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THE BRESSI RANGE STUDY

FINAL REPORT

Edward E. Bailey, Forest Technician
California Division of Forestry
Department of Natural Resources
Riverside, California

Victor W. Brown, Farm Advisor
Agricultural Extension Service
University of California
San Diego, California

C O N T E N T S

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THE BRESSI RANCH RANGE STUDY

FINAL REPORT

History and Objectives

The Bressi Ranch Range Study is a cooperative 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 were to be 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 "The Bressi Range Study - Second Progress Report, 1955 - 1957."

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 fasiculatum), scrub oak (Quercus spp.), and laurel-sumac (Rhus laurina). Associated with these taller shrubs was a number of lower-growing species. The most important were wild buckwheat (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 areas, 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 Brossi 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.

ferent 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.

Summary of Project Activity January 1955 - July 1957

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 percent ground cover in 1955 to 13.4 percent ground cover in 1957. This may be partially caused by season of herbicide application (July 1955).

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.

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 percent--occurred in November, 1956, and the lowest single reading of 2 percent occurred on November 19, 1958. These extremely dry conditions are brought about by fall and winter Santana winds that blow from the desert areas into much of coastal southern California.

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

Standard Height - 4½ foot Level

Month	1955 to 1956 Temp.	Humid.	1956 to 1957 Temp.	Humid.	1957 to 1958 Temp.	Humid.	1958 to 1959 Temp.	Humid.	1959 to 1960 Temp.	Humid.
July	--	--	67	75	69	70	72	75	74	74
August	--	--	--	--	71	68	75	77	72	73
September	--	--	70	65	67	69	75	64	69	60
October	--	--	64	68	65	74	74	59	--	--
November	--	--	67	35	61	66	67	50	--	--
December	--	--	61	48	63	62	67	42	54	80
January	54	--	55	74	61	60	63	66	46	78
February	52	66	57	69	61	77	59	66	53	77
March	56	57	56	51	58	74	65	65	57	76
April	57	69	58	77	64	74	67	72	60	70
May	63	64	63	72	66	76	65	70	64	71
June	65	68	67	72	69	74	69	74	End of Project May 1960	

Precipitation totals have been less than normal 1/ (Table 2) during the winters of 1954-55 and 1955-56, 1958-59, and 1959-60, and exceeded normal during 1956-57 and 1957-58.

A close examination of the precipitation data shows that the fall months of each year (including the wet years of 1956-57 and 1957-58) 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. The 3.35 and 3.06 inch, departure from normal for the months of February and March 1958 brought this year above normal rainfall.

1/ 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 2. Comparison of precipitation recorded on the Bressi Range Study during the period July, 1954 to May 1960 with the normal precipitation for the area (Lockwood Mesa).

	1954-1955			1955-56		1956-57		1957-58		1958-59		1959-60	
	In.	In.	Depart. from Normal	In.	Depart. from Normal	In.	Depart. from Normal	In.	Depart. from Normal	In.	Depart. from Normal	In.	Depart. from Normal
July	0.00	0.00		0.08	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
August	0.10	0.00	-0.10	0.10	0.00	0.00	-0.10	0.00	-0.10	0.00	-0.10	0.00	-0.10
September	0.06	0.00	-0.06	0.00	-0.06	0.02	-0.04	0.00	-0.06	0.22	+0.16	0.00	-0.06
October	0.54	0.00	-0.54	0.00	-0.54	0.06	-0.48	1.63	+1.09	0.45	-0.09	0.75	+0.21
November	1.23	1.00	-0.23	0.00	1.23	0.00	-1.23	0.80	-0.43	0.15	-1.08	0.00	-1.23
December	2.63	1.15	-1.48	1.45	-1.18	0.23	-2.40	1.56	-1.07	0.15	-2.48	2.90	+0.27
January	1.68	2.77	1.09	2.97	1.29	5.05	4.37	0.90	-0.78	0.62	-1.06	3.03	+1.35
February	1.53	1.45	-0.08	0.36	-1.17	1.10	-0.40	4.88	+3.35	4.40	+2.87	2.60	+1.07
March	1.84	0.30	-1.54	0.26	-1.58	1.61	-0.21	4.90	+3.06	0.00	-1.84	0.32	-1.52
April	0.96	1.10	0.14	1.71	0.75	1.38	0.42	2.45	+1.49	0.68	-0.28	0.85	-0.11
May	0.19	1.23	1.04	0.03	-0.16	1.73	1.54	0.30	+0.11	0.00	-0.19	0.25	+0.06
June	0.06	0.03	-0.03	0.00	-0.06	0.34	0.28	0.00	-0.06	0.00	-0.06	--	--
Totals	10.82	9.03	-1.79	6.96	-3.86	12.52	11.47	17.42	+6.60	6.67	-4.15	10.70	-0.12

The wet Januarys of 1954 - 1957 have been followed each year by a comparatively dry February and March. In some years April, May, and June have had slightly more rain than normal. The trend is almost reversed for the years of 1957 through 1960.

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. (Table 3).

This ground level hygrothermograph recorded higher maximum temperature and lower humidity readings than were recorded at standard height (Tables 1 and 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 3. Mean Monthly Temperature & Humidity Recorded on a Hygrothermograph at the Bressi Range Study Weather Station. Ground Level - ½ Foot.

MONTH	1957 to 1958		1958 to 1959		1959 to 1960	
	Temp.	Humid.	Temp.	Humid.	Temp.	Humid.
July	73	68	74	74	77	74
August	74	67	77	76	76	74
September	71	67	75	67	74	74
October	65	70	74	68	66	75
November	60	68	65	56	65	50
December	63	65	65	54	59	68
January	61	64	60	73	53	72
February	60	82	57	72	54	75
March	57	80	63	71	58	77
April	63	76	67	67	61	69
May	68	77	66	73	63	68
June	71	74	72	75	End of Project May 1960	

Vegetation Surveys

During the period covered by this report six 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 studies on other areas.

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 in the first 3 years, 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) at first appeared to be regrowing to brush much faster than the other plots. However, at the end of the survey period (1960) it does not appear to have as much brush as some of the other plots. Although at first showing poor results in the establishment of grasses and forbs, it now has a good cover of these species.

Table 4. Trends in composition of plant cover, Bressi Range Study Area: 1953 - 1960.1/

Vegetation class	Plot No.	1953	1955	1956	1957	1958	1959	1960
Shrubs	1	36.7	0.7	9.3	10.5	20.0	24.3	5.3
	2	38.1	2.8	7.6	17.4	22.2	22.4	20.0
	3	2/	6.3	7.6	16.0	16.6	11.9	15.4
	4	2/	1.2	22.0	48.0	14.4	12.6	10.7
	5	31.4	8.0	10.6	9.8	18.4	25.4	4.0
	Average3/	34.8	4.5	8.8	13.4	19.3	21.0	13.7
Perennial grasses	1	4.0	12.6	14.1	5.8	12.6	22.7	9.7
	2	4.5	8.4	10.2	9.7	17.1	27.6	10.0
	3	2/	10.9	10.5	8.8	8.6	9.2	14.2
	4	2/	0.0	0.2	1.0	11.4	10.6	6.4
	5	1.4	7.0	5.5	15.5	2.2	14.0	3.9
	Average3/	3.0	9.7	10.1	10.0	10.1	18.4	9.5
Annual grasses	1	2.0	17.2	35.8	54.7	37.3	15.4	20.2
	2	2.0	21.2	26.2	29.3	48.0	22.2	25.7
	3	2/	16.5	33.2	26.8	48.5	22.8	22.6
	4	2/	0.0	3.2	0.0	53.3	20.9	21.5
	5	7.6	15.3	39.2	30.7	73.8	17.6	22.8
	Average3/	3.9	17.6	33.6	35.4	51.8	19.5	22.9
Forbs	1	0.0	9.0	8.5	19.5	2.4	1.8	5.1
	2	0.6	5.6	9.8	17.1	1.8	5.2	5.9
	3	2/	16.1	10.0	24.1	9.5	10.7	0
	4	2/	14.5	14.0	3.7	4.2	10.4	8.5
	5	0.4	12.2	2.8	15.1	0.6	4.6	8.3
	Average3/		10.7	7.8	20.0	3.5	5.6	4.8
Average Total Plant Cover			82.5	60.3	78.8	84.7	65.5	50.9
Average Bareground			17.5	39.7	21.2	15.3	34.5	49.1

1/ This table is graphed in the appendix by individual plots for each vegetation type.
2/ Data not available.
3/ Average does not include plot 4

Plot Treatments

Plot 1 - Brush railed July 1954.
Plot 2 - Simultaneous ignition - alternate strips railed.
Plot 3 - Chained down 1 year before burning.
Plot 4 - 1953 check plot -- no treatment.
Plot 5 - Aerial application of herbicides. Spring 1954.

Despite the effort made to control brush sprouts and seedlings this form of vegetation increased over the entire area. From an average of less than 4.5 percent ground cover in 1955, the brush cover increased to an average of 21.0 percent in the spring of 1958. There has been a decline the last two years, (1959-1960) until the brush cover is 13.7 percent. Some of this decline may be attributed to a deficiency of precipitation causing the young brush sprouts and seedlings to die-back. Some evidence of this has been noticed throughout the district. How much, if any, of this decrease in brush cover could have been caused by the herbicide treatment has not been evaluated.

In considering the grasses, both seeded and native, as a group, the proportion of the ground covered by their crowns indicates a general increase through 1958. Since then there has been a decrease which in all probability is again due to a precipitation deficiency.

One of the most significant items indicated by the data has been the steady and somewhat rapid increase in both forbs (annual and perennial) and annual grasses (Figure 1), especially up through the period of normal precipitation (1958). Since that time there has been a slight decrease in these species. These two groups increased from an average of 28.3% of the ground cover in the spring of 1955 to an average of 55.3% in 1958. Currently they comprise an average of 27.7% of the ground cover.

Although the percentage of ground covered by the leafage of the perennial grasses has declined to some degree, an examination of the individual species gives an entirely different picture. The number of native stipa plants has had the greatest fluctuation, but at the current time they are greater in number than at any time. Hardinggrass has had little fluctuation and is now second in number of plants. Veldtgrass has increased steadily to the point where it now ranks third in number of plants. The number of smilo plants has changed very

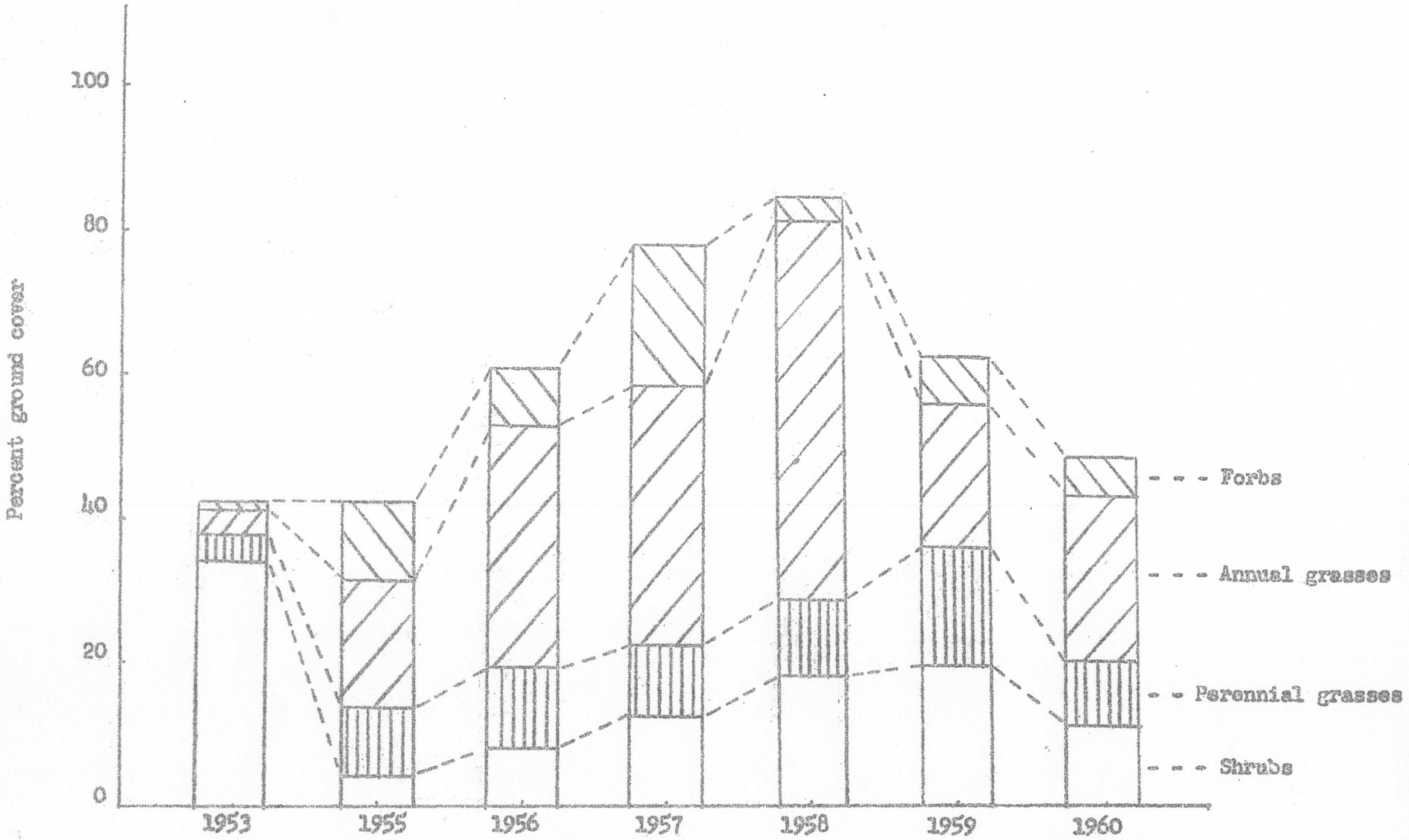


Figure 1. Trends in composition of ground cover. Bressi Range Study Area: 1953 - 1960. This is a pictorial representation; area occupied by each kind of vegetation in the figure, for each year, indicates the area occupied by that kind on the ground. The slope of an individual line from one year to the next has no significance of itself.

little, and at the end of six years has only increased in number from 0.04 to 0.05 in a ten foot transect (Table 5 and Figure 2). The data for 1960 show only 55% of the number of individual plants present in 1955. The greatest decline in number of plants occurred in ryegrass.

The data show there was an increase in basal area (ryegrass excepted) by all species until at this time the basal area is 2.58 times greater than in 1955 (Table 6 and Figure 3). Apparently all plants that established themselves grew rapidly at first and total basal area increase offset loss by mortality of some plants.

During the seeding 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 in the spring of 1955 (Table 7). However, crimson and subterranean clover disappeared by 1956, and rose clover by 1958. Bur clover--on the other hand--decreased in numbers and volume in 1956, and then materially increased in 1957, and decreased slightly in 1958 (Figure 4), and disappeared again in 1959 and 1960. Bur clover is known to respond markedly to yearly weather variations, as do many other annual forbs. The additional study needed to determine if this response was due in part to the various applications of fertilizer on the project could not be completed because of discontinuance of the project (Figure 5).

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

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

Species	Years 1955	1956	1957	1958	1959	1960
Stipa	1.23	1.32	0.43	0.53	1.58	1.27
Smilo	0.04	0.22	0.12	0.17	0.38	0.05
Hardinggrass	0.67	0.39	0.27	0.21	0.30	0.34
Ryegrass	1.52	0.57	0.25	0.01	0.02	0.02
Veldtgrass	0.12	0.13	0.37	0.42	0.16	0.29
Total	3.58	2.63	1.44	1.34	2.44	1.97

Each transect was 10 feet in length.

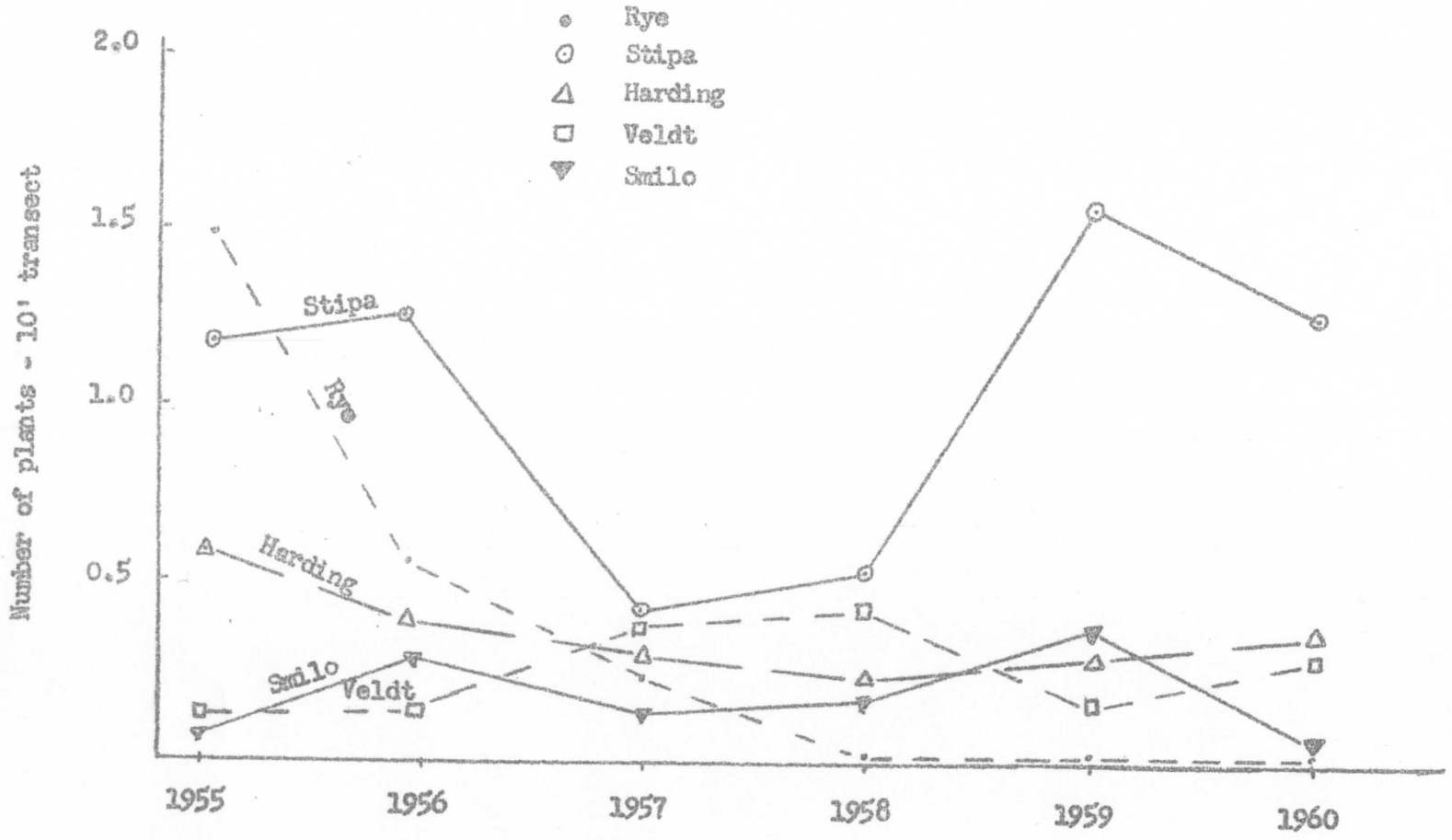


Figure 2. Trend in average number of perennial grasses. Bressi Range Study Area.

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

Species	Ground cover (percent)					
	1955	1956	1957	1958	1959	1960
Stipa	1.23	2.00	1.11	1.32	4.18	3.89
Smilo	0.00	0.34	0.08	0.73	0.81	0.15
Hardinggrass	0.39	0.75	0.63	0.67	0.69	1.44
Ryegrass	0.86	0.99	0.55	0	0	0.06
Veldtgrass	0.04	0.22	0.53	0.74	0.32	0.98
Total	2.52	4.30	2.90	3.46	6.00	6.52

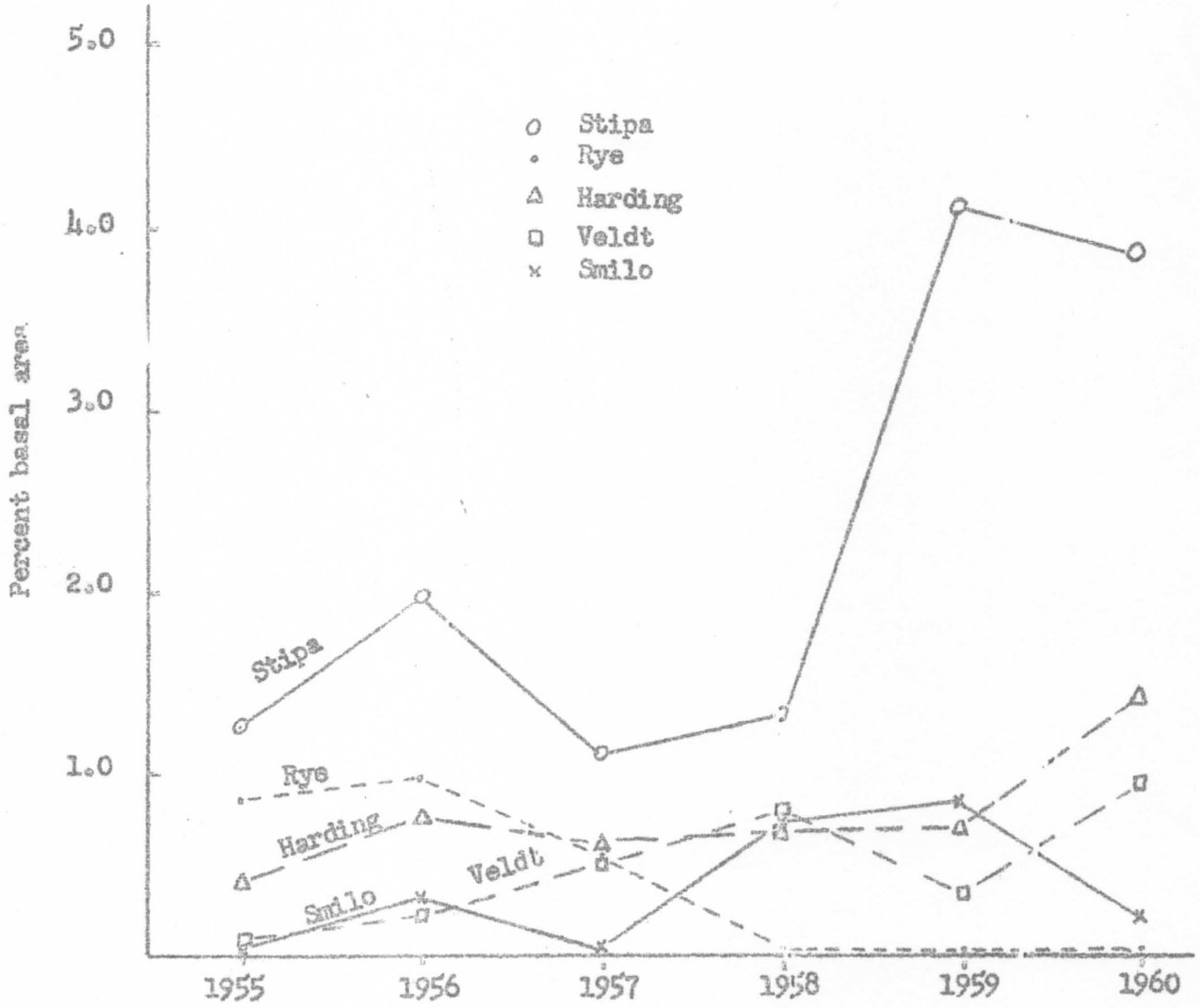


Figure 3. Total basal area of perennial grasses, Bressi Range Study Area.

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

	Number of Plants			Percent Ground Cover			Number of Plants			Percent Ground Cover		
	1955	1956	1957	1955	1956	1957	1958	1959	1960	1958	1959	1960
Rose clover	0.4	0.2	--	0.3	0.1	--	0.08	--	--	0.05	--	--
Bur clover	0.3	0.1	1.7	0.1	--	0.2	0.22	0.07	0.02	0.22	0.01	0.04
Subterranean clover	0.1	--	--	0.1	--	--	--	--	--	--	--	--
Crimson clover	0.3	--	--	0.2	--	--	--	--	--	--	--	--

Data collected by line transect method from all plots.

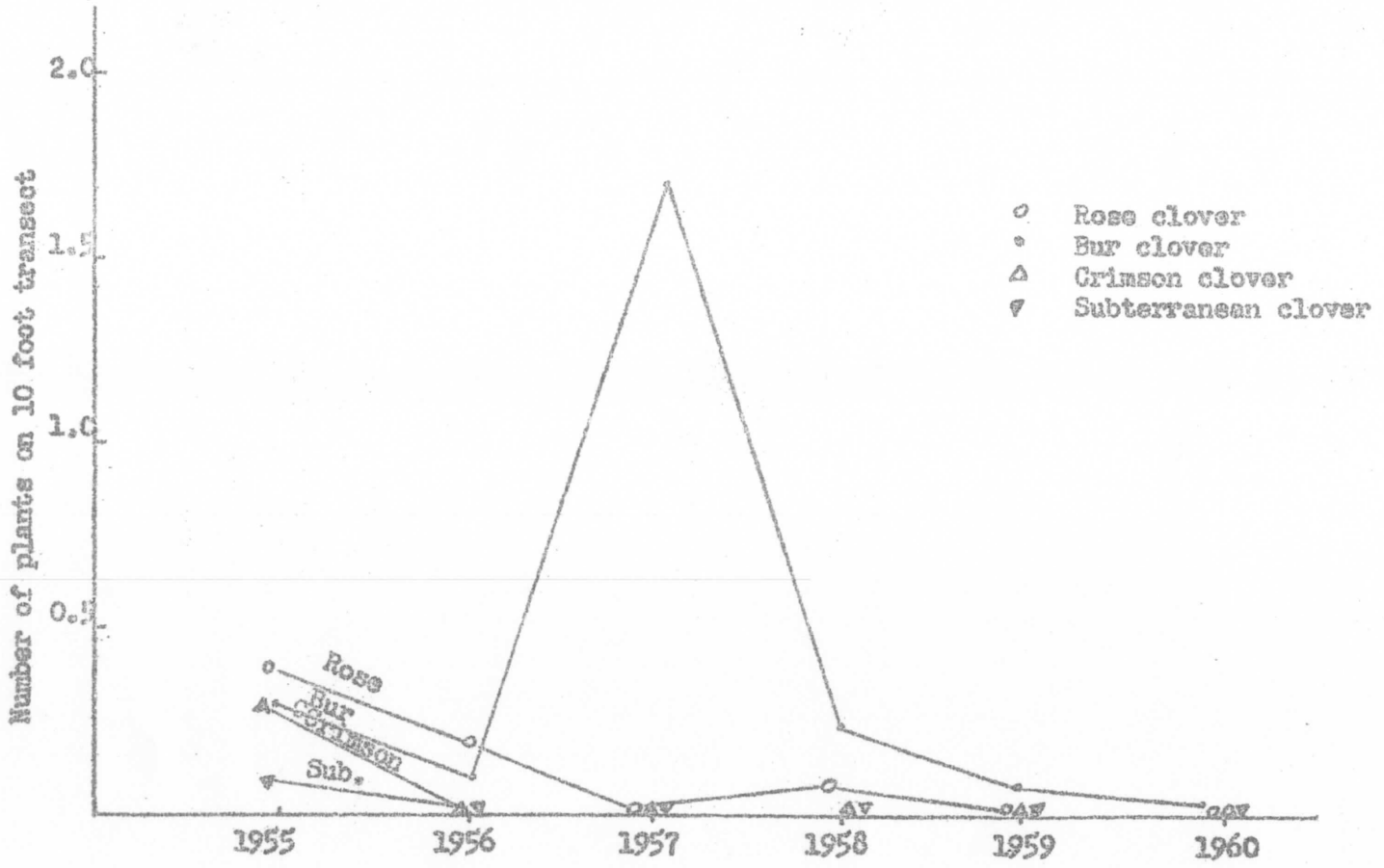


Figure 4. Trends in numbers of clover plants, Brassi Range Study Area. 1955 - 1960.

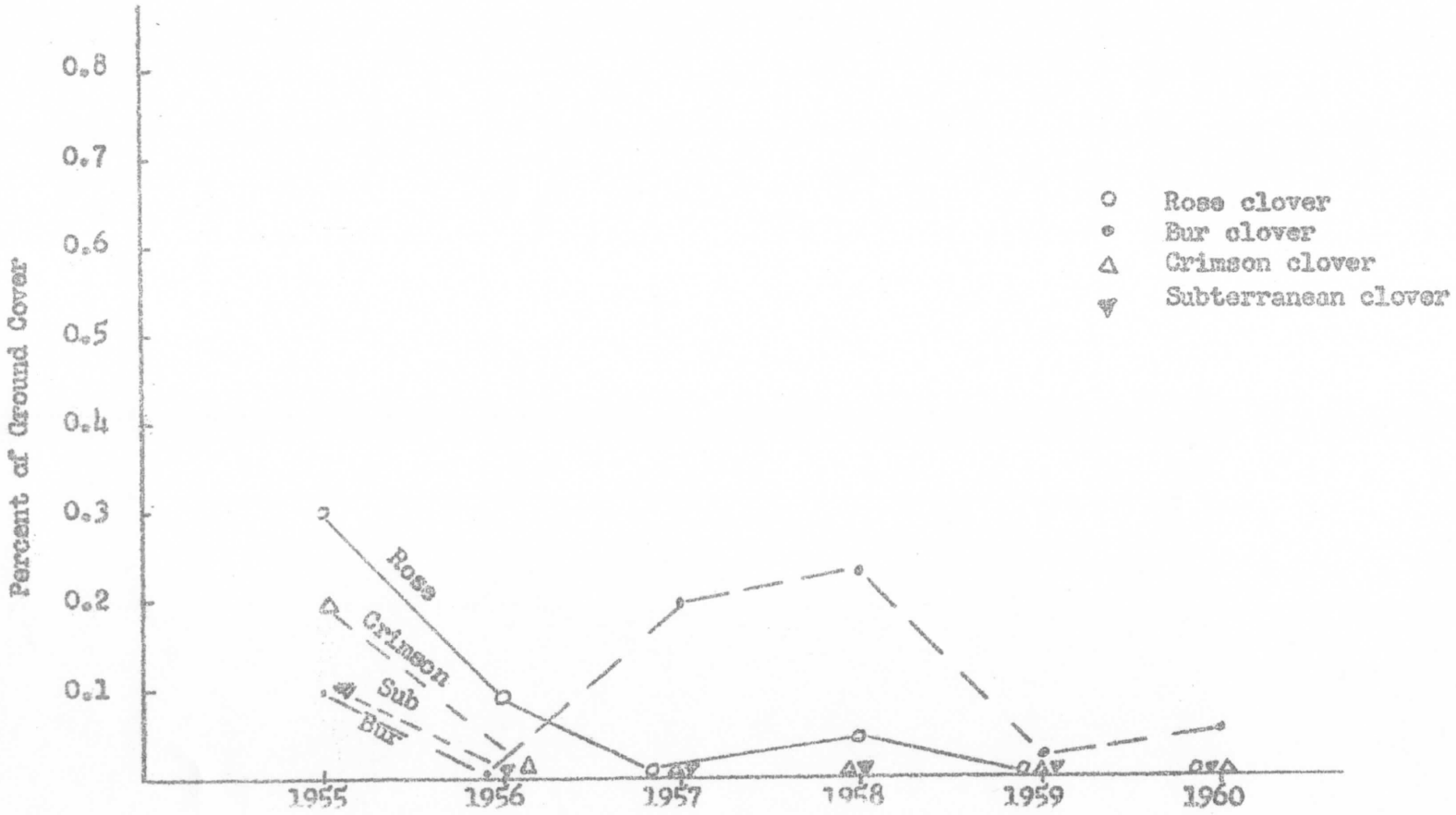


Figure 5. Trends in proportion of ground cover occupied by clovers, Bressi Range Study Area.

that have occurred each December just as the perennial grasses have been commencing growth (Table 2). The rain-fall 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 the second progress 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. 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. Studies should be continued by locating and examining similar areas that have received the various treatments.

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, 1955, 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 peremnial 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.

On October 23, 1958, sixteen cows and nine calves were placed on the study area. These were removed on November 11 as the area was not carrying the animals satisfactorily. Although there appeared to be sufficient forage it did not have the food value.

Ten head of cattle were grazed on the area from May 1 to May 18, 1959. In June, six more head were placed on the area. It was estimated that 17 animal unit months of forage was available for the year. Because there was a lack of forage and since it was a dry year the gates between the study

area and the other parts of the range were left open. A supplement of cull lima beans, bean straw, and volunteer oat hay was fed to the livestock, consequently, the perennials were grazed very lightly this year.

Seventeen head of yearlings were placed on the area on March 20, 1960. On May 11, an additional 66 cows and 43 calves were grazed on the area. These were removed prior to May 19, 1960 when the final vegetative survey was made.

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

1. Clipping studies.

2. Observation 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-rabbit 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 10). However, casual observations show a definite utilization of forage by both cattle and rodents.

Table 10. 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)
Rabbit 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 (1957) were not readily detected.

As would be expected, the stock apparently concentrated on the irrigated plot and used 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 the 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 percent increase in ground cover of herbaceous vegetation (over data collected during 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, 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 and climatic conditions were favorable. This would still leave on the ground more than 60 percent 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 the succulent period.

In those areas where the competition of shrubs has been greatly decreased or eliminated the perennial grasses are doing much better. This tendency has been noted in other areas where such competition has been removed.

In July 1955, herbicide test plots were established using combinations of 2,4-D and 2,4,5-T. Using information obtained from these plots the entire area was sprayed in the spring of 1956 and 1957. Effectiveness of the herbicide applications has left much to be desired. In the light of present knowledge, spraying should have been done in the spring of 1955--the spring following the burn--and followed up in 1956 with a second application to have been the most effective. Detailed data covering costs and chemicals for this work are given in Appendix B taken from the second progress report.

The data for the 1958 herbicide application are given below:

1958 Herbicide Application on Bressi Project

Hand Spraying

Plot #2.

3 gals. Brush Killer[1/]	$8.51 + tax	$26.57
15 gals. Diesel		1.90
Total.		$28.47

45 man hrs. & 130 crew truck miles

Plot #5

7 gals. Brush Killer		$62.95
35 gals. Diesel		5.49
Total.		$68.44

212 man hrs. & 681 crew truck miles

1 lb. Analin Dye Marker		6.24
Total.		$103.15

Tractor Spraying

Plot #3.

20 gals. of Brush Killer @ $8.51 $170.20

A cletrac spray rig was used for 6 hrs. of equipment time and 30 man hours were expended.

Disking

Plot #1. This was disked in July 1958 with a TD-18 and a brush disk with the following expenditures:

24 F.E.O. man hours	18 gals. gasoline
8 Tractor hours	50 gals. diesel fuel
120 miles for service unit	4 qts. motor oil
60 miles for transport	

(This also included disking the fire breaks around plot #2 in preparation for possible burning.)

1/ 2,4-D & 2,4,5-T l.v.e. herbicide.

The application of fertilizer on dry land range to the soils represented in the study area has been pondered for many years. By increasing the nutrient level of these soils it was hoped that not only would perennial grass establishment be aided, but that an increased nutrient level would perpetuate the annual clovers and thereby increase quality as well as quantity of forage.

The first exploratory trial was applied in November of 1953. The conclusions from these trials indicated that there was no response from potash or sulphur applied separately. A slight response was seen to phosphate and nitrogen when applied individually. However, the best response occurred from the application of nitrogen and phosphate in combination. The plot layout of these trials is covered in the fertilizer trial section of the First Progress Report. Response from the combination application of N & P was seen for two years.

In the spring of 1958 a heavy growth of clovers was seen in the squares treated with phosphate. Nitrogen effects had completely disappeared by this time.

The fertilizer section of the Second Progress Report shows the plot layout for the combinations of nitrogen and phosphate that were applied in three locations in November of 1955. No yields by clipping were taken, but observations showed a similar response to that of the original exploratory trials. The 250 foot phosphate strip described in the Second Progress Report was for the purpose of growth stimulation for the introduced species of legumes.

Using the step-point system of vegetative survey a 2-4 percent of ground cover by clovers was noted while in the adjacent unfertilized area only 1.0 percent of the ground cover was in clovers. With the exception of

a few small areas where rose, crimson, and sub-clovers appeared in patches the fertilized and unfertilized area showed no marked differences in subsequent years either inside or outside of this phosphate strip. During a field day held on the project in April 1958 it was of interest to note a marked phosphate response in the exploratory trial applied in November 1953. This suggests a possible carry-over response of phosphorus for 5 years. This response was not seen in either the year before or the year after the 1958 growing season. This particular year was known by local cattlemen as a "good clover year."

The only conclusions that can be drawn from these fertilizer studies on this range project are:

1. The addition of single elements of sulphur and potash showed no response.

2. Responses to single applications of phosphate and nitrogen are visible.

3. The combined application of nearly equal amounts of nitrogen and phosphate showed the greatest response.

4. Rates of 160 pounds of P_2O_5 did not succeed in establishing legumes in the soils represented in the study area.

perennial grasses seeded into areas of established annuals failed almost completely. The 1960 data does not appear to uphold this. Perennial grasses have maintained since 1955 an average ground cover of 9 to 10 percent while the annual grasses have fluctuated from approximately 4 percent in 1955 to a high of 52 percent in 1958 and are now only 23 percent (Table 5 and Figure 1). Much of the annual fluctuation is directly related to the variation in precipitation and some change in percent of ground cover by perennials may have been due to grazing practices.

As a follow-up on the conclusions stated in the 1957 report an area was selected to further test species competition. The area was summer fallowed and in the spring of 1956 sudan grass was planted to clean up the area. This was grazed down in the summer of 1956. In January 1957 the selected site was staked and planted to the mixtures shown in Figure 6. A band seeding method was used.

Several things occurred in this test that possibly negated any of the results.

1. The sudan grass did not clean up the area.
2. Weed competition was severe in all plots.
3. Fertilizer applied to the indicated areas showed prominent results.
4. Grazing for weed control was not successful as forage was good over the entire project.

As a result of this the test was charged off as a failure. However, observation in 1959 did indicate that there was a better stand of harding and smilo established than expected. No clovers were sustained in either the fertilized or unfertilized plots.

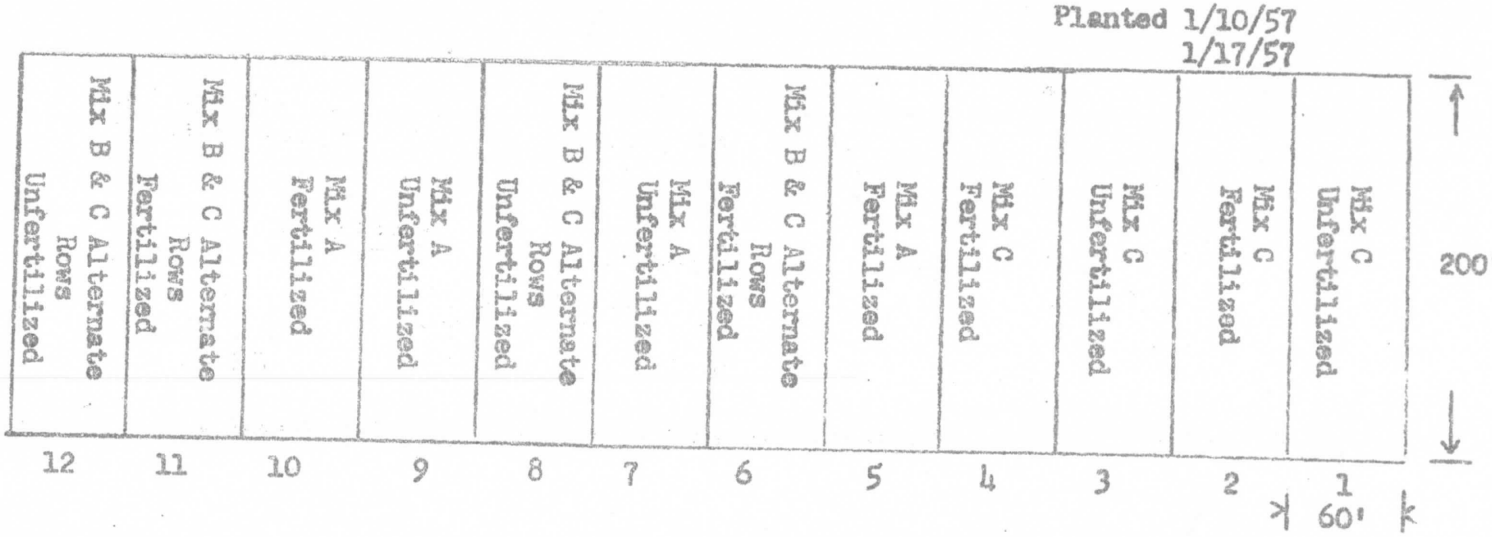


Figure 6. Layout and treatment of competition study plots, Bressi Range Project, 1957.

MIX A -- Clover-grass

Rose Clover	2 lbs.
Crimson Clover	2 lbs.
Mt. Barker Sub	2 "
Harding	3 "
Veldt	2 "
Smilo	1 "
	13 lbs/ac.

MIX B -- Grass Mix

Harding	3 lbs.
Veldt	2 lbs.
Smilo	1 lbs.
	6 lbs./ac.

MIX C -- Clover Mix

Rose Clover	2 lbs.
Crimson Clover	2 lbs.
Mt. Barker Sub-clover	2 lbs.
	6 lbs./a

Fertilizer equivalent 21 lbs. N/ac.
53 lbs. P/ac.

Procedure:

In an effort to check soil moisture in relation to rainfall data, two soil moisture test locations were established: one on the Ayar clay loam and one on the Linne clay soil type. A permanent stake was driven on these two locations and soil samples were taken from a location the same distance from the stake, about three feet from the preceding sample location. Subsequent samples were taken in a clock-wise direction around the stake as follows:

Samples were made with 3 inch soil augers and taken at three levels -- 0 to 6 inches, 6 to 12 inches, 12 to 18 inches. Moisture determinations were made on an oven-dry basis. The soil was placed in an oven at 95° to 110° C. until there was no weight change. The difference obtained was then divided by the dry weight obtained to give soil moisture on a dry weight basis.

The data are included in the appendix and a brief analysis indicates that soil moisture in this area, on these soil types, and under the precipitation patterns recorded follows a general pattern as shown by other studies. 1/

1/ Pacific Southwest Forest & Range Experiment Station studies.

BRESSI - WIEGAND PROJECT
Moisture Tests (Dry Weight Basis)
at various Depths

	PLOT 5			PLOT 3		
	0 - 6"	6" - 12"	12" - 18"	0 - 6"	6" - 12"	12" - 18"
	Percent	Percent	Percent	Percent	Percent	Percent
1955						
January 13,	19.71	20.22	19.33	20.90	21.39	15.62
February 10,	18.88	20.43	19.47	21.64	20.24	17.01
March 10,	17.30	19.31	17.98	18.20	17.26	16.72
April 14,	12.71	14.60	30.93	13.12	11.96	13.58
May 9,	14.17	15.71	15.98	16.47	16.73	14.38
June 9,	13.07	14.08	11.09	17.02	18.20	17.59
July 7,	10.48	11.90	11.40	12.33	12.17	12.93
August 4,	15.80	10.78	10.89	11.89	12.40	11.83
September 15,	10.41	9.84	10.14	8.58	9.95	10.69
October						
November 28,	14.21	11.54	11.02	12.29	12.76	12.37
December						
1956						
January 5,	11.48	11.68	11.12	12.98	13.66	13.74
February 3,	21.5	21.1	17.7	20.7	21.6	21.8
March 15,	15.07	17.49	17.86	14.79	13.89	16.33
March 30,	12.01	14.35	14.61	14.57	13.36	13.39
April 5,	13.03	14.57	14.81	14.74	15.23	12.36
May 10,	14.06	12.97	12.13	12.06	14.91	14.03
June 28,	10.24	11.81	11.17	12.12	12.61	13.46
August 9,	8.92	11.05	10.79	10.35	11.11	11.44
September 6,	6.87	9.27	8.82	7.52	7.76	6.67
October 18,	6.84	8.66	10.65	6.16	8.11	9.47
November 21,	7.63	8.33	8.36	9.15	9.30	9.82
December 21,	7.78	9.11	8.40	8.51	10.44	10.50
1957						
January 30,	26.56	25.09	23.39	16.64	17.52	16.27
February						
March 21,	22.63	17.72	17.16	21.45	18.27	18.18
April 4,	20.47	18.22	17.36	17.43	18.16	15.61
May						
June	11.46	13.79	13.13	13.93	14.58	13.52
July 10,	9.95	11.69	11.58	11.51	12.09	11.35
August 20,	7.80	9.17	9.84	8.49	9.72	10.07
September 5,	8.43	10.84	11.30	9.38	10.56	9.02
October 29,	12.78	11.53	10.92	8.51	8.98	7.52
November						
December						
1958						
January 2,	11.87	12.11	11.15	15.52	15.01	11.98
February 6,	24.03	25.96	21.24	19.11	22.38	22.12
March 19,	17.22	23.89	10.36	18.41	18.26	20.51
April						
May						
June						
July 10,	10.00	12.09	10.30	12.08	13.36	13.08
August 12,	7.59	9.99	10.76	10.91	9.84	11.58

Soil Expansion Test:

It was reported in the prior progress report that a noticeable expansion of the soil occurred after the area was burned and seeded. To check this, two locations within exclosures were located and two stakes driven at each location. One stake was driven to a 12 inch depth and the other stake to a 36 inch depth. The stakes were marked so that any upheaval or retraction of the soil could be detected on the stake. The stakes were placed in exclosures to prevent soil disturbances from grazing and any possible soil compaction.

Dr. Martin H. Huberty[1/] considered the problem and concluded that the following sequences of events occurred to produce the uplifting of the ground surface following burning:

"a)[2/] The heat generated by the fire was of sufficient intensity to affect the calcium carbonate in this high lime soil,

b) Shortly after, the burn reference stakes were driven into the soil,

c) With the coming of the rain or heavy fog, the lime was hydrated, thus causing the soil to expand. The reactions might be as follows:

$$CaCO_3 + \text{heat} \rightarrow CaO + CO_2 \uparrow$$

$$CaO + H_2O \rightarrow Ca(OH)_2$$

The hydrated lime would have a loose structure and could possibly account for a slight rise in elevation of the ground surface."

Dr. Martin Huberty did further soil analysis on the project soils and Table 8 is a result of these tests.

1/ Chairman, Department of Irrigation & Soils, U.C.L.A.
2/ Letter to Elwood Moore, director A.E.S., San Diego County from Dr. Martin H. Huberty, dated January 9, 1956.

Table 8. Mechanical Analysis, and Moisture Percentage (dry wt. basis) at 60 cm and at 15 atmospheres.

Location No.	Soil Series	Soil Cond.	Det. No.	Texture %Sand	%Silt	%Clay	Moisture % at 15 atm.	60 cm.
1	Ayar	Burned	1	55	19	26	11.8	
			2	56	18	26	12.4	
			Av.	55.8	18.5	26	12.1	28.1
1	Ayar	Not Burned	1	55	19	26	14.4	
			2	57	18	25	13.7	
			Av.	56	18.5	25.5	14.0	41.8
2	Linne	Burned	1	58	19	23	12.0	
			2	55	22	23	13.7	
			Av.	56.5	20.5	23	12.9	31.3
2	Linne	Not Burned	1	60	18	22	14.7	
			2	58	20	22	17.1	
			Av.	59	19	22	15.9	34.9

The 15 atmosphere values are comparable to the soil moisture content at the wilting percentage, while the 60 cm values are slightly higher in field capacity. From the results obtained it is indicated that burning has affected the water retention characteristics of the soils with the burned soils having a lower moisture retention capacity at the wilting and field capacity percentages.

1. The establishment of the seeded species cannot be correlated with the various brush removal methods originally applied on the area.

2. The methods of brush removal used to clear the area shows no correlated affects on the regrowth of the brush on the project area.

3. Vegetation surveys using the line transect method of sampling were made during the spring of each year from 1955 through 1960 by the California Division of Forestry (Appendix C). Sampling by the step-point analysis has also been made each spring for the same period by the San Diego County Farm Advisor's office (Appendix A). Information gathered during these surveys indicate the following:

   a) Both methods of vegetation survey give a similar picture of conditions and either method would be applicable to use on a similar study.

   b) Forbs have increased 15 points in the average percent of ground cover while annual grasses have increased 6 times. Perennials have increased three times and shrubs have decreased by 2.5 times or 60 percent since treatment. However, shrubs are increasing with time as they have increased from an average of 4.5 percent in 1955 to an average of 13.7 percent in 1960. They composed 34.8 percent of the ground cover prior to new treatment.

   c) All perennial grasses, with the exception of veldtgrass, have in general decreased in the total number of plants, but the basal area has increased approximately 2.6 times.

4. The use of herbicides at the proper season of the year can be beneficial in controlling sprouts and seedlings as shown by the data obtained in the test plots vs. the actual operational program in 1956 and 1957. Disking of a portion of the area showed some beneficial results for a temporary period. Grazing methods and rates of stocking have varied considerably as conditions on the area have changed. The Bressi Range Project, in its improved condition and under proper management, could in all probability carry 70 - 80 animal unit months annually.

5. Fertilizer studies.

   a) The addition of single elements of sulphur and potash showed no response.

   b) Responses to single applications of phosphate and nitrogen were feasible.

   c) The combination application of nearly equal amount of nitrogen and phosphate showed the clearest response.

   d) Rates of 160 lbs. of P_2O_5 did not succeed in establishing legumes in the soils represented in the study area.

6. Competition studies. The data obtained from this study left much to be desired and did not give any substantial information.

7. Soil studies. In clay soils of this type there is indication that burning affects the water retention capacity of the soil by lowering it.

8. Some of the project area has now been converted to agricultural and truck crop use. The San Diego County Farm Advisor plans to continue step-point analysis on the unaffected areas as long as possible in the future. The area will not be grazed in the future or have any future treatment for brush removal.

Table 9. Step-point vegetative data summary for the Bressi Range Study Project.

	Plot Number	1955	1956	1957	1958	1959	1960
Seeded Perennials △							
	1	4.10	8.08	6.09	3.62	4.93	3.31
(Ryegrass)	2	4.56	4.07	6.96	3.17	3.27	.60
(Harding)	3	2.64	2.50	9.69	3.91	7.12	8.36
(Veldt)	4	.06	.15	.16	1.61	.78	.54
(Smilo)	5	6.66	7.40	18.45	17.78	14.54	10.26
Seeded Clovers ○							
	1	2.17	.54	.78	1.14	.48	.00
(Bur Clover)	2	.71	.26	.08	.13	.00	.00
(Rose Clover)	3	.56	.19	.51	.79	.00	.00
(Sub Clover)	4	.01	.00	.00	.00	.00	.00
(Crimson Clover)	5	1.44	.04	.91	.31	.00	.00
STIPA - Giant Stipa □							
	1	1.73	2.72	5.71	3.22	5.61	6.30
	2	1.60	1.73	5.04	2.66	7.40	6.70
	3	2.00	2.41	7.81	4.00	8.89	10.34
	4	.11	.47	1.13	2.84	3.00	5.52
	5	1.76	2.94	8.37	3.08	9.73	8.10
ANNUAL GRASSES ◎							
	1	1.39	1.54	9.37	15.48	14.11	20.16
(Wild Oats)	2	.24	.85	5.20	6.77	4.33	5.20
(Soft Chess)	3	1.36	2.65	16.62	17.45	10.75	22.00
(Red Brome)	4	.01	.01	.31	2.07	.12	1.26
(Annual Fescue)	5	.32	1.36	5.84	16.41	6.81	13.68
(Ripgut)							
FORBS ▲							
	1	3.61	5.62	7.05	5.04	3.87	1.73-
(Filaree)	2	4.89	3.09	9.22	6.27	5.00	7.50
(Sweet Clover)	3	5.44	4.75	16.37	8.35	4.24	3.30
(Weeds)	4	.81	1.87	2.40	4.98	5.10	4.68
(Lotus)	5	1.82	2.76	11.43	6.42	5.92	3.96

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)
¾ gallon 2, 4-D	1	100
1 ½ 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 percent 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 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.

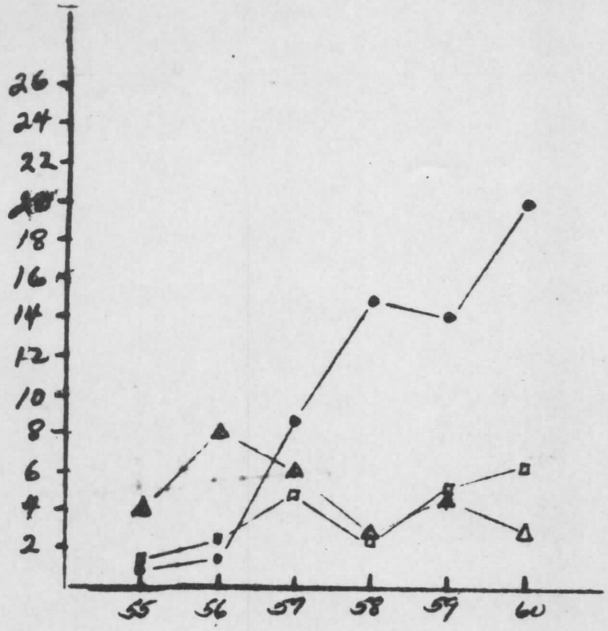
During September, 1955, an inspection of results was made and results estimated (Table 11).

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

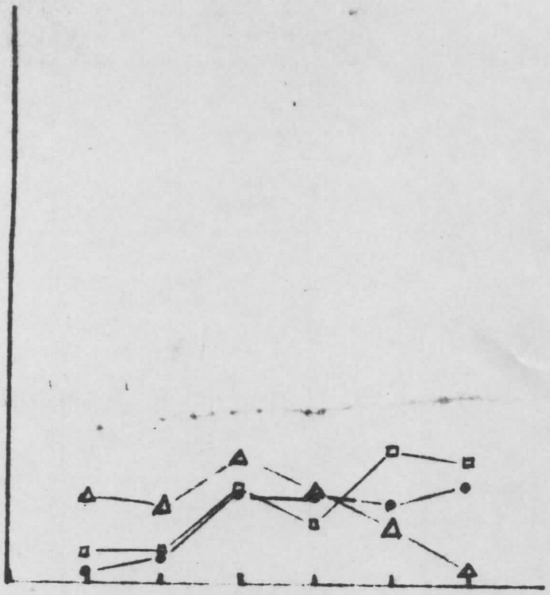
Chemical	Sprout kill (percent)
2,4-D	75
2,4,5-T	85
2,4,5-T-2, 4-D	98

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.

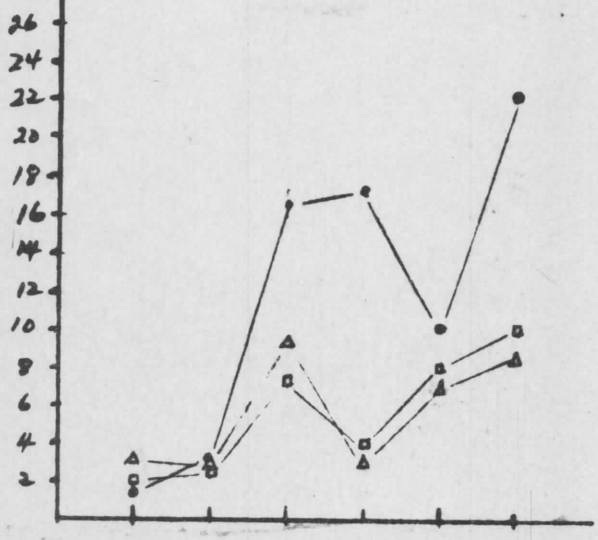
PLOT I



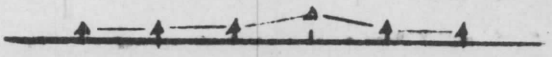
Plot 2



PLOT 3



PLOT 4



△ Perennials

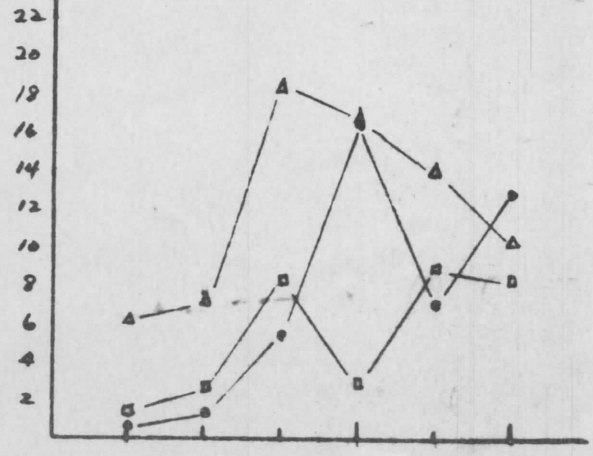
○ Clovers

□ Stipa - Giant Stipa

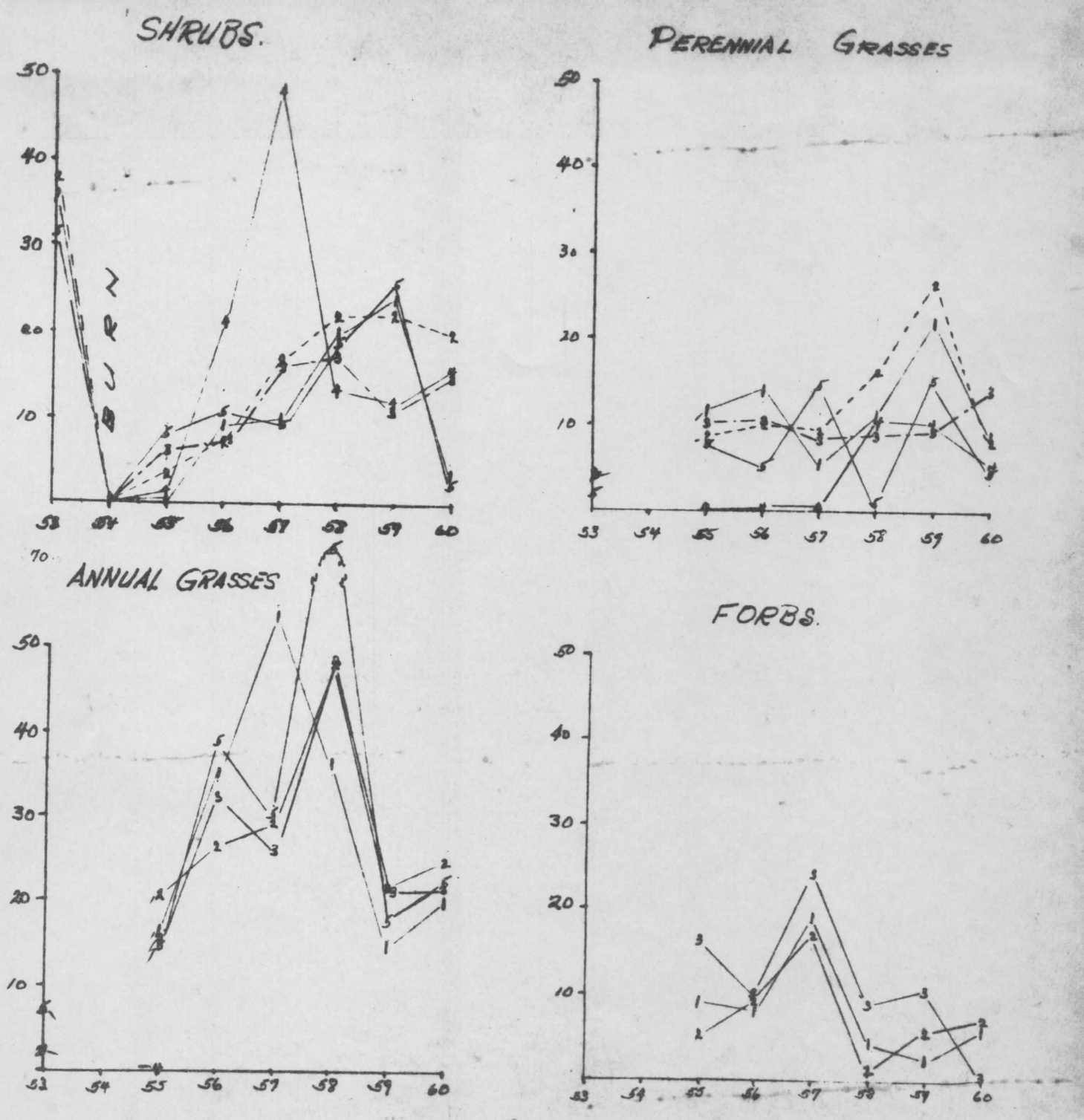
● Annual Grasses

▲ Forbs

PLOT 5



Percent Ground Cover of Vegetation by Type, Plots 1 - 5, Bressi Project, Step-point Analysis.

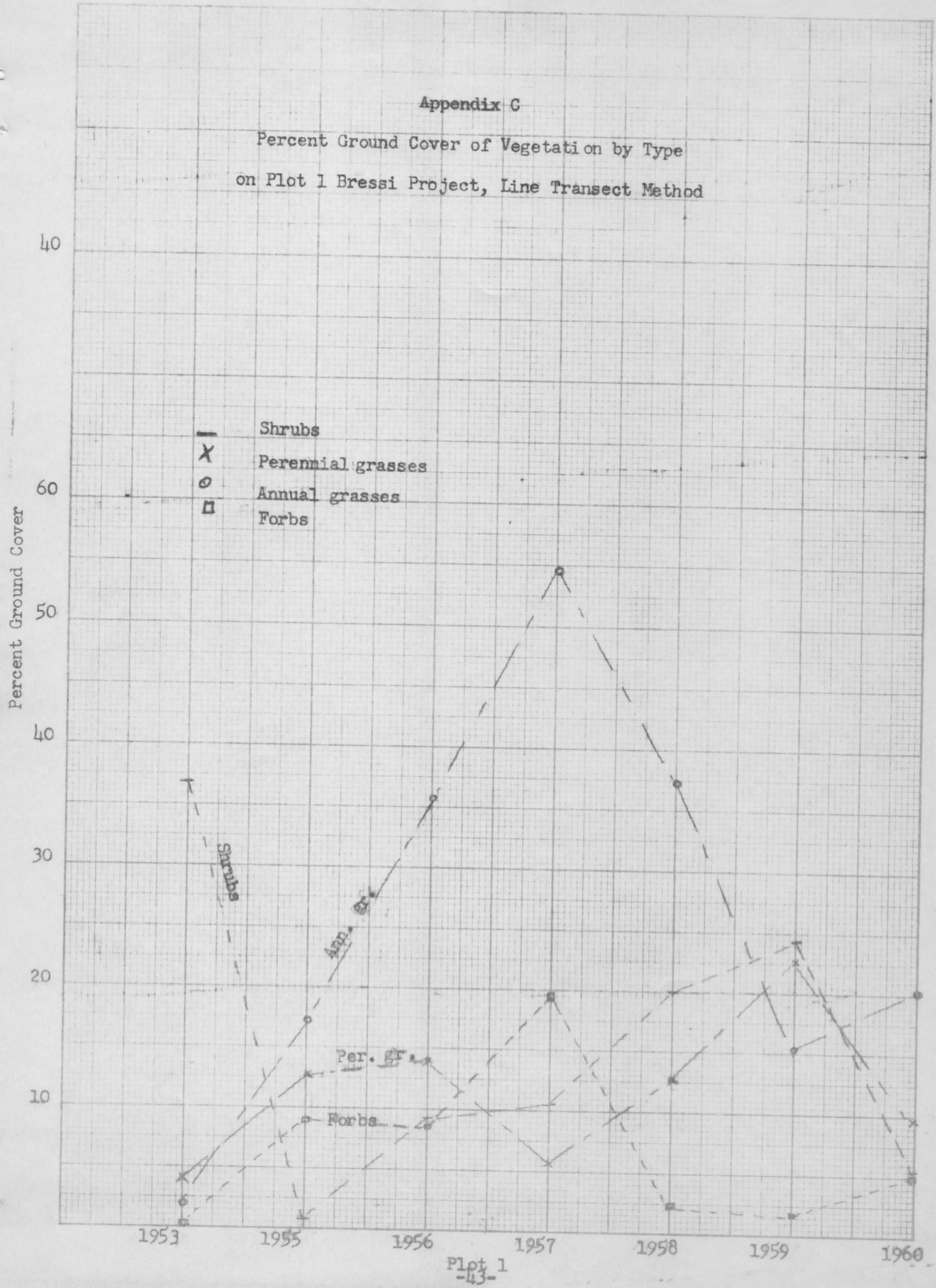


Percent Ground Cover by Vegetation for Plots 1 - 5, Bressi Ranch Project, Step-point Analysis.

Appendix C

Percent Ground Cover of Vegetation by Type

on Plot 1 Bressi Project, Line Transect Method

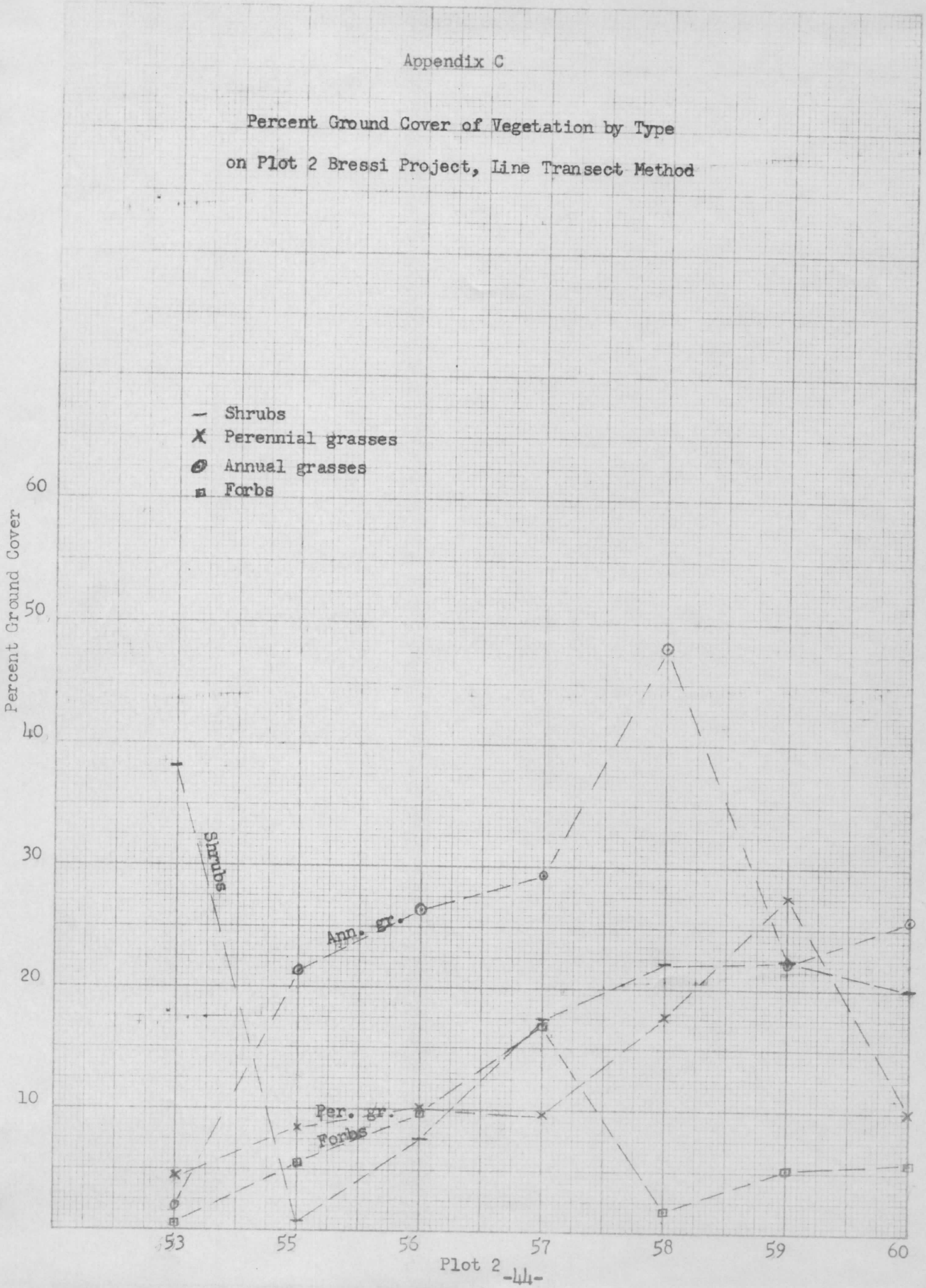


Plot 1

Appendix C

Percent Ground Cover of Vegetation by Type

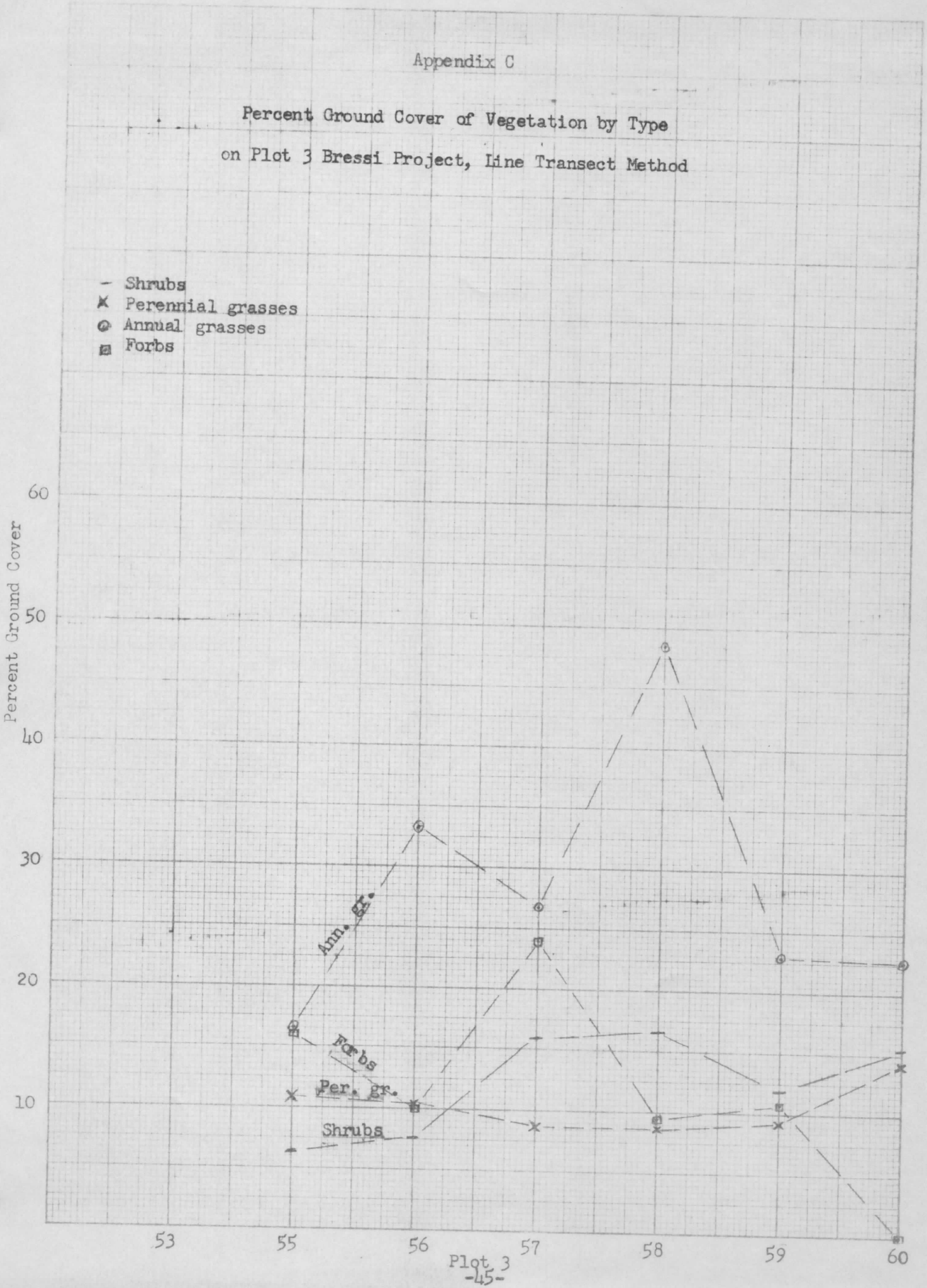
on Plot 2 Bressi Project, Line Transect Method



Appendix C

Percent Ground Cover of Vegetation by Type

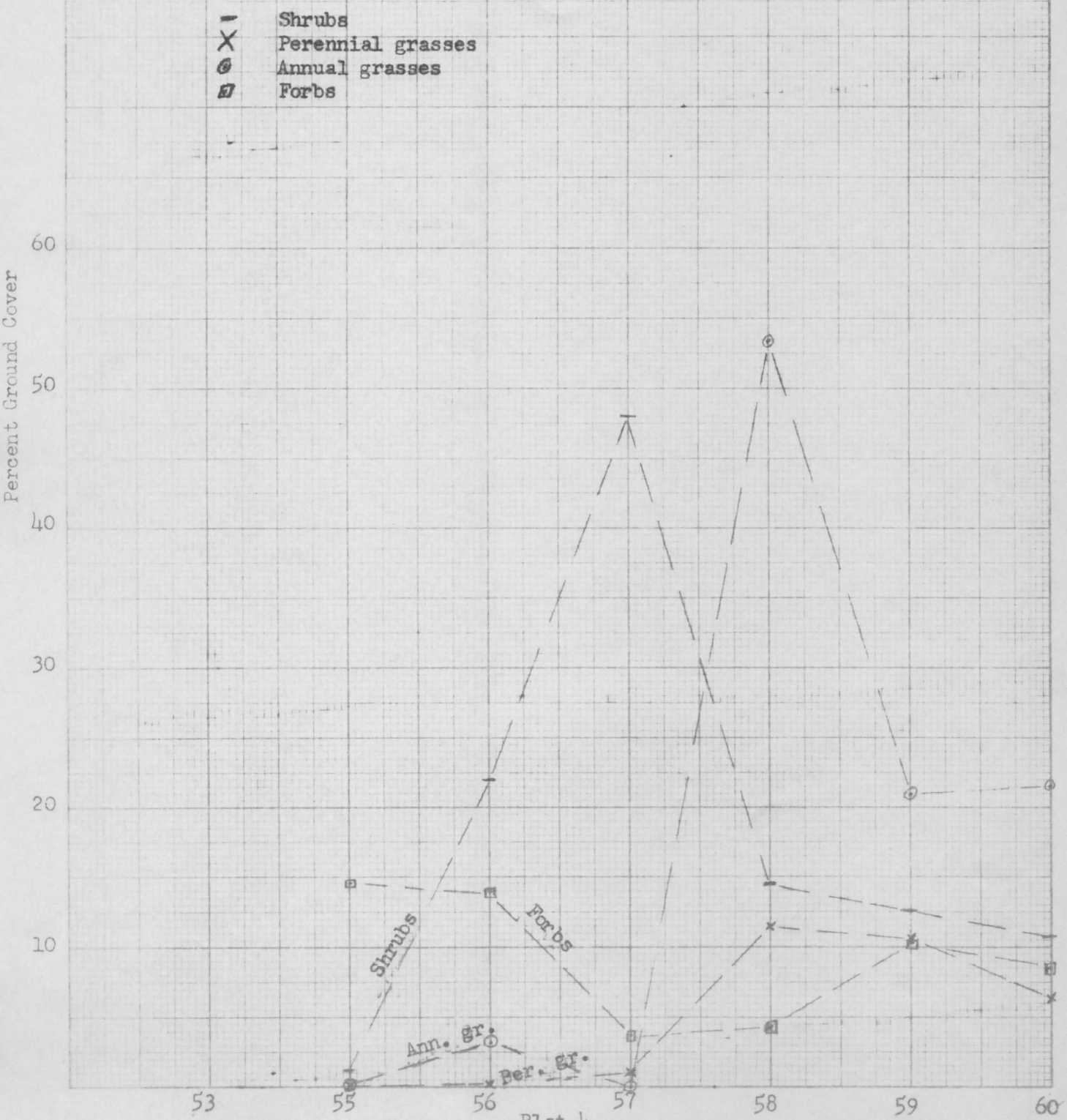
on Plot 3 Bressi Project, Line Transect Method



Appendix C

Percent Ground Cover of Vegetation by Type

on Plot 4 Bressi Project, Line Transect Method



Appendix C

Percent Ground Cover of Vegetation by Type

on Plot 5 Bressi Project, Line Transect Method