices were $14.24 per lb ($31.40 per kg) for bitterbrush and $28.48 per lb ($62.80 per kg) for wedgeleaf ceanothus. Nursery costs were $47.13 per thousand graded and packed 1-0 transplants.

CONCLUSIONS

The planting was designed to test the applicability of procedures recommended for improving deteriorated deer winter ranges in southwestern Idaho by artifical revegetation. Subobjectives were to compare: (1) two planting methods--direct seeding and transplanting; (2) two browse species--antelope bitterbrush and wedgeleaf ceanothus; and (3) two bitterbrush seed sources--southwestern Idaho and northwestern Nevada--for both the seeding and transplanting methods.

Although expensive, the pilot planting demonstrated that shrubs can be successfully established by either seeding or transplanting methods in environments typical of many southwestern Idaho deer winter ranges. Our investigation supports the notion that adequate technology is generally available for revegetating winter range problem areas and that inconsistent results are at least partly due to improper application of recommended procedures. The findings are not conclusive because the planting was done under a single set of environmental conditions. Adverse environmental extremes may cause planting failures regardless of the care used in following procedural details.

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The planting compared: (1) two browse species--antelope bitterbrush (*Purshia tridentata* [Pursh] DC.) and wedgeleaf ceanothus (*Ceanothus cuneatus* [Hook.] Nutt.); (2) two planting methods--direct seeding and transplanting; and (3) two bitterbrush seed sources--southwestern Idaho and northwestern Nevada. Overall, the seeding treatments had a sixth-year survival of 80 percent; transplanting treatments had a sixth-year survival of 62 percent. Bitterbrush from local seed sources, whether seeded or transplanted, outperformed other plants significantly in survival and nonsignificantly in height growth.

KEYWORDS: *Purshia tridentata* (Pursh) DC., *Ceanothus cuneatus* (Hook.) Nutt., seeding, transplanting, shrubs, site relations, deer winter range.

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