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A Bioecological Study of Pinyon Pine-Juniper Association at Juan Tabo in the Sandia Mountains of New Mexico

Robert Hallett Parker

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Pinyon
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Association
at
Juan Tabo

A BIOECOLOGICAL STUDY OF THE PINYON PINE-JUNIPER ASSOCIATION AT JUAN TABO IN THE SANDIA MOUNTAINS OF NEW MEXICO

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by

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CHAPTER I

THE PROBLEM

A survey of the literature shows that no community or bioecological study has ever been made of the pinyon pine-juniper association as it occurs in the Upper Sonoran Life Zone in New Mexico and southern Colorado. This deficiency of knowledge relative to the pinyon pine-juniper community is in direct contrast to several studies that have been made of the same community in Arizona (Nichol, 1943) and Utah (Hardy, 1945; Woodbury, 1947). The association in New Mexico differs from that of Arizona and Utah by the presence of dominant trees of entirely different species. Relative to the association in New Mexico, one of the dominant trees, the pinyon pine (Pinus edulis Engelm.), has been investigated (Phillips, 1909), but no bioecological and community studies have been made of the association as a whole.

Recognizing this deficiency in our knowledge of the communities of New Mexico, the writer undertook an investigation of the pinyon pine-juniper community as represented at Juan Tabo, 18 miles northeast of Albuquerque, New Mexico. Special emphasis was directed to the nature of the soil, the climate, the climax vegetation, the forbs and grasses, and the influent animal life. Considerable attention was given to the effect of the dominant and subdominant plants in the

community. During the course of the study, data were secured on the relationship of numbers and kinds of flowering plants and seasonal changes in soil and climate. Lists giving the seasonal distribution of birds and mammals were compiled. The difficulty of securing rapid and reliable species determination of the invertebrates precluded detailed studies of these animals.

The long neglected pinyon pine-juniper community is worthy of some study and attention since it is of considerable economic importance, being utilized for grazing and as a source of fuel and fence posts. In some localities, the nuts of the pinyon pine are valuable as human food, but in the immediate area studied, the nut crop is scant and its value small.

The present study includes: 1. An interpretation of the community concept as applied to the pinyon pine-juniper community; 2. A review of the literature relating to the pinyon pine-juniper community; 3. Methods of field study; 4. Data secured, with interpretation and possible significance; 5. A summary of the results.

CHAPTER II

AN INTERPRETATION OF THE BIOME CONCEPT AS APPLIED TO THE PINYON PINE-JUNIPER COMMUNITY

Ecologists[1] today recognize the natural unity of certain aspects of the landscape, such as tundra, coniferous forest, deciduous forest, and the like. These units are floral and faunal entities and each typifies the basic and largest community unit, or biome, as used in synecology or community ecology. Biomes are, according to Shelford (1932:111), the largest plant and animal communities in dynamic equilibrium in the final climax stage. These large units or biomes are broken down into smaller taxonomically uniform units called associations, which are bound together into the biome by certain binding species of plants and animals. These binding species usually exist in all the associations of a given biome (Peterson, 1942:23). Like the biome, the association is climax and final, being in equilibium with the climatic factors. As to the spacial magnitude of these communities, the biome is extensive and

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1 The biome or community concept was promoted chiefly by Clements, Shelford, Weaver, and Carpenter, and has been perpetuated by more recent authors. For a discussion of the basic concepts of synecology, one may consult the following publications: Clements and Shelford, 1939; Carpenter, 1939; Weaver and Clements, 1938.

may cover as much as 1,000,000 square miles, while the association, often a smaller area, covers about 100,000 square miles.

In terrestrial communities, plants usually constitute the dominant or controlling elements of the community since they determine to a large degree the nature of the soil and the animals of the community. Animals, on the other hand, exert an effect on the community, but are influents rather than dominants since most of their effects are on the dominant plants. The part played by an organism in the community depends on the abundance, size, and habits of the specific animal or plant.

There is in every natural region a definite order of communities, which successively occupy originally or secondarily formed bare areas. This series of communities is termed a sere. Each community, except the last, in the sere is a seral stage; the last community is the climax community or association. This community is self perpetuating and is characterized by the life-form or taxonomic uniformity of the dominants, such as grasses, deciduous forest trees, and coniferous forest trees. The stage immediately preceding the climax is termed the subclimax community. The dominants of the various developmental stages within a biome are not necessarily of the same life-form as those of the climax. The distributional control of biomes is, broadly speaking,

climatic, and their limits are recognized by the occurrence of the climax associations. The climax may be interrupted locally by the presence of edaphic communities characterized by dominants differing from those of the climax community and prevented from developing into the climax by the nature of the soil.

The pinyon pine-juniper community is one of the principal and more conspicuous communities of the western and southwestern areas of the United States and adjacent Mexico, since it covers approximately 76,000,000 acres in the United States and extends from northern Mexico to the Snake River in Idaho (Daubenmire, 1943). This association is recognized as the pinyon pine-juniper and interior chaparral formation by Weaver and Clements (1938) on an equal basis with the moist coniferous forest, sage-brush desert, coastal chaparral, and creosote bush desert. Sufficient study of a bioecological nature has not been made to justify designation of these formations as biomes, but some at least constitute associations (Pitelka, 1941:113-114). Daubenmire (1943) in defining the vegetation of the Rocky Mountain region distinguishes six major vegetation zones making up a needle-leaved forest formation. To the pinyon pine-juniper community, he gives the designation of the juniper-pinyon zone of the above formation, the subdivision lowest in elevation of the coniferous vegetation. Daubenmire places the pinyon pine-

juniper community between the ponderosa pine zone, which occurs at higher elevations, and the oak-mountain mahogany zone at lower elevations. In contrast, Graham (as reported by Daubenmire, 1943) in a study of the Uinta Basin in Utah and Colorado places the pinyon pine-juniper community below the submontane shrub zone and above the mixed-desert shrub zone. He also shows that it is variously called woodland, pinyon, juniper-pinyon, cedar-pinyon, and pigmy forest and that it is part of the Upper Sonoran Life Zone, which is variously designated as foothill, lower temperate, or sage-brush areas. In all references considered, there is no definite assignment of the pinyon pine-juniper to a particular biome such as the grassland or montane coniferous forest. There is a tendency to consider the pinyon pine-juniper community as a separate and well-characterized association. Ultimately the association may attain the status of a biome.

CHAPTER III

REVIEW OF THE LITERATURE

While no complete ecological studies have been made of the pinyon pine-juniper community, there are a few contributions covering certain aspects of the community. Perhaps the nearest approach to an ecological study of the pinyon pine-juniper association is a paper by Emerson (1932), in which he discusses the tension zone between the mixed grass and pinyon pine-juniper associations in northeastern New Mexico. A very important aspect of this study is a consideration of the nature of the root systems of the climax vegetation. The paper includes a discussion of the climatic factors of both associations and a partial list of flowering plants. The species of plants differ somewhat from those found in the Juan Tabo area, but this can be expected since Emerson's study was conducted in an area located about 150 miles north of Juan Tabo.

Important results of Emerson's work appear in the following quotation:

> "Soils in which the piñon-juniper association thrives, vary from fine adobe to outcrops of limestone, sandstone, and igneous gravels. The grasses are always poorly developed in the woodland soils. The combined effects of the condition of the stand of grasses and the efficiency of the agents of dissemination appear to be responsible for the location of the woody plants. Soil character and geological formation are only indirectly important as they control the growth of grasses.

> "Roots of the piñons and junipers assume both horizontal and vertical positions in any soil they can penetrate. Both sets of roots are found to be capable of active absorption. In rocks lying horizontally, the taproots develop very little, being replaced by laterals that follow the seams in the rocks. Grass roots are mostly in the first foot of soil in direct competition with the horizontal roots of the trees and with all of the roots of the tree seedlings. This is probably a principal reason why the woody plants fail to establish themselves in close stands of grass.
>
> "Differences in rainfall are too slight and fluctuating to be responsible for the differences in vegetation. Rains seldom affect soil moisture below the roots of grasses and the horizontal roots of the trees. The vertical roots of trees may reach a continuous supply of moisture that follows the deep rock strata.
>
> "Woody plants are found to grow in clumps well separated from each other. On level ground the seedlings practically never develop except near shelters of some kind. On hillsides, on the other hand, they establish themselves in open places below parent trees. This proves that their usual position with older trees is not an obligate shade relation. Seeds dropped by birds and buried by rodents explain the presence of most of the seedlings under the adults and the consequent grouping into clumps" (Emerson, 1932:358).

Emerson also reported that the juniper is the pioneer of the two species and is followed by pinyon pine and occasionally by shrubby plants.

Since the appearance of Emerson's publication, Howell (1941) published an article on the pinyon and juniper woodlands of the Southwest. This is in no way a bioecological study and is written in the vernacular of the forester. The article deals primarily with the value of this community as a source of lumber and the yield and management of the community. Of value to the present study are several tables

relating to maximum sizes of the trees, composition of woodland types by tree classes, number of trees per acre, and habits of growth.

In connection with the species of birds in the pinyon pine-juniper community, Hardy (1945) published a paper concerning the breeding birds of the pigmy conifers. The study was conducted in the Book Cliff Region of eastern Utah, an area that has a somewhat different climate and vegetation than central New Mexico. The juniper is the Utah juniper, Juniperus utahensis (Engelm.) Lemmon. This paper supplies some information regarding the possible reasons for the limited number of birds in the community as compared to other communities.

> "The pigmy conifers place limitations upon the birds that can live under their influence through limitations in such necessities as space, food, water, shelter, protection, nesting material and nesting sites. The crops of juniper berries and pine nuts and the seeds of the interspersed plants are about the only products directly usable as food by the birds. Indirectly, however, the scanty resiniferous foliage, the tough wood, and the roots of the junipers and piñons, as well as similar parts of the minor plants, yield food for insects or rodents which in turn are used by the birds.
>
> ". . . . . because of aridity, the pigmy forest and near-by areas support little plant life. Those plants which do grow are small-leaved desert forms which support a minimum of insect life. This means that birds nesting in such an area must claim a large territory to obtain enough food for their young" (Hardy, 1945:526).
>
> "The excessive grazing of the area by livestock has, in many cases, reduced plant life to a minimum. This, without doubt, makes itself felt by a decreased yield of seeds and insects which serve as food for the birds" (Hardy, 1945:527).

Hardy observed 79 species of birds in the pigmy conifers. Among these, only eight are classed as permanent residents. Of these eight, three are obligate residents and five are species that nest also in surrounding areas. Fourteen summer residents and seventeen winter visitants were recorded. All others were considered as migrants or foragers from nearby areas. The fourteen nesting summer residents are chiefly "passerine birds and are primarily insect and seed eaters that, in winter, are unable to find sufficient food of the proper kind and hence must migrate from here and return at the winter's end" (Hardy, 1945:541).

An important paper dealing with the pinyon pine-juniper community in Utah and Arizona was published by Woodbury (1947), who discussed the distribution of the pigmy conifers in these states. His conclusions are listed below.

> "The pigmy conifer community, otherwise known as juniper-pinyon woodland in Utah and northeastern Arizona, ranges in altitude from an extreme lower limit of about 3200 feet in the Virgin River drainage in southwestern Utah to an extreme upper limit of about 8400 feet in the Book Cliffs of Carbon County. Within these limits are many discontinuities in the forest, usually occupied by sagebrush which has an even greater range in altitudinal limits.
>
> "The forest comprises three species of junipers (Juniperus utahensis, J. monosperma and J. scopulorum) and two species of pinyons (Pinus monophylla and P. edulis). The community lies mainly within the 10 to 15 inch precipitation belt with an average precipitation of about one inch per month, a monthly mean temperature ranging from 23° to 69° F. and a mean frost-free period of 120 days. It usually increases upward in (a) size of individual trees, (b) proportion of crown to root and

(c) density of stand.

"This community is intimately related to the sagebrush community which occurs either as separate or mixed stands and the two together form in the mountains a belt or zone, above which lie successively the zones of submontane shrub or ponderosa pine, the coniferous forest and the alpine tundra and below which lie the zones of chaparral and creosote brush.

"Where the lower limits of the community occur within a given soil type, the limit may be set where the decreasing precipitation downward results in deficiency of available water supply, especially for seedling establishment. Evidence is presented to indicate this cannot be due to excessive temperature effects. A similar explanation may be given for setting the lower limits of submontane shrubs and ponderosa pines at the 15 inch precipitation line.

"Where the community limits adjacent to discontinuities in the forest coincide with changes in soil type, the explanation may lie in the water-supplying conditions of the different soil types. If the limits in either case occur at that line under which temperature inversions occur, cold extremes may be instrumental in setting limits" (Woodbury, 1947:125).

Woodbury's study is helpful in understanding the possible causes for area limitations of the pinyon pine-juniper community, but the community studied by him is older and is bordered by a different type of vegetation than the area included in the present study. In Utah and Arizona, the lower limit of the community is bounded by sagebrush chaparral and creosote bush, while in the Juan Tabo area the lower limit is bounded by grassland, without sagebrush or creosote bush. It is interesting to note that there is a maximum amount of moisture beyond which pigmy conifers do not survive. As a result, oaks and other shrubs grow where

the snow accumulates in the winter and the pinyon pines and junipers occur only on well-drained slopes that are blown free of snow cover. Also the conifers are more vigorous along watercourses, but die in the presence of excessive water (Woodbury, 1947:124).

Further information regarding the pinyon pine-juniper association in Arizona can be found in a bulletin by Nichol (1943). In this publication on the vegetation of Arizona, there is a brief description of the pinyon pine-juniper community as it occurs in Arizona. Of special interest are Nichol's discussion of the wildlife of the association and his review of the succession of mammals in the community since early times. The seasonal succession of animals is also discussed (Nichol, 1943:192).

Miller (1946) published a short paper on the vertebrates inhabiting the pinyon pine-juniper association of the Death Valley region, an area somewhat too far west to be of immediate value in the present study. In contrast to Hardy's (1945) listing in Utah of approximately 14 summer resident birds, Miller found 56 summer resident birds and 12 transient and vagrant birds.

Dice (1930) has written a paper on the mammalian inhabitants of the pinyon pine-juniper association in the Alamogordo region of New Mexico in which he gives a list of mammals occurring within the community and a summary of the

climatic factors. This paper is especially useful for comparing the mammalian population of the pinyon pine-juniper community with those of the surrounding communities.

Kuthven (1907), Kearney and Peebles (1942), and Vernon Bailey (1913, 1931) have published papers which deal with certain aspects of the pinyon pine-juniper association. Those papers by Kuthven and Bailey emphasize the vertebrate inhabitants of the pinyon pine-juniper association rather than ecological factors.

Among other publications consulted was a paper on the pinyon pine by Phillips (1909). This paper, although somewhat outdated, is of some value since it is concerned chiefly with the manner of growth, tolerance to climate and edaphic factors, and growth form of the pinyon pine. A short paper by Wilmore (1945) concerning the Rocky Mountain juniper was not available for review.

CHAPTER IV

METHODS

The area of pinyon pine-juniper community studied is situated in a fenced, range check-plot of about 10 acres, in the center of a representative stand of pinyon pines and junipers. This plot has been maintained without grazing by the United States Forest Service since 1932 and is therefore an ideal area in which to study the flowering plants typical of the pinyon pine-juniper association. The plot is located about 17 miles northeast of the city of Albuquerque, New Mexico, in a Forest Service recreation area situated in a series of granite hills on the west slope of the Sandia Mountains. The elevation is approximately 6800 feet, and the preserved area lies within the limits of the Upper Sonoran Life Zone of Merriam, according to Bailey (1913). The fenced check-plot is bounded by a dirt road on the south and east and a steep slope on the west. Two sandy-bottomed arroyos dissect the area from north to south. Each of these is about six to ten feet across at the bottom and has been dammed at intervals of about ten yards to retard erosion and run-off. The dams were constructed in 1933 by the Civilian Conservation Corps.

A transect ten yards wide was staked out across the plot from east to west, so that areas of both east- and west-

facing slopes were included (figure 1). Since one of the objects of the present study was to secure as much climatic data as possible, especially for the purpose of explaining the seasonal distribution of plants, several meteorological instruments were placed within the transect. The first instrument placed in the transect was a Taylor maximum-minimum thermometer of the two leg type. This instrument was placed in the center of a clump of pinyon pines and junipers on the east-facing slope on April 8, 1948, just before the earliest flowering plants had begun to blossom. The thermometer was placed about 18 inches from the ground in such a position that the sun would never strike the mercury column. The thermometer was read and reset one to three times a week until, during the months of September and October, the condition of the road to Juan Tabo prevented more than one visit every two weeks.

On April 28, a rain gauge was placed within the transect in the smaller of the two arroyos. The gauge was placed in this locality because the slope of the ground is slight and because this locality provides sufficient soil to retain supports for the gauge. In lieu of a standard rain gauge, a galvanized sheet metal funnel with a diameter of $10\frac{1}{2}$ inches was used. This funnel was mounted on four supports so that the open end was 18 inches above the ground. Water falling into the funnel ran into a four liter, narrow-mouth bottle,

somewhat sunken into the ground for stability. In order to prevent evaporation between readings, a small amount of mineral oil was placed in the receiving bottle. At each visit to the area, the water, if any, was emptied into a graduated cylinder and the volume determined in cubic centimeters. The rainfall in cubic centimeters was converted to rainfall in inches by means of a calculated conversion factor of 0.0007044.

The third instrument, a standardized Livingston white spherical atmometer, was placed near the summit of a hill in the transect near the center of the fenced plot. The reservoir used was a graduated chemical mixing cylinder of one liter capacity fitted with a two-hole rubber stopper. The glass tube leading from the reservoir to the atmometer was fitted with a mercury trap to prevent water from flowing into the reservoir during heavy rains. The bulb was approximately 18 inches above the surface of the ground. All readings were made at the same time of day, 10 a.m., so that the average daily evaporation rate could be computed. The porous bulbs were changed three times during the study, correction factors being used to compute the evaporation rate in terms of the standard instrument.

Besides securing climatic data, an attempt was made to obtain data relative to soil and edaphic factors. The soil moisture, pH, and organic carbon content were deter-

somewhat sunken into the ground for stability. In order to prevent evaporation between readings, a small amount of mineral oil was placed in the receiving bottle. As an aid to visit to the area, the water, if any, was emptied into a graduated cylinder and the volume determined in cubic centimeters. The rainfall in cubic centimeters was converted to rainfall in inches by means of a determined conversion factor of 0.0007/cc.

The third instrument, a recording type water spherical atmometer, was placed near the summit of a hill in the transect near the center of the Jemez plot. The reservoir used was a graduated cylinder mounted vertically with a two-hole rubber stopper. One glass tube leading from the reservoir to the atmometer was fitted with a rubber tube to prevent water from flowing into the reservoir during heavy rains. The unit was approximately 12 inches above the surface of the ground. All readings were made at the same time of day, 10 a.m., so that the average daily evaporation rate could be computed. The porous bulbs were changed three times during the study, correction factors being used to compute the evaporation rate in terms of the standard instrument.

Besides securing climatic data, it was also necessary to obtain data relative to soil moisture, pH, and organic carbon content. The

mined, and the soil was classified according to a mechanical analysis. The soil moisture was determined as the percentage of water by weight, based on soil dried to a constant weight at 105° C. Soil samples were taken at a three-inch depth once a week during the late spring and summer. At each sampling, one sample was secured from the west-facing slope and another from the east-facing slope of the transect. A few soil samples were obtained from the floor of the largest arroyo for purposes of comparison with soils of the west- and east-facing slopes. Samples were taken in tared, screw cap jars of eight ounce capacity.

The pH determinations of the soil were made with a La Motte soil testing set on samples in the field or on samples of oven-dried soil. Phenol red indicator was found suitable for the soils of the Juan Tabo area. In general, tests were made in the areas from which soil moisture samples were regularly taken, although a few samples tested were from the bottom of the arroyo.

Mechanical analysis of the soil was made by Dr. C. Clayton Hoff of the Department of Biology of the University of New Mexico. The soil subjected to analysis was taken from the east-facing slope. The analysis was made by the hydrometer method using sodium silicate and sodium oxalate as dispersing agents, as outlined by George John Bouyoucos (1936) of the Michigan Agricultural Experimental Station.

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Doctor Hoff also made determinations of the percentages of organic carbon in samples of soil collected at various distances from the base of a juniper so that samples were included within and without the litter area under the tree. One set of data were secured from the soil at a depth of one to two inches and another of soil at a depth of three to four inches. The organic carbon analyses were made according to the Schollenberger method as modified by Allison (1935:311-320). In brief, this method involves the oxidation by chromic acid of the organic matter in a weighed oven-dry soil sample in concentrated sulfuric acid containing excess potassium dichromate. The method includes heating to 175° C. for 90 seconds. After cooling, the unused chromic acid is determined by titration with a standard solution of 0.2 N ferrous ammonium sulfate, using diphenylamine as an internal indicator.

Several methods were used in studying the plants. At each visit, the flowering plants were observed and collected for herbarium specimens. This made possible a compilation of a seasonal list of flowering plants from the date on which the first flower appeared in the spring until the middle of October, when the majority of fall flowers had finished blooming. Identifications were made chiefly from fresh specimens, but pressed plants were used for checking and records. Identifications for most of the plants were

made by the author and checked by Dr. Edward F. Castetter and Dr. Howard J. Dittmer of the Biology Department of the University of New Mexico. Plants of the genus Penstemon Pursh were checked by Mrs. Gladys Nesbitt of Springer, New Mexico. Keys used for identification were The Flowering Plants and Ferns of Arizona by Kearney and Peebles (1942) and Flora of New Mexico by Wooten and Standley (1915). The nomenclature followed is chiefly that of the first publication.

Differences in degree of cover or abundance of vegetation were determined by clip quadrats and by basal area quadrats. These quadrats were established on the east- and west-facing slopes to show the differences in vegetational cover on the two slopes. The quadrats were laid out by means of a quadrat frame made by tying a heavy string to four metal stakes that were driven into the soil. The quadrat measured one meter on each side, thus covering an area of one square meter. In the clip quadrats all of the vegetation was clipped from within the marked square at a uniform distance, about one inch, from the surface of the ground, put in a bag, and dried to constant weight at 105° C. Results are expressed in grams weight per square meter. In the basal area quadrat, the area covered by each plant within the quadrat was obtained by measuring the diameter of the base of the plant at one inch from the ground. Results are expressed as the percentage of the surface of ground covered by the plants.

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Ages of the trees were secured from cores taken with an increment borer. Whenever possible, the borings were near the base of the trunk in order to determine the maximum age. Age determinations were made of both junipers and pinyon pines.

In order to secure a census of the larger soil invertebrates, soil to a depth of four inches within a square foot quadrat was sifted onto a white cloth, (figures 2 and 3) and the invertebrates manually removed. Samplings were made under large junipers and pinyon pines, and in open areas devoid of litter. The invertebrates found were preserved in 95% alchol.

During the course of field work, observations were made on the reptiles of the area and a list was compiled from sight records made during the trips to Juan Tabo and from reptiles killed by vehicles on the road. Doctor William J. Koster of the University of New Mexico Biology Department made identification of a snake found dead in the road. The Handbook of Lizards by Hobart M. Smith (1946) and the Field Book of Snakes of the United States and Canada by Schmidt and Davis (1941) were used in identifying the other reptiles.

A list of birds of the community was compiled from sight records, a permit not being available for taking skins. These records are of birds present in the pinyon pine-juniper community located on the west slope of the Sandia Mountains

and the northern end of the Manzano Mountains rather than the intensively studied fenced plot. An attempt to find nesting birds was made by systematically examining various sections of the fenced area. Also likely nesting places nearby were examined for nests whenever singing males were consistantly observed in the same area.

Seasonal lists of the mammals were compiled from data secured by live and snap trapping, by sight census, and from records obtained from a State Game Department predator trapper, who trapped in the Juan Tabo area during the spring. In addition, records of some mammals not actually observed are based on scats and signs. In trapping, snap traps and two kinds of live traps were used. Some of the live traps were made by Mr. Larry Gordon, a graduate student in Biology at the University of New Mexico, from large fruit juice cans with small mouse traps supplying the tripping mechanism. Smaller live traps were supplied by Mr. DeWitt Ivey of the Biology Department, University of New Mexico. These were of a type designed by Dr. H. B. Sherman of the University of Florida. Trapping was carried out over a five day period from August 10 to August 15, 1948. On each of the first two nights, 72 live traps were placed in the center and southern half of the fenced plot. On each of the next two nights, 25 additional live traps were set in the northern part of the plot. On the final, or fifth night, 200 "museum special"

and the northern end of the mesquite [illegible] rather than the intensively studied fenced plot. An attempt to find nesting birds was made by systematically searching various sections of the fenced area. Also likely nesting places nearby were examined for nests whenever singing males were consistently observed in the same area.

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snap traps were placed in the area along with the live traps. All the traps were collected on the morning of August 15th. The traps were set every evening at 5:30 p.m. and checked in the morning before sunrise at about 5:30 a.m. All sprung traps were reset each morning in order to trap diurnal mammals.

Many color and black and white photographs were taken, using an Argus C-3, 35 mm. camera.

CHAPTER V

RESULTS OF SOIL INVESTIGATIONS

Origin of the Soil and Geology of the Area. The area in which this study was conducted is located near the center of an uplift known as Rincon Mountain. This is mainly an uplift of metamorphic schists and gneisses that joins the sediments of the mesa on the south and west and is overlain on the north by Pennslyvanian rocks. The Rincon Mountain uplift is about five miles long and one mile wide, with the longer axis trending about 25° east of north.

> "The essential topographical feature is a mountain uplift, having an elevation of 8,000 feet. The surface slopes in a general way from this peak, which is approximately in the center of the area. The mountain as a whole forms a sort of hook to the main Sandia ridge, with the point toward the south. The area between Rincon Mountain and the main Sandia range is a series of rounded granite hills traversed by drainage channels" (Ellis, 1922:24).

The fenced area, in which the major portion of this study was made, covers most of two of these rounded granite hills.

> "The rocks comprise hornblende and mica schists and gneiss. All are much contorted. The general color is a dark greenish gray. Dikes of light-colored granite are frequent along the west side, cutting the schists transversely to the edge. The dip of schistosity is steeply eastward, varying from 40° to 70°. The series partly overlies the granite mass that forms the core of the Sandias. It is thus evidently older than the granite and has been raised to its present position by the intrusion of the latter" (Ellis, 1922:24-25).

Also quite evident are veins of quartz which contribute many quartizite rocks to the thin cover of soil. A fairly complete

geologic history of the Sandia Mountains and surrounding area can be found in Ellis's publication (1922:34-37).

Nature of the Soil. For the most part, the soil cover is thin, seldom over four inches deep, extremely rocky, and highly eroded. The soil on the steep west-facing slope is mixed with large gravel, while the soil on the east-facing slopes and on the tops of the small hills contains less gravel. The soil is derived locally from quartz, gneisses, granites, and schists.

From soil analyses made by Dr. Hoff, the soil can be classified as sandy loam, although the soil on the floor of the arroyos is almost pure sand. Results of analyses are shown in table I. The first sample analyzed was taken in early May from the east-facing slope at a depth of two to three inches. Later in the year, on August 23, 1948, ten samples, five from one to two inches deep and five from three to four inches deep, were taken by Dr. Hoff in a linear series from the base of a juniper to beyond the litter line. This series was taken from the west-facing slope. The system of classification used is the United States Bureau of Chemistry and Soil System in which sand is considered as being particles 2.000-0.050 mm. in diameter, silt as particles 0.050-0.002 mm. in diameter, and clay as particles of 0.002 mm. or less in diameter.

Concerning the soils in which the pinyon pine-juniper association occurs, Emerson has the following comment:

> "The types of soil on which the piñon-juniper association occurs differ very widely from each other, both as to character and as to geological origin. Occasionally this association is found thriving in fine, compact adobe soils, but usually it occurs in rocky places. The studies reported here [Las Vegas, New Mexico] were made chiefly on Greenhorn limestone, which belongs to the upper Cretaceous, and on Dakota sandstone of the lower Cretaceous . . . . . Some additional observations were made on an extensive bed of igneous gravels and boulders that had the appearance of glacial deposit. Because of the great diversity of soil types on which the piñon-juniper association thrives the observer soon becomes convinced that the limiting factors are not primarily those of soil or geological formation" (Emerson, 1932:349).

Howell also has a few comments concerning the soils of the pinyon pine-juniper association as a whole:

> " . . . . . the soils upon which the woodlands are found are for the most part calcareous and somewhat alkaline. In some places the subsoil is exposed due to accelerated erosion and in other places the soil has never been able to establish and maintain a surface horizon" (Howell, 1941:542).

Finally, Phillips (1909:217) mentions the type of soils in which the pinyon pine occurs most frequently.

> "The best stands [pinyon pine] are found on coarse gravel, gravelly loam, or a coarse sand of 1.5^{m} (5 feet) or more in depth, on which humus and ground cover are almost entirely lacking. The species often occurs on rocky areas, where the soil is only 15 to 30^{cm} ($6\text{-}12^{in}$) in depth, and frequently it is found growing in rock crevices. It is one of the first trees to gain a foot hold on the lava overflows which are known throughout the southwest as mal pais. This rock in its disintegrated form supports fair tree growth, but even before disintegration has progressed very far, the junipers and piñon may be found encroaching upon it."

Soil Moisture. The results of soil moisture determinations are shown in table II and figure 4. By reference to figure 4, it will be noticed that there is considerable difference in the moisture of the two slopes, the moisture of the soil of the east-facing slope usually being greater than that of the west-facing slope. It is distinctly evident that from the middle of June until late summer there is a marked lack of moisture as far as mesophytic vegetation is concerned. Moisture determinations of two samples from the bottom of the arroyo were made for comparison with the soil on the slopes, and it was found that there was much less soil moisture in the sandy soil of the arroyo, even though it was considerably more damp to the touch. This was probably due to the fact that the sandy loam of the slope has organic matter and smaller particles that retain much more bound and capillary water.

As might be expected the greatest amounts of soil moisture occur simultaneously with the greatest amounts of precipitation. In early March determinations were high due to the melting of snow that had fallen in February and early March. The relationship of soil moisture and rain is shown in figure 5. By reference to this graph, it will be seen that periods of increased precipitation were nearly always coincident with periods of increased soil moisture.

The only mention in the literature of soil moisture determinations in the pinyon pine-juniper association is

found in Emerson's (1932) paper. One of his sets of soil moisture data is given in tabular form, and is reproduced below (Emerson, 1932:349).

"Soil moisture records 24 hours after .75 inch of rainfall. Expressed in percentage of dry weight of soil

Source	Non-available Water[1]	Total Water	Available Water
15-30 cm. deep Piñon-juniper assoc . . .	13.7	22.5	8.8
30-45 cm. deep Same location	13.6	15.3	1.7
15-30 cm. deep Grassland	12.0	14.75	2.75

1 Determined by perminent [sic] wilting of Milo maize seedlings in each type of soil. Averages from four to eight tests for each soil. This set of soils derived from Greenhorn limestone."

Other experiments conducted by Emerson at other times of the year, but under the same conditions, show these results to be reliable and representative of conditions during the summer rainy period.

> "Examination of this table shows that even such a considerable rain as .75 inch affects soil moisture comparatively little below the upper foot (30 cm.) of soil, and that in the fine adobe soil where the grass was growing, most of the moisture remained in the upper 15 cm. of soil.
>
> "These differences of soil moisture lead to a consideration of the relation of available water to the positions of the roots in the soil" (Emerson, 1932:350).

From observations made on ecology class field trips to ponderosa pine forests, it was found that the soil moisture

content is almost the same for both the pinyon pine-juniper and ponderosa pine communities. However, if one goes to a higher elevation and into the spruce forest and aspen groves, the soil moisture content increases considerably. This is probably due to the increase in organic material in the soil, increased precipitation, and less evaporation. The grassland disclimax bordering the area studied has a lower soil moisture content.

Soil Hydrogen-ion Concentration. The pH of the soil ranged from 7.4 to 7.8 as shown in table III. Soils of this pH are considered slightly alkaline. All samples of soil from the west-facing and drier slope had a pH of 7.4 to 7.8 while the samples from the east-facing slope, which has deeper soil, were somewhat lower, 7.4 to 7.6. It can be observed from table III that the pH decreases on each slope from early spring to mid-summer, with pH values for the west-facing slope dropping the more. Towards the middle of July the pH values were the same for both slopes. This seasonal change in hydrogen-ion concentration of the soil can be attributed to the seasonal utilization of mineral salts by plants and by the leaching effect of rain during the summer.

No literature concerning the pH of the soil in other localities of pinyon pine-juniper communities appears to be available. Neither do there appear to be published records

of the hydrogen-ion concentrations of the soil in bordering grassland and ponderosa pine communities. Series of pH determinations made by members of the Biology Department of the University of New Mexico in these bordering communities indicate a generally higher pH on the more arid mesa and a lower pH in the coniferous tree communities at higher altitudes. The lower limits of the ponderosa pine, however, has about the same pH as the upper reaches of the pinyon pine-juniper community.

Organic Carbon of the Soil. On the ten soil samples of the linear series of soil samples used in the mechanical analysis of the soil, Dr. Hoff made a determination of organic carbon. Although some of these samples were taken from under a tree where the fallen juniper needles had accumulated, the percentage of organic carbon was low. In the one to two inch deep samples, the average percentage of organic carbon was 1.5% by weight, ranging from one to two per cent. In the three to four inch deep samples, the average percentage of organic carbon was 1.0% by weight, ranging from 0.91% to 1.25%. No determinations from other areas, from either pinyon pine-juniper communities or bordering communities, are available for comparison.

CHAPTER VI

RESULTS OF THE CLIMATIC INVESTIGATIONS

Precipitation. The precipitation was measured with a rain gauge during the period from April 28 to October 24, 1948. Results indicate that fairly heavy rains occurred at Juan Tabo during the last week of May, during the first and third week of June, and during the last week of July and first week of August. The average rainfall per week was about two tenths of an inch, while the total for the approximately six months period was 4.78 inches. Table IV gives the amount of rainfall for each observed period and the total accumulative rainfall after each reading, as well as comparative data for Albuquerque. The Albuquerque data were secured from the Albuquerque station of the United States Weather Bureau, located at the Municipal Airport, approximately 18 miles southwest of Juan Tabo. A graph (figure 6) shows the accumulative rainfall for the observed period on the dates on which the gauge was read. It was found that the amount of precipitation is somewhat greater at Juan Tabo than at the United States Weather Bureau Station at Albuquerque, 1500 feet lower in elevation. In contrast to the total for the observed period at Juan Tabo of 4.783 inches, the Weather Bureau recorded a rainfall of only 3.58 inches.

Thus the rainfall was 1.20 inches or about one third greater in the area studied than at the Weather Bureau Station. Considering the normal precipitation for Albuquerque as eight inches annually, one can compute the annual precipitation at Juan Tabo by setting up a proportion in which the precipitation at Albuquerque for the growing season (3.58 in.) is to that at Juan Tabo (4.78 in.) as the annual precipitation at Albuquerque (8.06 in.) is to the annual precipitation at Juan Tabo (x). Mathematically the proportion would appear thus 3.58:4.78::8.06:x. The resultant equation solved for x would give approximately 10.7 inches annually of precipitation at Juan Tabo, a figure in fair agreement with the precipitation recorded by various workers in the same community in other localities.

In discussing the pinyon pine-juniper community in Arizona, Nichol (1943:192) states that it is more sparsely watered than the ponderosa pine community, with the mean annual rainfall varying from 12 to 15 inches. Although Nichol's results are slightly higher than those of the present author, Hardy (1945:524) in his study of the pigmy conifers in Utah found the mean annual rainfall to be from 10.6 inches to 13.5 inches, varying with the vicinity. Hardy also states that precipitation increases with altitude at the rate of about one inch for every 328 feet. Woodbury (1947:122-123), in his study of the pigmy conifers in Utah

and Arizona, found that the precipitation in the pigmy conifer zone ranges from 10 to 15 inches, with a few trees occurring below the 10-inch precipitation line. In his study of the pinyon pine, Phillips (1909:218) found that the pinyon pines and junipers succeed where the average annual precipitation is less than 13 inches, and that under drought conditions the pinyon pines suffer considerably more than the junipers. Emerson (1932:354-355) in a graph of the rainfall in the pinyon pine-juniper community for the growing season from June 5 to August 14, 1931, showed the precipitation for the vicinity of Las Vegas, New Mexico, to be about seven inches. This is still considerably above those obtained by the present author for the Juan Tabo area in 1948, but a part of this difference may be due to the dry season in 1948.

Evaporation. The evaporation as measured with the aid of a Livingston atmometer was determined from May 5 to September 5, with the exception of the period from July 10 to August 4, when the atmometer did not function properly. The data are shown in table V. The average hourly rate is 2.48 cc., with a range from 0.73 to 4.13 cc. per hour. The higher evaporation rates appear to show a slight correlation with periods of little precipitation and high temperature, and the lower evaporation rates appear to have a little correlation with the periods of increased rainfall and low temperature,

as shown in table VI, but the nature of the data prevents accurate determination of degree of correlation.

Only two publications give a discussion of evaporation in connection with the pinyon pine-juniper community. Emerson's (1932:353-354) information on evaporation is contained mainly in graphs, which show a rate ranging from 190 to 320 cc. per week or 1.13 to 1.90 cc. per hour. These figures are an average of readings from several atmometers placed 30 rods apart in the association. Because of frequent frosts, the readings were considered reliable only for the period from July 3 to August 14, 1931. Emerson found that the evaporation rate is high during periods of reduced rainfall and low following heavy rains.

In Williams and Holch's (1945) study of the Black Forest of Colorado, a comparison is made of the evaporation rates from May 16 to September 12, 1938, in the grassland, pine belts, and the scrub oaks.

> "Evaporation rates were not markedly different in the three habitats from the middle of May to the middle of June nor after September 1. From the middle of June to the end of August, however, the evaporation rate was rather consistently greater in the pine community, lowest among the scrub oaks, and intermediate in the grassland. The evaporation rate was high in all three habitats: 35.2 cc. daily in the pines, 33.3 cc. in the grassland, and 29.3 cc. among the scrub oaks" (Williams and Holch, 1945:140).

The above records when compared with those from Juan Tabo show that the evaporation rate is considerably higher than in the localities studied by Emerson and by Williams

and Holch. This may be due to a number of factors. For example, the Juan Tabo area is at a lower latitude, the summer temperatures at Juan Tabo are higher, and the summer of 1948 was relatively dry. It is also possible that the topography may have some influence upon evaporation.

Air Temperatures. The maximum and minimum air temperatures were taken on the average of twice a week from April 8 until July 3, and about once a week from July 3 until September 5, as shown in table VII and figure 7. Freezing temperatures did not occur between April 28 and late October, while the average temperatures by months was as follows: April, 60°; May, 66.5°; June, 74.3°; July, 81.1°; and August, 80.2°. In general, the monthly average temperatures at Albuquerque from maximum and minimum temperatures for a similar period was never more than 2.8 degrees cooler or 1.95 degrees warmer than at Juan Tabo. In the summer months, June, July, and August, the maximum temperatures at Juan Tabo were considerably higher than at Albuquerque, while for the same period the minimum temperatures at Juan Tabo were approximately the same as those at Albuquerque. It must be remembered, however, that the thermometer at Juan Tabo was not in a standard Weather Bureau shelter and may, as a result, have registered somewhat higher temperatures.

Emerson (1932:355) using United States Weather Station records within the pinyon pine-juniper association at an

altitude of approximately 7,000 feet, obtained the following normal monthly temperatures: May, 59°; June, 65.5°; July, 68°; August, 65.5°; September, 64.7°; and October, 54.4°. These temperatures are considerably lower than those obtained by the author, but it must be remembered that Emerson worked at higher latitudes and utilized a sheltered thermometer. Emerson found that the highest temperatures of the year are coincident with the rainy season, making this the period of most active growth. Somewhat the same results were obtained by the present author as one of the periods of greater rainfall, occuring in July, can be correlated with the period of highest temperatures, also occurring in July. The period of the most rainfall occurred in the last two weeks of May, when the temperatures first went above 90°.

Woodbury (1947:122) gathered information concerning the temperatures of the pigmy conifers in Utah and found the average annual temperature of about 47° F., and extremes ranging from -26° to 101° F., a monthly mean ranging from 23° to 69° F. and a mean frost free period of 120 days.

Williams and Holch (1946) in Colorado found the average day temperature for the year in the pine community to be 66.88° F., the grassland to be 68.16° F. and the scrub oak to be 68.0° F. The average night temperatures for the year were highest in the pine forest (56.95° F.), lowest in the grassland (50.34° F.) and nearly as high (55.75 °F.)

in the scrub oak community as in the pine forest.

> "The mean weekly temperatures computed upon the daily maxima and minima reveal that the lowest minimum temperatures (. . . . .) were recorded in the grassland (43.6° F.), and the highest in the scrub oak community (51.7° F.), with the pine community nearly as high (51.4° F.). Mean weekly maximum temperatures (. . . . .) were 76.0° F. in the grassland, 78.0° F. in the scrub oak community, and 78.9° F. in the pine community.
>
> "There is a considerable daily range of temperature in all three communities, reaching an average of more than 32 degrees daily in the grassland habitat" (Williams and Holch, 1946:145-146).

Nichols (1943:192) in discussing the pinyon pine-juniper community in Arizona mentioned that the mean growing season temperatures range from 60 to 70 degrees with minima as low as 10 degrees above zero. In Utah, Hardy (1945:524) gives the average mean temperature for the pigmy conifer community as approximately 47.5° F., the average maximum temperature as about 61° F. and the average minimum as about 34° F.

CHAPTER VII

THE PLANTS AND ANIMALS AT JUAN TABO

Major Dominant Plants. Considerable attention was given the major dominant plants, the pinyon pines, Pinus edulis Engelm. in Wisliz., and the junipers, Juniperus monosperma (Engelm.) Sarg. In the area studied, there are approximately 10 pinyon pines and 10 junipers to every 100 square meters on the more moist east-facing slope, while on the west-facing slopes the proportion of junipers to the pinyon pines is considerably larger, about two to one. The density of stand diminishes toward the floor of the arroyo where the pinyons and junipers are replaced by scrub oak Quercus gambelii Nutt.; gooseberry, Ribes leptanthum A. Gray; and Apache plume, Fallugia paradoxa (D. Don) Endl.

Increment cores were taken from four of the larger pinyon pines and two of the larger junipers. The four pinyons have a diameter of 9.9, 8.3, 6.4, and 5.5 inches and an age of 85, 71, 63, and 57 years respectively. One juniper with a diameter of 7.0 inches has an age of 42 years; another of 13.3 inches diameter has an age of 86 years. The latter is the oldest tree measured in the area.

It was observed that the pinyons at Juan Tabo nearly always grow in juxtaposition with the junipers. Although it cannot be proved definitely that the junipers are the older

of the two climax trees, some substantiation for such a belief lies in the fact that the pinyons for the most part are smaller and grow from underneath the junipers. This is thought to indicate that the junipers sprout first and supply shade for the pinyon seedlings. The idea is further supported by observations on the pinyon pine-juniper community on the east side of the Sandia Mountains, as shown in figure 8, where the junipers appear to precede the pinyons, the latter developing only after the junipers furnish shade and shelter.

Howell (1941:543-544) in a study of the size and density of stand of the pinyon pine, Pinus edulis Engelm. in Wisliz.; Rocky Mountain juniper, Juniperus scopulorum Sarg.; and oneseed juniper, Juniperus monosperma (Engelm.) Sarg., in New Mexico, Arizona, and southern Colorado found that the average tree in this association is six inches in diameter at one foot above the ground and is 8.8 feet tall and has an average crown width of 7.2 feet. Although the average total height is below ten feet, he found that over 20 per cent of the oneseed junipers exceed 17.5 feet. As to stand composition, Howell found that the woodlands range from almost pure pinyon pine to pure juniper.

Phillips (1909:217-218) in west Texas, New Mexico, Arizona, and southern Colorado found that the pinyon pine, Pinus edulis Engelm. in Wisliz., reaches a maximum height of

40 to 50 feet and a diameter of between two and two and one half feet at breast height, but most mature individuals range from 10 to 35 feet in height and from one half to one and one half feet in diameter. On the most exposed sites, shrublike trees were found which were 50 to 80 years old and only 6 to 10 feet in height, with a crown diameter reaching a maximum of two to four times the height of the tree.

Woodbury (1947) in Utah and Arizona made an extensive study of the density of stand and composition of the pigmy conifers and found that in a mixed stand of pinyons and junipers the percentage of pinyon pine ranges from 17 to 90 per cent, with the pinyon pines increasing in number with increase in altitude. In Carbon County near Price, Utah, data based on a count of more than 1,000 trees show that 26.4 per cent of the trees are pinyons, while in Garfield County, Utah, at the upper limits of the pigmy conifer growth the pinyons make up 80 to 90 per cent of the stand.

> "The stand varies in density a great deal. In general, it is more open in the lower part of its altitudinal range showing a gradual increase in density with increase in altitude until the ecotone at the upper limit is reached where the stand rapidly thins out and is replaced by other vegetation. In the opposite direction near the lower limits, the stand often thins out gradually and leaves a straggling line at the bottom but there is often a sharp line of demarcation at the edge, especially in the discontinuities.
>
> "In the region of greatest density just below the upper edge of the zone, the trees appear to grow fastest,

> attain largest size and reach maximum development. Trees of both juniper and pinyon in this region have been measured that reach over 30 feet in height. Although these are unusual, it is believed that some get even taller. At lower altitudes, correspondingly shorter trees are often found and occasionally old trees no taller than a man are found in exposed habitats" (Woodbury, 1947:114-116).

This relationship of increase in the height of the pinyons with altitude was observed by the author in the Juan Tabo area. Those pinyons situated below 6,000 feet are stumpy and usually about 10 to 15 feet in height, while above 7,000 feet, where the pinyons compose 90 per cent of the community, the pinyons are from 20 to 30 feet in height.

Grasses. As the area studied has not been grazed for sixteen years, the stand of grass is relatively dense in comparison with that of the surrounding and heavily grazed areas of the pinyon and juniper community. The grasses of the area, along with their growing seasons and relative abundance, are listed in table VIII. By reference to this table, it will be seen that the more abundant grasses are, Bouteloua gracilis (H.B.K.) Lag. ex Steud., Bouteloua curtipendula (Michx.) Torr. in Emory, Poa longipedunculata Scribn., Hilaria jamesii (Torr.) Benth., Aristida longiseta Steud., and Stipa neomexicana (Thurb.) Scribn. Tall luxuriant grasses such as Hordeum murinum L. or mouse barley, Bromus frondosus (Shear) Woot. and Standl. or brome, and Eragrostis pilosa (L.) Beauv. or India lovegrass grows only

on the floor of the arroyos in corners where the soil cover is thick and a higher percentage of soil moisture is present. On the other hand, the center of the arroyo floor is apparently too sandy to permit growth of any of the grasses.

The effect of east and west exposure on vegetation is best demonstrated with respect to the stand of grasses. The grass is several times more dense and is composed of more species on the east-facing slope than on the west-facing slope. The results of basal area quadrat determinations clearly demonstrate this fact. The basal area covered by plants on the east-facing slope was computed to be approximately 397.3 square centimeters or about four per cent of the total area. This determination was made on June 23, 1948. The basal area covered by plants on the west-facing slope as determined on June 30, 1948, was found to be 260.3 square centimeters or 2.6 per cent of the total area. Weight determinations were made of grass clipped from the same basal area quadrats. On the basis of oven-dry weight, the grass clipped from the square-meter quadrat on the east-facing slope weighed 43.9 grams, while the grass from the quadrat on the west-facing slope weighed only 30.5 grams. Both determinations were made in unshaded areas with typical grass cover. The results indicate that the east-facing slope is approximately one third more productive than the west-facing slope so far as the grasses are concerned.

Observations of the bordering overgrazed area show that grazing prevents the variety and density of grasses that are present in the preserved area. Most of the grass in the grazed area is short and of limited use as forage. This is typical of most grasses in the pinyon pine-juniper association in the Southwest.

A study of the grasses found in the pinyon pine-juniper association near Las Vegas, New Mexico, by Emerson (1932:348) permits a comparison with the grasses at Juan Tabo. At Las Vegas the grasses consist of Bouteloua gracilis (H.B.K.) Lag. ex Steud., blue grama; Bouteloua curtipendula (Michx.) Torr. in Emory, side-oats grama; Buchloë dactyloides (Nutt.) Engelm., buffalograss; Hilaria jamesii (Torr.) Benth., galleta grass. All these are grasses typical of the surrounding grassland. In addition, Emerson found Aristida longiseta Steud., three-awned grass, which is more or less typical of the pinyon pine-juniper community. These grasses are about the same as those found at Juan Tabo, with the exception of Buchloë dactyloides (Nutt.) Engelm., which does not occur south of Sante Fe, New Mexico.

In the pinyon pine-juniper association in Utah, Hardy (1945:525) found that June grass (Bromus tectorum L.) and wheat grasses (Agropyron Gaertn. spp.) are commonly interspersed among the trees; while in Arizona, Nichol (1943:190) found that,". . . . . grasses such as bluestem (Agropyron

smithii), blue grama (probably the most outstanding single species of the forage grasses), galleta (Hilaria jamesii), and other less prominent grasses grow between the trees".

Forbs and Shrubs of the Climax. Because the area studied is protected from overgrazing, there occurs an abundance of flowering plants that is far greater than is to be found in the surrounding grazed areas of pinyon pine and juniper. Many more diverse genera grow within the fenced quadrat, while few genera, mostly composites and hardy perennials that can live in trampled thin soil, grow in the overgrazed land. It was also observed that when a certain species of flowering plant is in bloom, there are a great many more individuals in the fenced area than in an equal unit area outside the fence.

A list of forbs and shrubs observed between April 4 and September 16 and their time of blooming is given as a graph in figure 9, while table IX lists the scientific and common names, abundance, and location within the fenced area. The first plant to bloom was Lomatium nevadense (S. Wats.) Coult. and Rose, one of the parsley family. It was observed to blossom from April 4 until May 5. The most abundant plants during the spring growing season are Castilleja integra A. Gray in Torr., Fallugia paradoxa (D. Don) Endl., Actinea acaulis (Pursh) Spreng., Penstemon jamesii Benth in DC.,

Penstemon virgatus A. Gray in Torr., Verbena wrightii A. Gray, Gaura coccinea Nutt. ex Pursh, Melampodium leucanthum Torr. and Gray, Erysimum capitatum (Dougl.) Greene, Aplopappus wootoni (Greene) Standley, Erigeron flagellaris A. Gray, Solanum eleagnifolium Cav., and Cleome serrulata Pursh. Flowering plants that were the last to start blossoming are Dyssodia papposa (Vent.) Hitchc., Pectis papposa Harv. and Gray in A. Gray, and Oenothera albicaulis Pursh. Those forbs still blooming at the time of last observation in late October are Senecio longilobus Benth., Gutierrezia microcephala (DC.) A. Gray, Chrysothamnus parryi (A. Gray) Greene, and Pectis papposa Harv. and Gray in A. Gray. The abundance of flowering plants at various periods of the growing season is shown by figure 10. The greatest abundance of flowers occurs in the second week of June, attaining two small peaks again in August, and then decreasing steadily until mid-September, at which time only a few composites remain. The relative abundance of flowering plants from April to September in comparison to soil moisture is shown graphically in figure 11. To some extent, the increase in the number of species in blossom can be correlated with the increase in soil moisture. This was especially true in the later part of May and early part of June when there was a period of increased soil moisture, and also in August when both the number of species of forbs and shrubs in flower and soil moisture

fluctuated in the same direction on the same dates.

The flowering times of related species and genera were observed to overlap somewhat. Chief of these was in the genus Penstemon, in which three species P. jamesii, P. virgatus, and P. barbatus, all very similar in appearance, follow each other in time of initial blooming as shown in figure 12. As indicated in the same figure, related cacti also follow each other in time of blooming.

It was also observed that many more flowering plants appear on the east-facing slope than on the more xeric west-facing slope. Color photographs of parts of the fenced area with some typical flowering plants in bloom are given as figures 13 to 17. Black and white photographs allowing comparison of the vegetation on the east-facing and west-facing slopes and showing the general appearance of the vegetational cover within and without the fenced area may be found in figures 18 to 23.

A comparison of the forbs and shrubs at Juan Tabo with those found by other workers in pinyon pine-juniper communities is of considerable interest. The flowering plants inhabiting the pinyon pine-juniper community and surrounding grassland as described by Emerson (1932:348) for the Las Vegas, New Mexico region are ". . . . . Yucca glauca Nutt., Malvastrum coccineum (Pursh.) Gray, Gaura neomexicana Wooton, Ambrosia psilostachya DC., Actinella

simplex A. Nels., Aster ericaefolius Rothrock." In higher more xeric and rocky localities associated with the pinyon pine-junipers, Emerson found large thickets of Fallugia paradoxa (D. Don) Endl., Opuntia arborescens Engelm. in Wisliz., Quercus undulata Torr., and Rhus trilobata Nutt. ex Torr. and Gray. Essentially these are the same genera as found at Juan Tabo, but some of the species are different.

Hardy (1945:525) made brief mention of the flowering plants that are interspersed among the pigmy conifers in Utah. His list parallels the list for Juan Tabo and includes Artemisia tridentata Nutt., Gutierrezia sp., Gilia aggregata (Pursh) Spreng., several penstemons, a number of Astragalus, many species of Eriogonum, and numerous Cruciferae.

Plants of the Arroyo. The greatest number of plants was observed on the floor of the arroyo, which contained an entirely different type of vegetation, oak and berry bushes being the apparent major dominants. Members of the Cruciferae or mustard family are the most common flowering plants in the arroyo. These are of the genera Corydalis, Descurainia, Lesquerella, and Erysimum. Also very common were members of the genera Fallugia, Ribes, Cleome, Quercus, Philadelphus, Solanum, and Lycium. The only member of the genus Penstemon that grows in the arroyo is P. barbatus, of which there were only two plants in the summer of 1948. The

only flowering plant common to both the climax community at Juan Tabo and the seral stage within the arroyo is Verbena wrightii.

As for the flowering plants in such terrain as found in the arroyo, Nichol (1943:190) states that ". . . . . cliff rose, mountain mahogany, scrub oak (Quercus turbinella), spirea (Chamaebatiaria millefolium), mimosa (Mimosa biuncifera), algerita or barberry (Berberies fremontii), snakeweed (Gutierrezia tenuis), rabbit brush (Chrysothammus spp.), and many others occur." Since Nichol's paper is concerned with the pinyon pine-juniper community in Arizona, considerable difference can be expected between plants found in his locality and those found at Juan Tabo.

Invertebrates. The only work carried out in connection with the invertebrate population was a study of the number of soil invertebrates present under varying conditions within the study area. On July 10, 1948, a count of the invertebrates in a square foot of soil and litter to a depth of four inches was made beneath a pinyon pine tree and a similar count was made beneath a juniper tree. Both of these trees are on the east-facing slope. From beneath the pinyon only two invertebrates, an adult scarabeid beetle and a beetle pupa, were secured. The litter here appeared to contain little decomposed organic matter. From underneath the juniper, three invertebrates, two ants and one small spider, were found in a

square foot of soil and litter to a depth of four inches. Somewhat more organic matter was present here than beneath the pinyon. On July 17, two more samples were examined, these being from the southeast-facing slope. Underneath the pinyon there were found eight invertebrates, two small ants, two large mites, three small spiders, and one beetle larva, per square foot. Under the juniper there were collected nineteen invertebrates, five small spiders, two large and four small ants, six large mites, and two small beetle larvae. This is more than twice the number found under the pinyon. As before, there was considerably more organic material in the soil under the juniper than under the pinyon. On August 11, three more soil invertebrate determinations were made. The first was made in the open among grasses in the center of the transect. This count yielded six animals, two spiders, three small ants, and one beetle larva. The second was taken from beneath a pinyon on the east border of the fenced area, where the litter was about one half of an inch deep. There were six soil invertebrates, one large and two small spiders, one small ant, one beetle larva, and one large red mite. The third and last sample was taken from beneath a nearby juniper. Here there was an inch and a half of litter, this being somewhat more decomposed than the litter in the other two sampling areas. The count for this area was 14 invertebrates, including one large beetle, three large red mites, three small

ants, six small spiders, and one beetle larva. From these investigations it can be seen that there are usually twice as many soil invertebrates in the litter and soil under the junipers than under the pinyon pines.

In comparison to the pinyon pine-juniper community, Blake (1931:514) found that the soil invertebrate population of the elm-maple community in Illinois was from 80 individuals in March to three individuals in June, 1925, per square foot of soil and leaf litter 10 cm. deep. Davidson (1932), also working in Illinois but in the maple-red oak community, found a soil invertebrate population averaging about 155 individuals per square foot in the upper 10 cm. of soil and litter. It is quite apparent that in the deciduous forest community the soil is many times richer in soil invertebrates than is the soil of the relatively unproductive pinyon pine-juniper community. In making comparison with the pinyon pine-juniper community, one must not forget that the maple-red oak community and the elm-maple community are not climax communities and that the soil is deep and moist.

A comparison of the various soil invertebrate counts in communities near Albuquerque is possible by use of studies made during the fall of 1947 by a class in Ecology. The data include two invertebrates per square foot of soil in the grassland disclimax; eight soil invertebrates in the over-grazed pinyon pine-juniper community; three soil invertebrates

in the grazed ponderosa pine community; and finally in an aspen grove, 15 soil invertebrates. The invertebrates of the last community differ very much taxonomically from those found in other communities. The soil invertebrates of the grassland, pinyon pine-juniper, and ponderosa pine communities are taxonomically related.

Reptiles. The first appearance in the spring of a reptile was on April 16, 1948, when a male Southern Plateau lizard or fence lizard (Sceloporus Wiegmann) was observed sunning himself on a large rock in the arroyo. From that time until early September these lizards were frequently seen, especially in the arroyo and on rocky slopes. The mountain boomer or western collared lizard (Crotaphytus collaris Say) was observed for the first time on May 5. This lizard is a common resident of the entire fenced area, not being seen, however, after early September. The most common lizard at Juan Tabo is the racerunner (Cnemidophorus Wagler), which first appeared on May 21 and was common in the area until late August. There appear to be either two separate species of racerunner or the smaller of the two groups may possibly be the young of the larger. In one group individuals, with distinct spots on their backs, were found to be 12 to 14 inches in length. These larger lizards frequent large rocks on the sides of the arroyos as well as the tops of small hills. The

In the grazed ponderosa pine community and about an aspen grove, 15 soil [illegible] were tabulated. The [illegible] of the last community differ very much ecologically from those found in other communities. The soil arthropods of the grassland, pinyon pine-juniper, and [illegible] communities are taxonomically related.

Reptiles. The first appearance of the [illegible] reptile was on April 16, 1941, when a male Southwestern [illegible] lizard or fence lizard (Sceloporus [illegible]) was seen sunning himself on a large rock in the arroyo. From that time until early September these lizards were frequently seen, especially in the arroyos and on rocky slopes. The [illegible] boomer or western collared lizard (Crotaphytus collaris [illegible]) was observed for the first time on May 5. This lizard is a common resident of the entire Jemez area, not being seen, however, after early September. The most common lizard at Juan Tabo is the racerunner (Cnemidophorus sexlineatus), which first appeared in May [illegible] and was common in the area until late August. There appear to be either two separate species of racerunner or the smaller of the two groups may possibly be the young of the larger. In one group individuals, with distinct spots on their backs, were found to be 12 to 14 inches in length. These larger lizards frequent large rocks on the sides of the arroyos as well as the tops of small hills. The

other group is composed of individuals that are from three to six inches long, darker, and decidedly striped. The latter are more common on the sandy floor of the arroyos. Due to the lack of captured specimens, it was impossible to make certain species determinations of these lizards.

The first snake observed in the spring was a Great Basin garter snake (Thamnophis ordinoides vagrans Baird and Girard) that appeared on May 19, but was not observed again during the summer. The only other snake observed was a gopher snake (Pituophis catenifer Blainville) that had been killed in the road a quarter of a mile from the fenced area. Rattlesnakes have been reported from time to time at Juan Tabo, but the author did not observe them.

In comparison with the grassland and desert-grassland at lower elevation, the reptile population is somewhat smaller and less diversified. Ruthven (1907) in a study of the Alamogordo region in New Mexico and an area near Tucson, Arizona, found a few reptiles inhabiting the pinyon pine-juniper community. For the Alamogordo area, these are Uta ornata Baird and Girard, Sceloporus consobrinus Baird and Girard, Phrynosoma hernandesi Girard, and Pituophis catenifer sayi Schlegel. Ruthven gives the same list for the Tucson area except that Pituophis catenifer sayi Schlegel is absent. In summarizing the reptilian population of this association, he states, ". . . . . That the reptile fauna of the Pine-

Spruce and Pinon-Cedar association is (considered together) composed of but few species, some of which are partly arboreal in habits." (Ruthven, 1907:600).

Birds. Since the collecting of birds is forbidden without a special permit, all records, as given in table X, are based on field identification. The subspecific names are assumed from the locality in which the birds were observed rather than from identification of specimens. For the most part, the birds were identified in the field with the aid of Peterson's A Field Guide to the Western Birds. The table includes the writer's records for 1947 as well as 1948 and is extended to include areas of the community ranging from 14 miles south of Juan Tabo in the Manzano Mountains to a mile north of the Juan Tabo recreation area. None of the nesting sites for the birds observed were found in the pinyon pine-junipers, although the literature lists several birds that are known to nest exclusively in this community. Hardy (1945) claims that in Utah the pinyon jay, Cyanocephalus cyanocephalus (Wied.) and the gray titmouse, Baelophus inornatus griseus (Ridgway), breed, raise their young, and spend the winter in the pinyon pine-juniper association. The lead-colored bush-tit, Psaltriparus plumbeus Baird, is also considered an obligate permanent resident except that it is known to nest occasionally in the lower limits of the ponderosa pines (Hardy, 1945:528).

Since no nests were found, only the fact that certain birds were observed in the pinyon pine-juniper community throughout the whole year could be used as a basis for classifying these birds as permanent residents. These birds are the Woodhouse jay, Aphelocoma californica woodhousei (Baird); mountain chickadee, Penthestes gambeli gambeli (Ridgway); and possibly the gray titmouse. Permanent residents that are not confined to the pinyon pine-juniper community are the turkey vulture, Cathartes aura septentrionalis Wied; desert sparrow hawk, Falco sparverius phalaena (Lesson); pinyon jay; canyon wren, Catherpes mexicanus conspersus Ridgway; common rock wren, Salpinctes obsoletus obsoletus (Say); and possibly the canyon towhee, Pipilo fuscus mesoleucus Baird. Hardy (1945:531) also lists permanent residents that are not limited to the pinyon-junipers in Utah. These are the western red-tailed hawk, Buteo borealis calurus Cassin; the golden eagle, Aquila chrysaëtos canadensis (L.); eastern sparrow hawk, Falco s. sparverius L.; the Montana horned owl, Bubo virginianus occidentalis Stone; and the American raven, Corvus corax sinuatus Wagler.

During the summer the violet-green swallow, Tachycineta thalassina lepida Mearns; Woodhouse jay; western robin, Turdus migratorius propinquus Ridgway; and the gray titmouse are the more abundant birds in the area studied by the present author. The only migrant birds observed were

the mountain bluebird, Sialia currucoides (Bechstein), and Audubon's warbler, Dendroica a. auduboni (Townsend). Undoubtedly there are many more migrant visitors, although for the most part migrant birds travel either in the valley or through the ponderosa pine community. A comparison based on observations of other nearby communities indicates that the pinyon pine-juniper association has a relatively low bird population.

Hardy (1945:541) found 14 other birds that are summer residents and that breed in the pinyon pine-juniper community in Utah. Most of these are passerine birds, which in winter are forced to migrate from the pinyon pine-juniper community when they are unable to find sufficient food. These birds nest in cavities in trees, on the limbs of trees, on the ground, and beneath rocks upon the ground.

Miller (1946:58-59) compiled a list of the birds found in the pinyon pine-juniper association of the Death Valley region where the dominant trees are the pinyon pine, Pinus monophylla Torr. and Frém. in Frém., and juniper, Juniperus utahensis (Engelm.) Lemmon. For the most part, the list parallels the present writer's list except for specific and subspecific names. Miller found 55 summer residents and 12 additional transient and vagrant birds in his study, while only 31 species were observed at Juan Tabo. Possibly the pinyon pine-juniper association of the Death Valley region

has a greater variety of birds due to its proximity to the Pacific coast migration flyway and as a result of the variety of habitats in the vicinity.

In comparison with other woodland communities in various parts of the United States, the number of birds at Juan Tabo is relatively small. This is probably due to the scarcity of water and a possible inadequacy of food.

Mammals. A list of mammals was compiled for the Juan Tabo area from the writer's trapping and sight records, records of scats or other signs, and from information submitted by a State Game Department trapper. In table XI are listed the animals frequenting the area and the relative abundance of each. The subspecific names given for the mammals in the table and the text are assumed from the geographic localities in which the mammals were observed or trapped and not determined from examination of preserved specimens. This table shows that the common mammals present at Juan Tabo include Say's rock squirrel, Citellus variegatus grammurus (Say); larger Colorado chipmunk, Eutamius q. quadrivittatus (Say); cedar-belt cottontail, Sylvilagus auduboni cedrophilus Nelson; Texas plains coyote, Canis latrans texensis Bailey; hoary wood rat, Neotoma micropus canescens Allen; and the white-throated wood rat, Neotoma a. albigula Hartley. Individuals were observed or skins were secured of all these species and of the two kinds of Peromyscus: tawny deer mouse,

Peromyscus maniculatus rufinus (Merriam); large-eared deer mouse, Peromyscus t. truei Shufeldt; and Baird's pocket mouse, Perognathus f. flavus (Baird). The State trapper submitted evidence for the mountain wild cat, Lynx rufus uinta Merriam; common badger, Taxidea taxus (Schreber); and Rocky Mountain cougar, Felis concolor Merriam; while the presence of deer is verified by one sight record and by many tracks and scats. Virtually all the pinyons showed evidence of the feeding of porcupines, as bark was frequently stripped from trees, especially in early spring.

A majority of the rodents nest in the rocky sides of the arroyo. Chief among these are the wood rats and chipmunks. Many wood rat nests were found, characterized by accumulations of cactus branches, pine cones, and detritus. Most of these nests are in crevices in the large boulders, although two nests were found among small rocks on the east-facing slope. The rock dams built by the Civilian Conservation Corps provides shelter and protection for many of the rodents as evidenced by large piles of scats and food remains. No mammals were ever trapped, however, in the vicinity of these dams.

Several rock squirrel dens were found on the east-facing slopes of the area, but they were possibly unoccupied due to disturbance by badgers. The only mammals trapped beneath the climax trees were one Baird's pocket mouse,

Perognathus f. flavus (Baird), and one tawny deer mouse, Peromyscus maniculatus rufinus (Merriam). The cedar-belt cottontail, Sylvilagus auduboni cedrophilus Nelson, and Say's rock squirrel, Citellus variegatus grammurus (Say) have been observed frequently underneath the pinyons and junipers.

Some idea of the part played by many of these animals in the community can be secured from a study of their food. From evidence in rock crevice dens, it seems that the wood rats utilize as food cactus fruit, pinyon nuts, and various large seeds. The squirrels and chipmunks also feed on the pinyon nuts, but there is some doubt as to whether the nuts form the main part of their diet. In the winter, the deer browse heavily on the juniper as shown by the condition of the trees themselves and by the presence of juniper leaves in the deer scats. The porcupine has a singular place in the community as it feeds directly on the pinyon pines throughout the year, and may be responsible for the death of a few of them. For some reason, only the pinyons are debarked by the porcupines.

Although many mammals are found at Juan Tabo, the writer was able to secure little data on population numbers. Those rodents most frequently trapped were two species of wood rat, which are very abundant on the rocky sides of the arroyo. The Peromyscus are more common on hilltops under the climax vegetation, but are not as numerous as the wood

rats, chipmunks, and rock squirrels, which ranged over the entire fenced area. The coyote is very common, several being observed in the area during the nights spent trapping. Twelve coyotes were trapped at Juan Tabo by the State trapper in two weeks. The trapper also trapped three wild cats in the spring and found evidence of the Rocky Mountain cougar.

Several investigators of the pinyon pine-juniper association have mentioned the mammalian inhabitants of this community. Chief of these investigators is Miller (1946:55) who studied an area in the Death Valley region, where the species of dominant plants differs from those at Juan Tabo. The life form and general appearance are very similar, however, to the plants of the Juan Tabo area. Miller remarks that the characteristic mammals of the community are the Panamint chipmunk, Eutamius panamintinus (Merriam); pinyon deer mice, Peromyscus t. truei (Shufeldt); and the mule deer, Odocoileus hemionus (Say). A list of mammals compiled (Miller, 1946:60) parallels the list obtained at Juan Tabo remarkably close except for the species and subspecies.

"Mammals

Black-nosed Bat, Myotis subulatus melanorhinus
Canyon Bat, Pipistrellus hesperus hesperus
Badger, Taxidea taxus
Coyote, Canis latrans
Antelope Ground Squirrel, Citellus leucurus leucurus
Panamint Chipmunk, Eutamias panamintinus panamintinus
Pocket Gopher, Thomomys bottae oreoecus
Great Basin Pocket Mouse, Perognathus parvus olivaceus

rats, chipmunks, and rock squirrels, which ranged over the entire fenced area. The coyote is very common, several being observed in the area during the eight-day trapping. Twelve coyotes were trapped at dawn made by the State trapper in two weeks. The trapper also trapped three wild cats in the spring and found evidence of the rocky Mountain cougar.

Several investigators of the pinyon pine-juniper association have mentioned the mammalian inhabitants of this community. Chief of these investigators is Miller (1946:85) who studied an area in the Death Valley region, where the species of dominant plants differs from those at Dugway. The life form and general appearance are very similar, however, to the plants of the Dugway area. Miller reports that the characteristic mammals of the community are the Panamint chipmunk, Eutamias panamintinus (Merriam); pinyon deer mice, Peromyscus t. truei (Shufeldt); and the mule deer, Odocoileus hemionus (Say). A list of mammals compiled (Miller, 1946:80) parallels the list obtained at Dugway remarkably close except for the species and subspecies.

Mammals

Black-tailed Hare, Lepus californicus melanotis
Canyon Rat, Piglodontia Neotoma cinerea
Badger, Taxidea taxus
Coyote, Canis latrans
Antelope Ground Squirrel, Citellus leucurus leucurus
Panamint Chipmunk, Eutamias panamintinus panamintinus
Pocket Gopher, Thomomys bottae browsoe
Great Basin Pocket Mouse, Perognathus parvus olivaceus

Long-tailed Pocket Mouse, Perognathus formosus mohavensis
Harvest Mouse, Reithrodontomys megalotis megalotis
Common Deer Mouse, Peromyscus maniculatus sonoriensis
Pinyon Deer Mouse, Peromyscus truei truei
Canyon Deer Mouse, Peromyscus crinitus stephensi
Desert Deer Mouse, Peromyscus eremicus eremicus
Desert Wood Rat, Neotoma lepida lepida
Porcupine, Erethizon epixanthum
Nuttall Cottontail, Sylvilagus nuttallii grangeri
Audubon Cottontail, Sylvilagus audubonì arizonae
Mule Deer, Odocoileus hemionus
Mountain Sheep, Ovis canadensis"

Svihla (1932:71) in a study of the ecological distribution of mammals in Utah, states that there are 18 different species of mammals inhabiting the pinyon pine-juniper association. The list is much the same as Miller's except for the subspecific names.

In Nichol's (1943:192) discussion of the pinyon pine-juniper association of Arizona, he states:

> "The native wildlife was correspondingly scarce but has increased with the development of water. Antelope preyed upon by wolves and coyotes was the most abundant large mammal, with occasional herds of mule deer. In winter, elk and additional herds of mule deer wintered in this forest finding excellent protection and less severe temperatures."

Dice (1930) also lists the mammalian population of the pinyon pine-juniper community. Although the area studied by Dice is situated near Alamogordo in southern New Mexico, the appearance of the vegetation is very similar to that at Juan Tabo. However, there is a much longer growing season and the precipitation, 20 inches annually, is much greater than at Juan Tabo. Dice (1930:15-16) states that few mammals are

characteristic of and none are restricted to the association. The most abundant mammals are the rock squirrel, pinyon mouse, and Mexican wood rat. Quoted below is the complete list of mammals observed and trapped by Dice in the pinyon pine-juniper community.

"Citellus grammurus grammurus. Rock squirrel, numerous.
Eutamias cinereicollis canipes. Gray-footed chipmunk, 3.
Perognathus intermedius intermedius. Rock pocket-mouse, 1.
Peromyscus maniculatus rufinus. Tawny deer-mouse, 1.
Peromyscus truei truei. Pinyon mouse, 33.
Neotoma mexicana mexicana. Mexican woodrat, 9.
Lepus californicus texianus. Texas jack-rabbit, 2.
Sylvilagus audubonii minor. Desert cottontail, 5.
Odocoileus couesi. Coues deer, 1.

". . . . . Aerial community (pinyon-cedar belt):
Pipistrellus hesperus hesperus. Canyon bat, 1.
Eptesicus fuscus fuscus. Large brown bat, 1."
(Dice, 1930: 16-17).

In comparison with nearby communities, the pinyon pine-juniper association is fairly rich in mammalian life. This is probably due to the protection afforded by the rough terrain and to the vegetational cover.

CHAPTER VIII

SUMMARY AND CONCLUSIONS

The pinyon pine-juniper association in the foothills of the Sandia Mountains near Albuquerque, New Mexico, has a position in altitude between the lower short or mixed grass association and the higher ponderosa pine association. The community has an altitudinal range of about 6,000 to 7,200 feet. At the lower elevations, the junipers predominate; at the higher range of elevation, the pinyons occur in an almost pure stand.

The soil in the Juan Tabo region, the area of intensive study, is a sandy loam derived chiefly from granites, schists, quartz, and related rocks. As a result of the rough topography and marked erosion, there is little opportunity for the accumulation of silt and clay soil fractions. The soil is shallow, often only a few inches deep, and is underlain with slowly disintegrating bedrock. The pH of the soil varies from 7.4 to 7.8, indicating the lack of salts in the soil due to leaching. During the summer of 1948, the soil moisture varied from 1.3 to 14.8 per cent of dry soil weight. The higher value was found in mid-March and at no other time did the soil moisture exceed 10 per cent. Some difference in soil moisture is found between the east- and the west-facing slopes, the former being slightly more moist. The amount of organic matter in the soil is small as

indicated by organic carbon determinations ranging from one to two per cent of organic carbon by weight in the soil of the one to two inch depth and an average of one per cent in the soil of the three and four inch depths.

The climate of the area studied is moderate and semi-arid. The precipitation for the period from April 28 to October 24, 1948, is 4.78 inches, with most of the precipitation being in the last week in May, first and third week of June, and in late July and early August. During the same period, there was recorded 3.58 inches of precipitation at the Albuquerque weather station. Assuming that the average annual precipitation for Albuquerque is about eight inches and assuming that the same relationship in amounts of precipitation is true for the entire year between the Juan Tabo area and Albuquerque, one may compute an annual precipitation of about 11 inches annually for the Juan Tabo area. This appears to be slightly less than reported for the association in Arizona and Utah. The evaporation rate is high, often exceeding more than 60 cc. per day, and reaching as much as 99 cc. per day during one period in mid-August. Maximum and minimum daily air temperatures during the growing season appear to be very similar to those for Albuquerque, but the lack of standard weather instruments and housing precludes an exact comparison. In general, the Juan Tabo area appears to be somewhat warmer than other localities in the pinyon

pine-juniper communities of the Southwest as recorded in the literature.

The major dominant plants are the pinyons and the junipers. It was found that the typical stand of pinyons and junipers in the area under intensive investigation is composed of about equal numbers of the two dominant trees. The density is about 20 trees for each 100 square meters. The age of the larger pinyons as determined by increment cores ranged from 57 to 85 years, while two junipers were determined to have ages of 42 and 86 years. The trees do not attain a diameter in the lower part of the trunk of more than 15 inches and seldom more than 10 inches. The arrangement of the two types of climax trees with respect of one to the other indicates the possibility that the junipers develop first and that the pinyon seedlings develop only in the shade and protection of the juniper seedlings.

The preserved area studied is rich in grasses and appears to have about the same composition as the bordering grassland association, the more common grasses being blue grama grass, side-oats grama, three-awned grass, mutton grass, and galleta grass. This similarity may indicate that the area studied was originally grassland and that, as a result of overgrazing and erosion, the pigmy conifers have found it possible to invade the area. The extent of the development of the grasses is indicated by basal area

quadrats, which indicate a coverage of about four per cent, and by clip quadrats, which indicate a dry weight of grasses of about 40 grams per one square meter of area. There is slightly better coverage by grasses on the east-facing than on the west-facing slope.

During the growing season, 57 species of forbs and flowering shrubs were collected in the preserved area. Based on records of the seasonal distribution of these plants, it is apparent that there is a correlation between the actual number of species flowering at a given time and the amount of soil moisture and precipitation. The greatest number of flowering plants were found from June 5 to 11 and a second but lesser peak occurred about August 1. From general aspection, it is obvious that many more flowering plants are to be found in the preserved area than in the bordering grazed country-side. Entirely different species of flowers are found in the arroyo bottoms than are found on the hillsides and hilltops. The flowering plants reported as being typical of the association at Juan Tabo appear closely related taxonomically to the plants reported as characteristic of the same association in other parts of the Southwest.

Investigation of the soil invertebrates in the pinyon pine-juniper community indicates a low population density. At the most, there were found no more than nineteen invertebrates in the upper four inches of soil and the overlying

litter. This is somewhat more than can be expected in the grassland, but lower than is to be found in the montane forests at higher elevations. This number is extremely low when compared with the numbers of soil invertebrates found in the north temperate deciduous forests or the coniferous forest of the Pacific northwest. The low population of soil invertebrates is probably correlated with the small amount of decomposing organic matter, the low moisture content of the soil, and the sandy nature of the soil.

The Juan Tabo area is fairly rich in reptiles, birds, and mammals. The reptiles are represented by five different genera and possibly six species. Although the number of kinds is small, the population density is fairly great. With respect to birds, 31 different species of birds were observed. Few birds are true obligate residents of the area, but there are numerous transient species. During the summer, the more commonly observed birds are Woodhouse jay, mountain chickadee, gray titmouse, common rock wren, white-throated swift, turkey vulture, desert sparrow hawk, and pinyon jay. It is possible that a lack of water during the hottest part of the summer drives some birds out of the immediate area. The list of birds compiled for the pinyon-juniper association in the Sandia Mountains is much smaller than lists available for the same association in Utah, Arizona, and California. With respect to mammals, the rodents are the most abundant. These appear

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to be confined chiefly to the sides of arroyos where there is considerable protection and cover. Of the 14 species and subspecies of mammals found, deer, wood rats, squirrels, porcupine, and some predators possibly exert considerable influence on the community. The mammals appear to be of the same general kinds throughout the areas of the pinyon pine-juniper association of the Southwest, differing chiefly as to subspecies from one geographical locality to another.

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TABLE I

MECHANICAL ANALYSES OF SOIL AT JUAN TABO

Soil fractions are given according to the system of classification of the United States Bureau of Chemistry and Soils.

	Sand	Silt	Clay
West-facing Slope	One to Two Inches Deep		
Percentage by weight in each class.	70.8%	21.7%	7.5%
Range of the five samples.	68.9-74.0%	18.7-24.2%	6.1-9.3%
	Three to Four Inches Deep		
Percentage by weight in each class.	70.1%	19.8%	10.1%
Range of the five samples.	68.2-73.8%	17.8-21.5%	6.4-11.9%
East-facing Slope	Two to Three Inches Deep		
Percentage by weight in each class.	69.0%	21.8%	9.2%

TABLE II

SOIL MOISTURE

Date	East-facing slope % of dry weight	West-facing slope % of dry weight	East minus West
March 14*	14.8	5.4	9.4
March 25**	7.5	7.8	-0.3
April 4	8.8	4.4	4.4
April 8	3.2	3.6	-0.4
April 16	3.0	1.4	1.6
April 23	8.7	6.4	2.3
April 30	5.5	2.5	3.0
May 8	2.3	1.7	0.6
May 14	1.3	1.1	0.2
May 21	Not valid	1.1	
May 28	9.3	5.7	3.6
June 5	8.2	3.7	4.5
June 11	4.4	1.1	3.3
June 19	1.8	1.3	0.5
June 27	1.4	1.8	-0.4
July 3	1.9	1.1	0.8
July 10	1.3	1.5	-0.2
July 17	1.5	1.0	0.5
July 25	3.4	1.3	2.1
August 1	4.3	1.4	2.9
August 11	2.1	3.0	-0.9
August 17	3.2	1.4	1.8
September 5	1.6	1.1	0.5

* Moisture determination of soil in arroyo for this date was 4.2%.

** Moisture determination of soil in arroyo for this date was 3.8%.

TABLE II

SOIL MOISTURE

Date	% of dry weight		
March 14*	3.2	5.4	4.4
March 25**	4.2	1.2	3.2
April 4	3.	4.	4.2
April 8	3.	3.8	3.4
April 15	3.0	4.4	4.2
April 22	3.3	4.	4.2
April 30	3.3	4.2	3.8
May 6	3.3	4.	3.5
May 14	4.	4.1	4.2
May 21	Not Valid	4.	
May 28	3.3	4.	4.2
June 5	3.2	3.7	4.3
June 11	4.4	4.	4.1
June 19	4.3	4.	4.2
June 27	3.4	4.2	4.2
July 3	4.	4.	4.3
July 10	4.3	4.	4.2
July 17	4.3	4.	4.2
July 26	3.4	4.2	4.
August 1	4.3	4.	4.2
August 11	3.2	3.9	4.2
August 17	3.2	4.	4.3
September 5	4.3	4.3	4.2

* Moisture determination of soil in trays for this date was 4.2%.

** Moisture determination of soil in trays for this date was 3.8%.

TABLE III

HYDROGEN-ION CONCENTRATION OF THE SOIL, EXPRESSED AS pH

Date	East-facing	West-facing	East minus West
March 25, 1948	7.4	7.8	-0.4
April 4	7.6	7.8	-0.2
April 8	7.6	7.8	-0.2
April 16	7.6	7.8	-0.2
April 30	7.6	7.8	-0.2
May 14	7.6	7.6	0.0
May 28	7.6	7.6	0.0
June 11	7.4	7.6	-0.2
June 27	7.6	7.6	0.0
July 10	7.4	7.4	0.0
July 17	7.4	7.4	0.0

TABLE IV

PRECIPITATION RECORDED FROM APRIL 28 TO OCTOBER 24

Results are given as the number of cubic centimeters of actual water collected in the rain gauge, computed inches of rainfall for each period, accumulative rainfall, and inches of rainfall in Albuquerque for equal periods.

Period	Number of cc.	Rainfall, inches		Total rainfall inches	
	Juan Tabo	Juan Tabo	Alb.	Juan Tabo	Alb.
Apr 28-May 14	00	0.00	0.00	0.00	0.00
May 14-19	25	0.02	.01	0.02	0.01
May 19-21	00	0.00	.00	0.02	0.01
May 21-25	485	0.34	.64	0.36	0.65
May 25-June 2	1505	1.06	.72	1.42	1.37
June 2-5	00	0.00	.00	1.42	1.37
June 5-11	00	0.00	.00	1.42	1.37
June 11-19	22	0.02	.10	1.44	1.47
June 19-23	500	0.35	.04	1.79	1.51
June 23-27	00	0.00	.00	1.79	1.51
June 27-30	00	0.00	.00	1.79	1.51
June 30-July 3	75	0.05	.00	1.84	1.51
July 3 -10	232	0.16	.03	2.00	1.54
July 10-17	00	0.00	.00	2.00	1.54
July 17-25	460	0.32	.35	2.32	1.89
July 25-Aug 4	520	0.37	.15	2.69	2.04
Aug 4-11	540	0.38	.38	3.07	2.42
Aug 11-13	00	0.00	.00	3.07	2.42
Aug 13-17	42	0.03	.01	3.10	2.43
Aug 17-23	103	0.07	.01	3.17	2.44
Aug 23-Sept 5	100	0.07	.02	3.24	2.46
Sept 5-17	272	0.19	.28	3.43	2.74
Sept 17-Oct 24	1910	1.35	.84	4.78	3.58

TABLE V

EVAPORATION RATE

Period	Evap. in cc.	Corrected Evap. in cc. for Standard Atmom.	Evap. cc. per day	Evap. cc. per hr.
May 5-8	260	210.60	70.20	2.92
May 8-12	230	186.30	46.58	1.94
May 12-14	160	129.60	64.80	2.70
May 14-19	530	429.30	85.86	3.57
May 19-21	190	153.90	76.95	3.21
May 21-25	320	259.20	64.80	2.70
May 25-28	65	52.65	17.55	0.73
May 28-June 2	355	287.55	57.51	2.39
June 2-5*	220	178.20	59.40	2.48
June 5-11	520	390.00	65.00	2.71
June 11-19	880	660.00	82.50	3.44
June 19-23	280	210.00	52.50	2.19
June 23-27	370	277.50	69.38	2.89
June 27-30	260	195.00	65.00	2.71
June 30-July 3	315	236.25	78.75	3.28
July 3-10	232	174.00	24.86	1.04
July 10-17	---	Atmometer		
July 17-25	80	not		
July 25-Aug 1	80	working		
Aug 1-4	---			
Aug 4-11**	390	312.00	44.57	1.86
Aug 11-13	80	64.00	32.00	1.33
Aug 13-17	248	198.40	99.20	4.13
Aug 17-23	535	428.00	53.50	2.23
Aug 23-Sept 5	965	772.00	59.38	2.47

* Atmometer #4 with a correction factor of 0.81 was replaced on June 5 by atmometer #S48-111 with correction factor of 0.75.

** Atmometer #S48-111 was replaced on August 4 by atmometer #S48-181 with a correction factor of 0.80.

TABLE VI

A COMPARISON OF THE EVAPORATION, PRECIPITATION, AND AIR TEMPERATURES AT JUAN TABO

Period	Evaporation per day	Rainfall	Maximum temperature	Minimum temperature
May 5-8	70.20 cc.	0.00 in.	82°F.	38°F.
May 8-12	46.58	0.00	78	36
May 12-14	64.80	0.00	85	48
May 14-19	85.86	0.02	94	52
May 19-21	76.95	0.00	91	54
May 21-25	64.80	0.34	94	48
May 25-28	17.55	1.06	74	44
May 28-June 2	57.51		91	50
June 2-5	59.40	0.00	89	53
June 5-11	65.00	0.00	85	56
June 11-19	82.50	0.02	98	53
June 19-23	52.50	0.35	89	74
June 23-27	69.38	0.00	95	65
June 27-30	65.00	0.00	94	50
June 30-July 3	78.75	0.05	96	62
July 3-10	24.86	0.16	102	61
July 10-Aug 4	No datum	0.69	104	60
Aug 4-11	44.57	0.38	97	66
Aug 11-13	32.00	0.00	95	64
Aug 13-17	99.20	0.03	99	60
Aug 17-23	53.50	0.07	99	58
Aug 23-Sept 5	59.38	0.07	100	65

TABLE VII

A COMPARISON OF THE MAXIMUM AND MINIMUM AIR TEMPERATURES

AT JUAN TABO AND AT ALBUQUERQUE

The equipment at Juan Tabo and at Albuquerque is not comparable as the thermometer at Juan Tabo was not in a standard Weather Bureau shelter. As a result the Juan Tabo thermometer probably registered higher temperatures.

Period	Maximum Temperature Juan Tabo	Alb.	Minimum Temperature Juan Tabo	Alb.	Approximate Monthly mean
Apr 8-14	78°F.	80°F.	30°F.	37°F.	Juan Tabo
Apr 14-16	80	83	44	41	60°F.
Apr 16-23	88	86	40	39	
Apr 23-28	82	86	30	37	Albuquerque
Apr 28-30	87	86	42	46	61.95°F.
Apr 30-May 5	80	84	42	40	
May 5-8	82	84	38	46	Juan Tabo
May 8-12	78	69	36	42	66.5°F.
May 12-14	85	89	48	46	
May 14-19	94	92	52	56	Albuquerque
May 19-21	91	89	54	56	66.45°F.
May 21-25	94	89	48	49	
May 25-28	74	85	44	48	
May 28-June 2	91	88	50	51	
June 2-5	89	87	53	56	Juan Tabo
June 5-11	85	94	56	58	74.3°F.
June 11-19	98	97	53	57	
June 19-23	89	86	74	49	Albuquerque
June 23-27	95	91	65	57	72.4°F.
June 27-30	94	90	50	53	
June 30-July 3	96	93	62	61	Juan Tabo
July 3-10	102	99	61	64	81.1°F.
July 10-17	104	100	60	63	
July 17-25	100	96	65	62	Albuquerque
July 25-Aug 1	99	96	62	63	79.7°F.
Aug 1-4	98	94	62	63	
Aug 4-11	97	92	66	59	Juan Tabo
Aug 11-13	95	91	64	62	80.2°F.
Aug 13-17	99	95	60	64	
Aug 17-23	99	95	58	60	Albuquerque
Aug 23-Sept 5	100	96	65	59	77.40°F.
Sept 5-Oct 24	88	93	32	44	

TABLE VIII

THE GRASSES OF JUAN TABO

Names employed by Kearney and Peebles (1942) are used except for the grass marked with an asterisk, for which Wooton and Standley (1915) is followed.

Common and Scientific Name	Growing Season	Location
Bromus frondosus (Shear) Woot. and Standl. Brome grass	May-September	Few in arroyo
Festuca octoflora Walt. Fescue	April-June	Scarce
Poa longipedunculata* Scribn. Mutton grass	May-September	Common
Eragrostis pilosa (L.) Beauv. India lovegrass	May-October	Few in arroyo
Hordeum murinum L. Mouse barley	April-July	Common in arroyo
Stipa neomexicana (Thurb.) Scribn. Needlegrass	May-August	Fairly common
Aristida longiseta Steud. Three-awned grass	April-October	Common
Hilaria jamesii (Torr.) Benth. Galleta grass	May-September	Common
Bouteloua gracilis (H.B.K.) Lag. ex Steud. Blue grama	July-August	Very common
Bouteloua curtipendula (Michx.) Torr. in Emory Side-oats grama	April-October	Very common

TABLE IX

LIST OF FLOWERING FORBS AND SHRUBS WITH ABUNDANCE AND OCCURRENCE

The names employed by Kearney and Peebles (1942) are used except for those marked with an asterisk, which are found in Wooton and Standley (1915).

Scientific Name	Common Name	Abundance	Location
Yucca glauca* Nutt.	Soapweed	Several	East-facing side of arroyo
Yucca baccata Torr.	Blue yucca	Two	East-facing slope
Nolina microcarpa S. Wats	Bear grass	Common	Slopes of arroyos
Quercus gambelii Nutt.	Gambel's oak	Common	Arroyo slopes
Eriogonum rotundifolium Benth. in DC.	Buckwheat brush	Common	West-facing slope
Eriogonum aureum M. E. Jones	Buckwheat brush	Common	East- and west-facing slopes
Delphinium camporum* Greene	Larkspur	Common	Open area at north end
Corydalis aurea Willd.	Corydalis	Common	Arroyo bottom
Lesquerella fendleri (A. Gray) S. Wats	Bladderpod	Common	Arroyo bottom
Descurainia andrenarum* Cockerell	Tansymustard	Common	Arroyo bottom
Erysimum capitatum (Dougl.) Greene	Western wall-flower	Common	Arroyo bottom
Cleome serrulata Pursh	Rocky Mountain beeplant	Common	Arroyo bottom

TABLE IX (continued)

LIST OF FLOWERING FORBS AND SHRUBS WITH ABUNDANCE AND OCCURRENCE

Scientific Name	Common Name	Abundance	Location
Philadelphus microphyllus A. Gray	Mockorange	Three shrubs	East side of arroyo
Ribes leptanthum A. Gray	Gooseberry	Common	Sides of arroyo
Fallugia paradoxa (D. Don) Endl.	Apache-plume	Common	Sides of arroyos
Lupinus (sp.) L.	Lupine	One	Top of granite hill
Astragalus (sp.) L.	Milkvetch	Two	Top of granite hill
Malvastrum coccineum* (Pursh) A. Gray	False mallow	Several	Open area at north end
Mentzelia pumila (Nutt.) Torr. and Gray	Blazing-star	Common	Arroyo bottom
Echinocereus polyacanthus Engelm. in Wisliz.	Hedgehog cactus	Several	East-facing slope
Echinocereus coccineus Engelm. in Wisliz.	Hedgehog cactus	Three	East-facing slope
Mammillaria (sp.) Haw.	Pincushion cactus	Several	East-facing slope
Opuntia polyacantha Haw.	Prickly pear	Several	South end of arroyo
Opuntia phaeacantha Engelm. in A. Gray	Prickly pear	Several	Arroyo bottom

TABLE IX (continued)

LIST OF FLOWERING FORBS AND SHRUBS WITH ABUNDANCE AND OCCURRENCE

Scientific Name	Common Name	Abundance	Location
Opuntia arborescens* Engelm. in Wisliz.	Cane cactus	Several	Bare area on east side
Oenothera albicaulis Pursh	Evening-primrose	Several	Arroyo bottom
Gaura coccinea Nutt. ex Pursh	Gaura	Common	East-facing slope and arroyo
Gaura coccinea (glabra) (Lehm.) Torr. and Gray	Gaura	Common	East-facing slope and arroyo
Cymopterus fendleri A. Gray	Cymopterus	Several	East-facing slope
Lomatium nevadense (S. Wats.) Coult. and Rose	Biscuitroot	Several	East-facing slope
Asclepiodora decumbens (Nutt.) A. Gray	Antelope-horns	Several	Top of granite hills
Gilia inconspicua (Smith) Dougl.	Gilia	Several	East-facing slope
Lithospermum incisum Lehm.	Gromwell	Several	Arroyo bottom
Verbena wrightii A. Gray	Vervain	Common	Over entire area
Lycium pallidum Miers	Desert-thorn	One shrub	South end of arroyo
Chamaesaracha coronopus (Dunal) A. Gray	Chamaesaracha	Several	Arroyo bottom
Solanum elaeagnifolium Cav.	Bullnettle	Common	Slopes and floor of arroyo

TABLE IX (continued)

LIST OF FLOWERING FORBS AND SHRUBS WITH ABUNDANCE AND OCCURRENCE

Scientific Name	Common Name	Abundance	Location
Penstemon barbatus (Cav.) Roth	Beard-tongue	Two	Arroyo bottom
Penstemon jamesii Benth. in DC.	Beard-tongue	Very common	East- and west-facing slopes
Penstemon virgatus A. Gray in Torr.	Beard-tongue	Very common	East-facing slope
Castilleja integra A. Gray in Torr.	Indian paint-brush	Very common	East-facing slope
Gutierrezia microcephala (DC.) A. Gray	Snakeweed	Very common	Over entire area
Aplopappus wootoni* (Greene) Standley	Aplopappus	Common	East- and west-facing slopes
Chrysothamnus parryi (A. Gray) Greene	Rabbitbrush	Several	North end of arroyo
Monoptilon bellioides (A. Gray) H. M. Hall	Monoptilon	Common	East- and west-facing slopes
Erigeron flagellaris A. Gray	Wild-daisy	Very common	Over entire area
Melampodium leucanthum Torr. and Gray	Melampodium	Common	East-facing slope
Berlandiera lyrata Benth.	Berlandiera	Four	East-facing slope
Zinnia grandiflora Nutt.	Zinnia	Common	East-facing slope
Actinea acaulis (Pursh) Spreng.	Actinea	Very common	Over entire area

TABLE IX (continued)

LIST OF FLOWERING FORBS AND SHRUBS WITH ABUNDANCE AND OCCURRENCE

Scientific Name	Common Name	Abundance	Location
Gaillardia pinnatifida Torr.	Blanketflower	Common	East- and west-facing slopes
Dyssodia acerosa DC.	Dyssodia	Few	West-facing slope
Dyssodia papposa (Vent.) Hitchc.	Dyssodia	Common	East- and west-facing slopes
Senecio longilobus Benth.	Threadleaf groundsel	Several	East-facing slope
Cirsium ochrocentrum A. Gray	Thistle	Several	East-facing slopes
Malacothrix fendleri A. Gray	Malacothrix	Several	East-facing slopes
Lygodesmia exigua A. Gray	Lygodesmia	Several	East-facing slope
Pectis papposa Harv. and Gray in A. Gray	Fetid-marigold	Several	East- and west-facing slopes

TABLE X

LIST OF BIRDS OBSERVED IN THE PINYON PINE-JUNIPER ASSOCIATION ON THE WEST SLOPE OF THE SANDIA AND MANZANO MOUNTAINS

These names are as given in the A.O.U. Check List of North American Birds, Abridged edition, 1935, as reproduced in Hausman (1944) except for the birds marked with an asterisk, whose names are as given in Birds of New Mexico by Florence Merriam Bailey (1928).

The subspecific names for the above birds are assumed from the locality in which they were observed and not determined from specimens.

Permanent residents:

Woodhouse jay	Aphelocoma californica woodhousei (Baird)
Mountain chickadee	Penthestes g. gambeli (Ridgway)

Permanent residents not confined to pinyon pine-juniper area:

Turkey vulture	Cathartes aura septentrionalis Wied
Desert sparrow hawk	Falco sparverius phalaena (Lesson)
Piñon jay	Cyanocephalus cyanocephalus (Wied)
Common rock wren	Salpinctes o. obsoletus (Say)
Cañon towhee	Pipilo fuscus mesoleucus Baird
Gray titmouse	Baelophus inornatus griseus (Ridgway)
Cañon wren	Catherpes mexicanus conspersus Ridgway

Summer residents:

Western mourning dove	Zenaidura macroura marginella (Woodhouse)
Western nighthawk	Chordeiles minor henryi Cassin
White-throated swift	Aëronautes s. saxatalis (Woodhouse)

TABLE X (continued)

LIST OF BIRDS OBSERVED IN THE PINYON PINE-JUNIPER ASSOCIATION ON THE WEST SLOPE OF THE SANDIA AND MANZANO MOUNTAINS

Violet-green swallow	Tachycineta thalassina lepida Mearns
Western robin	Turdus migratorius propinquus Ridgway
San Lucas gnatcatcher	Polioptila caerulea obscura Ridgway
Rocky Mountain evening grosbeak*	Hesperiphona vespertina warreni Grinnell
Spurred towhee	Pipilo maculatus montanus Swarth
Occasional visitants:	
Golden eagle	Aquila chrysaëtos canadensis (Linnaeus)
Western red-tailed hawk	Buteo borealis calurus Cassin
Road runner	Geococcyx californianus (Lesson)
Western horned owl	Bubo virginianus pallescens Stone
Broad-tailed hummingbird	Selasphorus p. platycercus (Swainson)
Red-shafted flicker	Colaptes cafer collaris Vigors
Arkansas kingbird	Tyrannus verticalis Say
American raven	Corvus corax sinuatus Wagler
Rocky Mountain black-headed grosbeak*	Hedymeles melanocephalus papago Oberholser
Winter residents:	
Shufeldt junco	Junco oreganus shufeldti Coale
Gambel sparrow	Zonotrichia leucophrys gambeli (Nuttall)
Townsend solitaire	Myadestes townsendi (Audubon)
Migrant visitors:	
Mountain bluebird	Sialia currucoides (Bechstein)
Audubon's warbler	Dendroica a. auduboni (Townsend)

TABLE XI

A LIST OF MAMMALS FREQUENTING JUAN TABO

The source for the names given in the list is Vernon Bailey (1931).

The subspecific names are assumed from the locality and not determined from specimens.

Common and Scientific Name	Possible Abundance	Evidence
Rocky Mountain mule deer *Odocoileus hemionus macrotis* (Say)	Common in winter	Scats, sight
Cedar-belt cottontail *Sylvilagus auduboni cedrophilus* Nelson	Common	Sight
Larger Colorado chipmunk *Eutamius q. quadrivittatus* (Say)	Common	Trapped 4
Say's rock squirrel *Citellus variegatus grammurus* (Say)	Very common	Sight
Tawny deer mouse *Peromyscus maniculatus rufinus* (Merriam)	Several	Trapped 1
Large-eared deer mouse *Peromyscus t. truei* Shufeldt	Fairly common	Trapped 2
Hoary wood rat *Neotoma micropus canescens* Allen	Common	Trapped 4
White-throated wood rat *Neotoma a. albigula* Hartley	Common	Trapped 8
Yellow-haired porcupine *Erithizon e. epixanthum* Brandt	Fairly common	Stripped trees, scats

TABLE XI (continued)

A LIST OF MAMMALS FREQUENTING JUAN TABO

Common and Scientific Name	Possible Abundance	Evidence
Baird's pocket mouse *Perognathus f. flavus* (Baird)	Scarce	Trapped one (under juniper)
Texas Plains coyote *Canis latrans texensis* Bailey	Common	State trapper trapped 12
Rocky Mountain cougar *Felis concolor* Merriam	Scarce	State trapper reported one in vicinity
Mountain wild cat *Lynx rufus uinta* Merriam	Occasional	State trapper trapped 3 (in Spring)
Common badger *Taxidea taxus* (Schreber)	Several	State trapper trapped 2

FIGURE 1. General view looking east of a major portion of the range check-plot studied at Juan Tabo. The transect extends from the bare area in the immediate foreground to the mid-point of the hill somewhat above the center of the photograph.

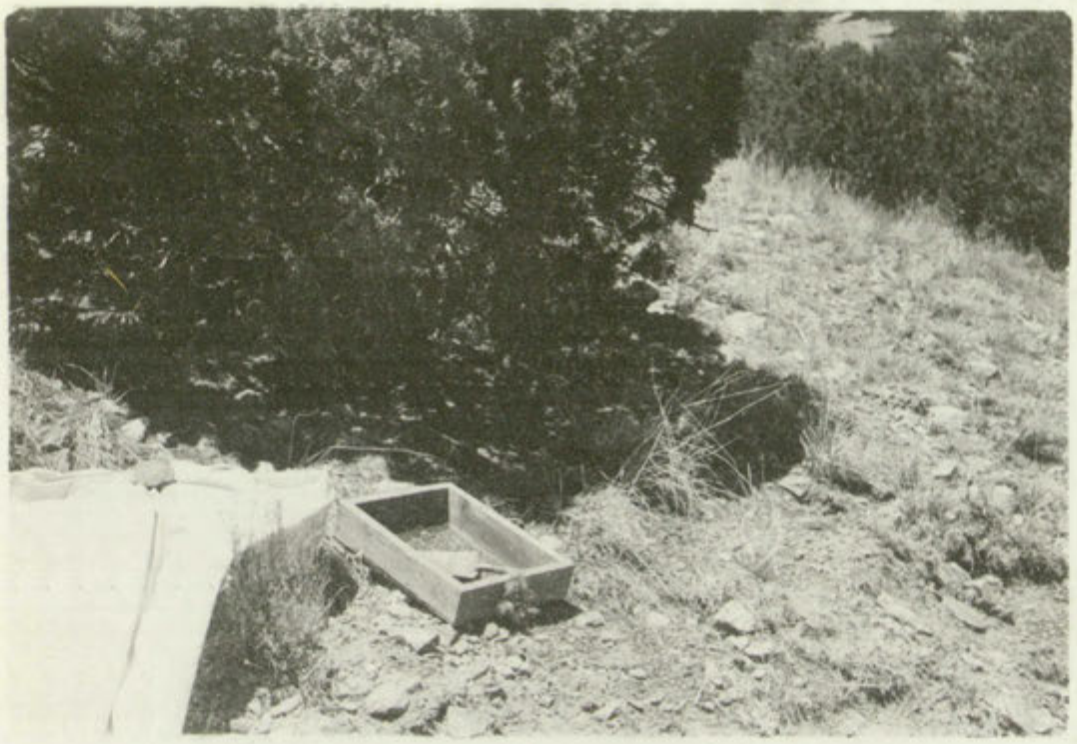

FIGURE 2. A photograph of the equipment used in securing a count of the soil invertebrates. The juniper shown above is typical of those on the east-facing slope.

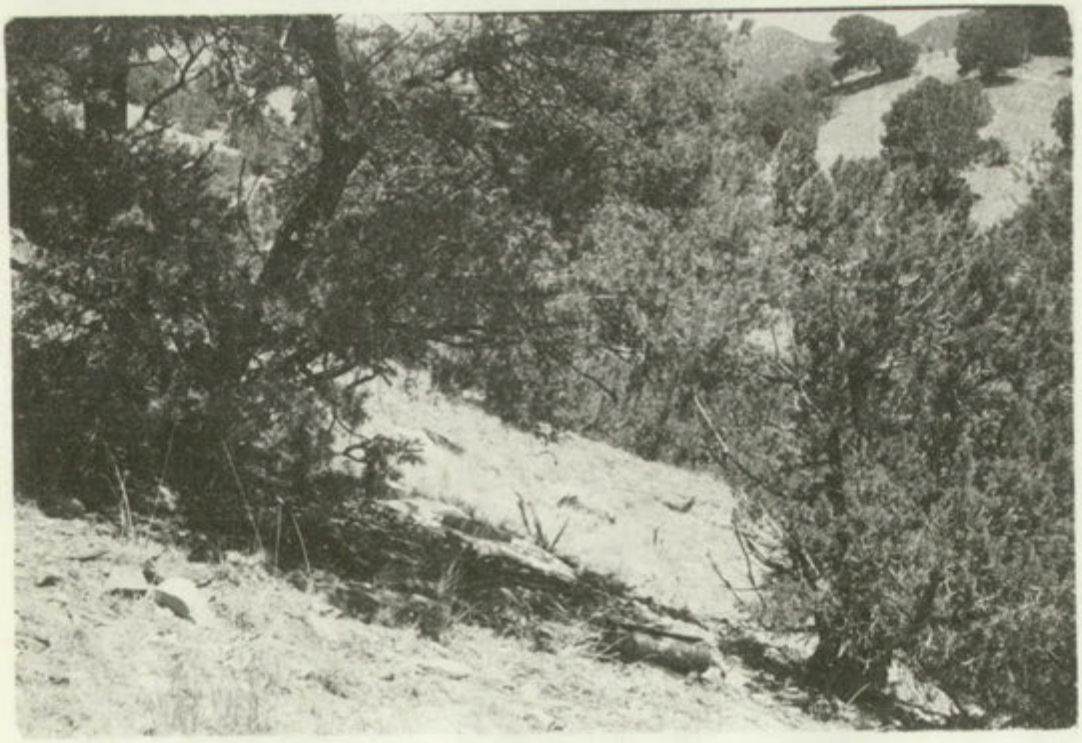

FIGURE 3. View of one of the pinyons under which a sample of soil invertebrates was made.

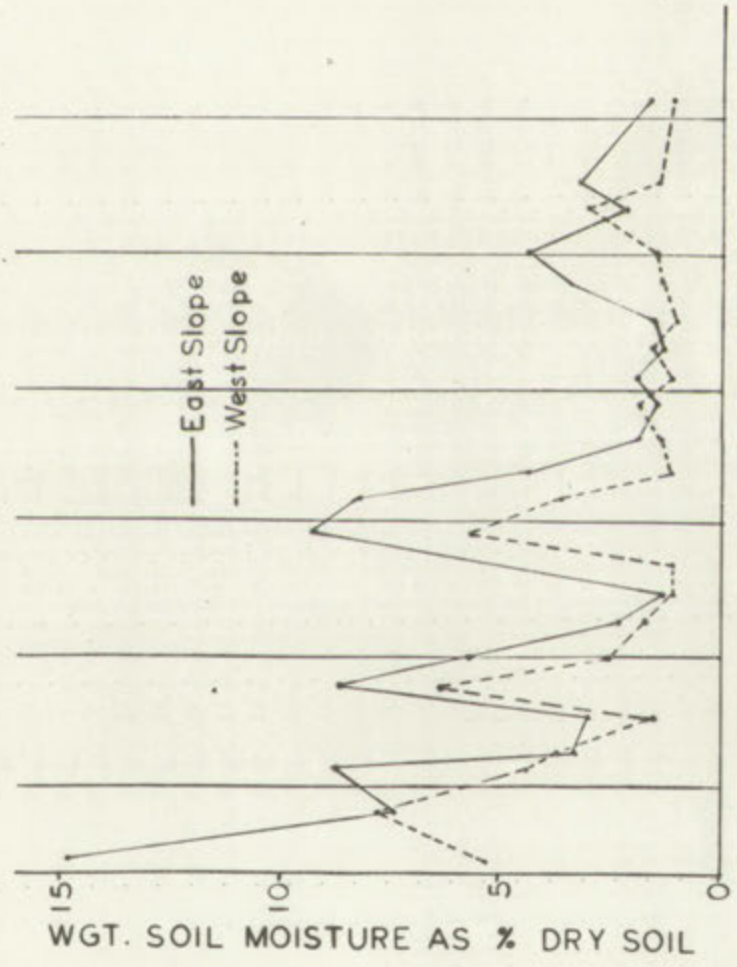

FIGURE 4. Graph of soil moisture from Mar. 14 to Sept. 5, 1948.

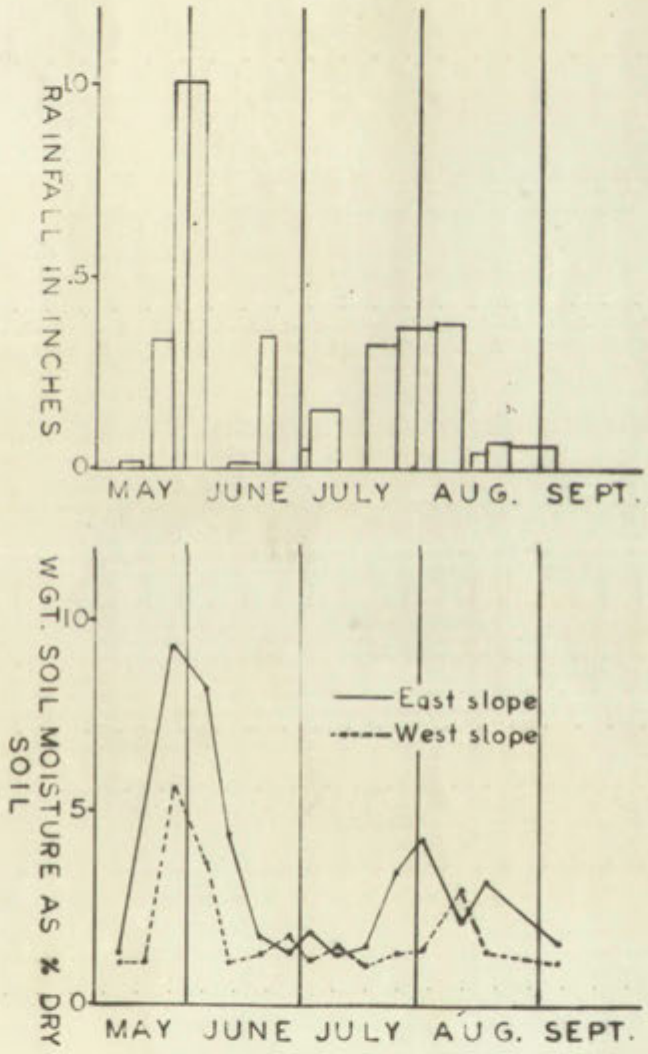

FIGURE 5. Graph showing relationship of rainfall and soil moisture from May 8 to September 5, 1948.

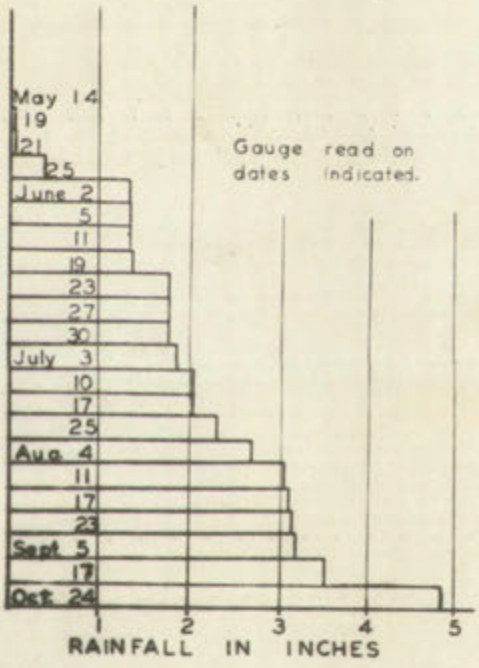

FIGURE 6. Accumulative rainfall from April 28 to Oct. 24, 1948.

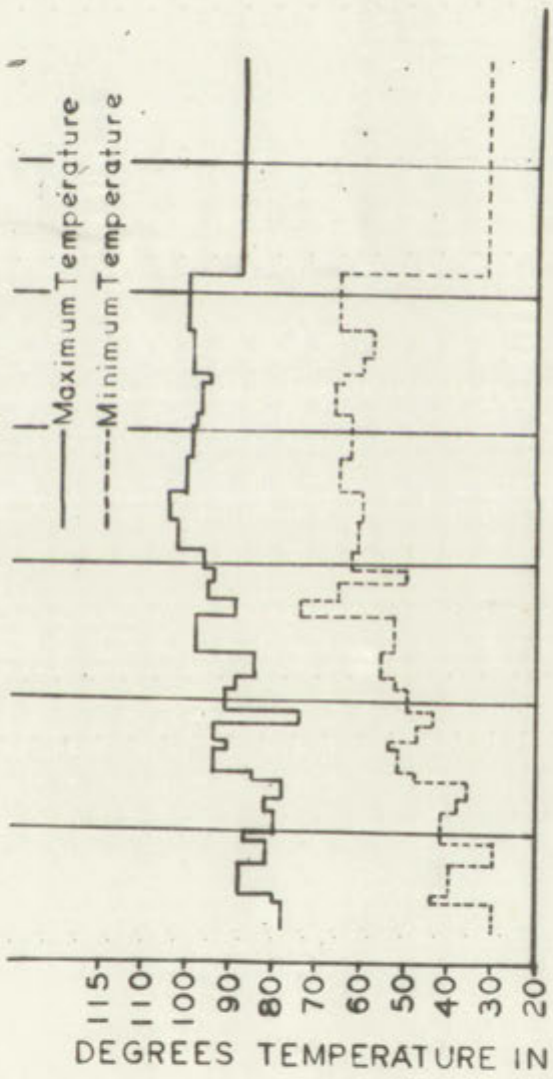

FIGURE 7. Graph of the maximum and minimum temperatures from April 8 to October 24, 1948.

FIGURE 8. A view of the stand of pinyon pines and junipers on the east side of the Sandia Mountains.

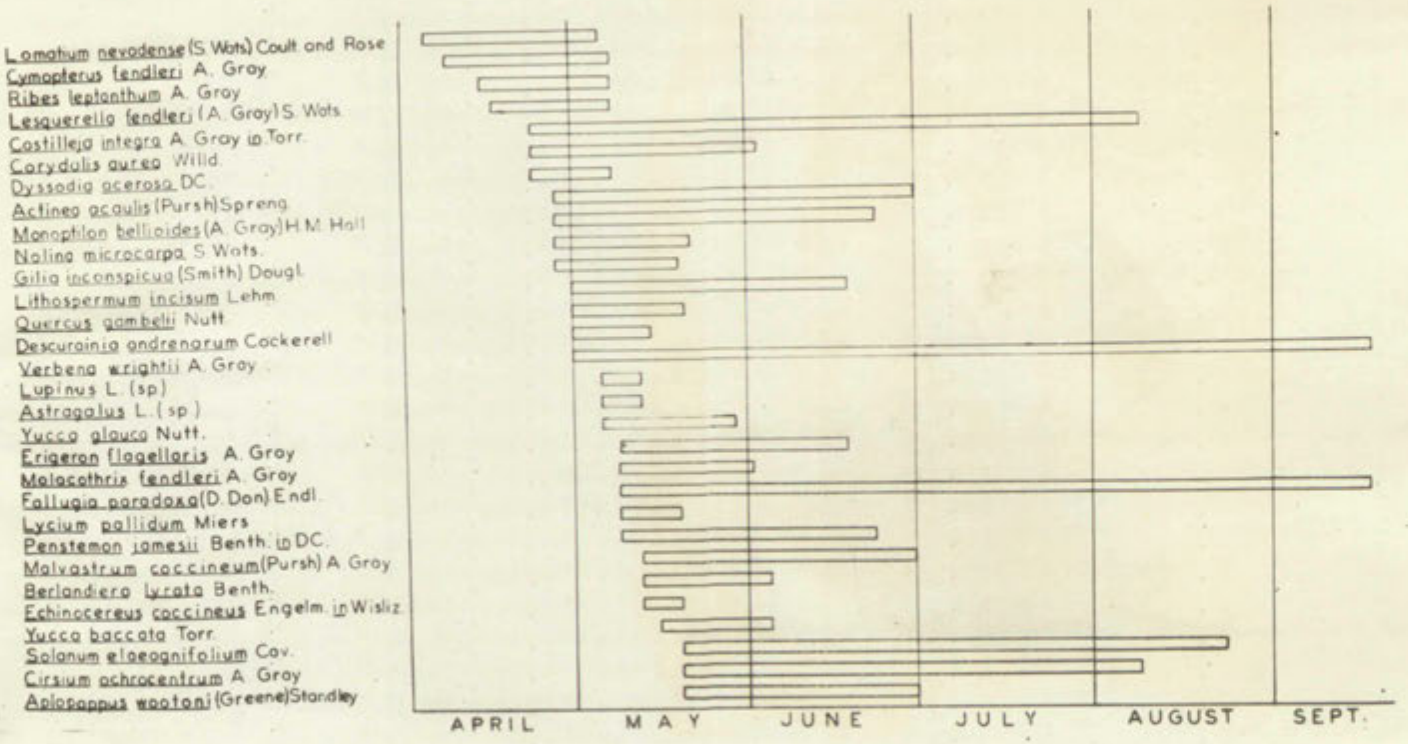

FIGURE 9. Graph of flowering periods of forbs and shrubs from April 4, to Sept. 23, 1948.

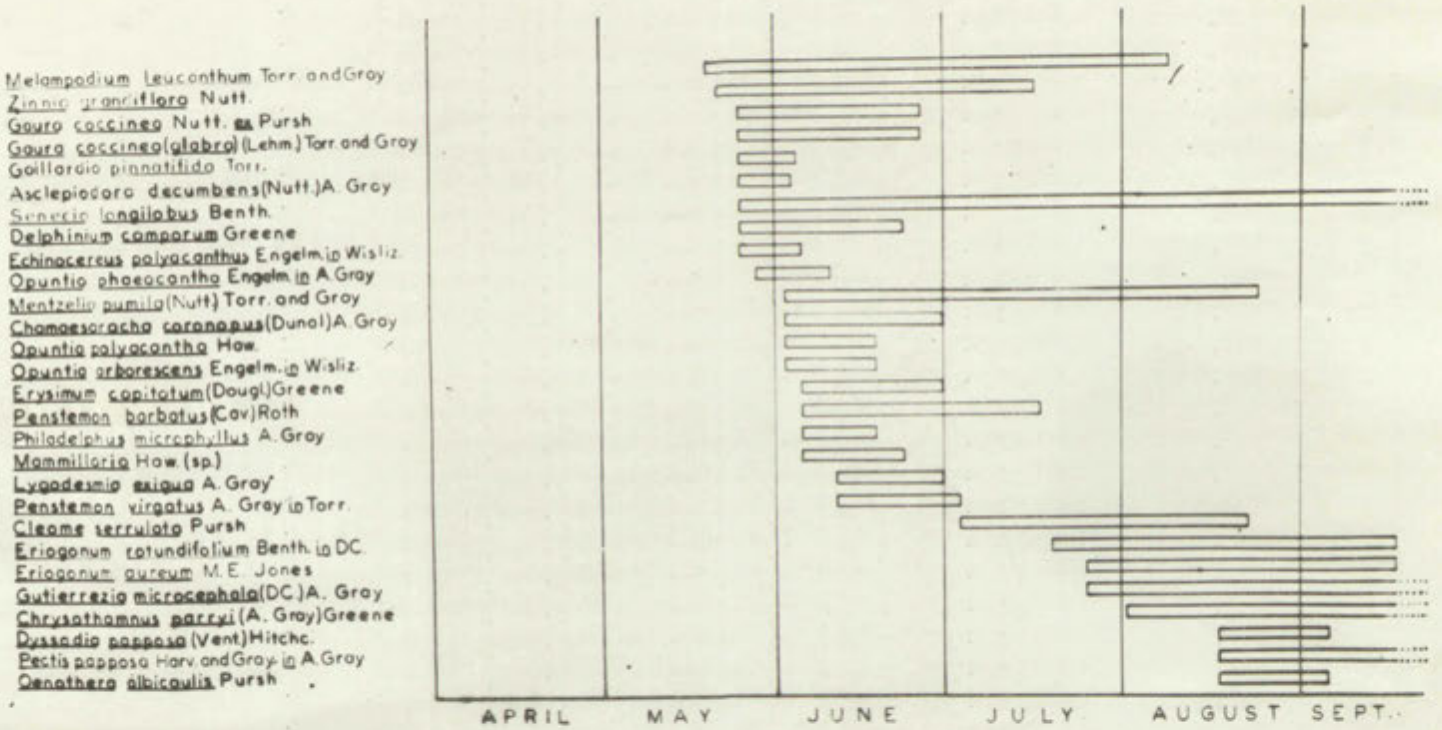

FIGURE 9. (continued) Graph of flowering periods of forbs and shrubs from April 4 to Sept. 23, 1948.

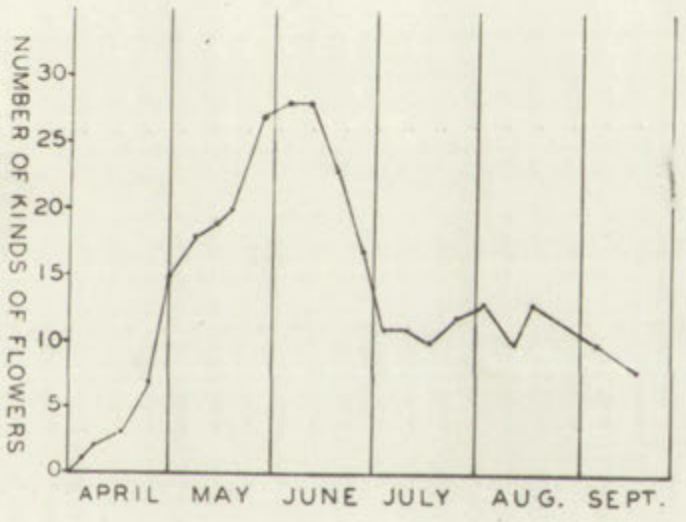

FIGURE 10. Graph of the number of species of forbs and shrubs in flower at various dates.

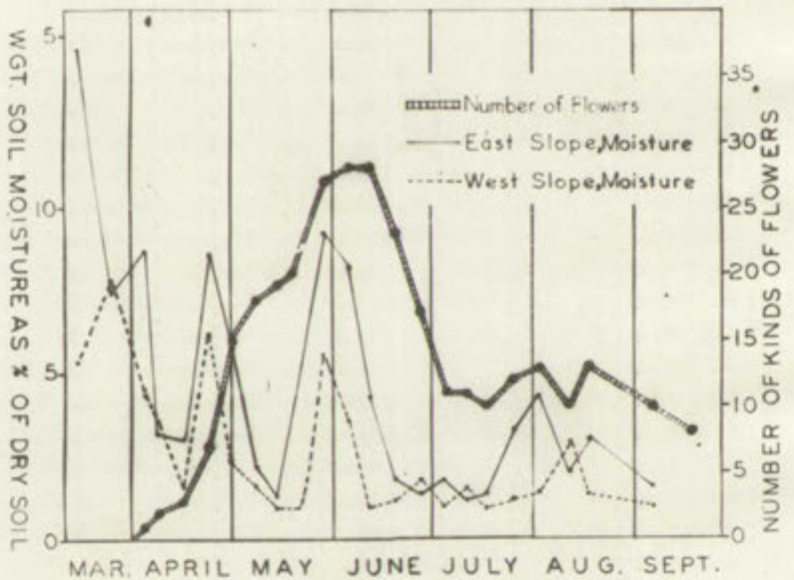

FIGURE 11. Graph showing a comparison of soil moisture with number of kinds of forbs and shrubs in flower.

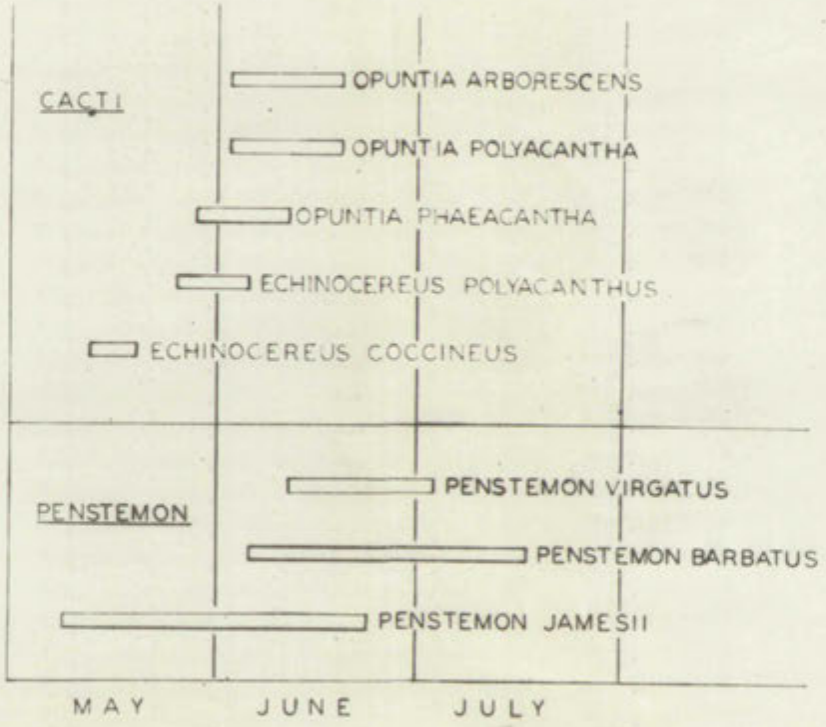

FIGURE 12. Graph of the flowering periods of penstemons and cacti.

FIGURE 13. View of an east-facing slope, showing typical grass cover and Indian paint-brush in foreground.

FIGURE 14. A view of the rocky terrain near the top of a west-facing slope, showing beargrass and penstemons.

FIGURE 15. A view of an open area at the north end of fenced plot, showing sparse grass cover and small shrubs.

FIGURE 16. View of the overgrazed area outside of the fenced plot, showing the thin eroded soil cover and typical composites.

FIGURE 17. View of the sandy bottom of an arroyo with Penstemon barbatus (Cav.) Roth in foreground. Note the tall grasses and Apache plume, both typical of the vegetation of the arroyo.

FIGURE 18. A photograph of the area on the east-facing slope inside the preserved plot. Note the fair stand of grasses.

FIGURE 19. View of an overgrazed area outside the fenced plot. Note the thin cover of grasses.

FIGURE 20. General view of the east- and west-facing slopes within the preserved plot. The rocky west-facing slope is in the foreground. In the immediate foreground are some scrub oaks typical of this slope.

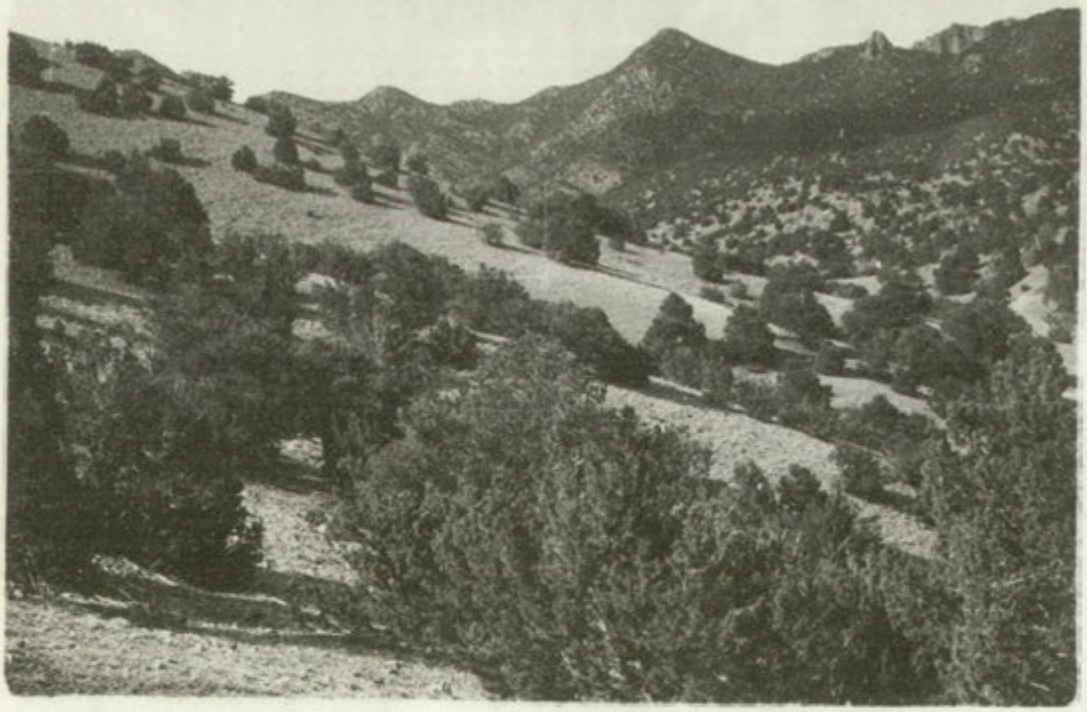

FIGURE 21. Photograph of an east-facing slope. The stand of trees at higher elevation in the background is composed of 90% pinyon pine and 10% juniper.

FIGURE 22. General appearance of arroyo that runs through Juan Tabo. Note that the west-facing slope on the right is more steep than the opposite east-facing slope.

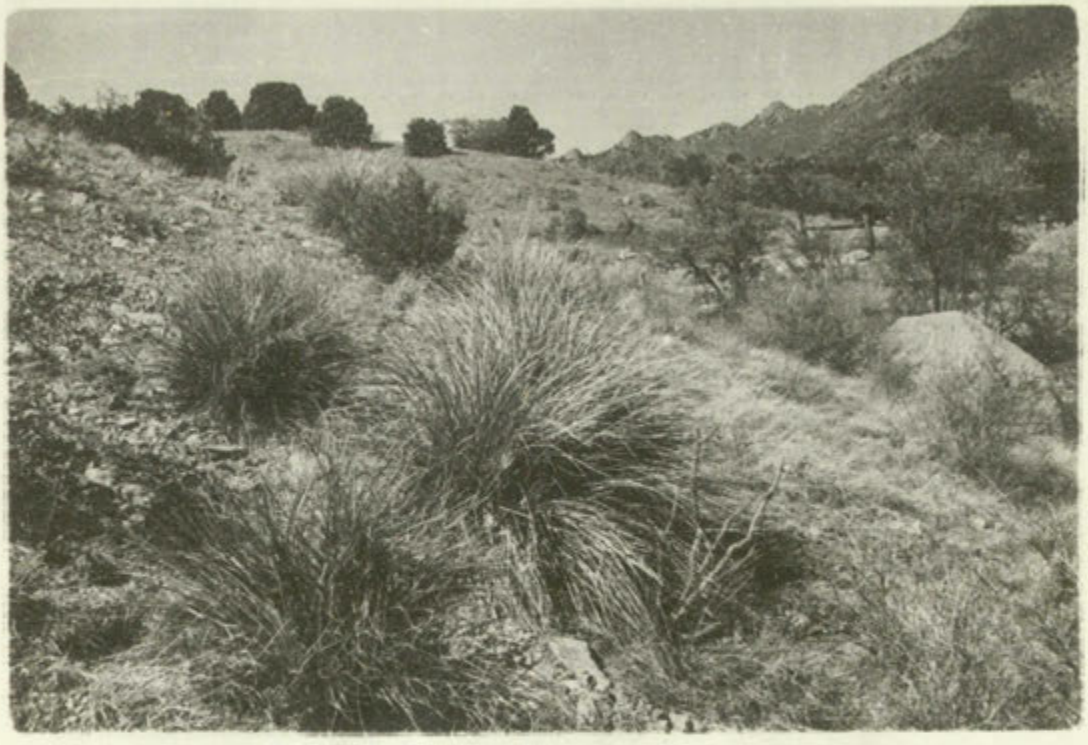

FIGURE 23. A view of the arroyo bank at the north end of the preserved area. Note the typical arroyo vegetation composed of bear grass, oak, Apache plume, and tall grasses.

Date Due			