

ECOLOGY AND SECONDARY SUCCESSION
ON A MOUNTAIN NEAR TERBOL, BEKAA

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THE ECOLOGY OF MOUNT TERBOL

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I INTRODUCTION

Various methods have been utilized to study the effects of overgrazing. Undoubtedly the most valid of these is the comparison of an area which has never been grazed with an overgrazed area near it. Larson and Whitman (44) compared two such locations on South Dakota mesas. However, it is only under rare circumstances that one is able to find truly primitive conditions in proximity with a grazed area.

In lieu of such an ideal situation, studies can be carried on wherever overgrazed areas are found bordering on spots which have been protected for long enough periods that they can be assumed to have reached the climax condition. Such places are relatively common and have been made the basis for several investigations of this type. A good example is the report of Costello and Turner (18) on the study of 139 such areas including cemeteries, city watersheds, National Forest land etc.

In some parts of the world, holy places of various sorts have often been protected for long periods of time and thus provide reserves of previously existing vegetation. Eig (27) has utilized such places for his work on the Quercus forests of Palestine.

Unfortunately incidental enclosures of this type are often not available in a given region. In this case, areas must be enclosed specifically for the purpose of study.

There is an obvious disadvantage to this method. At best, succession is a slow process, and usually one or more factors are present which will further retard it, such as soil depletion, prolonged drought, or lack of propagules (18).

Considering the time factor, enclosures do not seem to be a very ideal way to study the effects of grazing as compared to the undisturbed condition. However, they provide an excellent opportunity for studying the process of secondary succession on an area that is recovering. For this reason enclosures are often used in conjunction with other methods.

By means of range surveys, permanent quadrats, repeat photographs etc., precise quantitative and qualitative changes can be noted. Of necessity such an investigation must extend over many years and generally will have been under the direction of more than one person. One such a long-term study has been maintained for forty-seven years on the Wasatch Plateau in Utah. During this period there have been six different directors of the project (30).

In view of these facts, it should be evident that any conclusions resulting from a study based solely on a recent enclosure and extending over a short period of time will be tentative.

In the following pages an account is given of an area which had been protected for an eight-year period. Since records at the time of enclosure are lacking several reservations must be made.

First it is impossible to be certain that conditions outside and inside the fence were the same at the time of enclosure. Also the enclosure may have imposed secondary changes other than the exclusion of domestic animals. Thirdly, consideration must be given to the fact that the existing differences represent not only the succession of the protected area but the continuing regression of the overgrazed part (18).

With these reservations in mind, the enclosed area and the grazed area adjacent to it were compared to determine what successional changes, if any, had occurred. Other studies were made on a non-comparative basis in order to describe existing conditions on both sides of the fence.

II DESCRIPTION OF THE AREA

TOPOGRAPHY, GEOLOGY, AND HISTORY

At the eastern end of the Mediterranean Sea lies the narrow strip of land which forms the country of Lebanon.

The Lebanon Mountains, the highest peak of which is 3100 meters, run the length of the country parallel to the sea. A second, lower range of mountains, the Anti-Lebanon, separated from the Lebanon by the fertile Bekaa valley, forms approximately the border between Lebanon and Syria. These mountains vary in altitude from 1200 meters to 2650 meters.

Fisher (34) has described how the two mountain ranges were formed by a slow folding at the end of the Cretaceous period. During the Eocene there appears to have been a rest period followed by another folding, probably late in the Tertiary period, which has given the mountains a steeper position. Throughout the folding process and especially during the Quaternary period sediment has been washed into the valley. Today the floor of the valley slopes up towards the center. The elevation ranges from 800 to 900 meters.

The Anti-Lebanon range has no streams draining into the Bekaa. The water that falls is almost entirely absorbed into the ground. (34)

The hill on which the studies were made is a western facing slope. It is located on the eastern side of the Bekaa

near the Anti-Lebanon Mountains. It lies just east of the village of Terbol on the property of the Terbol experimental farm. The hill is of Eocene limestone and has Terra Rossa soil.

The Bekaa is very fertile and has been cultivated since the dawn of civilization. On the slopes where cultivation is more difficult, shepherds continue to graze their flocks just as they have done for perhaps ninety centuries.

Since excavations in the Bekaa have only reached to the 35th century B.C., it cannot be ascertained for how long the valley has been grazed, but, according to Baramki (4), in 3500 B.C. the Calcolithic inhabitants of Syria were definitely grazing livestock away from their settlements. It is possible that this area has been grazed since 7000 B.C. when the Natufians first domesticated animals.

The Roman Emperor from 117 to 138 A.D., Hadrian Augustus, established forest reserves from which grazing animals were excluded. Nearly 100 stones marking the boundaries have been found in the Lebanon Mountains. (4)

This would seem to indicate that the problem of overgrazing existed even then because, in moderation, grazing is not detrimental to the natural vegetation.

Fisher (34), Sauer (67), and others have pointed out that it was not only grazing that has caused the devegetation which has occurred. It was the sum of man's activities such as the indiscriminate cutting of trees for building and fuel

poor methods of agriculture, and overgrazing which have led not only to the removal of the original vegetative cover but to consequential soil erosion.

Even today this process continues, and scrub formation continues at the expense of forests (53).

Under good conditions a goat grazes more lightly than a cow (55), but the climate of the Mediterranean area is such that pressure is easily brought to bear on the vegetation. During the months when ample grass is available, large numbers of animals can be supported. However, when the annual plants have withered in the summer drought, the goats continue to graze. When most livestock are no longer able to survive, goats still thrive (67). The goat is able to eat almost anything including the woody portion of plants. See Figure 1.

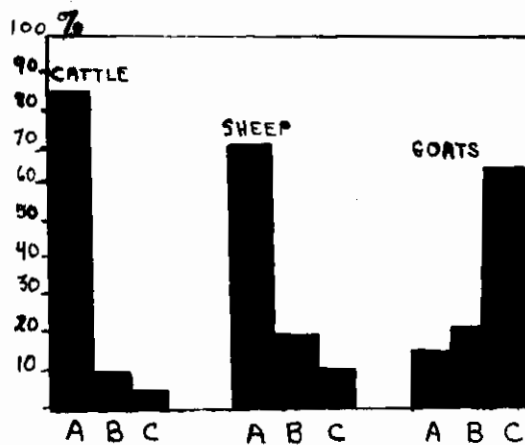


Fig. 1.--Graphs showing grazing preferences of cattle, sheep, and goats. (A) Grasses; (B) Forbs; (C) Shrubs. From a table by P.W. Chapman, Pastures, (1949)

Moreover, being extremely sure-footed, he can graze spots inaccessible to other domestic animals. It is these habits which enable goats to keep potential scrub-oak forests only a few

inches high throughout the Middle East (55).

When the trees are destroyed, the insolation near the ground prohibits the growth of the mesophytic species which would be expected to occur in sub-humid or semi-arid climates. Thus, xerophytes which ordinarily are rare in such a climate are favored (53).

Drought has undoubtedly had a deleterious effect, but only because it has occurred in combination with overgrazing. Each time a drought occurred the range capacity was reduced and was unable to revive later. The only life able to survive was the most undemanding -the xerophytic plants. The goats, another undemanding form of life, were likewise able to survive on the reduced vegetation (67).

Also, as Sauer (67) has observed, although soil from limestone parent material is high in fertility and attractive to farmers, the soil is shallow and particularly susceptible to erosion. As the land became more and more unsuitable for agriculture, due to misuse, the economy shifted away from crops and toward pastures.

There has been a substantial amount of speculation and study on whether the pastoral society developed from the crop society or vice versa. Today the two societies are divided on the basis of environment. Crops are grown where soil and moisture conditions allow, while flocks are grazed on the mountains and dry land. There is evidence that this may have been the case from the beginning (67) (34).

The grazing culture of the area is not strictly nomad-

ic, although some Bedouins from the Syrian Desert do bring in their flocks for the winter. Mostly the grazing is transhumanic which implies a change in altitude more than a change in horizontal distance. (34)

CLIMATE

DESCRIPTION The climate of the coastal area of Lebanon is typically Mediterranean, but inland where the study was made, the air is too dry and the rainfall too scanty to be considered typical. The rainfall schedule, however, is characteristic of a Mediterranean climate with the coincidence of the hot and dry seasons.

The meteorological data were obtained from reports of the Ksara weather station (2)(3) which is nine kilometers from Terbol and in the same rainfall range (65). Unfortunately the reports of Terbol were incomplete and generally inaccurate. Therefore, data not attributable to published records are those of the Ryak sub-station on file at Ksara. Ryak is only five kilometers from Terbol.

The summer drought in Terbol and vicinity begins in May and extends through the month of September. Seldom does any rain fall in the months of June, July, August, or September. The days of these months are sunny and cloudless.

The annual rainfall is normally from 500 to 700 millimeters. The largest amount of precipitation is in January. The months of December and February are quite wet, but May, April, October and November have less rainfall. See Table 1.

The rainfall on the coast is 915 millimeters per year. In the upper zone of the Lebanon this increases to 1270 millimeters. However, by the time the air reaches the Anti-Lebanon

TABLE 1.--Mean monthly rainfall in millimeters
1951-1959, Ryak, Lebanon

| | |
|--------------|--------------|
| Jan....176.5 | July...0 |
| Feb....128.0 | Aug....0 |
| Mar....90.2 | Sept...0 |
| April..35.6 | Oct....10.4 |
| May....15.1 | Nov....57.9 |
| June...0 | Dec....119.4 |

the precipitation is reduced to half of this amount.

Since 1955 Lebanon has been suffering from a drought. In 1961 the drought appears to have broken in some parts but it is still severe in the Bekaa. See Figure 2.

During the months of December and January snow and snow mixed with rain occur. Some years there are occasional rainy snows up through February or March.

In addition to being the wettest month January is the coldest one. The temperature rises slowly during February and more and more rapidly during the following months. July and August are the hottest months, August being only slightly warmer than July. From about the first of September the weather begins to become cooler. See Table 2.

In Beirut the percentage of relative humidity remains in the high seventies throughout the year. The Bekaa has a winter humidity even higher than that of Beirut, but the high mountain range between the valley and the sea acts as a barrier during the summer, and the normal relative humidity falls below

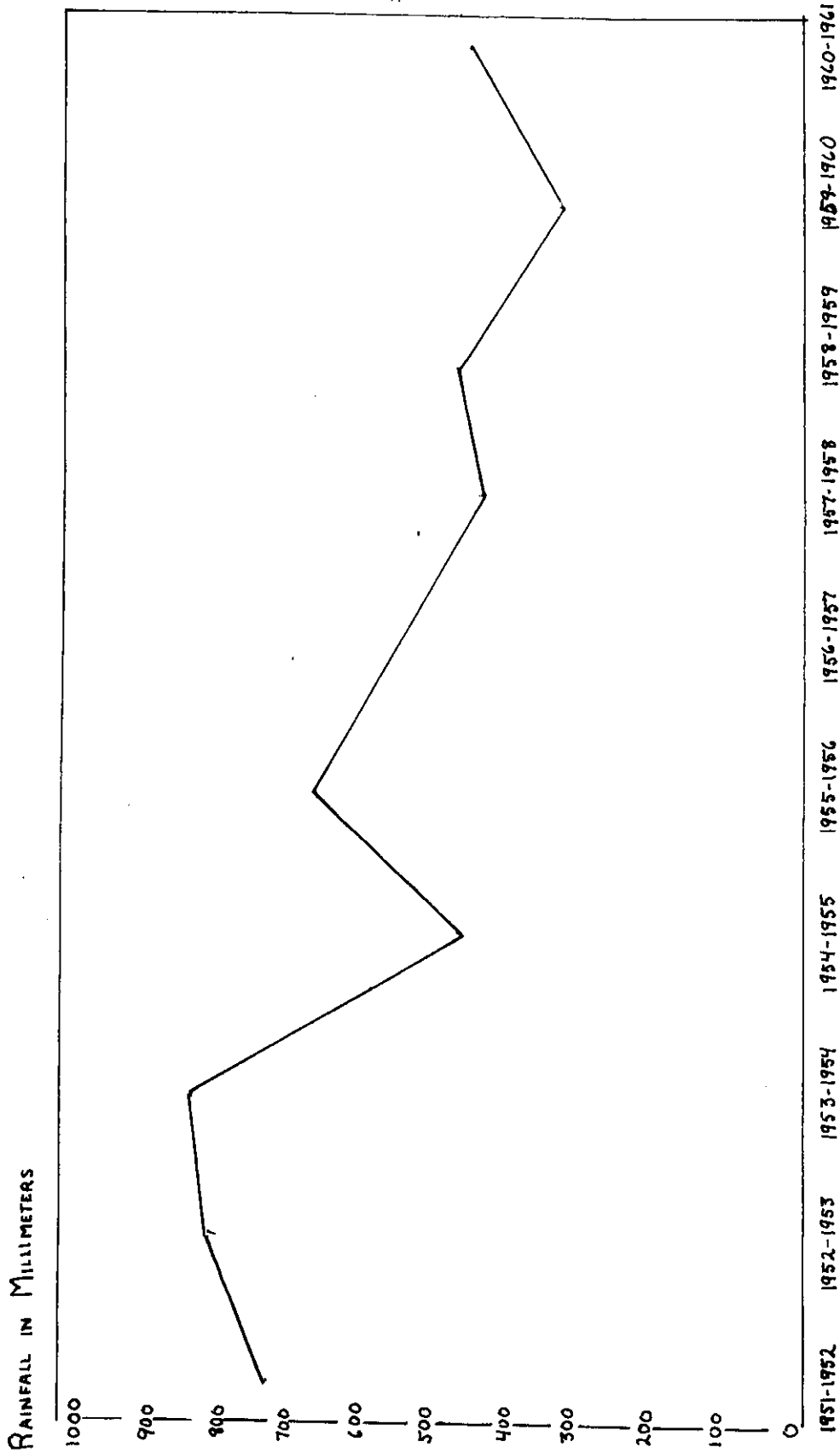


FIG. 2. -- GRAPH SHOWING SEASONAL RAINFALL OF RYAK FOR THE YEARS 1951-1961 (1960-1961 IS TENTATIVE)

TABLE 2.--Mean minimum and maximum temperatures C
Ryak 1951-1959

| | |
|-------------------|-------------------|
| Jan.....4; 10.1 | July...13.6; 32.4 |
| Feb....1.4; 11.5 | Aug....14.0; 33.1 |
| Mar....2.6; 15.0 | Sept...12.1; 30.3 |
| April..5.4; 20.0 | Oct....9.2; 25.9 |
| May....8.4; 25.2 | Nov....5.6; 19.6 |
| June...11.1; 29.5 | Dec....2.1; 12.8 |

forty percent in July and August. See Figure 3.

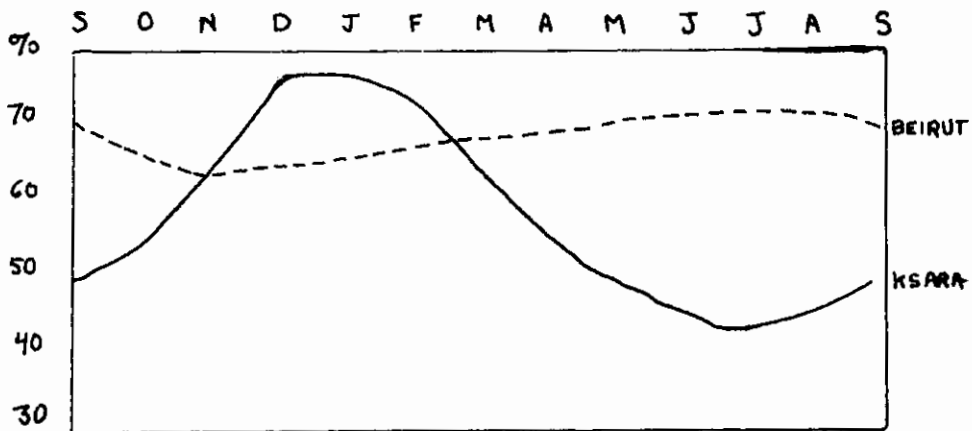


Fig. 3--Graph showing yearly relative humidity of Beirut and Ksara Adapted from J. Rey Carte Pluviométrique du Liban (1954)

In general the winds of the Mediterranean region are periodical both diurnally and annually. During the day the wind is from the sea to the land, but at night the direction is reversed. In summer the prevailing winds are north, north-west or west winds, while in winter they are west, southeast, or east winds.(39)

In the Bekaa, western winds predominate throughout the year but tend to decrease in the winter. They blow in from the sea and effect both the temperature and the humidity. The east winds are dry, continental winds and may be hot or cold depending on the season. They tend to increase during the winter. South and north winds are infrequent. (3)

STABILITY In attempting to determine the climax conditions of an area which has suffered misuse for so many centuries, the question of climatic stability immediately presents itself. Is the climax condition of the area today likely to be the same as it was so many centuries ago when the area was undisturbed, or have climatic conditions changed to the extent that if succession were allowed to proceed to the climax of today the result would not be the same as the virgin area?

Mouterde (57) emphasized this in a personal communication when he said, "Depuis des millinaires, aucun arbre ne croit spontanément dans cette plaine! Comment oser reconstituer l'état du pays avant l'homme, ses cultures et ses chèvres?"

"En admettant, à cette date (1500 au moins avant notre ère) les mêmes conditions, nous devons dire!"

However, scientists in Palestine are in general agreement that there has been no great, regional, climatic change in historic times (34)(64)(68).

Whyte (78), in referring to the whole area from Portugal to East Pakistan, stated that at least during the time in which most of the devegetation had occurred there was no evidence

of climatic change.

In Tunisia the climate does not appear to have changed at least since Phoenecian and Roman times. In reclamation of the Sfax region, olive trees were planted experimentally when an ancient olive press was discovered. The trees were successfully planted according to the specifications of the ancient agronomists. Also many water sources which were indicated in Roman ruins have been found to be still useful today. These facts have prompted Tixeront (74) to support the viewpoint of a great climatic stability.

There have been similar conclusions made concerning India (63).

Flassard (61) has shown that two different rainfall cycles exist in Lebanon, one of thirty-five years and another of seventy years. His conclusions were based on the records of Beirut, Ksara, and Jerusalem since 1859. Moreover, the graphic representation of the cyclic nature of rainfall shows that there has been no overall trend towards either a wetter or a drier climate.

Semi-desert areas are characterized by great variations in rainfall from year to year and in the course of consecutive groups of years (74). According to Tixeront (74), the cyclic nature of rainfall cannot be ascertained since meteorological records are so limited in time, but he agreed that the large variations in time do not represent a change in climate.

Dixey (24) has emphasized that cycles of rainfall may

vary in amplitude from short periods to very long periods of time and that what may seem to be progressive changes may be no more than a curve of a larger cycle.

Those who are of the opinion that climatic change has occurred recently emphasize that such changes are extremely slow and even over many centuries would not exhibit more than very slight change. Thornthwaite (73) has noted that the last long-period change has extended over 25,000 years, and even in this amount of time change in some areas has been practically non-existent.

That man and his animals have caused devegetation and the spread of deserts is recognized as a fact. However, it has often been presumed that this is due not only to direct destruction but also to changes in precipitation brought about by modifications of the vegetation (73)(69).

Since climates are characterized by extreme variability, it would be almost impossible to discover what influence man may have had. It seems clear, however, that man's influence on the climate as such is negligible, the extension of deserts and other changes being due either to changes in the vegetation directly or to the effects on the water economy of the soil (24)(73)(78). Conversely, there is no reason to suppose that if the original vegetation of misused areas were to be restored there would be any change in the existing climate (86).

SOIL

The hill is of Terra Rossa soil, a type which develops only in a climate of Mediterranean rain schedule which is more or less humid. Although ample winter rainfall is necessary for its development it has many characteristics of an arid soil due to the summer drought (64).

Kellogg (48) has discussed some of the characteristic properties of arid soils.

Organic matter is low and may vary from less than one per cent to almost ten per cent. Generally arid soils are alkaline in reaction. If the alkalinity is due to calcium carbonate and calcium clays the pH will be below 8.4. If the pH is higher it is probably due to sodium carbonate. Usually there is a high accumulation of soluble salts and lime due to their development under conditions in which little leaching occurs.

He has also noted that the effects of vegetation can cause great variations in the soil over relatively small area due to the fact that plants vary in the amounts of salts which they absorb.

The parent material of a soil is often just as important as the secondary characteristics it assumes. Apparently in some cases the parent material compensates for the climate. Limestone seems to allow species to extend farther than usual into wet or cold climates and consequently higher in altitude (8). In Bangor, Wales, Bradshaw and Pritchard (11) have reported that a large number of areas of soft alkaline rock

have been found to strongly influence the vegetation. When such rock occurs on the slopes, a grassland which ordinarily is only found in the lowland base-rich area is able to grow.

Beadle (6) has shown that in Eastern Australia the degree of xeromorphism is directly dependent on the phosphate content of the soil.

The properties of Terra Rossa have been discussed at length by Reifenberg (64).

Under most conditions limestone does not give rise to Terra Rossa soil. Even in Mediterranean areas such soils result only from harder types of limestone and not from the softer calcareous parent materials.

It is low in humus due not only to the summer drought but to the calcareous substratum. Its pH ranges from 7.2 to 8.4. Its soluble salt content is high.

Terra Rossa is rich in iron which gives to it the characteristic red color. In winter the humid conditions enable hydrolysis of the sesquioxides and of the silicons to occur. Also, due to the heavy winter rains, calcium carbonate is dissolved and is leached out of the soil. Thus Terra Rossa has a high silicon and sesquioxide content in relation to that of the parent material.

In mountainous areas it is particularly susceptible to erosion.

According to Clark and Wooley (16) an acre inch of water weighs more than 113 tons. They have reported a study

of the soil loss from a ten percent, 200-foot slope. They showed that the first ninety-foot section lost 9.85 tons of soil per acre in one year. The loss from the second ninety feet was more than double that of the first, and the loss from the third section nearly double that of the second.

The primary reason for accelerated erosion on arid soil is the lack of protection. A mulch layer of dead and decaying material offers resistance to the falling water and enables it to be absorbed into the soil.(42)

The living plants are also important in protecting the soil. When a drop of water hits a plant before falling onto the soil, the impact is greatly diminished. Weaver (96) has shown that when the tops of plants are cut off erosion is from one to seven times faster than when the whole plant is present. He also demonstrated that there is a great increase of erosion in overgrazed as compared to ungrazed areas.

Erosion is indicated when the rate of soil loss is obviously faster than the rate of soil formation, when bare surfaces appear in gullies and depressions, or when the plant cover at the land surface is below normal. Also obvious signs of erosion are seen in rill patterns in the soil and in muddy runoff. (28)

Due to increased erosion under dry condition the whole terrain assumes an angled aspect in contrast to the rounder hills and valleys of a less arid area (48)

However, the presence of bare rock does not mean that accelerated erosion has definitely occurred. When rocks are cracked the water will carry the clay particles down into the cracks. Terra Rossa soils will therefore often be very rocky and irregular without accelerated erosion having occurred (48).

PHYTOGEOGRAPHY

FORMATIONS In Palestine Eig (26) has subdivided the natural vegetation into basic groups; the mesophytic flora which is primarily confined to the ephemerals of the rainy season or to plants associated with cultivation, the halophytes, the hydrophytes, and the xerophytes.

The xerophytic flora is further subdivided into the Mediterranean formations and the oriental steppe formations.

The Mediterranean formations include the forests, maqui, garigue, and batha.

The maqui is a closed shrub formation, mostly evergreen.

The garigue is considered as a degradation of maqui and is found under conditions of less rainfall. It is a more open formation of shrubs smaller than those of the maqui.

The batha is a still further degradation consisting of dwarf shrubs and perennial herbs.

The classification of Zohary (79) essentially agrees with that of Eig, but he has given annual rainfall as his basis of division. The eu-Mediterranean zone has a yearly rainfall of 300 to 1000 millimeters; the steppe zone, from 200 to 300 millimeters; and the desert of less than 200 millimeters.

According to Zohary, the batha is limited to the Mediterranean-Irano-turanian borderlands. He has extended the classification one step lower than the batha to the Mediterranean semi-steppe batha.

The use of the word "steppe" is not to be understood in its usual sense. Eig (26) has acknowledged that the maqui and all of its degradations would be considered steppe by most phytogeographers.

Also Rolley (66) has noted that the word "forest" in the Levant, applies to any formation which includes trees. This term has a much more narrow use in other regions. Dansereau (20) has defined a forest as a formation of trees which are above eight meters in height and have a crown cover of at least sixty percent.

Furthermore, the terms maqui and garigue are not used in a consistent way. Fisher (34), for example, has used the word garigue in a much broader sense to include all types of Mediterranean flora.

In this paper the various terms are to be understood as they are used by Eig or as they are generally understood in this region.

Among those who have studied the question there seems to be general agreement that the various scrub formations represent degradations of an original oak forest climax. A large amount of the evidence for this has come from the study of past and present Quercus forests in Palestine by Eig (27).

He has established the presence of vast open forests of oak throughout Palestine. His study was facilitated by old maps and journals, by remnants of forests preserved for religious reasons, and by geographical names which imply original

forests. Also he has relied heavily on the plant sociology principles of Braun-Blanquet.

Workers in other parts of the Mediterranean have also concluded that the scrub formations are generally degradations of former forests (38) (87).

The reasons that destruction of the forests has been able to occur on such a large scale has been explained in various ways.

The factors of climate and the grazing habits of goats have already been mentioned. Rolley (66) has observed that lack of pasture makes the forest trees particularly subject to attack. Fisher (34) has pointed out that in the Levant woodland is a marginal growth and conditions are only barely suitable for its existence. Therefore, when forests are destroyed renewal does not easily occur. Also with unrestrained grazing the seedlings are destroyed as soon as they develop. Gilmingham and Walton (38) have noted that a young tree with a single vertical shoot is most susceptible to destruction by grazing animals, and that even moderate grazing should lead eventually to the destruction of a forest.

According to Mouterde (56), the simple division between Irano-turanian and Mediterranean is not sufficient to explain the phytogeography of Syria and Lebanon.

The Lebanon Mountains which border the sea have prevented the Mediterranean zone from extending far into the interior. Also the strong winds along the coast have compli-

cated the situation.

On the sea coast the plants are typically Mediterranean but beyond the mountains a region of much greater dryness and of freezing winter temperatures has changed the vegetation.

On the basis of these differences Mouterde had divided Syria and Lebanon into the following floral zones each with its own characteristic plants.

1. Coastal zone. Sea-coast to 1,400 meters.
2. Montaine zone. 1,400 to 2,000 meters
3. Summit zone. 2,000 meters and above
4. Zone of the interior plain (Mediterranean continental, or Syrian). Rainfall 500 to 700 millimeters per year.
5. Steppe zone. Rainfall less than 500 millimeters per year.

Terbol which has an annual rainfall of 500 to 700 millimeters is included in the Mediterranean continental zone. Mouterde has described the area as having a probable climax of Crataegus or of very open forests of Quercus or Pyrus.

If such forests did exist in the past, they have been completely obliterated in the Terbol region.

Rolley (66) has made a survey of forests in Syria and Lebanon. He has stated that the Middle East was rich in forests which have continued to be destroyed by the extensive flocks of goats.

He has reported evergreen oak forests near Hermel and Baalbeck. He noted that there were 28000 hectares in the Leb-

and 5,000 hectares in the Anti-Lebanon which were even then on the verge of extinction. The number of goats in Lebanon at that time was estimated at one-half million.

FLORAL ELEMENTS Dansereau (19) has pointed out that the flora of a given area does not consist entirely of plants that are well adapted to the present environment but represents the "residuum of the specific composition of various plant...populations which have succeeded one another in a certain region".

Tristram (43) has referred to early exploration of Sir J.D. Hooker in Lebanon.

Hooker showed that the Miocene flora of Germany extends to Palestine. This is explained by the theory that the whole of the area must have been dry land while most of the Mediterranean and its coast were still submerged beneath the sea.

Hooker attributed the scarcity of boreal plants in the Lebanon mountains partly to the drying desert winds but mainly to the warm period succeeding the most recent glacial period.

Post (62) has confirmed Hooker's observations on the lack of arctic species in the alpine regions of Lebanon. He agreed that they were obliterated by the warm period succeeding the most recent glacial period and noted that they had been replaced by a highly specialized local flora.

Anti-Lebanon, according to Post, has much in common with Lebanon but the flora is generally poorer and less distinctive.

Mouterde (56) has further pointed out that the flora of the Mediterranean continental zone is neither Irano-turanian nor Mediterranean but a homogeneous mixture of both elements.

III. REVIEW OF THE LITERATURE

The amount of work done on the effects of grazing and on secondary succession of protected areas which had formerly been overgrazed is vast. However, due to the great economic importance of the problem, most of the studies have focused attention on grasses and increased yield of forage crops rather than on specific vegetational changes. Only those of specific interest to this study will be mentioned.

OVERGRAZING Daubenmire and Colwell (21) have demonstrated that overgrazing on a prairie of Agropyron and Poa in southeastern Washington caused the perennial Agropyron to be replaced by dwarf annuals. The replacement of perennial plants by short-lived annuals is a common result of overgrazing (70).

Also, due to the selectivity of the grazing animals the more palatable plants are liable to decrease while those that are less palatable increase (28).

Palatability is only one of the factors influencing the selectivity of grazing. Various adaptations can enable plants to survive under conditions of excessive grazing. Some of these characteristics were studied by Gillham (36) while investigating the effects of rabbit grazing on vegetation.

Hemicryptophytes and dwarf forms are particularly well adapted to withstand grazing as are ephemerals and other plants which achieve rapid maturity, or which have the capacity

for regrowth after cropping, or the location of the apical meristem at or below the ground level.

Most of these characteristics would be assumed to preserve the plant against trampling as well as against consumption by the grazing animals. This is supported by studies done by Gillham (37) in a situation under which no grazing occurred but only trampling and manuring.

Trampling not only breaks off the tops of the plants but cuts off aeration of the soil (15) and may increase erosion along trails which are formed (29).

Erosion is a common effect of overgrazing and is due not only to the effect of trampling but to the loss of protective mulch and decrease in cover. However, according to Kellogg (48) the occurrence of accelerated erosion is natural under some conditions and is not necessarily due to misuse as some authors would imply. Drought alone can destroy the vegetative cover allowing an increase in erosion regardless of grazing practices.

Under some conditions the changes resulting from grazing are beneficial to the area. In Scotland, Fenton (33) has shown the importance of trampling by cattle in checking the spread of the bracken fern.

Gillham (36) has shown that in some species close grazing stimulates the reproductive phase of the life-cycle. In other cases destruction of the leaf apices encourages the production of vegetative tillers.

These and many other claims to the beneficial effects of grazing have been critically studied by Ellison (31) and have been found generally weak and unconvincing, at least in their application to sub-humid or semi-arid areas. It can be assumed, according to him, that under such conditions any amount of grazing will reduce production and modify species.

The effects of overgrazing are not limited to the soil and vegetation. The initial changes which occur result in a change of habitat for the animal life which is, according to Smith (70), unfavorable for most species.

Some rodents seem to increase under these conditions due to the predominance of fleshy-rooted and bulbous plants which the animals eat.

Ellison (29) has attributed the increase of Jack rabbits in the southwestern United States to the increased visibility provided by shorter growth.

The increase in rodents permits further degradation not only because of the food they eat but because of their destructive burrowing. Effects of burrowing have been studied by Gillham (37). They involve direct effects such as the burial or exposure of plants and indirect effects such as initiation of erosion and the dessication of soil overlying the burrows by evaporation into the air of the burrow.

In connection with trampling, caving in of the roofs is liable to occur leading to more exposure of soil and to the extension of living quarters.

Some insects such as grasshoppers also increase in overgrazed areas (29). The oviposition habit by which eggs are laid on bare ground makes an overgrazed habitat ideal for grasshoppers (75). Ulvarov (75) has stated: "In the dry hill pastures of the Mediterranean countries excessive overgrazing and destruction of perennial shrubs for fuel and by goats have resulted in a cover of short bunch grass with abundant bare spots, and here the Moroccan locust is enabled to thrive".

According to Smith (70), insects generally increase when overgrazing occurs but decrease again with erosion.

PROTECTION Costello and Turner (18) have added considerably to the understanding of the changes which occur when an overgrazed area is protected.

They have emphasized that the enclosure should be large for several reasons. On small enclosures, rodents often increase so rapidly as to obscure the effects of protection from domestic animals. Drifted snow or soil may accumulate against the fence effecting the area bordering it. Also gross effects of overgrazing such as accelerated run-off and sheet erosion, invasion of introduced species, or the lowering of the water table may be extended into the protected area.

Gardner (35) has added that a large area will offer a greater variety of conditions of soil, slope, aspect, etc.

A number of factors which may influence the rate of succession in plowed land and which might also be applied to

grazed areas have been mentioned by Costello (17), Among these factors are unfavorable amount and distribution of rainfall, certain topography or soil types and the presence of non-domestic animals.

Costello and Turner (18) have advised that lack of contrast should be given as much emphasis as outstanding differences. In a period of drought there may be no succession whatsoever. Also in the absence of representatives of the original vegetation, reinstatement cannot be expected by protection alone. On the other hand, if potential is strong good results can be expected in ten years.

Particular attention should be given to perennials which react more slowly but more positively to the environment. Annuals may vary from year to year (74) (18).

Gillham (36) found that upon enclosure the smaller species were crowded out by the larger ones. As the bare soil became covered, species increased in number but later decreased to less than half the number of the earlier stages.

Occasionally density is less within the enclosure than on the grazed area. This is contrary to what would normally be expected. This has been explained by Costello and Turner (18) in two ways. The grasses which normally replace weeds and shrubs are likely to be of a lower density. Also, in cases of drought grazed plants may be able to survive better than non-grazed plants because of the decreased transpiring surfaces which aids in the conservation of soil moisture.

Nevertheless, studies by Albertson (1) have shown that generally prairies overgrazed in the past suffered much more severely from drought than did those areas which had been more properly utilized.

In the study of enclosures the common measures of vegetation such as frequency, density, abundance are employed with special emphasis on cover and on yield obtained by clip quadrats.

Dix (23) has made a study on grazing more from the botanical and ecological point of view. He has developed what he calls grazing susceptibility numbers which give a quantitative value to the effect of grazing on an individual species. The number is calculated by multiplying by 10 the sum of the densities on the ungrazed area minus the sum of the densities on the grazed area. This is divided by the sum of the densities on grazed or ungrazed depending on whether it is a positive or negative number. High positive numbers will indicate adverse effect by grazing and a high negative number indicates beneficial effects.

IV. PROCEDURE

FIELD METHODS

A seventy-five hectare area which had been fenced by the Lebanese government in 1953 was utilized in this study. The original plan of reforesting this enclosed area was never realized, but the exclusion of livestock enabled secondary succession to occur.

The area outside of the fence was heavily grazed primarily by goats but sometimes also by sheep. The only grazing permitted within the area during the eight-year period had been at the bottom of the hill. This part of the enclosure was not considered. There is evidence that goats had occasionally been able to get inside of the enclosure but this had been rare enough that little harm could have resulted.

The study was made between September 1960 and May 1961.

One section of the fence bisected the hill from top to bottom. It was the area along this part of the fence that was chosen for study. The first site, "A", was picked at random along the first 20 meters of fence at the top of the hill. The next site was 80 meters from Site "A", Site "C" was 80 meters farther etc. Distance between sites was approximated by counting 20 fence posts, each of which was about 4 meters apart. See Figure.

Different methods were used in sampling according to

the data needed and to the vegetation at the season in which the samples were taken.

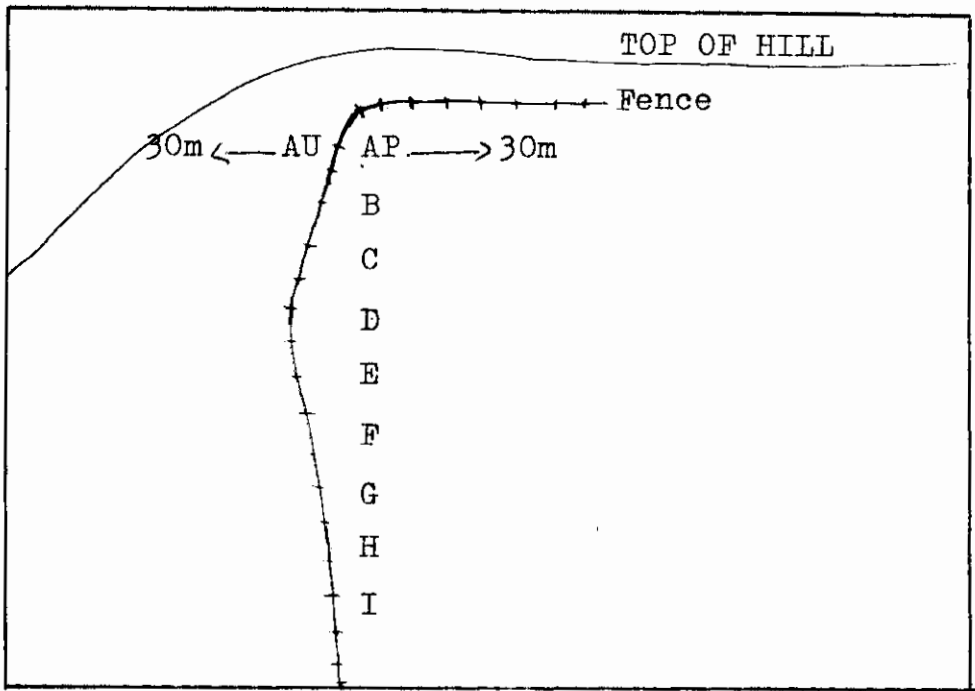


Fig. 3; Diagram showing location of the fence and of sites along the fence in relation to the hill.

In the early autumn, when vegetation was scanty, line-count transects were taken. A steel, 30-meter measuring tape was used as the line. The tape was secured firmly five meters from the fence and stretched out perpendicular to it. The five meters on either side of the fence were not considered in order to eliminate any error caused by the effect of the fence. Each plant which had any living part directly under or over the line was listed and the number of times it occurred noted. These transects were taken on both sides of the fence at each of the nine sites along the hill.

Once in the fall and again in May, five points along the line were chosen at random and circular samples taken with

the points as centers. To determine the sample unit a steel hoop, one meter in diameter was used which had cross-wires to mark the center.

There were two purposes for this modification. First, it was considered desirable to add an element of randomness. Secondly, with the plants of the sample extended along a line it was impossible to determine their associations. With the hoop it was possible to retain the stratification and yet have random samples and to have the advantage of length which a line provides combined with discrete units to observe plant associations.

When the plants were not too numerous, each specimen was counted and recorded, but during the season of the ephemerals only flowering plants were noted. When it was feasible counts were made, but the very minute and numerous species were not counted.

Plants were identified and placed on file at the Post Herbarium, American University of Beirut. All identification was checked by Père Paul Mouterde and additional species were identified by him.

Total cover was estimated by the line-transect method of Canfield (14). No individual species formed more than a very small amount of the total cover, and therefore no estimates of cover were made for individual plants.

In February ten traps were set at each site to collect a sample of rodents.

Soil was tested in the field for free carbonates with dilute HCl.

TREATMENT OF THE DATA

The data of trips made in September and October were pooled and used as the basis for subdividing the community. The first subdivision was based on the relatively small number of perennial plants which had survived the dry summer months. When the presence of these plants was plotted onto a map, communities could be easily distinguished.

Two other methods were used to verify these results and to perhaps detect more subtle differences.

The first of these two methods was the d^2 method of Harberd (41). By comparing the data of each site with every other site the number of species found only once in each pair of lists was determined. This number was considered as the difference between the two sites. When all of these numbers had been included in a table, sites were grouped by eye into more or less homogeneous groups. This test was performed twice. The first time the rather scanty data of the autumn were used. Later data obtained the following April were subjected to this analysis.

The second method was based on association analysis using the data of the hoop studies. The procedure recommended by Williams and Lambert (77) was used. Only the most common plants were considered in an effort to have the final groups be statistically meaningful.

The plants which occurred within the quadrats were assigned letters and recorded on a map within the units in which they appeared.

A two by two contingency table on the basis of presence and absence was made for each pair of plants and a chi-square test performed to determine whether or not the association was significant.

| | | Plant X | |
|---------|---|-----------------------------|-----------------------|
| | | + | - |
| Plant Y | + | No. of samples both present | Y present X absent |
| | - | X present Y absent | both absent |

The chi-square values of all significant associations whether positive or negative were added to a matrix and the sum determined for each plant. The plant with the highest total value was the species on which the first subdivision was made.

The second subdivision was made on the species which had the highest sum significant chi-square values in the presence or absence of the first subdivision species, etc.

Individual plants were analyzed as to the following characteristics:

1. Periodicity of flowering and fruiting. Fruiting periods were given only when the plant was actually seen in fruit.

2. Community

3. Grazing susceptibility number of Dix. Brown (12) has pointed out that "density" is used by range investigators in the United States to express the area covered by a species. This is ~~the~~ how Dix appears to have used the word. In this study the more general meaning has been used. The grazing susceptibility number was obtained in the same way that Dix used but it should be noted that it ~~was~~ based on number and not cover.

4. Percentage frequency. The figure here was based on the percentage of quadrats within its own community. The area of its occurrence and not the communities designated by number was considered as the plant community.

5. Abundance value (Density). This number is the average number of times that an individual occurred within quadrats in which it was present. For plants too numerous to be counted this value is represented by ∞ .

6. Probable distribution. This is a more subjective estimate than the others because it is based largely on field observations. True measures of dispersion are possible but it was not thought to be worthwhile in this study.

7. Site of highest frequency. This was expressed as A,B,C...if there was no great difference between the protected (P) and non-protected area (U). If there was a difference the site was expressed by AP, AU, BP, BU, etc.

8. Percentage of total plants at the level of highest

frequency. This figure should give an indication to the extent to which the plants are limited by factors other than grazing.

Beyond April 17 no plants collected were considered in the individual analyses except those that had been considered the previous autumn.

Plants found to be particularly affected by grazing or protection and those that were not affected at all were analyzed as to structure. The classification of Dansereau was used (19).

A complete list was made of all of the geographical names of the region in order to see if mention was made of vegetation directly or by implication.

V. OBSERVATIONS, RESULTS AND DISCUSSION

The growing season at Terbol began during the month of February. When the weather become warm enough for the ephemerals to keep from freezing and yet the rains were still frequent the whole ground became carpeted with tiny plants. Along with the ephemerals came the vegetative growth of many later-flowering annuals including fine hair-like grasses and the flowers of many geophytes. There was no evidence of any of the spiny plants at that time. Because of the time lapse that was involved between collection and identification a few of the ephemerals were not identified.

During this period of growth both the enclosure and the grazed range were abundantly covered. It has been shown that dwarf and ephemeral plants are well-adapted to withstand grazing. A species that grows for a long period of time before flowering and which extends high above the ground is obviously going to be more affected by grazing than a very small inconspicuous plant which can complete its entire life-cycle in a matter of days.

By April many of the longer living annuals were in bloom, and the ephemerals had decreased in number. Now more differences could be observed between the two areas.

In May many of the grasses reached maturity and all of the perennials which had been observed the previous fall could be identified.

By late May some of the plants which were first observed blooming during September 1960 were flowering. These included both Ononis antiquorum and Ononis Natrix. It was not determined whether there were two periods of flowering or if they flower throughout the summer. Post (62) has given the period of flowering for both plants as from April to June.

At this time the number of plants flowering had dwindled considerably and consisted almost entirely of thistles, perennials, euphorbs and grasses.

It was noted that when the rains had begun to fall the previous October a few annuals appeared, but they were soon eliminated by the rapidly falling temperature.

Results of the first subdivision made on the basis of plants found in September and October are given in Figure 4.

The most common of the perennials, Ononis natrix, showed a low fidelity to any particular area but, by its absence in the lower levels, differentiated Communities IV and V from the areas above "F". IV and V were differentiated from one another by Phlomis syriaca and Marrubium radiatum in IV and by two non-flowering compositae in Alkanna syriaca in V. Community I was characterized by Prunus prostrata. This plant was also present on the protected side but I was distinguished from "AP" by the presence of Euphorbia macroclada. Community II was characterized by Ononis antiquorum and Community III by Noeoa mucronata.

Plants that were generally confined to one side of

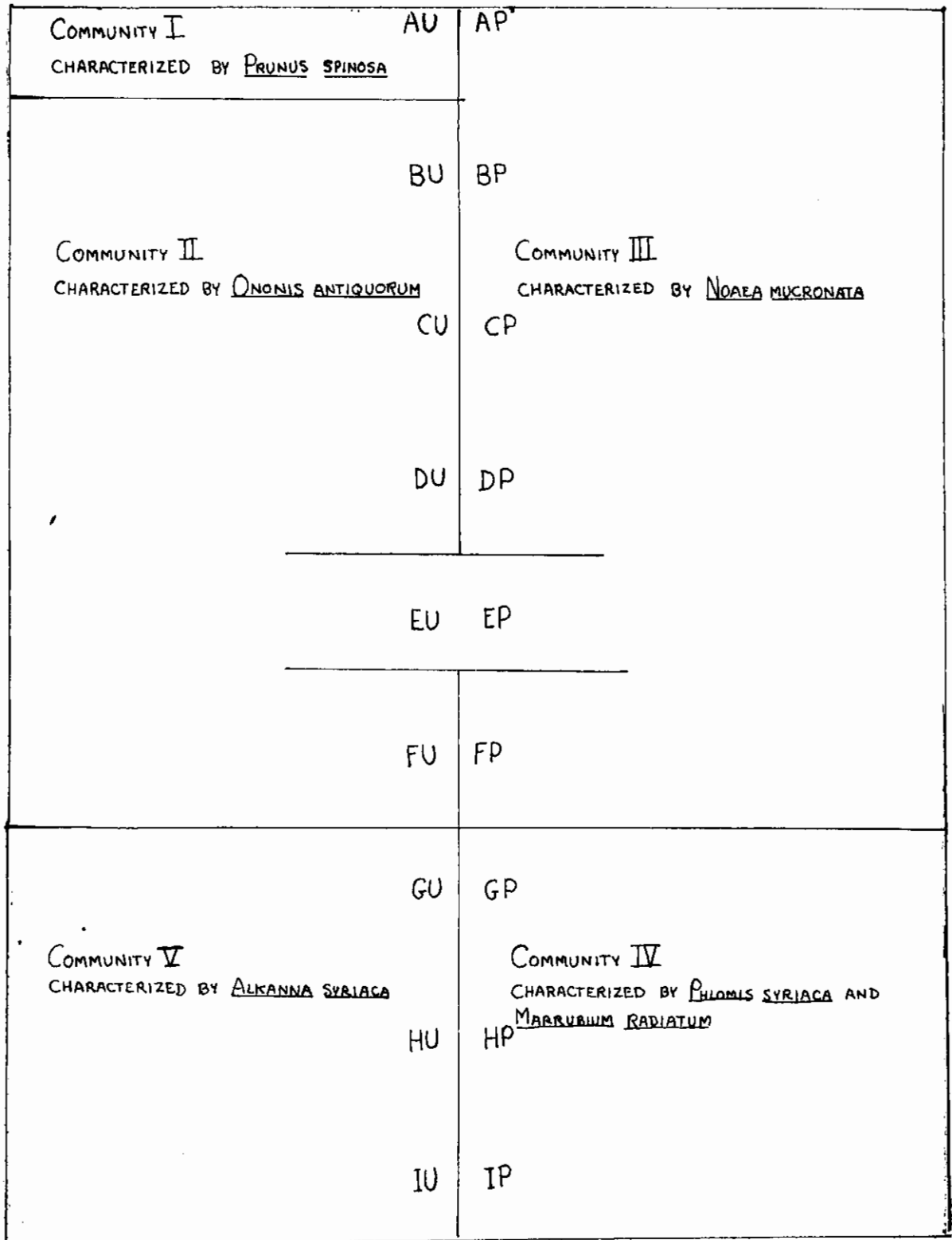


Fig. 4.--Diagram of community subdivision made on the basis of September and October Vegetation.

the fence or the other sometimes were found on the opposite side at the "D" level. This also has been indicated on the diagram.

The results of the analysis by d^2 are given in Table 3 and Table 4.

As regards Community I, both tables clearly confirm the results of the previous division. They further show that area "AP" should be considered as a separate community.

The remainder of the communities seem to be basically three. They are not distinct but overlap in several places.

Figure 5 and Figure 6 show the patterns which resulted when the data of each d^2 analysis was diagrammed.

The diagrams do not confirm the supposition that altitude was an important limiting factor.

Also, if the two primary factors are assumed to have been altitude and grazing then the sites at the same altitude should be closer than two sites that differ as to altitude as well as to grazing. At most levels this does not appear to be the case.

That altitude is not an important factor can further be shown by comparing the various d^2 according to level. Figures 7 and 8 show the d^2 for "BP" and the other protected sites and for "BU" and the other unprotected sites. "B" was chosen rather than "A" because "A" has already been shown to be distinguished from the others and probably is distinguished by factors other than altitude.

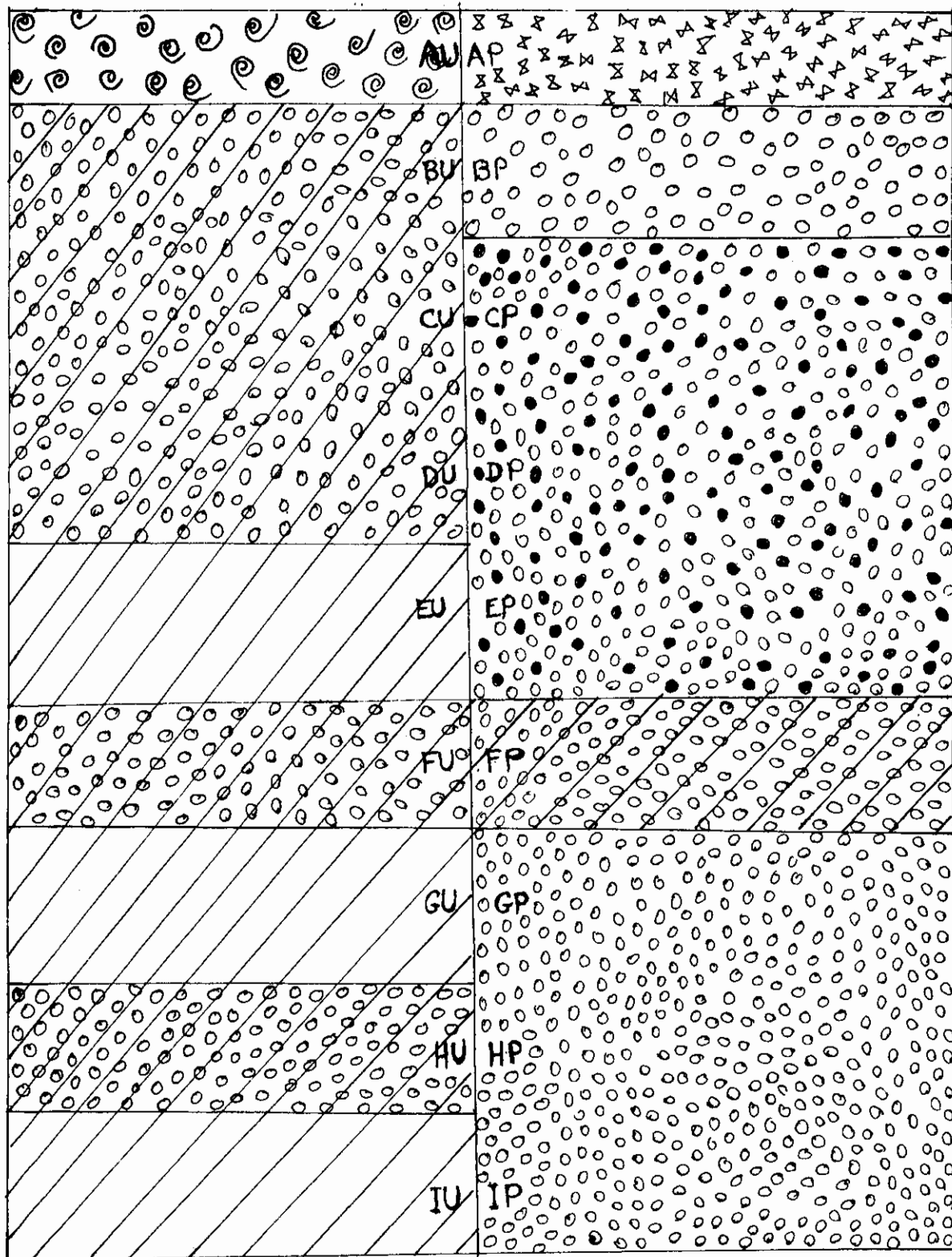


Fig. 5.--Diagram showing pattern of area based on September data. Symbols are arbitrarily chosen to show homogeneity. The same symbol indicates similarity of communities as indicated by low d^2 between them.

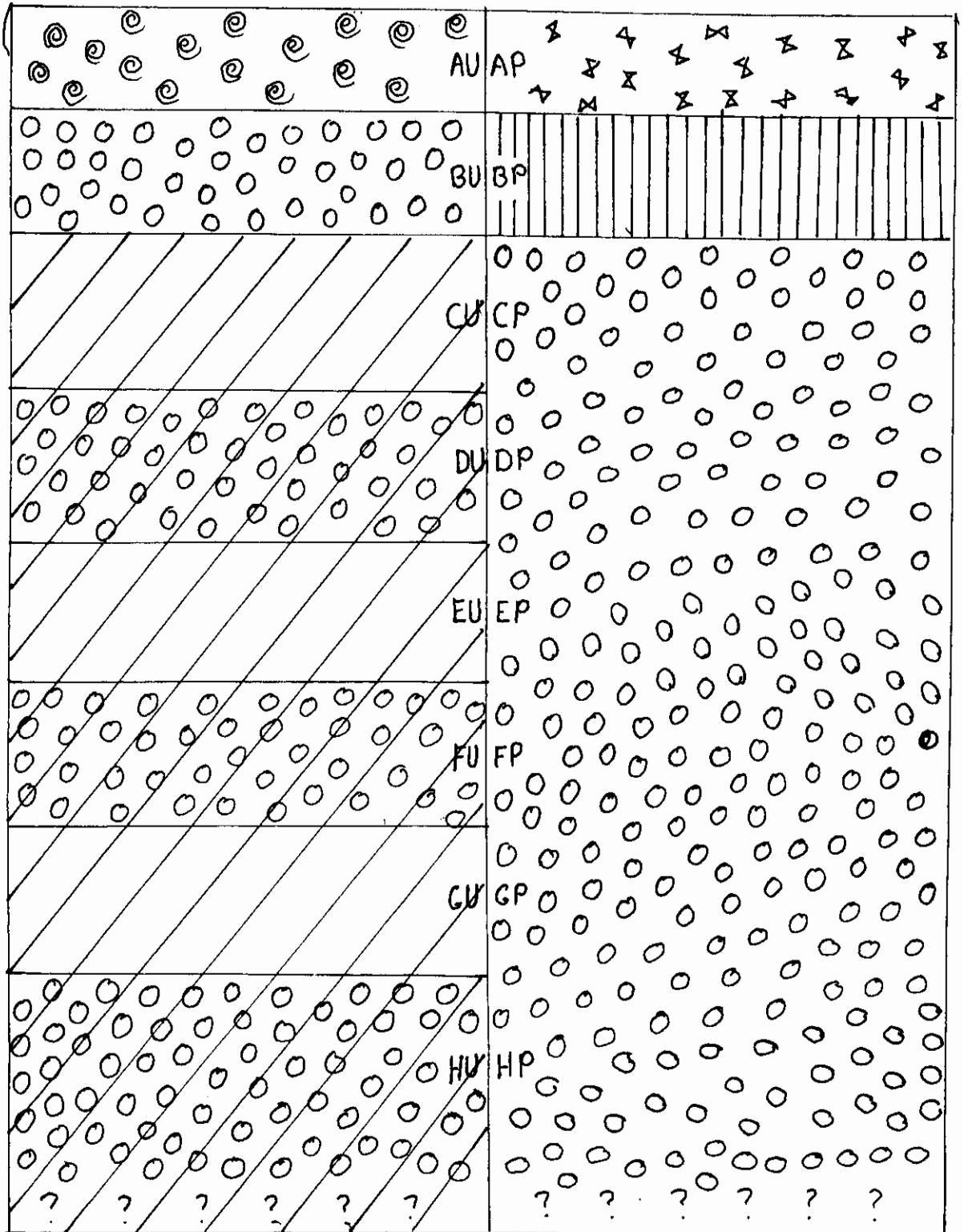


Fig. 6.--Diagram showing pattern of area based on April data. Symbols are arbitrarily chosen to show homogeneity. The same symbol indicates similarity of communities as indicated by low d^2 between them.

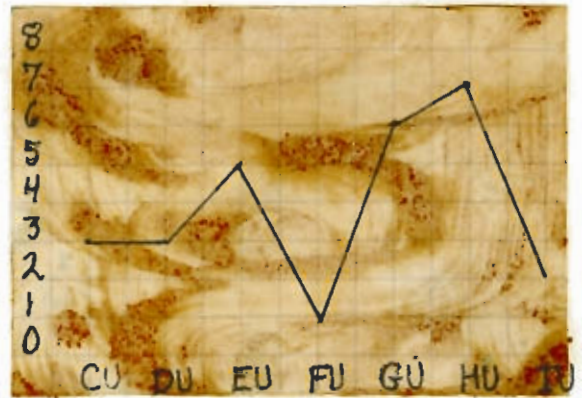
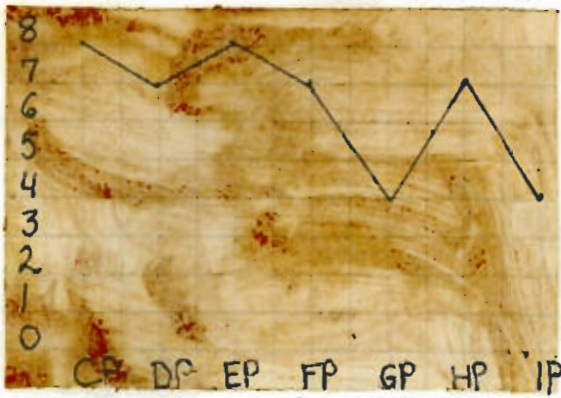


Fig. 7.--d² for "BP" and other "P" sites and "BU" and other "U" sites. Data of September

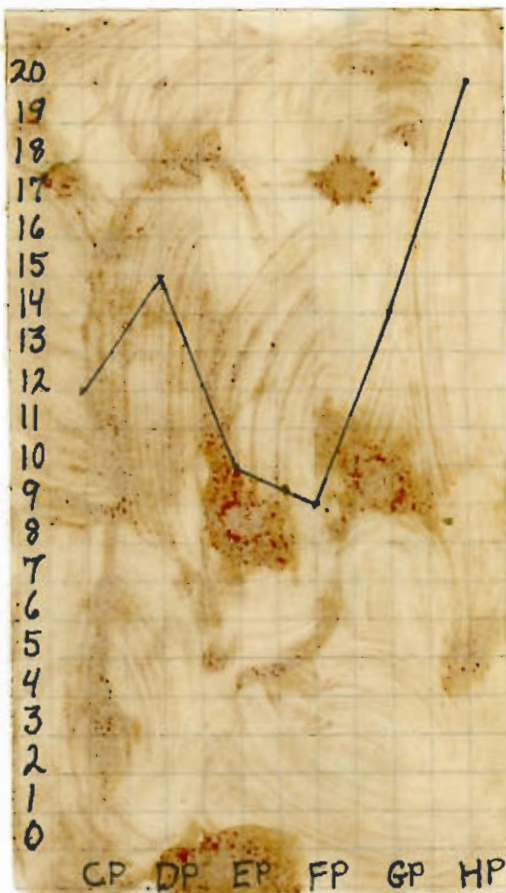


Fig. 8.--d² for "BP" and other "P" sites and "BU" and other "U" sites. Data of April.

The graphs indicate that altitude was not an important enough factor to be responsible for gross differences in communities. However, it will be shown that altitude was probably important in limiting individual plants.

When the change in communities was found not to be attributable to altitude the area was critically surveyed to try to determine what factors had contributed to the difference in communities. No conclusive observations were made, but the most likely explanation for the differences seemed to be change in soil or in water conditions due to variations in slope.

The altitude was measured with a pocket altimeter as 1240 at the top of the hill and 1000 at the lowest site that was studied. Since the distance between the highest and lowest sites was approximately 640 meters the hill had an average slope of about 37 per cent. However, the slope varied greatly. Some areas were extremely steep while others were only slightly sloping. The top of the hill was nearly level. This may explain the uniqueness of "A". At the other levels, the circles represent the areas that later observations showed to be steeper and the cross-hatched areas represent the less steep parts. Again see Figures 5 and 6.

When the average d^2 was obtained for comparisons within the grazed area, within the protected area and between areas the results were as follows:

TABLE 5.- Average d^2 Within Groups of Sites

| | | |
|------------------------------------|-----------------|-----------------|
| Between protected sites | 4.87 | 10.25 |
| Between grazed sites | 4.1 | 7.31 |
| Between protected and grazed sites | 4.91 | 10.78 |
| | <u>Sept. 28</u> | <u>April 17</u> |

In both cases the average differences between the grazed and protected areas is the highest figure indicating that protection from grazing has influenced changes in communities.

Also in both cases the average d^2 between the sites on the grazed area was much less than it was between the sites on the protected area. This is probably explained by the smaller number of total plants that are able to grow in the more severe conditions in the overgrazed area. Also, within the enclosure the influence of environmental factors other than the goats can be expressed more strongly.

Association analysis yielded no results that were of additional value for subdivision beyond what information had already been gained by division on the basis of autumn species and d^2 .

Williams and Lambert (77) have stated that subdivisions which consist of less than about eight quadrats are statistically meaningless. The only resulting group of more than eight quadrats was the one that included Ononis antiquorum and corresponded with Community II.

O. antiquorum was never found within a quadrat which

contained another perennial. When the first samples were taken this was thought perhaps to be due to a toxic substance because no other perennial was found alone. However, in the spring a totally different relationship with the annuals was observed. Ononis antiquorum is very spiny and seems to be well adapted to its environment. Probably it is not palatable to the goats. Every time the plant was observed in the spring it was completely entangled with the annuals which probably could not have survived in the grazed area without its protection.

If Ononis antiquorum has a very low water requirement the close association between it and the spring annuals might explain the strong negative associations which existed at the end of the summer. By the time the annuals will have completed their life cycle the soil moisture will have been depleted by such a large group of plants growing in such a small area. Since the soil moisture cannot be replenished during the summer it would not be possible for any new perennials to become established. This explanation is only conjecture because the water requirements of O. antiquorum in relation to the other perennials of the area is not known. Several members of this species were usually found within a quadrat and so if their water requirements are not less than the other plants this explanation cannot be the answer.

The results of individual plant analysis are given in Table 6.

TABLE 6.-- INDIVIDUAL ANALYSIS OF SPECIES.

| PLANT | PERIODICITY | COMMUNITY | SUSC. NO. | % FREQ. | ABUNDANCE | PROP. DISTRIB. | MOST FREQ. SITE | % OF TOTAL |
|-------------------------------|--|---------------------------|-----------|---------|-----------|-------------------|----------------------|------------|
| | | | | | | | | |
| <i>Campanula obscura</i> | ○ APRIL 5, 17 ● MAY 11 | ENTIRE AREA | 0* | 45% | UNKNOWN | SCATTERED GROUPS | F | 50% |
| <i>Eryngium yuccifolium</i> | ○ MAY 26 ● NOT OBSERVED | 1) ABOVE "F" | -10 | 30% | 1.4 | SCATTERED | AU | 71% |
| <i>Eryngium yuccifolium</i> | ○ APRIL 5, 17; MAY 11, 26 ● MAY 11, 26 | BELOW "E" | 0* | UNKNOWN | 1 | SCATTERED | NONE | — |
| <i>Eryngium yuccifolium</i> | ○ APRIL 17, MAY 11 ● APRIL 17, MAY 11, MAY 26 | ENTIRE AREA | +7 | 21% | UNKNOWN | RATHER AGGREGATED | NONE | — |
| <i>Grassia serotina</i> | ○ MAR. 5, APRIL 5 ● NOT OBSERVED | P ABOVE "F" | +6 | 47% | 8.5 | AGGREGATED | VARIABLE WITH SEASON | — |
| <i>Campanula rotundifolia</i> | ○ APRIL 5, APRIL 17 ● APRIL 17 | AREA EXCEPT AT "A" LEVEL | +7 | 18% | UNKNOWN | SCATTERED | F | 50% |
| <i>Lactuca scariola</i> | ○ APRIL 17 | ENTIRE AREA | 0 | 7% | UNKNOWN | AGGREGATED | VARIABLE WITH SEASON | — |
| <i>Muscicapa arborea</i> | ○ MAR. 5, APRIL 5 ● APRIL 5, APRIL 17 | "P" ABOVE "F" | + | 65% | UNKNOWN | AGGREGATED | F | 64% |
| <i>Nolina pauciflora</i> | ○ SEPTEMBER ● OCTOBER 31 | "P" ABOVE "F" | +10 | 36% | 2.1 | SCATTERED | A | 70% |
| <i>Oenothera biennis</i> | ○ SEPT., MAY 26 ● SEPT., OCT. 31 | BU, CU, DU | -10 | 60% | 2.3 | RATHER AGGREGATED | NONE | — |
| <i>Oenothera biennis</i> | ○ SEPT., MAY 26 ● SEPT., OCT. 31 | ENTIRE AREA ABOVE "F" | -6 | 54% | 2.1 | DISPERSED | A | 74% |
| <i>Oenothera biennis</i> | ○ APRIL 17 ● APRIL 17 | "B", "C" | +3 | 27% | 3.0 | AGGREGATED | VARIABLE WITH SEASON | — |
| <i>Prunella sp.</i> | ○ NOT OBSERVED | GP, HP, IP | +10 | 100% | 1.8 | SCATTERED | H | 85% |
| <i>Ranunculus abortivus</i> | ○ APRIL 17 ● APRIL 17 | ENTIRE AREA | +7 | 25% | 1 | SCATTERED | F | 50% |
| <i>Salvia nemorosa</i> | ○ APRIL 17 ● NOT OBSERVED | ALL OF P | +10 | 30% | 3.0 | LARGE PATCHES | D | 88% |
| <i>Senecio vernalis</i> | ○ APRIL 5, 17 ● NOT OBSERVED | ENTIRE AREA | +2 | 64% | UNKNOWN | IN SMALL GROUPS | NONE | — |
| <i>Thalictrum flavum</i> | ○ MAR. 5, APRIL 5 ● APRIL 5 | ENTIRE AREA | 0* | 34% | ∞ | AGGREGATED | VARIABLE WITH SEASON | — |
| <i>Thalictrum flavum</i> | ○ APRIL 17 ● APRIL 17 | ENTIRE AREA | 0 | 80% | ∞ | RATHER AGGREGATED | NONE | — |
| <i>Trifolium pratense</i> | ○ APRIL 17 | ENTIRE AREA | +2 | 21% | UNKNOWN | SCATTERED | NONE | — |
| <i>Veronica sp.</i> | ○ MAR. 5, APRIL 5 ● APRIL 17 | AREA EXCEPT RP, BP AND CU | -9 | 29% | 3.2 | SCATTERED | VARIABLE WITH SEASON | — |
| <i>Viola sororia</i> | ○ MAR. 5, APRIL 5, 17 ● NOT OBSERVED | BU AND CU | -10 | 20% | 6.5 | AGGREGATED | BU | 78% |

○ = PERIOD OF FLOWERING
● = PERIOD OF FRUITING
* = APPROXIMATED

Only the most important plants were analyzed but some of considerable importance were also omitted because they were not properly distinguished from one another in the field. Among these were some of the ephemerals and the three species of yellow Ranunculus.

A few other plants, although too uncommon for analysis must be given special attention.

Poterium spinosum was not common but was always observed on the protected side. It was only seen at "A" level and below "I" level.

Prunus prostrata was found on both sides at "A" level and apparently was not limited by grazing.

Rhamnus palestina, Prunus tortuosa, and Crataegus azarolus are of particular importance because of their potential size. Both Prunus tortuosa and Crataegus azarolus are capable of becoming trees.

Crataegus was found in the grazed area as often as in the enclosure, but within the enclosure some plants were as high as 120 centimeters while on the grazed area they were never taller than about fifteen centimeters. Prunus tortuosa and Rhamnus palaestina were not found on the grazed side. It should be made clear that this does not necessarily indicate that they are absent from that area. If they are present they also are probably closely hedged, and being much less common than Crataegus would be difficult to notice.

Judging from the data it appears that Noaea mucronata

is highly favored by protection. This plant is dry and shrubby with flowers born from the bases of the branches. Structurally it does not seem to be the type of plant that would be susceptible to grazing. However, until May of 1961 not a single plant had been observed on the grazed area although it was common within the enclosure. Then, quite by chance a large patch of healthy plants was found on the grazed side of the fence. Since it was impossible to cover the whole area in detail there may easily be other plants which were misclassified as to grazing susceptibility.

On the basis of the present vegetation of the enclosure the climax vegetation cannot be determined. Perhaps it is one of the shrubs which is already present, or perhaps it is another plant that has been completely eliminated by the goats and therefore cannot become re-established. Relevés taken by Eig (27) in Palestinian oak forest included both Rhamnus palaestina and Crataegus azarolus.

Arabic geographic names did not give any indication of the original vegetation. This is not surprising because the area has probably not been in its natural state since the various places have been given their Arabic names. An indication of the long-standing cultivation of the area is seen by the rather frequent occurrence of the word for vegetable garden, "haouch".

Total cover as estimated by the line transect method is shown in Figure 9. Although some difference is seen it

probably would have been greater if the estimates had been made after the period of growth of the ephemerals.

No cover estimate was made for individual species but observations showed that no single plant was common enough to be considered dominant, or at least not for more than a very short time.

No animals were trapped. The reason for this is probably that the traps were set at a time when the natural vegetation was preferred to the bait. Bodenheimer (2) has given this as the reason for failure to trap or poison voles in the spring months.

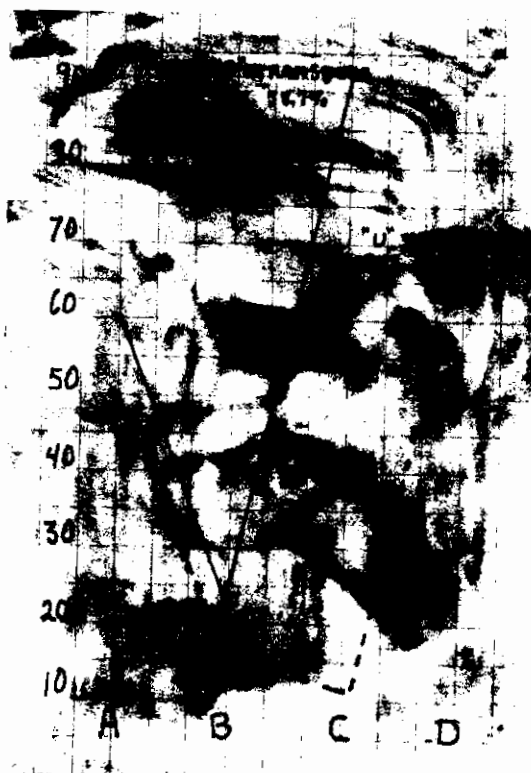


FIG. 9.-- COMPARISON OF COVER BETWEEN GRAZED AND UNGRAZED AREAS. MARCH 5, 1961

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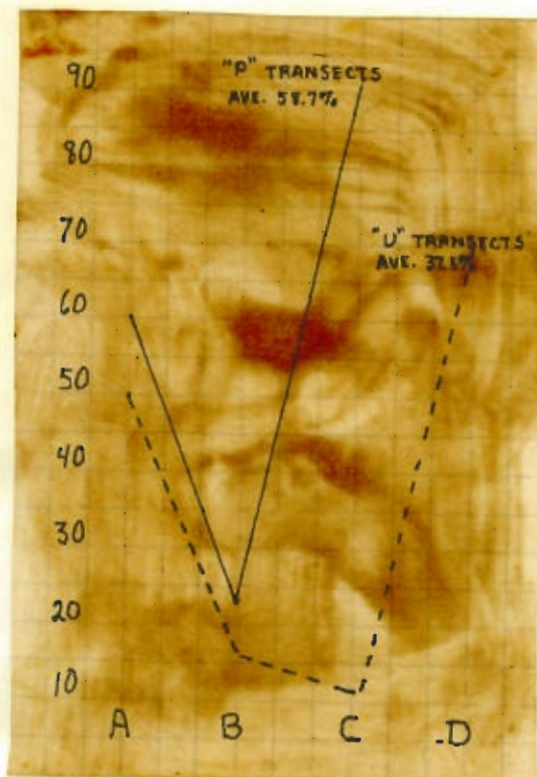


FIG. 9.-- COMPARISON OF COVER BETWEEN GRAZED AND UNGRAZED AREAS. MARCH 5, 1961

Burrows of small mammals were common within both areas.

On September 27 a fox was seen and on October 21 a Jackal. These animals are probably important predators of the rodents. Hawks are also quite common.

Soil at all levels showed effervescence when tested with dilute HCl indicating the presence of carbonates.

VI. CONCLUSION

In spite of the rather short period of enclosure and of almost continuous drought the area studied shows some signs of recovery.

The succession so far is more quantitative than qualitative and can best be seen in the d^2 analysis. Also some individual plants appear to have reacted to the enclosure either positively or negatively. It should be emphasized that after so many centuries of severe grazing probably almost all of the plants are adapted to survive its effects, but some are better adapted than others.

Studies of the summer vegetation, grasses in particular and comparative analyses of the soil would undoubtedly have been of great value.

A study of this enclosure after several years would be expected to show much more striking signs of succession than have already been exhibited.

APPENDIX

Complete List of Plants Identified

1. Alkanna syriaca (Boiss. et Hohen) Boiss.
2. Arum dioscoridis Sibth. et Sm.
3. Caucalis leptophylla L.
4. Chamaemelum oreades Boiss.
5. Cotyledon umbilicus L.
6. Crataegus azarolus L.
7. Erodium cicutarium (L.) L. Hér.
8. Erodium romanum (Burm. F.) L. Hér.
9. Erophila setulosa Boiss. et Bal.
10. Euphorbia apios L.
11. Euphorbia macroclada Boiss.
12. Euphorbia thamnoides Boiss. var. Jumulosa Post
13. Fibigia rostrata (Schenk.) Boiss.
14. Fumaria densiflora DC.
15. Gagea bohémica (Zauschner) A. et. R. Sch. ssp. aleppoana Pascher.
16. Gagea rigida Boiss et Spruner (Renculata V. rigidia in Dinsmore).
17. Galium articulatum (L) Roem. et Schult.
18. Geranium molle L.
19. Geranium tuberosum L.
20. Holosteum umbellatum L.
21. Lagoecia cuminoides L.
22. Lamium amplexicaule L.

23. Lathyrus pseudocicera (?) Pampanini (L. cicera L. v. lineatus Post).
24. Lens orientalis (Boiss.) Handel-Mazzetti
25. Lloydia rubroviridis Boiss.
26. Marrubium radiatum Del.
27. Minuartia tenuifolia (L.)
28. Muscari racemosum (L.) Mill.
29. Noaea mucronata (Forsk.) Asch. et Schweinf.
30. Ononis antiquorum L. (spinosa)
31. Ononis natrix L.
32. Ornithogalum lanceolatum Labill.
33. Papaver rhoeas L.
34. Parentucellia latifolia L.
35. Phlomis syriaca Boiss. (P. niss. L. var. leptorrhacos Boiss.)
36. Poterium spinosum L.
37. Prunus prostrata Labill.
38. Prunus tortuosa (Boiss. et Hausskn.) Auch et Hemsl
39. Ranunculus asiaticus L.
40. Ranunculus cuneatus Boiss.
41. Ranunculus damascenus Boiss.
42. Ranunculus hierosolymitanus Boiss.
43. Rhagadiolus stellatus (L.) Willd.
44. Rhamnus palaestina Boiss.
45. Salvia acetabulosa L.
46. Senecio vernalis W.K.
47. Thlaspi perfoliatum L.
48. Trifolium curvisepalum v. Tackholm

49. Trifolium formosum D'Urv
50. Trifolium stellatum L.
51. Valerianella vesicaria (L.) Moench
52. Veronica syriaca Roem. et. Schult.
53. Vicia perigrina L.
54. Viola ebracteolata Fenzl.
55. Ziziphora capitata L.

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