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THE BRESSI RANCH RANGE STUDY

Second Progress Report

1955 — 1957

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Cover picture: The results of a good conversion job.

THE BRESSI RANCH RANGE STUDY

Second Progress Report

History and Objectives

The Bressi Ranch Range Study is a co-operative project of the California Division of Forestry; Agricultural Extension Service of the University of California; Alwin Wiegand and Sons, operators of the Bressi Ranch; and Mrs. Vincent Bressi, the landowner.

The project was established in 1953 to determine and demonstrate practical methods of replacing brush with a permanent forage cover of palatable grasses and legumes within the southern California coastal area. Various methods of brush removal, revegetation, and grazing management are being tested and results demonstrated.

The work accomplished prior to January, 1955, has been reported previously in "The Bressi Range Study - First Progress Report." Activities on the project from January, 1955, through July, 1957, are covered in this report.

The Study Area

The study area is located 5 miles southeast of the town of Carlsbad in the San Diego County coastal area--a region of rolling hills, narrow valleys, and occasional mesas. Summers are warm and dry, and winters generally mild, with an average annual precipitation of approximately 10 inches - almost all occurring during the winter months.

The principal woody vegetation consisted of a coastal sagebrush association dominated by lemonade-berry (Rhus integrifolia), toyon (Photinia arbutifolia), chamise (Adenostoma fasciculatum), scrub oak (Quercus sp.), and laurel-sumac (Rhus laurina). Associated with these taller shrubs was a number of lower-growing species. The most important were wild buckwheats (Eriogonum spp.), various species of sage (Salvia spp.) and California sagebrush (Artemisia californica).

Herbaceous cover under the brush was sparse consisting primarily of small individual plants of needlegrass (Stipa spp.). Open areas and former cropland supported a fairly heavy cover of mixed annual grasses consisting largely of wild oats (Avena spp.) and bromegrasses (Bromus spp.).

The study area contains 123 acres, comprising five nearly parallel ridges. Each ridge serves as a separate test plot. The elevation of the project varies from 170 to 450 feet above sea level.

The ranch has been subjected to grazing by livestock from the early days of Spanish colonization in the San Diego region.

Four soil series have been recognized on the project: Olivenhain, Altamont, Ayar, and Linne. With the various depth phases present the soil pattern is quite complex; however, with minor exceptions the soils are all fine-textured in both surface and subsoil.

Summary of Project Activity 1953 - December, 1954

The Bressi Range Study was divided into five major plots during 1953; various test facilities were installed, including 203 sample subplots, two exclosures, and a weather station. A topographic map was prepared, which served as a base for detailed vegetation and soil surveys, made that year and early in 1954.

To demonstrate methods of brush removal, the cover on the different plots was crushed with heavy equipment or sprayed with herbicides, and burned during the summer of 1954.

During the late fall of 1954 a mixture of perennial grasses and legumes consisting of Hardinggrass, smilo, ryegrass and veldtgrass and rose, subterranean, crimson, and bur clovers was seeded by aircraft.

In order to secure better germination the seed was covered by two methods - light disking, and rolling with a sheep's-foot roller. comparable areas were left uncovered to serve as a check.

Triple-superphosphate at the rate of 400 pounds per acre was applied to a 250-foot wide strip the full length of the project area.

Outline of Project Activity January 1955 - July 1957

1. Vegetation survey. In order to determine how effectively introduced perennials and legumes succeeded in germinating and establishing themselves, and to evaluate successional trends in revegetation, data were collected from the permanent subplots during the spring of 1955, 1956, and 1957.

2. Grazing management. Management of livestock was aimed at controlling weedy annuals and brush seedlings, and encouraging the seeded forage grasses and legumes. The extent of grazing was adjusted according to varying conditions in an attempt to meet these objectives. Stock watering facilities were developed and maintained to obtain maximum results in line with these objectives.

3. Herbicides The entire area was treated with herbicides, in an attempt to control brush regrowth. Different chemicals and methods of application were tried to determine their effect on brush regrowth and new seedlings.

4. Fertilizers. Fertilizer plots already established were continued, and additional plots using various combinations were added, to determine plant requirements.

5. Competition. Test areas were established to determine what factors of competition between annual and perennial grasses limited development of the perennials, and to develop practical methods of overcoming this competition.

6. Weather data. A detailed record of precipitation, humidity, and temperature was obtained using standard weather instruments. Two atmometers were installed to provide a record of evaporation.

Weather Data

Information on precipitation, temperature, and relative humidity has been gathered on the Bressi Range Study since the middle of 1954 by weather instruments, including a non-shielded cylindrical rain gauge, and a recording hygrothermograph installed in a standard weather instrument shelter. During the entire period of observation, temperature has never dropped below freezing at the weather station and temperatures above 100 degrees F. have occurred on very few days. There is a uniform yearly cycle in mean temperature with a maximum in July or August; however, mean humidity values tend to fluctuate with some of the highest values occurring during the summer months (table 1). The lowest mean humidity value--35 per cent--occurred in November, 1956 as did the lowest single reading of 7 per cent. These extremely dry conditions are brought about by fall and winter Santa Ana winds that blow from the desert areas into much of coastal southern California.

Precipitation totals have been less than normal* during the winters of 1954-55 and 1955-56 and exceeded normal during 1956-57.

A close examination of the precipitation data shows that the fall months of each year (including the wet year of 1956-57) have had a deficiency in precipitation for plant growth. This amounted to more than four inches below normal during the fall of 1956. January of each year has experienced more than the normal rainfall. If it had not been for 4.37 inches of extra rain during January of 1957 that year would have been below normal also.

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* The Normal precipitation is based on data collected at Lockwood Mesa on a similar site in the San Diego County coastal plain approximately 15 miles south of the Bressi Ranch Range Study. Records have been kept at this station for 16 years.

Table 1. Mean monthly temperature and humidity recorded on a hygrothermograph at the Bressi Range Study weather station.

Month	1955 - 56		1956 - 57	
	Temp.	Humid.	Temp.	Humid.
July	-	-	67	75
August	-	-	-	-
September	-	-	70	65
October	-	-	64	68
November	-	-	67	35
December	-	-	61	48
January	54	-	55	74
February	52	66	57	69
March	56	57	56	51
April	57	69	58	77
May	63	64	63	72
June	65	68	67	72

The wet Januarys have been followed each year by a comparatively dry February and March. In most cases April, May, and June have had slightly more rain than normal.

Starting in April of 1957 a second hygrothermograph was installed at a point six inches above ground level to measure actual conditions at the level in which plant growth was taking place.

This ground level hygrothermograph recorded higher maximum temperature and lower humidity readings than were recorded at standard height (table 3).

Although mean monthly maximum temperature at the low level varied from 1.8 degrees warmer in April to 4.0 degrees higher in June than the standard height, daily extremes showed an even greater range. Low level temperatures--particularly after a prolonged hot spell--were occasionally 5 to 6 degrees higher than at the 4½ foot level.

The relationship between minimum temperature and maximum humidity comparisons were not so clear except night time readings varied little from night to night. For example, night time minimum temperature readings are frequently the same three and four nights in a row at ground level--something that never happened at standard height.

Table 2. Comparison of precipitation recorded on the Bressi Range Study during the period July, 1954 to June, 1957 with the normal precipitation for the area (Lockwood Mesa).

	Normal		1954-55		
Month	Inches	Percent	Inches	Percent	Departure from normal
July	0.00	0.00	0.00	0.00	
August	0.10	0.92	0.00	0.00	-0.10
September	0.06	0.55	0.00	0.00	-0.06
October	0.54	4.99	0.00	0.00	-0.54
November	1.23	11.37	1.00	11.07	-0.23
December	2.63	24.31	1.15	12.74	-1.48
January	1.68	15.53	2.77	30.67	1.09
February	1.53	14.14	1.45	16.05	-0.08
March	1.84	17.01	0.30	3.32	-1.54
April	0.96	8.87	1.10	12.18	0.14
May	0.19	1.76	1.23	13.62	1.04
June	0.06	0.55	0.03	0.33	-0.03
Totals	10.82	100.00	9.03	100.00	-1.79

	1955 - 56			1956 - 57		
Month	Inches	percent	Depart. from norm.	Inches	percent	Depart. from norm.
July	0.08	1.14	0.08	0.00	0.00	0.00
August	0.10	1.43	0.00	0.00	0.00	-0.10
September	0.00	0.00	-0.06	0.02	0.15	-0.04
October	0.00	0.00	-0.54	0.06	0.47	-0.48
November	0.00	0.00	1.23	0.00	0.00	-1.23
December	1.45	20.85	-1.18	0.23	1.83	-2.40
January	2.97	42.68	1.29	6.05	48.33	4.37
February	0.36	5.17	-1.17	1.10	8.78	-0.40
March	0.26	3.73	-1.58	1.61	12.86	-0.21
April	1.71	24.57	0.75	1.38	11.02	0.42
May	0.03	0.43	-0.16	1.73	13.82	1.54
June	0.00	0.00	-0.06	0.34	2.71	0.28
Totals	6.96	100.00	-3.86	12.52	100.00	1.70

Table 3. Mean monthly temperature and relative humidity at two different levels, Bressi Range Study Area.

	Avg. Low		Avg. High.		Mean	
	Standard	Ground	Standard	Ground	Standard	Ground
	Temperature (degrees F.)					
April	48.2	49.4	64.8	66.6	56.5	58.0
May	54.7	53.3	66.7	69.2	60.7	61.2
June	60.1	60.1	75.0	79.0	67.6	69.6
	Humidity (percent).					
April	60.2	52.4	98.9	97.3	79.6	74.8
May	56.7	48.5	95.3	97.1	76.0	72.8
June	49.5	42.0	94.3	93.4	71.9	67.7

Vegetation Surveys

During the period covered by this report three vegetation surveys were made to find how well the introduced perennials and legumes had established themselves, to determine plant successional trends and to evaluate the effect of our grazing management and cultural treatments.

This information was needed in order to measure the effectiveness of what had already been done on the study, and to help in developing future plans.

During the surveys the line transect method was used in collecting data. In this method a 10 foot tape was stretched out on the ground with its mid point touching the plot marker stake. The tape was oriented up and down the steepest slope gradient. Vegetation touching the tape or projecting into a vertical plane above it was recorded by species and the tape length intercepted. Information was recorded on number of plants, species present, crown spread and basal area, if applicable.

For purpose of analysis, the vegetation was divided into four classes.

1. Shrubs
2. Perennial grass
3. Annual grass
4. Forbs

The data indicate that with the exception of Plot 4 there appears to be no significant difference between plots in either establishment of introduced species or changes in vegetation classes (table 4).

Plot 4 (no treatment prior to burning) appears to be regrowing to brush much faster than the other plots and shows poor results in the establishing of grasses or forbs.

Despite the effort made to control brush sprouts and seedlings this form of vegetation is tending to increase over the entire area. From less than 4.5 per cent ground cover in 1955, the brush cover has increased to 13.4 per cent in the spring of 1957. Allowing sprouts to develop a year and then burning, as was done on plot 3, had no apparent effect in reducing sprout regrowth.

Considering all perennial grasses--both native and seeded--as a group, the proportion of ground covered by their crowns tended to increase the first year, but showed a slight decline from 1956 to 1957.

One of the most significant items indicated by the data has been the steady and rapid increase in both forbs (annual and perennial) and annual grasses (fig. 1). These two classes of plants taken together have increased from 14.6 per cent ground cover to 55.4 per cent--more than three times--in two years. Total ground cover has evidently doubled since the spring of 1955.

Although the percentage of ground covered by the leafage of perennial grasses has declined only slightly during 1956, a detailed examination of individual species gives an entirely different picture. All species with the exception of veldtgrass have declined greatly in numbers of plants (table 5 and fig. 2). Data collected in 1957 show only 41 per cent of the number of individual plants present in 1955. The greatest decline in number of plants occurred in ryegrass.

Table 4. Trends in composition of plant cover, Bressi Range Study Area: 1953 - 1957.

Vegetation class	Plot No.	Ground cover (per cent) 1953	1955	1956	1957
Shrubs	1	36.7	0.7	9.3	10.5
	2	38.1	2.8	7.6	17.4
	3	*	6.3	7.6	16.0
	4	*	1.2	22.0	48.0
	5	31.4	8.0	10.6	9.8
	Average**	34.8	4.5	8.8	13.4
Perennial grasses	1	4.0	12.6	14.1	5.8
	2	4.5	8.4	10.2	9.7
	3	*	10.9	10.5	8.8
	4	*	0.0	0.2	1.0
	5	1.4	7.0	5.5	15.5
	Average**	3.0	9.7	10.1	10.0
Annual grasses	1	2.0	17.2	35.8	54.7
	2	2.0	21.2	26.2	29.3
	3	*	16.5	33.2	26.8
	4	*	0.0	3.2	0.0
	5	7.6	15.3	39.2	30.7
	Average**	3.9	17.6	33.6	35.4
Forbs	1	0.0	9.0	8.5	19.5
	2	0.6	5.6	9.8	17.1
	3	*	16.1	10.0	24.1
	4	*	14.5	14.0	3.7
	5	0.4	12.2	2.8	15.1
	Average**		10.7	7.8	20.0

* Data not available
** Average does not include plot 4.

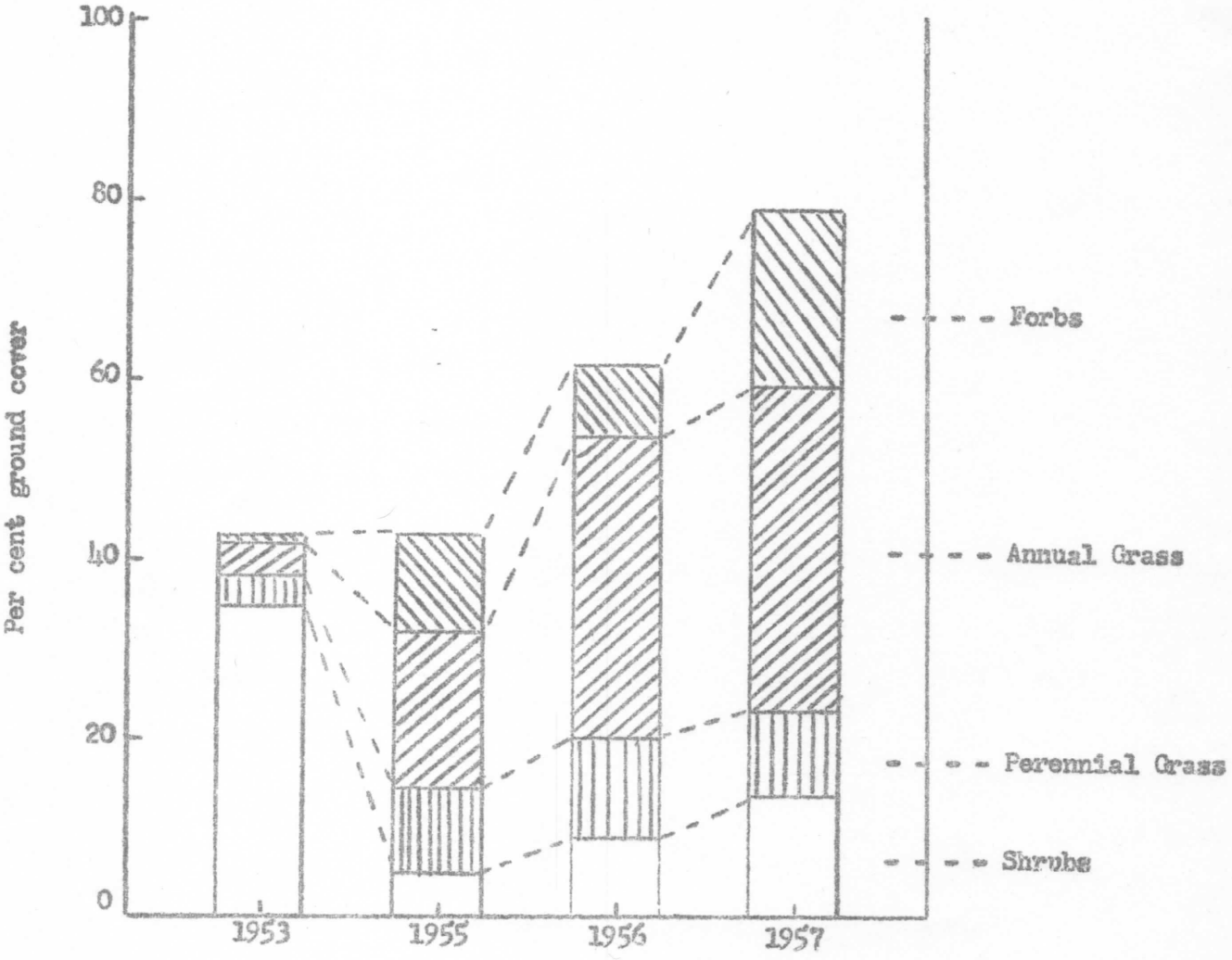

Figure 1. Trends in composition of ground cover, Bressi Range Study Area: 1953 - 1957. This is a pictorial representation; area occupied by each kind of vegetation in the figure, for each year, indicates the area occupied by that kind on the ground. The slope of an individual line from one year to the next has no significance of itself.

Table 5. Average number of perennial grasses per transect, Bressi Range Study Area.

Species	Years		
	1955	1956	1957
Stipa	1.23	1.32	0.43
Smilo	0.04	0.22	0.12
Hardinggrass	0.67	0.39	0.27
Ryegrass	1.52	0.57	0.25
Veldtgrass	0.12	0.13	0.37
Total	3.58	2.63	1.44

Each transect was 10 feet in length.

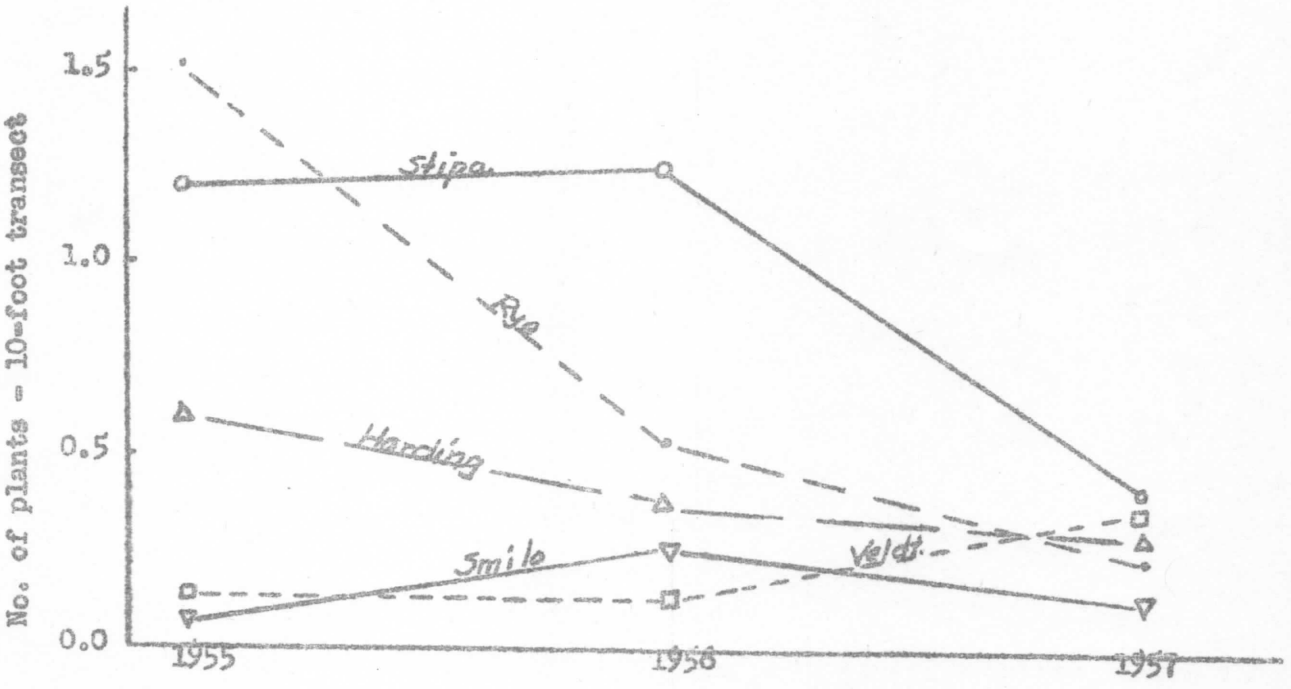

Figure 2. Trend in average number of perennial grasses, Bressi Range Study Area.

The data show there was an increase in basal area by all species from 1955 to 1956; then a sharp decline by all except veldtgrass in 1957 (table 6 and fig. 3). Apparently all plants that established themselves grew rapidly at first and total basal area increase offset loss by death of some plants. However, as a greater portion of the ground surface became occupied by plants, competition among individuals became more intense and the growth rate of perennial grasses began to slow down. As the growth rate became slower, loss of plants that died was greater than the increase by growth, so net basal area declined.

Veldtgrass, on the other hand, has made a steady increase in numbers and is now second only to the native stipas in abundance. Although ranking third among the introduced perennials in basal area it has increased in size while all other perennials have shown a decline (table 6 and fig. 3).

During the seeding operation in 1954, rose, crimson, subterranean, and bur clovers were seeded onto the study area. Individual plants of all four species were found during the vegetation survey made during the spring of 1955 (table 7). However, crimson and subterranean clover disappeared by 1956, and rose clover by 1957. Bur clover (on the other hand) decreased in numbers and volume in 1956, and then materially increased in 1957 (figs. 4 and 7). Bur clover is known to respond markedly to yearly weather variations, as do many other annual forbs. However, additional study will be needed to determine if this response may be due in part to the various applications of fertilizer on the project.

Table 6. Basal area of perennial grasses, Bressie Range Study Area.

Species	Ground cover (per cent)		
	1955	1956	1957
Stipa	1.23	2.00	1.11
Smilo	0.00	0.34	0.08
Harding grass	0.39	0.75	0.63
Ryegrass	0.86	0.99	0.55
Veldtgrass	0.04	0.22	0.53
Total	2.52	4.30	2.90

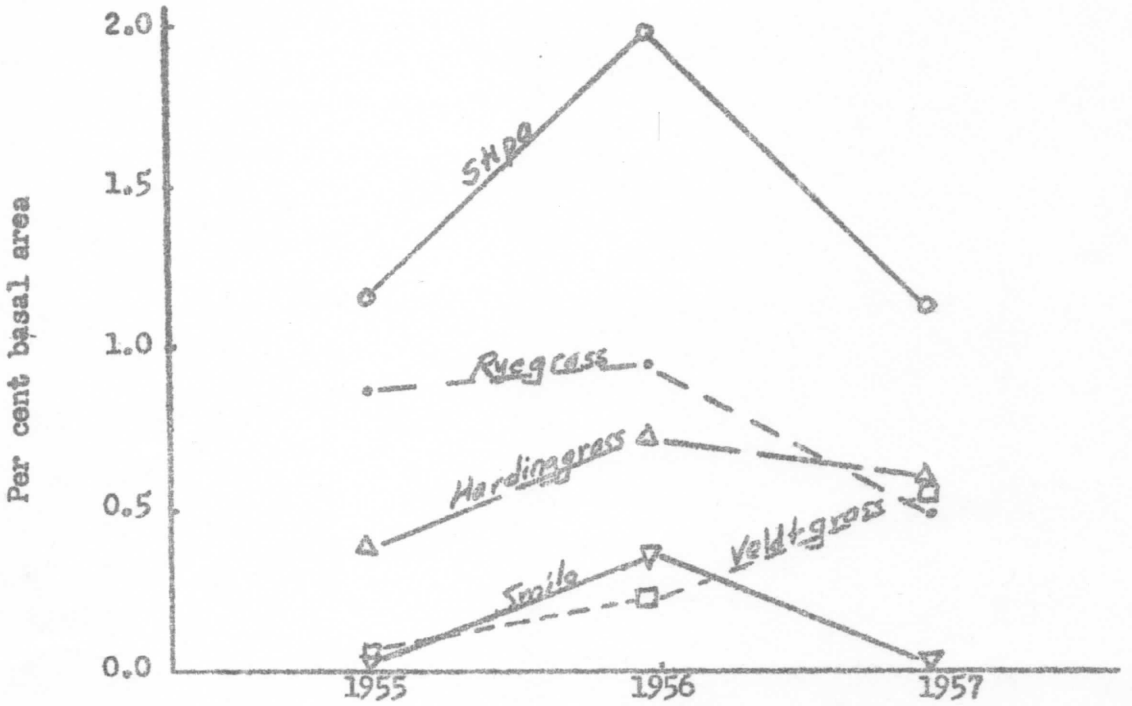

Figure 3. Total basal area of perennial grasses, Bressi Range Study Area.

Table 7. Frequency of occurrence and proportion of ground covered by clovers, Bressi Range Study Area.

	Number of Plants			Per cent Ground Cover		
	1955	1956	1957	1955	1956	1957
Rose clover	0.4	0.2	-	0.3	0.1	-
Bur clover	0.3	0.1	1.7	0.1	-	0.2
Subterranean clover	0.1	-	-	0.1	-	-
Crimson clover	0.3	-	-	0.2	-	-

Data collected by line transect method from all plots.

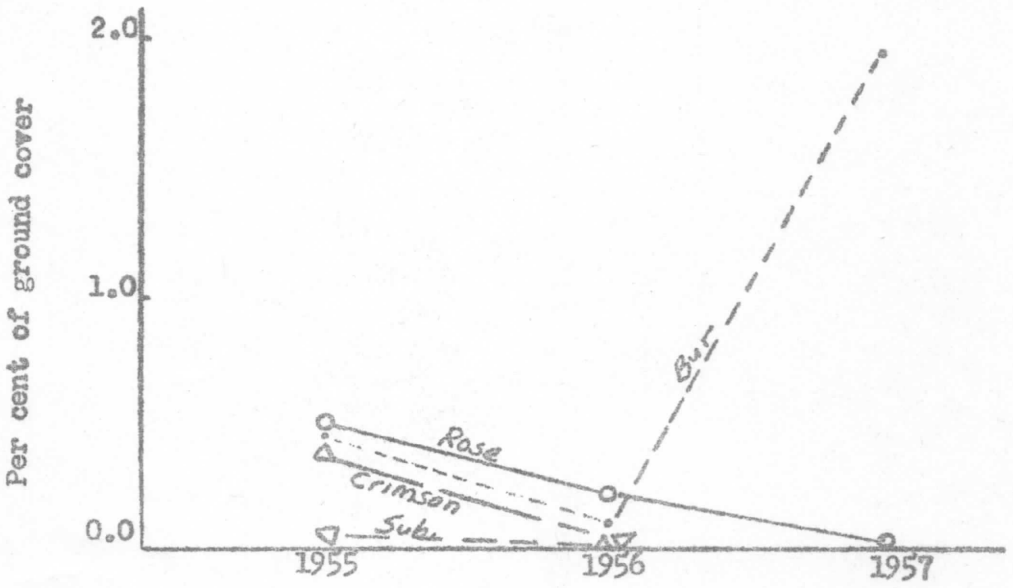

Figure 4. Trends in proportion of ground cover occupied by clovers, Bressi Range Study Area.

It has been pointed out previously in this report that there has been a sequence of both seasonal and annual precipitation deficiencies. Probably more important than the total yearly shortage of precipitation in the development of perennials have been quite severe shortages of moisture at critical times for plant growth. Examples of this are precipitation shortages of from one to nearly two and one-half inches that have occurred each December just as the perennial grasses have been commencing growth (table 2). The rainfall during December of 1954 was 1.48 inches below normal--a condition that may have had a considerable effect on the establishment of the seeded species germinating at that time.

Following the seeding operation portions of the area were either rolled with a sheep's-foot roller, disked, or left untreated to serve as a check. Data collected during the period covered by this report indicate that the type of treatment used to cover the seed had a very material effect on both number of plants and basal area. The total number of seeded plants counted on the rolled area in all years showed from two to three times the number occurring on the other two areas (table 8 and figs. 6 and 7). Although the data indicate disking failed to assist in establishing a permanent perennial grass cover, it does not bring out the lack of comparability between areas receiving different treatment. For the most part, the sheep's-foot rolling was confined to areas formerly in brush cover while the disking was done on areas previously covered with annual grass. Undoubtedly the competition from the regrowth of annual grass was an important factor in the establishment of the introduced species. Additional studies should be made by locating and examining identical areas that have received the various treatments.

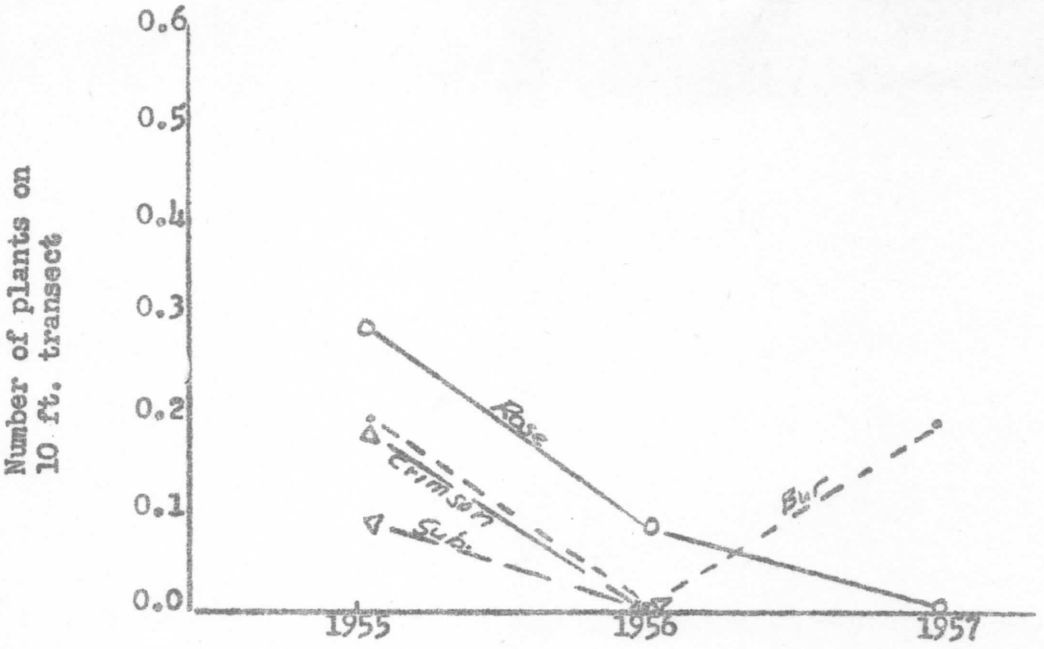

Figure 5. Trends in numbers of clover plants, Bressi Range Study Area.

Table 8. Relationship between establishment of seeded perennials and method of seed coverage, Bressi Range Study Area.

Method of seed coverage	1955		1956		1957	
	No.	Basal area	No.	Basal area	No.	Basal area
Sheep's-foot roller	5.6	3.1	3.3	4.7	2.6	4.2
Disk	2.7	2.6	1.2	2.4	0.6	1.1
Uncovered	2.1	2.0	2.3	4.0	0.7	1.5

Number of plants on a 10 foot transect and basal area in per cent of ground cover based on site treatment following seeding i.e., rolling with sheep's-foot roller, disking, or no mechanical post seeding treatment.

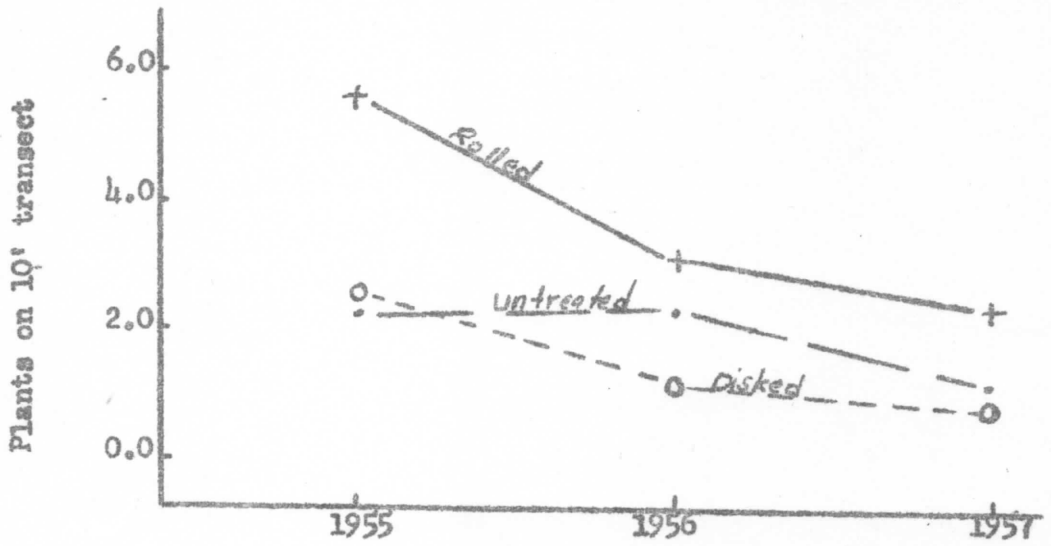

Figure 6. Relationship between method of seed coverage and numbers of perennials, Bressi Range Study Area.

Grazing Management and Forage Production

From the time the project was seeded in late 1954 until may, 1955, no livestock were grazed on the Bressi Range Study Area in order to allow the newly seeded plants a chance to develop. On May 7, approximately 75 head of cattle were placed on the range. However, due to the lateness of the season, the introduced perennial grasses proved to be so much more palatable than the annuals that the stock concentrated their grazing on these plants and let the annuals alone. Grazing became so destructive that the stock had to be removed by May 19.

Following seed casting by the perennial grasses, stock were put back on the study area. About 30 head of cattle and horses grazed for a month.

On July 15, 1956, fifteen head of cattle were placed on the project area and were removed on October 15, when the perennial grass began to sprout.

On February 23, 1957, 16 head of cattle were allowed to enter the study area in order to utilize weedy annual grasses while in their most palatable stage and to reduce annual grass competition. The animals found the annuals sufficiently palatable and readily took them until March 30, when they were removed.

Production of forage on the Bressi Range Study Area was determined by two methods:

1. Clipping studies.

2. Observations of range condition.

In 1954, during the early part of the project development, two one-quarter acre exclosures were constructed. A third exclosure was built in 1956. All three were divided into two compartments--a cattle-and-rodent exclosure and an exclosure from cattle only. The areas surrounding the exclosures are open to grazing by livestock and feeding by rodents.

The two original exclosures are situated in dryland pasture sites, while the area in and adjacent to the third exclosure is irrigated with a sprinkler system.

In addition to the regular annual vegetation survey, clipping studies were made at all three exclosures during May of 1957, following 20 animal unit months of grazing that year. A total of 24 samples was collected in and around each of the areas, and the material oven-dried. An examination of the data shows that with the exception of exclosure three, the irrigated area, there is no significant difference between forage condition or ground cover density inside or outside the exclosure (table 9). However, casual observations show a definite utilization of forage by both cattle and rodents.

Table 9. Forage production on three exclosures and the adjacent areas, Bressi Range Study Area.

Type of Exclosure	Forage production (pounds per acre, ovendry)*		
	No. 1 (Unirrigated)	No. 2 (Unirrigated)	No. 3 (Irrigated)
Rodent and cattle	1197.90	2395.80	4501.20
Cattle only	2341.35	871.20	3158.10
Open to grazing	1815.00	1244.57	2178.00

* Results based on 60 clipping tests.

This probably means that individual site differences cause such variation in plant growth that amounts taken by a grazing pressure of 0.16 animal unit months per acre--this year's amount--are not readily detected.

As would be expected, the stock apparently have concentrated on the irrigated plot and have taken approximately 2,000 pounds of vegetation per acre. Total production in excess of 4,500 pounds of ovendry material

was recorded for this area.

The dryland pasture exclosures show that on an average 1,644 pounds of ovendry forage are produced per acre.

The second method of estimating forage consisted of taking random observations of range condition while recording animal unit months of grazing.

Total grazing for the year 1955 amounted to 67 animal unit months or a yield of 1 AUM per 1.8 acres. Although undoubtedly some damage was done to the perennial grass it was probably due to placing the stock on the range too late in the year rather than by too intense utilization. Surveys the following spring indicate a 40 per cent increase in ground cover of herbaceous vegetation (over data collected during the spring of the previous year).

In 1956 the range produced 45 animal unit months of forage; stocking was at a rate of 2.7 acres per animal unit month.

By the end of July, 1957 (the end of the report period), 20 animal unit months of forage have been consumed and as has been previously mentioned clipping studies have, in general, shown no measurable degree of utilization.

The foregoing indicates that ground cover in herbaceous vegetation increases rapidly under a stocking rate of 1.8 acres per animal unit month. In addition, 20 animal unit months of grazing utilized so little forage that it was not readily recordable.

Assuming the requirements for one animal unit per month to be 900 pounds, the present range could be grazed at the rate of 1.5 acres per animal unit month provided grazing dates were properly controlled. This would still leave on the ground more than 60 per cent of the 1,644 pounds of ovendry forage produced--a sufficient amount to insure a steadily improving range condition.

Previously mentioned data indicate that annual grasses and forbs appear to be increasing at the expense of the perennials. This would indicate a continuation of the program of spring and fall grazing with somewhat greater utilization of the annuals during their succulent period.

Herbicide Applications

During the period covered by this report herbicides were used in an attempt to control brush regrowth. On July 13, 1955, a series of herbicide test plots was established on the Bressi Range Study Area. The objective of these tests was to determine the effect of different herbicides on sprout growth at a time when plant physiological processes were slowed down and resistance to herbicides was at a maximum. In addition, information on

time and cost of spot spraying was obtained. The theory involved was that a rancher might have some spare time or hired help between major ranch operations which might be used to advantage in checking sprout growth on a brush range improvement project. Table 10 lists the herbicides used on the test plots.

Table 10. Chemical formulations used on the herbicide test plots, July 13, 1955, Bressi Range Study Area.

Chemical *	Diesel Oil (wetting agent) (gallons)	Water (gallons)
1/2 gallon 2,4-D	1	100
1½ gallons 2,4-D - 2,4,5-T	4	100
3/4 gallon 2,4,5-T	0	100

* Four pounds acid equivalent per gallon.

One half-acre plot was sprayed with each mixture. Shrubby plants constituted about 6 per cent of the ground cover on each plot. A three-gallon back-pack type sprayer was used; the operator, employing the spot spray method, walked from one sprout clump to another; each clump was given a good drenching of spray. The operator attempted to get a uniform coverage of each sprout without spending too much time.

Time and quantity of spray required for each of the three plots sprayed were very nearly the same, with some variations in herbicide cost being the major factor in differences in total cost per acre.

Eight gallons of spray solution were required per acre; approximately an hour's time was required to mix, transport, and spray the herbicide on each acre.

During September, 1955, an inspection of results was made and results estimated (table 11).

Table 11. Rate of sprout kill on herbicide test plots, Bressi Range Study Area.

Chemical	Sprout kill (per cent)
2,4-D	75
2,4,5-T	85
2,4,5-T-2,4-D	98

Using information obtained from these studies, all sprout growth on the study area was sprayed during the springs of 1956 and 1957 in an attempt to control shrubby regrowth. Although slightly more expensive, the 2,4,5-T-2,4-D mixture gave the higher kill of sprouts. It was decided to use this mixture in sprout control operation.

In April, 1956 spraying of brush sprouts was begun, using the mixture of 1½ gallons of 2,4-D-2,4,5-T in 4 gallons of oil and 100 gallons of water. The spray was applied using a high-pressure pump mounted on a four-wheel-drive truck. Several break-downs hampered the operation, and more spray was required than had been anticipated since spray material had been ordered on the basis of quantities required for the test plots in 1955, when the brush sprouts covered six per cent of the ground. When spraying commenced in 1956, sprouts had increased until they constituted nine per cent of the ground cover--consequently requiring more material. Only plots 2, 3, and 5 were completed in 1956. Plots 1 and 4 were sprayed in the spring of 1957.

Data collected so far do not indicate that effective control is being obtained. Shrubby vegetation increased an average of 66 per cent on the sprayed plots during the year following spraying.

Information gathered to date probably does not show effect of the spraying done in 1957.

In the light of present knowledge the spraying should have been done in the spring of 1955--the spring following the burn--to be the most effective.

Fertilizer Studies

In 1954, at the time of seeding, a 250-foot wide strip of phosphate fertilizer was applied the full length of the study area. This application--at the rate of 400 pounds per acre--was based on exploratory information that most soils in the study area were deficient in phosphorus. It was hoped that fertilization would stimulate growth of the introduced species--particularly the legumes. Such a vigorous herbaceous growth would tend to retard the growth of brush seedlings and sprouts.

In November, 1955 three additional fertilizer plots were established for further tests of fertilizers, in conjunction with the 1954 phosphate application.

Bands of the same concentration of phosphate 198 feet wide and 396 feet long were applied next to the original strip. These applications would help to determine the effect of fertilization the year following seeding.

Bands of ammonium nitrate 160 feet long and 66 feet wide were applied at right angles to the phosphate strip (fig. 7). The nitrate was applied at the rates of 50 and 100 pounds of nitrogen per acre.

At this time no quantitative analysis has been made of the response of the plants to fertilization; however, visual observations show a definite response to the nitrogen. Plants receiving the nitrogen fertilizer appear to be darker green in color and are growing more vigorously.

Precipitation shortages may have partially limited the response of both the nitrogen and phosphates.

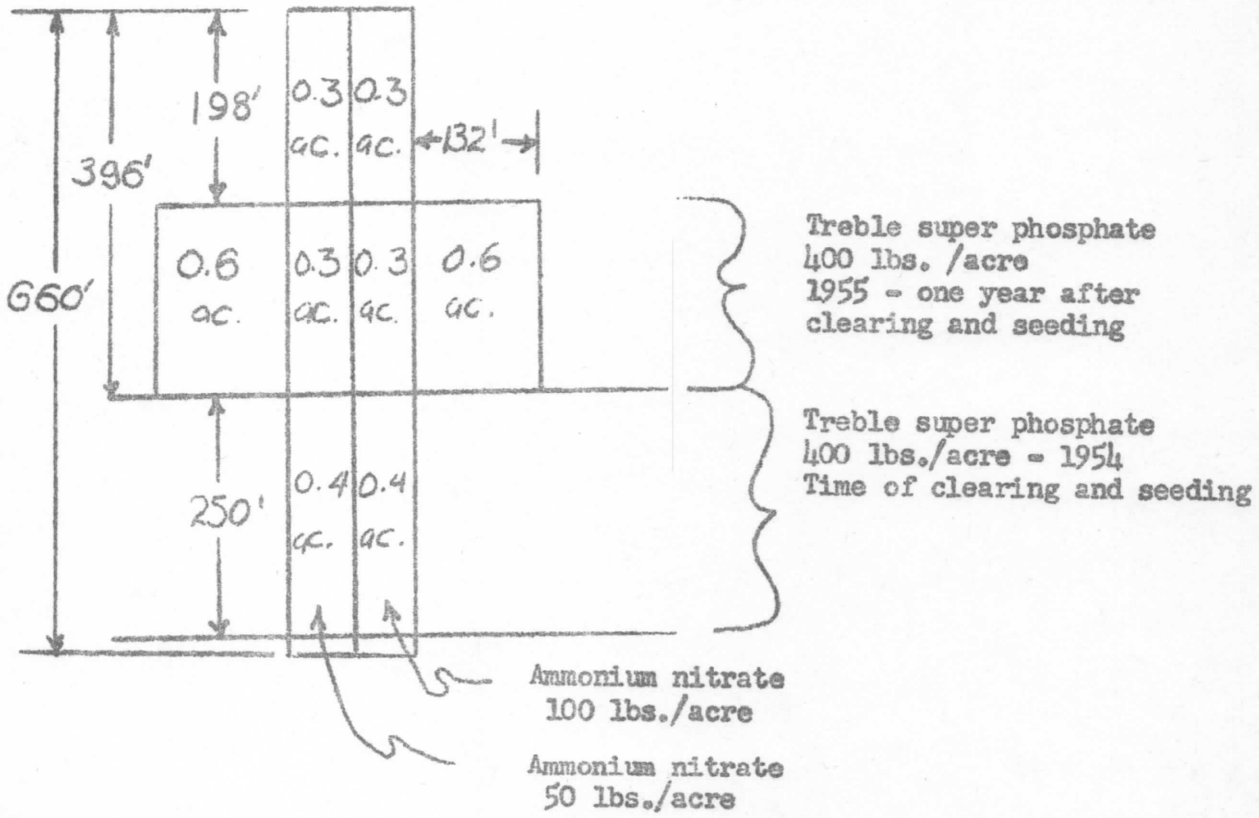

Figure 7. Fertilizer plot layout, Bressi Range Study Area.

Competition Studies

Both detailed studies and random observations made in 1955 have shown that perennial grasses seeded into areas of established annuals have failed almost completely. This occurred even where the annuals had been disked under in an effort to set them back. Subsequent vegetation surveys have shown a steady increase in both annual grasses and forbs, while perennials have declined in number and amount of area occupied. Since perennial grasses appear to have several advantages over annuals for livestock production including high palatability for an extended period into the summer, it appears worthwhile to seek out key elements of this competition. Once the key elements have been determined it may be possible to eliminate or lessen the competition. In order to accomplish this objection the following

tests and observations are being made:

1. Fertilizer plots. Data from existing fertilizer plots are being analyzed to see if addition of fertilizer has any effect on plant composition. Results may show if availability of soil nutrients is a limiting factor in perennial grass development.

2. Grazing pressure. Long term analysis of data collected in and out of the exclosures may give information on the effect of grazing on perennial grass establishment.

3. Irrigation tests. During May of 1956 a 0.2 acre test area was established near the water development and divided into three compartments: a cattle and rodent exclosure; an exclosure for cattle only; and an area open to grazing. This area was seeded during January of 1957 and irrigated with sprinklers. The amount of irrigation required is based on water consumption calculated from atmometer readings from instruments installed at the project weather station. Studies of clipped plots in the cattle-rodent exclosure show a yield of 4,501.20 pounds of ovendry forage per acre compared to an average of 1,796.85 pounds per acre for the same part of the other two exclosures on dry pasture. Although stock took the equivalent of more than 2,000 pounds of forage per acre from this irrigated and grazed area the residual stand consisted of 2,178.00 pounds of ovendry forage--more than the average of the protected areas of the dry pasture exclosures.

4. Deferred competition. One of the problems in the establishment of perennial grasses and forbs is that relatively slow-growing perennial seedlings cannot compete favorably with the vigorous annual seedlings for moisture, nutrients, or light during the early stage of its development. Once the perennial is established, however, under proper management it may be able to succeed. A three-acre plot was laid out to test the feasibility of eliminating competition of resident annuals during the period when perennial grass seedlings were becoming established; the additional objective of this test was to produce some forage during the process. This plot was disked three times during the winter of 1955-56 after the annual grasses had started to develop, in an attempt to kill them. On April 28, 1956, the area was band seeded with sudan grass and fertilized with 16-20-0 fertilizer in alternate rows. Forty pounds of sudan and 66 pounds of fertilizer were applied per acre. On July 20, 1956, the sudan grass area was mowed to produce crown sprouts. Cattle had already utilized most available forage. By October 15 the sudan grass had begun to sprout; stock were again placed on it to utilize all possible forage. During January various combinations of the same species used originally in seeding the study area were band seeded into the sudan plot. Although complete data on development of the seeded species are not yet available there was a spectacular response to this fertilization by mustard (Brassica sp.) and wild oats (Avena barbata and fatua). These plants grew so vigorously that they had to be mowed in February in order to allow the seeded plants a chance to establish themselves. Apparently it requires more than one year and lighter grazing to enable sudan to control annual grasses and forbs. Also, it was very apparent that resident plants can respond spectacularly to fertilizer applications intended to benefit introduced species.

So far it is too early to determine answers to competitive factors from these studies, however, a continuation of present methods should yield valuable basic information.

Summary

Vegetation surveys using the line transect method of sampling were made during the spring of 1955, 1956, and 1957. Information gathered during these surveys indicate the following.

1. There has been a three-fold increase in the ground cover in annual grasses and forbs.

2. Despite the use of herbicides, brush sprouts and seedlings have increased from 4.5 per cent ground cover in 1955 to 13.4 per cent ground cover in 1957.

3. All perennial grasses, with the exception of veldtgrass, have declined in both numbers and basal area. Veldtgrass has increased and is now the most abundant of all introduced species.

4. Rolling with a sheep's-foot roller appears to be the best method of seed coverage. When the broadcast seed is not covered very poor germination results. Disking results in good germination but where valuable native perennials are present it may destroy or injure some of them.

5. Grazing methods and rates of stocking have varied considerably as conditions on the area have changed. Present management plans call for heavy spring grazing to utilize weedy annuals and then lighter summer and early fall stocking to take perennials after their seed has been cast. The 20 animal unit months of grazing so far in 1957 has not been heavy enough to be indicated by clipping tests. The Bressi Range Area in its present condition could probably annually carry 80 animal unit months.

Detailed studies on fertilizer, postponement of annual grass competition in relation to perennial development, and effects of irrigation are being carried on and will be continued.

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August 18, 1958