University of California

Wildland Research Center

MEDITERRANEAN ANALOGS OF CALIFORNIA SOIL VEGETATION TYPES

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A report on field work conducted in Italy and Greece
Partially supported by U.S. Army, Natick Laboratories, Natick, Massachusetts
Contract DA 19-129-AMC-203(N) Project No. 1K025001A129
(As part of Project 1762, California Agricultural Experiment Station)

Berkeley, California

January 15, 1965

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Errata

Page	Line	Correction
32	2	Paulilatino
43	20	Brachy podium
45	13	Brachy podium
49	12	Several
57	15	$\frac{1}{SHyG}$ or $\frac{1}{SGHy}$
67	8	Muscovite
88	2	Umbria
88	11	sylvatica
90	22	pH
92	1	Permanente
97	2	Vallombrosa
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125	9	Arctostaphylos
143	22	2' to 3'
173	2nd from bottom	Greek
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NOTE: In the vegetation description portion of the Soil-Vegetation Plot tables, the following symbols were used for Abundance:

XXX "Abundant" This species occurs on about 60% of the area of the plot.

XX "Frequent" This species covers from 15% to 60% of the area of the plot.

X "Occasional" This species covers less than 15% of the area of the plot.

Plots examined were circular, 118' in diameter, or one acre in area.

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MEDITERRANEAN ANALOGS OF CALIFORNIA SOIL-VEGETATION TYPES

INTRODUCTION

This report summarizes the progress made to date in a study comparing the soils and vegetation of Italy and Greece with those of California. The major accomplishments of the study were the assembling of a systematic approach to the numerous soil series classification units being applied to the wildland areas of California, the formulation of sampling sequences based on elevation transects on various types of geology in Italy and Greece, the recording of characteristics of the vegetation and soil at the points on these sequences in Italy and Greece, and the sampling of the soil at these observation points with the samples to be used for subsequent analysis.

It has been a fairly common observation that there are similarities between the vegetation and the soils of Mediterranean countries and California. However this has usually been limited to the gross characteristics; for example, noting that there is chaparral or that red soils are prevalent in both areas. Plant species introductions from the Medditeranean countries to California indicate that the California environment of climate and soil is within the tolerance of many typical Mediterranean plant species such as olive (Olea europea L.), Aleppo pine (Pinus halepensis), oleander (Nerium oleander), cork oak (Quercus suber), and various species of Cistus. The world wide plant geography study of Schimper (1903), called attention to the similarities between the vegetation of the Mediterranean countries and California, but he also pointed out that not much was known about California.

Since that time there has been gained a considerable knowledge in California concerning the vegetation, and in the past fifteen years about the soils of the wildland areas of California. A soil-vegetation survey has covered more than ten million acres of the California landscape, and the vegetation type maps that were the forerunner of the soil-vegetation survey (Wieslander, 1935) also covered millions of acres of California. It was noticed in this work that typical groupings of vegetation species into types occurred and that these could be described in terms of vegetation structure. This led to an aerial photo technique of describing vegetation types (Jensen, 1947) which then formed the basis for subsequent vegetation mapping work. Generally it was found that in the relatively undisturbed vegetation of the wildland areas of California that characteristic groupings of vegetation species and associated vegetation structure occurred in response to the occurrence of soil types which in turn were mainly dependent upon geology, but also upon the past landscape history, the topography, and the climate. The result is a mosaic of soil-vegetation types on the landscape.

In the classification of the soil-vegetation types of the California landscape the initial step is the subdivision of the vegetation as viewed on aerial photographs into various units of homogeneous crown density and of structure such as grass, shrub, hardwood trees, and coniferous trees. Bare ground, rock, areas of water and other miscellaneous land types also being delineated at the same time. Field observations are then made relating the dominant soil type and the species of vegetation in order of abundance in each of these previously delineated types on the aerial photographs. The resulting soil-vegetation maps have contributed much to present knowledge of the California landscape. The techniques developed enable one to develop considerable knowledge about the soil and vegetation of an area from aerial photo interpretation supplemented by detailed field observations at selected points on these photographs; and also the extension of this knowledge to similar types that are inaccessible from the ground.

The study to be reported here was planned to investigate some of the analogies that might exist between the soil-vegetation types of Italy and

Greece and those of California, establishing field plots and making observations of the soil and vegetation similar to those made in the California Soil-Vegetation Survey.

Objectives of the Study

The objectives of this study were to observe soil-vegetation types in Italy and Greece from the standpoint of determining what similarities they had to types in California. Observations were to be made at selected locations in Italy and Greece that would give a range of conditions similar to the range of climatic, geologic, and altitudinal conditions which exist in California areas having relatively undisturbed vegetation. Since much soils information had already been gathered in California it was found necessary also to systematically organize this knowledge as one of the objectives of this study. This was then to be used in making the comparisons with comparable soils in Italy and Greece. The vegetation was to be compared on the basis of structure with notation of the dominant vegetation species and their abundance.

Schedule of Work Accomplished

This study was accomplished during a period extending from July, 1963 to November, 1964. The systematic approach to the forest soils of California was developed and brought up to a final publishable form (Zinke, Colwell, 1963); a study was initiated and completed of the selected physical and chemical properties of these California soils during the period from August, 1963 until presentation of the material at the International Soil Science Society meeting in Bucharest, Romania in August, 1964 (Perry, Zinke, Heater, 1964). Once this basis of some systematic organization of the knowledge of the soils on the California landscape had been made it became possible to make meaningful observations of the soils of relatively undisturbed landscapes of

Greece and Italy in relation to those of California. The field work in Italy and Greece was carried out after establishing residence in Italy in September of 1963; the author working in association with the faculty of Agriculture and Forestry and the University of Florence. Here a library review was made of the literature concerning the soils, geology, and vegetation of Italy and Greece. Then, a scheme of field observation points was formulated based upon this literature. Field work was begun in February, 1964 with the observation of sampling points on two elevation sequences, one on basalt rock and one on granite rock.located in Sardegna. Then, in April a similar sequence on sedimentary rocks in northeastern Sicily was observed, and later in April two sequences were completed on granitic rocks in southern Italy (Calabria). In May a sequence of observations was made on marl rocks in central Italy (Abruzzi). In June and July sequences of observation points were visited in Greece on granitic rocks (west from Florina toward the Albanian border, and north from Serrai toward the Bulgarian border); on metamorphic rocks (Mt. Olympos, and near Sparta); on limestone rock (near Sparta); and a landscape sequence involving sedimentary rocks into which serpentine and peridotite had been intruded (in the northern Pindus Mountains near Metsovon). Observations were then completed with a sequence of points on sedimentary rocks in northern Italy (Tuscany) in August. Following this soil samples which had been collected from each of these points were shipped back to the laboratory at the University of California where they are being analyzed and this current progress report has been written.

SYSTEMATIC RELATIONSHIPS AMONG CALIFORNIA FOREST SOILS

A systematic arrangement of the information concerning forest and wildland soils of California was necessary to facilitate the comparisons to be made in Italy and Greece. The extensive mapping which has been carried out in

California in the Soil-Vegetation Survey has provided observations not only for a systematic description of soil series in areas of natural vegetation but also a factual basis for relating and grouping these soils.

Field men mapping in the soil-vegetation survey have observed predictable relationships between the type of soil profile and certain variables in the landscape, particularly the type of parent material or the geology of the area, the relative age and the topography of the land surface and the large-scale differences in elevation. Associated with the interaction of these landscape variables are soils having various degrees of development.

That soils can be grouped according to degree of development on a given parent material is obviously not new to the soils literature. Gerhardt (1900) noted that he could classify sand dunes, from white to yellow to reddish, in relation to increasing age of dune. Shaw (1928) established a grouping of soils into families ranging from an immature soil to a mature soil on each parent material. Storie and Weir (1953) have developed these concepts into a guide to soil series in California.

Many new soil series have been described during the soil-vegetation survey.[1/] They can be related as sequences of increasing degree of development on each rock type which probably occur due to increasing time of weathering. There will be some variation in the developmental sequence on a given parent rock, depending upon present or past climatic differences. Also, in some areas an entire sequence may not be present due to excessive soil erosion, to colluvial deposition, or to past stripping of the soils by glaciation thus resulting in a lack of developed soils.

This paper will be an approach to relating the numerous forest soil series in California (more than 85 at present) in terms of developmental

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[1/] Descriptions available in limited quantity from Soil Conservation Service, USDA, 2020 Milvia Street, Berkeley, California. Some of these soil series names are subject to final correlation.

sequences on the various rock types from which they are derived. Examples from published maps will be used to show the landscape relationships, and laboratory data for modal profile samples taken from type locations in the areas mapped will be used to show the soil properties.

Soil Development Sequences

Examples of soil development sequences can be found on soil-vegetation maps published for areas dominated by each of the main parent rock types. The broad categories of rock types in California are basic igneous, acid igneous (with associated metamorphic rocks), and sedimentary rocks (Figure 1). A transect across a landscape dominated by any one of these rock types will often show variations in properties of soil profiles which can be arranged in sequence of degree of development. Locations of four such transects are indicated by number in Figure 1.

A developmental sequence on schist rock, for example, is shown on the Soil-Vegetation Survey map of the Hoopa Quadrangle (DeLapp and Skolmen, 1961). A transect across Bald Mountain (location number 1 in Figure 1) generalized from a portion of this map is shown in Figure 2. This topographic sequence of soil series begins with the less developed Sheetiron soil series on the steep slopes in the Trinity River Canyon, proceeds to the more developed Masterson and Orick soils on the less steep slopes, and then finally to the well developed Sites soil series on the nearly flat ridgetop.

This sequence illustrates that the most developed soil is often found on plateau-like ridge tops and always on apparently older surfaces in this rough terrain. Just southeast of the Klamath River mouth there is evidence that uplift of a broad plain and its later dissection by streams may be one of the causes of this relationship. River gravels are perched on ridgetops two to three thousand feet above the present level of the river, and clayey red soils have developed on the gravels. In other areas, however, different processes may bring about similar older surfaces.

Sequences of decreasing soil development with increasing elevation over wide ranges of elevation change are however usually the rule in California mountain forests. In the Blocksburg quadrangle (Colwell, et al., 1955) on a long slope of increasing elevation a sequence of soil profiles of lessening degree of development with increasing elevation occurs on graywacke sandstone (transect 2, Figure 1). The transect (Figure 3) begins with the better developed Josephine soil series (815) at the lower elevations. With increasing elevation it progresses through the lesser developed Hugo soil series (812) to the least developed Hoover soil series (822). Similar sequences are found on granitic and andesitic parent materials (Figure 3).

These observations have indicated two general relationships: (1) Each parent rock type will usually have a sequence of soil profiles of increasing degree of development related either to climatic difference or topographic variation. (2) Similar sequences occur on each of the parent rock types with variation reflecting differences in the physical and chemical properties of the rocks. These conclusions were then used as a basis for assessing the soils in Greece and Italy as to their similarity to California.

Soil Properties[2]

Certain soil properties of the soil series in each of these sequences on the various rock types show a fairly consistent relationship to degree of development of the soil.

Color

The most obvious change apparent in the field with increasing soil development was in the soil color. Thus, in the four sequences shown in

[2] Acknowledgement is made to Dr. Esther Perry and the Department of Soils and Plant Nutrition, Univ. of California for soils analysis.

Figure 4 the color progressively changes from grayish brown to reddish brown with increasing soil development. This color change is more noticeable in the lower horizons, and less in the A horizons, apparently because of organic matter from forest litter that was incorporated in the soil. Some variability in color may be related to differences in parent material. For example, in the sequence from Lytton to Aiken soil series on andesite and basalt parent rock, the initial color is warmer (light brown) than in the other parent materials, on which the initial soils are generally light gray. Also in the sequence from Corbett to Musick on granitic rocks, the Stump Springs series is less red than expected even though it is slightly more developed than the Holland series. This is probably due to the granitic parent material of the Stump Springs being more silicic in composition. However, the general relationship is apparent that for most rock types in the forest areas of California a sequence of soil series with increasing redness of the soil can be found. Presumably this parallels soil development. Mature red soils are a characteristic of many California forest areas. There are notable exceptions to this color sequence on a minor portion of the areas mapped that are related to initial strong color in the parent material, or to soil development under conditions of poor drainage. The question then posed for the analogies to be tested in Greece and Italy is whether this holds for the soils in these countries.

Gravel and Stone Content

The field mappers of the soil-vegetation survey also noticed that another property of the forest soil that changed with the degree of development of the profile on a given rock type was the stoniness of the soil. Data for modal profiles for soil series in developmental sequences are shown in Figure 5. These data indicate generally a progressive decrease in the percent by weight of the greater than 2 mm fraction in bulk soil samples (stones greater than 5 cm discarded) with increasing development of the soil. This change is most apparent at a depth of 30 inches in the soil. Differences related to parent material are evident. The soils derived from granitic rocks had fewer coarse fragments because initial weathering produced grains the size of the mineral crystals in the rock. The other parent rocks tended to weather initially into larger fragments. The soils derived from basic igneous rocks are more variable in rock content and as a result show a less consistent trend of diminishing rock content with increasing development. This is due partly to the large size of the rocks in the field profiles, many of which were beyond the size limits of the samples taken. A general relationship apparent in most of these sequences is that the content of coarse fragments decreases with increasing development of these forest soils. A similar situation might be expected in the Italian and Greek soils if they are analogous to those of California.

Clay Content

Again from the observation of many profiles, the mappers found clay content of the soil profile another obvious criterion of increasing degree of development of the soil on any of the parent rocks. This relationship is apparent from the laboratory data shown for developmental sequences in Figure 6. The percent clay (less than 2 microns) in the fine earth fraction of the soil ranges upward from low amounts of 6% in the immature soils. The soils derived from granitic rocks had the lowest clay content, and those derived from sandstone (graywacke) had the highest. The clay content became greater with increasing development, especially in the subsoil, reaching 36% in the Musick series from granitic rocks and more than 60% in the Sites series derived from graywacke sandstone. The general relationship, an old one in soil science, is that on the developmental sequences associated with each of the main rock types in California forest areas, clay content increases with increasing maturity of soil. An important observation is that clay content at comparable stages of soil development will differ on different parent rocks. It was also observed that with increasing degree of development in each sequence there was a lowering of the ratio of vermiculite clay to kaolinite clay.[3/]

Chemical Properties

Some chemical properties of the soils, such as contents of carbon, nitrogen, water soluble phosphorus, exchangeable cations and exchange capacity, and pH, were also determined. Carbon and nitrogen do not appear from the data to have a clear-cut relation to the developmental sequence. Perhaps these properties respond more rapidly to changes in external variables such as age of forest cover, effect of fires, change in climate, etc. There was a tendency for a predictable change in water soluble phosphorus associated with these sequences. The phosphorus content in the subsoil was usually higher in the early stages, lower in the middle of a sequence, and slightly higher toward the end member of the sequence. Of the chemical properties examined, only the phosphorus content (water soluble) seemed to support a general relationship. The other chemical properties apparently varied in response to transitory temporary variables or were different depending on original parent rock. Our data did not show trends common to all rock types.

Relating California Wildland Soil Series as Sequences

These observations indicate that it is possible to relate the numerous soil series currently being used in the classification of California forest lands according to degree of development from a given parent rock type and that likewise this could be applied to areas similar to California. The usual

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3/ Personal communication with Dr. Isaac Barshad, Department of Soils and Plant Nutrition, University of California, Berkeley.

sequence in its simplest form progresses from soils with slight development, through moderate development to well developed soils. In the terminology of Storie and Weir (1953) this involves a sequence from lithosols to gray-brown podzols to red-yellow podzolic soils. According to that of Kubiena (1953) the sequence would begin with ranker soils, progressing through brown earths with increasing degree of leaching to end with red loams. Although the sequence involving a red soil end member is the usual one, there are other sequences occupying much less area. For example, there is a sequence which involves podzols, with a thin A_2 in the slightly developed stage to a thick A_2 with a clay pan B horizon in the intermediate stage, and a thick A_2 with an iron pan in the subsoil in the well developed stage. The mature soils on every parent material type, because of higher clay content, present a similar road building problem necessitating less steep gradients for unsurfaced roads because of poorer traction when the soil is wet, and a need for greater thickness of surfacing material for stabilization.

These findings summarized in terms of the Unified Soil Classification indicate that with increasing degree of development the soil will progress from stony coarse-grained soils with little development such as GW soils to soils of increased development in terms of amounts of fines such as SC, CL and CH to well developed soils having a large amount of clay such as the CH and MH soils. However, with extremely well developed soils there will be a tendency for higher amounts of kaolinite clay which will be less plastic than vermiculite and montmorillonite clays.

THE CLASSIFICATION OF THE VEGETATION OF CALIFORNIA

In order to make comparisons between the vegetation at selected sites in Italy and Greece with the vegetation of California, it was felt necessary to either develop or utilize an existing method of categorizing the vegetation types in California, thet in its broader generalities could then be applied to the vegetation types of Italy and Greece. A regional zoning of vegetation could be fitted into the early life zone formulations of Merriam which, although supposedly based on climatic variables, are more usually defined in terms of vegetation zones (Baker, 1934; Merriam, 1898). A classification of the vegetation of California deriving the information principally from aerial photographs has been described by Jensen (1947). It provides a technique which can be applied to such areas as Italy and Greece, as well as other lands around the Mediterranean and Black Seas. More recently, Munz and Keck (1950 and 1959) have categorized California plant communities. These classifications simplify the making of analogies between the vegetations of the Mediterranean area and California. There are nearly 5,000 species of plants comprising the vegetation of California (Munz and Keck, 1959), and 3,446 species in the vegetation of Italy according to Baroni (1955); but by the technique of grouping these species into vegetation types a system for making the analogies between the California and the Meditteranean vegetation will be made.

Life Zones and California Vegetation

Merriam (1898) defined life zones for the United States which have some utility if used wisely in application to California conditions. The application of these zones to categorize California vegetation types was made by Jepson (1923). They can be summarized as follows:

Zone	Typical form and type of vegetation
Lower Sonoran	Desert vegetation
Upper Sonoran	Grassland and Oak woodland, Juniper woodlands, Chapparal, and Digger pine
Transition (arid)	White fir, incense cedar, sugar pine; mixed conifer forests of the Sierra Nevada, the south coast ranges, and the southern Cascade Mtns. Some hardwoods such as *Quercus kelloggi* & *Cornus nuttali*

Zone	Typical form and type of vegetation
Transition (humid)	The coastal forests of northern California, and the interbedded brush types and grasslands. Typical species are redwood, Douglas fir,
Canadian	High elevation conifer forests characterized by such species as *Abies magnifica*, *Pinus monticola*, and *Pinus contorta*
Hudsonian	Open conifer woodlands of small bushy trees such as *Tsuga mertensiana* (hemlock), *Juniperus occidentalis* (western juniper), and *Juniperus communis* L.
Arctic Alpine	Open fields of herbs, sedges, and grasses with low dwarf shrubs of *Erica* (heather), willow, etc. Characteristic genera are *Carex*, *Erica*, *Salix*, *Juniperus*.

A similar life zone scheme exists for Italy, and comparisons and analogies to this will be made later.

Plant Communities in California

Munz and Keck (1959) in their flora of California have defined major vegetation types and plant communities in California as in the following table:

Vegetation type	Plant community
I. Strand	1. Coastal strand
II. Salt Marsh	2. Coastal Salt Marsh
III. Freshwater Marsh	3. Freshwater marsh
IV. Scrub (brush)	4. Northern Coastal scrub
	5. Coastal sage scrub
	6. Sagebrush scrub
	7. Shadscale scrub
	8. Creosote bush scrub
	9. Alkali sink
V. Coniferous forest	10. North Coast coniferous forest
	11. Closed cone pine forest
	12. Redwood forest
	13. Douglas fir forest
	14. Yellow pine forest
	15. Red fir forest
	16. Lodgepole pine forest
	17. Subalpine forest
	18. Bristle cone pine forest

Vegetation type	Plant community
VI. Mixed Evergreen Forest	19. Mixed evergreen forest
VII. Woodland Savanna	20. Northern oak woodland 21. Southern oak woodland 22. Foothill woodland
VIII. Chaparral	23. Chaparral
IX. Grassland	24. Coastal prairie 25. Valley grassland
X. Alpine Fell-fields	26. Alpine fell fields
XI. Desert Woodland	27. Northern juniper woodland 28. Pinyon-juniper woodland 29. Joshua tree woodland

Lists of typical species of vegetation for these plant communities have been offered by Munz and Keck (1959).

A Technique of Classifying Vegetation and Land Cover

A technique of classifying vegetation and land cover based upon elements of the vegetation and land cover which are readily identifiable from aerial photographs has been presented by Jensen (1947), and is being used as a basis for widespread mapping of Soils and Vegetation in California (California, 1958). The advantage of this classification is that it can be applied without seeing the area, except on aerial photographs. It depends upon the recognition of readily identifiable structures in the vegetation seen on the aerial photographs. The basic delineation made is based upon various structural classes of the vegetation or the land cover. These are as follows:

C Conifers, commonly so called commercial or large coniferous trees.

K Scrubby conifers. Coniferous trees of small size or stature.

H Hardwoods. Broad leaved trees. Further subdivided into old or large hardwoods H_o , and young hardwoods H_y .

S Chaparral. Shrubs of the tall, dense, heavily branched type such as manzanitas, scrub oaks, and chamise.

T Sage. Soft shrubs lower in stature, usually grayish to light colored in tone and characteristic of desert, or coastal sand areas.

F Bushy herbs, mainly ferns such as *Pteris aquilina*.

G Grasses. Grasses, sedges and other associated herbaceous vegetation.

M Marsh.

B Bare ground.

R Rock.

A Cultivated.

U Urban Industrial.

For the purposes of classifying the vegetation and land cover as seen at the various observation points visited in Greece and Italy, it was felt that the following adaptation of the Jensen classification would be made:

C Conifers

H Hardwoods with H_o and H_y

S Chaparral and Sage (for example, including Artemesia spp. as well as shrubby oaks)

G Grasses, Herbs and Fern cover

M Marsh

B Bare ground

R Rock

A Cultivated

These would be elements of vegetation cover as they would be viewed from aerial photographs, but likewise observed on the ground. A further stratification is obtained by identifying a total woody vegetation density. This density classification is expressed also in terms such that it is also identifiable on aerial photographs, the density being the crown cover density of the woody vegetation. The following legend is used for density classes (Jensen, 1947):

1 Dense. Stands in which the crowns of the vegetation elements cover greater than 80% of the ground area.

2 Semidense. Stands in which the crowns of the vegetation element being considered cover 50-80% of the ground space.

3 Open. Stands in which the crowns of the vegetation element being considered cover from 20-50% of the ground space.

4 Very open. Stands in which the crowns of the vegetation element being considered cover from 5 to 20% of the ground space.

5 Unstocked. Areas having less than 5% of ground space covered by crowns of the vegetation element being considered.

Examples of aerial photo interpretations using these types of legends are presented in the paper by Jensen (1947). For the study areas in Italy and Greece, a classification was given to the vegetation which included the crown density of the woody vegetation including conifer and hardwood trees, and shrubs, this being noted in the numerator of a fraction. The vegetation elements present were then grouped in order of abundance in the denominator of the same fraction. The densities and orders of abundance are those which would appear on the basis of ground cover as viewed from the air. A symbol reading 5/G for a type indicates less than 5% woody vegetation cover, and a cover which is composed mainly of herbaceous vegetation such as grasses, etc. When coniferous trees are present, an age class has been given to the conifers, designated by Y or O or a mixture depending upon whether the trees are greater than 150 years old (O), or less (Y). Three density figures are used to characterize the vegetation type with conifers. These are: density of all conifers greater than approximately 1' in diameter, density of conifer trees of all sizes, and finally the third figure for all woody vegetation density. Thus a typical cover class cymbol describing a dense young stand of coniferous trees is Y111/C, and it states that the vegetation type is coniferous forest less than 150 years old, with greater than 80% crown density of saw log size trees, and likewise greater than 80% coniferous trees, and greater than 80% total woody vegetation canopy density. This allows a comparison to be made directly with Timber Stand Density Maps which are published for most of the wildland areas of California (California, 1958).

THE CLASSIFICATION OF THE VEGETATION OF ITALY AND ADJACENT MEDITERRANEAN AREAS

Life Zones and Italian Vegetation

A similar life zone classification to that previously described for California has been developed for Italy by using a classification developed by Mayr for Europe and modifying it for the Italian dry summer conditions (dePhillipis, 1937). This climatic classification is as follows:

ZONE	TEMPERATURE Average annual	Coldest months mean	Minimum mean
A) LAURETUM			
1. Type 1 uniform precipitation hot	15-23°	> 7°	> -4°
2. Type 2 with summer drought	14-18°	> 5°	> -7°
3. Type 3 with summer rain	12-17°	> 3°	> -9°
B) CASTANETUM			
1. Warm subzone	10-15°	> 0°	> -12°
Type 1 without summer drought			
Type 2 with summer drought			
2. Cold subzone	10-15°	> -1°	> -15°
Type 1 precipitation more than 700 mm			
Type 2 precipitation less than 700 mm			
C) FAGETUM			
1. Warm subzone	7-12°	> -2°	> -20°
2. Cold subzone	6-12°	> -4°	> -25°
D) PICETUM			
1. Warm subzone	3-6°	> -6°	> -30°
2. Cold subzone	3-6°	< -6°	> 15° also < -30°
E) ALPINETUM	< 2°	< -20°	> 10° also < -40°

An analogy can be made between these climatic types and those of California described earlier, as follows:

California Life Zone (Merriam)	Italian Life Zone (dePhillipis)
Upper sonoran	Lauretum warm subzone
Transition	Lauretum cold subzone and Castanetum
Canadian	Fagetum
Hudsonian	Picetum
Artic Alpine	Alpinetum

However, missing from the Italian life zones and also those of Greece would be the Lower Sonoran representing the Deserts of California. However if one were to go further east or south in the Mediterranean region one can find life zones which would encompass the desert areas of California. For example, Gindel (1964) has referred to phytogeographic zones in Israel to include the Mediterranean Maqui zone which coincides with the Upper Sonoran in California, and then defines the following dryer zones:

IRANO-TURANIAN	SEMI-DESERT	200mm-350mm precipitation
SAHARO-SINDIAN	DESERT ZONE	25mm-200mm precipitation

both of which would fall within the lower Sonoran Zone in California, the first being within the Mojave and the Valley Sonoran of Jepson (1923), and the second within the Colorado Desert Sonoran of Jepson (1923).

Relating to Elevation

These life zones, of course, progress from the warmer at the lower elevations to the cooler at higher elevations. In this respect there is another way of making an analogy on the basis of the climatic zones based upon temperature. For central Italy a regression equation of the mean annual temperature (Y in degrees centigrade) as a function of altitude (X in meters) has been published by Gentilli (1959) as follows:

$$Y = 15.62 - 0.0059X \qquad r = -0.89$$

Fortunately a California analogy is available here in that Harradine (1958) has published a similar regression equation for the Sierra Nevada in California which is as follows:

$$Y = 17.7 - 0.0051X \qquad r = -0.90$$

This indicates that for similar climatic conditions based upon mean temperatures in central California one would have to be 450 meters above a comparable level in north central Italy. Presumably this difference may be due to latitude differences.

ITALIAN AND GREEK PLANT COMMUNITIES AND SOME CALIFORNIA ANALOGIES

The major plant formations of Italy have been described (Touring Club Italiano, 1957). The following is a list of them with the California plant community analogy as described by Munz and Keck, and presented earlier:

Italian Vegetation and Plant Community	Analogous California Plant Community
I. Montane Forests	
1. Oak-chestnut woodlands (Quercus-castanea)	Northern oak woodland
2. Beech Forest (Fagus)	Partially -- Northern oak woodland; however, the closest species analogy is the tanoak of northwestern California.
3. Fir forests (Abies)	Red fir forest or North Coast coniferous forest, and to some extent the Douglas fir forest.
4. Mountain pine forests (Pinus nigra)	The Yellow pine forest, Lodgepole pine forest.
II. The Evergreen Forest	
A. Evergreen oak forests	
1. Cork oak forests (Quercus suber L.)	Southern oak woodland (Mainly those with Quercus engelmanni)
2. Holly leaf oak forest (Quercus ilex L.)	Foothill woodland (Mainly those with species such as Quercus wizlizenii, and Quercus chrysolepis.
3. Scrub oak forest (Quercus cerris-pubescens)	Foothill woodland, i.e. Quercus douglasii.

Italian Vegetation and Plant Community	Analogous California Plant Community
II., continued	
B. Littoral pine forests	
1. Domestic pine forest (Pinus pinea L.)	Closed cone pine forest (especially the coastal Torrey pine forest of southern California).
2. Aleppo pine forest (Pinus halepensis)	Closed cone pine forest (particularly the Monterey pine forest of central California).
3. Cypress forest (Cupressus sempervirens)	Either the northern portion of the closed cone pine forest or the upper portions of the Pinyon-Juniper woodland.
C. Olive and Carob forests (Olea europa and Ceratonia siligua)	Southern oak woodland.
III. Macchia (Brushfields)	
A. Holly leaf oak macchia (Quercus ilex)	Chaparral (especially with Quercus dumosa).
B. Macchia of Erica and Arbutus (Erica scoparius - Arbutus unedo)	Chaparral (especially with chamise and manzanita.
C. Cistus macchia (Cistus salvifolius)	Chaparral (especially with species of Salvia).
D. Olive macchia (Olea europa)	Chaparral.
E. Dwarf palm macchia (Chamerops humilus)	None in California.
F. Broom macchia (Cytusus scoparius)	Chaparral with Pickeringia montana or Ceanothus species.
G. Oleander macchia (Nerium oleander)	Chaparral with Rhus laurina.
IV. The Gariga	Various types of scrub as defined. Northern Coast scrub, Coastal sage scrub, but excluding the desert and alkalai soil scrubs; such as sage-brush, shadscale, creosote bush and alkali sink which were not observed in Italy and Greece.
V. Degraded Macchia and Gariga	Degraded (very low, sparse chaparral or scrub).

Italian Vegetation and Plant Community	Analogous California Plant Community
VI. Steppes and Prairies	
A. High altitude pasture (above timber line) (*Carex curvula*)	Alpine fell fields.
B. Mediterranean steppes (low altitude grasslands) (*Festuca* -- *Bromus*)	Coastal prairie and valley grassland.
VII. Littoral sand and Salt Flat Vegetation	Coastal strand and Coastal salt marsh.

SPECIES OF ITALIAN AND GREEK VEGETATION AND CALIFORNIA ANALOGIES

The work in Italy and Greece involved the assessment of the species of vascular plants comprising the vegetation at numerous sampling points, the data to be presented later. However a list of the species observed at all of the points and their California analogies in the case of the woody species is presented in Table 1. These Mediterranean species are tabulated, indicating what form they would have in the vegetation classification used by Jensen (1947). Also where a close analogy exists in my opinion with a California species that species is given as an analogy. For example for *Quercus ilex* of Italy and Greece a striking analogy exists in the *Quercus chrysolepsis* of California, also a "holly leaved oak", evergreen, and ecologically analogous in terms of the types of situations which it favors in California. The analogies were judged from an ecological as well as a morphological basis.

Table 1. Plant Species Listed at Soil-Vegetation Plot Locations in Italy and Greece, with California Species Analogies for Woody Vegetation

Species (Baroni or Index Kewensis)	Aerial Photo Vegetation Element Classification (Jensen)	California Species Analogy for Woody Vegetation
Abies cephalonica Lk.	C	Abies concolor
Abies pectinata DC.	C	Abies concolor or grandis
Acer creticum L.	S or H_y	Acer glabrum
Acer monspessulanum L.	H_y	Acer macrophyllum
Achillea millefolium L.	G	Achillea millefolium L.
Achillea tomentosa L.	G	
Alopecurus pratensis L.	G	
Ampelodesma tenax Lk.	G	
Andropogon ischaemum L.	G	
Anthoxanthum odoratum L.	G	
Arbutus unedo L.	S	Shrub form of Arbutus menziesii or various species of Arctostaphylos
Asparagus officinalis L.	G	
Asphodelus ramosus L.	G	
Avena fatua L.	G	
Borago officinalis L.	G	
Bromus squarrosus L.	G	
Brachypodium pinnatum P.B.	G	
Brachypodium sylvaticum P.B.	G	
Carduus species	G	
Carex curvula All.	G	Carex exserta
Carlina corymbosa L.	G	
Castanea sativa Mill.	H_y H_o	Lithocarpus densiflora, or less closely -- Quercus kelloggi
Chrysopogon gryllus L.	G	
Cistus Albidus L.	S	Salvia mellifera
Cistus salvifolius L.	S	Salvia mellifera
Clematis vitalba L.	S (vine)	Clematis
Coronilla species	G	
Cynosurus echinatus L.	G	
Cytisus scoparius Lk.	S	Introduced to California. Various Ceanothus species

Species (Baroni or Index Kewensis)	Aerial Photo Vegetation Element Classification (Jensen)	California Species Analogy for Woody Vegetation
Dactylis glomerata L.	G	Also in California
Elymus arenarius L.	G	
Elymus caput-medusae L.	G	An introduced weed
Erica arborea L.	S	Adenostoma fasiculatum
Erica carnea L.	S	Erica
Erica scoparia L.	S	Adenostoma fasiculatum
Euphorbia amygdaloides L.	G	
Fagus silvatica L.	H_y H_o	Quercus kelloggi
Festuca heterophylla Lam.	G	
Festuca ligustica Bertol.	G	
Festuca ovina L.	G	
Festuca rubra L.	G	
Foeniculum vulgare Mill.	G	
Fragaria vesca L.	G	
Genista aspalathoides L.	S	
Genista corsica DC	S	Lotus scoparius Pickeringia montana
Hedera helix L.	G (as identified on aerial photos)	
Hieracium villosum L.	G	
Hypericum crispum L.	G	
Hypericum perfoliatum L.	G	Weed in California
Ilex aquifolium L.	S H_y	
Juniperus communis L.	S	Juniperus communis L.
Juniperus oxycedrus L.	S	Juniperus californica
Koeleria cristata Pers.	G	
Lavandula stoechas L.	S (T, Jensen)	Trichostema
Lolium perenne L.	G	
Lotus corniculatus L.	G	
Melica cliata L.	G	
Myrtus communis L.	S	Vaccinium ovatum
Nardus stricta L.	G	
Olea europea L.	S H_y H_o	
Opuntia Ficus-Indica Mill.	S.	Opuntia
Orobanche crenata Forsk.	G	Orobanche

Species (Baroni or Index Kewensis)	Aerial Photo Vegetation Element Classification (Jensen)	California Species Analogy for Woody Vegetation
Paliuris australis Gaertn.	S	
Phillyrea variabilis Rimb. var. media L.	S	
Phleum pratense L.	G	
Picea excelsa Lk.	C	Picea engelmanni
Pinus nigra var. Laricio (Poir.)	C	Pinus jeffreyi or Pinus ponderosa
Pinus pinea L.	C	Pinus torreyana or Pinus sabiniana
Pinus silvestris L.	C	Pinus contorta
Pirus communis L.	S	
Pistacia lentiscus L.	S	Rhus laurina
Potentilla species	G	
Potentilla alba L.	G	
Poterium sanguisorba L.	S.	
Poterium spinosum	S ?	
Primula officinalis Hill.	G	
Pteris aquilina L.	G (F, Jensen)	Pteris aquilina L.
Quercus cerris L.	S H_y H_o	Quercus kelloggi
Quercus coccifera	S	Quercus dumosa
Quercus ilex	H_y H_o	Quercus chrysolepis
Quercus pubescens Wild.	H_y H_o	Quercus lobata upland aspect
Quercus suber L.	H_y H_o	Quercus engelmanni
Rhamnus alaternus L.	S	
Rubia peregrina L.	S	
Rubus Idaeus L.	S	Rubus vitifolius
Rumex acetosella L.	G	Rumex acetosella
Sorbus aucuparia L.	S H_y	
Spartium junceum L.	S	Also introduced
Trifolium angustifolium L.	G	
Trifolium arvense L.	G	
Trifolium echinatum M.B.	G	
Trifolium filiforme L.	G	
Trifolium hirtum All.	G	
Trifolium montanum L.	G	

Species (Baroni or Index Kewensis)	Aerial Photo Vegetation Element Classification (Jensen)	California Species Analogy for Woody Vegetation
Trifolium procumbens L.	G	
Trifolium repens L.	G	
Trifolium scabrum L.	G	
Thymus serpyllum L.	S (T, Jensen)	Trichostema lancolatum
Vinca major L.	G	

OBSERVATIONS ON SOIL-VEGETATION TYPES OF ITALY AND GREECE

Planning Sampling Locations

The planning of a program of observations of soil vegetation conditions in Italy and Greece with the objective of establishing the analogies with the soil and vegetation of California involved a review of the literature on these subjects, the determination of map locations which would predict the field locations which would be most representative for sampling and description, and then the carrying out of an extensive field program.

The literature review unearthed a wealth of references on the subject of the soil and vegetation types of Italy and Greece. A bibliography of this material is presented at the end of this report. In making the review, it soon became apparent that there would be similar sequences of soil property change with increasing altitudes on a given parent material as has been noted earlier for California. In Italy, Comel (1939 -Gorizia) noted that the properties of soils derived from limestone changed progressively with increasing elevation. In mounting from low to high elevations across the karst north of Trieste, one progressed through the following soil sequence:

Elevation (Meters)	100	300	1000	1500
Soil type	terra rossa without humus	terra rossa with humus	terra gialla	humus rendzina
Precipitation (mm)	1000	1200	2000	2500

This sequence on limestone is somewhat analogous to those previously described in this report from California in which with increase in elevation the soil progressed from a red soil through a brown soil to a dark humus rich soil. The general effect being a decrease in the amount of clay rich B horizon of the soil and an increase in the amount of humus rich A horizon of the soil with increasing elevation, and with the accompanying increase in precipitation and decrease in mean annual temperature.

Rode[1] has shown a similar example from the Caucasus Mtns. in southern Russia in which there are changes in soils from low to high elevations in this area of Mediterranean type climates in which the soil is a Mediterranean red earth at the lower elevations and progresses through soils of lesser development to a humus rich Ranker type soil at high elevations.

Mancini (1960) in his soils map of Italy implies such sequences. Thus wherever there is a change in elevation over a wide range, one can trace changes in soil types usually in the sequences mentioned previously.

Thus the literature supported the hypothesis that elevation sequences of sampling sites on the same geologic rock type would make a reasonable way of establishing the presence or absence of analogies between the areas sampled in Italy and Greece and those of California.

A key element in locating the sampling sites thus became the geology of the landscape, and a sufficient altitude difference to allow the broadest possible range in soil development on the rock type.

Since in California the major rock types forming soils are Basic igneous rocks (i.e. basalt), acid igneous rocks (i.e. granite), sedimentary rocks (i.e. sandstones), and metamorphic rocks (i.e. schists or serpentines), it was desirable to sample on these types of rocks in Italy and Greece. Also, the extensive areas of calcareous rocks such as limestone and marl in these countries necessitated sampling on them; although areas of these rock types extensive enough to give full developmental sequences of soils are absent in California. After reference to the geologic and topographic maps of Italy and Greece, the locations in Table 2 for sampling sequences were determined.

The field work of establishing soil and vegetation sampling points on these elevation sequences was begun in February 1964 and completed in August 1964. On each sampling sequence, except for the limestone sequence (No. 7) on

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[1] Rode, A. 1962. Soil Science. Trans. from Russian by Israel Program for Scientific Translations. Nat. Sci. Foundation, Washington, D.C. 517 pp.

Table 2. Summary of Soil-Vegetation Elevation Sampling Transects

No.	Location	Type of Rock	
1.	Italy, Sardegna, between Oristano and Macomer	Basic Igneous rock	Basalt and andesite
2.	Italy, Sardegna, between Lago Coghinas and Monte Limbara	Acid Igneous rock	Granite
3.	Italy, Sicily, between Capod'Orlando and Floresta	Sedimentary rocks, slightly metamorphosed	Sandstones and shales
4.	Italy, Calabria, between Rosarno and Serra San Bruno	Acid Igneous rock	Granite
5.	Italy, Calabria, between San Giovanni and Lago Arvo (Sila)	Acid Igneous rock	Granite
6.	Italy, Abruzzi, between Sangro River Valley and La Maiella Mtn.	Calcareous rock	Marl
7.	Italy, Umbria, Mt. Terminillo	Calcareous rock	Limestone
8.	Italy, Tuscany, nr. Firenze to Pratomagno nr. Vallombrosa	Sedimentary rock	Sandstone (Macigno grande)
9.	Greece, northwestern, transect through Pindus Mtns. west of Trikkala	Metamorphic intrusive and associated country rocks	Serpentine, peridotite, gabbro and sandstone
10.	Greece, Peleponnisos from near Sparti to Taygetos Mtns.	Metamorphic rocks	Schists
11.	Greece, Peleponnisos, near Sparti to Kosmas in the Parnon Mtns.	Limestone	
12.	Greece, Macedonia and Thrace from Serrai to Lailia and Florina to crest of mtns. to west	Acid Igneous rocks	Granite
13.	Greece, Thrace, South slope, Mt. Olympos	Metamorphic rocks	Schist

Mt. Terminillo, locations were established which represented the range of soil development present on the rock type. This involved a sampling point located at low elevation and low rainfall, followed by others at intermediate elevation and finally one at the uppermost elevation (and the highest rainfall) available on that parent material. At each location observations were made and recorded of the vegetation characteristics and the soil properties. Soil samples were obtained at each observation point and these samples, following preparation, which consisted of sieving out coarse materials, were shipped to the laboratory in Berkeley for later analysis. The observations will be presented in tables along with details on the location.

Sequence of Soils and Vegetation on Basic Igneous Rock in Sardegna

Northwest Sardegna between Sassari and Oristano offers one of the places in Italy where a cover of basic igneous rock as lava flows of basalt and andesite and interbedded tuffs occupy an area having a wide range in elevation and precipitation. A sequence of observation points was chosen at locations which did not show abnormal disturbance and which were similar in slope and exposure and represented increasing elevation and rainfall, and all on the same type of parent rock. The points chosen and their observational data are presented in tables 3, 4, 5, and 6. These tables are presented in order of increasing elevation and rainfall at each site.

The landscape transect on basic igneous rocks as presented in these plot data had the characteristics with increasing elevation as shown in Table 7.

Table 3. Soil-Vegetation Plot I.

LOCATION: Italy, Sardegna, Map Fo 205-206. At Km. 109 V Carlo Felice Hwy. SS No. 131.

Elevation: 54 meters
Precipitation: 700 mm.
Slope: N 50° W 5%

Physiography: Slightly sloping basalt flow with a few incised streams.

VEGETATION

Cover Class: $\frac{5}{G}$ - $\frac{4}{GS}$

Species type: Gr

Overstory:

Species	Height	Abundance
Miscellaneous grasses (Gr)	3"	XXX
Asphodelus ramosus L.	6"	XX

No understory noted.

Remarks: Although the vegetation is maintained in pasture where possible, a spontaneous vegetation sequence in the area is:

Herbs →	Shrubs →	Hardwoods
Grasses	*Pistacia lentiscus*	*Olea europaea* L.
Asphodelus ramosus L.	*Olea europaea*	*Pistacia lentiscus*
	Pirus communis	
	Myrtus communis	
	Opuntia ficus indica	

Opuntia ficus indice also is on stone walls and adjacent Nuraghe (prehistoric buildings).

Table 3, continued

SOIL

Parent rock: Basalt
Permeability: Interrupted in surface/Poor in subsoil
Surface drainage: Good
Ground water: None
Rockiness: Little in profile; surface rocks removed to make numerous stone walls.
Root distribution: Fine herbaceous roots throughout profile -- most are less than 5 mm. diameter
Erosion: Apparently a dimunition of A_1 by 5 cm. due to land use.
Soil profile description:

Horizon	Depth (cm.)	Foundary	Color	Texture	Structure	Consistence	pH	Miscellaneous
1	0-10	wavy	7-5 YR 5/4	clay loam	3fsabk	mfi	6.0	Fine charcoal fragments
2	10-25	abrupt	reddish brown 5 YR 4/4	loamy clay	1cbk	mvfi	6.5	15% stone (cobbles)

Rocks have deeper soils.

Classification:
International: Non calcic brown (Storie & Weir), Shantung brown
7th Approximation: 7.45 Typustalf
Unified Soil Classification: CL
California Soil Series Analogy: The Sobrante Soil Series and the Guenoc Soil Series are similar to this soil.

Table 4. Soil-Vegetation Plot II.

LOCATION: Italy, Sardegna, Map Fo 205-206. On road west of Paulitatino towards Seneghe.

Elevation: 309 meters
Precipitation: 900 mm
Slope: NW 5%

Physiography: Slightly undulating tableland of basalt flows

VEGETATION

Cover class: $\frac{3}{\text{GS Ho}}$

Species type: Gr Qp Qs

Overstory:

Species	Height	Abundance
Quercus pubescens wild. (Qp)	30- (with many 3' sprouts) (shrubs)	XX
Quercus suber L. (Qs)	30'	X
Carlina corymbosa L.	1'	XX
Foeniculum vulgare Mill.		X

Understory:

Species	Height	Abundance
Grasses (Gr)	6"-1'	XXX

Remarks: An abandoned pesture with many sprouts and bushy shrubs of *Quercus pubescens* coming back. Apparently in the undisturbed state the cover will progress toward oak woodland.

SOIL

Parent rock: Basalt
Permeability: Good in surface/Good in subsoil
Surface drainage: Locally poor
Ground water: None
Rockiness: Occasional surface rock outcrops (less than 10% of surface). Frequent stone walls may have utilized most of surface rockiness.
Root distribution: Throughout soil profile
Erosion: Little to none apparent

Table 4, continued

Soil profile description:

Horizon	Depth (cm.)	Boundary	Color	Texture	Structure	Consistence	pH	Miscellaneous
1 (A_1)	0-20	diffuse	brown 7-5 YR 4/4	clay loam	2 fcr	mfi	6.5	
2	20-30	abrupt	reddish brown 5 YR 4/4	loamy clay	2 msabh	mfi	6.5	
3	30-35	abrupt	reddish brown 5 YR 4/4	clay	3 mbh	mvfi	6.5	Some weathered basalt

Parent rock

pH was 6.0 under mature *Quercus pubescens* and 5.5 under *Quercus suber*.

Classification:
International: Reddish Brown Lateritic (U.S.D.A., 1938)
7th Approximation: 8.230
Unified Soil Classification: CL
California Soil Series Analogy: Cohasset Soil Series, or Salminas Soil Series

Table 5. Soil-Vegetation Plot III.

LOCATION: Italy, Sardegna, Map Fo 205-206. 4 kilometers north of Sette Fuentes near San Leonardo, west of Macomer.

Elevation: 715 meters
Precipitation: 1000 mm
Slope: SW 5%

Physiography: Undulating basalt tableland

VEGETATION

Cover class: 3 / GFS Hy

Species type: Gr Pta Qp

	Species	Height	Abundance
Overstory:	*Pteris aquilina* L. (Pta)	3'	XX
	Grasses (Gr)	6"	X
	Quercus pubescens wild. (brush)(Qp)	3'	X
	Quercus pubescens wild. (trees)	20'	X
	Rubus spp.	3'	X
	Carlina corymbosa L.	2'	X
Understory:	*Hedera helix* L.	vine	X
	Pteris aquilina L.	3'	XX
	Grasses	6"	X
	Quercus pubescens wild.	3'	X

SOIL

Parent rock: Basalt
Permeability: Good in surface/Good in subsoil
Surface drainage: Good
Ground water: None
Rockiness: Little. However rock walls which probably represent past rockiness are present.
Root distribution: Throughout soil profile
Erosion: None -- slight

Table 5, continued

Soil profile description:

Horizon	Depth (cm.)	Boundary	Color	Texture	Structure	Consistence	pH	Miscellaneous
1 (A_1)	0-30	clear-wavy	brown--dark brown 7-5 YR 4/2	loam	2vfcr	mfr	6.0	many fine grass roots
2 (A_3)	30-45	clear-wavy	brown--dark brown 7-5 YR 4/2	clay loam	2 fsabk	mfi	5.5	shiny ped faces. Possible clay migration
3 (B_3)	45-60	gradual-irregular	dark grayish brown 10 YR 4/2	stony clay loam	2 fsabk	mfi	5.5	shiny ped faces
4 (C)	60-70	abrupt-irregular	dark yellowish brown 10 YR 4/4	stony clay	2 csabk	mfi	5.0	shiny brown clay

Parent rock

Numerous 2 mm. pores were present in upper 2 horizons.

Classification:
International: Reddish brown lateritic (U.S.D.A., 1938)
7th Approximation: 8.230
Unified Soil Classification: CL
California Soil Series Analogy: Cohasset Soil Series

Table 6. Soil-Vegetation Plot IV.

LOCATION: Italy, Sardegna, Map Fo 205-206. Road from Santu Lussurgiu to Cuglieri. 200 meters north of Nuraghe Silvanus. (Prehistoric stone structure)

Elevation: 850 meters
Precipitation: 1200 mm
Slope: N 20%

Physiography: Basalt flow, ridge top. A windswept ridge top which catches the northwest wind off the Mediterranean Sea.

VEGETATION

Cover class: $\frac{3}{\text{F Hy S}}$

Species type: Pta, Ru, Ia, Qi, Qp

Overstory:

Species	Height	Abundance
Pteris aquilina L. (Pta)	3'	XX
Rubus spp. (Ru)	3'	X
Quercus ilex L. (Qi)	15'	XX
Ilex aquifolium L. (Ia)	20'	XX
Quercus pubescens wild. (Qp)	15'	X
Pirus communis L.	8'	X

Understory: Very little under dense cover of hardwoods and shrubs. Mainly miscellaneous herbs and *Pteris* where present.

SOIL

Parent rock: Basalt -- Basalt Breccia
Permeability: Good surface/Good subsoil
Surface drainage: Good
Ground water: None
Root distribution: Throughout soil
Rockiness: Little (necessitated use of thorny shrub fences)

Table 6, continued

Soil profile description:

Horizon	Depth (cm.)	Boundary	Color	Texture	Structure	Consistence	pH	Miscellaneous
1 A	0-20	diffuse	very dark grayish brown, 10 YR 3/2	gravelly loam	0	ml	5.5	
2 (A_1)	20-55	gradual	dark grayish brown 10 YR 3/2	loam	1 vfcr	mvfr	5.0	
3 (A_3)	55-110	abrupt	dark grayish brown 10 YR 4/2	loam	2 mcr	mfr	4.5	
4 (C)	110-150		yellowish brown 10 YR 5/4				5.5	

Parent rock

Classification:
- International: Ando like
- 7th Approximation: 3.330
- Storie & Weir: Podzolic
- Unified Soil Classification: OL
- California Soil Series Analogy: Windy Soil Series

Table 7. Landscape Sequence on Basic Igneous Rocks in Sardegna

Landscape	Elevation (meters) 0-200	200-500	500-800	800 +
Vegetation				
Structure	Open woodland herbs, shrubs, hardwoods	Open woodland herbs, shrubby sprouts, herdwoods	Open woodland herbs, fern, shrubby hardwoods	Open woodland fern, hardwoods
Woody species	Olea Pistaccia Myrtus Pinus	Quercus pubescens Q. suber	Q. pubescens Q. suber Q. ilex	Ilex aquifolium Q. ilex Q. pubescens
Soil				
Classification	Mediterranean red earth	Terra bruna	Terra bruna leached	Ranker
A horizon	Lacking to thin	Moderate	Thick	Thick
A horizon color	Reddish brown	Reddish brown	Dark grayish brown	Dark grayish brown
B horizon (with clay development)	Thick	Moderate	Nearly lacking	Lacking
Texture of lower portion of soil profile	Clay	Clay	Clay loam	Loose loam
pH of subsoil	6.5	6.5	5.5	4.5

Thus, the vegetation was open woodland throughout the transect. However at the lower elevations there was a greater abundance of shrubs due to shrubby species or continuous shrubby sprouting of the species which would normally form hardwoods. The soil progressed through a sequence from a Mediterranean red earth through a brown woodland soil, with increasing amount of leaching to finally a very acid ranker soil. The pH of the soil became more acid with elevation and in the subsoil ranged from 6.5 at the lower elevations to 4.5 at the higher limits of this transect. A corresponding color change occurred from reddish brown through dark grayish brown. The occurrence of a component of Pteris aquilinum (bracken fern) could be correlated with the more acid portions of this sequence. Physically the soil had high amounts of clay in the lower elevations of the transect and with increasing elevation this decreased in amount until at the upper end the soil was a loose organic loam. The most obvious visible change on the landscape was the change from a distinctly reddish soil to a very dark soil, and this could be observed at a distance from road cuts or any soil disturbance.

There were several landscape types occurring on this basic igneous rock area which were not included in the sampling sequence. On the level plateau tops formed by the most recent lava flows there were areas of nearly flat, shallow, very stony soils which resemble the Toomes Soil Series of Tehama and Shasta counties in California. The vegetation is a grass-shrub-hardwood woodland with less than 50% cover of woody vegetation. The species of vegetation are as herbs, various species of Medicago, Trifolium, and Carlina corymbosa, Carlina lanata; as shrubs, various Rubus species and sprouts of Quercus pubescens; and as hardwoods, Quercus pubescens and Quercus suber in dwarf form. Bordering these tablelands are rimrock cliffs formed from the edge of old lava flows. Frequently below those cliffs are outcrops of tuff which had been buried by the lava flows. A lithosol of sandy soil forms on these, with frequent outcrops of the white tuff.

This landscape sequence of soil-vegetation types finds an almost perfect analogy in California. In the northern part of the Sacramento Valley, near Red Bluff, broad lava flows fringe the eastern side of the valley. On these one finds a similar sequence of soil and vegetation types. There one finds the same tablelands with shallow rocky surfaces. These lay over beds of tuff yielding shallow sandy soils. There are also broad lava flows with increasing degree of soil development with decreasing elevation. A woodland, of shrubs and oaks of low density occurs in much the same manner. Another similar sequence occurs in southeastern Lake County California, extending easterly from Hobergs Hot Springs to Jerusalem Valley. However there are differences also. The California soils are about one pH unit higher (that is, the acidity is less) than in the corresponding sequence in Sardegna. Also, the California sequence has comparable soils at a higher elevation, approximately 500 meters higher than the corresponding sequence in Italy, and there is a richer forest flora of coniferous species at the higher elevations of the sequence than in Sardegna.

Sequence on Granitic Rocks in Sardegna

The second sequence of soil-vegetation types sampled was on granite in northern Sardegna. In Galluria, the northeast quarter of Sardegna, there is a large area of granite which has considerable relief. South of Tempio Pausania, from the Summit of Mt. Limbara and south to Lago Coghinas, there is a change of elevation of from more than 1300 meters to 164 meters at Lago del Coghinas. A series of sampling points was located along the highway south from Tempio Pausania, and three sites were selected for recording soil and vegetation properties. The data for these sites are presented in tables 8, 9, and 10 in order of increasing elevation. A summary of the main soil and vegetation features of this sequence is found in Table 11.

Table 8. Soil-Vegetation Plot V.

LOCATION: Italy, Sardegna; Map Fo 181 (Tempio Pausania). Highway Tempio Pausania to Oschiri 10.7 km marker.

Elevation: 300 meters
Precipitation: 700 mm
Slope: S70W 40%

Physiography: Mountainous.

VEGETATION

Cover class: $\frac{1}{S\ Hy}$

Species type: Cs, Ea, Mc, Qs

Overstory:

Species	Height	Abundance
Myrtus communis L. (Mc)	3'	XXX
Erica arborea L. (Ea)	6'	XX
Lavandula stoechas L.	1/2'	X
Phillyrea variabilis Timb.	3'	XX
Pistacia lentiscus L.	3'	X
Quercus suber L. (Qs)	15'	X
Cistus salvifolius L. (Cs)	3'	X

SOIL

Parent rock: Grano-diorite
Permeability: Good surface/Imperfect subsoil
Surface drainage: Good
Ground water: Some seasonal seepage (interflow) over rock
Root distribution: Throughout profile
Rockiness: Little -- rocks weathered into soil

Table 8, continued

Soil profile description:

Horizon	Depth (cm.)	Boundary	Color	Texture	Structure	Consistence	pH	Miscellaneous
1 (A_1)	0-9	clear-smooth	grayish brown 10 YR 5/2	gritty loam	1 fcr	ml	6.5	pH under Qs - 5.5
2 (A_2)	9-34	clear-wavy	lt. yellowish brown 10 YR 6/4	gritty loam	2 msabk	mfr	6.0	
3 (A_3)	34-50	gradual-irregular	yellowish red 5 YR 5/8	gritty clay loam	3 msabk	mvfi	6.0	
4 (B_1)	50-83	gradual-irregular	yellowish red 5 YR 5/8	gritty loamy clay	3 msabk	mvfi*	5.5	
5 (B_2)	83-88	diffuse-irregular	2-5 Y 7/6 with flecks of 5 YR 5/8	gritty sand	3 csabk	mfi	5.0	
6 (C)	88-130	gradual-irregular		gritty sand	†	mvfi	5.0-	

Parent rock

* Soil has a tendency to crack along blocks 6"x6"
† Massive pseudomorphs of original rocks

Classification:
International: Rotlehm (Kubiena), Krasnosem (Afanasiev)
7th Approximation:
Unified Soil Classification: GM/GP subsoil
California Soil Series Analogy: Musick Soil Series, Cuyamaca Soil Series

Table 9. Soil-Vegetation Plot VI.

LOCATION: Italy, Sardegna; Map Fo 181 (Tempio Pausania). Highway Tempio Pausania to Oschiri, 1 km. south Passo Variante.

Elevation: 500 meters
Precipitation: 1000 mm
Slope: N 10° W 35%

Physiography: Mountainous.

VEGETATION

Cover class: $\frac{2}{S\ Hy\ G}$

Species type: Cs, Ea, Ls, Au, Qs, Qi, Gr

Overstory:

Species	Height	Abundance
Cistus salvifolius L. (Cs)	1'	XX
Lavandula stoechas L.	1 1/2'	XX
Erica arborea L. (Ea)	3'	X
Arbutus unedo L. (Au)	4'	X
Myrtus communis L.	1'	X
Asphodelus ramosus L.	2'	X
Quercus suber L. (Qs)	15-20'	X
Quercus ilex L. (Qi)*	1-3'	X
Rubia peregrina L.	2'	X

Understory: Grasses and miscellaneous herbs (mainly *Brachy podium pinnatum*) — XX

Remarks: *The *Quercus ilex* has been thinned out to favor *Quercus suber*, otherwise it would be about 15' high. The general appearance on the ground is that of a thinned out hardwood stand, with brush in the spaces between the remaining *Quercus suber*. Where not thinned out the type is cover class 1/Hy S, and species: Qi, Qs .

SOIL

Parent rock: Grano-diorite (Quartz-orthoclase)
Permeability: Good in surface/Good in subsoil
Surface drainage: Good
Ground water: None

Root distribution: Throughout profile, with *Quercus suber* roots penetrating deep into rock.

Rockiness: 5% surface rockiness, large rocks, colluvial creep.

Table 9, continued

Soil profile description:

Horizon	Depth (cm.)	Boundary	Color	Texture	Structure	Consistence	pH	Miscellaneous
1 (A_1)	0-10	gradual-wavy	grayish brown 2-5 Y 5/2	gravelly sandy loam	0	ml	6.5-7.0*	
2 (A_2)	10-25	diffuse-wavy	grayish brown 2-5 Y 5/2	gravelly sandy loam	1 fcr	mfr	5.5	
3 (A_3)	25-35	gradual-irregular	pale brown 10 YR 6/3	gravelly loam	1 msabk	mfi	5.5	
4 (B)	35-65	abrupt-irregular	very pale brown 10 YR 7/4 - 6/4	gravelly loam to gravelly clay loam	2 cabk	mfi	5.0	
5 (C)	65-80		yellow 10 YR 7/8 with flecks of strong brown 7-5 YR 5/8 where orthoclase is weathering		0 ≁	mvfi	4.5	Weathered rock

* pH varied from 7.0 under Au bushes, to a general 6.5 .
≁ Pseudomorphs of rock crystals. Large earthworms squeezing through old root pores despite hardness of B horizon.
Depth of this profile to rock varies from 30-70 cm.

Classification:
International: Reddish Brown Lateritic (U.S.D.A., 1938), Braunlehm (Kubiena), Terra Bruna (Mancini)
7th Approximation:
Unified Soil Classification: GM
California Soil Series Analogy: Similar to the Holland Soil Series developed on granitic rocks in the Sierra Nevada

Table 10. Soil-Vegetation Plot VII.

LOCATION: Italy, Sardegna; Map Fo 184. About 2 km. southwest of Val Licciola on summit plateau of Monte Limbara.

Elevation: 1000 meters
Precipitation: 1300 mm
Slope: N 10%

Physiography: Rolling granite plateau.

VEGETATION

Cover class: $\frac{1}{S}$

Species type: Ea, Es

	Species	Height	Abundance
Overstory:	*Erica arborea* L. (Es)	3'	XXX
	Erica scoparia L. (Es)	2'	XX
	Genista corsica DC	1'	XX
	Pteris aquilina L.	3'	XX
	Brachy podium pinnatum P.B.	6"	X
Understory:	*Cistus salvifolius* L.	1'	X
	Brachypodium pinnatum P.B.	6"	X
	Lichens	2"	X

Remarks: Solid low brush cover dominated by *Erica* species. Some lichens on soil surface.

SOIL

Parent rock: Grano-diorite (Quartz-Orthoclase porphyry)
Permeability: Good on surface layers/Good in subsoil
Surface drainage: Excellent
Ground water: None
Root distribution: Throughout top 60 cm., above C horizon
Rockiness: About 5%, however in vicinity rocky outcrops of Granite are numerous

Table 10, continued

Soil profile description:

Horizon	Depth (cm.)	Boundary	Color	Texture	Structure	Consistence	pH	Miscellaneous
1 (A_1)	0-15	diffuse-wavy	very dark grayish brown 10 YR 3/2	gritty loamy sand	0	mlo	5.0	
2 (A_2)	15-30	gradual-wavy	dark grayish brown 10 YR 4/2	gritty loamy sand	1 fcr	mfr	5.0	
3 (A_3)	30-40	gradual-irreguler	brown 10 YR 5/3	gritty loam	1 fsabk	mfi	5.5	
4 (A_3)	40-55	clear-i. regular	very pale brown 10 YR 7/4	gritty loamy sand	2 fsabk	mvfi	5.5	
5 (C)	55	weathered rock					4.0	

Parent rock

Numerous clean white quartz crystals in top four horizons giving soils a salt and pepper look. Rock outcrops occur on about 5% of area. Noted a large earthworm in horizon 3. This vegetation-soil type is abundant on both north and south slopes of Mt. Limbara Plateau. Most obvious gross appearance is the dark A horizon over the nearly yellow C . Area is being cleared in strips 2 meters wide for planting Austrian black pine, Pinus nigra var. austriaca.

Classification:
International: Dystrophic Ranker (Kubiena), Ranker (Mancini)
Unified Soil Classification: SM with high amount of organic matter
California Soil Series Analogy: The soil analogy is the Sheridan Soil Series in San Mateo County and Santa Cruz County, California. The soil at the Ben Lomond Nursery of the California State Division of Forestry being an example.

Table 11. Summary of Soil and Vegetation Features of Landscape Sequence on Granite in Sardegna

Landscape	Elevation (meters)		
	300	500	1000
Vegetation			
Structure	Shrub hardwood	Shrub hardwood	Shrub
Soil			
Classification	Mediterranean red earth	Terra bruna or reddish brown lateritic	Ranker
B horizon thickness	Thick	Moderate	Absent
Subsoil color	Yellowish red	Pale brown	Brown
pH	5.0	5.0	5.5
Texture	Loamy clay	Gravelly clay	Loamy sand

The vegetation features of this sequence are a matrix of brushy species throughout, becoming dominated by Erica arborea with increasing elevation. There are a few scattered hardwoods (Quercus suber) at the lowest plot site. This may be due to effects of fire and grazing. At the intermediate elevation site the hardwoods increased to give a definite shrub hardwood woodland in which many of the shrubs are coppice growth of the hardwood species. This reflects a coppice with standards management which is applied to the area to obtain fuelwood yield. At the highest elevation the vegetation cover is a solid stand of Erica arborea. The analogy for such a vegetation sequence is found in San Diego County, California where in mounting the Laguna Mtns. from the west (for example, from Alpine to Descanso to the summit of the mountains) one proceeds through similar types of vegetation, and also similar soils.

The most noticeable soil feature is the change in subsoil color from a noticeable red subsoil at lower elevations, through a pale brown and finally a dark brown subsoil at the higher elevations. There is also a progressive deepening of a dark colored portion of the A horizon until the entire soil appears to be very dark in the higher elevations. The texture also changes such that progressively decreasing clay content is noticeable in the subsoil with increase in elevation. For example, the subsoils progress from a GP, through GM, to SM soil types with increasing elevation.

California analogies to this sequence of soil and vegetation changes with elevation occur in San Diego County (West slope -- Laguna Mtns.), on portions of the western slope of the Santa Lucia Mountains having granitic rocks in central Monterey County, north of Santa Barbara in ascending the Santa Barbara Mountains in Santa Barbara County, and finally on Montara Peak in northwestern San Mateo County, California. The presence of a summer dry climate, with the added component of a frequent cool northwest summer wind at higher elevations, especially typical of the northern California examples mentioned, is comparable to the condition in Sardegna where a cool northwest wind at higher elevations is a local peculiarity. The differences occur mainly in a more acid soil condition in the sequence in Sardegna relative to the analogous sequence in California. Also, the vegetation in the upper part of the sequence in California tends toward coniferous forest unless the California vegetation has been burned, in which case it reverts to a low cover of brush much like that on the summit of Mt. Limbara.

Sequence of Soils and Vegetation on Slightly Metamorphosed Sandstones and Shales in Sicily

The presence of a broad area of sedimentary rocks north of Mount Etna in Sicily provided an opportunity for a sampling sequence with altitudinal and thus climatic sequence. The area extending from severl miles west of Capo d'Orlando to several miles west of Floresta on the north slope of the Nebrodi Mountains offered several types of sedimentary rocks, claystones, silt stones, and sandstones, with some minor metamorphism such that the less resistant claystones and silt stones were flattened and oriented into a weakly metamorphosed schist. Following this bed of rock which was about three miles wide across the countryside from nearly sea level to the top of the mountains a sequence of three sampling sites was located and observations of the vegetation and soil were made. The data are presented in tables 12, 13, and 14; these tables being in order of ascending elevation and increasing rainfall.

This sequence involved a change in vegetation structure from shrub hardwood woodland at its lower limits to hardwood woodland at the intermediate elevations to pure grassland and herbaceous cover at the upper elevations. The hardwood species component at lower elevations was *Quercus suber*, with *Quercus pubescens* at the intermediate elevations and some scattered *Fagus sylvatica* at the upper elevations. With reference to the Italian and Greek plant community types mentioned earlier; at the lower elevation was a *Broom*

Table 12. Soil-Vegetation Plot IX.

LOCATION: Italy, Sicilia; Map Fo 252. Km. 2II on road from Zapulla-Capri Leone.

Elevation:	150 meters	Physiography:	Mountainous
Precipitation:	800 mm		
Slope:	NW 40%		

VEGETATION

Cover class: $\frac{1}{S\ Hy}$ Species type: Cs, Ea, Qs

Description:	Species	Height	Abundance
Overstory:	*Cytisus scoparius* Lk. (Cs)	5'	XX
	Quercus suber L. (Qs)	5-15'	XX
	Erica arborea L. (Ea)	3'	X
	Ampelodesma tenax Lk.	2'	X
	Cistus salvifolius L.	1'	X
	Quercus pubescens wild.	8'	X
	Orobanche crenata Forsk.	1'	X parasitic on *Cytisus* & *Cistus*

Remarks: *Ampelodesma* and *Orobanche* also in understory at same densities. Vegetation shows reaction to goat grazing in that it had a browsed appearance though not heavily.

SOIL

Parent rock:	Meta-sedimentary-clay stone some schist
Permeability:	Good in surface/Impeded in subsoil
Drainage:	Good
Ground water:	None
Root distribution:	Mainly in top 50 cm. although *Quercus suber* went deeper
Surface rockiness:	Not much surface rockiness

Table 12, continued

Soil profile description:

Horizon	Depth (cm.)	Boundary	Color	Texture	Structure	Consistence	pH	Miscellaneous
1 (A)	0-15	clear-wavy	very pale brown 10 YR 7/4	gritty loam	2 fcr	dsh	6.5	20% rock
2 (B)	15-60	gradual-diffuse	yellowish red 5 YR 4/8	gritty clay loam	mabk	mvfi	5.0	+30% rock
3 (C)	60-90	abrupt-irregular	yellowish red 5 YR 4/6	stony clay	mabk	mvfi	4.5	+40% rock

+90 cm. rock claystone and schist

Remarks: Spotty erosion in places due to past use by goats. The angular blocky structure (mabk) is related to the shape of the parent rocks and seems to be pseudomorphs of original rocks.

Classification:
International: Rotlehm (Kubiena, 1953); Reddish brown lateritic (U.S.D.A.); red podzolic (Storie & Weir)
7th Approximation: 8.220 Orthic rhodocrult
California Soil Series Analogy: Sites (m)
Unified Soil Classification:

Table 13. Soil-Vegetation Plot X.

LOCATION: Italy, Sicilia; Map Fo 252. 2 km. west of Tortorici near highway intersection. San Salvatore--Tortorici.

Elevation: 850 meters
Precipitation: 1200 mm
Slope: E 40%

Physiography: Mountainous

VEGETATION

Cover class: $\frac{4}{G\ Hy}$

Species type: Gr, Qp

Overstory:

Species	Height	Abundance
Grasses and herbs (Gr)	2"	XXX
Quercus pubescens wild. (Qp)	20'	X

Understory: Miscellaneous annual grasses and herbs

Remarks: A small vegetation type squeezed in between areas planted to *Corylus avellana* on terraced slopes.

SOIL

Parent rock: Meta sedimentary -- clay stone, some schist
Permeability: Good in surface/Impeded in subsoil
Drainage: Good
Ground water: None
Root distribution: Throughout profile and into rock
Rockiness: Very little on surface $< 1\%$

Table 13, continued

Soil profile description:

Horizon	Depth (cm.)	Boundary	Color	Texture	Structure	Consistence	pH	Miscellaneous
1 (A_1)	0-25	clear-wavy	grayish brown 2-5 Y 5/2	gritty loam	2 vfcr	mfr	7.0+	
2 (A_3)	25-35	gradual-wavy	light brown-gray 2-5 Y 6/2	stony loam	2 fcr	mfr	5.5	
3 (B)	35-75	gradual-wavy	very pale brown 10 YR 7/4	stony clay	2 mp to sabk	mvfi	5.0	
4 (C)	75-100	abrupt-irregular	white 5 YR 8/1 with yellow mottles 10 YR 7/8	stony clay	2 fp	mvfi	4.5	Irregular streaks of mottling

+100 Rock.

Remarks: B and C horizon clays appeared sericitic. Samples taken under nearby _Quercus pubescens_ had a pH of 5.5 at surface.

Classification:
International: Terra Bruna Lessive (Mancini), Podzolic brown earth (Kubiena)
Storie & Weir: Gray brown Podzolic
Unified Soil Classification: GM surface/ GC subsoil
California Soil Series Analogy: Sheetiron Soil Series or Hugo Soil Series

Table 14. Soil-Vegetation Plot VIII.

LOCATION: Italy, Sicilia; Map Fo 261. Approximately 3 km. southwest of Floresta, 12 km. northwest of Randazzo.

Elevation:	1350 meters	Physiography:	Rolling ridge top
Precipitation:	1300 mm		
Slope:	S 70° W 25%		

VEGETATION

Cover class: 5/G Species type: Gr, Pta

Overstory:

Species	Height	Abundance
Herbs	1" (springtime aspect)	XX
Pteris aquilina L. (Pta)	not up yet	XX (old fronds)

Remarks: Nearby ridges and north slopes have *Ilex aquifolium* and *Fagus sylvatica* shrubs 6-18' high. The vegetation has the appearance of the windswept grassy hills of higher elevations along the northern California coast as at Kneeland Prairie or Bear River ridge in Humboldt County, California. Apparently a wind exposed situation, and kept cool during summer by a strong northwest wind, as in these California analogies.

SOIL

Parent rock:	Eocene fine grained sandstone with slightly metamorphosed interbedded clay stone
Permeability:	Good in surface/Good in subsoil
Surface drainage:	Good
Ground water	None
Root distribution:	Fine herbaceous and coarse fern roots throughout profile
Rockiness:	About 30% surface rocks

Table 14, continued

Soil profile description:

Horizon	Depth (cm.)	Boundary	Color	Texture	Structure	Consistence	pH	Miscellaneous
1 (A_1)	0-5	diffuse-wavy	dark grayish brown 10 YR 4/2	loam	0	mvfr	5.5	
(A_3)	5-35	abrupt-wavy	dark grayish brown 10 YR 4/2	loam	0	mvfr	5.0	30% rock
2 (C)	35-45	abrupt-irregular	light gray 10 YR 7/2	stony clay loam	fabk	mvfi	4.0	70% rock

Parent rock at +45"

Remarks: This soil has the appearance of a fern root ranker soil in which the darkness of the A horizon is apparently due to the large amount of humus added to the soil by decomposing fern (Pteris aquilina L.) roots. Similar soils in California are the Wilder and the Kneeland soils of Humboldt County. The rocks on the surface of this soil may be due to frost heaving, or possibly due to erosion. In the similar Kneeland soils of California there are often rock layers at about 1' in the soil profile seeming as if they had once been on the surface, but later buried by the accretion of soil material. This soil material in these root ranker types of soils accumulates to a large extent from plant remains.

Classification:
International: Ranker (Kubiena), Regosol (U.S.D.A., 1938)
7th Approximation: 3.33-1 Entic Haplumbrept
Storie & Weir: Prairie
Unified Soil Classification: OL
California Soil Series Analogy: Wilder Soil Series, Cahto Soil Series

macchia with Quercus suber, apparently derived from degradation through fire and present intensive goat grazing from former Cork oak forest. At the intermediate elevations was Scrub oak forest (Quercus pubescens), and the upper elevation type was High altitude pasture, possibly derived by clearing much earlier from Beech forest. The same strong, cool northwest wind mentioned for Sardegna also strikes these high ridges along the backbone of northern Sicily and tend to maintain an open "wind exposure" grassland on the ridge tops. The effect of this wind is less noticeable on the peninsula of Italy than on the westerly Islands of Sardegna and Sicily.

The soils sequence represented by these data shows, as for the sequence on granite in Sardegna, a change from a soil having a characteristic yellowish red subsoil at the lower elevation to pale brown at intermediate elevations to dark grayish brown at the highest elevation. The texture change is not so pronounced, probably due to a clay source in the claystone and silt stone parent material. However, the highest elevation soil is definitely lighter in texture, being a loam relative to the other soils.

The California analogy for a transect such as this on sedimentary rocks would be found in the inner coast ranges of California. The general sequence of soils from the reddish more developed soils at lower elevations to the dark grayish brown soils at higher elevations can be found in most areas of the California coast range from Humboldt County to southern Monterey County on sedimentary rocks of the Franciscan formation. The specific case of the transect involving both a correspondence of vegetation and soil is more difficult to establish. However the same mosaic of vegetation types involving chaparral, oak woodland, and open grassland is also present in the central California coast range to the interior of the redwood--Douglas fir coastal forest belt.

Several altitude sequences other than those sampled were observable in this area in Sicily. A parallel sequence from a ranker soil at high elevations to a red soil at lower elevations was evident on nearby sandstone area that paralleled the silt and claystone area which was sampled. Where more clay was present in the parent rock a heavier soil without the red color would develop at the lower elevations. This resembles the Sehorn and the Millsholm soil types which form at lower elevations on clay rich sedimentary rocks in California (Glenn and Tehama counties).

The result is a mosaic of soil-vegetation culture types as one ascends Mt. Nebrodi in Sicily as follows:

A viewpoint at lower elevation near Zapulla (on Fo 205-206) on road to Capri Leone showed the following soil-vegetation types:

	Cover Class	Vegetation (in order of abundance)	Soil	Slope
1.	3 / G Hy	Olea--Grass	Terrace-red	15% W
2.	2 / S Hy G	Cytisus scoparius, Pistacia lentiscus, Cistus salvifolius, Ampelodesma tenax, Quercus suber	Terrace break-lithosol	60% W
3.	1 / S Hy	Pistacia lentiscus, Cytisus scoparius, Ampelodesma tenax, Quercus suber, Quercus pubescens (more Q. pubescens, less Q. suber with increasing elevation)	Mediterranean red earth	30% NW
4.	2 / S G	Cytisus scoparius, Cistus salvifolius, Pistacia lentiscus, Ampelodesma tenax	Lithosol (similar to Maymen soil series in California)	60% W
5.	1 / S	Cistus salvifolius (invaded old fields)	Non calcic brown	20% NW
6.	5 / G	Grass (pasture)	Non calcic brown	30% W
7.	2 / S G	Cytisus scoparius, Cistus salvifolius, Pistacia lentiscus, Ampelodesma tenax	Recent alluvial fan	10% W
8.	3 / Ba Hy	Citrus orchard	Recent valley alluvium	4% NW

A viewpoint at intermediate elevation on the mountain slopes near Tortorici (map Fo 205-206) showed the following soil-vegetation types:

	Cover Class	Vegetation (in order of abundance)	Soil	Slope
1.	$\frac{3}{G\ S\ Hy}$	Grasses, Quercus pubescens, shrubs, and trees	Brown forest soil	20-40% W
2.	$\frac{2}{Hy\ G}$	Corylus avellana plantations	Brown forest soil-gray brown podzol	20-60% W
3.	$\frac{1}{S}$	Cistus salvifolius, Cytisus scoparius	Lithosol	Upper ridge top
4.	$\frac{3}{G\ Hy}$	Grass -- Olea europa orchards	Non calcic brown soil-lower slopes	30% S
5.	$\frac{3}{B\ S\ G}$	Barren, Cistus salvifolius, grasses	Eroded old field--non calcic brown	30% S

Finally at high elevations near Floresta the following soil-vegetation types were observable from a landscape viewpoint:

	Cover Class	Vegetation (in order of abundance)	Soil	Slope
1.	$\frac{5}{G\ F}$	Grasses, and Pteris aquilinum	Ranker 2-3' deep	On 5-60% all exposures
2.	$\frac{3}{Hy\ G}$	Castanea sativa plantation, grass	Ranker 2' deep	30% NW
3.	$\frac{3}{Hy\ G}$	Fagus sylvatica, grasses	Ranker 2' deep	60% N
4.	$\frac{4}{G\ S}$	Grasses, Ilex aquifolium (holly)	Ranker 2' deep	60% slope

The departures which these soil-vegetation types represent from the main sequence sampled are due to erosion and the resultant formation of more youthful soils on steeper slopes, due to human culture activities with either currently managed areas, or recently abandoned areas.

Sequences on Granite in Calabria

Two locations for sequences of soil vegetation sampling sites were chosen on granitic rocks in southern Italy. One which had the most complete sequence of soil profiles was located in southern Calabria on the west slope of Serra San Bruno between Rosarno and Serra San Bruno. The other which had only the moderately developed higher elevation soils was located on the Sila plateau north of Catanzaro.

The complete sequence on granite on the Sierra San Bruno was represented by four soil-vegetation sampling plots. The data from these plots are presented in tables 16, 17, 18, and 19. Generally these show a sequence of soil and vegetation properties as summarized in Table 15.

Table 15. Summary of Soil-Vegetation Changes on Altitude Sequence on Granite in Calabria

Landscape	Elevation (meters) 75	650	950	1300
Vegetation				
Cover class	3 / G S Hy	5 / G	Y 221 / C Hy	1 / Hy
Vegetation type	Olive macchia	Grassland cleared from scrub oak forest	Fir forest	Beech forest
Soil				
Classification	Mediterranean red earth (Kubiena)	Mediterranean red earth (Terra bruna)	Terra bruna lessive Podzolic brown earth	Terra bruna lessive Podzolic brown earth (Kubiena)
Unified soil class	SC	SC	GM	SM
Subsoil texture	Clay	Gritty clay	Gritty clay loam	Gritty sandy loam
Subsoil color	Dark red brown	Yellowish red	Brown	Brown

Table 16. Soil-Vegetation Plot XV.

LOCATION: Italy, Calabria; Map Fo 246. 6.5 km. NNE of Rosarno on new road. Along the west side of Torrente Mammella on west slope of hill from 10 km. milestone on old road.

Elevation:	75 meters	Physiography:	Rolling hilly.
Precipitation:	800 mm		
Slope:	W 30-45%		

VEGETATION

Cover class $\frac{3}{G\ S\ Hy}$ Species type: At, Cs, Qs, Oe

Overstory:

Species	Height	Abundance
Ampelodesma tenax Lk. (At)	2'	XXX
Cistus salvifolius L. (Cs)	3'	XX
Myrtus cummunis L.	3'	XX
Cytisus scoparius Lk.	6'	X
Erica scoparia L.	3'	X
Rhamnus alaternus L.	3'	X
Pistacia lentisius L.	5'	X
Quercus suber L. (Qs)	15'	X
Quercus pubescens wild. *Salish.*	6'	X
Olea europaea L. (Oe)	15'	X

Remarks: A very aromatic type, similar to chaparral types in California dominated by *Salvia mellifera*.

SOIL

Parent rock:	Biotite diorite
Permeability:	Excessive in surface/Impeded in subsoil
Drainage:	Good
Ground water:	None
Surface rockiness:	None
Root distribution:	Throughout profile and into C horizon

Table 16. Soil-Vegetation Plot XV., continued

Soil profile description:

Horizon	Depth (cm.)	Boundary	Color	Texture	Structure	Consistence	pH	Miscellaneous
1 (A_1)	0-10	abrupt-wavy	brown 10 YR 6/3	loam	2fcr	dsh	6.5	
2 (A_2)	10-25	gradual-wavy	brown 10 YR 4/3	loam	2mgr	dh	6.0	
3 (A_3)	25-50	gradual-irregular	brown 10 YR 4/3	clay loam	3cabk	dh	5.5	
4 (B)	50-75	abrupt-irregular	dark red-brown 5 YR 3/3	clay	3cpr	dvh	4.5	
5 (C)	75-150+	gradual-irregular	dark brown 7-5 YR 4/4	gritty sandy loam	3cabk	dvh	6.0	

Highly altered rock in subsoil.
Charcoal in top three horizons.

Classification:
International: Terra Bruna (Mancini); Mediterranean red earth (Kubiena)
Unified Soil Classification: SC
California Soil Series Analogy: Sierra soil series or Merriam soil series

Table 17. Soil-Vegetation Plot XIV.

LOCATION: Italy, Calabria; Map Fo 246. Near km. 43 I., SS 182 (Highway 182) Vibio Valenta to Serra San Bruno, West of Serra San Bruno.

Elevation: 650 meters
Precipitation: 1600 mm
Slope: W 30%

Physiography: Sloping terrace or block in large granite area

VEGETATION

Cover class: $\frac{5}{G}$

Species type: Various grasses

The overstory is grassland and grain. However the spontaneous vegetation which invades the area if a farm is abandoned or a grass pasture allowed to remain idle is usually shrubby and composed of *Erica arborea* L. and *Cytisus scoparius* Lk.

SOIL

Parent rock:	Grano-diorite
Permeability:	Rapid in surface/Good in subsoil
Drainage:	Good
Ground water:	None
Root distribution:	Throughout profile
Surface rockiness:	None

Table 17. Soil-Vegetation Plot XIV., continued

Soil profile description:

Horizon	Depth (cm.)	Boundary	Color	Texture	Structure	Consistence	pH	Miscellaneous
1 (A)	0-30	diffuse-wavy	yellowish brown 10 YR 5/4	loam	2fgr	dh	5.0	
2 (A_3)	30-45	abrupt-irregular	yellowish brown 10 YR 5/4	gritty loam	3 cbk	mvfi	5.0	
3 (B)	45-65	abrupt-irregular	yellowish red 5 YR 4/8	gritty clay	3cpr	mvfi	4.5	Cracks and root channels of 5 YR 8/3
4 (C)	65-150	diffuse-gradual	yellowish red 5 YR 5/8 mottles against pink 5 YR 8/3	silty clay	*	mvfi	4.0	

* Pseudomorphs of original rock weathered into soil

Classification:
International: Red yellow podzolic (Storie & Weir)
Unified Soil Classification: SC
California Soil Series Analogy: Musick Soil Series or Cuyamaca Soil Series

Table 18. Soil-Vegetation Plot XIII.

LOCATION: Italy, Calabria; Map Fo 246. At km. 40.6, S.S. (Highway) 110, southeast of Sierra San Bruno

Elevation:	950 meters	Physiography:	Mountainous with block faulting topography typical of granitic areas
Precipitation:	1900 mm		
Slope:	N 50 W 25%		

VEGETATION

Cover class: Y221 / C Hy — Species type: Ap, Fs

	Species	Height	Abundance
Overstory:	*Abies pectinata* D.C. (Ap)	50-150'	XX
	Fagus silvatica L. (Fs)	40'	XX
Understory:			
	Pteris aquilina L.	1' (leafing out)	XX
	Rubus spp.	2'	X
	Abies pectinata D.C.	3'	XX
	Fagus silvatica L.	2-6'	X
	Hedera helix L.	vine	X
	Lonicera spp.		X
	Potentilla spp.		X
	Cytisus scoparius Lk.	3'	X

Remarks: Many fir stumps, about 48" diameter. Shown an inch a year of growth at time of cut. Plot is just beyond 40.6 marker, beyond bridge and around curve.

SOIL

Parent rock:	Granitic, Quartz diorite
Permeability:	Good in surface/Good in subsoil
Drainage:	Good
Ground water:	None
Root distribution:	Throughout profile and into rock
Rockiness:	None on surface

Table 18. Soil-Vegetation Plot XIII., continued

Soil profile description:

Horizon	Depth (cm.)	Boundary	Color	Texture	Structure	Consistence	pH	Miscellaneous
L & F	2	abrupt-smooth			platy, matted			Mixed *Fagus-Abies*
1 (A_1)	0-15	abrupt-wavy	very dark grayish brown, 10 YR 3/2	sandy loam	0	mvfr	6.5	
2 (A_2)	15-50	gradual-wavy	brown 10 YR 5/3	sandy loam	1vfcr	mfi	5.0	
3 (A_3)	50-70	gradual-wavy	brown 10 YR 5/3	sandy loam	2fcr	mfi	5.0	
4 (B)	70-100	gradual-wavy	brown 10 YR 5/3	gritty clay loam	2msabk	mfi	4.5	
5 (C)	100-140	gradual-wavy	brown-yellow 10 YR 6/8 mottled with white 10 YR 8/1	sandy loam	0	mfi	4.2	

Weathered diorite rock

Classification:
International: Yellowish brown lateritic (Storie & Weir)
Unified Soil Classification: GM
California Soil Series Analogy: Stump Springs Soil Series
Holland Soil Series

Table 19. Soil-Vegetation Plot XII.

LOCATION: Italy, Calabria; Map Fo 246. At milestone 48, S.S. 110 Southeast of Serra San Bruno.

Elevation: 1300 meters
Precipitation: 2000 mm.
Slope: N 40 W 40%

Physiography: Mountainous

VEGETATION

Cover class: $\frac{1}{Hy}$

Species Type: Fs

	Species	Height	Abundance
Overstory:	Fagus silvatica L. (Fs)	40'	XXX
Understory:			
	Fagus silvatica L. (sprouts)	5'	X
	Viola spp.	6"	X
	Vinca major L.	1'	X

Remarks: A coppice forest showing large interlocked root platforms which take up almost all the top 2' of the soil A horizon.

SOIL

Parent rock: Granite
Permeability: Good in surface/Good in subsoil
Drainage: Good
Ground water: None
Root distribution: Throughout profile, but most abundant in top 2', especially around trees
Rockiness: 5% on surface

Table 19. Soil-Vegetation Plot XII., continued

Soil profile description:

Horizon	Depth (cm.)	Boundary	Color	Texture	Structure	Consistence	pH	Miscellaneous
L & F*	122	abrupt						
1 (A_1)	0-25	diffuse-smooth	very dark gray 0-10" 10 YR 3/1 dark gray brown 10 YR 4/2	gritty loamy sand	0	ml	5.0	
2 (A_3)	25-60	diffuse-smooth	brown 10 YR 5/3	gritty sandy loam	0	ml	4.5	
3 (C)	60-100		brown 10 YR 5/3	gritty sandy loam	lmgr	mvfr	4.5	

Granite rock rich in muscorite mica

* Leaf litter, beechnut mast and twigs, some moss

Remarks: From 0-5 cm. there is a darker surface horizon 10 YR 3/1 (very dark gray) of gritty loamy sand having a pH of 5.0. Some strips of more humus rich soils follow old roots.

Classification:
International: Gray Brown Podzolic (U.S.D.A.); Podzolic Brown Earth (Kubiena); Terra Bruna lessive (Mancini)
Storie & Weir: Gray Brown Podzolic
Unified Soil Classification: SM
California Soil Series Analogy: Shaver or Corbett Soil Series in the Sierra Nevada.

This soil sequence is similar to that found on granite in Sardegna. However, the vegetation is more luxurious due, perhaps, to the higher rainfall.

California analogies to this sequence on granite are offered on the west slope of the Sierra Nevada in areas of granite rock. It would begin at lower elevations with the distinctly red-colored Sierra Soil series, and proceed through the Musick Soil series to the Holland and the Corbett Soil series at high elevations. The vegetation sequence is chaparral on the lower elevation soil; for example, between Shingle Springs and Placerville in El Dorado County. The natural vegetation at the next stage of the sequence, east of Placerville near Camino and Pollack Pines, would be Ponderosa pine-Black Oak Forest, but frequently cleared for agricultural use. The analogy to the 950 meter elevation location on the Serra San Bruno would be near Kyburz east of Placerville. Although the soil is similar, the forest would have a greater mixture of coniferous species. There is, however, a large amount of Abies concolor which is the California analogy to the Abies pectinata of Italy. Finally, at higher elevations in the Sierra Nevada would be a red fir forest (Abies magnifica) on soils (Corbett Series) corresponding to those at the 1300 meter location. At higher elevations in the Sierra Nevadas, the landscape has been subjected to glaciation and the conditions are different then in the gran'tic areas of southern Italy and Greece. There are also analogous portions of the sequence on granite in Monterey County in the Santa Lucia Mountains south of Big Sur River. For example, the granitic headlands jutting into the Tyrrhenian Sea near Joppolo, south of Vibo Valentia resemble granitic headlands of the Santa Lucia mountains.

The Sila Plateau north of Catanzaro and east of Cosenza in Calabria offers another elevation sequence on granite rock. However, it was difficult to find the well developed lower elevation soils. The Sila Plateau is a large granite plateau uplifted in a pattern of block faulting. The sides of the plateau are steep. In the place of well developed soils at lower elevations there are steep colluvial slopes with coarse immature soils formed at the angle of repose. These are clothed with holly leaf oak forest (*Quercus ilex*). The upper elevations of the plateau have moderately developed soils to immature ranker soils as represented by the soil-vegetation plot data in tables 20 and 21. A California analogy to this is offered by the western slope of the southern Sierra Nevada, and by the San Bernardino Mountains in southern California. Each of these is bordered by steep slopes with colluvial soils (clothed with *Quercus chysolepis*, the California analogy of *Quercus ilex*), and summit plateaus with coniferous forests.

Table 20. Soil-Vegetation Plot XVI.

LOCATION: Italy, Calabria; Map Fo 237. Highway S.S. 108 from Lorica to San Giovanni at k 53 VI milestone. Stand of pines 50 meters southeast of highway intersection with small unpaved road.

Elevation: 1300 meters
Precipitation: 1200 mm
Slope W 30%

Physiography: Rolling hilly -- mountainous on high granite plateau of the Sila.

VEGETATION

Cover class: YIII / C

Species type: Pn

	Species	Height	Abundance
Overstory:	*Pinus nigra* var. *Laricio* (Poir) (Pn)	70'	XXX
Understory:			
	Various grasses and herbs	6"	X
	Pinus nigra var. *Laricio* (Poir)	2'	X
	Cytisus scoparius Lk.	3'	X

Remarks: A fairly simple type which has been logged in the past. It is adjacent to agricultural fields.

SOIL

Parent rock:	Granite
Permeability:	High in surface/High in subsoil
Drainage:	Good
Ground water:	None
Surface rockiness:	None
Root distribution:	Throughout profile and into decomposed rock

Table 20. Soil-Vegetation Plot XVI., continued

Soil profile description:

Horizon	Depth (cm.)	Boundary	Color	Texture	Structure	Consistence	pH	Miscellaneous
L	1							Sparse leaf litter & cones
F	2							Decomposed leaf & bark litter
1 (A_1)	0-10	abrupt-wavy	brown 10 YR 5/3	sandy loam	0	mfr	6.0	
2 (A_2)	10-30	gradual-wavy	yellowish brown 10 YR 5/4	sandy loam	1 vfcr	mfr	5.5	
3 (A_3,C)	30-45	abrupt-irregular	brown 7-5 YR 5/6	loamy sand	0	ml	5.5	
4 (C)	45-100	gradual-wavy	brown 7-5 YR 5/6 with flecks of white 10 YR 8/2	gritty loamy sand	0	mfi	5.2	

Classification:

International: Terra Bruna with umbric epipedon (Mancini); Gray-brown Podzolic (Storie & Weir)
7th Approximation: 3.33 (Haplumbrept
Unified Soil Classification: GM
California Soil Series Analogy: Corbett Soil Series -- Shaver Soil Series

Table 21. Soil-Vegetation Plot XVII.

LOCATION: Italy, Calabria; Map Fo 237. Near point 1605 meters 1 km. west of summit road between Lorica and Silvana mansio.

Elevation: 1600 meters
Precipitation: 1500 mm
Slope: N 80° W 20%

Physiography: Rolling granitic upland plateau

VEGETATION

Cover class: 3/GFHy

Species type: Gr, Pta, Fs

Overstory:

Species	Height	Abundance
Miscellaneous herbs (Gr)	2" (mostly emerging from soil)	XXX
Asphodelus ramosus L.	(dry remains -- last year)	X
Pteris aquilina L. (Pta)	(not up yet)	XX
Fagus silvatica L. (Fs)	15-35'	XX

Understory: Same as above except for Fs.

Remarks: *Fagus silvatica* trees 30 years old and 35' tall on this location. Crowns are bushy and broad. Some past cutting has resulted in many sprouts.

SOIL

Parent rock: Granite
Permeability: High in surface/High in subsoil
Drainage: Good
Ground water: None
Surface rockiness: 10% by area of large granite boulders
Root distribution: Very thick and dense in top 2' of profile making it difficult to dig near old beech tree. Fewer roots below 2', but roots throughout profile.

Table 21. Soil-Vegetation Plot XVII., continued

Soil profile description:

Horizon	Depth (cm.)	Boundary	Color	Texture	Structure	Consistence	pH	Miscellaneous
1 (L)	2				matted	loose		Leaf litter
2 (F)	1				matted	loose	5.5	Decomposing leaf litter
3 (A)	0-60	abrupt-wavy	dark brown 10 YR 3/3	sandy loam	1fcr	mfr	5.0	Dense mat of roots
4 (C)	60-90	abrupt-irregular	dark brown 10 YR 4/3	loamy sand	0	ml	4.5	Charcoal fragments at top of C

Granite rock 10 YR 6/4 yellow-brown

Classification:
International: Gray Brown Podzolic
7th Approximation: 3.33-1 (Haplumbrept)
Unified Soil Classification: GM
California Soil Series Analogy: Shaver Soil Series

Sequence on Marl Rock in the Abruzzi

A large area of calcareous rocks occupies southeastern Italy, beginning with the heel of the peninsula southeast of Taranto and extending north westerly, gradually penetrating into the center of the peninsula northeast of Rome. A distinct type of these calcareous rocks differing from the hard limestones and dolomites is the soft marl rock. This soft marl rock weathers much more readily to heavy clay soils. La Maiella, a large mountain mass of marl rock, offers the opportunity of observing an elevation sequence of soils and vegetation. The sequence of observations were made beginning along the Sangro River near Bomba (due south of Lanciano) and ending at the upper elevation near the summit of La Maielleta at the end of the highway south of Passo Lanciano. The soil vegetation data obtained on four sampling plots, in order of increasing elevation, are presented in tables 22, 23, 24, and 25. The general features of the change with elevation on this sequence are seen in table 26.

Table 22. Soil-Vegetation Plot XXI.

LOCATION: Italy, Abruzzi; Map Fo 147. Km. 28 on Sangro River Road to Bomba.

Elevation: 200 meters

Precipitation: 800 mm (between Perano with 720 mm and Bomba with 950 mm)

Slope: W 20%

Physiography: Canyon side

VEGETATION

Cover class: $\frac{1}{\text{S Hy}}$

Species type: Cb, Mc, Qi

Overstory:

Species	Height	Abundance
Carpinus betulus L. (Cb)	10'	XX
Quercus ilex L. (Qi)	15'	XX
Cornus mas L.	10'	X
Smilax aspera L.	vine	X
Quercus pedunculata wild. *salisb.*	15'	X
Myrtus communis L. (Mc)	6'	X
Asparagus spp.	1'	X
Rosa spp.	4'	X

Understory: Low growing grasses and herbs.

Remarks: This type is being managed as a coppice woodland with standards of *Quercus ilex* to give a tufted appearance to the aerial view of the type.

SOIL

Parent rock: Marl

Permeability: High in surface/Poor in subsoil

Surface drainage: Good

Ground water: None

Surface rockiness: 10% widely scattered rocks

Root distribution: Throughout profile

Table 22. Soil-Vegetation Plot XXI., continued

Soil profile description:

Horizon	Depth (cm.)	Boundary	Color	Texture	Structure	Consistence	pH	Miscellaneous
1 (A_1)	0-15	abrupt-wavy	dark gray 10 YR 4/1	gritty clay loam	2mcr	mfr	8.2	30% rock
2 (A_2)	15-35	gradual-wavy	gray 10 YR 5/1	stony clay	2ccr	mfr	8.2	40% rock
3 (A_3)	35-60	gradual-wavy	light gray 10 YR 6/1	stony clay	2msabk	mfr	8.2	50% rock
4 Ca	60-100	abrupt-irregular	light gray 10 YR 7/1	stony clay	2mabk	mvfi	8.2	50% rock

Rock showing colluvial action.

Remarks: Some charcoal fragments in profile,especially in horizon 3. Horizon 4 shows calcium carbonate accumulation, especially on surfaces that have dried out.

Classification:
International: Sierozem with A/Ca/C (Storie & Weir)
Unified Soil Classification: CH
California Soil Series Analogy: Linne or Zaca Soil Series

Table 23. Soil-Vegetation Plot XX.

LOCATION: Italy, Abruzzi; Map Fo 147. On road to Passo Lanciano from Pretoro at curve on road south of 860 meters note on Fo 147.

Elevation: 875 meters
Precipitation: 1300 mm
Slope: W 30%

Physiography: Lower slopes of mountains

VEGETATION

Cover class $\frac{5}{G}$

Species type: Gr

Overstory:

Species	Height	Abundance
Miscellaneous herbs & grasses	6"	XXX
Quercus pedunculata wild. (Scattered sprouts in rock outcrops)	1'	X

Remarks: Apparently area has been cleared from oak woodland dominated by *Quercus robur* var. *sessiliflora*.

SOIL

Parent rock: Marl
Permeability: High in surface/Impeded--poor in subsoil
Surface drainage: Good
Ground water: None
Surface rockiness: 10% in isolated rock outcrops
Root distribution: Throughout profile, but with turf of roots mainly in top 15 cm.

Table 23. Soil-Vegetation Plot XX., continued

Soil profile description:

Horizon	Depth (cm.)	Boundary	Color	Texture	Structure	Consistence	pH	Miscellaneous
1	0-8	gradual-wavy	dark brown 7-5 YR 3/2	clay loam	1mcr	mfr	8.0	Large rocks scattered in 0-20 cm.
2	8-20	abrupt-wavy	brown 7-5 YR 4/2	clay	2mcr	mfr	8.0	
3	20-55	abrupt-irregular	brown 7-5 YR 4/4	clay	3mabk	mfi	8.0	Some charcoal

Rock stained brown (10 YR 4/4-5/8) on outside

Remarks: Profile depth is variable from 20 cm. to 100 cm. Shallow areas lack the brown horizon 3. Drying surfaces such as on road cuts form a very loose fine angular blocky structure upon drying. Area shows signs of former clearing from forest, then cultivation, and currently an abandonment of cultivation and current use as pasture.

Classification:
International: Terra Gialla (Comel); Terra Bruna (Mancini); Earthy Terra Fusca (Kubiena)
7th Approximation: Rendall
Unified Soil Classification: CH
California Soil Series Analogy: None in the current soil classification scheme

Table 24. Soil-Vegetation Plot XIX.

<u>LOCATION</u>: Italy, Abruzzi; Map Fo 147. About one mile beyond Passo Lanciano on road to La Mailetta.

Elevation:	1500 meters	Physiography:	Steep mountainous
Precipitation:	1300 mm		
Slope:	N 30° W 65%		

<u>VEGETATION</u>

Cover class $\frac{1}{Hy}$ Species type: Fs

Overstory:	Species	Height	Abundance
	Fagus silvatica L. (Fs)	40'	XXX

Understory: Little to sparse. Ground covered with leaf litter.

Remarks: A completely pure stand of beech which ends abruptly in a timberline at an elevation of 1600 meters. Above this is an alpine turf as in Plot XVIII.

<u>SOIL</u>

Parent rock:	Marl
Permeability:	High in surface/High in subsoil
Drainage:	Good
Ground water:	None
Surface rockiness:	5% small rocks widely scattered
Root distribution:	Throughout profile and into rock

Table 24. Soil-Vegetation Plot XIX., continued

Soil profile description:

Horizon	Depth (cm.)	Boundary	Color	Texture	Structure	Consistence	pH	Miscellaneous
1 (L+F)	2	abrupt-wavy			mottled			Beech leaf litter
2 (A)	0-10	gradual-wavy	very dark brown 10 YR 2/2	loam	2ccr*	mfr	7.5	15% rock, 10% roots
3 (C)	10-35	abrupt-irregular	very dark brown 10 YR 2/2	loam	2mcr	mfr	7.5	40% rock

abrupt transition to strongly fractured marl rock

* Structure has appearance of earthworm workings.

Classification:
International: Mull rendzina A/C Profile on marl (Kubiena)
7th Approximation: 5.1 (Rendall)
Unified Soil Classification: MH
California Soil Series Analogy: None

Table 25. Soil-Vegetation Plot XVIII.

LOCATION: Italy, Abruzzi; Map Fo 147. Near summit of La Mailetta 1/4 mile northwest of Rifugio; along road.

Elevation: 1900 meters
Precipitation: 1400 mm
Slope: N 10 W 30%

Physiography: Mountain ridge top

VEGETATION

Cover class: 5/G

Species type: Grass

Overstory:	Species	Height	Abundance
	Miscellaneous grasses	6" (turf)	XXX
	Juniperus communis L.	1' matted	X

No understory

SOIL

Parent rock:	Marl
Permeability:	High in surface/High in subsoil
Drainage:	Good
Ground water:	None
Surface rockiness:	20% scattered small rocks
Root distribution:	Thick in top 15 cm. of profile

Table 25. Soil-Vegetation Plot XVIII., continued

Soil profile description:

Horizon	Depth (cm.)	Boundary	Color	Texture	Structure	Consistence	pH	Miscellaneous
1	0-10	gradual-wavy	very dark grayish brown 10 YR 3/2	loam	lmcr	mfr	7.0	
2	10-45	abrupt-irregular	dark brown 10 YR 3/3	clay loam	lmcr	mfr	6.0 5.0	
Rock								

Remarks: Depth is variable and may be as low as 15 cm. as some soil material extends into cracks in rock. The micro-relief is composed of undulating terrain with deep soils on the concave portions and shallow rocky soils on gentle ridges.

Classification:
International: Alpine pitch rendzina (Kubiena)
7th Approximation: 5.1 (Rendoll)
Unified Soil Classification: OL
California Soil Series Analogy: None. Marl does not reach high enough elevation in California to have this type of soil developed on it.

TABLE 26. Summary of main features of Elevation Sequence on Marl Rock

Landscape	Elevation (meters) 200	875	1500	1900
Vegetation:				
Cover class	$\frac{1}{SHy}$	$\frac{5}{G}$	$\frac{1}{Hy}$	$\frac{5}{G}$
Vegetation type	Hollyleaf oak macchia	Grassland cleared from Scrub Oak Forest	Beech Forest	High altitude pasture
Soil:				
Classification	Sierozem with A/Ca/C	Earthy terra fusca (Kubiena) Terra Gialle (Comel)	Mull rendzina (Kubiena)	Alpine pitch rendzina (Kubiena)
Unified class	CH	CH	MH	OL
Subsoil:				
Texture	Stony clay	Clay	Loam	Clay loam
Color	Light grey	Brown	Very dark brown	Dark brown
pH	8.2	8.0	7.5	5.0

The sequence of soils on marl generally has a decrease in the amount of clay with increasing elevation. At the lower elevation there is a distinctly gray soil with calcium carbonate accumulation in the subsoil. This is related to the lower extent of leaching of bases including calcium, at the lower rainfall; and to the ease of weathering of calcium from the parent rock. These factors, when coupled with the high clay content of the marl rock, result in a heavy clay high calcium content soil having a high pH at the lower elevation. A distinctive brown clay soil was found at the next higher elevation. It was slightly less alkaline in pH. The soils in this elevation zone had been cleared for agricultural uses from scrubby hardwood forests of Quercus pubescens. The soils above this are rendzinas, a mull rendzina under beech forest; and an acid pitch rendzina above timberline under the alpine pasture.

California analogies for this sequence are not complete. In California marl rocks are usually confined to lower elevations on the south coastal plain. The lower elevation plot in this transect is analogous to the soils derived from marl rocks in western San Diego County (near Vista) Los Angeles County in the hills just west of Pomona, and in southern Santa Barbara County along the coast, west of Goleta. In these areas the Linne and Zaca soil series form analogous soils to that found in the Sangro Valley on Marl. The natural vegetation in California would be a woodland of Quercus engelmanni, or open grassland; but most of them are utilized for agriculture. The higher elevation portions of the sequence on marl in California are lacking.

Sequence on Limestone Mt Terminillo

Mt. Terminillo, northeast of Rome near Rieti in Unbria, with an elevation of 2,213 meters, offers an opportunity for a fairly complete elevation sequence on limestone. A series of observations were made at various elevations on such a transect. The same general sequence of vegetation communities with increasing elevation and change in soil types occurs on the limestone as in the sequence on marl rock, with the difference that the lower elevation has a terra rossa soil on the limestone instead of the sierozem that occurred on the marl. The observation details presented for the sampling points in order of increasing elevation in tables 27, 28, 29, and 30. The main details of the sequence are summarized in table 31. This sequence is much like that described by Comel (1939 Gorizia). The general type of change from a heavy textured clay subsoil at lower elevations (a CH soil) to slight textured stony sandy loam (GM) at higher elevations, was similar to the sequences on the other rock types. However, the red color was much more intense and noticeable at the lower elevations on limestone than on the other types of rock. Although not sampled there was a distinctly yellowish brown soil between the terra rossa at 600 meters and the mull rendzina at 1500 meters, corresponding with the Terra Gialla which Comel described east of Gorizia.

The vegetation sequence on Mt. Terminillo was from hardwood forest at the lower elevations with oak and chestnut forests predominant; through hardwood forests of beech extending to timberline; above which was open grassland. This differed from the vegetation sequences on the other parent rock types in that a coniferous belt between the oak and the beech forests was absent.

The California analogy to this soil-vegetation sequence is only partly present. Limestone rock at lower elevations with the development of a Terra

TABLE 27. Soil-Vegetation Plot. Lower elevation Mt. Terminillo

LOCATION: Italy, Umbria, northeast of Rieti Km. 7 on Mt. Terminillo Highway.

Elevation: 600 meters
Precipitation: 1300 mm
Slope: N.W. 30%

Physiography: Lower 1/3 of slope of large mountain ridge

VEGETATION:

Cover Class: $\frac{1}{Hy}$

Species Type: Cs, Rp

Overstory:

Species	Height	Abundance
Castanea sativa Mill (Cs)	30'	XXX
Robinia pseudoacacia L. (Rp.)	20'	X
Acer opalus Mill	15'	X

Understory:

Species	Height	Abundance
Acer opalus Mill	6'	XX
Corylus avellana L.	4'	XX
Tilia Spp.	6'	X
Cornus mas L.	6'	X
Quercus cerris L	8-	X
Pteris aquilina L	2'	X

Also some Rubus spp, Crataegus spp. and Rosa spp.

Remarks: This is a luxurious coppice forest of chestnut. In this area chestnut is confined to this deep non-rocky Terra Rossa.

TABLE 27 (continued)

SOIL:

Parent Rock:	Limestone
Permeability:	Good in surface/impeded in subsoil
Surface drainage:	Good
Ground water:	None
Root distribution:	Throughout profile with an accumulation in subsoil of large roots
Rockiness:	None on surface

Soil Profile Description:

Horizon	Depth	Color		Texture	Struct.	Consistence	PH
1	0-18	Reddish brown	5 YR 4/4	(clay loam	2 mcr	d?	6.0
2	18-40	Dk reddish brown	(2.5 YR 3/4*	clay	3 m sabk	dfi	5.8
3	40-60	Dark red	2.5 YR 3/6	clay	3 c sabk	dh	6.1
4	60-100	Red	2.5 YR 4/6	clay	3 c sabk	dh	6.[illegible]
5	100-170	Red	2.5 YR 4/6	clay	3 c sabk	dvh	6.0

Old terrace or soil creep materials have added to this soil.

*Wet color

Very small content of coarse materials in this soil profile

Classification:

International:	Terra Rossa
Unified Soil class:	CH
California analogy:	Permanente Soil Series near Sonora, Tuolumne County, California

TABLE 28. Soil-Vegetation Plot. Middle elevation Mt. Terminillo

LOCATION: Italy, Unbria, near resort area of Monte Terminillo, about one mile northwest of church.

Elevation: 1500 meters.
Precipitation: 1600 mm.
Slope: South 40%

Physiography: Middle of slope, large mountain ridge

VEGETATION:

Cover class $\frac{5}{G}$

Species Type: Gr (misc. herbs)

Species: Miscellaneous grasses and herbs not keyed out.

Nearby on same terrain and soil is a nearly pure stand of beech (*Fagus sylvatia*) with a cover class of $\frac{1}{Hy}$ with an understory of scattered *Salix* bushes.

SOIL:

Parent Rock	Limestone
Permeability:	Rapid in surface/ good in subsoil
Surface drainage:	Good
Ground water:	None
Erosion:	Some surface slumping
Roots:	Throughout profile to 60 cm
Surface rockiness:	None

Soil Profile description

Horizon	Depth	Color		Texture	Structure	P:
1	0-12	Dark grayish brown	10 YR 4/2	Clay loam	ifer	5.5
2	12-30	Pale brown	10 YR 6/3	Clay	2 mcr-m sabk	6.0
3	30-60	Pale brown	10 YR 6/3	Stony clay	2 m sabk	6.5
4	C_2	between rocks Cherty limestone parent rock	10 YR 6/3	Stony clay		8.0

Classification:

International:	Mull rendzina
Unified:	CH
California analogy:	Intermediate to higher elevation areas in Marble Mountains of Siskiyou County. No soil series analogy at present.

TABLE 29. Soil-Vegetation Plot. High Elevation Mt. Terminillo

LOCATION: Italy, Umbria, on Monte Terminillo Road for Campo Sorogna, about 2 km east of main ski lift

Elevation: 1800 meters
Precipitation: 1700 mm
Slope: south 40%

Physiography: Large open slope on steep south slope of Mt. Terminillo

VEGETATION:

Cover class: $\frac{5}{G}$

Species Type: Gr (misc. herbs)

Species	Height	Abundance
Lotus corniculatus L.	6"	XX
Rumex acetosella L.	6"	X
Mentha species	12"	X

About 200 meters above timberline.

SOIL:

Parent rock: Cherty limestone
Permeability: Good in surface/ good in subsoil
Surface drainage: Good
Ground water: None

Root distribution: throughout profile
Surface rockiness: About 5%

Soil Profile Description

Horizon	Depth	Color		Texture	Structure	PH
1	0-10	Dark brown	10 YR 3/3	loam	1 fcr	6.5
2	10-35	Dark brown	10 YR 3/3	loam	1 fcr	5.0
3	35-40	Dark brown	10 YR 3/3	clay loam	2 mcr	5.0
4	40-75	Yellowish brown	10 YR 5/4	clay loam	2 mcr	4.5

Horizons 1 and 2 represent new slope creep horizons over an older buried A horizon (horizon 3), with a subsequent A_3 horizon resting on a rocky C horizon.

Classification:

International: Mull rendzina
Unified: CL
California Soil Series analogy: None available

TABLE 30. Soil Vegetation Plot. High elevation Mt. Terminillo

LOCATION: At Passo Sella di Leonessa on northside Mt. Terminillo

Elevation: 1950 meters
Precipitation: 1800 mm
Slope: S 40-60%

Physiography: Mountainous

VEGETATION: Cover class: 4/GS   Species type: Gr Jc

Species	Height	Abundance
Juniperus communis L. (Jc)	12"	XX
Grasses (Gr)	12"	XX
Dryas octopetala L.	8"	X

Clumps of low shrubby Junipers. These showed slightly different grass composition and as they matured and died, a darker green clump of grass remained where the Junipers had been.

SOIL:

Parent rock:	Cherty limestone
Permeability:	Rapid in surface/ rapid in subsoil
Surface drainage:	Good
Ground water:	None
Root distribution:	Dense sod of roots to 50 cm.
Surface rockiness:	15%-20%

Soil Profile description:

Horizon	Depth (cm)	Boundary	Color	Texture	Structure	Consistence	PH
1(A)	0-25	ai	Dark brown 10 YR 3/3	Stony loam	1 fcr	Ml	6.8
2(C)	25-50		Very pale brown 10 YR 8/3	Stony sandy loam	0	mfi	

Some colluvial creep in parent material.

Classification:

International:	Mull like Rendzina (Kubiena)
Unified:	GM
California Analogy:	No established soil classification. However possibly in the Marble Mountains in Siskiyou County at higher elevations (6,000') on limestone.

TABLE 31. Summary of limestone sequence on Mt. Terminillo

Landscape	Elevation (meters)			
	600	1500	1800	1950
Vegetation				
Cover class	$\frac{1}{Hy}$	$\frac{5}{G}$ or $\frac{1}{Hy}$	$\frac{5}{G}$	$\frac{4}{GS}$
Plant Community	Oak-Chestnut woodland	Beech Forest or High Altitude Pasture	High Altitude Pasture	High Altitude Pasture
Soil				
Classification Unified Class	Terra Rossa CH	Mull rendzina CH	Mull rendzina CL	Mull-like rendzina GM
Subsoil: color	Red	Pale brown	Dark brown	Dark brown over very pale brown
pH	6.1	6.5	5.0-4.5	6.8
texture	Clay	Stony clay	Clay loam	Stony sandy loam

Rossa soil occurs between Sonora and Columbia in Tuolumne County (Permanante soil series), and as in Italy, it has an oak woodland vegetation. At higher elevations in California limestone is not abundant enough to give much area showing the remainder of the sequence. There are some areas of limestone in Trinity County near Hayfork; and in another small area south of the Bear River, south of Ferndale in Humboldt County, which have the stage of soil development corresponding with the yellowish brown clay soil or Terra Gialla of Comel. At the headwaters of the Nacimiento River in the Santa Lucia mountains in Monterey County there are small limestone areas that reach this degree of development. Interestingly, there is a conifer, Abies venusta, which occurs along with several oaks on this latter example. These areas are all limited and do not represent the broad landscapes developed on limestone that are present in Italy and Greece.

SEQUENCE OF SOIL-VEGETATION ON SEDIMENTARY ROCKS IN TUSCANY

Large areas of sandstone rock in Tuscany (Italy) give the opportunity to observe a wide range of soil development representative of the weathering of these types of rocks. A sequence was selected on Macigno Grande (a thick bedded yellow sandstone which resembles the Eocene and late Jurassic sandstone of the Knoxville Formation in the coast ranges of California). The low elevation point of the sequence was located south of Florence and the upper elevation point was located on the ridge of Prato Magno near Vallombrosa east of Florence. The data from soil vegetation observation points on this sequence are presented in tables 32, 33, and 34 in order of increasing elevation.

Table 32. Soil-Vegetation Plot XXXVIII.

LOCATION: Italy, Toscana, Firenze. 6 mi. southwest of Firenze on road to Volterra. Map Fo 106. At Km 8, road from Galluzo s.w. to Romola

Elevation:	198 meters	Physiography:	Rolling hilly
Precipitation:	900 mm		
Slope:	W 40%		

VEGETATION

Cover class: $\frac{Y441}{S\ Hy\ C}$ Species type: Ea, Qc, Pp

Description:	Species	Height	Abundance
Overstory:	*Erica arborea* L. (Ea)	3'	XXX
	Cistus salvifolius L.	3'	XX
	Juniperus oxycedrus L.	3'	X
	Arbutus unedo L.	3'	X
	Quercus cerris L. (Qc)	15'	XX
	Pinus pinea L. (Pp)	30'	X

Remarks: A very sparse overstory of oak and pine with the shrub species appearing both as overstory and understory. The *Pinus pinea* has been introduced in the past as a plantation.

SOIL

Parent rock:	Sandstone (so called "macigno grande")
Permeability:	Rapid in surface/Rapid in subsoil
Surface drainage:	Good
Ground water:	None
Surface rockiness:	None
Root distribution:	Throughout profile
Erosion:	Some loss of A horizon

Table 32. Soil-Vegetation Plot XXXVIII., continued

Soil profile description:

Horizon	Depth (cm.)	Boundary	Color	Texture	Structure	Consistence	pH	Miscellaneous
1	0-15	abrupt-irregular	light yellowish brown 10 YR 6/4	loam	1fcr	dfi		
2	15-30	gradual-wavy	strong brown 7-5 YR 5/6	clay loam	2msabk	dh		
3	30-55	abrupt-irregular	reddish yellow 7-5 YR 6/6	clay loam	3mabk	dh		
4	55-82	abrupt-irregular	reddish yellow 7-5 YR 6/8	sandy loam	2fsabk	dh		

Abrupt transition to unweathered massive sandstone.

Remarks: A few large sandstone rocks occur sporadically in the profile.

Classification:
International: Terra Bruna lessive (Mancini)
Unified Soil Classification: MH
California Soil Series Analogy: Josephine Soil Series

Table 33. Soil-Vegetation Plot XXXIX.

LOCATION: Italy, Toscana, Prato Magno. 20 Km. southeast of Firenze. Map Fo 107.

Elevation: 1460 meters
Precipitation: 1900 mm
Slope: W 30%

Physiography: Mountain ridge top

VEGETATION

Cover class: $\frac{5}{G}$ or $\frac{4}{GS}$

Species type: Gr or Gr Ec, Jo

Description:

Overstory: Species	Height	Abundance
Erica carnea L. (Ec)	6"	X
Carex curvule Ait. (Gr)	3"	XXX
Nardus stricta L.	6"	XX
Juniperus oxycedrus L. (Jo)	6"	X
Cirsium spp.	6"	X
Spartium junceum L.	1'	X

Remarks: No understory. Site is a windswept ridge. The exposure has apparently maintained the site free of elevated woody vegetation such as Fagus sylvatica. The timberline of this species is only 30 meters below this site.

SOIL

Parent rock: Sandstone
Permeability: Rapid in surface/Rapid in subsoil
Surface drainage: Good
Ground water: None
Surface rockiness: Few on surface
Root distribution: Mainly in top 20 cm. representing a root bound sod
Erosion: Slight

Table 33. Soil-Vegetation Plot XXXIX., continued

Soil profile description:

Horizon	Depth (cm.)	Boundary	Color	Texture	Structure	Consistence	pH	Miscellaneous
1 (A_1)	0-15	abrupt-wavy	dark gray brown 10 YR 4/2	loam	1vfcr	dl	4.5	
2 (A_3)	15-35	gradual-wavy	pale brown 10 YR 6/3	loam	2fsabk	mfi	5.0	
3 (C)	35-55	abrupt-irregular	very pale brown 10 YR 6/3-7/3	loam	2vfsabk	mfi	5.0	

Irregular abrupt transition to shattered sandstone rock.

Remarks: Generally the first horizon is a sod horizon of *Carex* roots. Nearby below the sharp timberline under *Fagus sylvatica* shrubs, this layer was absent. There seems to be a relation between the stability of this timberline and the possible inability of the *Fagus* to invade a *Carex* sod.

Classification:
International: Alpine humus (Jenny); Alpine sod podzol (Kubiena)
Unified Soil Classification: OL
California Soil Series Analogy: Kneeland Soil Series, or Wilder Soil Series, Humboldt County, California.

Table 34. Soil-Vegetation Plot XL.

LOCATION: Italy, Toscana, Vallumbrosa Forest. Map Fo 107. About 2 Km. north of Vallembrosa near chapel on road to Tosi.

Elevation: 900 meters
Precipitation: 1500 mm
Slope: NW 30%

Physiography: Mountainous, middle slopes of mountain ridges

VEGETATION

Cover class: Y111/C

Species type: Ap

Description:	Species	Height	Abundance
Overstory:	*Abies pectinata* DC (Ap)	70'	XXX
Understory:	*Rubus idaeus* L.	2'	XXX
	Fraxinus ornus L.	20'	XX
	Acer monspessulanum L.	30'	X
	Abies pectinata DC	3'	X
	Castanea sativa Mill.	15'	X

Remarks: This type is a plantation of *Abies* with a volunteer understory. Some *Picea excelsa* has been planted nearby.

SOIL

Parent material: Mixed sedimentary rocks, mainly sandstone
Permeability: Rapid in surface/Good in subsoil
Surface drainage: Good
Ground water: None
Surface rockiness: Few
Root distribution: Throughout profile
Erosion: Possibly in past about 1'

Table 34. Soil-Vegetation Plot XL., continued

Soil profile description:

Horizon	Depth (cm.)	Boundary	Color	Texture	Structure	Consistence	pH	Miscellaneous
1	0-5	abrupt-	10 YR 5/2	loam	2fcr	dl	5.5	
2	5-22	abrupt-wavy	10 YR 6/3	loam	2msabk	dfi	5.0	
3	22-50	gradual-wavy	10 YR 7/4	loam	2mabk	mfi	5.0	
4	50-120	abrupt-irregular	10 YR 7/4	loam	2mabk	mfi	4.5	

Sandstone parent rock indicating colluvial action in the past.

Classification:
International: Gray brown podzolic (Storie & Weir); Terra Bruna lessive (Mancini)
Unified Soil Classification: SC
California Soil Series Analogy: Hugo Soil Series

Table 35. Summary of Sequence on Sedimentary Rocks in Tuscany

Landscape	Elevation -- Meters 300	 900	 1460
Vegetation:			
Cover Class	$\frac{Y441}{SHyC}$	$\frac{Y111}{C}$	$\frac{5}{G}$ or $\frac{4}{GS}$
Plant Community	Scruboak forest*	Fir Forest	High Mountain Pasture
Soil:			
Classification	Terra bruna lessive	Gray brown pod-zolic	Alpine Humus (Jenny)
Unified Class	MH	SC	OL
Subsoil Properties:			
Colorq	Reddish yellow	Very pale brown	Very pale brown
pH		5.0	5.0
Texture	clay loam	loam	loam

*Degraded to macchia and planted with <u>Pinus pinea</u>

The details of this sequence summarized in table 35, show the typical change from a high clay content soil with a red color at the lower elevations to a soil low in clay content and brown in color at the high elevations.

The vegetation types show considerable effect of man, but still remain within the context of the usual sequence of change with elevation increase. At the lower elevation plot, the original vegetation appears to have been scrub oak forest of Quercus pubescens and Quercus cerris. As past economic conditions changed, and with it the demands which men made upon the vegetation changed, the vegetation type was reduced to a degraded macchia of Erica arborea with occasional Arbutus unedo. Plantations of Pinus pinea were then introduced into this degraded macchia both for a timber and a nut crop. The Erica arborea remains as an understory and is harvested for brooms.

Thus, in this area where human use has been present for a long period, the appearance of the vegetation type reflects the economic environment that is prevalent. This was described well by Lenoble[1] in a discussion describing the economic basis of certain forestry practices in Tuscany. The development of a brushy coppice out of a hardwood forest of Quercus cerris and Quercus pubescens was correlated with the economic environment in which the landowner was immersed. As an example, a farmer in Valdarno di Sopra, east of Florence, had 250 oaks of various sizes which he cut as they reached merchantable size, and he received 175 lire per year income from this prior to 1820. In 1820 he decided to cut down the oaks and raise firewood faggots (small bundles of twigs) by a coppice system, utilizing the sprouts from

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[1]Lenoble, Felix. 1923. La legende du deboisement des Alpes. Revue de Geographie Alpine XI: 5-116.

these oaks. He received 2800 lire for the oaks he cut down. He invested this and received an annual interest of 140 lire. By 1825 the sprouting oak coppice was producing 1,000 faggots per year, with 7 lire per 100 income -- or 70 lire, and 4 heaps (Castate) of firewood yielding 48 lire per year. Thus, with an annual income from interest and fuel, he now made 258 lire per year, for a gain of 83 lire per year over the income from the hardwood forest. Thus the present appearance of the plant community partly reflects the past ec onomic history as well as the climate and soil of the area.

The Abies pectinata forest, which occurs at the intermediate elevation of this sequence, also represents a man-made vegetation type. However, it is a vegetation type that would have occurred naturally at this elevation. This type occurring in the forest at Vallombrosa has been cultured there for more than 500 years by monks from the monastery at Vallombrosa.

The open grassland occurs at the highest site above a very sharp timberline. This seems partly correlated with the development over a long time of a characteristic soil under the herbaceous sod. This sod is difficult for woody plants to invade, and the difficulty is increased by grazing pressure maintained on any tree seedlings which present themselves.

THE SOIL MOSAIC ON SEDIMENTARY ROCKS

Since sedimentary rocks such as form the main backbone of the Apennines are variable, the sequence of soil types described above on a single type of sandstone may not always be found. For example, where the geology is more complex as in the Apuan Alps (Alpi Apuane) northwest of Lucca, the soil-vegetation types change with each change of rock type. They do not present an orderly change of soil and vegetation with elevation change, but show fragments of the portions of the sequence for each rock type and elevations at which it appears on the landscape. In a transect across these mountains from near Massa east to the Serchio River Valley, one finds the transect of soil vegetation types as shown in table 36. This is an area that has its landscape analogy in northern California, particularly in the inner north coast ranges in eastern Humboldt and Trinity counties where sedimentary rocks are fringed by metamorphic rocks on their eastern edge in which some limestone and marble are to be found (as in the Marble Mountains).

Some of the variability of soils on the sedimentary rocks in the Apennines is related to the variability in their composition. The main variables in the sedimentary rocks that are related to soil differences being in their particle size distribution and in their base content. Where the sedimentary rock becomes finer in texture, as would be expected, the resulting soils also become more clay rich in texture. Thus, along the northeastern side of the Apennines, from an area about 20 miles southwest of Bologna, trending southeasterly past San Marino into the Abruzzi, there is an area of Pliocene and Miocene sedimentary rocks very high in clay content. These give rise to soil-vegetation landscapes of gray slipping clay soils with grassland vegetation, or where more stable, with scrub oak woodland (with Quercus pubescens). The California analogy for this is the Yorkville soil series in the north coast ranges in the Russian River and the Eel River drainages.

In the central southern Apennines in the vicinity of Potenza, there are sedimentary rocks of Pliocene and Eocene age on which heavy clay soils develop. A suite of soils develops on these rocks which resemble the soils developed on similar rocks in the inner coast ranges of California, either west of Coalinga or in western Glenn and Tehama counties. Thus, soils resembling the Sehorn, Millsholm, Vallecitos, and Los Osos soils of these California areas are developed. On a transect east of Potenza, following

Table 36. Landscape Soil-Vegetation Profile Across the Apuan Alps*

LOCATION:	2 km NW Massa		3 km E of Massa	5 km E of Massa to 10 km E of Massa (Isola Santa)	Isola Santa	South of Castelnuovo di Garfagnana
Elevation:	300 meters		800 meters	900 m to 1589 meters to 691 meters		600 meters
VEGETATION:						
+	Macchia	Plantations	Plantations		Cs plantation	Cs plantation or scruboak woodland QpQc
General type	Ea, Fo	Rp, Pm, or Cs	Pm or Cs, Gr	Cb woodland or grassland	With Cv understory	
SOIL:						
Classification	Lithosol	Terra Bruna and Gray-brown podzolic	Gray brown podzolic	Rendzina	Gray brown podzolic (Terra bruna lessive)	Terra bruna
California series analogy	Maymen	Josephine and Hugo	Sheetiron or Hugo m	None at present	Hugo m or sheet-iron	Josephine
ROCK:	Sandstone (Macigno grande)		Schist	Marble	Schist	Sandstone (Macigno grande)

* Map Foglio 96 Masse

\+ Species abbreviations:

Cb	*Carpinus betulus*	Pm	*Pinus marittima*
Cs	*Castanea sativa*	Qc	*Quercus cerris*
Cv	*Calluna vulgaris*	Qp	*Quercus pubescens*
Ea	*Erica arborea*	Rp	*Robinia pseudoacacia*
Fo	*Fraxinus ornus*		

the highway to Metera, one encounters first a large area of heavy clay soils with grassland vegetation. These resemble the Sehorn and Millsholm soils series of California. Where rockier areas exist in these clay soil areas, they are invaded by Cytisus brush, giving a vegetation cover class of 3/BS. Further east these Eocene rocks contain interbedded sandstone and claystone (flysch) on which developed a soil similar to the Los Osos soil series of California with a vegetation cover class of 2-3/GH_y with species of grasses in <u>Quercus pubescens</u>, <u>Quercus cerris</u> woodland. It was noticeable in this area that where the soil had a higher pH, <u>Quercus pubescens</u> was more prevalent. At the edge of the Eocene rock near Tricarico, there were conglomerate rock outcrops. These were easily identifiable because of a dense young hardwood cover (cover class 1/H_y) with a species composition of <u>Quercus ilex</u> and <u>Quercus pubescens</u>. The holly leaf oak (<u>Q. ilex</u>) gives a dark green color to the types. The soil was similar to the Bunnell soil series in California, derived from conglomerate rocks in Glenn County near Elk Creek.

SEQUENCE OF SOIL VEGETATION TYPES IN NORTHERN PINDUS MOUNTAINS -- GREECE

The northern Pindus mountains present a mosaic of geologic types in which there are a series of peridotite and serpentine intrusions oriented on a northwesterly axis extending from central Greece into central Yugoslavia. These are intruded into adjacent sedimentary rocks (sandstone, flysch, and limestone) and have associated with them, intrusions of gabbro. The intruded ultra basic igneous rocks are either unaltered and remain as peridotite, or are altered upon cooling to form serpentine. The resulting landscape is a mosaic of soils and associated vegetation types related to the occurrence of the various rock types. A transect across these mountains from Ioannina to Kalabaka allows one to observe most of the soil types in this sequence.

This transect of soil-vegetation types across the Pindus Mountains along the route of the highway from Ioannina to Kalabaka included observations on Flysch (table 37), serpentine and peridotite (tables 39, 40, 41, and 42), on gabbro (table 43), on sandstone (table 44), and on conglomerate (table 45).

The general sequence of soils and vegetation had its landscape analogy in the northern California coast ranges where serpentine and peridotite intrusions occur into general country rock of sandstones, conglomerates, and interbedded claystones and sandstones, along with intrusions of gabbro and basalts. Thus, the soil-vegetation type observed on Flysch (table 37) has its counterpart in soils on the shales near Elk Creek, Glenn County, California in the Lodo soils series and the associated Sehorn and Millshom series. The California vegetation type often found on the lithosol (Lodo series) is a sparse scattering of Juniperus californica on otherwise bare ground.

This zone of rocks characterized by Flysch extends southerly all the way down the back bone of Greece. On the geologic map of Greece[1] these rocks denoted as Flysch are seen to begin in Albania and to continue into the Peloponnesos. An example of an elevation sequence near the southern end of this zone of Flysch rocks was observed between Tripolis and Olympia. It occurred as follows, from higher to lower elevation:

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[1] Kingdom of Greece. Institute for Geology and Subsurface Research. 1954. Geologic Map of Greece, 2 sheets 1/500,000.

Table 37. Soil-Vegetation Plot (XXII-C)

LOCATION: Greece, and Kalabake. Summit of first pass, 10 miles east of Ioannina on road from Ioannini to Metsovon

Elevation: 1000 meters
Precipitation: 40 inches
Slope: SW 40-70%

Physiography: Steep mountainous

VEGETATION

Cover class: $\frac{4}{B\ S}$

Species type: Barren, Jo

Description:
Overstory:

Species	Height	Abundance
Juniperus oxycedrus L. (Jo)	3'	X
Quercus coccifera L.	3'	X
Pteris aquilina L.	1'	X scattered patches

Understory: A few herbs and miscellaneous annual grasses under protection of *Juniperus*.

Remarks: The land surface is about 80% bare ground. The density of cover of shrubs increases with increasing soil depth and the shifts toward a *Quercus coccifera Carpinus betula* type heavily grazed by goats.

SOIL

Parent material: Sedimentary rock - Flysch. Interbedded sandstone and claystone.
Permeability: Excellent in surface/Excellent in subsoil
Surface drainage: Good
Ground water: None
Surface rockiness: About 90% scattered sandstone rocks
Root distribution: Roots throughout profile and into softer strata of rock.

Table 37. Soil-Vegetation Plot (XXII-C), continued

Soil profile description:

Horizon	Depth (cm.)	Boundary	Color	Texture	Structure	Consistence	pH	Miscellaneous
1	0-10	abrupt-irregular	brown 10 YR 5/3-5/4	stony clay loam	1fcr	mfr	7.0	80% rock

Remarks: A strongly eroded area with erosion pavement of rocks covering most of surface. Originally a 2-3' clay loam with 10 YR brown color.

Classification:
International: Lithosol
Unified Soil Classification: GC
California Soil Series Analogy: Lodo, Hulls, and Maymen soil series.

Table 38. Soil-Vegetation Plot (XXII-B)

LOCATION: Greece, Thessaly. 6 miles west of Tryghona, 3 miles southeast of Korydalos on road between Kalabaka and Metsovon.

Elevation: 1000 meters
Precipitation: 30 inches
Slope: S 20%

Physiography: Gentle slope at foot of steep ridge

VEGETATION

Cover class: $\frac{5}{G}$

Species type: Grasses and grain

Remarks: Solid cover of perennial grasses about 6" high. Some shallower patches of same soil have heavily browsed clumps of *Juniperus oxycedrus* L.

SOIL

Parent rock:	Serpentine-peridotite
Permeability:	Excellent in surface soil/Poor in subsoil
Surface drainage:	Good
Ground water:	None
Surface rockiness:	A trace; less than 1% on surface
Root distribution:	Grass roots in top 30 cm.

Table 38. Soil-Vegetation Plot (XXII-B), continued

Soil profile description:

Horizon	Depth (cm.)	Boundary	Color	Texture	Structure	Consistence	pH	Miscellaneous
1 (A_{11})	0-6	abrupt-wavy	gray-brown 2-5 YR 5/2	clay loam	2fcr	dl	7.5	Sod layer
2 (A_{12})	6-20	abrupt-irregular	dark gray-brown 10 YR 4/2	clay	3mabk	dh	7.8	
3 (A_{13})	20-36	abrupt-irregular	dark gray-brown 10 YR 4/2	clay	3mabk	dvh	7.8	
Rock (serpentine-peridotite) at irregular depths; or someplaces horizon 4								
4	36-100	abrupt-irregular	dark gray-brown 10 YR 4/2	clay	3mabk	dvh	7.8	

Remarks: Horizon 4 generally not present.

Classification:
International: Lithosol. Brunizemic regosol.
7th Approximation: 5.52-1.43
Unified Soil Classification: CH
California Soil Series Analogy: Montara

Table 39. Soil-Vegetation Plot XXII.

LOCATION: Greece, Km. 52 on Hwy. west to Metsovon 14 miles west Ortho Bouyni, and east of Trighona

Elevation: 900 meters
Precipitation:
Slope: S 40%

Physiography: Mountainous

VEGETATION:

Cover class: $\frac{3}{B\ S}$

Species type: Barren, Bs, Jo

Overstory:

Species	Height	Abundance
Juniperus oxycedrus L. (Jo)	2'	XX
Buxus sempervirens L. (Bs)	3'-6'	XX
Cistus incanus L.	1'	X
Quercus pedunculata wild.	1'	X

Understory: A few scattered herbs.

Remarks: An open sparse type with much bare ground and rocks between shrubs. The *Quercus* is very heavily browsed, but in nearby areas some shrubby trees are present. It has deep tap roots. The area is similar in vegetation appearence to brush covered serpentine areas in California (Lake, Glenn, Mendocino counties). It is used as goat pasture. Flat areas are cleared, stones removed and terraced.

SOIL

Parent rock: Serpentine
Permeability: High in surface/Impeded in subsoil
Surface drainage: Good
Ground water: None
Surface rockiness: 30-40%; large rocks
Root distribution: Throughout profile and into rocks

Table 39. Soil-Vegetation Plot XXII., continued

Soil profile description:

Horizon	Depth (cm.)	Boundary	Color	Texture	Structure	Consistence	pH	Miscellaneous
1	0-15	abrupt-irregular	dark reddish brown 5 YR 3/4	clay loam	2fcr	ds	6.5	Local patches of higher pH due to limestone road dust
2	15-50	abrupt-irregular	dusky red 2-5 YR 3/4 mottles of light yellow brown 2-5 YR 6/4	gritty clay	3cabk	dh	7.5	
Rock								

Remarks: A darker surface color and a deeper horizon 1 occurs under adjacent plants.

Classification:
International: Brunizem
Unified Soil Classification: GC
California Soil Series Analogy: Henneke Soil Series of serpentine intrusions in Lake County and Mendocino County of California.

Table 40. Soil-Vegetation Plot (XXII-D)

LOCATION: Greece, Pindus Mtns. 1 mile east of summit of Pindus Mtns. on road from Metsovon to Kalabaka.

Elevation: 1690 meters
Precipitation: 50"
Slope: SE 30-60%

Physiography: Mountainous

VEGETATION

Cover class: $\frac{\text{Y0432}}{\text{B S C}}$

Species type: Barren, Bs, Pn

Description:

	Species	Height	Abundance
Overstory:	*Pinus nigra* Arnold (Pn)	35'	XX
	Buxus sempervirens L. (Bs)	3'	XXX
	Abies pectinata Lam. & D.C.	15'	X
Understory:	*Buxus sempervirens* L.	3'	XX

Remarks: A type which has a very natural appearance, having many old mature pines.

SOIL

Parent material: Serpentine, peridotite
Permeability: Good in surface/Good in subsoil
Surface drainage: Good
Ground water: Some spring seepage in parent material
Surface rockiness: 20% scattered rock
Root distribution: Throughout profile and into loose colluvium
Erosion: None to very slight

Table 40. Soil-Vegetation Plot (XXII-D), continued

Soil profile description:

Horizon	Depth (cm.)	Boundary	Color	Texture	Structure	Consistence	pH	Miscellaneous
1	0-15	diffuse-wavy	brown 5 YR 3/3	stony clay loam	1fcr	mfr	6.0	40% rock
2	15-45	diffuse-wavy	dark red-brown 2-5 YR 3/4	gritty clay	1fcr	mfr	6.0	60% rock
3	45-125	abrupt-wavy	dusky red 10 YR 3/4	stony clay	1fcr	mfr	7.5	>80% rock

Peridotite-serpentine parent rock.

Remarks: Some colluvial action and spring seepage through lower parts of soil.

Classification:
International: Regosol or Brown Forest Soil.
7th Approximation: 3.330 Orthic Haplumbrept
Unified Soil Classification: GC
California Soil Series Analogy: Dubakella Soil Series, Huse Soil Series

Table 41. Soil-Vegetation Plot XXIII

LOCATION: Greece, On highway between Metsovon and Kalabaka; half way between top of pass and Panayia (first town to east), on side road to north -- 300' .

Elevation: 1400 meters
Precipitation: 60"
Slope: South 30%

Physiography: Mountainous

VEGETATION

Cover class: Y0432 / BSC

Species type: Barren, Bs, Pn, Ap
Site tree; Pn 16" DBH, 45' tall, 62 years.

Description:
Overstory:

Species	Height	Abundance
Buxus sempervirens (Bs)	4'	XX
Juniperus oxycedrus	2'	X
Pinus nigra (Pn)	30'	XX
Pteris aquilina	2'	X
Abies pectinata (Ap)	10'	X very few

Understory: Bare ground -- litter covered

Remarks: The Austrian black pine grows to 60' at 300 years with flat top old trees. The *Buxus* is variable in color; some is an intense deep green; and some is yellowish green as if possibly due to a response to some nutrient variable. There are only a few scattered *Abies pectinata* present. The *Pinus* is generally harvested at an age of 100 years and the remaining trees show a good ability to increase growth in response to this release; growing 1/2" per year after release compared to 1/8" per year before release.

SOIL

Parent material: Peridotite, with some serpentine
Permeability: High in surface/Good in subsoil
Surface drainage: Good
Ground water: None
Surface rockiness: 20%
Root distribution: Throughout profile
Erosion: Very little; slight amount of slope creep

Table 41. Soil-Vegetation Plot XXIII, continued

Soil profile description:

Horizon	Depth (cm.)	Boundary	Color	Texture	Structure	Consistence	pH	Miscellaneous
1	0-7	abrupt-wavy	dark red-brown 5 YR 3/3	clay loam	1fcr	dl	5.5	
2	7-30	diffuse-irregular	dark red-brown 2-5 YR 3/4	clay loam	2 mcr	mfr	6.0	
3	30-70	abrupt-irregular	dusky red 10 YR 3/4	clay loam	2mcr	mfi	6.5	
Rock (serpentine) - Peridotite.								
4	variable	abrupt-irregular	yellowish red 5 YR 5/8 with mottles of pale olive 5 YR 6/4	gritty clay loam	pseudo-morphs of rock		6.5	

Classification:
International:
Unified Soil Classification: GC (Stony)
California Soil Series Analogy: Cornutt Soil Series

Table 42. Soil-Vegetation Plot XXIV.

LOCATION: Greece, On road from Kalabaka to Metsovon; 1 mile west of summit of pass near Metsovon.

Elevation: 1500 meters
Precipitation: 65"
Slope: NW 30-40%

Physiography: Mountainous

VEGETATION

Cover class: YO 442 / SGC

Species type: Barren, Bs, Gr, Pn*
Site class: *30' at maturity

Description:	Species	Height	Abundance
Overstory:	*Buxus sempervirens* L. (Bs)	3'	XXX
	Grasses (perennial) (Gr)	1 1/2'	XX
	Pinus nigra Arnold (Pn)	20-30'	X
Understory:	Grasses (perennial)	1 1/2'	XX

SOIL

Parent material: Serpentine
Permeability: Rapid in surface/Good in subsoil
Surface drainage: Good
Root distribution: Througrout profile and into surface broken rock
Erosion: None

Table 42. Soil-Vegetation Plot XXIV., continued

Soil profile description:

Horizon	Depth (cm.)	Boundary	Color	Texture	Structure	Consistence	pH	Miscellaneous
1	0-10	abrupt-irregular	dark reddish gray 5 YR 4/2	clay loam	1fcr	ml	6.5	
2	10-30	gradual-wavy	dark brown 10 YR 4/3	clay loam	2mcr	mfr	7.0	Pieces of charcoal
3	30-60	abrupt-irregular	brown--dark brown 7-5 YR 4/4	stony clay loam	2mcr	mfr	7.0	

Serpentine parent rock

Remarks: This soil becomes redder in hue in places than the profile described, and depth becomes greater in concave portions of the terrain due to colluvial action.

Classification:
International: Terra Bruna lessive (Mancini)
Unified Soil Classification: GC
California Soil Series Analogy: Weitchpec Soil Series

Table 43. Soil-Vegetation Plot (XXV-B)

LOCATION: Greece, Thessalia. On road from Kalabaka to Metsovon, 1 mile north of Korydalos.

Elevation: 850 meters
Precipitation: 30"
Slope: W 40%

Physiography: Rolling mountainous

VEGETATION

Cover class: $\frac{4}{\text{G Hy}}$

Species type: Gr, Qp

Description:	Species	Height	Abundance
Overstory:	Grasses (Gr)	1'	XXX
	Quercus pubescens willd. (Qp)	15'	X
Understory:	Grasses	1'	XX

Remarks: Qp is browsed heavily. California analogy is clumps of *Quercus garryana* in grassland.

SOIL

Parent material: Basalt-intrusion into metisedimentary rocks
Permeability: Rapid in surface/Impeded in subsoil
Surface drainage: Good
Ground water: None
Surface rockiness: None
Root distribution: Throughout profile

Table 43. Soil-Vegetation Plot (XXV-B), continued

Soil profile description:

Horizon	Depth (cm.)	Boundary	Color	Texture	Structure	Consistence	pH	Miscellaneous
1	0-15	gradual-wavy	dark red-gray 5 YR 4/2	clay loam	2fabk	dh	7.0	
2	15-45	abrupt-wavy	weak red 2-5 YR 4/2	clay loam	3mabk	dh	6.5	
3	45-60	abrupt-irregular	dark red-gray 5 YR 4/2	clay	3mabk	dvh	6.0	

Intruded basalts, meta shales and partially serpentinized rocks.

Classification:
International: Terra Bruna (Mancini)
Unified Soil Classification: CL
California Soil Series Analogy: Comptche or Tatu

Table 44. Soil-Vegetation Plot (XXV-A)

LOCATION: Greece, Thessalia. On road from Kalabaka to Metsovon, 1/2 mile south of Korydalos.

Elevation:	800 meters	Physiography:	Mountainous
Precipitation:	30"		
Slope:	W 40%		

VEGETATION

Cover type: $\frac{1}{Hy}$ Species type: Qp

Description:	Species	Height	Abundance
Overstory:	Quercus pubescens wild. (Qp)	15"	XXX

Remarks: A pure oak thicket which has apparently been cut in the past and has regrown as a coppice.

SOIL

Parent material:	Sandstone
Permeability:	Rapid in surface/Impeded in subsoil
Surface drainage:	Good
Ground water:	None
Surface rockiness:	None
Root distribution:	Throughout profile and into rock

Table 44. Soil-Vegetation Plot XXV-A., continued

Soil profile description:

Horizon	Depth (cm.)	Boundary	Color	Texture	Structure	Consistence	pH	Miscellaneous
1	0-20	abrupt-wavy	brown 10 YR 5/3	sandy loam	0	mfr	5.5	
2	20-35	gradual-wavy	red 2-5 YR 5/6	clay loam	2fsabk	mfi	5.0	Charcoal present
3	35-85	abrupt-irregular	red 2-5 YR 4/6	clay	3mabk	mvfi	5.0	

Sandstone rock.

Remarks: A small isolated block of sandstone in a contact metamorphic zone adjacent to serpentine stocks.

Classification:
International: Terra bruna lessive (Mancini)
Unified Soil Classification: CL
California Soil Series Analogy: Josephine Soil Series

Table 45. Soil-Vegetation Plot (XXII-A)

LOCATION: Greece, Moni Roussanou. Near Kalabaka, on road to Meteora, 1/3 mile north of the monastery

Elevation: 500 meters
Precipitation:
Slope: SW 40%

Physiography: Mountainous

VEGETATION

Cover class: $\frac{1}{S}$

Species type: Qc, Qr

Description:
Overstory:

Species	Height	Abundance
Quercus robur var. sessiliflora Salish. (Qr)	8'	X
Quercus coccifera L. (Qc)	3'	XX
Fraxinus ornus L.	8'	X
Phillyrea variabilis Timb.	6'	X
Cornus mas L.	6'	X
Colutea artorescens L.	2'	X
Salvia spp.	1'	X

Understory: A few miscellaneous herbs.

Remarks: North slopes tend toward pure Quercus robur var. sessiliflora and Fraxinus ornus; while south slopes tend to have more Quercus coccifera. Analogous to types in chaparral of western Lake County.

SOIL

Parent material: Conglomerate (Oligocene) with high proportion of granitic cobbles
Permeability: High in surface soil/Impeded in subsoil
Surface drainage: Good
Ground water: None
Surface rockiness: 10% scattered rocks weathered out of conglomerate
Root distribution: To 1-1/2 meters.

Table 45. Soil-Vegetation Plot (XXII-A), continued

Soil profile description:

Horizon	Depth (cm.)	Boundary	Color	Texture	Structure	Consistence	pH	Miscellaneous
1	0-25	abrupt-wavy	brown 7-5 YR 5/4	sandy loam	1fcr	mfr	7.0	
2	25-40	diffuse-wavy	dark red 2-5 YR 3/6	gritty clay loam	3fabk	mvfi	5.5	
3	40-80	diffuse-wavy	dark red 2-5 YR 3/6	gritty clay loam	3mabk	mvfi	5.5	
4 (C)	80-150	abrupt-irregular	yellow red 2-5 YR 5/8	gritty clay loam	3mabk to platy	mvfi	5.0	

Conglomerate rock or grayish colluvial material from conglomerate rock.

Remarks: Surface pH represents influence of *Quercus coccifera*.

Classification:
International: Reddish brown podzolic (Storie & Weir)
Unified Soil Classification: MH
California Soil Series Analogy: Sites Soil Series

Decreasing elevation, westerly ——————

Location	Near Vytina			10 km West of Lanadia
Vegetation:	Abies cephalonica forest	Abies cephalonica with Quercus pubescens woodland	Oak woodland Quercus pubescens	Oak woodland
Soil:	Gray brown podadic	Lithosols		Abrupt transition to terra rossa
Calif. analogy	Hugo series	Maymen series Ledo series Millsholm		Permanente

This terrain was badly eroded in places as is the tendency with areas underlain by Flysch rock.

A major feature of the transect over the Pindus Mountains is a broad area affected by serpentine and peridotite intrusions. Where the serpentine is intruded into the country rock, there is frequently a margin of metamorphosed rock and serpentine more rich in calcium content then the main body of the serpentine. This frequently gives rise to a grassland on a heavy clay soil, a situation reflected in table 38. The analogous situation also is found at the margins of serpentine areas in California in the north coast ranges where the heavy clay Montara and Climax soils, characterized by grasslands, are found. Leaving the marginal area and proceeding into the main mass of the serpentine on this transect in the Pindus Mountains, one enters into a large area of macchia, characterized by boxwood and juniper vegetation on a shallow reddish brown clay rich soil developed from the serpentine. This has a striking California analogy in the Henneke soil series. This soil in California is also covered with a macchia-like vegetation, a chaparral characterized by various species of Arctostaphylos, some Cupressus species, and a characteristic scrub oak, Quercus durata. The result is a similar vegetation cover class designation when viewed on aerial photographs. With increasing rainfall associated with elevation change on the serpentine, a deeper, reddish brown heavy clay forest soil develops (table 40) for which the California analogy is the Dubakella soil series. The Greek vegetation on this soil is a sparse conifer cover with brush and bare ground beneath, and for this one finds an analogous vegetation for such soil in California, where a sparse stand of Pinus jeffreyi over a brush cover of Artostaphylos and bare ground is usually present. The larger serpentine intrusions usually include unaltered peridotite, and on this a soil that is less heavy in clay, but redder in color, is found (table 41). This soil derived from peridotite has its direct analogy in the Cornutt soil series found on Peridotite outcrops in northwestern California and southwestern Oregon. A good example is found on Big Red Mountain in north central Mendocino County, and this has a similar vegetation cover class as well as soil. At the highest elevations in the Transect over the Pindus Mountains, such as at Metsovon pass, the soil development on the serpentine and peridotite was retarded, as in other elevation sequences, and a soil (table 42) less red in color and lighter in texture was formed. This is analogous to the Weitchpec soil series found at higher elevations on serpentine and peridotite in north eastern Humboldt County in California.

Associated with the intrusions of serpentine and peridotite rock are gabbro and basalt outcrops. On this transect in the Pindus Mountains, these had a reddish gray soil with a distinct purplish cast (table 43). An analogy to this occurs in California in that, associated with the intrusions of serpentine and peridotite, are areas of basalt and gabbro intrusions on which several analogous soil series (Comptche, Hohman, Foutz, Tatu) are found, all of which have purplish hues to their color (probably due to manganese in various degrees of oxidation). It was noted that these soils followed a belt of gabbro and basalt intrusions southeasterly from this area on the Pindus Mountains transect, to appear at the summit of the mountains north of Lamia. In this southern extension they were characterized by a sparse cover of brushy Quercus coccifera.

Local outcrops of the sandstone country rock into which the serpentine and peridotite were intruded occurred on the transect. These had a degree of soil development (table 44) analogous to the Josephine soil series in California, or the same as the lower elevation soils on sedimentary rocks previously described in this paper for Italy. This soil in Greece had a low hardwood cover, and finds its analogy in the oak woodland vegetation that characteristically covers the areas of Josephine soil series in interior Mendocino County in California. At lower areas near Meteora, just north of Kalabaka, there were conglomerate rock outcrops on which the soil had developed to the red soil stage and represented the analogous Sites Soil Series of California, found in Glenn, Lake, and Colusa counties. The Quercus coccifera scrub oak cover characteristic of the Greek soil-vegetation landscape, has a California counterpart in the Quercus dumosa chaparral cover on some areas of the same soil in California.

A summary of the soil and vegetation types encountered on this transect across the Pindus Mountains is shown in table 46. This transect is much like one that would be found in a transect across the north coast ranges of California from Dos Rios, Mendocino County to Stonyford, Glenn County.

Table 46. Transect of Soil Vegetation Types Across the Pindus Mountains Following the Highway from Ioannina to Kalabaka via Metsovon Pass.

LOCATION: Feature	Ioannina	Summit first pass		Dipotamos River	Voutnosi	
Distance	0	16		25	46	
VEGETATION: Cover Class Species Type *	5/G Gr	3/CSHy Gr Jo Qp	1/SHy Qc Cb Qp	4/BS Ba Jo Qc	5/B Ba	2/SHyG Qc Qp Gr
SOIL: Classification	Lithosol or Terra Rossa	Terra rossa-rendzina	Terra bruna (non calcic brown)	Lithosol (eroded)	Lithosol	Terra bruna lessive
Unified	CH	CH -	GC			
Calif. series analogy	Permanente 3' deep	Permanente (none for rendzina)	Sehorn 3' deep	Lodo, or Millsholm 1' deep	Lodo	Josephine or Hugo 2'-3' deep
GEOLOGY:	Limestone	Limestone	Sandstone-Shale (Flysch)			Sandstone
Reference (Table)			(37)			

*Vegetation species abbreviations:

Ap - Abies pectinata
Ba - Barren-bare ground
Bs - Buxus sempervirens
Cb - Carpinus betulus
Fs - Fagus sylvatica
Gr - Misc. grasses and herbs
Jo - Juniperus oxycedrus
Pn - Pinus nigra
Qc - Quercus coccifera
Qp - Quercus pubescens
Qr - Quercus robur var. Sessiliflora

Table 46. Transect of Soil Vegetation Types Across the P ndus Mountains Following the Highway from Ioannina to Kalabaka via Metsovon Pass (continued)

LOCATION:						
F	Metsovon	Metsovon Pass		Koutsoufliani	Korydhallos	
D (km)	54	68 5,594' elev.		84		
VEGETATION:						
C.c.	4/GSC	Y0443/BSC	Y441/SC	5/G	1/Hy	5/G
S.t.	Gr Jo Pn	Ba Bs Pn Ap	Bs Pn	Gr	Qp	Gr
SOIL:						
C.	Terra bruna lessive, Gray brown podzol	Terra bruna or Brunizehm	Mediter-ranean red earth.	Terra bruna	Terra bruna Lessive	Non calcic brown
U.		GC	GC	CL	CL	
C.s.a.	Hulls - Sheetiron complex (some Poleber)	Weitchpec or Dubakella	Cornutt 4' deep	Comptche or Sobrante	Josephine 3' deep	Laughlin 3' deep
GEOLOGY:	Flysch with some metamorphism	Serpentine	Peridotite	Gabbro and Basalt	Sandstone	Shale
Reference (Table)		42 and 40	41	43		

Table 46. Transect of Soil Vegetation Types Across the Pindus Mountains Following the Highway from Ioannina to Kalabaka via Metsovon Pass (continued)

LOCATION:							
F			Trighona			Kalabaka (Meteora)	
D (km)			97			131	
VEGETATION:							
C.c.	5/G	3/BS	3/BS	5/G	5/G	4/BS-3/BS	1/S
S.t.	Gr	Ba Bs Jo	Ba Bs Jo	Gr	Gr	Ba Jo	Qc Qr
SOIL:							
C.	Brunizemic regosol	Lithosol	Brunizehm	Terra bruna	Non Calcic brown	Lithosol	Mediter-ranean red earth
U.	CH						MH
C.s.a.	Montara / 2' deep	Huse / 2' deep	Henneke / 2' deep	Goulding / 3' deep	Laughlin / 3' deep	Bunnell or Maymen / 1' deep	Sites / 4'-5' deep
GEOLOGY:	Serpentine	Peridotite	Serpentine	Greenstone (meta gabbro)	Sandstone	Conglomerate	
Reference (Table)	38		39				45

SEQUENCE ON SCHIST NEAR SPARTA

An elevation sequence on metamorphic rocks is offered by a wide range of elevations on which schist rock is found near Sparta. Semi-metamorphosed sedimentary rocks are found at low elevations about 20 km south of Sparta, and at higher elevations on the Taygetos Mountains near Artemesia (northwest of Sparta), and on the Parnon Mountains near Kosmas (east of Sparta). Two stages of the soil development sequence on schist are presented by the data in tables 47, 48, and 49. These data indicate some generalities which had appeared in this study in the investigations of the sequences in Italy. At the lower elevation there is a macchia-type vegetation (a degraded macchia with Erica arborea and Arbutus unedo) on a reddish clay soil, progressing to a coniferous forest vegetation at the upper elevations on a brown soil with less clay content. It was not possible to make an observation above timberline on schist rocks in this area because the mountains did not rise high enough.

Despite the long time human occupancy of this area, it was interesting to note that the same sequence of soils and vegetation occurred as would be expected from less disturbed areas. The sampling sites are all located in the countryside around ancient Sparta, and there have been records of some drastic changes in the vegetation very recently. For example, the area in the Parnon Mountains is said to have been burned over completely by the retreating Turks under Abrahem in 1821. The Abies cephalonica forest noted in the plot in table 49 has established itself since this burning. On the west slope of the Taygetos Mountains, there are brush fields of macchia which directly adjoin the conifer types. These are characterized by a cover class of 1/S and a species type of Quercus coccifera and Genista aspalathoides. These brushfields have the appearance of having been former

Table 47. Soil-Vegetation Plot XXIX.

LOCATION: Greece, Lakonia. Km. 23 south on road from Sparta to Gytheion.

Elevation: 300 meters
Precipitation: 600 mm
Slope: NW 30%

Physiography: Rolling foothills

VEGETATION

Cover class: $\frac{4}{G\ S}$

Species type: Dg, Au, Ga, Ea

Description:

Overstory: Species	Height	Abundance
Cistus albidus L.	1'	XX
Thymus vulgaris L.	6"	X
Arbutus unedo L. (Au)	2' (sprouts)	XX
Dactylis glomerata L. (Dg)	6"	XX
Pistacia lentiscus L.	2' (sprouts)	X
Genista aspalathoides L. (Ga)	2'	X
Erica arborea L. (Ea)	3"	X

Remarks: Erica arborea seeds in after fire as in this plot resulting in many seedlings 3" tall. The area was burned about 3 years previous to the date of observation. A sequence following fire can be judged from the local vegetation mosaic to be as follows:

Cover: Fire — $\frac{5}{G} \longrightarrow \frac{4}{G\ S} \longrightarrow \frac{3}{S\ G} \longrightarrow \frac{1}{S}$

Species types: Dactylis —— Dg & sprouts of shrubs Au, Ga ⟶ Ea, Au, Ga, Dg ⟶ shrub stage.
Ea, Au.

SOIL

Parent material: Schist (Oligocene)
Permeability: Rapid in surface soil/Impeded in subsoil
Surface drainage: Good
Ground water: None
Surface rockiness: 10%. Small rocks resulting from erosion pavement
Root distribution: Throughout profile. Larger shrubs -- Arbutus unedo & Pistacia lentiscus -- rooting into rock
Erosion: Moderate. Apparently a removal or inhibited formation of an A_1.

Table 47. Soil-Vegetation Plot XXIX., continued

Soil profile description:

Horizon	Depth (cm.)	Boundary	Color	Texture	Structure	Consistence	pH	Miscellaneous
1	0-10	abrupt-wavy	brown 10 YR 4/3	loam	2vfcr	dl	6.5	
2	10-25	abrupt-wavy	red-yellow 5 YR 6/4	clay loam	3mabk	dvh	6.0	Clay films on peds.
3	25-75	abrupt-irregular	red-yellow 5 YR 6/8	clay	3 mabk-cabk	dvh	5.5	

Schist rock.

Remarks: In places limestone road dust may raise surface pH of these soils to pH 7.5.

Classification:
International: Terra Bruna lessive (Mancini)
Unified Soil Classification: CL
California Soil Series Analogy: Josephine (m) or Sites (m)

Table 48. Soil-Vegetation Plot XXVI.

LOCATION: Greece, Lakonia. 1 km. north of Kosmas; east of Sparta, north of Gheraki.

Elevation:	1000 meters	Physiography:	Mountainous
Precipitation:	800 mm		
Slope:	SE 30%		

VEGETATION

Cover class:	Y11 / C	Species type:	Ac
		Site tree:	Ac 18" diameter BH; 60' tall; 60 years

Description:	Species	Height	Abundance
Overstory:	Abies cephalonica Lk. (Ac)	50'	XXX
Understory:	Acer creticum L.	15'	X
	Quercus coccifera L.	5'	X
	Rubus idaeus L.	6'	X
	Spartium junceum L.	2'	X
	Clematis vitalba L.	vine	X
	Pteris aquilina L.	2'	X
	Fragaria vesca L.	6"	X
	Gallium spp.	6"	X

Remarks: Most of the area was burned by retreating Turks under Abraham in 1821.

SOIL

Parent material:	Schists and meta sediments
Permeability:	Rapid in surface/Impeded in subsoil
Surface drainage:	Good
Ground water:	None
Surface rockiness:	Less than 1%
Root distribution:	Throughout profile

Table 48. Soil-Vegetation Plot XXVI., continued

Soil profile description:

Horizon	Depth (cm.)	Boundary	Color	Texture	Structure	Consistence	pH	Miscellaneous
1	0-10	diffuse-wavy	pale brown 10 YR 6/3	stony loam	1mcr	dl	7.0	
2	10-30	abrupt-irregular	pale brown 10 YR 6/3	clay loam	2sabk	dh	6.5	
3	30-60	abrupt-irregular	pale brown 10 YR 6/3	clay	2abk	dvh	6.5	

Parent rock.

Remarks: Some colluvial creep from adjacent limestone area.

Classification:
International: Gray Brown Podzolic (Storie & Weir); Terra Bruna lessive (Mancini)
Unified Soil Classification: GC
California Soil Series Analogy: Sheetiron Soil Series

Table 49. Soil-Vegetation Plot XXV.

LOCATION: Greece, Lakonia. 10 miles northeast of Artemesia on road branching north along crest of Taiygos Mountains from road between Sparta and Kalamata.

Elevation: 1600 meters
Precipitation: (40" estimate)
Slope: W 50%

Physiography: Mountainous

VEGETATION

Cover class $\frac{Y222}{CF}$

Species type: Pn, Pta

Description:	Species	Height	Abundance
Overstory:	*Pinus nigra* L. (Pn)	35'	XXX
	Pteris aquilina L. (Pta)	3'	XX
Understory:	*Pteris aquilina* L.	3'	XX
	Abies cephalonica Lk.	6"	X
	Gallium spp.	2"	X

Remarks: On this broad ridge there is a mosaic of vegetation types depending upon the stage in a succession of vegetation occurring with time since clearing on fire. This succession is: open field ⟶ Pta Pn ⟶ Ac . When fire burns the fir type the vegetation type is thrown back to the pine type as the pine reproduces well after fire.

SOIL

Parent material: Sericite schist
Permeability: Rapid in surface/Good in subsoil
Surface drainage: Good
Root distribution: Throughout soil and into rock
Erosion: Slight to none

Table 49. Soil-Vegetation Plot XXV., continued

Soil profile description:

Horizon	Depth (cm.)	Boundary	Color	Texture	Structure	Consistence	pH	Miscellaneous
1	0-10	diffuse-wavy	Brown 10Yr 5/3	stony loam	2fcr	dl	6.5	
2	10-30	abrupt-irregular	Yellowish brown 10 YR 5/4	stony loam	2mcr	dl	5.5 5.0	
Rock								

Soil classification:
International: Gray Brown Podzolic (Storie & Weir)
Unified Soil Classification: GM
California Soil Series Analogy: Sheetiron Soil Series

forested areas, now maintained by fire in a brush stage of vegetation. This is analogous to areas in California such as along the western slope of the southern Sierra, or the slopes of the San Gabriel - San Bernardino mountains where similar situations are maintained by fire kindled as a result of certain events such as lightning that have a natural probability of occurrence. Thus, the effect of man in a long settled area may duplicate the effects of nature where similar processes and similar periods of recurrence are involved. The recurrence interval of fire, when planned by graziers in the macchia around Sparta, is five years for Quercus coccifera macchia grazed by sheep, and ten years for Quercus coccifera macchia grazed by goats according to the district forester at Sparta.

There was a mosaic of types of soil and vegetation on the Schist rocks around Sparta, and they partly reflected the degree of development the soil would attain in the presence of a certain amount of normal erosion. This could be observed at several points north of Sparta on the road from Tripolis. For example, at km 54 on this road, there is a view east to a fairly steep west slo e on which occurred a soil that resembled the non-calcic brown soil of California called the Laughlin soil series -- 3' deep; and where the slopes were slightly less steep and the soil had apparently developed for a longer time. These had been cultivated to about a 20% crown density of olive trees (Olea europa). Where the slope became steeper still, with colluvial creep adjacent to small canyons, a shrub hardwood vegetation type (cover class 1/SHy) with a composition of Quercus coccifera, Pistacia lentiscus, Nerium oleander, and Quercus ilex occurred. On the upper slope of the hills an invading brush cover was crowding out sparse grass on what appeared to be a stony, eroded Laughlin as in the olive orchard. It was noteworthy that among the introduced trees on this soil complex on what is an arid hillside, the Cupressus sempervirens did very well, and it was planted along trails and around chapels.

A vegetation-type change associated with a change in geology and associated soils occurs near the summit of the Taygetos Mountains, on the road from Sparta to Kalamata. Limestone adjoins schist in the area just east of this summit. There is a forest cover of Abies cephalonica on a rendzina soil which forms on the limestone; and adjoining this on the schist rock is leached brown forest soil (terra bruna lessive) with a forest cover of Pinus nigra. The two rock types can be distinguished readily from either ground or aerial photo observation on the basis of these vegetation changes.

SEQUENCE ON LIMESTONE NEAR SPARTA

A large part of the Peloponnesian peninsula south and east of Sparta is limestone rock, and several observations of soil-vegetation types were made on this rock. These data are presented in tables 50 and 51. As a matter of interest, a soil-vegetation observation on limestone with a similar degree of soil development near Postumia in Yugoslavia is included in table 52.

This sequence near Sparta is of interest because it presents a well developed terra rossa stage on limestone at the lower elevations (0-800 meters) and a transition to the yellow brown Terra Gialla stage of Comel at the upper elevations (800-1200 meters), and above 1200 meters, a rendzina stage not sampled because of inaccessability. An interesting transition occurs in the terra rossa with increasing elevation and a correlated increase in vegetation cover and productivity. A browner colored surface (A) horizon tends to form over the distinctly red colored subsoil, extending to a greater depth as one ascends in elevation. This horizon is lacking between scattered shrubs of Quercus coccifera at the lower elevations, but tends to form under them. The implication is that any process which tends to decrease the density of the shrubs such as frequent fire, increasing aridity of climate, overgrazing, or harvest for fuelwood would tend to

Table 50. Soil-Vegetation Plot XXVIII.

LOCATION: Greece, Lakonia. Km. 21 on road from Sparta southeast to Geraki.

Elevation: 300 meters
Precipitation: 500 mm
Slope: NW 20%

Physiography: Rolling foothills

VEGETATION

Cover class: $\frac{1}{S}$

Species type: Qc, Pv, Pl, Ga, Au

Description:	Species	Height	Abundance
Overstory:	*Quercus coccifera* L. (Qc)	4'	XXX
	Phillyrea variabilis Timb. (Pv)	4'	XX
	Pistacia lentiscus L. (Pl)	4'	XX
	Geniste aspalathoides Lam. (Ga)	2'	XX
	Arbutus unedo L. (Au)	3'	X
	Cistus albidus L.	1'	X
Understory:	Minor annual herbs	6"	X

Remarks: Most of shrubs show signs of heavy browsing.

SOIL

Parent rock: Limestone
Permeability: Rapid in surface/Impeded in subsoil
Surface drainage: Good
Ground water: None
Surface rockiness: 15% surface
Root distribution: Throughout profile and into deep soil filled fissures
Erosion: Appears that an A_1 horizon may have been removed or its formation hindered by heavy browsing of vegetation.

Table 51. Soil-Vegetation Plot XXVIII., continued

Soil profile description:

Horizon	Depth (cm.)	Boundary	Color	Texture	Structure	Consistence	pH	Miscellaneous
1	0-25	diffuse-wavy	yellow-red 5 YR 4/8	clay loam	2fsabk	ds	7.5	
2	25-40	diffuse-irregular	red 2-5 YR 4/6	clay	3cabk	dh	6.5 7.8	
3	40-70	abrupt-irregular	dark red 2-5 YR 3/6	clay	3cpr	dvh	7.5	
	up to 130 cm.							

Parent limestone rock.

Remarks: Deep pockets of soil appear here to be on less resistant limestone.

Classification:
International: Terra Rossa
Unified Soil Classification: CH
California Soil Series Analogy: Permanente soil series, Tuolumne County, California

Table 51a. Soil-Vegetation Plot XXVII.

LOCATION: Greece, Lakonia. 2 km. south of Kosmas on road toward Gheraki. East of Sperta.

Elevation: 1000 meters
Precipitation: 700 mm
Slope: NW 40%

Physiography: Mountainous

VEGETATION

Cover class $\frac{\text{Ylli}}{\text{C}}$

Species type: Ac
Site tree: 8" DBH; 15' tall; 30 years

Description:	Species	Height	Abundance
Overstory:	*Abies cephalonica* Lk. (Ac)	15'	XXX
Understory:	*Rubus* spp.	1-3'	X

Remarks: Entire area said to have been burned by Abraham and the retreating Turks in 1821.

SOIL

Parent material: Limestone
Permeability: Rapid in surface/Good in subsoil
Surface drainage: Good
Ground water: None
Surface rockiness: 10%
Root distribution: Throughout profile

Table 51a. Soil-Vegetation Plot XXVII., continued

Soil profile description:

Horizon	Depth (cm.)	Boundary	Color	Texture	Structure	Consistence	pH	Miscellaneous
1	0-15	gradual-wavy	dark red-brown 5 YR 3/3	loam	1fcr	dl	7.8	
2	15-28	abrupt-irregular	red-brown 5 YR 4/4	loam	2fcr	dl	7.0	
3	28-49	gradual-irregular	yellow-red 5 YR 4/6	loam	2cr	df	7.8	
4	49-70	abrupt-irregular	yellow-red 5 YR 4/6	sandy loam	2fabk	df	6.5	

Limestone rock with fissures of varying depth.

Classification:
International: Terra Gialla (Comel); Terra Bruna (Mancini)
Unified Soil Classification: SM
California Soil Series Analogy: Tiger Soil Series, on limestone and dolomite outcrops in Shasta County.

Table 52. Soil-Vegetation Plot (XXX-A)

LOCATION: Yugoslavia, Slovenia. 6 Km. NW of Postumia at campground named "Camping Weekend".

Elevation:	600 meters	Physiography:	Limestone karst plateau
Precipitation:	2400 mm		
Slope:	East		

VEGETATION

Cover class:	Y211 / C Hy	Species type:	Ap, Pe, Fs
		Site tree:	*Abies pectinata*, 50' tall, 70 years

Description:	Species	Height	Abundance
Overstory:	*Abies pectinata* Lk. (Ap)	50'	XXX
	Picea excelsa Lk. (Pe)	50'	XX
	Fagus silvatica L. (Fs)	40'	XX
Understory:	*Smilacina* spp.	6"	XXX
	Geranium spp.	6"	XX
	Mosses		X
	Rocks on 40-50% of area		

SOIL

Parent material:	Limestone
Permeability:	Rapid in surface soil/Rapid in subsoil
Surface drainage:	Good
Ground water:	None
Surface rockiness:	40-50%
Root distribution:	Throughout
Erosion:	Little

Table 52. Soil-Vegetation Plot (XXX-A), continued

Soil profile description:

Horizon	Depth (cm.)	Boundary	Color	Texture	Structure	Consistence	pH	Miscellaneous
1 (A_1)	0-15	abrupt-wavy	10 YR 4/2	loam	2fcr	dl	6.5	70% rocks throughout profile
2	15-35	gradual-wavy	yellow-brown 10 YR 5/4	clay loam	2mabk	dfi	7.0	
3	35-80	gradual-irregular	strong brown 7-5 YR 5/6	clay	2mabk	dfi	7.5	
4	80-160+	abrupt-irregular	yellow-red 5 YR 4/6	clay	2mabk	dvfi	7.8	

Limestone parent material deeply fissured.

Remarks: Seams of clay deep in cracks of rock. Deeper fissures filled with soil.

Classification:
International: Terra Gialla (Comel); Terra Bruna lessive (Brown forest soil)
Unified Soil Classification: CH
California Soil Series Analogy:

accentuate the red appearance of the terra rossa; and that conversely with increasing density of vegetation, the brown A horizon would tend to form, and that this might be related to an opposite trend in the processes mentioned.

The sequence in vegetation from the macchia dominated by Quercus coccifera at lower elevations to the coniferous forest at the upper elevations is more gradual than is indicated by tables 50 and 51. Thus, between Geraki and Kosmas (East of Sparta) one ascends through the following vegetation sequence:

Elevation (meters)	300	500	1000
VEGETATION:			
Cover Class	3/BS	1/S	Y111/C
Species	Qc Pl Ga Jo	Qc Jp	Ac

Ac - Abies cephalonica
Ba - Bare ground
Ga - Genista aspalathoides
Jo - Juniperus oxycedrus
Jp - Juniperus phoenicea
Pl - Pistacia lentiscus

The macchia cover on the terra rossa phase of this sequence was consistent for a long distance across the countryside, changing mainly in degree of stocking, varying from 90% crown cover to less than 50% crown cover. Thus, following the same type to a point at km 51 on the road from Tripolis to Sparta, the shrub cover is Quercus coccifera - Phillyrea myrtifolius, Arbutus unedo on a 2 to 31 deep terra rossa. There were stringers of alluvial valleys through this rock type and these had oak savannah vegetation with 3-4/GHy cover classes. At places of geologic contact, the adjacent schist rocks would form islands in the limestone rock of deeper, less rocky soils, and generally would be cultivated while the adjacent terra rossa on the limestone was left under its brush cover.

Where the limestone was steeper, as it was up the east slope of the Taygetos Mountains, the sequence from terra rossa through terra gialla to rendzina was interrupted. At the base of the mountains north of Mystra there is a 2/SB to 3/BS vegetation cover of Quercus coccifera on a 2'-7' terra rossa. However, the mountains steepen rapidly to the west and the soil occurs only in limited patches between the rocks. Eventually, higher up on the north slopes, a rendzina with a few isolated Abies cephalonica occurs above 600 meters elevation. The rendzina stage extends to lower elevations on steeper colluvial slopes.

Northwest of Tripolis in Arcadia (north of Sparta) one finds a similar sequence on the same geologic type. From Vlakherna to Vytina on the north slopes, facing the highway, the following sequence with increasing elevation is apparent:

VEGETATION:					
Cover class	1-2/S or SB	1/Hy S	Y221/CHy	Y111/C	5/G
Species type	Qc Au with Ba	Qp Qc Fo	Ac Qp	Ac	Gr
SOIL:	Terra rossa		Terra gialla	Brown earth	Rendzina

Additional species not noted in previous examples are: Au, Arbutus unedo; Fo, Fraxinus ornus; Qp, Quercus pubescens.

Analogies to these sequences on limestone in California are incomplete, as explained for the sequence on Mt. Terminillo in Italy. In California it is possible to find the Terra Rossa stage near Sonora in Tuolumne County, but only minor areas of the other stages. However, the vegetation sequence from macchia through hardwood forest to coniferous forest with increasing elevation is typical of the western side of the southern Sierras, and in the San Gabriel, San Bernardino Mountains of California.

SEQUENCES ON GRANITE IN NORTHERN GREECE

A series of granitic areas forming high mountains in northern Greece along the Yugoslavian and Bulgarian borders offer the possibility of observing the change of vegetation and soil on these rocks. Two areas were found for such sequences; one from Chrysopighi to Lailias, north of Serrai (northeast of Thessaloniki), and the other from Florina toward the top of Pisoderi Pass west of Florina (near the Albania-Yugoslavian border). The observation data for soil-vegetation plots arrayed in order of increasing elevation are presented in tables 53-57, and a summary table of the pertinent properties of this sequence is presented in table 58.

The sequences on granitic areas and adjacent metamorphic rocks (gneisses and crystalline schists) indicate changes from red clay rich soils at lower elevations (below 800 meters) to dark grayish brown light textured and more stony soils at upper elevations (above 1500 meters). At lower elevations on this sequence, remnant areas of lower elevation vegetation indicate a scrub oak hardwood forest (Quercus pubescens, and Quercus robur var. sessiliflora) which has generally been cleared to grass. Widely scattered, heavily grazed remnant bushes of the previous oak forest are present. At higher elevation a zone of gray brown podzolic soils is reached (1000-1500 meters), and here the vegetation is either beech forest, or pine forest (Pinus sylvestris) with some intermixed beech trees. Above 1800 meters there occur high mountain pastures of miscellaneous herb s with scattered Juniperus communis. West of Florina this occurs above a very abrupt timberline of beech. Soils in this above timberline area are the organic-matter-rich ranker soils which are typical of most of the above timberline areas described earlier.

The California analogies to these soil vegetation types on granitic rocks and associated metamorphic rocks are to be found in the southern coast ranges and the southern Sierra Nevada. In the San Gabriel Mountains, and the San Bernardino Mountains of southern California are many areas where such metamorphic rocks as gneisses and schists are adjacent and interbedded with granites, and in these situations similar soil sequences are found related to increasing elevation.

Since soils on granitic materials are easily susceptible to erosion because of their usually coarse textured nature, it was noticed that there were some sequences of local vegetation change that occurred in this erosion process. Thus, where incipient gullies were forming by erosion in the grasslands, for exemple, at the location in the plot in table 54, a succession occurred with increasing severity of erosion as follows:

Degree of erosion:	Litte	Moderate	Severe
VEGETATION:			
Cover class	5/G	5/F	4/BS
Species type	Misc. herbs and grasses (table 54)	Pteris aqulina	Barren, Quercus coccifera

In a sense this represents the appearance at the surface of various soil media for plant growth, each degree of erosion representing the capacity of the successive soil horizon layer, appearing at the surface, to support cover in the presence of the climatic and grazing factors at the site. Thus the most severely eroded areas had a scattered cover of Quercus coccifera shrubs. A few scattered Juniperus oxycedrus also came in on these eroded areas. The presence of Pteris aquilina represents the appearance at the surface of the more acid subsoil which favors this fern, a point noted by Cato (Dickson[1]).

[1]Dickson, Adam. 1788. The Husbandry of the Ancients, Vol. 1, 527 pp. Robinson and Cadel, London.

The soil situations described here on granitic rocks extend northwestward into Yugoslavia and probably into Bulgaria, and can be expected to carry the same sequence of soils and vegetation on them with elevation change.

Table 53. Soil-Vegetation Plot XXXVII.

LOCATION: Greece, Macedonia, Florina. 1 Km. west of Florina on road west to Kastoria. On north side of road opposite old school building, in old quarry.

Elevation: 770 meters
Precipitation: 800 mm
Slope: S 30%

Physiography: Mountainous, on middle lower slope

VEGETATION

Cover class $\frac{5}{G}$

Species type: Gr

Description:

	Species	Height	Abundance
Overstory:	Chrysopogon gryllus L. (Gr)	6"	XXX
	Bromus squarrosus L. (Gr)	6"	X
	Plantago spp.	8"	X
	Brachypodium silvaticum (Gr)	6"	X
	Festuca megalura Nutt. (Gr)	6"	X
	Elymus caput-medusae L. (Gr)	6"	X
	Dianthus spp.	6"	X
	Mentha spp.	1'	X
	Trifolium angustifolium L.	6"	X
	Trifolium filiforme L.	5"	X
	Achillea tomentosa L.	8"	X
	Thymus spp.	6"	X
	Euphorbia spp.	1'	X
	Avena fatua L.	2'	X
	Melica ciliata L.		X
	Cynosurus echinatus L.		X
	Poterium sangui sorba L.		X
	Koeleria cristata Pess.		X
	Lolium perenne L.		X

Remarks: A vegetation type which appears to be a disturbance phase on a soil which previously had supported hardwood vegetation. The following seems to be the sequence of vegetation cover classes, with increasing degree of disturbance and intensity of use:

$\frac{1}{Ho}$ or $\frac{1}{Hy} \longrightarrow \frac{1}{S} \longrightarrow \frac{5}{Gr} \longrightarrow \frac{5}{B}$ (Quercus sessiliflora ⟶ Chrysopogon gryllus ⟶ Bare ground)

Table 53. Soil-Vegetation Plot XXXVII., continued

SOIL

Parent material: Micaceous schist
Permeability: Rapid in surface/Impeded in subsoil
Surface Drainage: Good
Ground water: None
Surface rockiness: <1% in surface
Root distribution: In horizons 1, 2, 3, but not in 4, below 51 cm.
Erosion: Slight on the profile, but much in area. Mainly removal of portions of A horizon.
Soil profile description:

Horizon	Depth (cm.)	Boundary	Color	Texture	Structure	Consistence	pH	Miscellaneous
1	0-10	gradual-irregular	yellowish brown 10 YR 5/4	loam	1fcr	dl	6.5	
2	10-23	abrupt-wavy	red yellow 7-5 YR 6/6	gritty loam	2msabk	dfi	6.0	
3	23-51	gradual-wavy	yellowish red 7-5 YR 5/8	gritty clay loam	3mabk	dvfi	5.5	
4	51-64	abrupt-irregular	yellow-red 7-5 YR 5/8	gritty clay	3mpl to abk	dvfi	6.0	

Abrupt transition to micaceous schist.

Classification:
International: Mediterranean red earth (Kubiena)
Unified Soil Classification: MH
California Soil Series Analogy: Sites (m)

Table 54. Soil-Vegetation Plot XXXI.

LOCATION: Greece, Makedhonia; Serrai. Road north of Serrai from Chrysopighi to Lailias, about 200 meters north of Km. 17.

Elevation: 1000 meters
Precipitation: 1000 mm
Aspect: W 30%
Physiography: Mountainous

VEGETATION

Cover type: 5/G
Species type: Gr

Description:	Species	Height	Abundance
Overstory:	*Festuca ligustica* Bertol.	3'	XXX
	Phleum spp.	1'	XXX
	Trifolium scabrum L.	6"	X
	Euphorbia spp.	6"	XX
	Borago officinalis L.	8"	X
	Chrysopogon gryllus Trin.	3'	X
	Astragalus spp.	1'	X
	Trifolium agrarium L.		X
	Plantago spp.	6"	X
	Achillea spp.	6"	X
	Elymus arenarius L.	8"	X

SOIL

Parent material: Granite, Gneiss with Aplite Dykes
Permeability: Rapid in surface/Rapid in subsoil
Surface drainage: Good
Ground water: None
Surface rockiness: 5% -- scattered
Root distribution: Mainly in upper 50 cm. of profile
Erosion: Appears to have about 6-8" of surface horizon missing

Table 54. Soil-Vegetation Plot XXXI., continued

Soil profile description:

Horizon	Depth (cm.)	Boundary	Color	Texture	Structure	Consistence	pH	Miscellaneous
1 (A_2)	0-12	gradual-wavy	pale brown 10 YR 6/3	loam	1fcr	dfi	6.0	
2 (A_3)	12-22	gradual-wavy	pale brown 10 YR 6/3	loam	2fcr	dvfi	6.0	
3 (A/C)	22-36		light yellow-brown 10 YR 6/4	stony loam	2fsabk	dvfi	5.5	
4 (C)	36-54	abrupt-irregular	light yellow-brown 10 YR 6/4	sandy loam	0	dvfi	6.0	

Rock beyond 54 cm.

Remarks: Along 100' of road cut this is a profile that is variable depending on whether Aplite dykes, veins of biotite granite or schist-gneiss rocks appear. The main variation is in the presence or absence of the light yellowish-brown horizons of 3 and 4, with the pale brown color extending clear to the rock.

Classification:
International: Brown Forest Soil. Terra Bruna (Mancini)
Unified Soil Classification: GM
California Soil Series Analogy: Similar to the soils on San Gabriel Metamorphics mapped as B or C having a moderate to low degree of development (Soil Survey, San Dimas Experimental Forest, U.S. Forest Service, Glendora, California)

Table 55. Soil-Vegetation Plot XXXV.

LOCATION: Greece, Macedonia, Florina. Florina--Pisoderi road, 11 Km. northwest of Florina.

Elevation: 1000 meters
Precipitation: 1200 mm
Slope: S 40%

Physiography: Mountainous

VEGETATION

Cover class: $\frac{1}{Hy}$

Species type: Qs, Fs

Description:	Species	Height	Abundance
Overstory:	Quercus robur var. sessiliflora salisb. (Qs)	20'	XXX
	Fagus silvatica L. (Fs)		XX
Understory:	Pteris aquilina L.	18"	XX
	†Brachypodium sylvaticum P.B.	12"	X
	†Festuca heterophylla Lam.	1'	X
	Anthoxanthum odoratum L.	6"	X
	oTrifolium montanum L.	6"	X
	Vicia spp.	6"	X
	Gallium spp.	6"	X
	Euphorbia spp.	6"	X
	Trifolium arvense L.	6"	X
	Dactylis glomerata L.	2'	X
	Rubus idaeus L.		X
	Coronilla spp.	6"	X
	Lathyrus silvestrus L.	6"	X
	Dorycnium spp.		X
	Trifolium repens L.		X
	*Lotus corniculitus L.		X

† Follows oak
o Follows beech
* Edges and bare soils

Table 55. Soil-Vegetation Plot XXXV., continued

SOIL

Parent rock: Granite
Permeability: Rapid in surface/Rapid in subsoil
Surface drainage: Good
Ground water: None
Surface rockiness: None
Root distribution: Throughout profile
Erosion: Reduction in depth of A horizon
Soil profile description:

Horizon	Depth (cm.)	Boundary	Color	Texture	Structure	Consistence	pH	Miscellaneous
1	0-3	abrupt-irregular	brown 10 YR 5/3	loam	1fcr	ms	6.0	
2	3-10	gradual-wavy	pale brown 10 YR 6/3	loam	1mcr	ms	5.2	
3	10-25	gradual-wavy	light yellow-brown 10 YR 6/4	loam	2msabk	mfi	5.5	
4	25-40	abrupt-irregular	light yellow-brown 10 YR 6/4	sandy loam	1fsabk	mfi	5.5	
5 (Dr)	40-68	gradual-wavy	light yellow-brown 10 YR 6/4	loamy sand	0	mfi	5.5	Decomposed granite

Granite parent rock.

Classification:
International: Gray brown podzolic (Storie & Weir); Terra Bruna lessive (Mancini)
Unified Soil Classification: GM
California Soil Series Analogy: Shaver Soil Series

Table 56. Soil-Vegetation Plot XXX.

LOCATION: Greece, Macedonia, Serrai. At summit of pass on forest road north of Serrai from Chrysopighi to Lailias.

Elevation: 1600 meters
Precipitation: 1100 mm
Slope: W 10%

Physiography: Mountainous

VEGETATION

Cover class: YO 322 / C G

Species type: Ps, Gr

Description:	Species	Height	Abundance
Overstory:	Pinus sylvestris L. (Ps)	20'	XXX
	Sorbus aucuparia L.	6'	X
	Juniperus communis L.	2'	XX
	Hypericum perfoliatum L.	1-1/2'	X
	Mysotis spp.		X
	Quercus robur var. sessiliflora Salisb.	3'	X
	Hypericum crispum L.		X
	Viola spp.	6"	X
	Vaccinium myrtillus L.	1'	X
	Euphorbia amygdaloides L.	2'	X
	Lotus ornithopodioides L.	6"	X
Understory:	Poa violacea Bell.	6-12"	XX
	Fagus silvatica L.	3'	X
	Phleum pratense L.	1'	X
	Lamium garganicum L.	1'	X
	Gallium spp.	6"	X
	Verbascum spp.	6"	X
	Potentilla alba L.	3"	X
	Rumex acetosella L.	6"	X
	Juniperus oxycedrus L.	1'	X

Remarks: Poa and Festuca are dominant grasses in opening. Dense clumps of Vaccinium myrtifolius occur under the pines.

Table 56. Soil-Vegetation Plot XXX., continued

SOIL

Parent material: Granite
Permeability: Rapid in surface/Rapid in subsoil
Surface drainage: Good
Ground water: None
Surface rockiness: None
Root distribution: Throughout
Er sion: None -- slight
Soil profile description:

Horizon	Depth (cm.)	Boundary	Color	Texture	Structure	Consistence	pH	Miscellaneous
A_{00}	4	abrupt-irregular			0	loose		Pine leaf litter
1	0-10	abrupt-irregular	very dark gray-brown 2-5 Y 3/2	loam	1fcr	ml	5.0	Many fine roots
2	10-40	gradual-wavy	very dark gray-brown 2-5 Y 3/2	loam	2fcr	mfi	5.0	Coarse roots 1-5 mm
3	40-65	abrupt-irregular	very dark gray-brown 2-5 Y 3/2	gritty loam	2fcr	mfi	4.5	

Slightly weathered granite.

Classification:
International: Gray Brown Podzolic (Storie & Weir)
Unified Soil Classification: GM -- 0 GM
California Soil Series Analogy: Shaver Soil Series

Table 57. Soil-Vegetation Plot XXXVI.

LOCATION: Greece, Macedonia, Florina. 3 Km. north of Pass near Piso deri on forest road leading toward Yugoslavia. (Area frequently invaded by Albanian partisans.)

Elevation: 1800 meters
Precipitation: 1500 mm
Slope: W 50%

Physiography: Mountainous

VEGETATION

Cover class: $\frac{3}{GS}$

Species type: Gr, Jc

Description:

Overstory: Species	Height	Abundance
Festuca rubra L.	1'	XXX
Festuca ovina L.	6"	X
Anthoxanthum odoratum L.		X
Phleum pratense L.		X
Alopecorus pratensis L.		X
Thymus serpyllum L.		XX
Hieracium villosum L.		X
Primula officinalis Hill.	6"	X
Helian themum spp.	6"	X
Lotus corniculatus L.		X
Cardus spp.	6"	X
*Juniperus communis L.		XX
Hypericum perfoliatum L.		X
Viola spp.		X
Trifolium repens L.		X
Achillea millefolium L.		X
Verbascum spp.		X
Rumex acetosella L.		X

*Too coarse for sheep therefore high density.

Deteriorated area just above timberline about 100 meters above timberline.

Table 57. Soil-Vegetation Plot XXXVI., continued

SOIL

Parent rock: Sedimentary rocks and meta sediments
Permeability: Rapid in surface/Rapid in subsoil
Surface drainage: Good
Ground water: None
Surface rockiness: 20%
Root distribution: Throughout profile
Erosion: Spotty, between shrubs of *Juniperus*
Soil profile description:

Horizon	Depth (cm.)	Boundary	Color	Texture	Structure	Consistence	pH	Miscellaneous
1 (A_1)	0-20	gradual-irregular	very dark grayish-brown 10 YR 3/2	organic loam	1fcr	ml	6.0	6.2 under nearby *Juniperus*
2 (A_3)	20-43	abrupt-irregular	dark grayish brown 10 YR 4/2	organic loam	2mcr	mfi	5.0	
3 (C)	43-85	abrupt-irregular	light yellowish-brown 10 YR 6/4	stony sandy loam	1mcr	mfi	5.0	

Classification:
International: Ranker (Kubiena)
Unified Soil Classification: OL
California Soil Series Analogy: Wilder or Cahto Soil Series

Table 58. Summary of Sequences of Soil-Vegetation on Acid Igneous Rock in Northern Greece

ELEVATION:	770	1000	1000	1600	1800
VEGETATION:					
Cover class	5/G	5/G	1/Hy	YO322/CG	3/GS
Classification	Scrub oak woodland cleared to grass	Scrub oak woodland cleared to grass	Beech Forest Qs, Fs	Ps Gr	G# Jc
SOIL:					
Properties of subsoil:					
Color	Yellowish red	Yellowish brown	Brown	Dark grayish brown	Dark grayish brown - Light yellow brown
Texture	Clay loam - clay	Stony loam	Sandy loam	Gritty loam	Stony sandy loam
PM	5.5	5.5	5.5	4.5	5.0
Classification	Med. red earth	Brown forest soil	Gray brown podzolic	Gray brown podzolic	Ranker
Unified	MH	GM	GM	GM - OGM	OL
California analogy	Sites (r)	San Gabriel Metamorphic L.A. County, Soil B-C*	Shaver	Shaver	Wilder, Cahto or Sheridan
GEOLOGY:	Gneiss and schist	and Gneiss - granite with Aplite dykes	Granite	Granite	Metamorphic gneiss, etc.

*Survey - San Dimas Experimental Forest -- Pacific Southwest Forest and Range Experiment Station.

SEQUENCE ON SCHIST ON MT. OLYMPOS

Mt. Olympos in north central Greece, although capped by limestone, has most of its western and southern slopes covered by Schist rocks and thus allows the examination of an elevation sequence of soils and vegetation on metamorphic rocks. Observations were made as recorded on tables 59 to 62, beginning with a lower elevation point near the upper end of the Tempi Gorge, and a high elevation point on the road to the Hellenic Alpine Club hut on the south slope of Mt. Olympos. This sequence, as has the others, began at its lower elevations with a Mediterranean red earth (Kubiena) and at successively higher elevations the soil became browner in hue with the addition of a dark A horizon at the highest elevation site. The soil at the lower elevations was a clay (MH) and became sandy loam (GW) with increasing elevation. There was a successive decrease in pH of the subsoil at higher elevations, indicating more leaching of the bases, probably due to higher rainfall. The lower elevation vegetation was a macchia of Quercus coccifera and the successively higher elevation sites were vegetated with grass apparently resulting from the clearing of oak woodland. That these grasslands had previously been woodland was evidenced by the presence of charcoal and burned red areas in the subsoils. Some of these plots were in areas that had been subject to heavy grazing pressure, partly because of being on migration routes, as in the case of the observation points presented in tables 60 and 61. (These also happened to be on the invasion route of Xerxes' Persian Army in 480 BC.)

The California analogy to this sequence on schist can be found in the northern coast ranges in eastern Humboldt, eastern Mendocino and northern Lake counties. A good example is the sequence in soils on the south side of Hulls Peak in the Mendocino National Forest. However, the vegetation is different in that on Mt. Olympos, particularly at the middle elevations, the oak woodland has been cleared to give open grasslands.

SOME SOIL VEGETATION TYPES OF THE TERTIARY ROCKS OF GREECE AND CALIFORNIA ANALOGIES

A large area of Greece, exclusive of the agricultural valleys and the mountainous areas, is composed of rolling hills and elevated terraces, dissected occasionally into small steep ravines and terrace breaks. These are based on extensive areas of Tertiary deposits (Geology map of Greece 1954). Large areas of these deposits occur as a margin around the Peloponnesian peninsula, in Attica near Tanagra, in the valley near Platea and Thebes, on the rolling plains of Thessaly south of Larissa, the broad valley of the upper Haliakman River south of Kastoria, the rolling hills northwest of Katerini, and similar areas, both northwest and southeast of Thessaloniki. These widespread areas have a soil vegetation landscape conditioned by the original nature of the deposit (whether sandy or heavy clay), by the climate of these lower elevations at which they occur, by the topography brought about by the type and degree of erosion, and by the use which man has made of them, such as rangeland and cropland.

Where these deposits are clay rich, they give rise to heavy clay soils and have an open grassland (cover class 5/G), or a savannah (cover class 4/GHy or Ho) with widely scattered oaks (Quercus trojana) or Pears (Pirus amygdaliformis). The Quercus trojana are particularly noteworthy on the plain south of Patras, and the Pirus on the rolling elevated terrain north and west of Katerini. The California landscape analogy for these areas are the sparse oak savannahs of the Sacramento-San Joaquin valleys on weakly consolidated alluvial deposits of Tertiary and more recent age. In Greece where the topography is not steep, these soils have been transformed into grain fields as, for example, in the south of Thessaly, and south of Kastoria, or northwest of Thessaloniki. The heavy clay content of the parent rock seems to arrest the development of these soils so they do not attain the red colors and profile differentiation that are typical of the soils at the lower elevations of the sequences previously described on the harder rocks. Where more calcium is present in the parent material, the soils may develop a carbonate rich horizon in the subsoil as in the soils in the vicinity of Pella, which have the appearance of dry rendzinas or Sierozems (Xerorendzina of Kubiena) such as the Linne or Zaca soil series of California. Where the topography is brought into sharper relief by dissection of these rolling plains by erosion, woody vegetation occupies the steep slopes of the ravines. This vegetation is of macchia or the softer sage-like Garige type. The counterparts of these are also found in California, where the steeper slopes, brought about by erosion of the savannah and grassland covered Tertiary and more recent deposits, will be covered with chaparral or with a soft sage-type of vegetation.

Some of the Tertiary deposits are more sandy and have less clay. For example, those in the vicinity of Olympia or near Sparta. These also tend to have more woody vegetation. Thus, there may be macchia of Oleander (Nerium oleander, Cytisus and Cistus), as around Sparta, or a macchia with Pinus halepensis, as in the vicinity of Olympia. Again, the woody vegetation is much more prevalent on the steeper slope breaks brought about by the erosion, while the less steep upper surfaces are cultivated. Erosion from these deposits is often very severe. An example is seen at the sanctuary of Olympia, where the river is depositing sediment from such erosion. In the past 1500 years, since the cessation of the Roman sponsorship of the Olympic Games, the buildings have been buried in from 20' to 30' of fine silt loam and sandy loam sediments. A deposition rate similar to that occurs in some California coast range areas, such as at Bull Creek Flat, Humboldt County. Comparable analogies to these conditions exist in California, where the most erodible soils in the state are such soils as the Elkhorn soil series of the coastal terrace deposits north of Watsonville, or the Las Flores and Carlsbad soil series of the terrace deposits north of San Diego. On these deposits between Watsonville and Salinas in Monterey County, where the slopes are not so steep, there is an open oak savannah, the Quercus agrifolia, playing the role of the Quercus trojana north of Olympia. In the analogy mentioned just north of San Diego, the natural vegetation on the slightly eroded areas is a chaparral (macchia) with a sparse stand of Torrey pines (Pinus torreyi). These Torrey pines occupy a niche similar to that occupied by Pinus halepensis on the terrace breaks in the Peloponnesos. It is interesting to note that southwest of Taranto, toward Calabria, the Pinus halepensis also occupies similar sites on terrace deposits. The development of the soils on these sandier terrace materials tends to go further toward the typical red soil development of these elevations, as found on the other harder parent rocks studied earlier. Thus, in the vicinity of the town of Sparta, the soil has the typical reddish-brown subsoil color on the Tertiary deposits. It is interesting to note that at the Acropolis of Sparta, where this soil had been disturbed in the building of the Acropolis and the subsequent Roman buildings, the soil has had time, since the abandonment, to form a light brown A horizon about one foot deep over the reddish brown B horizon. Supposedly this is related to the influence of annual grasses and olive tree leaf litter on the soil since that time. In the Eurota River Valley near Sparta, the flatter surfaces of these deposits were covered with olive orchards, but the steeper and eroding slopes were covered with a sparse oleander macchia, characterized by species of Genista, Spartium and by Nerium oleander. Where recently disturbed, such soils are invaded by various composites and soft sage-type species, such as Thymus, and Genista aspalathoides, as is seen, for example, at the recently excavated monument for Helen of Troy and King Menelaos. In California the analogies for these areas around Sparta are the

Table 59. Soil-Vegetation Plot XXXIV.

LOCATION: Greece, Thessaly, Larisa. Alongside motorway north of Larisa at the entrance to the Tempi river gorge, 500 meters west of motorway toll station, near railroad bridge over Tempi. Located in large borrow pit just east of highway.

Elevation: 50 meters
Precipitation: 600 mm
Slope: W 20%

Physiography: Lower mountain slopes

VEGETATION

Cover class: $\frac{3}{GS}$

Species type: Gr, Qc

Description:

Overstory: Species	Height	Abundance
Quercus coccifera L. (Qc)	3'	XXX
Cistus salvifolius L.	6"	XX
Cratcagus spp.	3'	X
Agriada (grass)	2"	X
Phyllirea variabilis var. *media* L.	1'	X
Paliurus australis Gaertn.	3'	X
Asparagus officinalis L.	1'	X

Remarks: A chaparral type of vegetation thinned down by grazing use with a light stand of annual herbs and grasses between the heavily browsed shrubs.

SOIL

Parent material: Schist
Permeability: Rapid in surface/Impeded in subsoil
Surface drainage: Good
Surface rockiness: None
Root distribution: Throughout and into loose rock
Erosion: Slight

Table 59. Soil-Vegetation Plot XXXIV., continued

Soil profile description:

Horizon	Depth (cm.)	Boundary	Color	Texture	Structure	Consistence	pH	Miscellaneous
1	0-11	gradual-wavy	yellow brown 10 YR 5/4	loam	1fpl	dh	7.5	5% rock
2	11-27	gradual-wavy	brown--dark brown 7-5 YR 4/4	loam	1fsabk	dh	6.5	5% rock
3	27-35	abrupt-wavy	red brown 5 YR 4/4	clay loam	2fsabk	dh	6.5	30% rock
4	35-59	abrupt-irregular	dark red-brown 2-5 YR 3/4	clay	3cabk	dh	6.0	30% rock

Schist rock

Classification:
International: Mediterranean red earth (Kubiena)
Unified Soil Classification: MH
California Soil Series Analogy: Sites (m)

Table 60. Soil-Vegetation Plost XXXII.

LOCATION: Greece, Thessaly, Larissa. Summit of road Katerini to Elyssona. Located on summit ridge forming boundary between Thessaloniki and Thessaly.

Elevation: 1000 meters
Precipitation: 1200 mm
Slope: E 30%

Physiography: Mountainous

VEGETATION

Cover class: 5/G

Species type: Gr

Description:

Overstory: Species	Height	Abundance
Rumex acetosella L.	6"	XXX
Festuca rubra L.	6"	XX
Cynosurus echinatus L.	6"	X
Phleum pratense L.	1'	X
Plantago spp.	8"	X
Elymus spp.	8"	XX
Achillea millefolium L.	8"	XX
Potentilla spp.		X
Trifolium hirtum All.	3"	X
Trifolium echinatum M.B.	3"	X
*Poterium spinosum L.	3'	X
*Quercus coccifera L.	3'	X
Mentha spp.		X
Koeleria cristata Pers.		X
*Juniperus oxycedrus L.	2'	X

and also present in minor amounts: Dianthus, Airia spp., Chrysopogon gryllus, Aegilops spp., Andropogon ischaemum, Agrostis spp.

* On eroded portions of area.

Remarks: Protected against grazing for two years and the present vegetation is in a state of change following this change.

Table 60. Soil-Vegetation Plot XXXII., continued

SOIL

Parent material: Schist
Permeability: Rapid in surface/Rapid in subsoil
Surface drainage: Rapid
Ground water: None
Surface rockiness: Less then 5%
Root distribution: Throughout profile. Forms a dense root mat in upper 10 cm. of soil
Soil profile description:

Horizon	Depth (cm.)	Boundary	Color	Texture	Structure	Consistence	pH	Miscellaneous
1	0-6	gradual-wavy	10 YR 5/3	sandy loam	2fsabk	dl	6.0	20% rock
2	6-27	abrupt-irregular	10 YR 5/3	sandy loam	2fcr	dh	5.5	50% rock

Schistose rock

Classification:
International: Ranker (Kubiena)
Unified Soil Classification: GW
California Soil Series Analogy: Hulls Soil Series

Table 61. Soil-Vegetation Plot (XXXIII-A).

LOCATION: Greece, Thessalia, Larisa. 5 Km. north of Elasson on road.

Elevation: 600 meters
Precipitation: 700 mm
Slope: NE 15%

Physiography: Rolling hills

VEGETATION

Cover class: 5/RG

Species type: Rocks -- Plantago, Chrysopogon

Description:

Overstory: Species	Height	Abundance
Plantago	6"	
Chrysopogon gryllus L.	6"	XX
Quercus coccifera L.	8"	X
Rock and bare ground on 60-70% of area		X

Remarks: This represents a vegetation that is severely deteriorated by being along an old livestock trail between Macedonia and the south.

SOIL

Parent rock: Schist
Permeability: Rapid in surface/Rapid in subsoil
Surface drainage: Rapid
Ground water: None
Surface rockiness: 40-100%
Root distribution: Throughout profile
Erosion: Entire landscape severely eroded

Table 61. Soil-Vegetation Plot (XXXIII-A), continued

Soil profile description:

Horizon	Depth (cm.)	Boundary	Color	Texture	Structure	Consistence	pH	Miscellaneous
1	0-20	abrupt-irregular	10 YR 5/3	sandy loam	0	dvfi	6.0 5.5	0-5 cm. 5-20 cm.

Schist rock

Remarks: Strongly eroded area.

Classification:
International: Lithosol
Unified Soil Classification: GW (very shallow)
California Soil Series Analogy: Maymen (m)

Table 62. Soil Vegetation Plot XXXIII.

LOCATION: Greece, Thessaly, Larisa. Located on road to Alpine Hostel on south slope of Mt. Olympos, at contact between schist rock and the limestone rock of the upper slopes.

Elevation: 1800 meters | Physiography: Mountainous
Precipitation:
Slope: E 40-50%

VEGETATION

Cover class: 5/G | Species type: Miscellaneous grasses and herbs

Description:
Overstory: A sod of grasses and herbs.

Remarks: This vegetation type, although presently a grassland, was previously in weedy vegetation as evidenced by charcoal in the subsoil.

SOIL

Parent rock:	Schist
Permeability:	Rapid in surface/Rapid in subsoil
Surface drainage:	Good
Ground water:	None
Surface rockiness:	Only a few surface rock outcrops
Root distribution:	Throughout profile
Erosion:	None recently

Table 62. Soil-Vegetation Plot XXXIII., continued

Soil profile description:

Horizon	Depth (cm.)	Boundary	Color	Texture	Structure	Consistence	pH	Miscellaneous
1 (A)	0-24	gradual-wavy	10 YR 4/2	loam	1fcr	mfi	5.2	5% rock
2 (C)	24-37	abrupt-irregular	10 YR 5/3	stony sandy loam	1fcr	mfi	5.2	50% rock

Schist rock fractured and weathered.

Remarks: The C horizon rocks show signs of previous fire effects in that there are reddened rocks in this portion of the profile.

Classification:
International: Ranker (Kubiena)
Unified Soil Classification: GW
California Soil Series Analogy: Kneeland Soil Series

coastal terraces north of Santa Monica, and corresponding terraces extending eastward along the base of the San Gabriel and the San Bernardino Mountains with the Ramona soil series. The upper surfaces of these are also cultivated, but the eroded breaks and ravines are covered with a woody vegetation dominated by Rhus laurina (a good species analogy of Nerium oleander) with other chaparral species such as Quercus dumosa and Adenostoma fasiculatum. Where the surface is recently disturbed, these are also initially invaded by a Garige-like sage vegetation of various salvia species.

This description of some of the soil-vegetation types occurring on the Tertiary deposits of Greece is not comprehensive. There is interbedding of many types of rocks and deposits in them, thus presenting much local complexity that can only be described by more detailed soil surveys. Some of these are now available as in the footnote references[1].

THE LOCAL MOSAIC OF SOIL VEGETATION TYPES IN ITALY AND GREECE

As is true of California, the general sequences of soil and vegetation change which occur with elevation on the various rock types form the warp and woof of the landscape over which is laid the local pattern or mosaic of varying soil vegetation types related to local variables. For the soil mosaic, such variables as steepness of slope and the resulting equilibrium amount of soil development attained in relation to this steepness; the pattern of local variability of geologic rock types and the degree of soil weathering attained by each rock type in the local context of climate and vegetation; the length of time the surface has existed relatively undisturbed,

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[1]Zvorykin, I. A. and P. J. Saul. 1948. Soil Map of Attica, 1/100,000. 1 sheet.

Zvorykin, I. A. and G. R. Stogiannis. 1958. Soil Map of Peloponnesus, 1/300,000. 1 sheet.

the degree of geologic changes in topography, such as uplifts in areas of block faulting; changes in elevation of the base level of stream erosion such as result from changes in sea level, or other local drainage features; the local pattern change between north and south slopes; the pattern of exposure of the dip and strike of the rocks, especially in the case of layered sedimentary rocks or interbedded volcanic rocks; the pattern of locations of the processes of erosion and of deposition -- (both colluvial or alluvial); the local occurrence of springs and seep areas; are all variables related to the local mosaic of soil types. These all contribute to making the soil landscape much more complex than just the elevation sequences which have been described; however, once the underlying foundation of the general sequences has been determined, it becomes far easier to understand the landscape and to predict what one might expect.

An example of a general pattern that was found to exist in the local mosaic of soil types over broad areas of elevation change on mountain slopes in most areas studied is shown in figures 8 and 9. Thus, in an area where the rock types are consistent, following a broad but not too steep a ridge with a western exposure from sea level to a ridge top at about 2500 meters, one will progress from Mediterranean red earths to brown soils (Terra bruna and Terra bruna lessive) through ranker soils to talus and finally rock if the ridge is high enough. Assuming that torrents bound this ridge to the north and the south, the soil types will extend high on the south slopes, and lower on the north slopes and will tend to be shallower on the south slopes and deeper on the north slopes. The entrenchment of the torrent into the mountain slope will result in an extension of colluvial soils down along the lower north slope exposures, and of lithosols along the lower south exposures. At the lower end of the torrent a deposit of recent alluvium will contain immature grey soils, while successively older deposits left stranded as terraces will be successively brown to red in color at the lower elevations.

Associated with such mosaics of soil types will be similar mosaics of vegetation types. For example, following the ridge top mentioned in the previous paragraph, there will be normal elevation sequence of vegetation types beginning with olive and oak woodlands associated with the red earths, scrub oak forests (of Quercus cerris and Q. pubescens) associated with the lower elevation brown soils (Terra bruna), and Beech forests, pine forests and fir forests associated with the leached brown earths (gray-brown podzols or Terra bruna lessive), and finally scrubby beech forests with the lower ranker soils, and alpine pastures with the upper ranker soils. Colluvial areas will tend to be colonized by Holly leaf oak forests (Quercus ilex), and the lithosols will be colonized by macchia. Recently eroding areas at lower elevations or areas of recent deposition will tend to have Garige (Gariga) type vegetation (sage-like), with the subsequent successional sequences as soil development proceeds back to the vegetation type associated with the older soil of the elevation zone. Generally, clearing utilization for agricultural purposes in the red soil zone was used as olive orchards; in the lower brown soil zone as grain crops, and as pasture with vineyards in both of the latter types. In the upper brown soil zone as chestnut orchards or hazelnut orchards, and in the high zone as high mountain pasture, with management of the forest zone in the brown soil belt as the existing beech fir or pine forests, or as fuel wood coppice in the scrub oak forest zone and some of the macchia, with goat pasture in the lower macchia. These various elements distributed on the landscape give the typical Mediterranean soil vegetation landscape. The analogies for California are similar if one substitutes for the Italian and Green community names the California analogies mentioned earlier in this paper.

The example mentioned in the above paragraphs dealt with a situation that was simplified by keeping the rock type constant. However, as was obvious in the transect in the Alpi Apuane, or across the Pindus Mountains, this is not always the case. As a result, to examine the local variation of soil vegetation types in a relatively complex area, a cooperative effort was carried out with Dott. Piero Piussi of the Institute of Applied Geology of the University of Florence, with the support of Professors A. de Philippis and F. Mancini of the Facolta di Scienze Agrarie e Forestali of the Universita degli Studi, Firenze.

The area chosen for the study was in the Colline Metalliferae, forming the southwest quarter of the Siena quadrangle (Fo 120, 1/100,000 series of the topographic map of Italy, Istituto geografico Militare). In this area the general geologic background was of eocene sedimentary rocks (sandstone and shale) with a terra bruna stage of development and a Quercus cerris, Quercus pubescens woodland vegetation. The local soil vegetation mosaic was then developed into this general background by variations in degree of erosion related to slope; by the occurrence of several other geologic types interbedded through the area, such as Mesozoic dolomites and Mesozoic congomerate (called Verrucano); and by a history of land use for agriculture and subsequent abandonment of many fields to invading vegetation, and current utilization of the forest for fuel and timber. The major background type was the Quercus cerris - Quercus pubescens woodland. The species composition for the types was fairly consistent over the landscape. The main vegetation soil types in the area were as follows:

Vegetation Species Type	Soil Type (California Analogy)	Geology
Quercus cerris, Erica scoparia understory	Chiusdino clay loam (Sutherland series)	Verrucano and sandstone
Quercus ilex, Quercus cerris	Scalvaia lithosol (Los Gatos series)	Acid sandstone
Erica scoparia - Arbutus unedo	Eroded Scalvaia lithosol (eroded Los Gatos)	Acid sandstone
Castanea sativa	Roccastrada sandy loam (Butte series)	Liparite (an acid igneous intrusive
Quercus ilex, Fraxinus ornus	Roccastrada sandy loam (Butte series)	"
Erica scoparia, Arbutus unedo, Quercus suber (where the soil becomes deeper, Quercus suber becomes dominant - as in areas just north of Roccastrada as on M. Betti)	Roccastrada lithosol (Kidd series)	"

Within the mosaic of these types, the boundary lines between the vegetation types as they appear on the landscape, or would appear on aerial photographs, are very abrupt where geologic types that are widely different adjoin each other. For example, where Liparite adjoins sedimentary rocks (south slope Monte Alto north of Roccastrada) the dark hardwood type of holly leaf oak (Quercus ilex) has a very conspicuous sharp boundary with the hardwood type, characterized by Quercus cerris on the adjacent heavier textured soils from the sedimentary rocks. A similar sharp boundary occurs where Quercus cerris occurs on a heavy clay soil, developed from sandstones and shales, adjoins a cover of Quercus ilex on a lithosol derived from limestone on steep slopes. The vegetation-type boundaries are more gradual where the change in soil is related to erosion; for example, patches of Erica scoparia occur on eroded soils of the same type as support the Quercus cerris in the above mentioned type on the south slope. These patches of Erica have gradual boundaries with increasing amounts of Quercus cerris of improving growth habit as one leaves the center of the eroded areas and passes into the adjacent uneroded soil. Ofentimes brushfields of Erica scoparia, Calluna vulgaris, and Arbutus unedo tended to come out on ridge top sites which are perhaps more eroded and acid. Usually the Erica brushfields are associated with more acid soils. However, it is a moot question as to whether this is due to the influence of the Erica on the soil, to the leaching of the eroded soils, or to the removal of the more base rich A horizon through erosion. Pinus pinaster has been invading these very acid eroded lithosols in a manner much like Pinus attenuata does on similar areas in California. Frequently the local residents in these Colline Metalliferae burn the Erica brushfields and seed them to Pinus pinaster, but other times the seed spreads from previously seeded areas to other Erica brushfields.

Where the areas have been influenced by man, a patchwork of small types with ragged edges and sharp boundaries and different than normal species combinations is found. There is an erosion sequence on the old fields that proceeds through Erica scoparia to a mixture of Erica and Quercus cerris, finally ending up with oak woodland on the better soils. Where a seed source of Pinus pinaster is present, it may invade the abandoned field and side track the process of change toward oak woodland. A noticeable and unique indicator of macchia and oak woodland being utilized for charcoal is a polka dot uniform pattern of white dots in the otherwise black vegetation type on the aerial photographs.

Soil boundaries that are diffuse, such as the change which soil undergoes in an elevation transect up a large mountain, also present gradual vegetation changes. Thus on the north slopes of Mt. Alto north of Roccastrada, there is a pure beech-type (Fagus sylvatica) on the upper portion of the slope which gradually intergrades into a pure stand of Quercus cerris and Quercus *pubescens* at lower elevations, with a mixture of beech and oak in between.

The California analogy for these soil vegetation types occurs in the southern part of Lake County, and northern Nape County in a transect to the northeast of Calistoga. It was interesting to note that despite the settlement of the Colline Metalliferae from earliest Etruscan times, that the mosaic of soil-vegetation types was not very different than one would expect in terms of analogous structure and species combinations in this area of the inner north coast ranges of California. As Corti (1934) so aptly put it, the influence of man on the vegetation is different from normal natural processes, mainly in a quantitative way; in the area influenced, or in the length of time needed to complete a process. The important thing is that man operates within the context of already existing natural processes upon the landscape, and it is mainly in relation to the degree or proportions of the change that take place that he is exerting a difference in the normal process.

DISCUSSION

The Mediterranean Soil-Vegetation Catena

During the work that was carried out in the field in this project, it became obvious that there were certain generalities that were true in nearly all of the sequences of soil and vegetation that were observed. One of these was the consistency of the change in soil properties and vegetation with increasing elevation, and the other was the existence of the local mosaic of soil and vegetation types.

The similarities between most of the sequences of change of soil and vegetation, whether in Italy, Greece, or California, are presented in table 63. The usual sequence of change is from a Mediterranean red earth at low elevation to a dark lithosol (Ranker, Rendzina or Ando soil) at higher elevations, with brown soils of various types (Brown forest soil, Grey-brown Podzol, Leached brown soil) in between. The main exception to this sequence occurred in the soils in the sequence on marl rock, and leads one to expect that where the parent material weathers readily and is rich in clay and such bases as calcium or possibly magnesium, another type of sequence typified by that on marl rock will be found (see table 28, page 83). The main difference between this sequence and the more usual one is that in place of the Mediterranean red earth at the low elevations (or a Terra Rossa), a Xerorendzina or Black earth would be found. This probably accounts for the difference in the types of soil development on the tertiary deposits (page 160) mentioned in Greece, in which those tertiary deposits which were clay rich and calcium rich developed dark rendzina-like soils, often called Terre Nere (Principi, 1943), or Mediterranean black earths. The vegetation sequences associated with these soil sequences were also consistent in beginning with grassland at lower elevations, almost always on the black earths, and frequently on the red earths, and progressing successively through macchia, oak woodland, beech and coniferous forest to high elevation pasture of grasses and carex. Thus sequences of soil vegetation types in terms of such broad categories of classification as World Soil Groups or Plant Communities exist that are typical of the areas examined. These usual categories of classification, however, would require boundaries to be placed on the landscape whenever the limits of definition of one of the groups had been reached in the sequence.

Each elevation sequence is seen, however, to amount to a gradual change in properties of the soil or of the vegetation as one ascends a uniform slope of broad elevation change. Since this was such a typical occurrence, it seems that the literature of soil science would encompass a definition and description of such a sequence in which a predictable change in soil properties was consistently related to a topographic change. Milne[1] deals with just such a problem. He felt the need for a classification

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[1]Milne, G. 1935. Some suggested units of classification and mapping, particularly for East African soil. Soil Research IV(3): 183-198.

TABLE 63. Soil-Vegetation Catenas Observed with Elevation Change on Most of the Rock Types of Italy, Greece, and California

Elevation* (meter)	Soil	Vegetation
High 1600+	Ranker soil (GM or OL), dk. grayish brown A horizon, A/c Profile pH 4.5-5.5 Stony, loam - sandy loam. Lithosol-minimal soil profile development	High mountain pasture Carex and grassland with some *Juniperus communis*
Mod. high 1000-1600	Terra bruna lisciviata or Gray brown podzolic (Cl, MH) brown-dark brown A horizon, B horizon present. Loam texture pH 5.5-6.5. Minimal soil profile development	Coniferous forest with genus *Abies* or *Pinus*. Hardwood forest Beech in Europe.
Low 500-1000	Terra bruna - Brown forest soil (CH - MH - CL), brown reddish brown. Loam - clay loam B horizon present. Medial soil profile development	Hardwood forest Lower Beech forests Scrub oak forest Closed cone pine forests *Pinus pinea*, *P. pinaster*, *P. attenuata*
Lowest 0-500	Mediterranean red earths (CH) reddish brown - red clay loams - clay. pH may be up to 7.5. Maximal soil profile development with clay accumulation	Oak woodlands - *Quercus ilex*, *Quercus chrysolepis*, *Quercus suber*, *Quercus engelmanni*. Macchia - or chaparral, *Quercus coccifera*, *Quercus dumosa*, *Erica arborea*, *Adenostoma fasiculatum*
	(Xerorendzina or Serozem (CH) on carbonate rich, clay rich easily weathered rocks. Dark brown A horizon, nearly white C horizon, with $CaCO_3$ deposition in C horizon. pH up to 8.5. Maximal soil profile development)	Grassland. Annual grasses and herbs

*Elevations noted for Italy and Greece

category for a situation in which there is a regular repetition of a certain sequence of soil properties in association with a certain topography, and in the case where uniformity of parent material might be of subsidiary interest. For the situation, he proposes the word CATENA to indicate "a grouping of soils which, while they fall wide apart in a natural system of classification on account of fundamental genetic and morphological differences, are yet linked in their occurrence by conditions of topography and are repeated in the same relationship to each other wherever the same conditions are met with." He advocates the use of such a composite mapping unit in preference to the suppression of all but one of the associated soil types on grounds of their being of arrested development, or intrazonal. He was referring particularly to a basin-ridge system of small dimensions in which the soil vegetation landscape continuously repeated itself. The problem had arisen while using such units as great world soil groups as to how to define the zonal soil for the area. He wished to base his classification upon the soils that were present in terms of the evidence that they themselves yield, not by a supposition of what would happen in the production of a zonal soil. He elaborated that in certain forms of the catena, only portions of the relationship with the topography may be present. The broader aspects of the catena would include also climatic zones that were related to topography, and thus catenas on a grand scale would be found on such mountains as Mt. Kenya in the tropics, or on Mt. Kilimanjaro, where conditions range from alpine to semi-arid within a score of miles. Thus the catena can express relationships of soils in directions that run across the main phyla of genetic and morphological classification. The conclusion one reaches from the field work in this study is that the various sequences of soil property change that have been described are in effect descriptions of typical Mediterranean catenas, and that there are two main ones; the most prevalent based on a red soil at the lower elevations, and the other less widely distributed (except for the lowest member) based on a black soil at the lower elevations. It was apparent in Italy and Greece that the elevation limits were lowered for the various types of soil in a catena, with increasing north latitude or with north slopes, so that the red soil lower member was attenuated and the others were lowered in elevation. The same catenas are present in Italy, Greece, and California; and presumably the other countries bordering on the Mediterranean and Black Seas; and probably in other areas of the world with a dry summer climate and temperate moist winter, and having the requisite topographic change.

The value of the catena concept in mapping areas on a reconnaissance basis, where limited access or funds are available to make a more intensive survey, was emphasized by Vageler.[1] He found application of the method in Brazil where mountain range after range had the same sequence of soil and vegetation types with change in elevation. He had found that the continental climate theory of soil formation with its great world soil groups did not adequately explain the principle of the regional soil mosaic. By using the catena concept in conjunction with change in vegetation types, he was able to make maps of these sequences of soil change that were useful, and was able to establish that consistent changes in physical and chemical soil properties occurred in these sequences. His application of the method was to tropical areas, but the general principles were the same as those noted by Milne.

Functional relationships between soil properties and the environmental variables -- Climate, Parent Material, Vegetation, Topography, and Time

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[1] Vageler, P. 1939. Praktische Grundsatze und Methoden der Agrogeologischen Landes aufnahme jungfraulicher Grossramlander der Tropen und Sudtropen. Bodendunde u. Pflanzenernahrung 17:1/2, 1-28.

have been proposed by Jenny[1]. If all of these variables are kept constant except one, in a study of soil properties, relationships which he calls sequences are developed. Thus the function that is established between soil property and change in climate, with all other factors kept constant, is called a Climo sequence. Thus in the terminology of Jenny, the Mediterranean Catenas described might be considered to be Climo sequences.

SUMMARY

Analogies have been established between Soil-Vegetation types in Italy and Greece to those in California on the basis of field observations. Consistent changes in soil and vegetation properties were observed as sequences with elevation change on typical rock types. These were considered to be consistent with the concept of the Soil Catena, and this concept is expanded to include vegetation in a Soil-Vegetation Catena. At any location local mosaics of soil-vegetation types were found in which the general background of soil and vegetation conformed with the position of the area in a Soil-Vegetation Catena (or sequence) and numerous local types occurred related to disturbance, degree of slope and erosion, seepage water, and changes in geologic type.

[1]Jenny, Hans. 1941. Factors of Soil Formation, A System of Quantitative Pedology. McGraw Hill Book Co., New York. 281 pp.

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APPENDIX A

Table 64. Soil-Vegetation Plot XI.
(Recent ash deposit on Mt. Etna)

LOCATION: Italy, Sicilia; Map Fo 262. South slope Mt. Etna, km. 20.5 on Mt. Etna Highway.

Elevation: 1400 meters
Precipitation: 1200 mm
Slope: NE 30%

Physiography: Cinder cone on flank of volcano

VEGETATION

Cover class: $\frac{4}{B\ CS}$

Species: Ba, Pinus nigra var. Laricio (Poir), Cytisus scoparius Lk.

Remarks: A planted type in which planting began with Cytisus and later included stands of Corsican pine.

SOIL

Parent rock: Volcanic cinders (basic igneous)
Permeability: Good in surface/Good in subsoil
Drainage: Good
Ground water: None
Root distribution: Throughout profile and into rock
Rockiness: Approximately 20% large volcanic bombs over surface

Soil profile description:

Horizon	Depth (cm.)	Boundary	Color	Texture	Structure	Consistence	pH	Miscellaneous
1 (A)	0-50	diffuse-irregular	very dark grayish brown, 10 YR 3/2	sand	0	loose	6.0	
2 (C)	+50		very dark grayish brown, 10 YR 3/2	sand	0	loose	6.0	

Classification:
International: Regosol (U.S.D.A.)
Unified Soil Classification: SP
California Soil Series Analogy: None. However landscape analogy is the area around Cinder Cone in Lassen National Park and also at Medicine Lake east of Mt. Shasta, California (1 mile NE of lake).

APPENDIX B

Field Description

Most of the abbreviations in the soil descriptions are from the Soil Survey Manual (Soil Survey Staff, 1951).

The legend used in describing soil horizon properties comes mainly from the Soil Survey Manual, U.S.D.A. Page references have been given.

HORIZON: Standard horizon nomenclature (See pp. 173 to 188).

DEPTH: In inches from the top of A_1, or surface mineral horizon, except for the surface of peat or muck in Bogs and Half-Bogs (See p. 185).

THICKNESS: Average thickness and range, as 6 (4-8).

BOUNDARY: Horizon lower boundaries are described as to:

(1) Distinctness:

abrupt	(<1" thick)	... a
clear	(1" - 2-1/2")	... c
gradual	(2-1/2" - 5")	... g
diffuse	(>5" thick)	... d

(2) Topography of boundary:

smooth	(nearly a plane)		... s
wavy	(pockets with width	depth)	... w
irregular	(pockets with depth	width)	... i
broken	(discontinuous)		... b

Thus an abrupt, irregular boundary is noted as ai (See p. 187).

MOTTLING: A description of mottling requires a notation of the colors and of the pattern. Colors may be noted by Munsell symbols for the matrix and color names for the mottles. Pattern may be noted in terms of:

(1) Abundance:

few	(mottles < 2% of surface)	... f
common	(mottles 2 - 20% of surface)	... c
many	(mottles > 20% of surface)	... m

(2) Size:

fine	(< 5 mm)	... 1
medium	(5 - 15 mm)	... 2
coarse	(> 15 mm)	... 3

(3) Contrast:

faint	(Hue and chroma of matrix and mottles closely related)	... 5
distinct	(Matrix and mottles vary 1-2 hues and several units in chroma and value)	... d
prominent	(Matrix and mottles vary several units in hue, value, and chroma)	... p

Thus a medium-gray horizon mottled with yellow and reddish brown is noted as: 10YR 5/1, c3d, yellow and reddish brown (See pp. 191-193).

STRUCTURE: (See pp. 225-230).

(1) Grade

structureless	... 0	(No observable aggregation or no orderly arrangement of natural lines of weakness).
weak	... 1	(Poorly formed indistinct peds, barely observable in place).
moderate	... 2	(Well-formed distinct peds, moderately durable and evident, but not distinct in undisturbed soil).
strong	... 3	(Durable peds that are quite evident in undisplaced soil, adhere weakly to one another, withstand displacement, and become separated when soil is disturbed).

(2) Size:

very fine	... vf	medium	... m
fine	... f	coarse	... c
		very coarse	... vc

(Read "thin" and "thick" for platy instead of "fine" and coarse"),

(3) Form or type:

platy	... pl	granular	...gr
prismatic	... pr	crumb	... cr
columnar	... cpr	(single grain	... sg)
blocky	... bk	(massive	... m)
angular blocky	... abk		
subangular blocky	... sbk		

Thus weak medium blocky structure is noted 1mbk, moderate very thin platy as 2vfpl, etc.

CONSISTENCE: (The notation of consistence varies with moisture content (See pp. 231 to 234).

(1) Wet soil:

nonsticky	.. wso	nonplastic	.. wpo
slightly sticky	.. wss	slightly plastic	.. wps
sticky	.. ws	plastic	.. wp
very sticky	.. wvs	very plastic	.. wvp

(2) Moist soil:

loose	.. ml	firm	.. mfi
very friable	.. mvfr	very firm	.. mvfi
friable	.. mfr	extremely firm	.. mefi

(3) Dry soil:

loose	.. dl	hard	.. dh
soft	.. ds	very hard	.. dvh
slightly hardq	.. dsh	extremely hard	.. deh

(4) Cementation:

weakly cemented	.. cs
strongly cemented	.. cs
indurated	.. ci

COLOR NOMENCLATURE: As per Munsell Soil Color Charts, 1954 Edition, available from Munsell Color Company, Inc., Baltimore 2, Maryland, U.S.A.

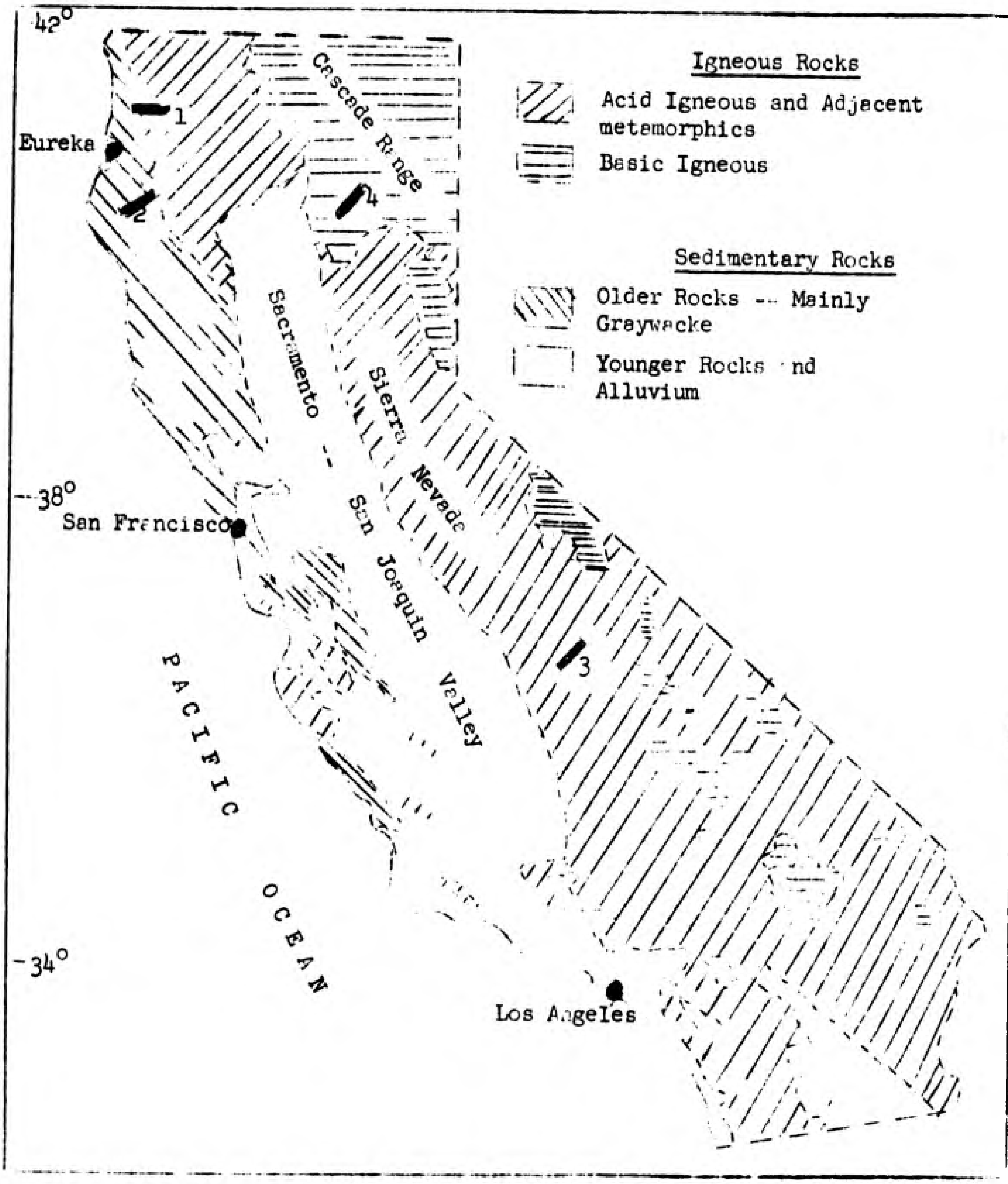

Figure 1: A map of California showing broad groups of soil parent materials. The locations of landscape profiles used are indicated by number.

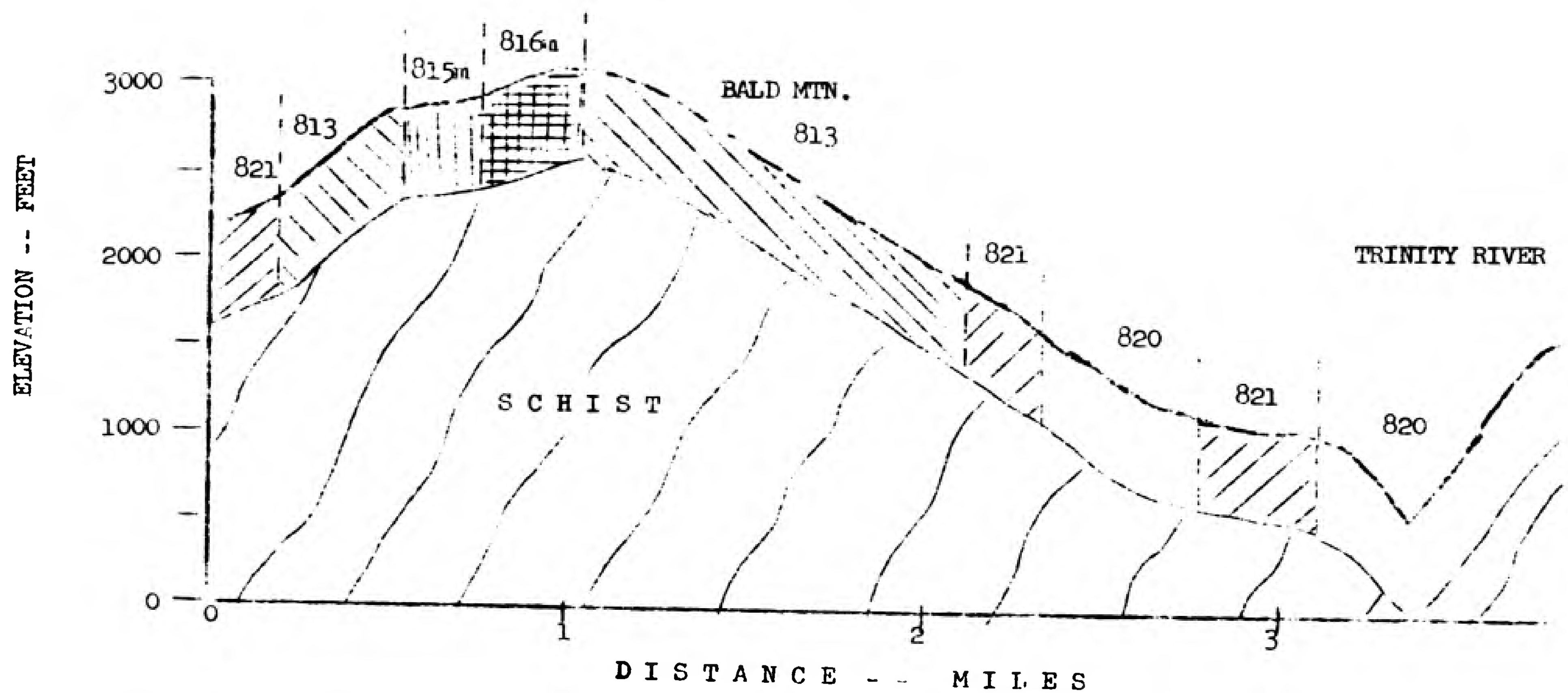

Figure 2: A topographic sequence on an area of schist parent material (No. 1 in figure 1) showing the less developed Sheetiron Soil Series (820); and, with increasing degrees of development, the following: Masterson Soil Series (821), Orick (813), Josephine (815m), and the Sites Soil Series (816m).

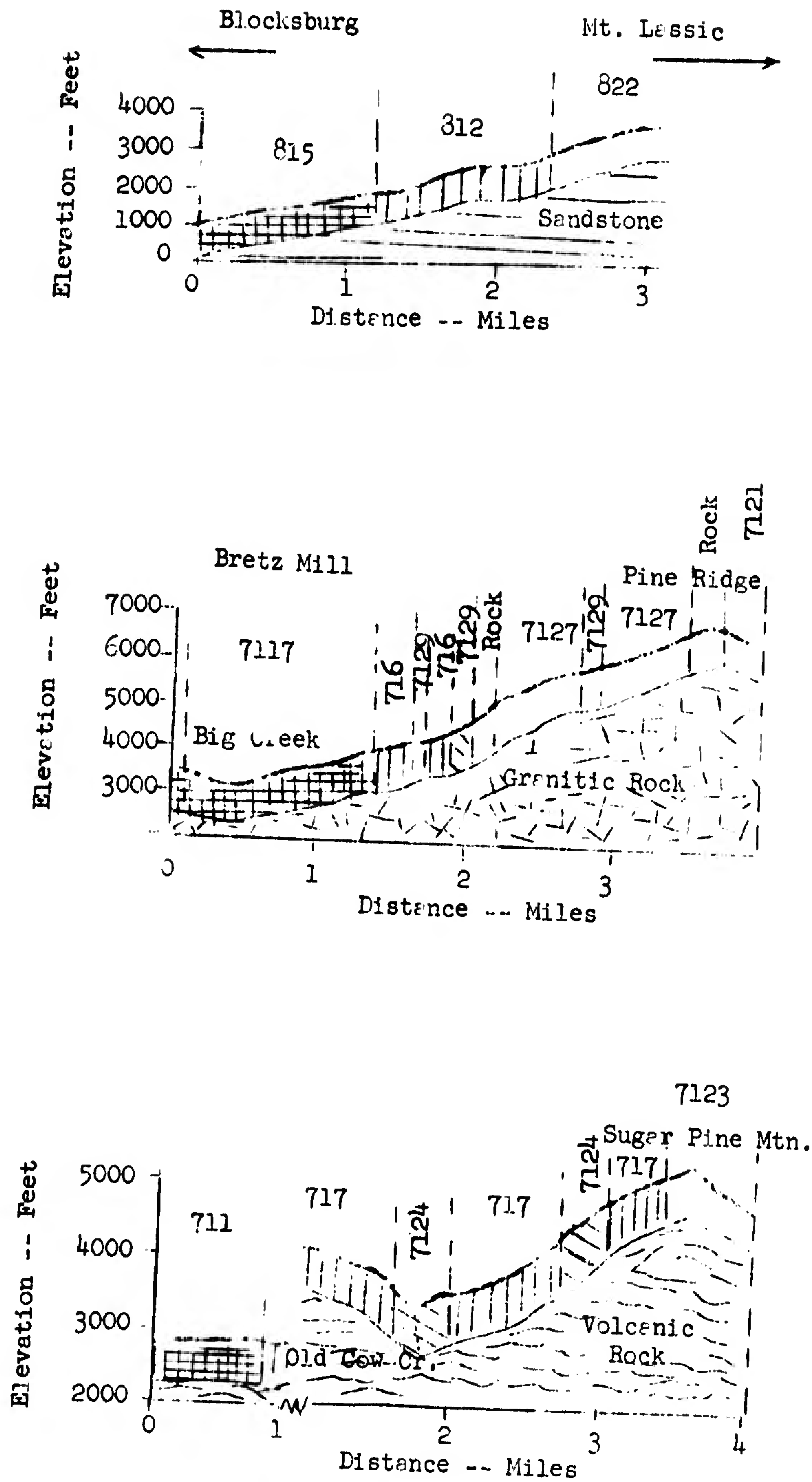

Figure 3: Developmental sequences of soil profiles on several parent rock types as related to elevation change. The sequence on sandstone (No. 2, figure 1) progresses from the minimal development of the Hoover Soil Series (822), through the Hugo (812), to the well developed soil series Josephine (815). The sequence on granitic rocks (No. 3 in figure 1) from the Corbett Soil Series (7121), and Shaver (7127) to the Holland (716), and the well developed soil series Musick (7117). The sequence on andesitic rocks begins with the immature endo-like soil series, Windy (7123) and McCarthy (7124), to the leached brown soil Cohasset, and the fully developed Aiken Soil Series (711) (No. 4 in figure 7).

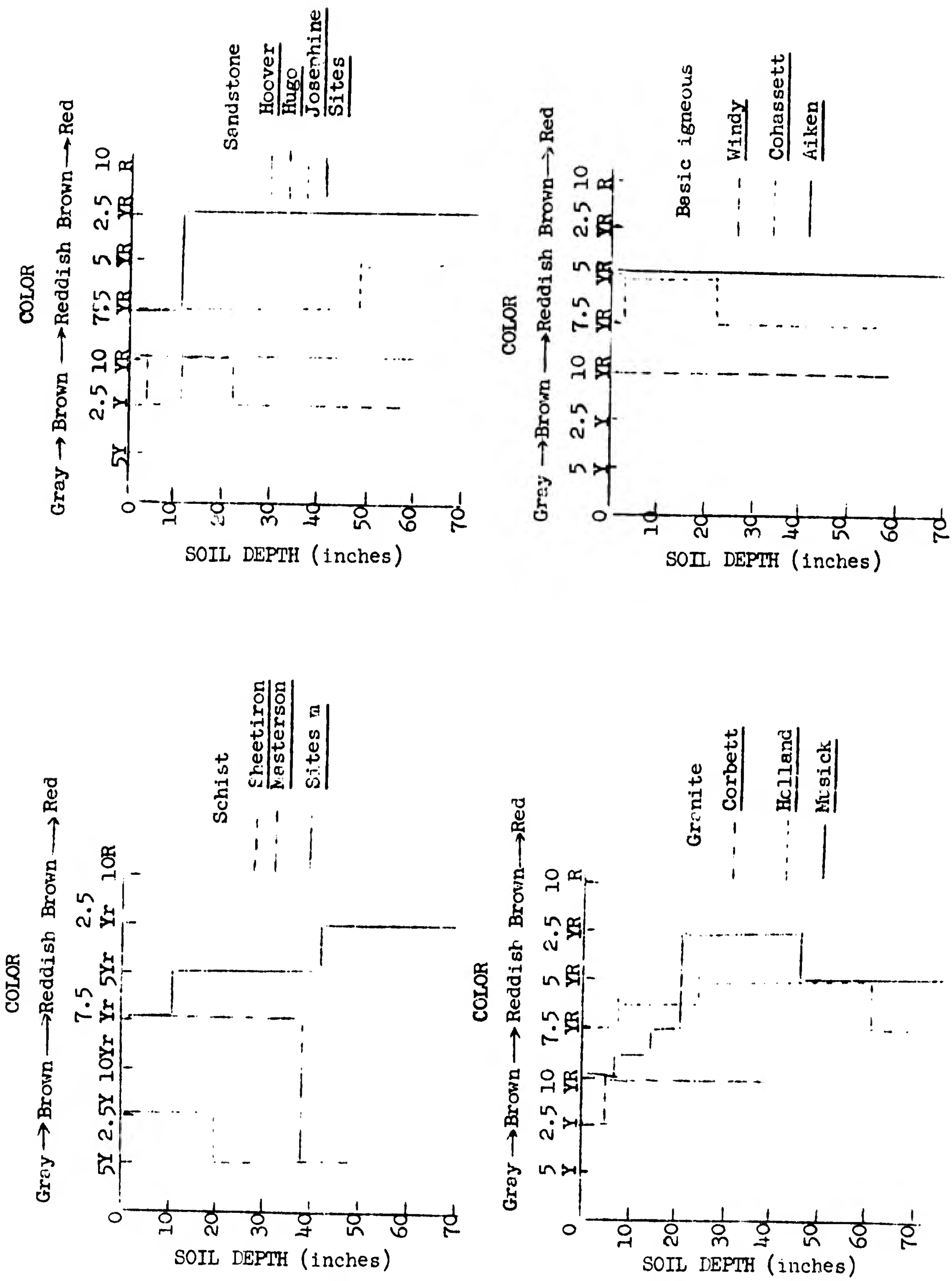

Figure 4: The Soil Colors of soils representing sequences developed on four parent rock types in California, showing increasing redness with increasing soil development (text reference page 7).

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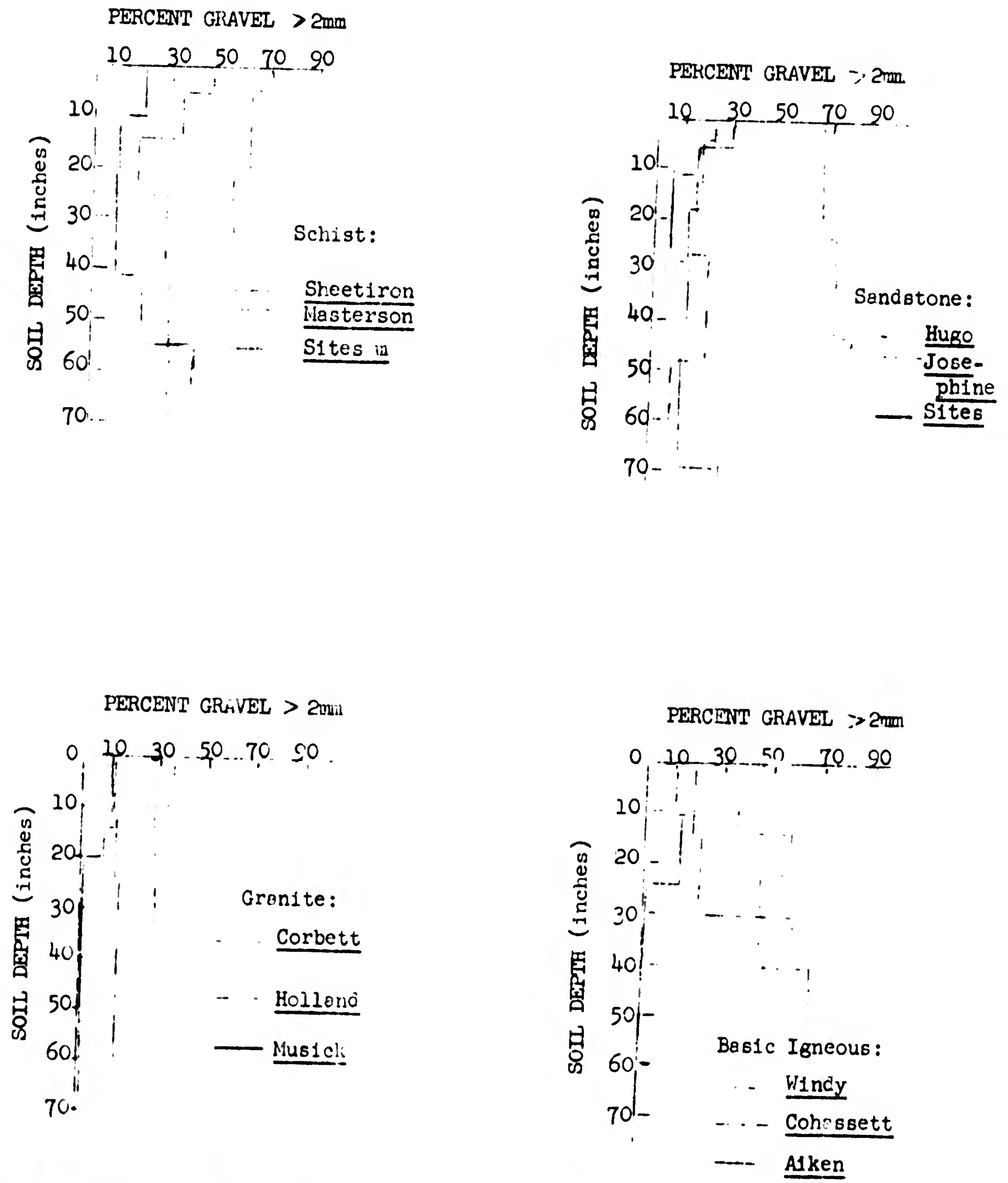

Figure 5: The coarse fragments of soils representing developmental sequences on four parent rock types in California; showing generally a decrease in coarse fragments with increasing degree of development.

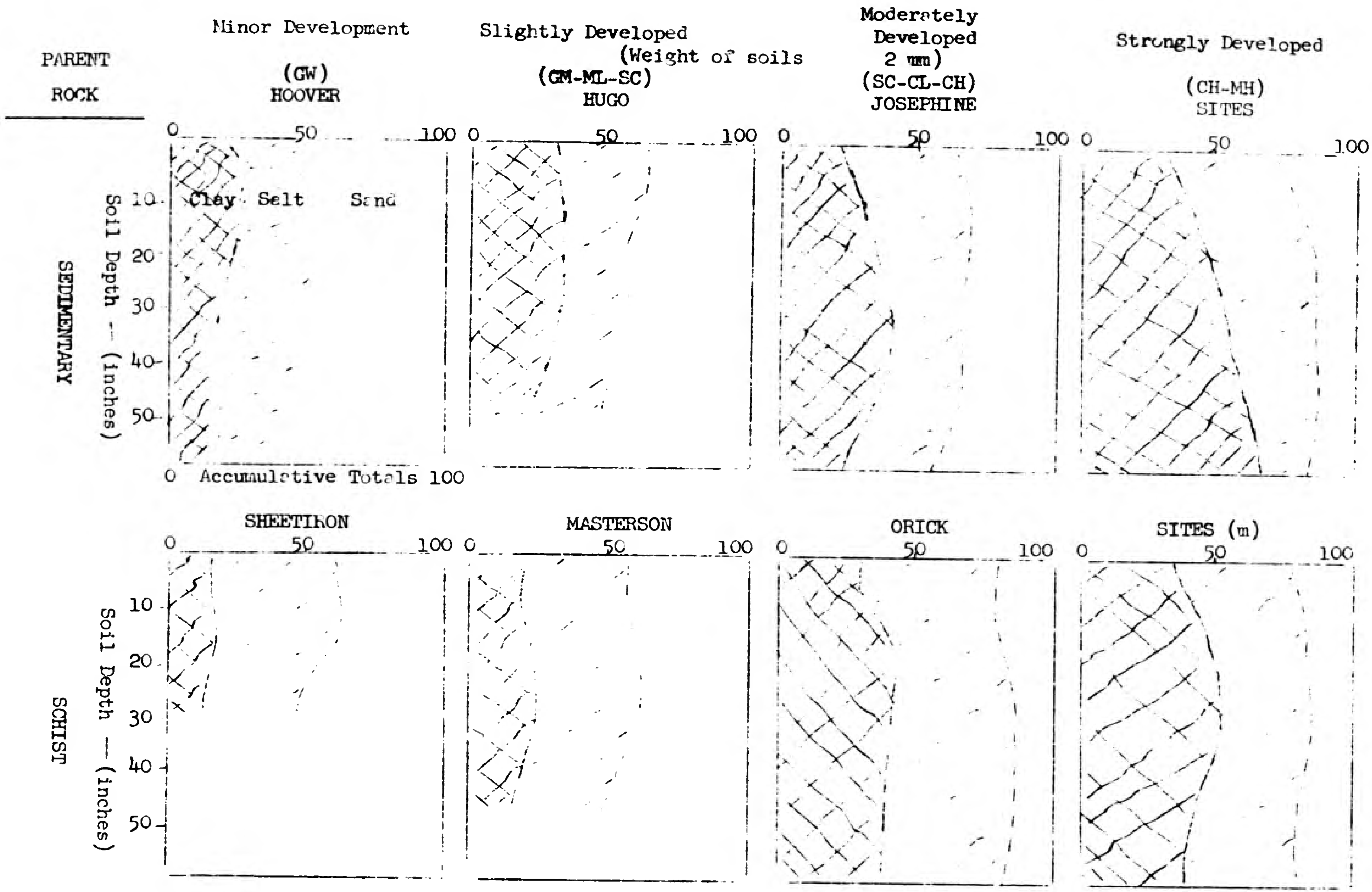

Figure 6: (Continued next page)

(Continued from Page 222)

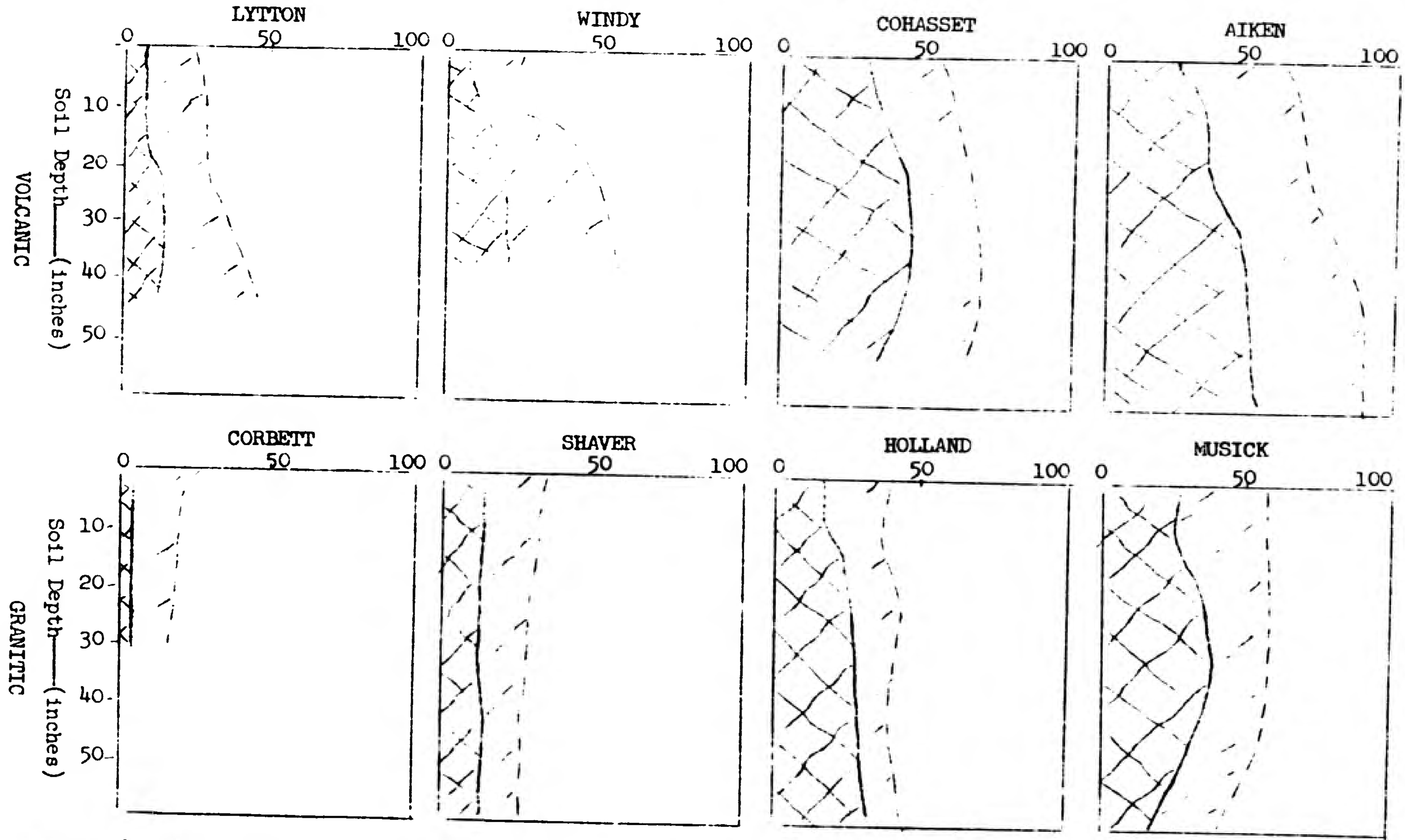

Figure 6: The clay, silt, and sand contents of the less than 2 mm fraction of soils representing sequences of increasing degree of development on several California rock types (contents expressed as percent by weight).

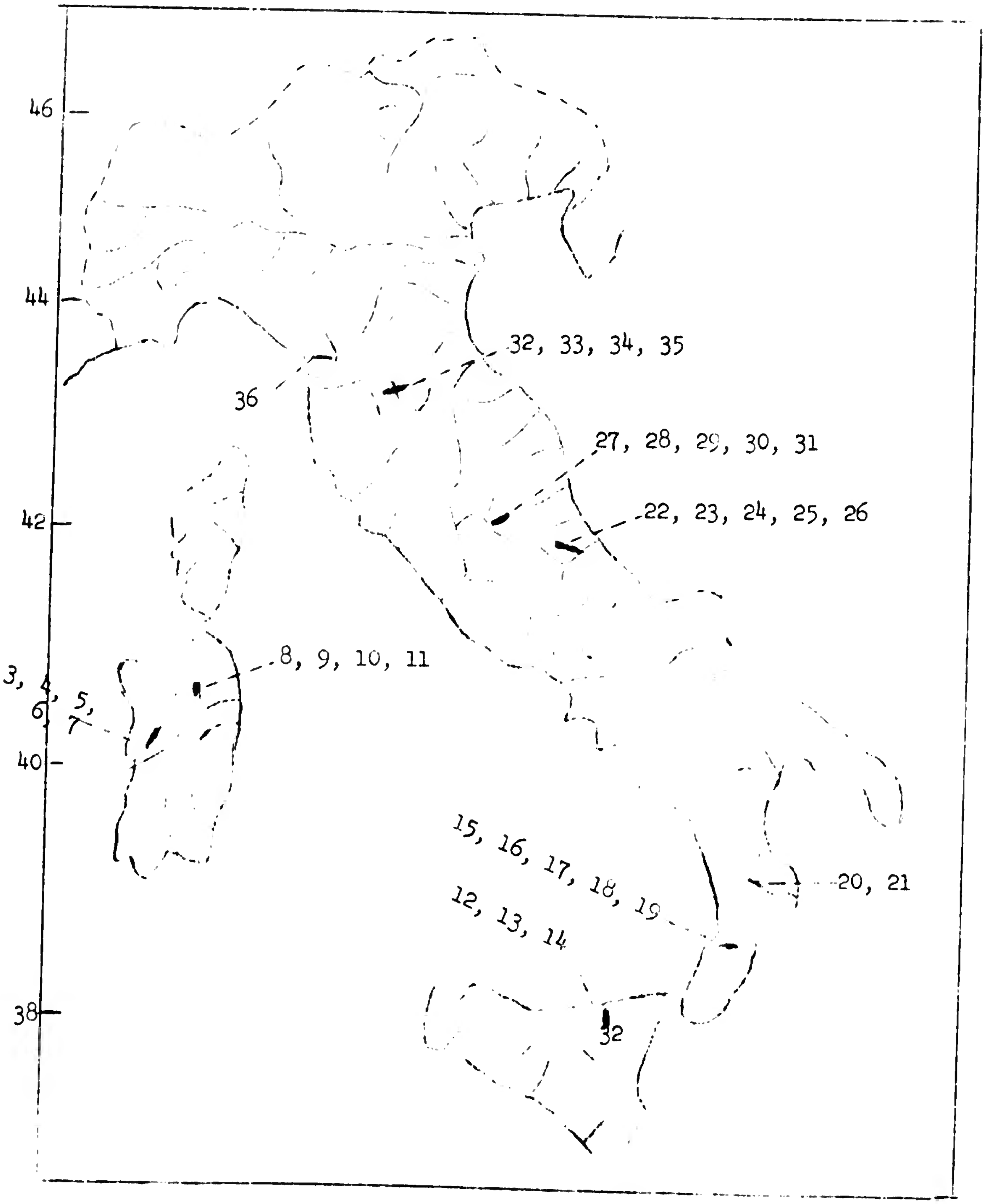

Figure 7f. Italy, showing locations of Soil-Vegetation observation points listed by table number in this text.

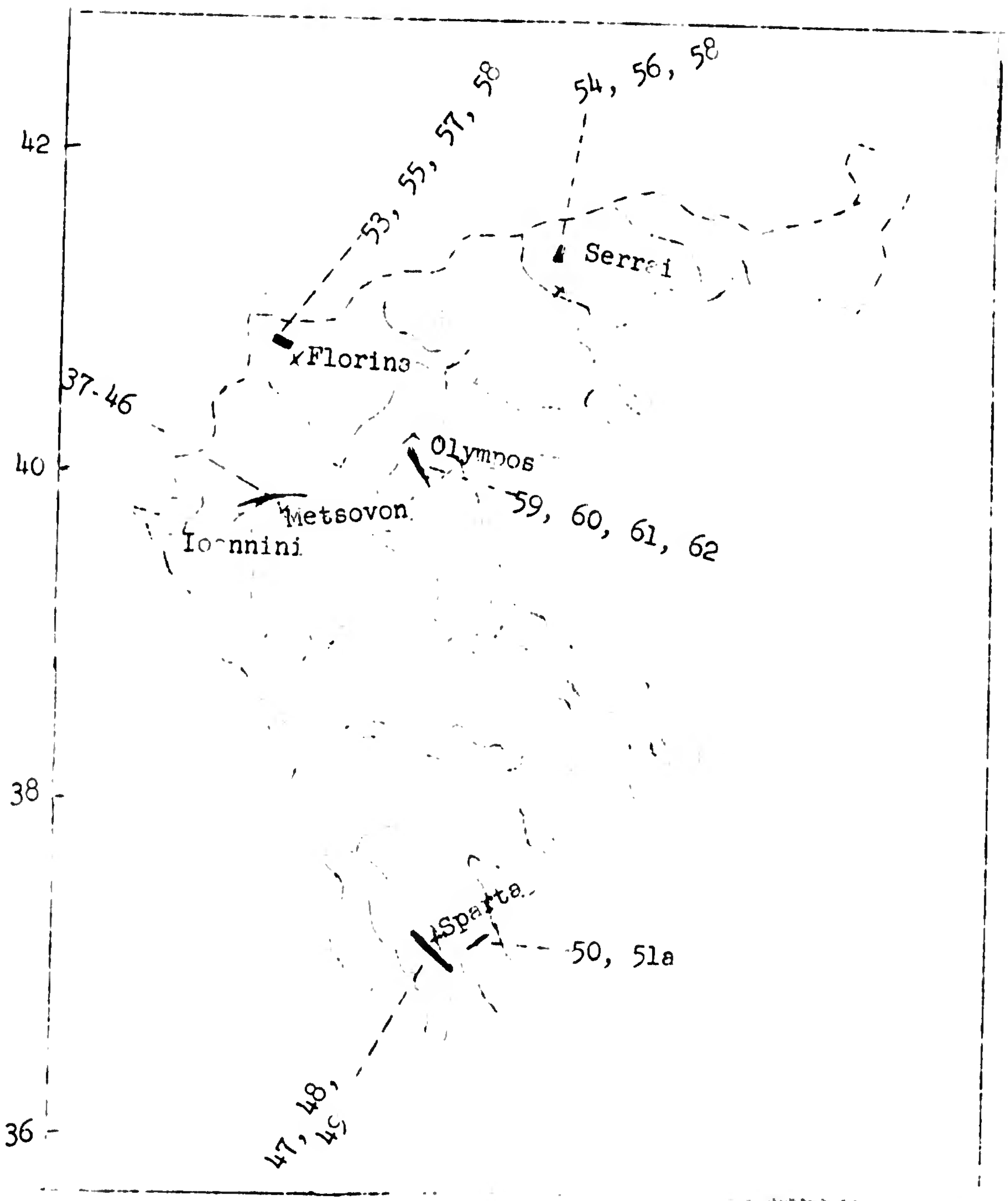

Figure 7b. Greece, showing locations of Soil-Vegetation observation points listed by table number in this text.

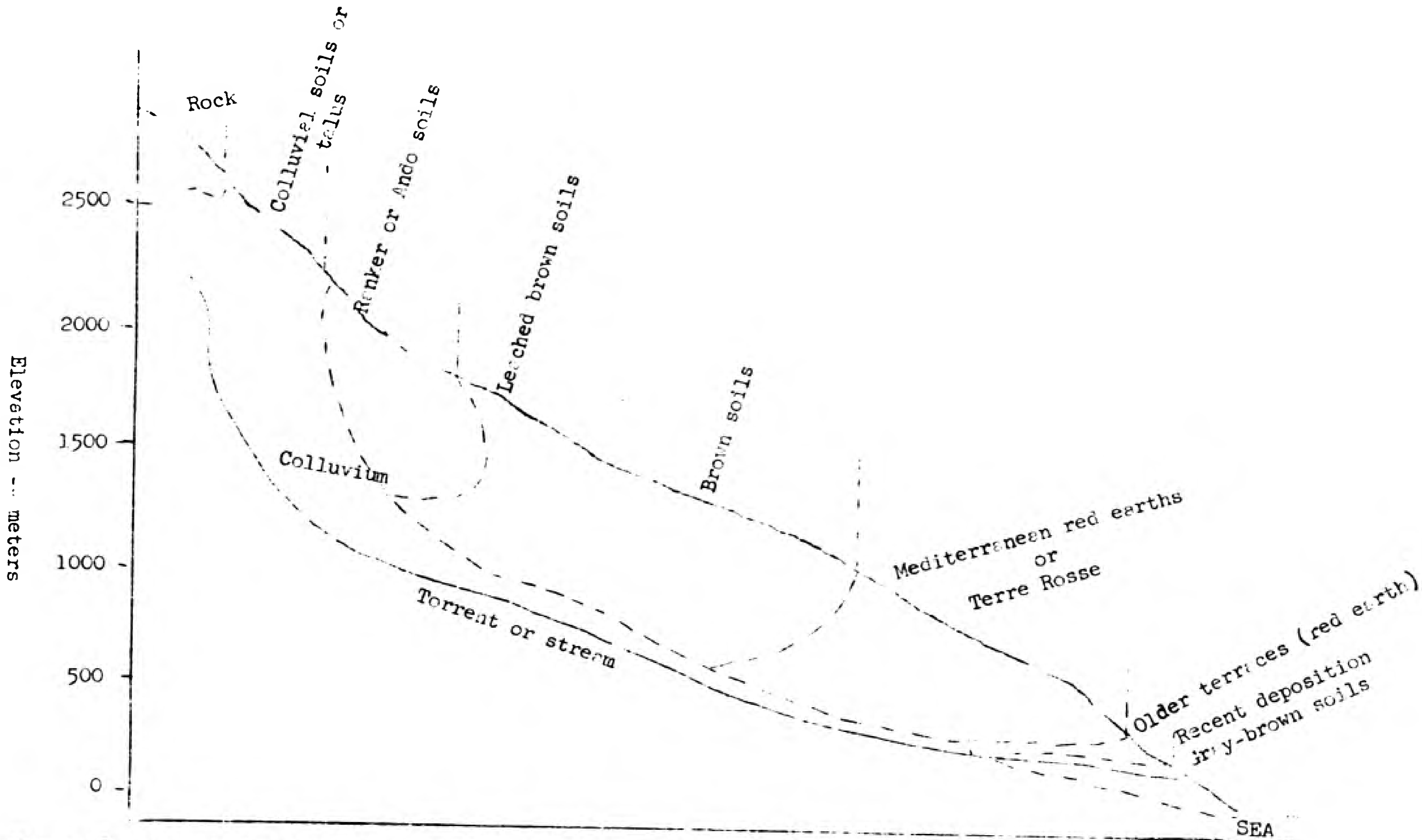

Figure 8. A typical sequence or catena of soils found in this study in Greece, Italy, and California.

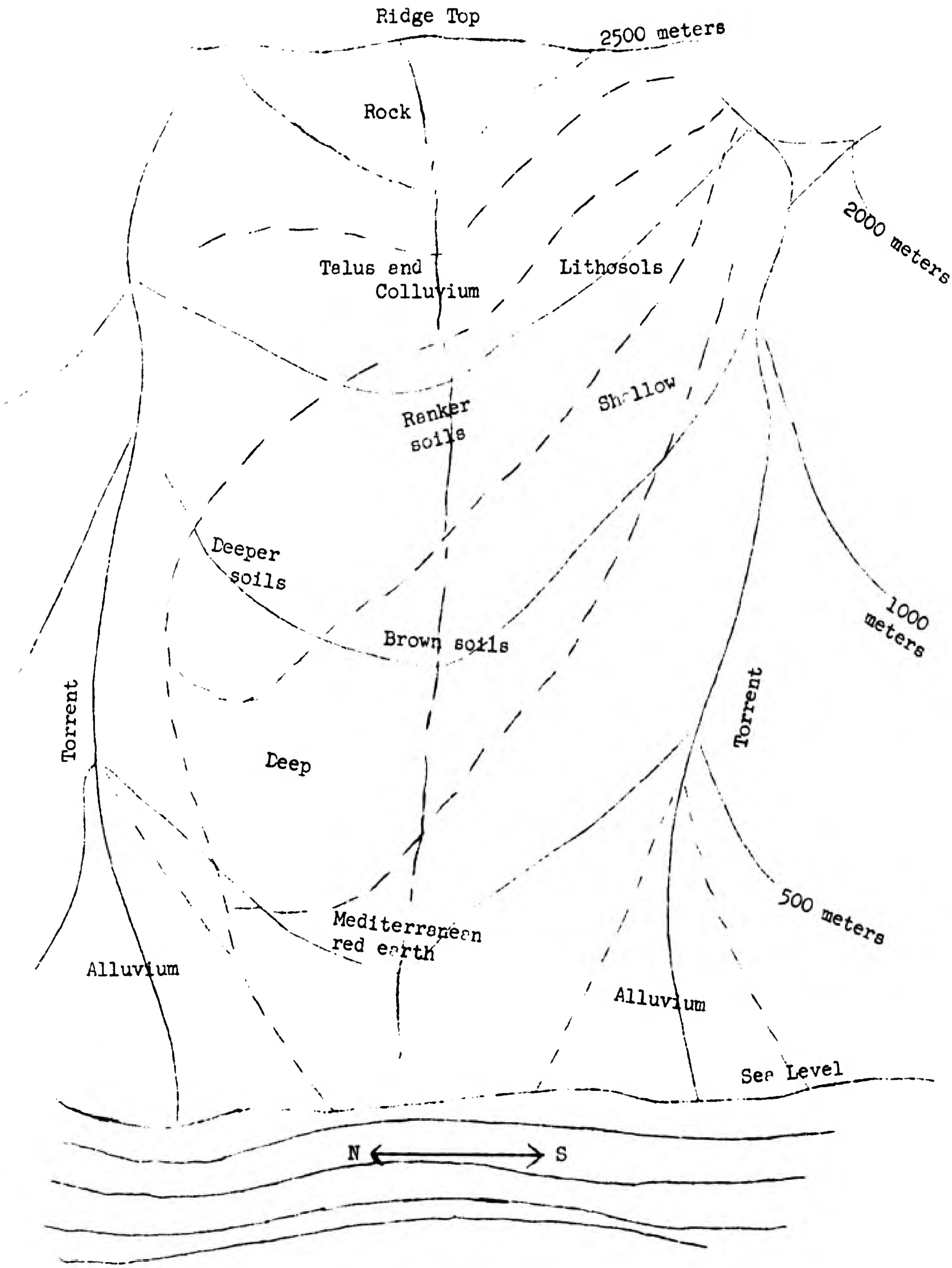

Figure 9. The typical elevation sequence up a ridge top between two torrents as it would appear in plan view, highest elevation at top of page.