Some Aspects of Range Improvement in a Mediterranean Environment

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The urgent need to gain self sufficiency in agricultural products has turned the attention of Israel's farmers, agronomists and planners to the potentials of natural pastures. These are located mostly in the northern mountainous part of Israel in typical Mediterranean climatic conditions and occupy non-arable lands with stony, shallow soils often on steep hillsides. In order to utilize these pastures for increased milk and meat production, a range improvement program must be undertaken. As Agricultural Officer for the F. A. O. from 1951 to 1953, W. H. Miles (1952) has made valuable contributions in this regard and has reviewed the general problems of range management in Israel. Investigations carried out by the Nve-Yaar Agricultural Experiment Station under the direction of J. Arnon have led to large-scale projects of controlled grazing, brush burning, spraying and reseeding conducted by the Israel Soil Conservation Office.

For full development of these lands, severely depleted by centuries of misuse, a dynamic ecological approach must be employed to convert the present unproductive areas into useful vegetational types. The principles of plant-community management developed by Egler (1949) may be applied to a range improvement program by which valuable forage plants are established and maintained.

Such an approach involves: (1) a study of herbaceous stages of succession and (2) full recognition and integration of the human factor as a decisive ecological influence. Thus, by an understanding of the role of burning, cutting, tilling and grazing, and by the control of such activities coupled with management based on sound ecological information, these non-productive lands may be reclaimed.

This paper reports a survey of the successional stages of several vegetational types in Israel and presents recommendations for a range improvement program based on plant-community management. Such a program may be found helpful in other comparable climates.

Successional Stages of Israel Pastures

Vegetational Changes After Cessation of Abuse

The evacuation of Arabs and Bedouins from northern Israel after the War of Independence in 1948 stopped the centuries-long destruction of vegetation. Studies of undisturbed plant succession during this period reveal three striking phenomena: (1) the rapid regeneration of trees and brush from surviving remnants; (2) the spread of dwarf shrubs and perennial weeds; and (3) the re-establishment of perennial grasses suppressed by continued overgrazing.

Regeneration of trees and brush.—In Mediterranean regions the young shoots of trees and bushes make up most of the forage consumed by grazing goats and a large portion of sheep and cattle feed during unsupplemented grazing. It is not surprising that, after cessation of unrestricted cutting and heavy grazing, the woody vegetation freely demonstrates its vigorous regenerative powers. Large-scale secondary successions progressing toward dominance by the original tree and brush cover are evident. Two examples may illustrate this process.

In an area of lower Galilea still under severe grazing by goats, the few unpalatable plants are insufficient to prevent runoff and further deterioration on the barren slopes. Evidences of former forests, as shown by Eig (1933), consist of

FIGURE 1. Undisturbed area of maqui-brush in Western Galilea. Unproductive dwarf shrubs (*Salvia triloba, Poterium spinosum*).

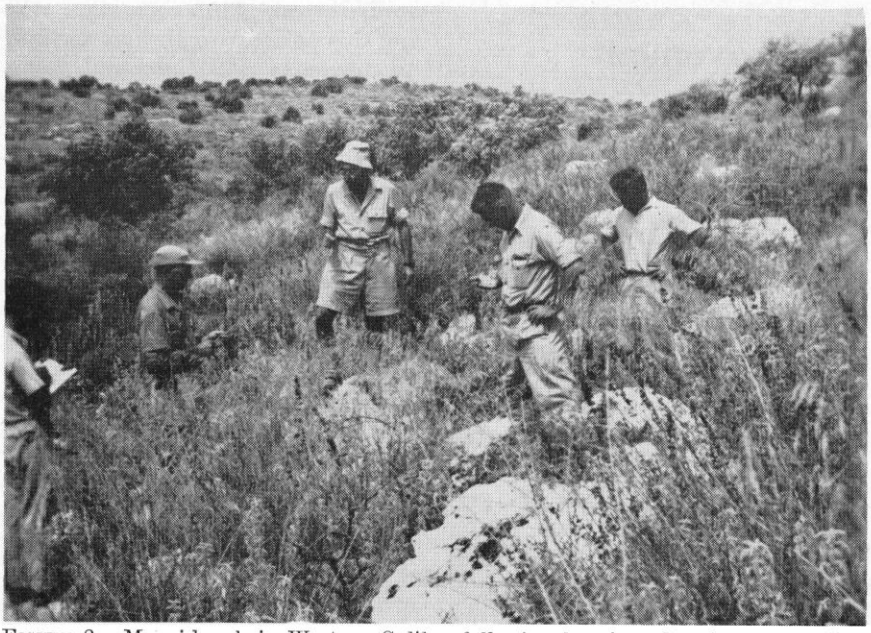

FIGURE 2. Maqui-brush in Western Galilea following burning. Dominants are *Oryzopsis milacea, O. coerulescens* and *Andropogon distachius;* carob trees in background.

oak stumps with a few degenerated lateral sprouts less than three feet in height and stunted plants of pistacia brush *(Pistacia lentiscus)*[1] averaging 18 inches in height and nearly denuded of leaves (Fig. 1).

On an adjacent area where the slopes have been moderately grazed in winter and spring by sheep and cattle for the past several years, a luxuriant sprout growth occurs on stumps of Vallonian oak (*Quercus aegilops* ssp. *ithaburensis.*) There are about 80 such regenerating oaks per acre with 5 to 10 stems, 6 to 9 feet in height, converting the once barren slopes into a typical Vallonian oak woodland. The oak population is also increasing by reseeding from acorns, which otherwise would be eaten by livestock.

A second example illustrates the rapid progression toward Maqui-brush, or Mediterranean scrub, in an area dominated by dwarf shrubs several years previous. The original continuous, close-grazed savannah of large carob trees (*Ceratonia siliqua L.*) with scattered low brush and annual vegetation was replaced after five years of controlled grazing by dense, almost impenetrable brush thickets. The annual vegetation has given way to perennial grasses, thistles, dwarf shrubs and brush, the short-lived annuals remaining only between rocks and on shallow soils.

Spread of dwarf shrubs and perennial weeds.—In the dwarf-shrub types of the foothills and in the transition between the Mediterranean and adjacent semi-arid regions, the cessation of goat grazing and cultivation of small terraces on the slopes has resulted in a steady increase of undesirable vegetation which is crowding out the palatable herbaceous plants and threatening the forage potential of these formerly favorable pastures.

Re-establishment of perennial grasses.—Striking and unexpected increases of perennial bunchgrasses were found. In vegetational surveys made prior to 1948 (Oppenheimer, 1950), undisturbed vegetation had been difficult to locate, because of heavy grazing pressure. Thus, even the usually protected "relicts" provided by cemeteries, roadsides, steep slopes, etc. were disturbed and grasses which suffered most from overgrazing had nearly disappeared. During the last five years, the lack of disturbance has allowed perennial grasses to return as part of the vegetational cover. It is thus evident that perennial grasses must be assigned a more important role in the floristic and structural characterizations of these plant communities (Boyko, 1949).

Mediterranean Pasture Communities

The data available from the initial studies permit only a preliminary definition of trends in the Mediterranean pasture communities which may be used as a basis for a management program of range improvement. Emphasis is placed on the role of perennial grasses in the following descriptions of trends.

Maqui-brush Communities.—Data on the Maqui-brush communities are based on detailed studies carried out since 1950 in Western Galilea.

Under favorable conditions in pre-brush successions, perennial bunchgrasses gradually suppress the annual species and, together with dwarf-shrubs, attain dominance. In secondary successions in which dwarf shrubs such as *Poterium spinosum, Salvia* and other mints are replaced by brush and trees, shade-tolerant perennial grasses *(Oryzopsis, Stipa bromoides)* persist as stable components of all stages leading to the true maqui community (Fig. 1).

In undisturbed successions following burning and cutting, the reappearance of perennial grasses is very striking. The grasses quickly spread from residual stands by regeneration from roots and undamaged vegetative portions of the plant and by volunteer reseeding. In the early successional stages following fires, these perennial grasses assume dominance and tend to prevent the establishment of dwarf-shrub seedlings (Fig. 2). The aggressively regenerating brush

1. *The nomenclature of plants follows that of A. Eig, M. Zohary and N. Feinbrun: Analytical Flora of Palestine. 2nd ed. Jerusalem.*

species soon demonstrate their ecological advantage and after a short period of equilibrium with the grasses again dominate the site.

It seems evident that elimination of brush competition favors the development of a highly desirable perennial grass cover which, in turn, is generally accompanied by a lush growth of annual grasses, legumes and broadleaved plants. These facts should be considered in the management of this community.

Brush-free Communities.— Brush-free communities in the Mediterranean environment may be divided into three categories, each with a different management approach.

(1) The poorest habitats (excluding the dunes and sandy soils of the coastal plains) are the dry southern slopes, shallow and stony soils and the severely eroded and deteriorated sites which are retrogressing towards bare rock. These communities consist mainly of xerophytic, short-lived species with low fertility and moisture requirements.

The only perennial grasses are bulbous bluegrass (*Poa bulbosa*), a low understory grass furnishing early green forage for sheep, and hairy beardgrass (*Andropogon hirtus*), a coarse bunchgrass palatable only in the early vegetative stages. The latter species is now gaining dominance over large areas of the rocky foothills and in the dwarf-shrub types of the limey sandhills of coastal plains. Legumes, principally *Trifolium* and *Medicago,* are the most valuable forage plants of these poor habitats.

(2) Areas of unfavorable soil conditions prevent the establishment of brush successions (Zohary, 1944). Topography and vegetation make these terrains well-suited for grazing and the areas were seriously overstocked prior to 1948. With the reduction in grazing, the herbaceous cover now shows a pronounced improvement in quality and quantity. Perennial and annual grasses and legumes have become important constituents. (Table 1).

On several sites, bulbous barley (*Hordeum bulbosum*) and/or wild oats (*Avena sterilis*) have become dominant, in association with perennial grasses and a highly variable population of annual grasses, legumes and forbs (Fig. 3).

FIGURE 3. Bulbous barley-annual grass community established in brush-free community following protection from grazing. *Avena sterilis* is the dominant annual grass.

(3) Sites with deep, fertile soils, favorable moisture and nutrient supplies, roadsides, field borders, etc., have higher forage yields and improved cover. Perennial bunchgrasses in these localities have shown a striking increase following protection from grazing. In addition to bulbous barley and wild oats, perennials such as Harding grass (*Phalaris tuberosa*), tall fescue (*Festuca arundinacea*) and perennial ryegrass (*Lolium perenne*) contribute toward suppressing the annual vegetation.

Unfortunately, perennial grasses are not the only plants benefitting from the protection from grazing. Evidence was found of strong competition between these and undesirable perennial herbaceous plants, dwarf-shrubs and bulbous plants. Most of these plants are readily consumed by goats and, though unpalatable to cattle and sheep, may be grazed under forced conditions. Where grazing is limited to spring pasturage by sheep and cattle, undesirable perennials have increased alarmingly. Under a plant-community management program, further spread of these undesirable plants must be rigorously controlled. Chemical sprays seem to be the most promising method of control.

The three categories of brush-free communities described need further study and ecological analysis. In their great variability and dependence on seasonal climatic fluctuations, the annual components of these vegetation types closely resemble the annual vegetation of California foothills as described by Bentley and Talbot (1948) and others.

Recommendations for a Plant-community Management Program

Development of the potentials of the Maqui-brush and brush-free communities described by a community management program should aim at: (1) the conversion of unproductive dwarf shrub and

Table 1. Principal species of a brush-free community on a shallow limestone soil near Daliah after five years of protection from grazing.

Species	Forage Value
Dwarf shrubs	
Majorana syriaca	Goats only
Sideritis perfoliata	Goats only
Perennial herbs	
Echinops blancheanus	Goats only
Gundelia tournefortii	Goats only
Verbaseum siniaticum	Goats only
Foeniculum piperitum	Goats, sheep
Perennial grasses	
Hordeum bulbosum	High
Dactylis glomerata	High
Oryzopsis holciformis	High
Arrhenatherum palaestinum	Medium
Annual grasses	
Avena sterilis	High
Phalaris brachystachys	High
Hordeum spontaneum	High
Annual legumes	
Trifolium campestre, T. purpureum	High
Hippocrepis unisiliqua	High
Psoralea bituminosa	Goats, sheep
Annual herbs	
Hedipnois cretica	Medium
Carthamus tenuis	Goats only
Rhagadiolus stellatus	Low
Linum nodiflorum	None
Echium judeum	None
Anagallis coerulea	Goats only

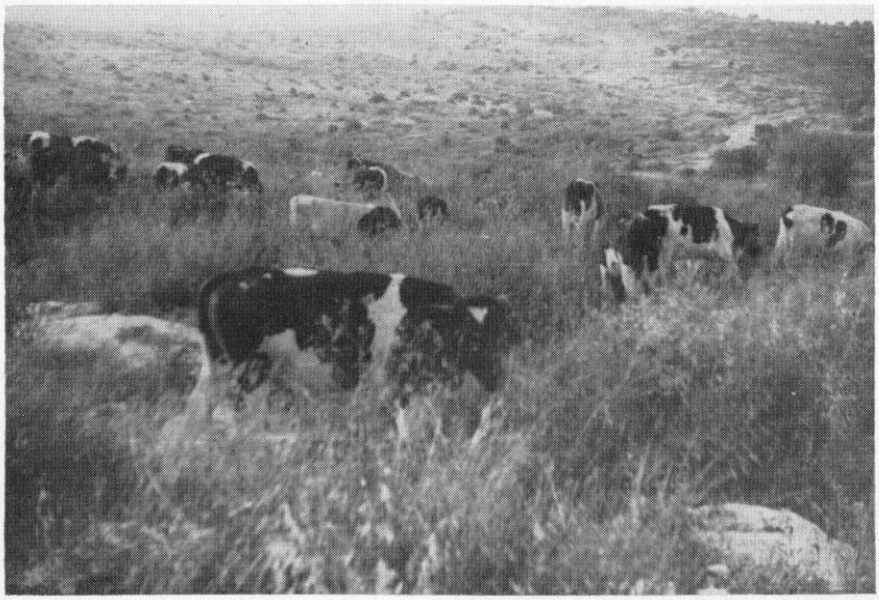

FIGURE 4. Cattle grazing on improved brush range.

brush communities into productive semi-natural tree-grass savannahs, and (2) the establishment of stable communities of valuable perennial grasses, annual grasses and legumes best adapted to the prevailing conditions of the brush-free areas. Specific procedures are outlined for the two major vegetational types.

Dwarf-shrub and Brush-free Communities

Objectives of a range improvement program in the dwarf-shrub and brush-free communities are:

1. Reduction in the grazing use of the herbaceous and woody vegetation which has resulted in retrogression and site deterioration.
2. Prevention of brush encroachment.
3. Conversion to productive cover of desirable forage plants and trees.

In 1950-54, tests were conducted in typical areas of Maqui-brush dominated by *Quercus calliprinos*, carob and pistacia in Western Galilea to control brush by burning and selective herbicides, followed by reseeding with promising perennial bunchgrasses. On the basis of encouraging results, a general management plan has been developed which includes two phases: conversion and long-range maintenance.

Conversion.—Conversion includes the elimination of unwanted woody vegetation by controlled burning of the dense brush cover and the prevention of regeneration by chemical sprays using 2,4-D esters in oil solutions. Revegetation of perennial grasses can be accomplished by volunteer reseeding from native stands and by distributing seed mixtures in the ash on burned areas. Harding grass and *Oryzopsis* have shown the greatest promise to date for this purpose.

The procedure must be adapted to the requirements of the site. In dwarf-shrub communities, for instance, reseeding is unsuccessful unless competition from annuals can be overcome. Blanket spraying in early spring shows promising results for the control of undesirable sprouting shrubs and emerging seedlings and against broad-leaved weeds.

In areas with insufficient brush cover to insure effective burning, undesirable woody plants can be killed by spraying the foliage with 2,4-D ester in the spring. The dead topgrowth can later be burned without difficulty. On areas formerly burned and since protected from grazing, spraying and reburning will ordinarily be sufficient to encourage the establishment of a desirable plant cover.

Maintenance.—Maintenance includes respraying and probably reburning to reduce the invasion of brush and weeds. On areas to be burned, properly spaced firelines should be cleared around well-developed trees, particularly carobs. Small saplings can easily be grafted on sprouting stems; on favorable sites, tree planting should be undertaken.

Valuable grasses and legumes should be protected by rotational-deferred grazing planned with par-

Table 2. Responses of the principal woody plants and perennial weeds to foliage sprays containing 2,4-D and 2,4,5-T esters

Species	Community	Forage Value
Highly resistant: not killed by repeated appls. of 2,4-D or 2,4,5-T		
Ceratonia siliqua	Brush-tree	High
Quercus calliprinos	Brush-tree	Low
Q. ithaburensis	Park forest	Medium
Semi-resistant; killed by repeated appls. of 2 lbs./A of 2,4-D ester in oil		
Pistacia palaestina	Brush-tree	Medium
P. lentiscus	Brush-tree	Low
Rhamnus palaestina	Brush-tree	None
Sensitive: killed by single appl. 2 lbs./A of 2,4-D ester in water		
Salvia triloba	Dwarf shrub	None
Majorana syriaca	Dwarf shrub; brush-free	None
Sideritis perfoliata	Brush-free	None
Ruta bracteosa	Dwarf shrub	None
Highly sensitive: killed by single appl. of 2,4-D ester at 1.5 lbs./A in water		
Calycotome villosa	Dwarf shrub	None
Poterium spinosum	Dwarf shrub	None
Foeniculum piperitum	Brush-free	Low
Echinops blancheanus	Brush-free	None

ticular reference to the seasonal development of perennial grasses and the protection of freshly-grafted or newly-planted trees.

Brush-free Communities

On eroded and deteriorated sites with low potentials, the most efficient management seems to be to graze the areas in early spring, leaving enough herbage to prevent further deterioration.

In more favorable sites in these communities, the chief methods for encouraging valuable forage plants are: (1) chemical control of weeds, (2) fertilization, (3) reseeding and (4) rotational-deferred grazing.

Chemical control.—Foliage spray tests with 2,4-D and 2,4,5-T, conducted since 1950, have demonstrated the value of selective herbicides (Table 2). Perennial broad-leaved plants and dwarf-shrubs were killed with one foliage spray application of 2,4-D ester in water at the peak of vegetative growth in the spring. Chemical control should play an important role in areas where goat-grazing has been entirely eliminated and conservative and controlled grazing is practiced.

Fertilization.—On areas with desirable grasses and legumes, fertilization with N and P has been shown to increase forage yields and lengthen the green-feed season. In several cases yields were more than trebled.

Reseeding.—Tillable sites, such as small terraces and fields remaining unplowed for reasons of soil conservation or submarginal crop production, may be successfully reseeded, provided the severe competition of undesirable annuals is reduced. In typical brushless areas of Israel, attempts to reseed have failed since most of these lands are non-arable. Without cultivation the forage plants are soon crowded out by annuals. A similar situation has been noted in California by Bentley and Talbot (1948).

Rotational grazing.—The relationship of seasonal development of perennial grasses to their palatability must be understood to appreciate the effects of overgrazing (Fig. 5). As indicated in the chart, most grasses start to grow at the onset of the autumn rains. However, on the basis of period of maturation the grasses may be divided into three groups: early spring, spring and late spring. These groups differ not only as to the time of seed ripening and drying-off but also as to palatability. It is probable that grazing pressure has resulted in the selection and survival of those perennial grasses which show a high regenerative power and low palatability during the reproductive phase. This group includes the early spring grasses such as bulbous barley and orchardgrass which have persisted in spite of continuous and close grazing. The late spring grasses are the most sensitive to uncontrolled grazing and are therefore most suppressed. The spring grasses or intermediate group represent a transition class and include two promising species for reseeding—Harding grass and and fescue.

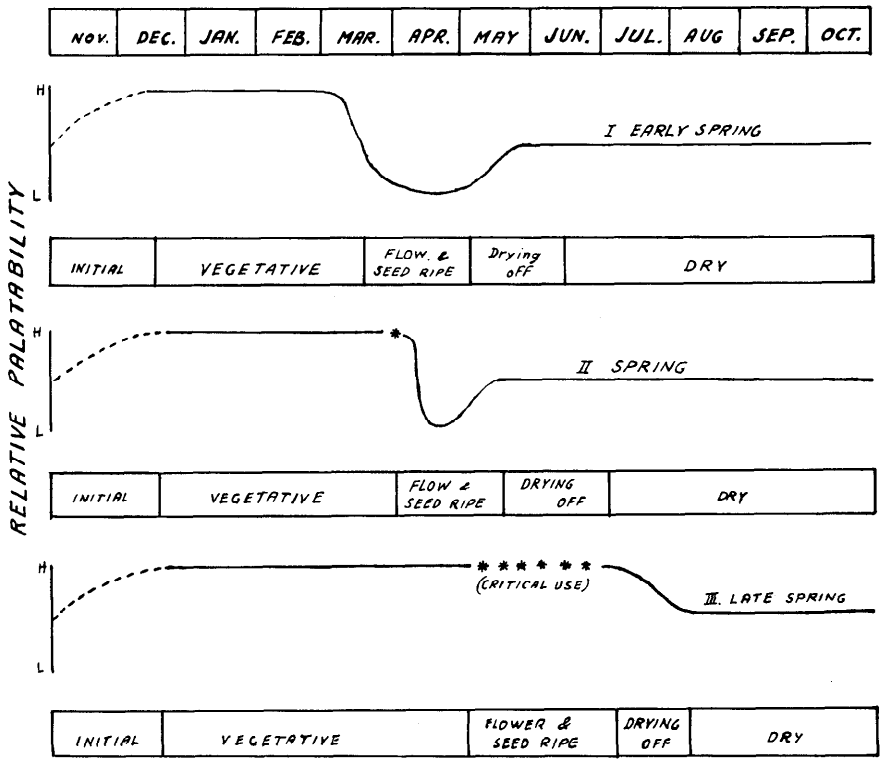

FIGURE 5. Relative palatability of perennial grasses as related to seasonal development.

I. Early Spring: *Hordeum bulbosum, Dactylis glomerata, Arrhenatherum palaestinum.*

II. Spring: *Phalaris tuberosa, Festuca arundinacea.*

III. Late Spring: *Oryzopsis miliacea, O. caerulescens, Stipa bromoides.*

It seems reasonable, therefore, to plan a rotational-deferred grazing system in order to use the existing cover most efficiently and to improve its composition. The following system, covering a three-year cycle, is suggested (Arnon and Hammelburg, 1953):

(1) In the first year, close grazing is advocated during the entire spring season; undesirable forbs are likely to be suppressed and full use is made of the forage.

(2) In the second year, grazing is deferred until summer, thus protecting all grasses flowering and seed setting and providing opportunity for their increase.

(3) In the third year, grazing is permitted during the early spring only, until flowering sets in; if sufficient grass remains, summer grazing may be allowed.

Thus, while the grasses serve fully as forage, they are entirely

protected during the critical period of late autumn at resumption of growth and during most of the flowering and seed-setting periods so that their increase is encouraged and undesirable weeds controlled by annual periods of grazing.

By the proper integration and use of controlled grazing, burning, spraying and tillage practices as tools in the management of these Mediterranean plant communities, man, the decisive factor, is converted from a destructive to a constructive ecological influent, restoring and purposefully utilizing the natural resources.

Summary

Principles of plant-community management are recommended for problems of range improvement in a Mediterranean environment. These principles are based on an ecological approach which includes knowledge of successional stages of pasture communities and the proper integration of the human factor as an ecological influent.

Observations of successional trends in natural pastures of Israel after five years of controlled use show that:

(1) Trees and brush regenerate rapidly and vigorously and the original woody cover regains dominance.

(2) In Maqui-brush and brush-free communities cessation of continuous and close grazing favor the encroachment of undesirable dwarf-shrubs and weedy perennials.

(3) Rapid and unexpected regeneration of perennial grasses from residual stands calls for their recognition as an important constituent of pasture communities in the Mediterranean environment.

The chief aims of a plant-community management program for range improvement are:

(1) Conversion of unproductive dwarf-shrub and brush communities into productive semi-natural tree-grass savannahs by controlled burning, chemical sprays, and natural and artificial revegetation of perennial grasses. Maintenance by rotational-deferred grazing, repeated spraying and burning and proper care of desirable trees.

(2) Establishment of valuable forage plants in brush-free communities by means of rotational-deferred grazing, fertilization, reseeding and chemical weed control.

In both vegetational types, rotational-deferred grazing, based on the seasonal development of the perennial grasses and on the vegetative and reproductive needs of the annual forage plants, is an important tool which allows the increase of desirable plants, suppression of undesirable weeds and efficient use of the forage.

LITERATURE CITED

ARNON, J. AND A. HAMMELBURG. 1953. Progress Report, prepared for the Working Party on Mediterranean Pasture and Fodder Development (2nd meeting, Algiers 28/4–3/5 1953). Agr. Res. Sta. Rehoboth—Nve-Yaar. mimeo.

BENTLEY, J. R. AND M. W. TALBOT. 1948. Annual plant vegetation of the California foothills as related to range management. Ecology 29: 1-15.

BOYKO, HUGO. 1949. On the climax vegetation of the Negev with special reference to arid pasture problems. Palest. Jour. of Botany, Rehoboth Ser. 7: 17-35.

EGLER, FRANK E. 1949. Right of way maintenance by plant-community management. Aton Forest, Norfolk, Conn.

EIG, A. 1933. An historical phytosociological essay on Palestine forests of *Quercus Aegilops* L. ssp. *ithaburensis* Desc. in past and present. Beiheft Bot. Ctrbl. Abt. 2: 51.

MILES, WAYNE H. 1952. Range management in Israel, yesterday, today and tomorrow. Jour. Range Mangt. 5: 207-211.

OPPENHEIMER, H. R. 1950. Geobotanical research in Palestine, 1938-1950. Vegetatio Acta Geobotanica 3: 301-320.

ZOHARY, M. 1944. Introduction to the geobotany of Palestine. Sifriat Poalim. (Hebrew)