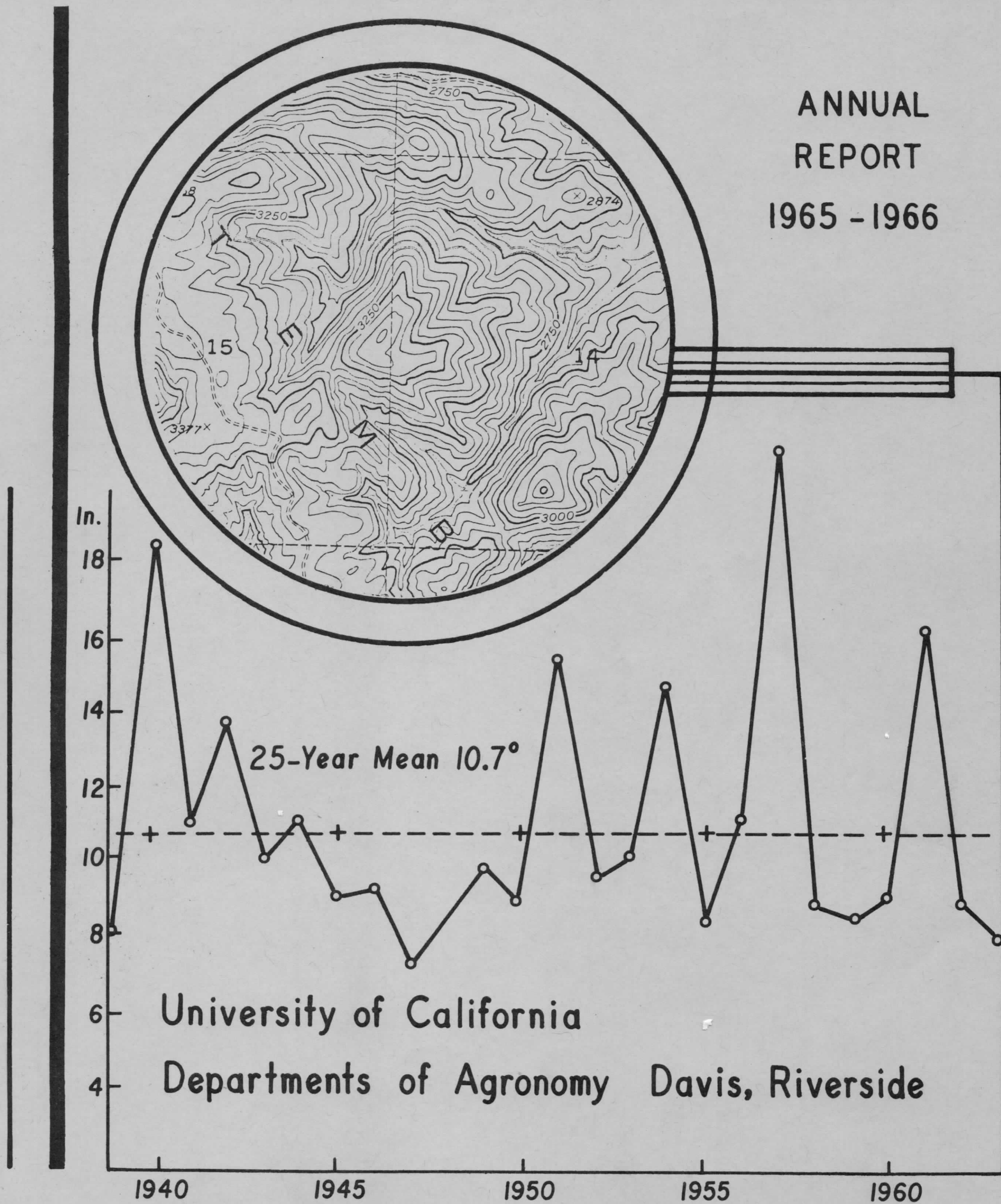
TEMBLOR RANGE RESEARCH

ANNUAL REPORT

1965 - 1966



University of California

Departments of Agronomy Davis, Riverside

The weather pattern in 1965-66 differed so greatly from that of 1964-65 that we were confronted with an entirely different environment this past year. This fact alone gives weight to our first suggestion: that this study must continue for 10 years at least in order to develop as good a pattern as possible of precipitation and soil moisture status during the year.

Our report this year details the studies continued in our research program during the past 12 months. While we are learning a lot, it is obviously too early to draw any conclusions.

We are sorry to report the resignation of Dr. F. C. Raney who has done yeoman service during the first two years of the project. He has accepted a teaching position at Western Washington State College. Mr. B. L. (Bud) Kay will take over Dr. Raney's responsibilities. Mr. Kay has had 12 years of experience in stand establishment, range weed control, and range management generally. He worked five years with Field Stations Administration of the University on the Demonstration Range Projects and moved into the Department of Agronomy in 1959. He is now Associate Specialist in Agronomy.

Mr. Jerry Chatterton, who graduated in March 1966 from Utah State University with a major in Range Management, has been employed at Riverside to work on the Temblor Range Project. During 1966-1967 he intends to work on ecology and physiology of allscale for the M.S. degree.

Minor changes: You will note we have discarded "cattle spinach" as the common name for Atriplex polycarpa in favor of the more acceptable "Allscale" following McMinn (Shrubs of California) who uses the term. We also decided to use the shorter term "Schismus" instead of "arabiangrass."

Again, we wish to acknowledge our thanks to the Boards of Supervisors of Kern and San Luis Obispo counties, Farm Advisors James Clawson and Roy Parker and officials of the Bureau of Land Management. A special "thank you" goes to Mr. Carl Twisselman for his personal cooperation. We thank Beecher Crampton for his advice on botanical nomenclature.

R. Merton Love, UCD
Cyrus M. McKell, UCR

September 1, 1966

This research is conducted by the Agronomy Departments, UC Davis and UC Riverside in accordance with Supplement No. 3 to the Master Memorandum of Understanding between the Bureau of Land Management, Department of the Interior and The Regents of the University of California. Effective date of Supplement September 13, 1963.

The work is supported in part by grants from the Counties of Kern and San Luis Obispo emanating from Taylor Grazing Fees.

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SUMMARY

The six interrelated lines of investigation reported in 1964-1965 were continued in 1965-1966.

1. PHYSIOLOGY, ECOLOGY AND FORAGE VALUE OF RESIDENT SPECIES

Allscale was clipped at intervals to observe tip regrowth behavior. No significant differences have been observed to date, but clipping in May seemed to stimulate short growth the most (Fig. 1) whereas April and December clippings reduced regrowth in comparison with controls.

Chemical composition of browsed parts of allscale was examined. New spring growth had about 27 percent protein when sugars were also most abundant (Fig. 2). During the fall and winter months protein content was about 19% and in July it was 15%.

The leaf anatomy of several relatives of allscale appeared to differ from that found in many arid zone species.

Forage quality of three annual resident species appeared to be better maintained when mowed and windrowed before maturity (Table 1).

II. SPECIES ADAPTATION

The eighteen species tested last year (Table 2) were again row-planted for verification of performance and several additional species were row-planted for trial inside the exclosure.

Ryegrass strains planted last year set seed, and following the dry summer of 1965 completed a second full life cycle last growing season and set viable seed in 1966.

Caucasian Sainfoin, which produced no stand in 1965-66, produced a thin stand in 1965-1966. The few plants were strong, flowered, and set viable seed. No root nodules were found.

To date cooperative work with a commercial legume inoculum company has not resulted in matching the legumes tested with a satisfactory rhizobium. This may have to be sought in the native home of the legume, although it may well be that the inhospitable environment precluded a satisfactory test.

In December twelve species (Table 3) were drilled into the unfenced range with Paraquat sprayed above the seeds to remove competing seedlings. Stock movement across the area prevented full assessment of the planting. No doubt remains that seedling establishment must be given special intensive attention.

Additional species will be tested in the future.

III. SOIL FERTILITY

In a greenhouse pot study of fertility using nutrient sensitive Blando brome and soil from the Temblor, nitrogen and phosphorus responses were obtained. Sand-soil mixtures with improved pot drainage yielded the most dry matter (Table 4).

Tissue analysis of these brome plants showed low phosphorous at all fertilizer levels; calcium, nitrogen and potassium were unchanged; plant tissue zinc was reduced by fertilization (Fig. 3).

In October, 1965, a field test revealed visually that on a deep profile of the Kettleman soil series treated with zinc the resident plant species were visibly greener and taller than on the untreated soil. Filaree seemed to benefit the most although the malpais bluegrass tillered more abundantly (Table 5). No legumes were present. Additional field study of microelement effects is merited.

IV. SOIL MOISTURE

Soil moisture was again measured at the experimental sites of treatment of resident plants with Eptam, 2,4-D, and Amytryne. Only during the brief period in January, 1966 was soil moisture favorable to plant growth in the top 12 inches and soil wetted to less than 36 inches (Fig. 4-13).

V. WEATHER CONDITIONS

1965-1966 was an "average" dry year (6.5 inches) on the crest of the southern Temblor Range although dry snow interfered with field work in November (Table 6, 7; Figure 16). Long windy gaps between wet periods resulted in dry surface soils and a poor forage year.

VI. LAND FORM ANALYSIS

Outside financial support has been sought for land form mapping in the Temblor Range. Meanwhile, much time this past season was devoted to field study of landscape form characteristics in order to simplify production of landscape maps with machinery now available at Davis. A slope facet map of an area in the southern Temblor is shown (Table 10, Fig. 17).

Correlations made between vegetation in the field with such a slope map indicate that the correlations will be difficult to use as management predictors.

I. PHYSIOLOGY, ECOLOGY AND FORAGE VALUE OF RESIDENT SPECIES

A. Allscale Clipping Study

Plant responses to harvesting treatments vary widely with species and location. Many shrubs respond to the removal of the branch ends by producing an increased number and amount of shoots from the remaining nodes. A study was made on the western foothills of the Temblor Range to determine the maximum regrowth of allscale possible after various seasons of treatment and intensities of cutting.

Clippings were made on three dates: May 25, 1965, December 17, 1965, and April 7, 1966. Twelve plants were selected on each clipping date. Three of these plants were left intact as controls; three were clipped lightly (approximately six inches were removed from all branches), three plants were moderately clipped (approximately 12 inches were removed) while the remaining three plants were heavily clipped (all herbage was removed down to a height of approximately six inches). Measurements of the average length of the current year's growth were made June 10, 1966.

There were no significant differences in response to season or degree of harvesting at the time of measurement (Fig. 1). However, the May, 1965, treatments appeared to increase the shoot length over control, and tended to increase regrowth with increased intensity of harvest. The December, 1965, and April, 1966 treatments reduced growth compared with the control plants.

B. Allscale Chemical Composition

Chemical composition of allscale varied throughout the season and showed a close relationship to precipitation (Fig. 2). During the fall and winter months of 1964 the protein content of small stems and leaves appeared to average around 19% but with the advent of new growth in the spring of 1965 protein increased to 26.8%. Shortly thereafter the protein content decreased and by July was 15.5%.

The total sugars present in saltbush stems and leaves showed a seasonal trend and were low through all of the season except during the late spring. Greater quantities of total sugars would be expected in the stems and roots since these are storage areas. Further study of the seasonal trends will be necessary to provide a background for plant response to clipping and ability to produce regrowth without permanent damage.

C. Saltbush Leaf Anatomy

In an attempt to understand the amazing drought tolerance of saltbush laboratory studies have been initiated to study the development, physiology, and anatomy of the leaf. Microscopic sections have been prepared for three saltbushes, *Atriplex halimus*, *A. hymenelytra*, and *A. nuttallii*. Leaf anatomy is quite similar in all three species, but differs greatly from what one would expect in a typical xerophyte. Whereas a highly structured leaf with a highly cutinized epidermis might be expected, saltbush appears to have a very loose-structured leaf with a poorly developed palisade layer and spongy mesophyll. The leaf surface is covered with very large, extremely thin-walled cells with intact protoplast. The only well-organized structure of the leaf is the vascular system and its deeply-stained surrounding cells which are apparently filled with chloroplasts, mitochondria, and other inclusions.

D. Forage Quality of Annual Species

Samples of schismus, fiddleneck and annual mustard were collected on the Carl Twisselman Ranch to learn the feed-value and nutrient content of freshly harvested samples vs. samples mowed, raked and cured in the field.

Collections of each of the three species were made March 16, 1966, at which time ranch personnel were mowing and raking the forage. The schismus was in early bloom, the fiddleneck in full bloom and the mustard past full bloom. Samples were again taken on April 7, from the windrows which had been harvested three weeks earlier (Table 1).

A comparison between recently-matured plants and those which had been harvested and allowed to cure in a windrow is of particular interest. They are good forage while green but begin to lose much of their nutritive value when they pass maturity and become dry. Mowing and windrowing the forage was tried as a means of reducing the nutritive losses due to leaching, trampling, etc. and thereby increasing both quality and quantity of livestock feed.

Analysis of the forage samples shows that annual plants can contain a very favorable percentage of protein and fat which are not readily lost when the forage is cured in a windrow. Schismus loses 46% of its protein content by curing while standing in the field. When competing species are harvested early it loses about 10% upon maturity. Fiddleneck loses about 8% of its protein when harvested and windrowed. In contrast, fiddleneck allowed to stand in the sun and cure loses about 40% of its protein in three weeks. There is no real difference between the protein quality of the harvested fiddleneck in the middle of the windrow pile and fiddleneck on the top of the pile exposed to the sun. The biggest difference was in the carotene content.

The protein quality of mustard apparently did not benefit from early harvesting since there was a slightly higher protein content in the plants that remained unharvested than those in the windrow.

Other features of the forage analysis did not reveal any noteworthy differences as a result of the mowing and windrowing except for a higher fat content of fiddleneck in the windrow and lower fat content of mustard in the windrow.

II. SPECIES ADAPTATION

A. Plot Trials

The eighteen species planted in rows last year were sown out again in order to test again their performance (Table 2). The ranking of the species did not change. Gaudin ryegrass set abundant seed and vigorously reappeared in the old row in October, 1965. The seed produced in 1965 was viable in laboratory blotter test, but that seed remaining on the ground disappeared, probably into the resident animals during the summer.

None of the other eighteen species oversummered and no seedlings were found in the fall. This may be due, at least in part, to late spring and summer grazing.

In order to expose these same species to both stock and rodent pressure, they were drilled into the range in December, 1965 (Table 3). The thrice-replicated rows were spaced 24 inches apart and the seed drilled at one inch beneath a six-inch band sprayed with paraquat to eliminate competitive seedlings. The planting looked good but as the seedlings were emerging stock driven across the area virtually destroyed the emerged seedlings. A long period of wind after the December planting but before the final big rain in February so dried out the surface six inches that the remaining seeds did not germinate. A reservoir of seeds remains in these bands which should be re-examined during the winter of 1966-67.

The feasibility of treating the soil surface to retard evaporation and aid seedling establishment merits study. No seedling appears to survive even the normal rainfree intervals unless it can reach a root depth of six inches or more. Slow germination or windy periods are lethal factors for seedlings in this arid environment.

B. Legume Inoculation

Despite the cooperative effort of a leading commercial cooperator* in providing rhizobia none of the legumes tried in the introduction rows produced nodules. This effort will continue until (it is hoped) a proper combination of soil amendment and rhizobia are obtained. A few plants of Caucasian sainfoin did set seed.

C. Other Plant Species for Trial

Additional species merit trial on the Temblor and will be tested in succeeding years. Many of these species are browse candidates and some endure limy soils. Deep rooting is a common characteristic. Once established some species should survive most of the severe environmental periods.

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*Nitragin Co., Inc., Milwaukee, Wisconsin.

III. SOIL FERTILITY

A. Greenhouse Pot Study of Temblor Range Soil

A greenhouse pot-test of soil fertility was designed using soil collected near the south exclosure on the Temblor ridge. Combinations of nitrogen, phosphorus, and sulfur were applied in liquid solution at varying rates. Nitrogen was applied as ammonium nitrate (50 lbs per acre and 100 lbs per acre), phosphorus was applied as calcium phosphate (44 lbs per acre and 88 lbs per acre), and sulfur was applied as a hydrate of calcium sulfate (20 lbs per acre). Blando brome was seeded evenly in the pots as the test plant. Five replications of each treatment were employed. Water was applied evenly throughout the experiment and observations were made during the growth period to determine comparative nutrient deficiencies.

One replication of each treatment was applied to a soil-sand mixture consisting of one part pure sand and four parts Temblor Range soil. This mixture reduced water logging and improved soil aeration; both are problems encountered when irrigating a soil high in clay content as is the soil from the Temblor area.

Observations revealed nitrogen and phosphorus deficiencies (Table 4). The test plants increased growth with increased rates of nitrogen and phosphorus fertilization but were depressed by the addition of sulfur. Initial growth was faster and final growth greater in nitrogen and phosphorus fertilized plants than the control plants.

The soil-sand mixture increased production more than any fertilizer addition except the 100 N + 88 + 20 S application. The addition of sand almost doubled the production of the control while the soil-sand + 100 N + 88 P + 20 S produced more than four times as much as the control and more than twice that produced by soil-sand with no fertilization.

B. Tissue Analysis

Tissues of the Blando brome plants harvested from the greenhouse pots were laboratory analyzed for minor elements. The analysis revealed a low level of phosphorus in all treatments (Fig. 3). The levels of calcium, nitrogen and potassium also did not reflect any change as a result of treatments. Copper levels were found to be within normal values except with the combination of N, P and S fertilization. Zinc levels were lower with all treatments than with the controls. Further interpretation of these results will be sought. Pot soil temperatures probably differ significantly from field conditions.

C. Field Trial with Zinc

Since zinc deficiency has been associated with low root temperatures in certain crop plants, especially on calcareous soils, a preliminary field trial was made after the October rains in order to see if the resident vegetation would respond to additions of zinc.

Duplicate plots of 2 x 2 feet on a three-foot deep soil profile were broadcast sprayed with a water-solution of zinc chloride ($ZnCl_2$) at rates of 0, 45, 90, 180, 360, 720, and 1440 grams of zinc/acre (about 0.1, 0.2, 0.4, 0.8, 1.6, 3.2 pounds per acre).

Almost no response was seen in December although the plants were greener in all but the two no-zinc plots. Table 5 gives the differences observed in the vegetation on February 8.

Evidently, addition of at least zinc among the microelements can affect both height (and probably dry matter gain) and species composition in the resident vegetation. No dry matter measurements were made in order to observe the community until maturity of the species. Further study of the microelements with NPK should show what amendments (if any) are able to produce a profitable forage yield.

IV. SOIL MOISTURE

A. Soil Moisture in Relation to Precipitation

The lack of adequate soil moisture is considered the most important factor limiting plant growth on the Temblor Range. The distribution of moisture throughout the soil during the year is highly complex. An intensive study of soil moisture at the two experimental exclosures was made to relate soil moisture content to plant growth and its effects on the introduction of new forage species.

Gypsum electrical-resistance blocks were placed at 12-, 24- and 36-inch depths in high-rate herbicide plots at both exclosures in the fall of 1963. These gypsum blocks in equilibrium with the surrounding soil moisture give an estimate of soil moisture since the measurable electrical resistance of the gypsum blocks is related to the moisture in the block which is in equilibrium with the surrounding soil.

B. Herbicide Application and Soil Moisture Conservation

Continued observations were made on the herbicide plots which were sprayed with three rates of Eptam, 2,4-D, and Ametryne. Observations included a study of the selective effects of chemicals upon plant growth, species composition changes, and any other notable benefits of chemical application.

Reapplications of 2,4-D made to the goldenbush plots in the south exclosure on December 17, 1965, and May 12, 1966, have not yet resulted in any visual effects. Observations made June 10, 1966, revealed that the treated plants were not affected and seed was produced as normally as on those plants receiving no treatment

In general, soil moisture measurements at both exclosures during the year indicated only a short period in January and February that soil moisture at 12 inches was favorable for plant growth. At greater depths, 24 inches and 36 inches, the status of soil moisture was limiting for active plant growth most of the year. Rainfall was insufficient to wet the soil to 36 inches (the solid line on Fig. 4-12).

Changes in the amount of plant cover on the herbicide-treated plots appeared to have only a limited effect on soil moisture content. Two main differences appear to be worth discussion. At the south exclosure where brush is the dominant plant cover the Ametryne plots lost the advantage of a favorable soil moisture reserve that was present at the end of the summer in 1965 (Fig. 4, 5, 6). Plots that were resprayed with 2,4-D appeared to be losing soil moisture at a slower rate than other plots and a favorable soil moisture situation is in prospect for the 24-inch and 36-inch depths of these plots (Fig. 5, 6) during the 1966-1967 forage year.

At the north exclosure which has a grass and forb cover, Ametryne reduced the plant cover significantly and also changed the ratio of forbs to grass on plots within the exclosure (Fig. 13). Soil moisture depletion on Ametryne plots was slower than on the other plots and a greater reserve was present at all depths through most of the season both inside and outside the exclosure with the greatest difference seen on grazed plots outside the exclosure (Fig. 7-12). Other treatments were ineffective in changing soil moisture levels the second year after application.

To make use of the more favorable moisture reserve on chemically-treated plots new plants or desirable surviving plants must be grown. At the end of the first growing season a sample of the top inch of soil from plots treated with 1, 2, and 4 pounds of Ametryne per acre was returned to the greenhouse for a bioassay. Results indicate that the 2- and 4-pound rate still maintained a residue in the soil (Fig. 14). Ametryne plots will be seeded in the fall of 1966 and a second bioassay will be conducted.

V. WEATHER CONDITIONS

A. Precipitation Records

Table 6 gives the 1965-1966 data for precipitation at the north exclosure, 3000 MSL, one-half mile north of the Crocker Springs-Recruit grade road on the summit of the Temblor Range. Figure 15 compares the 1964-65 data with the 1965-66.

Figure 15 and Table 6 show how very different two successive precipitation years can be even when the annual total is similar. The two years were opposites. The "wet" periods of 1965-1966 were dry periods last year. This year had two major wet periods on December and February. The deep soil profile was recharged. However, pronounced windiness during the year kept the surface half-foot of soil dry much of the time. Long, dry intervals occurred between precipitation and the spring (March-April) was very dry at a time when soil and air temperatures were favorable for elongation of grass culms and rosettes of filaree. This combination of environmental conditions resulted in a poor forage year and highlighted the need for soil-surface moisture control when seedlings are being established artificially.

Figure 16 shows the twenty-five precipitation year record for a station north of the north exclosure a number of miles. While the absolute values shown are higher than a long record will show for the area near the experimental exclosure, trends are probably indicative of the experimental area. Note the 3-4 year interval between precipitation peaks since 1950.

Table 7 gives a striking idea of the difficulty of using annual totals for explaining plant productivity. Years with similar total annual precipitations may have greatly different (and to plant growth important) distributions of rainfall during the year. For deep-rooted perennials growth may be best correlated with rainfall of the preceding year or two years (a response to deep recharge of soil), germination and stand of annuals appears to be correlated positively with fall rains, but productivity of annuals seems positively correlated with some minimum interval between rain and the occurrence of spring additions to precipitation. Important effects of local typography also need to be considered.

The state of the art does not yet permit prediction of rainfall a year ahead and thus an indirect prediction of forage productivity. We may be able to develop some measure of probability of given amounts of precipitation over certain intervals. The usefulness of such a prediction will depend on a much better understanding of the relationship between water budget (amount and timing) and the response of particular plant species to this budget and other environmental factors.

B. Soil and Air Temperature

Temperature records kept at the experimental exclosures (Tables 8, 9) demonstrate again that the valued resident species germinate in a cool soil, develop and complete their life cycle before rising soil temperatures and decreasing soil moisture supplies are crucial. Records were taken at 4 cm, about the maximum depth to which a strong filaree seed will "dig in". Both temperature extremes and soil moisture supplies will be greater nearer the surface.

For some introduced species planting depth with respect to soil temperature and moisture may be critical. It may be that a stand will establish and survive only when an abundant seed population is present at various depths.

VI. LAND FORM ANALYSIS

Land slope and the direction which slopes face (aspect) over a large area can be analyzed by digital machinery. While funds to do this are not yet at hand, a preliminary hand sketch of slope and aspect gives an appreciation of the problem. Figure 17 shows a six-square mile area of the Panorama Quadrangle in the Temblor Range with eight topographic slope classes outlines.

Table 10 tabulates the percent of the total area in each slope class. This area is neither geologically nor stratigraphically uniform. The Temblor general water divide strikes diagonally WNW to ENE dividing the area into one third (Southwest) and two thirds (Northeast). This ridge has faulted (the San Andreas Fault line is three miles West of the area shown) to produce a southwest-facing, steep, unstable, colluviating slope of exposed ends of Miocene sedimentary strata. On the other side of the ridgeline the surfaces of the strata dip generally less steeply toward the northeast.

The kaleidiscopic pattern of dissection of the surface on the opposite sides of this ridge line differs greatly. Slope facets are much smaller and narrower on the southwest face of the ridge. Colluviation on this face is so active that plant establishment and persistence is severely hampered. While all plant species are found on both faces of the ridge, stand density and production are both very low on the southwest face.

When full correlation between present plant communities and slope characteristics is available, some improvement in forage management may be possible. Dense populations of rodent seed-gatherers and the small sizes of slope facets add to the problem of management. However, it must be noted that correlations made to date between vegetation and slope strongly indicate extreme difficulty in using them as management tools.

VII. WORK PLAN FOR 1966-67

Work plans for the coming year include the continuation of all lines of study.

A. Physiology, ecology and forage value of resident species.

Growth behavior, yield, and response to various cultural treatments by allscale, schismus, Malpais bluegrass and several broad leaf species will be studied further. Of particular interest will be the growth responses of allscale in relation to forage removal times and rates.

To reach a better understanding of this plant's response to harvesting treatments, studies will be made during the coming year in areas on the eastern side of the Temblor Range in which plants will be treated at shorter and more uniform time intervals.

During the past year negotiations have been underway with the Bank of California in San Francisco to obtain permission to establish a cattle spinach study site on property they hold in trust. The site supports a dense stand of saltbush and is about 12 miles northwest of McKittrick adjacent to the Union Oil Company water pipe line. The exact section location has yet to be determined but would be within the area presently leased by Mr. Carl Twisselman for grazing. A license for University of California use of the proposed experimental site is currently under consideration by the Bank of California Trust Department. Indications are that it will be signed as soon as the Bank has agreements from Union Oil (lessee for oil exploration) and from Mr. Twisselman.

A proposal for the saltbush study was developed after discussions among the following: Mr. James Clawson, Dr. Merton Love, Dr. Cyrus McKell, Mr. Roy Parker, Dr. Frank Raney, and Mr. Carl Twisselman. Additional discussion of the proposed study ensued at the meeting of the Kern County Grazing Advisory Board on March 16, 1966.

As soon as permission for land use is obtained, the study of allscale manipulation and grazing use will commence north of McKittrick. A study plan for this program is included in appendix. Detailed studies of the allscale and associated species will be carried on adjacent to this manipulation experiment.

B. Species adaptation

Additional seeding trials are planned and a variety of measures will be employed to assist seedling establishment along with conventional methods of seeding. Timing of seeding, methods of concentrating precipitation in the seeded rows, soil moisture retention by soil surface sealing, pre-germination of seed before planting, and introduction of other species as yet untried will be involved.

C. Soil fertility

A combined herbicide and fertilizer application trial will be established on the summit of the Temblor Range From such a field trial will be sought an understanding of the yield of Malpais bluegrass (perennial) in the presence and absence of resident annual grasses and broadleafed plants when their nutrition is supplemented.

D. Soil moisture

Study of soil moisture will continue but will be expanded to examine the downward movement of water through the soil in relation to restrictive soil layers and zones of root concentration. Soil moisture readings on the chemically-treated plots of the last three years will be terminated.

E. Weather conditions

Information will be collected to continue to characterize better the temperature and moisture regimen in the experimental areas particularly as they relate to seedling environment and seedling success The remoteness of the sites and the absence of a resident observer preclude expanding these measurements into use of more sophisticated equipment.

F. Land form analysis

Investigations to date have indicated that this analysis is not likely to prove fruitful at the moment. Personnel changes and the need for fund support in order to conduct computer-directed mapping of slope and direction of slope will suspend the examination of land form mapping as a tool in management of this range area.

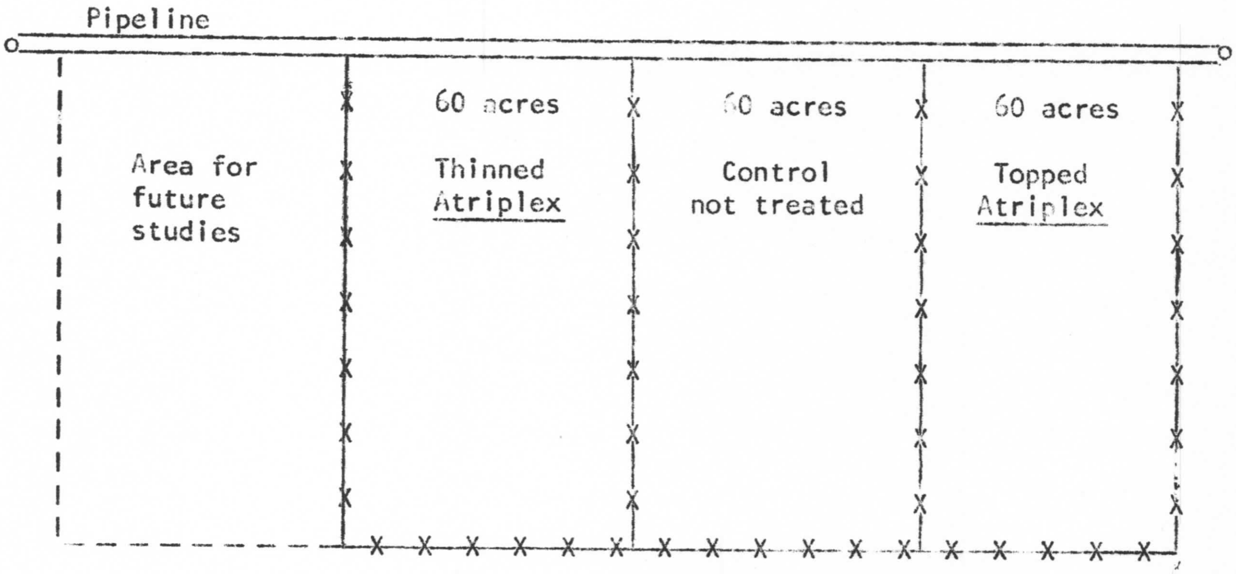
VIII. APPENDICES

APPENDIX 1

Proposed Allscale Study

I. Diagrammatic layout of plots.

Location of Area: Dense *Atriplex* stand about 12 miles NW of McKittrick, adjacent to Union Oil water pipeline.



Main Treatments: Plot 1. Density of *Atriplex* to be reduced by a crisscross plowing.

Plot 2. Control - no treatment.

Plot 3. Tops of *Atriplex* removed with cotton chopper or brush cutter. Degree of removal dependent upon observations and previous information.

Grazing: One month, with usual stocking rate and season for the area.

II. Observations, Plant:

1. Seasonal trend in food reserves, protein, salt, of *Atriplex*.
2. Growth rates of control and treated *Atriplex*.
3. Soil moisture supply in relation to treatments.

III. Observations, Animal:

1. Detectable animal responses in weight.
2. Animal preference for *Atriplex* untreated and treated. Particular attention would be given to animal response and plant analysis.
3. Animal grazing habits. Choice of *Atriplex* plant parts, other species, etc.

VI. Other Studies:

May be initiated adjacent to the research area on species introduction, seedling establishment, and vegetation manipulation. Information gained in original study will be helpful in pointing the way for further studies.

Other species, their nutritive value during Atriplex use and other seasons of the year, yield variation from year to year, and other pertinent information would be studied where possible.

Other Comments: Plant measurements may be made by a graduate student from UCR.

Fencing to be furnished by and remain the property of Carl Twisselman. Livestock arrangements will be the responsibility of Roy Parker in cooperation with Carl Twisselman.

APPENDIX 2

Species List: Common and Scientific Names Used in Text

Grasses

Bromegrasses	Bromus spp.
Blando brome	B. mollis L.
Erect brome	B. erectus Huds.
Fibrous brome	B. fibrosus Hack.
Red brome	B. rubens L.
Falujagrass	Phalaris tuberosa L. (Faluja)
Hardinggrass	Phalaris tuberosa var. stenoptera (Hack.) Hitch.
Maire fescue	Festuca mairei St. Yves
Malpais bluegrass	Poa scabrella (Thurb.) Benth. ex Vasey
Orchardgrass	Dactylis glomerata L. (Palestine)
Perlagrass	Phalaris tuberosa var. hirtiglumis Trabut ex Batt. & Trabut.
Ricegrass	Oryzopsis Sp.
Indian ricegrass	Oryzopsis hymenoides (R&S) Ricker
Ryegrasses	Lolium spp.
Gaudin ryegrass	L. gaudini Parl.
Wimmera 62	L. rigidum Gaud.
Schismus	Schismus arabicus Nees.
Smilo	Oryzopsis miliacea (L.) Benth. & Hook.
Wheatgrasses	Agropyron spp.
Davis slender wheatgrass	A. trachycaulum (Link.) Malte var. major (Vasey) Fern.
Intermediate wheatgrass	A. intermedium (Host.) Beauv.
Oriental wheatgrass	A. orientale R & S

Legumes

Alfalfa	Medicago sativa L.
Fenugreek	Trigonella fenugraecum L.
Hairy canary clover	Dorycnium hirsutum (L.) Ser.
Rose clover	Trifolium hirtum All.
Sainfoins	Onobrychis spp.
Caucasian sainfoin	O. transcaucasia L.
Trigonella	Trigonella sp.
Arabian trigonella	T. arabica Del.

Others

Bluebush	Kochia georgia Diels.
Fescue	Festuca sp.
Annual fescue	F. confusa Piper
Fiddleneck	Amsinckia douglasiana DC
Filaree	Erodium sp.
Redstem filaree	E. cicutarium (L.) L'Her
Goldenbush	Haplopappus linearifolius DC
Saltbush	Atriplex sp.
Allscale	A. polycarpa (Torr.) Wats.
Four-winged saltbush	A. canescens (Pursh.) Nutt.
Shrubby Orache	A. halimus L.

Table 1. Analysis of annual forage harvested at maturity and of forage left standing. Twisselman Ranch, 1966.

Species	Collection Date	Stage of Growth Harvesting Conditions & Treatments	% Protein	% NFE	% Fat	% Fiber	% Ash
Arabian-grass	Mar. 16	Early bloom - No field curing	17.2	46.8	3.3	22.3	10.4
"	Apr. 7	Mature. Collected from mowed area. Field cured, after other plants removed.	14.0	51.7	2.9	19.8	11.6
"	"	Mature. Collected from undisturbed area. Field cured in competition with other plants.	9.3	54.3	2.6	20.2	13.6
Fiddleneck	Mar. 16	Full bloom - No field curing	13.3	46.7	5.1	16.1	18.8
"	Apr. 7	Mature. Uncut area. Field cured standing.	8.0	42.6	6.6	15.7	27.1
"	"	From bottom of field-cured windrow	12.0	49.6	7.0	15.5	15.9
"	"	From top of field-cured windrow	12.2	50.7	5.4	15.2	16.5
Mustard	Mar. 16	Past full bloom - Uncut	19.4	45.5	2.9	20.4	11.8
"	Apr. 7	Noncut area. Cured standing	16.7	42.4	8.7	21.6	10.6
"	"	From harvested windrow.	14.9	53.6	3.2	20.9	7.4
Composition of other forage - as a comparison[1/]							
Fiddleneck, green roughage, seeds in dough stage			11.5			24.4	16.1
Burclover, mature, California grown			16.0			30.7	6.1
Orchardgrass, harvested at full bloom			8.5	47.2		33.1	7.9
Alfalfa hay, early bloom, California grown			18.3	42.2	1.9	29.5	8.1

[1/] Committee on feed composition, National Academy of Sciences, National Research Council, 1958. Composition of cereal grains and forages. Publication 585. 663 pp.

Table 2. Species adaptation trial, Temblor Range 1965-66

Grasses	Source	Emergence	Seedling Vigor
Erect bromegrass	Turkey	2	3
Fibrous bromegrass	Turkey	1	3
Maire fescue	France	2	4
Ricegrass	Afghanistan	1	-
Indian ricegrass (untreated)	California	1	-
Gaudin ryegrass	Israel	4	4
Wimmera 62 ryegrass	Australia	4	4
Davis slender wheatgrass	California	3	4
Oriental wheatgrass	Afghanistan	3	3
Smilo	California	3	2
Blando brome	California	3	2
Orchardgrass	Palestine	2	1
Hardinggrass (Faluja)	Israel	3	2
Legumes**			
Alfalfa	Spain	3	2***
Hairy canary clover	Turkey	3	3
Caucasian sainfoin	Soviet Union	4	3
Mountain sainfoin	Spain	3	3
Scurfy pea	Israel	2	2
Trigonella	Israel	2	2
Others			
Bluebush	Australia	None	
Shrubby Orache	Israel	None	
Allscale (unleached)	Kern County	None	
Allscale (water-leached)	Kern County	3	3
Four winged saltbush (unleached)	Kern County	0	0
Four winged saltbush (water-leached)	Kern County	3	3

* 0 = very poor; 1 = poor; 2 = fair; 3 = good; 4 = excellent

** Legumes may all be promising forage producers if inoculation rhizobia can be obtained

*** Inoculated with Nitragin Alfalfa Inoculant.

Table 3

Species drilled December, 1965

1. Lolium rigidum
2. Agropyron trachycaulum var. major
3. Bromus mollis
4. Oryzopsis miliacea
5. Dactylis glomerata (Palestine)
6. Phalaris tuberosa (Faluja)
7. Atriplex polycarpa
8. Atriplex canescens
9. Dorycnium hirsutum
10. Medicago sativa var. Ranger
11. Medicago sativa var. Lahontan
12. Psoralea bituminosa

Table 4. Temblor Range soil fertility. Yield of Blando brome used as a test species grown in the greenhouse.

Fertilizer Treatment	Temblor Soil* gms/pot	lbs/A	Temblor Soil + 1/5 Sand ** gms/pot	lbs/A
Control	.930	263	1.712	477
50 lb N/A	1.062	289	.867	238
100 N	1.549	426	2.044	565
44 P	1.168	326	1.342	376
88 P	1.140	314	1.450	401
20 S	.835	226	1.206	339
100 N + 88 P + 20 S	2.078	577	4.158	1154

* average of 4 replications

** single pot values

Table 5

Field Response of Range Plants to Zinc Amendment

Treatment	Height (in.) of dominant species	Remarks
g/$ZnCl_2$/acre		
0	2-3 (Brome)	Mostly red brome.
45	7-9 (Fescue)	*Festuca confusa* found *only* in these plots.
90	6-8 Filaree)	Redstem filaree rosettes dense shiny, overlapping, red brome scattered, small.
180	16-18 (Bluegrass)	Hollisteria abundant with filaree and Malpais bluegrass.
360	18-21 (Bluegrass)	Malpais bluegrass tillering vigorously.
720	19-20 (Brome)	Malpais bluegrass smothered in red brome.
1440	15-19 (Fiddleneck)	Fiddleneck abundant, tallest in these plots, much short red brome.

Table 6

Precipitation, Temblor Range, 1965-1966

Date	North Exclosure T31S R21E S22			South Exclosure T32S R21E S31		Frontal Passages
1965	Gages Installed October 23, 1964					
	cm	in.		cm	in.	
Oct. 20	2.67	1.05		2.79	1.10	Oct. 14-15
Nov. 4		0			0	Nov. 14, 18, 22-23, 27
Dec. 9	5.66	2.23		5.82	2.29	Dec. 9, 25, 29
17	1.53	0.62		1.28	0.52	
1966						
Jan. 27		0			0	Jan. 8, 26, 30
Feb. 8	5.96	2.35		5.85	2.30	Feb. 1, 4, 12, 22
Mar. 2	1.14	0.45	Snow 6-12"	1.27	0.50	Mar. 2
17	0.13	0.05		0.13	0.05	
30		0			0	
Apr. 13		0			0	Apr. 9-10
26		0			0	
May 26		0			0	
Sum	17.2 cm	6.75 in		17.20 cm	6.76 in	

Table 7. Twenty-Five Years of Precipitation
Las Yeguas Ranch
T 28S R19E S29 MDBM, 2700 MSL
1939-1964

	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Cum		Total
1939	1.43	.75	0	.99	1.85	2.22	.52	.50	0	0	0	0	8.26	1	8.26
1940	0	.42	.13	3.13	2.10	4.74	5.32	2.75	.03	0	0	0	26.88	2	18.62
41	0	.86	.39	4.50	.49	.71	1.30	1.99	.25	0	0	0	37.36	3	10.48
42	0	.45	.57	1.39	5.65	1.18	2.73	1.82	0	0	0	0	51.15	4	13.79
43	0	.70	.30	1.22	1.03	4.60	.47	.54	.29	0	0	0	60.01	5	8.86
44	0	0	4.57	.48	1.75	2.08	1.98	.08	0	.09	0	0	71.04	6	11.03
45	0	.30	.36	1.83	.27	1.26	4.39	.08	.36	0	0	0	79.89	7	8.85
46	0	.97	2.61	2.56	.32	.30	1.50	.46	.52	.13	0	0	89.13	8	9.24
47	.05	.22	.23	.96	0	1.88	1.94	1.52	.32	0	0	0	96.25	9	7.12
48	0	.10	.22	2.46	.77	.95	2.11	.50	1.56	0	0	0	104.92	10	8.67
49	0	0	.50	2.54	1.49	1.22	1.38	1.27	.27	0	1.05	0	114.64	11	9.72
1950	0	.99	1.04	.27	1.75	.15	.75	.80	.50	0	0	0	120.89	12	6.25
51	0	.35	1.20	2.43	5.42	.62	4.93	1.39	0	0	0	0	136.23	13	15.34
52	0	.11	2.88	3.33	1.19	.28	.15	1.08	.34	.05	0	0	145.61	14	9.38
53	0	0	1.00	.19	3.62	1.50	3.42	.25	0	0	0	0	155.59	15	9.98
54	0	0	0	.52	3.95	5.21	1.61	.76	1.05	1.96	0	0	169.65	16	14.06
55	0	0	.67	3.52	1.62	.77	0	1.03	.63	0	0	0	177.89	17	8.24
56	0	1.27	0	.52	3.12	2.07	.83	1.09	.96	.66	0	0	188.41	18	10.52
57	0	1.09	.81	2.14	1.72	4.47	4.70	4.47	1.59	0	0	.17	209.57	19	21.16
58	1.17	0	.42	.50	2.02	3.47	0	.50	.50	0	0	0	218.15	20	8.58
59	0	0	0	.35	2.26	3.08	.84	1.70	0	0	0	0	226.38	21	8.23
1960	0	.80	3.88	.80	1.05	.57	1.08	.37	.30	0	0	.08	235.31	22	8.93
61	0	0	1.98	2.78	1.52	7.98	1.66	.12	.04	0	0	0	251.39	23	16.08
62	0	.41	0	.08	.59	2.33	1.32	2.22	.97	.52	0	0	259.83	24	8.44
63	.78	1.40	1.26	0	1.64	.22	1.36	.48	.34	0	0	.26	267.57	25	7.74
Sum	3.43	11.18	25.02	39.49	47.19	52.86	46.29	27.77	10.82	3.41	1.05	.51			267.57
Mean	.14	.45	1.00	1.41	1.88	2.11	1.85	1.11	.43	.13	.04	.02			10.70

Table 8

Maximum Soil Temperature During Soil Moisture Season

Four Centimeters Deep

North Exclosure

October 20, 1965-June 20, 1966

Events	Dates	Days	Soil Maximum °F	Dates	Days	Events
			<34			
Filaree Begin Bloom	Dec 10-25	15	35-39	Jan 30-Feb 15	16	Malpais Bluegrass in Boot Stage
	Dec 10	-	40	Feb 15-Mar 5	18	Filaree Full Bloom
	Nov 15-Nov 30	15	45-49	Mar 5-Mar 15	10	
	Nov 10-Nov 15	5	50-54	Mar 15-Mar 30	15	Malpais Bluegrass Bloom
	Nov 5-Nov 10	5	55-59	Mar 30-Apr 10	20	Filaree Seeding
Filaree Seedlings	Oct 30-Nov 5	6	60-64	Apr 10-Apr 15	5	
	Oct 20-Oct 30	10	65-69	Apr 25-May 5	10	Soil PWP Sfc-3 feet

Table 9. Temperature
Temblor Range
1965-1966

1965	North Exclosure T35S R21E S22 Air 30 cm Max	Min	Soil 4 cm Max	Min	South Exclosure T31S R22E S31 Air 30 cm Max	Min	Soil 4 cm Max	Min
Oct. 20	74	NR	67	NR	68		64	NR
25	79	52	68	50	79	53	67	58
30	78	54	70	55	77	57	65	59
Nov. 5	62	51	59	50	58	46	61	56
10	69	50	55	45	58	49	54	51
15	66	48	54	47	57	46	57	54
20	Frontal Passages Roads Impassable							
25	"							
30	"							
Dec. 5	"							
10	46	39	46	42	46	33	45	42
15	39	37	34	30	37	29	34	30
20	47	35	34	29	44	33	41	38
25	43	30	31	29	37	29	40	39
30	42	24	40	34	42	33	44	41
1966								
Jan. 5	Frontal Passage, Roads Impassable							
10	Clock Malfunction, Record Lost							
15								
20	Vandalism, Instrument Lost							
25	Frontal Passages, Roads Impassable							
30	43	34	45	38				
Feb. 5	47	39	45	34				
10	52	33	36	33	-	-	35	31
15	43	31	42	32	44	34	40	31
20	51	39	48	38	47	28	47	37
25	Frontal Passage,. oads Impassable							
Mar. 5	64	48	44	37	67	49	47	38
10	59	42	54	42	61	54	56	42
15	59	40	52	39	65	42	58	41

Table 9 (continued)

Mar.	20	66	42	54	44	50	36	54	41
	25	65	39	56	43	62	43	61	42
	30	73	47	62	50	72	51	67	50
Apr.	5	73	53	65	55	74	53	71	55
	10	62	46	62	55	62	44	64	52
	15	77	52	66	52	78	52	72	54
	20	59	41	63	49	63	38	64	45
	25	81	53	76	59	82	54	79	57
	30	76	50	76	58	74	50	63	68
May	5	75	50	74	57	73	50	67	62
	10	90	59	82	65	91	59	73	68
	15								
	20	Vandalism, Instrument Lost							
	25								
	30	70	41	80	65	65	41	74	69
June	5	82	55	85	66	81	54	75	70
	10	79	51	86	68	79	55	77	72
	15	98	67	88	72	96	71	84	77
	20	88	60	94	75	89	64	85	78

Table 10. Distribution of Slope Facets in an Eight-Square Mile Area of the Temblor Range, Panorama Quadrangle

Direction of slope	SW side of Ridge		NE side of Ridge		Total
	mi^2	% of area	mi^2	% of area	mi^2
North	0.35	10.0	1.07	19.4	1.42
NE	0.28	0.8	1.13	20.7	1.41
East	0.64	18.3	0.74	13.6	1.48
SE	0.30	8.7	0.58	10.7	0.88
South	0.67	19.3	0.41	7.5	1.08
SW	0.26	7.5	0.27	5.0	0.53
West	0.88	25.4	0.41	7.5	1.29
NW	0.35	10.0	0.77	14.1	1.12
Flat	0.28	0.8	0.08	1.3	0.36
Total	3.47	100	5.45	100	8.92

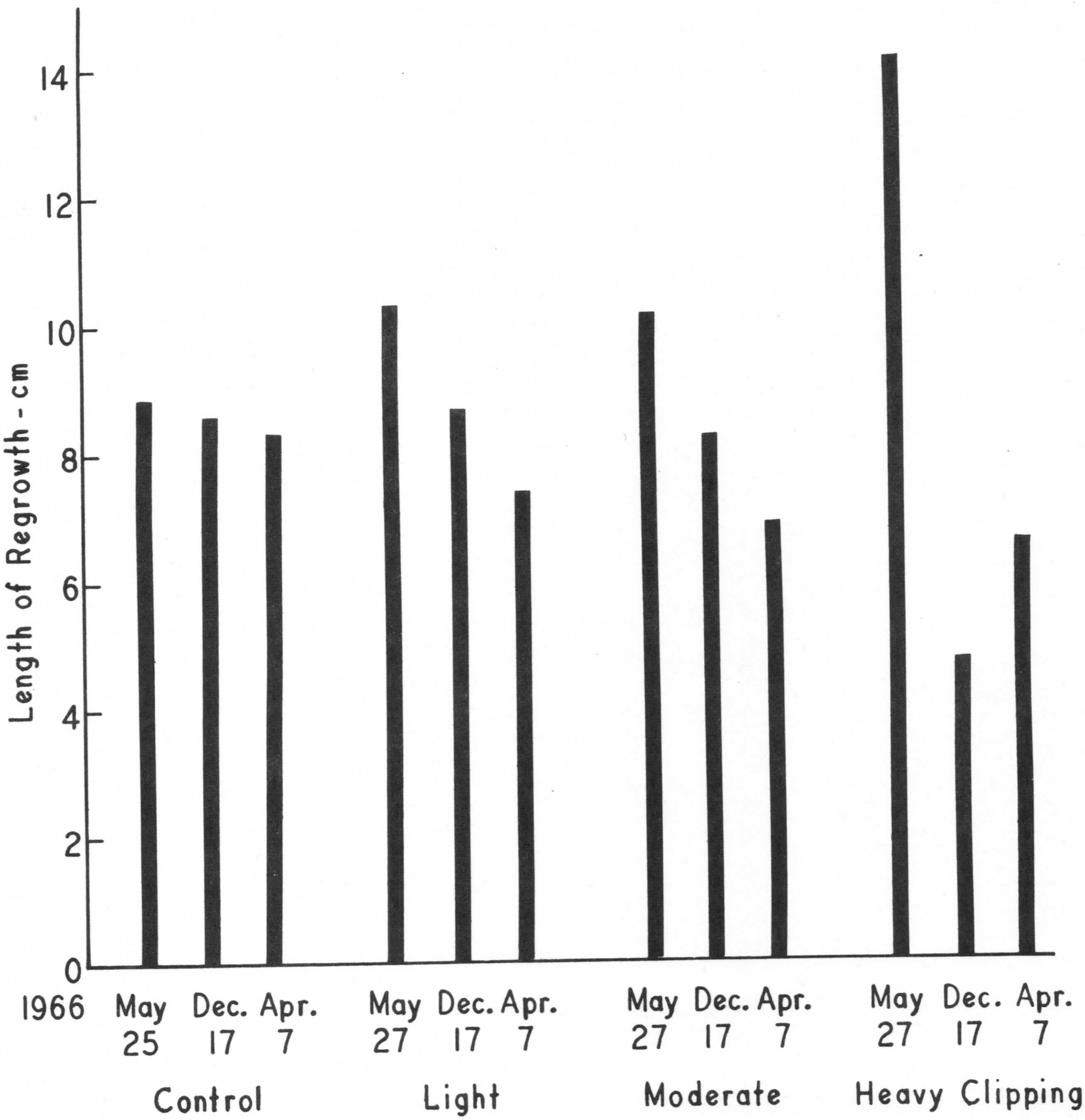


Fig. 1. Dates and degrees of clipping of allscale (Atriplex polycarpa).

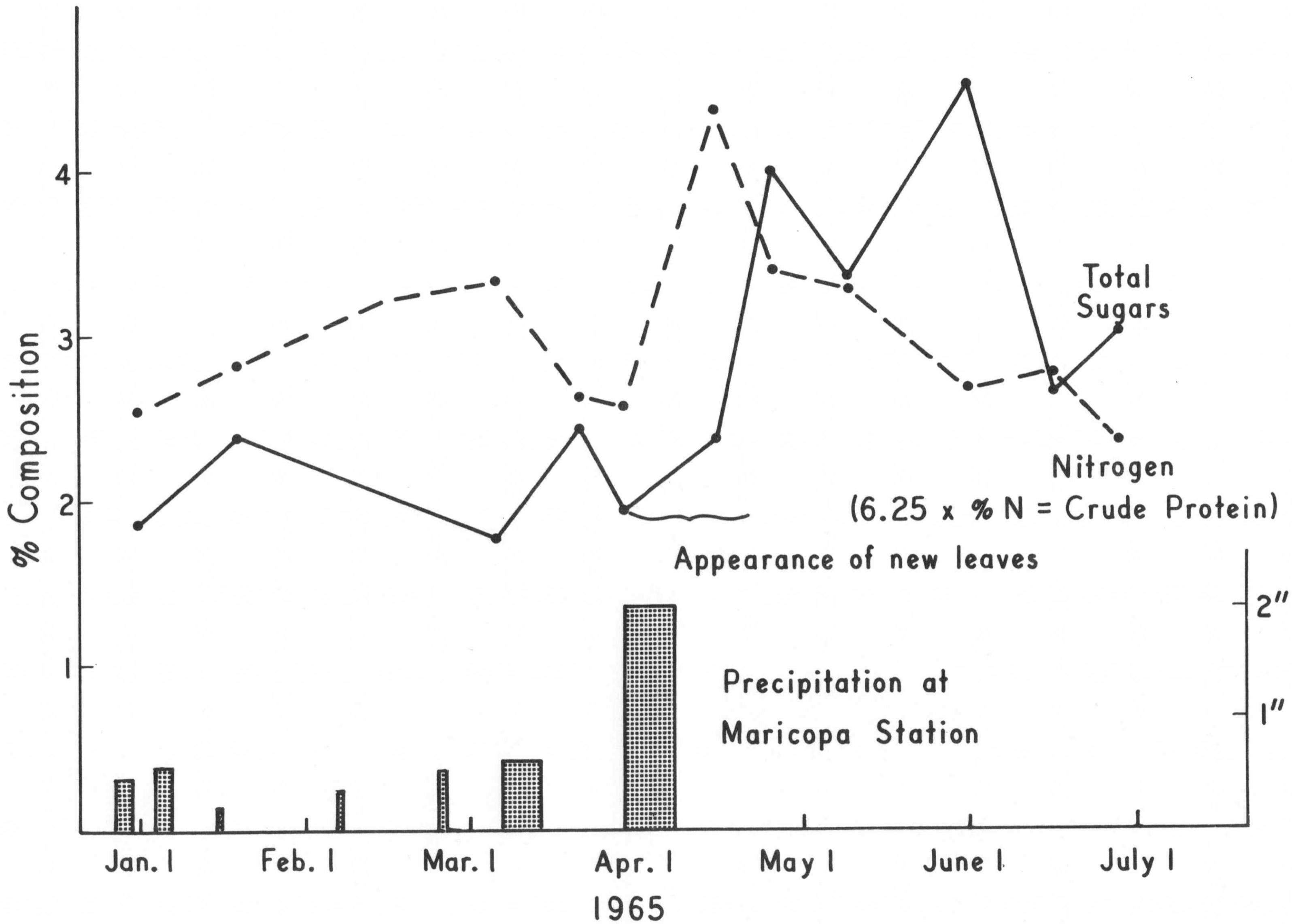


Fig. 2. Chemical composition of allscale forage, western side of Temblor Range. 1965 - 1966.

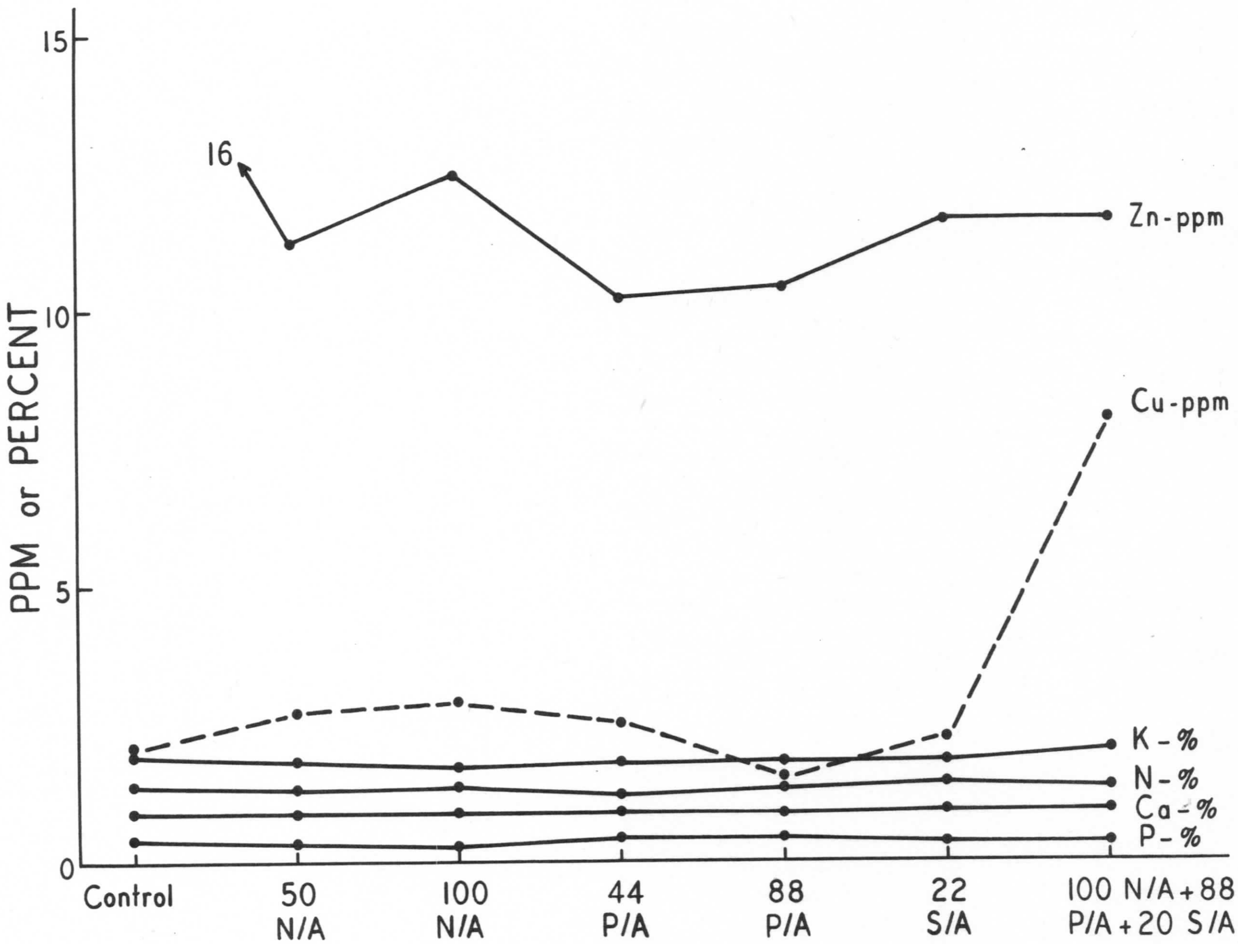


Fig. 3. Chemical composition of *Bromus mollis* (lbs/acre) grown in greenhouse under standard conditions with varied rates of different fertilizers. (Soil from summit of Temblor Range outside south exclosure.)

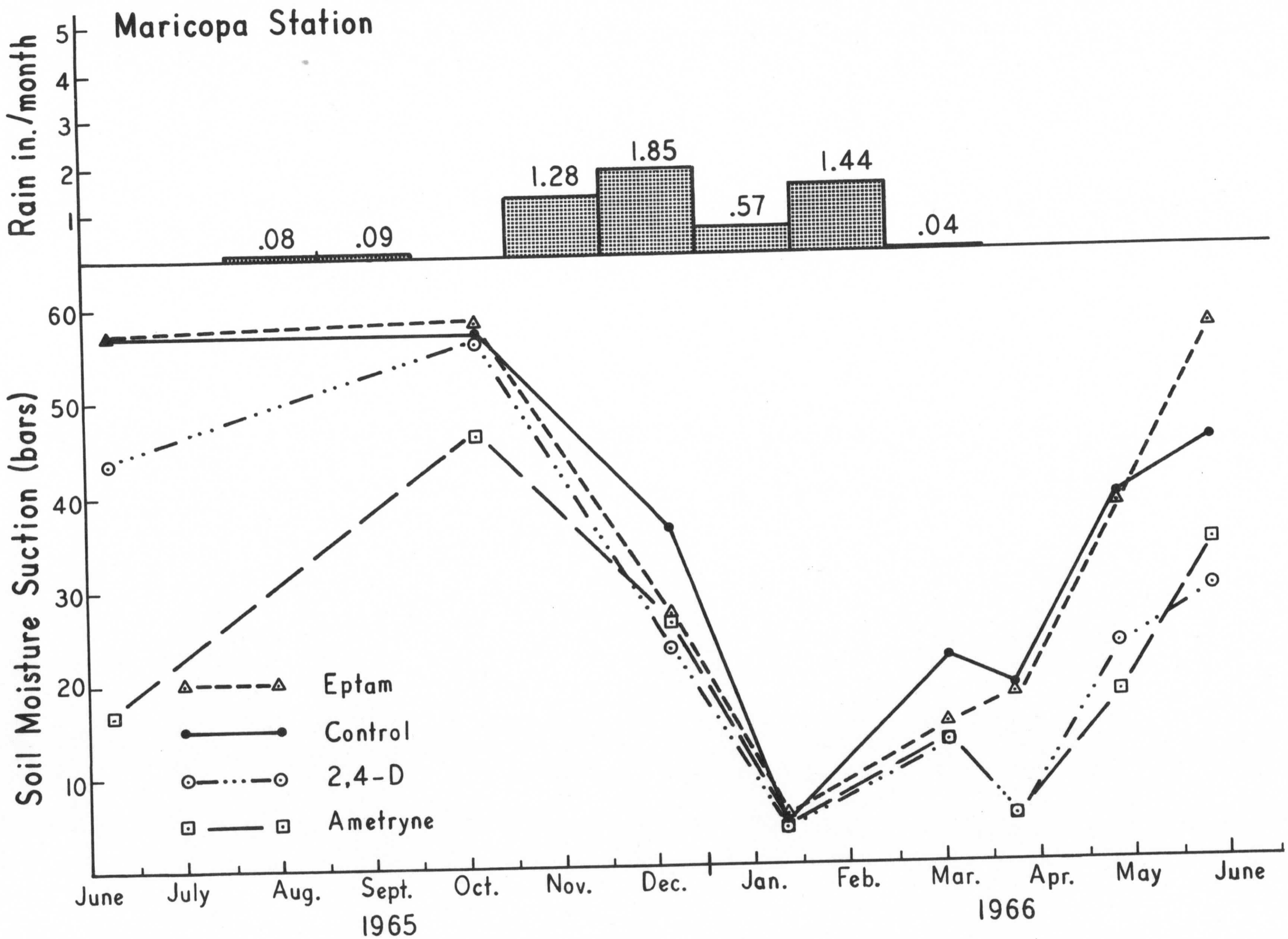


Fig. 4. Precipitation (Maricopa) and soil moisture, South Plots, 12″ depth, grazed.

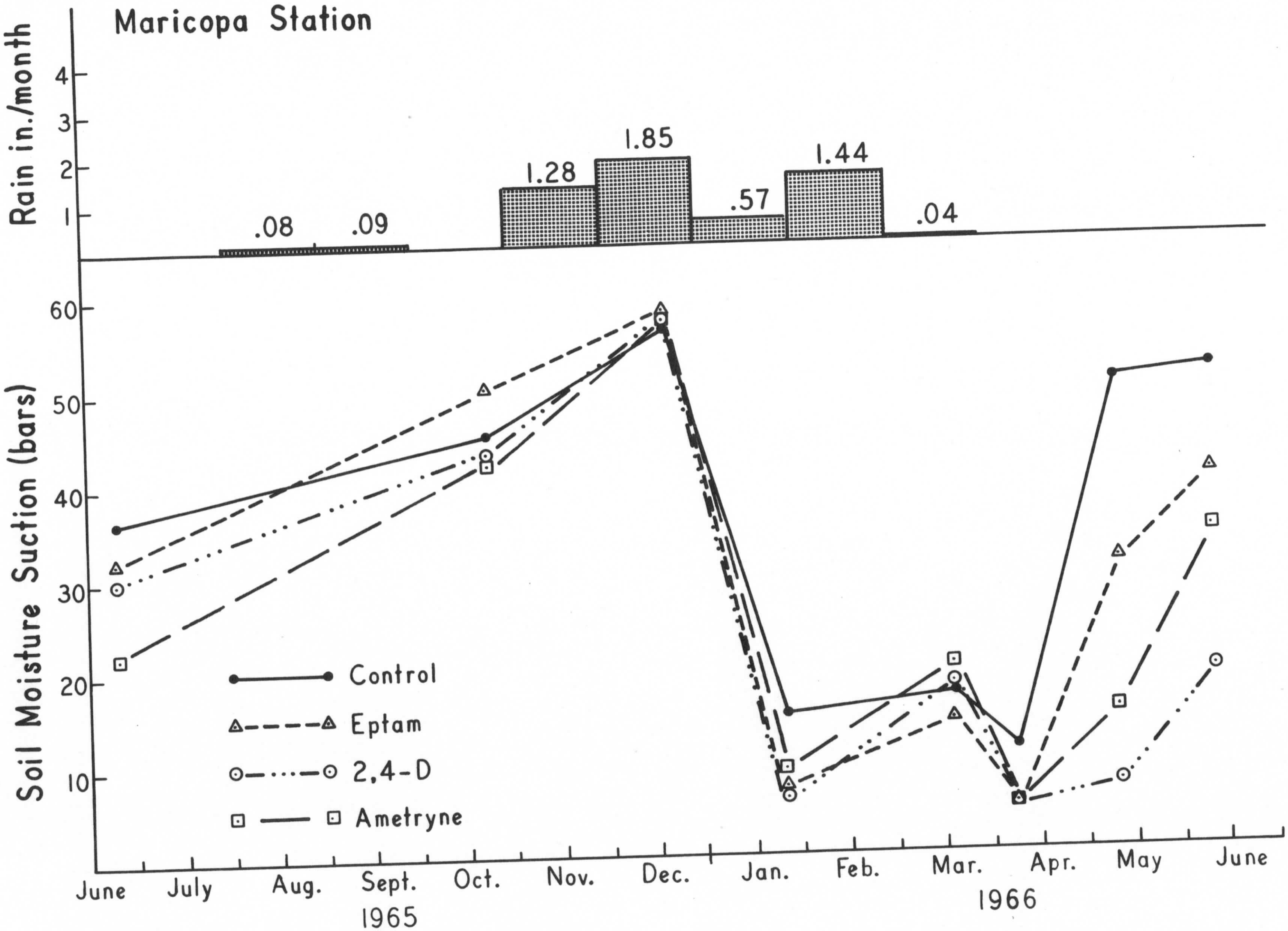


Fig. 5. South Plots, 24"-depth, grazed.

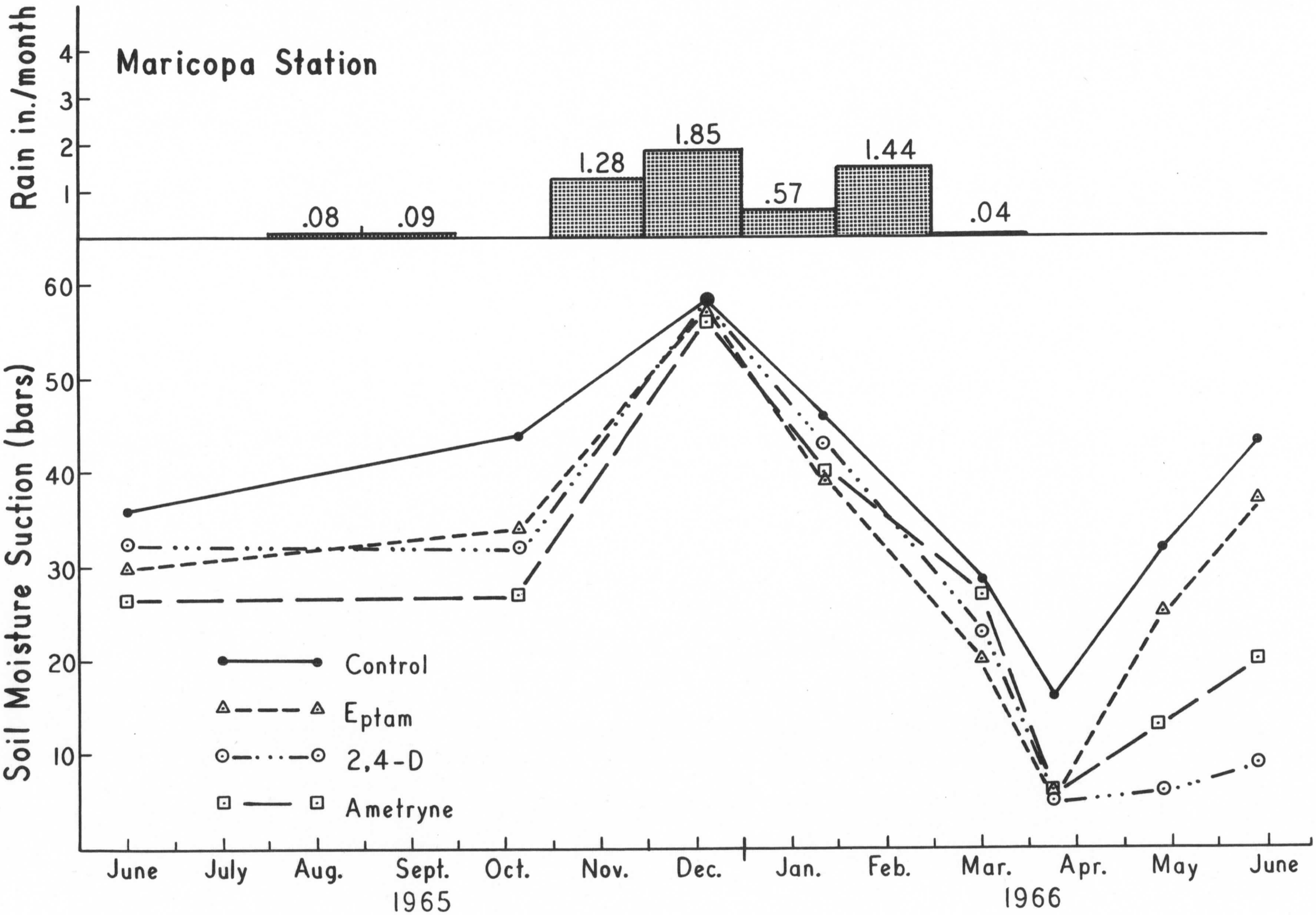


Fig. 6. South Plots, 36"-depth, grazed.

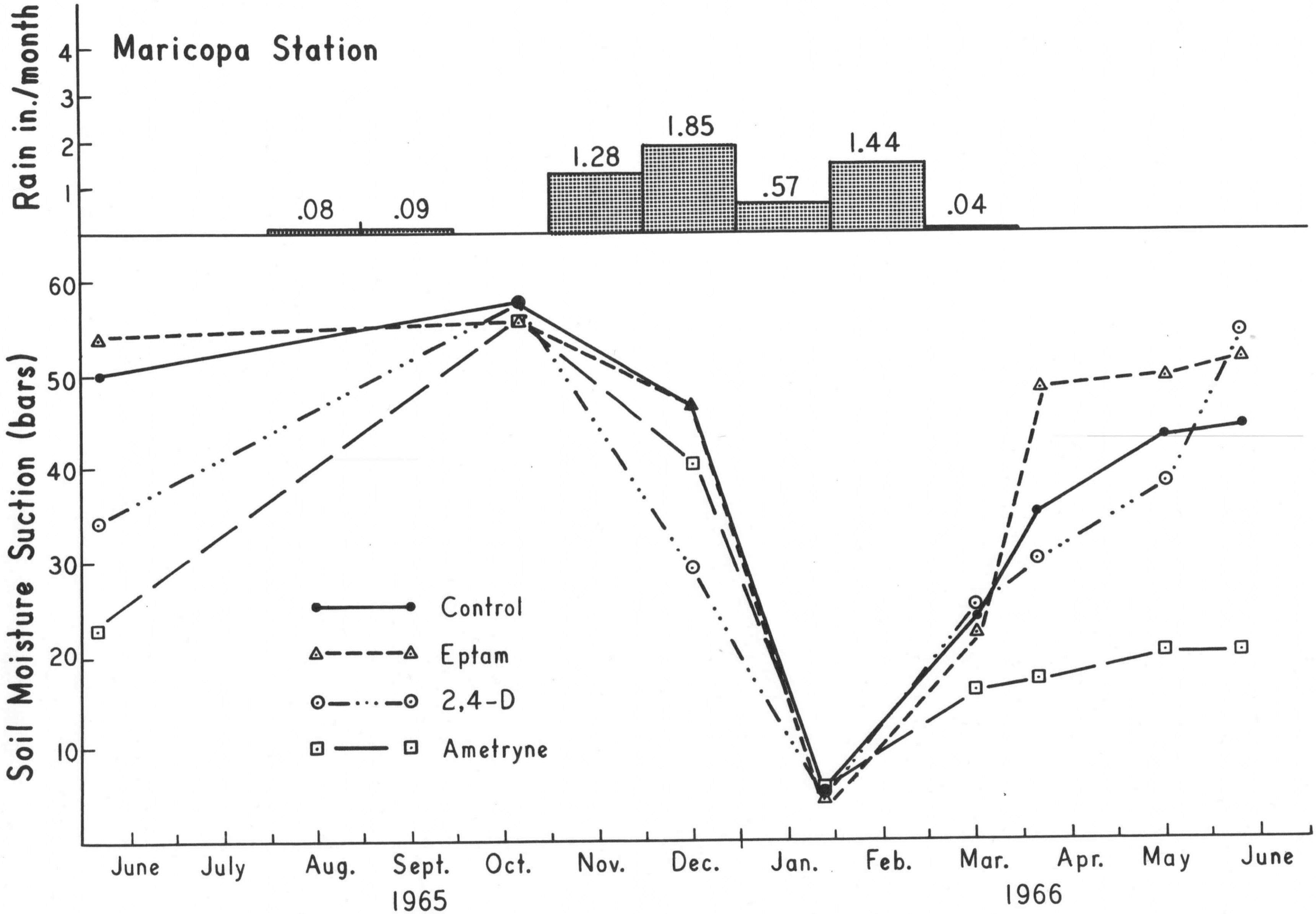


Fig. 7. North Plots, 12″-depth, grazed.

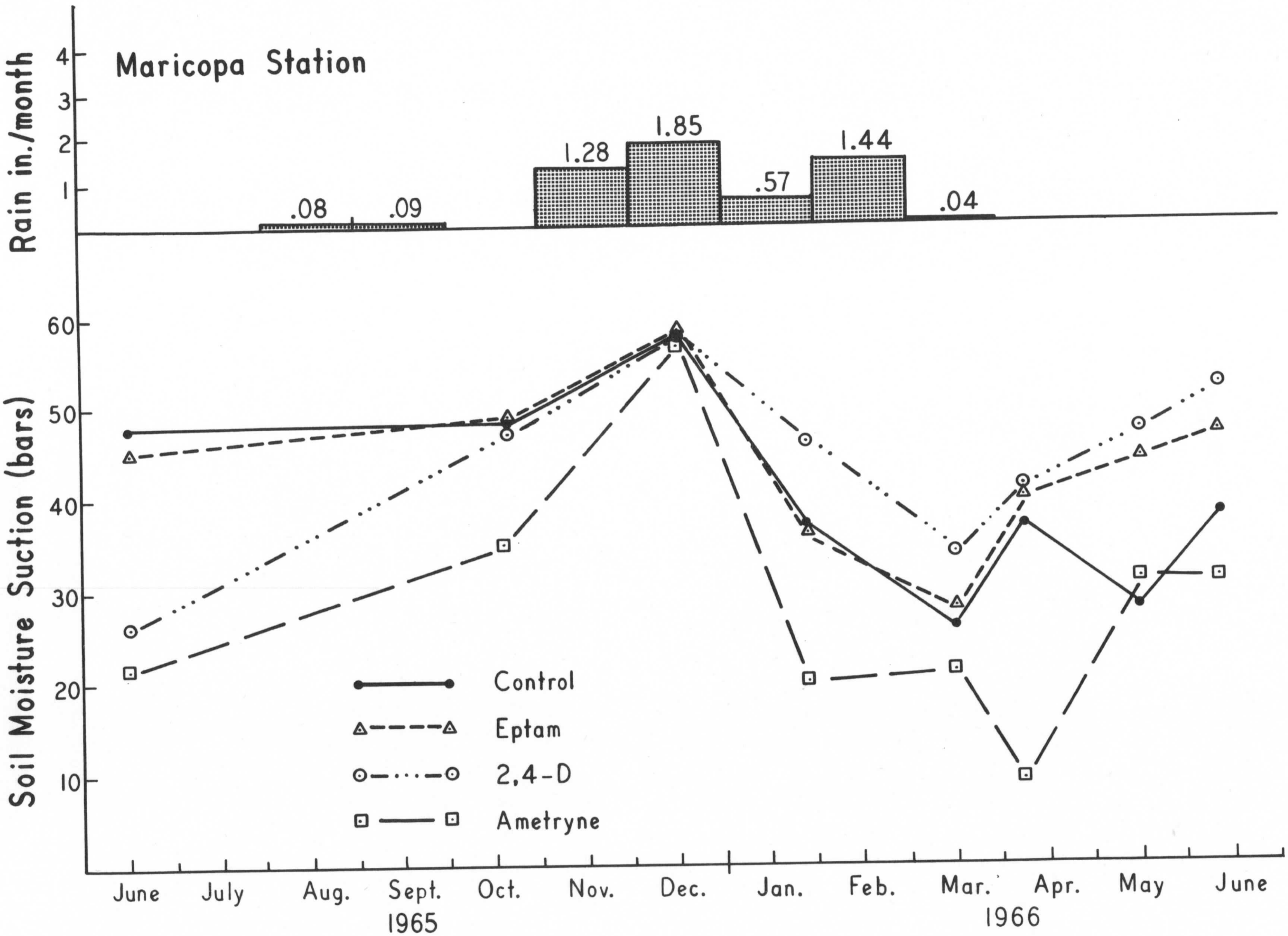


Fig. 8. North Plots, 24"- depth, grazed.

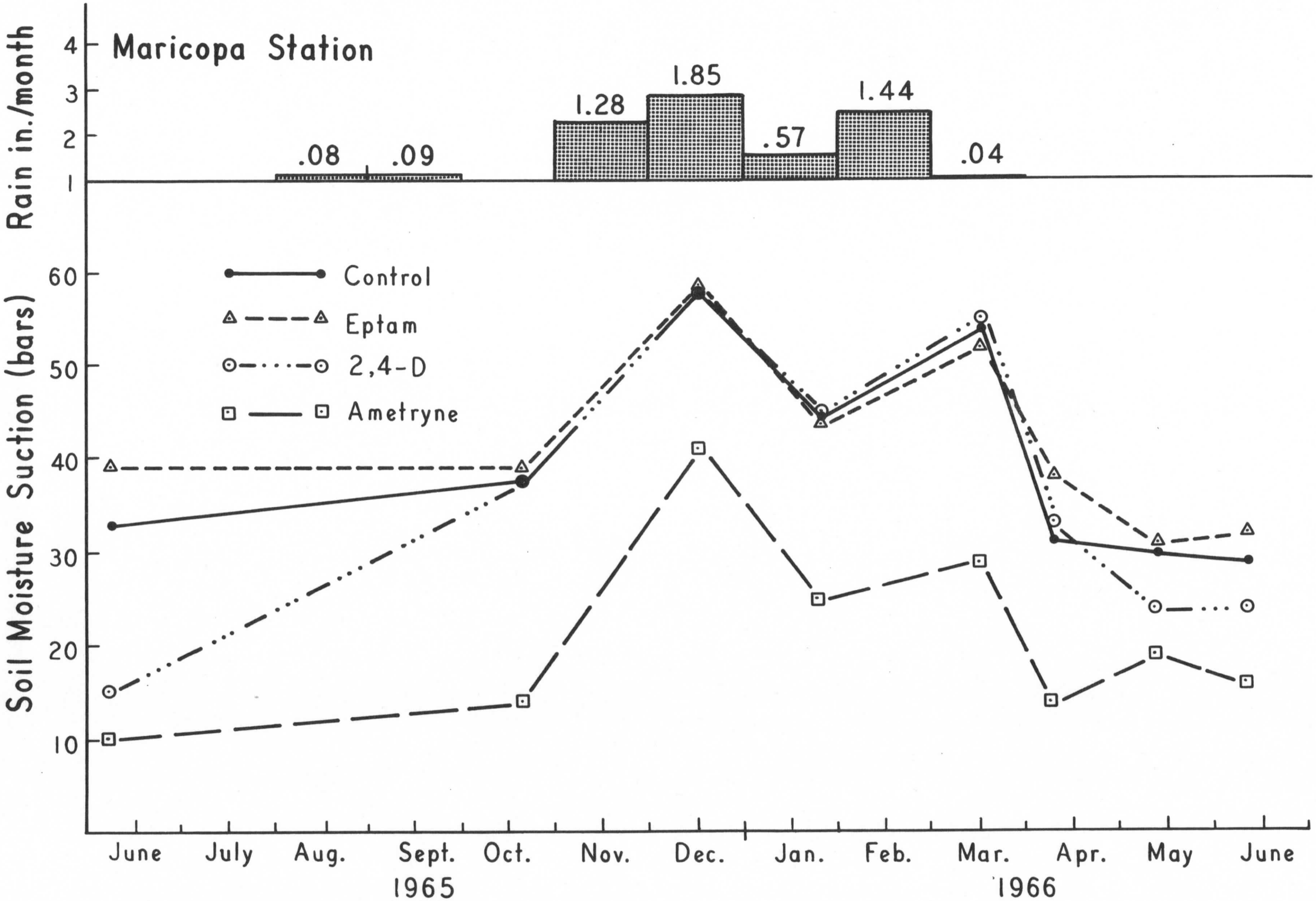


Fig. 9. North Plots, 36"-depth, grazed.

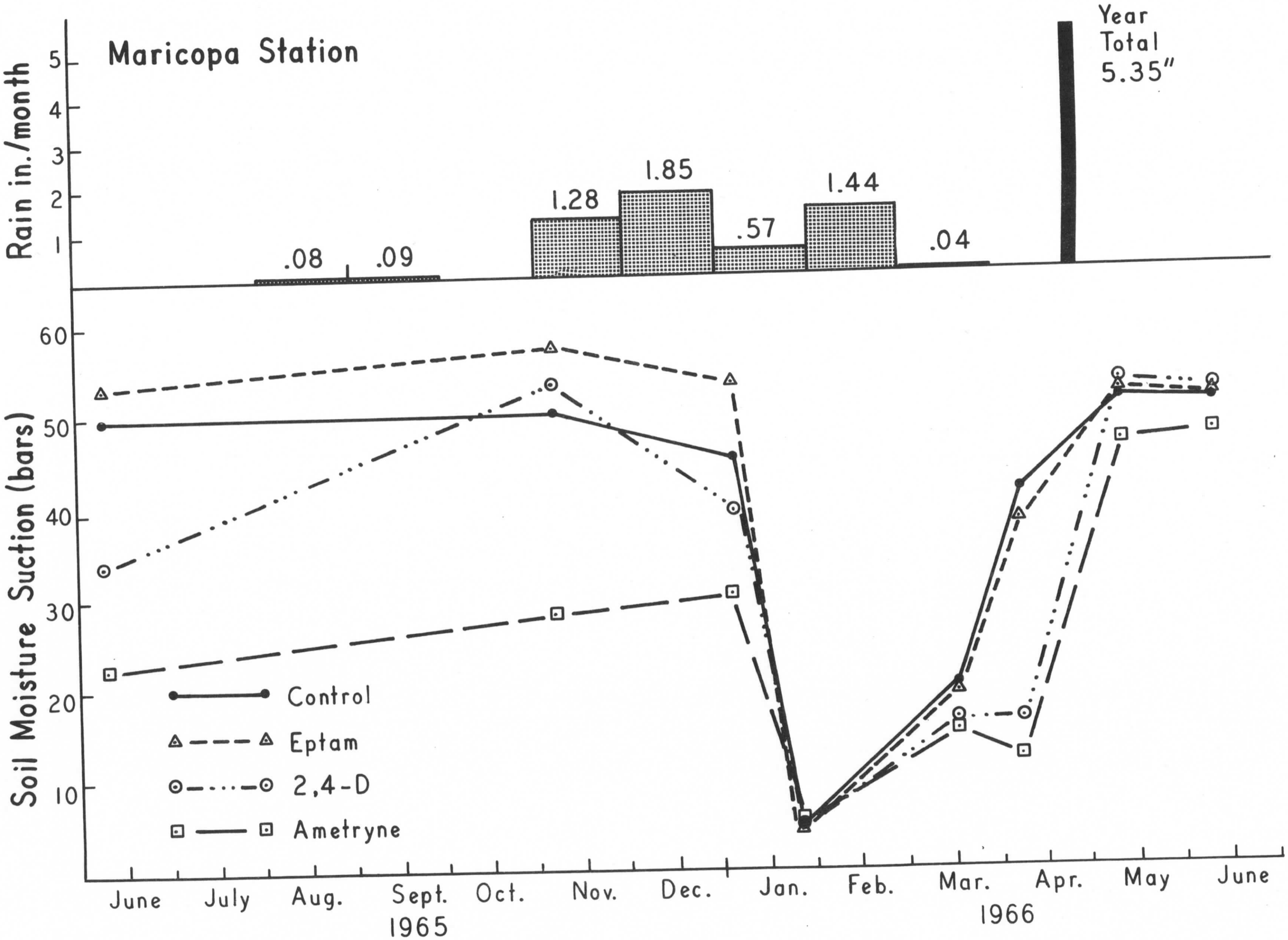


Fig. 10. North Plots, 12"- depth, ungrazed.

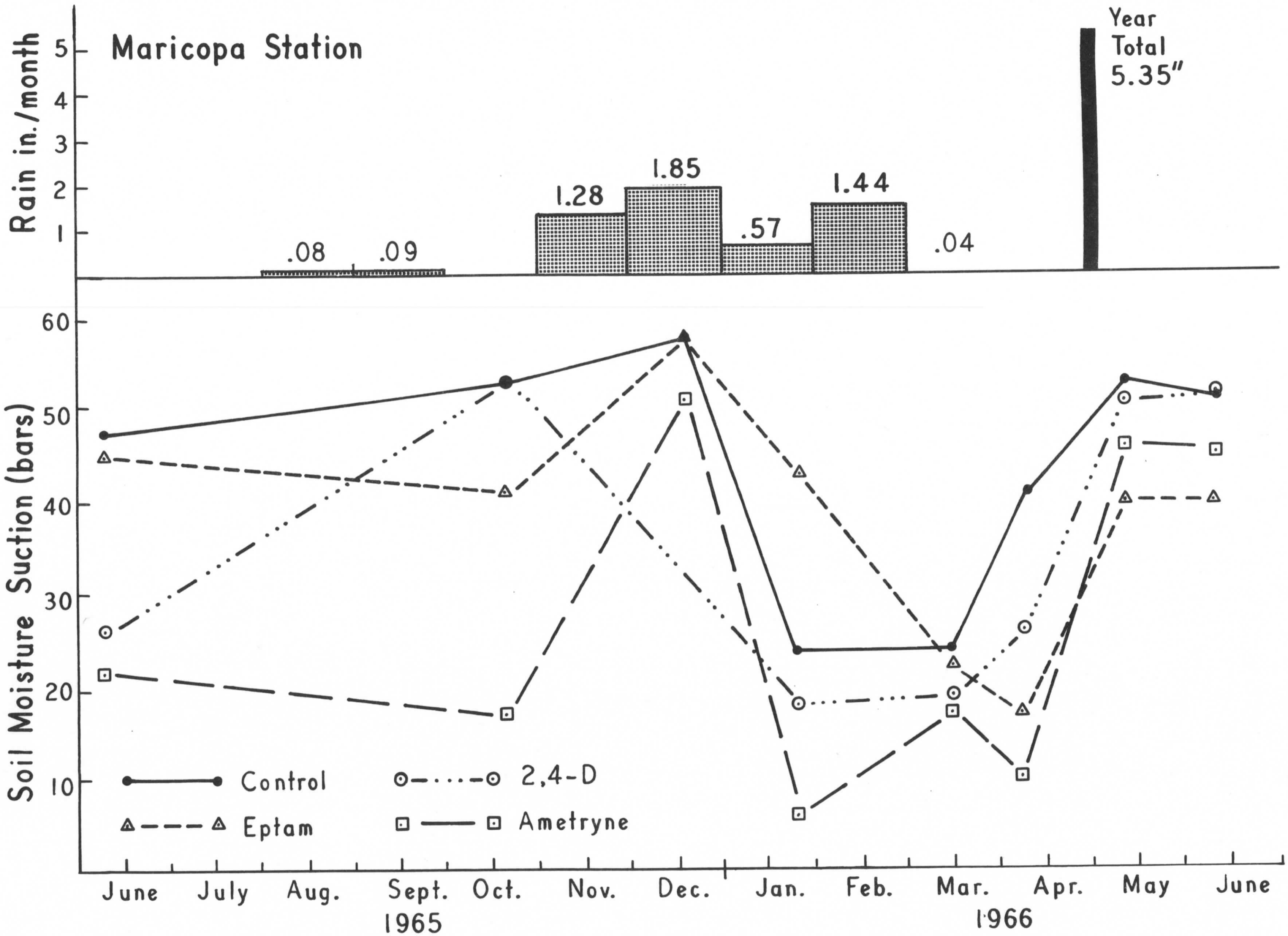


Fig. 11. North Plots, 24"-depth, ungrazed.

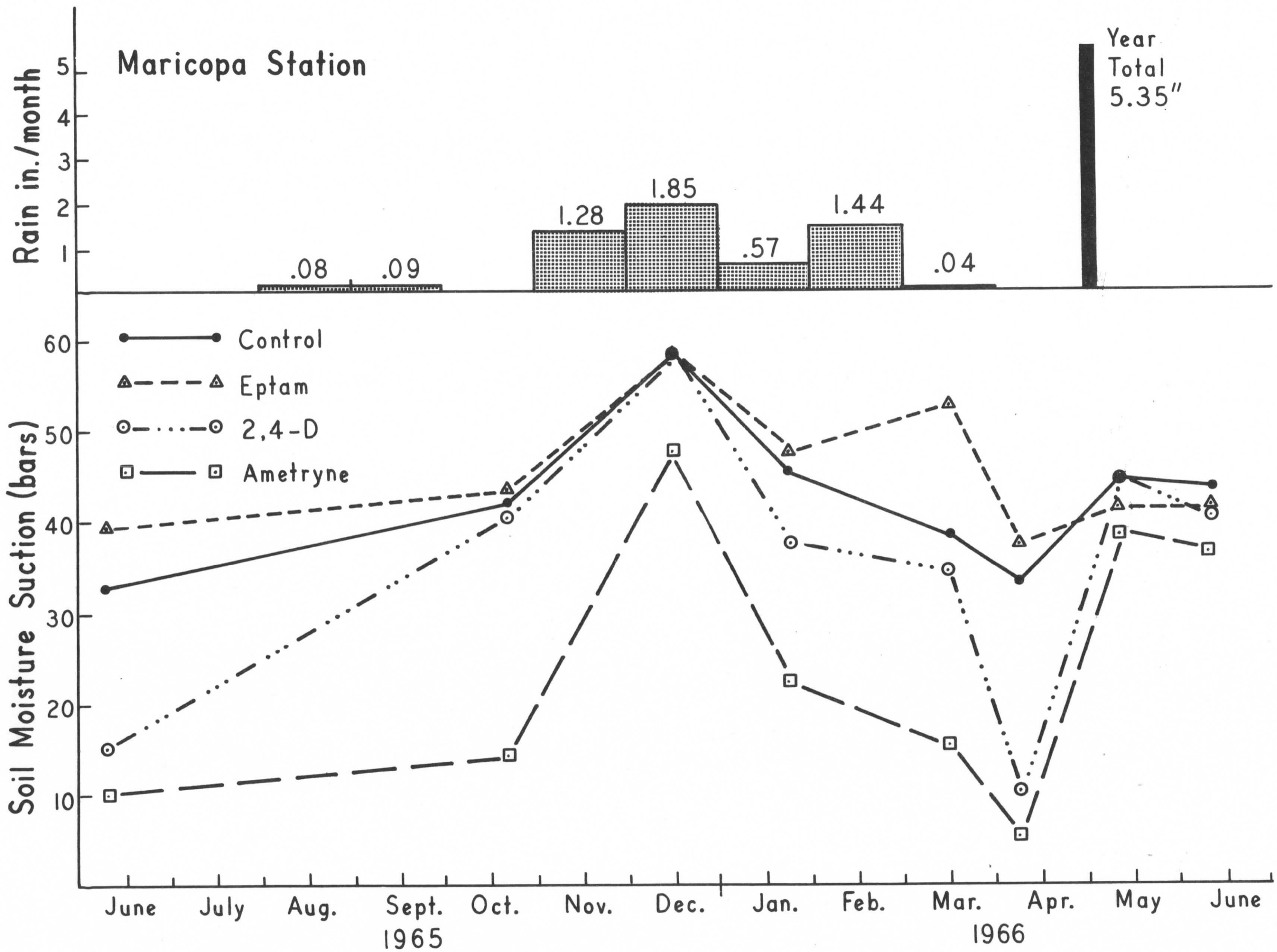


Fig. 12. North Plots, 36"-depth, ungrazed.

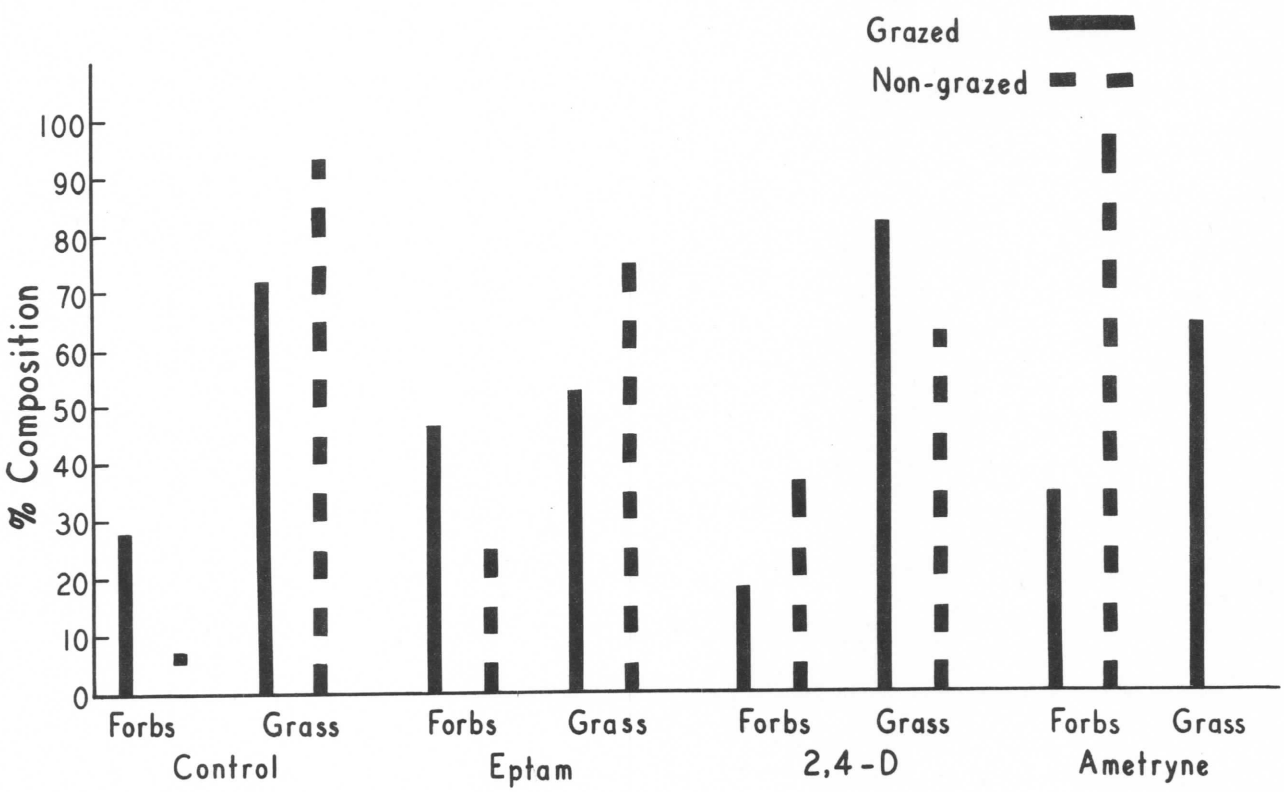
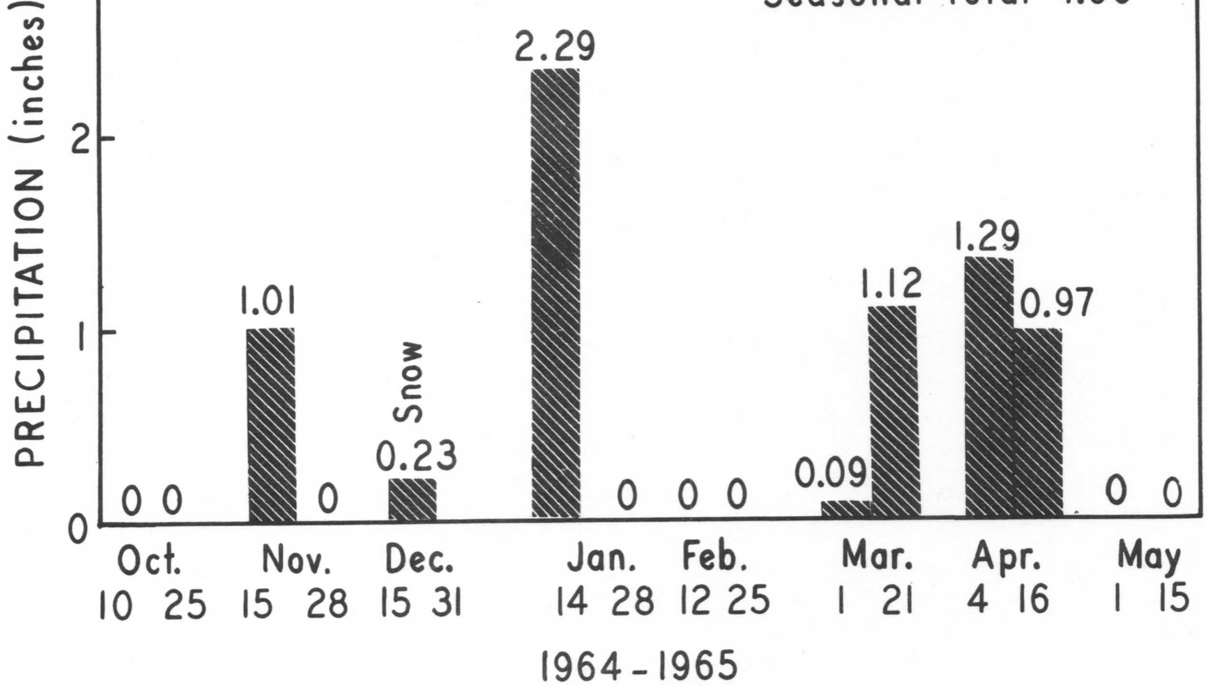


Fig. 13. Species composition, third year after herbicide application. (North study area.)

Fig. 14. Growth of Blando brome on soil treated with Ametryne. Treatments reading from left to right: control, 1 lb, 2 lbs and 4 lbs per acre of Ametryne application.



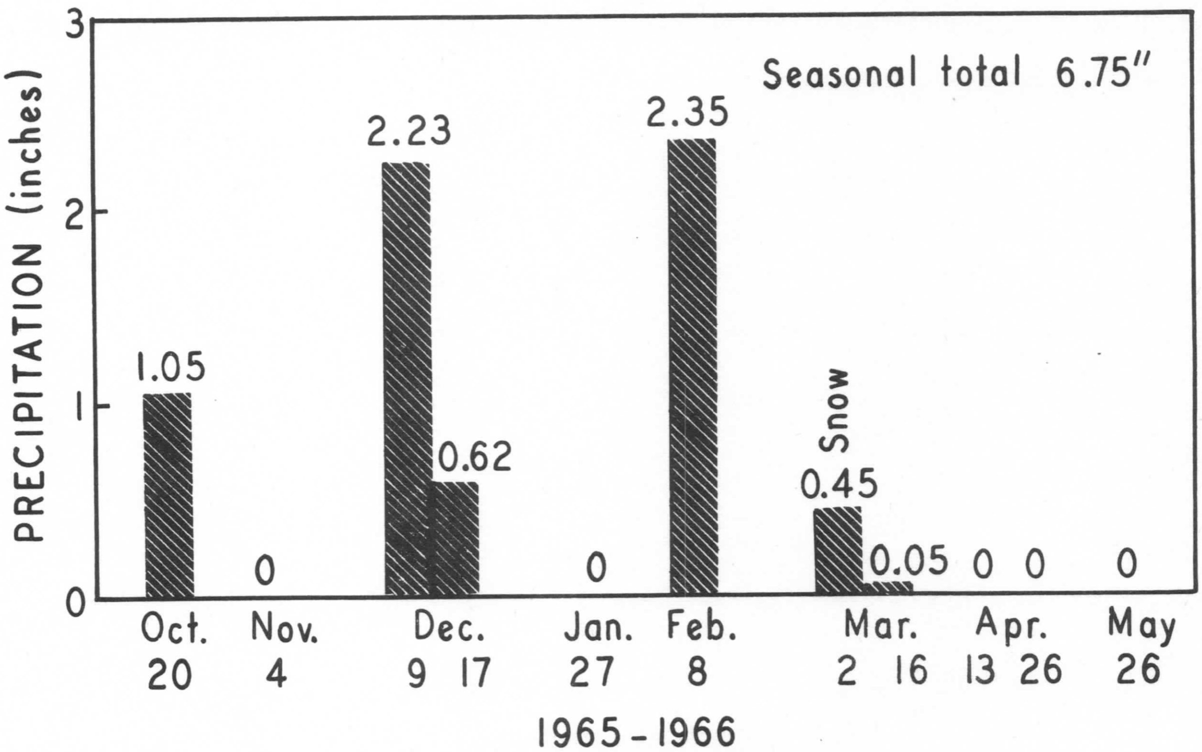


Fig. 15. Precipitation, Temblor Range, North Exclosure T31S, R21E, S22 MDBM, 3000 MSL, Panorama Quadrangle, California.

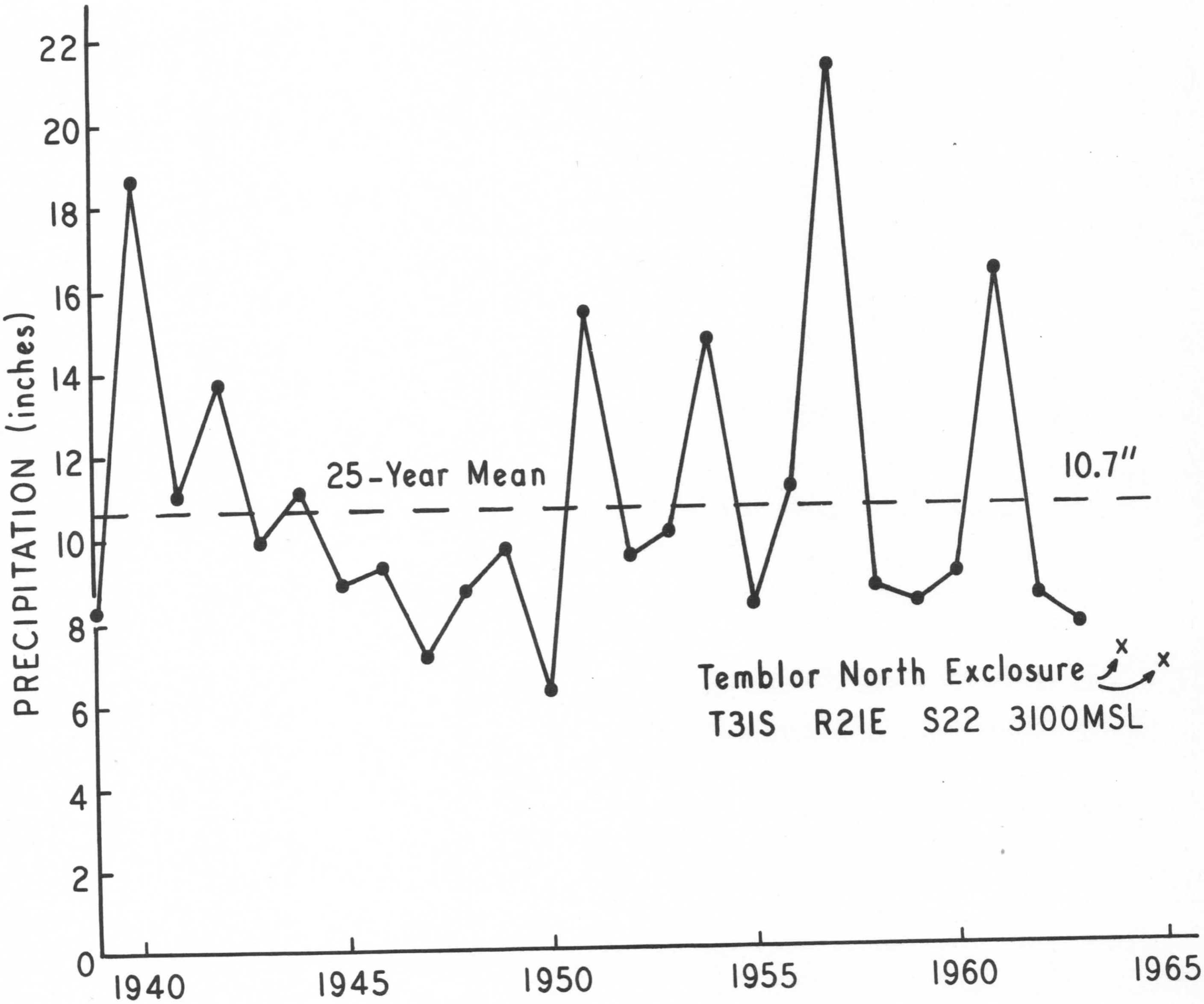


Fig. 16. Annual total precipitation, Las Yeguas Ranch, 10 miles south of Bitterwater Pumping Station, T28S, R19E, S29 MDBM, 2700 MSL, Las Yeguas Ranch, Quadrangle, California.

Fig. 17. Six-square mile area, Panorama Quadrangle, Temblor Range, with eight classes of topographic slope outlined.