Site research in beech forests of the Chortiatis Mountain Range, NE Greece

Bot Helv 103:23–37

0253-1453/93/010023-15 $1.50+0.20/0

Site research in beech forests of the Chortiatis Mountain Range, NE Greece

Vasiliki Karagiannakidou

Institute of Systematic Botany and Phytogeography, Department of Biology, University of Thessaloniki, 540 06 Thessaloniki, Greece

Manuscript accepted March 11, 1993

Abstract

Karagiannakidou V. 1993. Site research in beech forests of the Chortiatis Mountain Range, NE Greece. Bot. Helv. 103: 23–27.

By analysing the beech forests of Mt. Chortiatis the plant-sociological units 0^1, 0^2, 0^3, 0^4 and the site qualities II, III,IV, and V were distinguished. The first two plant-sociological units (0^1, 0^2) are rich in the species of plant-index groups A and B, which as demanding species grow in rich soils, mainly found on the northern slope of the mountain. Plant-sociological units 0^3 and 0^4 are mostly characterized as poor, since the species of group C contained there in are more or less xerophytic and grow in the poor soils of the northeastern and northwestern sides of the mountain.

Key words: Beech forests, Ecological research, NE Greece.

Introduction

Beech forests constitute 9% of the total Greek forests. Despite this low percentage they are of great interest because they are found in the best ecological sites of Greece (Dafis 1969).

According to Horvat et al. (1974), Raus (1979), Karagiannakidou (1983, 1988), the study of phytosociology in Greece, even nowadays, is still at an initial stage. The lack of comparable data creates significant difficulties and thus Greek forests are deprived of the essential bases for rationally programming and treating the forest ecosystems.

This paper aims to locate the ecological sites of the beech forests of Chortiatis, to define their characteristic features, similarities and differences, and to correlate these with the factors which determine the ecosystem (climate, soil, vegetation).

Research area, climate, geology and vegetation

Chortiatis has an altitude of 1201 m and geographically belongs to the prefecture of Chalkidiki, NE Greece.

The climate of the Chortiatis region is intermediate between mediterranean and Mid-european. According to Koeppen's climatic classification (Critchfield 1974) the climate belongs to type Csb. The ecologically dry period is limited to 1 – 1 ½ months with August being the driest month (Karagiannakidou 1983, 1988).

From the geological point of view, Chortiatis belongs to the Serbo-Macedonian massif, and it was found to consists of the following geological composition: a) on the northeastern side of sandstone schists, phyllites and limestone, b) in the central area of gneiss, c) in the central-eastern area of the magmatic course of Chortiatis and with limestone in places, and d) on the southwestern basis of ultrabasis petrifications (Kockel et al. 1977, Karagiannakidou 1983).

The vertical and horizontal spread of the Chortiatis vegetation zones is presented in Fig. 1. Many features of the Quercion ilicis zone are found in the S.W. part of the study area but do not appear on the map due to severe degradation (Karagiannakidou 1983, 1988).

Material and methods

The vegetation analysis is based on phytosociological measurements according to the standard method of Braun-Blanquet (1964). All the measurements were performed in areas where grazing is permitted. Plant sampling was carried out during May–July and September–October 1978–1981. Samples of material used for measurements are kept at the laboratory of Systematic Botany of the University (TAU).

The nomenclature and classification of the taxa mentioned are according to Strid (1986), Strid and Tan (1991), or Tutin et al. (1964–1980). The names of the taxa authors have been omitted for practical purposes.

The distinction of plant-sociological units was performed with the assistance of plant-index groups as they are described by Schlenker (1950), Ellenberg (1956, 1963, 1979), Dafis (1966, 1969), Smyris (1980), Nicolae Ponita et al. (1977).

Total nitrogen, organic matter, mechanical analysis and designation of acidity (Alexiadis 1972, Papamichos 1979, Ulrich 1977) were determined in the samples of thin soil investigated.

Results

The plant index groups found in the beech zone by the comparative processing of Table 1, are: Group A, mid-hygrophytes; indices of fertile soils with a normal moisture requirement which avoid the relatively dry and infertile soils. Group B, mesophytes; indices of fertile soils with larger ecological width some of which appear sporadically in dry sites as well. Group C, xerophytes; indices appearing mainly on ridges of southern slope exposure and in voids exposed to the south. By the combination of the above groups we have determined the following four (4) units and their respective site types (Table 1, 2).

The gradual increase in soil-coverage by the xerophytic group C and the respective gradual reduction in abundance-coverage of groups A and B have been shown by spectrum analysis (Fig. 2).

The distinction of the site types is conventional and applies for this area only. The distinction of the groundline vegetation into units according to the Braun-Blanquet system, and the plant-indices of Ellenberg, are considered to give bettern results in places where natural vegetation has been significantly disturbed (Papamichos 1979). On Mt.

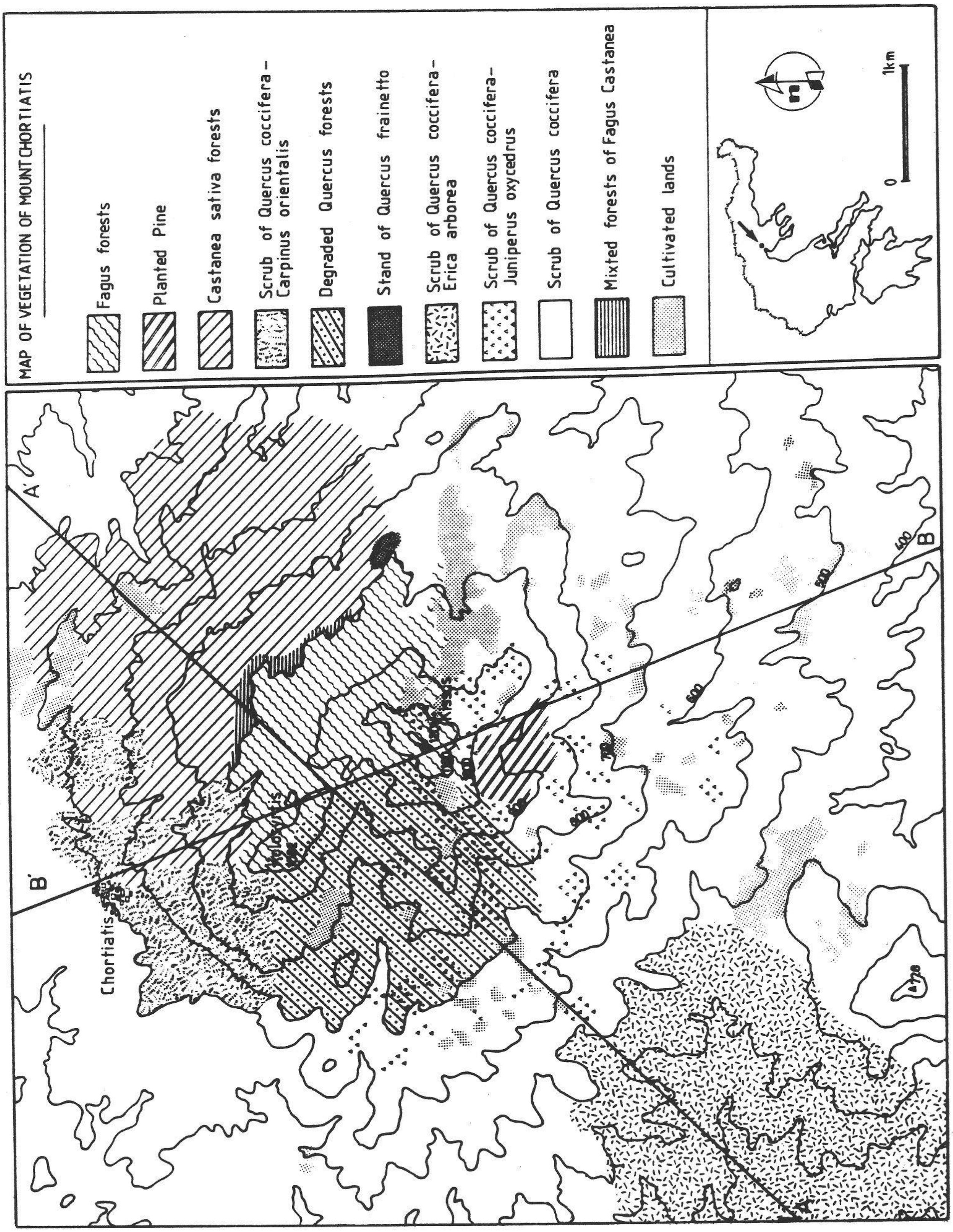

Fig. 1. Map of vegetation of Mount Chortiatis.

Table 1. Phytosociological table of forest *Fagus moesiaca*

Number of sampling plots	2	17	19	22	7	13	14	6	21	8	4	20	1	11	15	18	5	16	9	10	12	3	23	24	25	Constancy	C/max. constancy
Altitude	1050	950	1050	980	1050	950	1100	1000	900	1020	1100	1000	1000	1040	1030	920	1050	1000	900	1010	1040	1000	1000	850	800		
Exposition	NW	NE	NW	NW	N	NE	NE	N	N	NW	NE	N	NE	NE	E	W	N	NE	NE	NE	E	NW	NW	SW	SW		
Coverage %	95	60	100	90	100	90	80	80	95	80	100	100	100	95	90	100	70	95	95	90	90	80	80	60	70		
Surface (m^2)	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300		
Vocation %	50	45	45	60	50	40	70	80	60	80	45	50	70	60	80	45	70	70	40	45	70	80	50	35	40		
Number of species	45	47	45	49	36	32	32	36	35	36	32	34	39	23	27	24	23	20	24	15	17	45	41	51	45		
					0[1]						0[2]						0[3]							0[4]			
Fagus moesiaca	4	3	5	3	5	4	4	4	5	4	4	4	5	5	5	4	4	4	5	5	5	2	2	3	3	25	V
Rubus canescens	+	1	.	1	+	1	+	1	+	1	+	+	+	+	+	1	+	+	1	2	+	+	+	+	+	24	V
Rosa arvensis	+	1	+	1	+	+	+	+	.	+	+	+	+	+	+	+	+	+	.	.	.	+	+	1	1	21	V
Crataegus monogyna ssp. *monogyna*	.	+	r	+	.	.	+	.	+	+	+	+	+	.	.	+	.	+	.	.	.	+	+	+	+	15	III
Ilex aquifolium	1	1	.	1	.	r	.	+	+	+	1	+	+	.	.	+	+	.	r	.	.	.	.	+	+	15	III
Juniperus communis ssp. *communis*	.	+	.	1	.	+	.	+	.	.	.	+	.	.	+	+	r	+	.	.	.	2	1	+	+	13	III
Quercus frainetto	.	.	+	.	.	.	r	.	r	.	.	1	.	+	+	.	.	+	+	.	.	+	2	+	.	11	II
Quercus dalechampii	.	+	.	+	.	r	.	.	.	1	.	.	+	.	.	.	.	.	.	r	r	.	.	+	+	9	II
Prunus domestica ssp. *insititia*	.	+	+	+	r	.	.	.	.	.	.	.	+	r	.	.	.	+	.	.	.	.	.	+	+	9	II
Juniperus oxycedrus ssp. *oxycedrus*	.	.	.	+	.	+	.	.	.	+	.	+	+	.	.	.	.	.	.	.	.	.	.	+	.	6	II
Fraxinus ornus	+	.	.	+	.	.	.	.	.	+	.	+	.	.	+	.	.	.	.	.	.	.	.	+	.	6	II
Clematis vitalba	.	r	+	.	.	.	.	+	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	+	5	I
Carpinus orientalis	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	+	.	.	+	.	.	+	4	I
Clematis flammula	.	+	.	.	+	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	3	I
Cornus mas	r	.	.	+	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3	I
Prunus spinosa	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	r	.	3	I
Castanea sativa	.	+	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	I
Lonicera etrusca	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	2	I
Sorbus torminalis	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	2	I
Acer campestre	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	+	2	I
Pyrus amygdaliformis	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	+	2	I
Prunus avium	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	1	I
Salix alba	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	1	I

Primula veris																											
ssp. *columnae*	r	r	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3	I
Cystopteris fragilis	.	+	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3	I
Dryopteris expansa	+	.	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3	I
Symphytum bulbosum	1	.	r	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	4	I
Listera ovata	+	+	.	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	4	I
Angelica silvestris	+	.	+	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	4	I
Stachys silvatica	+	+	.	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	4	I
Scutellaria columnae																											
ssp. *columnae*	1	1	.	+	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	4	I
Melica uniflora	.	+	+	.	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	4	I
Epilobium lanceolatum	.	+	.	.	+	.	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	4	I
Viola tricolor																											
ssp. *macedonica*	+	+	.	.	+	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	4	I
Allium paniculatum	r	+	.	+	.	.	+	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	5	II
Stellaria nemorum	+	.	+	+	.	.	+	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	5	I
Carex flacca																											
ssp. *serrulata*	.	.	.	+	.	+	+	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	5	I
Silene vulgaris																											
ssp. *commutata*	.	+	.	+	.	.	+	.	r	.	.	.	+	1	.	.	.	.	.	.	.	.	.	.	.	6	II
Neottia nidus-avis	+	.	+	.	1	.	.	+	r	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	6	I
Ajuga reptans	.	+	.	+	.	+	+	.	+	.	r	.	r	.	.	+	.	.	.	.	.	.	.	r	.	9	II
Geum urbanum	1	.	.	.	.	.	r	+	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	4	I
Sanicula europaea	.	.	+	.	+	.	+	.	.	+	+	.	+	.	.	.	.	.	.	.	.	.	.	.	.	6	I
Galium odoratum	+	.	r	.	.	.	+	.	+	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	5	I
Epipactis latifolia	.	.	+	.	.	.	.	.	+	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	4	I
Geranium robertianum	+	.	.	+	+	.	.	+	.	.	+	.	+	.	.	.	.	.	.	.	.	.	.	1	.	6	II
Hedera helix ssp. *helix*	.	1	1	1	.	+	.	.	2	+	+	+	.	2	.	.	.	.	.	.	.	.	.	.	.	9	II
Campanula trachelium																											
ssp. *athoa*	+	+	+	.	.	+	+	+	+	+	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	10	II
Cardamine bulbifera	+	.	+	.	.	+	.	+	1	+	.	1	1	.	.	.	.	.	.	.	.	1	.	.	.	8	II
Polygonatum odoratum	+	.	+	.	r	.	.	1	1	.	1	1	1	.	.	.	.	.	.	.	.	.	.	.	.	8	II
Cyclamen hederifolium	.	1	1	1	.	1	r	1	.	1	.	+	.	.	.	+	.	.	.	.	.	.	.	+	.	9	II
Mycelis muralis	+	+	1	.	+	.	+	.	+	1	.	+	.	+	.	.	+	.	+	.	.	.	.	.	.	11	III
Prunella laciniata	.	.	.	r	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	1	1	+	+	6	I
Thymus sibthorbii	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	+	.	1	1	+	+	6	II
Genista carinalis	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	+	1	3	2	1	5	I
Hieracium bauhinii	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	1	1	1	1	5	I
Anthemis tinctoria																											
ssp. *tinctoria*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	+	+	+	+	5	I
Anthoxanthum odoratum	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	1	1	1	1	5	I
Teucrium chamaedrys	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	+	+	5	I
Orchis morio ssp. *morio*	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	+	1	.	+	4	I
Agrostis stolonifera	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	+	+	4	I
Poa bulbosa	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	+	.	.	.	.	.	.	+	+	.	4	I

Table 1 (continued)

Number of sampling plots	2	17	19	22	7	13	14	6	21	8	4	20	1	11	15	18	5	16	9	10	12	3	23	24	25	Constancy	C/max. constancy
Altitude	1050	950	1050	980	1050	950	1100	1000	900	1020	1100	1000	1000	1040	1030	920	1050	1000	900	1010	1040	1000	1000	850	800		
Exposition	NW	NE	NW	NW	N	NE	NE	N	N	NW	NE	N	NE	NE	E	W	N	NE	NE	NE	E	NW	NW	SW	SW		
Coverage %	95	60	100	90	100	90	80	80	95	80	100	100	100	95	90	100	70	95	95	90	90	80	80	60	70		
Surface (m^2)	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300		
Vocation %	50	45	45	60	50	40	70	80	60	80	45	50	70	60	80	45	70	70	40	45	70	80	50	35	40		
Number of species	45	47	45	49	36	32	32	36	35	36	32	34	39	23	27	24	23	20	24	15	17	45	41	51	45		
					0^1						0^2						0^3							0^4			
Pteridium aquilinum ssp. *aquilinum*	1	2	1	1	1	1	2	1	+	1	+	+	1	2	1	1	1	+	1	1	1	1	1	+	+	25	V
Poa nemoralis	+	r	.	+	.	+	.	+	1	1	1	1	+	+	+	+	+	+	+	+	+	+	.	1	1	21	IV
Helleborus cyclophyllus	+	+	+	+	+	+	+	+	+	+	+	+	+	.	+	.	+	.	.	.	.	1	1	+	+	19	IV
Veronica chamaedrys	.	+	+	+	+	+	+	+	+	.	+	.	+	.	+	+	+	+	+	.	+	+	+	+	.	19	IV
Aremonia agrimonoides	1	+	1	.	1	r	1	1	.	1	+	+	.	+	1	r	+	+	.	r	1	.	.	.	+	18	IV
Fragaria vesca	1	1	+	1	1	.	1	.	.	1	+	+	1	r	.	r	.	.	r	r	.	1	1	+	+	18	IV
Viola reichenbachiana	1	1	r	1	.	1	.	1	+	1	+	+	1	.	+	1	1	1	r	.	.	+	+	.	.	18	IV
Lapsana communis	+	+	+	+	+	.	1	1	.	1	.	1	+	.	1	.	1	.	.	+	1	.	1	+	.	16	IV
Doronicum orientale	r	.	1	.	.	1	.	1	1	.	1	1	.	r	.	.	.	.	1	+	1	1	1	+	+	15	III
Dactylis glomerata	.	1	.	1	1	.	+	.	.	+	.	.	1	1	.	+	+	.	.	1	.	1	1	1	1	14	III
Festuca heterophylla	.	+	r	.	1	1	1	.	+	+	.	1	+	.	.	1	.	.	+	.	r	.	1	+	.	14	III
Luzula forsteri	.	+	.	+	.	.	+	.	+	.	+	.	+	+	+	.	+	.	+	.	+	.	+	+	+	14	III
Galium rotundifolium	.	+	+	.	+	.	+	.	.	2	+	.	+	.	.	.	+	.	+	.	+	.	+	+	2	13	III
Clinopodium vulgare ssp. *vulgare*	+	.	+	.	.	+	.	+	.	+	.	+	.	.	+	.	.	+	.	+	.	+	.	+	+	12	III
Lathyrus laxiflorus	r	.	.	+	.	.	+	+	.	+	.	+	.	2	+	.	.	.	+	.	.	+	+	.	.	11	III
Luzula silvatica	.	+	+	.	.	+	.	+	.	.	.	.	+	.	+	.	+	.	+	.	+	.	+	.	+	11	III
Thalictrum aquilegifolium	.	.	.	.	+	.	.	.	.	.	.	+	.	+	.	+	.	+	.	+	.	+	.	+	+	9	II
Hieracium crinitum	.	.	r	.	.	.	.	+	.	.	+	.	.	.	r	.	.	+	.	.	+	.	+	+	+	9	II
Hieracium murorum agg.	.	+	.	+	.	+	.	.	.	+	.	.	.	+	.	.	+	.	1	.	.	.	+	.	.	8	II
Brachypodium silvaticum	.	.	.	+	.	.	+	.	.	.	+	.	+	.	.	+	.	.	+	.	.	+	.	.	.	7	II
Veronica serpyllifolia	.	.	+	.	.	.	r	.	+	.	.	.	.	.	+	.	.	.	+	.	.	.	.	+	+	7	II
Asplenium adiantum-nigrum	.	.	.	.	.	.	.	.	r	.	.	.	.	.	r	.	.	+	.	r	.	+	r	.	+	7	II
Silene italica ssp. *italica*	r	.	.	.	.	.	.	.	.	r	.	+	.	.	.	.	+	.	.	.	1	.	1	.	r	7	II
Myosotis silvatica ssp. *cyanea*	.	.	.	.	.	+	.	+	.	.	+	.	.	.	+	.	.	.	.	+	+	.	.	+	.	7	II
Galium verum ssp. *verum*	.	+	+	.	+	.	.	.	.	.	.	+	.	2	.	.	.	.	.	.	.	.	.	+	+	7	II
Lathyrus venetus	+	.	.	1	.	.	1	.	.	r	.	.	1	.	.	.	.	.	.	1	.	1	.	.	.	7	II
Verbascum nigrum ssp. *abietinum*	+	.	+	.	.	.	.	+	.	+	.	.	.	.	+	.	.	.	.	.	.	+	.	.	.	6	II
Lychnis coronaria	.	+	.	.	1	.	.	.	.	.	.	.	.	.	+	.	+	.	.	.	.	.	.	+	+	6	I

Campanula persicifolia ssp. *persicifolia*	.	.	.	r	.	.	.	.	+	.	.	.	+	.	.	.	.	+	.	.	.	.	+	.	.	5	I
Platanthera bifolia	.	.	.	+	.	.	.	.	+	+	+	.	.	.	.	.	.	.	.	.	.	+	.	.	.	5	I
Polypodium vulgare	.	.	r	.	.	.	.	.	.	.	+	.	.	+	.	.	.	.	+	.	.	r	.	.	.	5	I
Veronica officinalis	.	.	.	.	+	+	.	.	.	+	.	.	.	r	.	.	+	.	.	.	.	.	.	.	.	5	I
Digitalis viridiflora	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	+	.	.	.	.	.	.	+	+	.	4	I
Platanthera chlorantha	+	.	r	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	4	I
Lamium garganicum ssp. *garganicum*	.	.	r	.	1	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	+	.	.	4	I
Rubus hirtus	.	r	.	.	.	.	.	.	.	.	r	.	.	.	+	.	.	.	.	.	.	.	.	+	.	4	I
Rumex acetosella ssp. *acetosella*	.	.	.	.	.	.	.	1	.	.	.	.	+	.	1	.	.	.	.	.	.	.	.	+	.	4	I
Trifolium alpestre	.	.	.	r	.	.	.	+	.	.	.	.	.	.	.	+	.	.	.	.	.	+	.	.	.	4	I
Primula vulgaris	.	+	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	+	4	I
Trifolium medium ssp. *balcanicum*	+	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	.	4	I
Vicia tenuifolia ssp. *dalmatica*	+	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	1	4	I
Trifolium pignantii	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	r	.	3	I
Origanum vulgare ssp. *vulgare*	.	.	.	.	.	.	r	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	+	.	3	I
Cephalanthera damasonium	.	.	.	+	.	.	.	.	.	+	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	3	I
Galium aparine	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	+	.	+	3	I
Hypericum perforatum ssp. *angustifolium*	+	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	3	I
Achillea coarctata	.	.	.	.	.	+	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	+	.	.	.	3	I

Senecio jacobaea r (22), + (18), *Digitalis laevigata* + (4, 25), *Limodorum abortivum* r (4, 3), *Prenanthes purpurea* + (7, 16), *Calystegia sepium* r (7, 3), *Sedum cepaea* + (19, 4), *Ranunculus millefoliatus* r (17, 18), *Bromus* sp. + (9, 24), *Vicia hirsuta* r (22, 1), *Potentilla argentea* + (17, 23), *Lysimachia punctata* + (2, 3), *Melissa officinalis* + (5, 3), *Lilium martagon* r (17, 20), *Stachys plumosa* + (3), *Asplenium onopteris r* (13), *Carex divulsa* ssp. *divulsa* + (2), *Arabis turrita* + (4), *Festuca valesiaca* + (5), *Mercurialis perennis* + (7), *Aira caryophyllea* + (23), *Poa trivialis* + (25), *Arrhenatherum elatius* + (19), *Cardamine graeca* + (6), *Calamagrostis varia* + (8), *Muscari comosum* + (20), *Aegopodium podagraria* + (9), *Arum italicum* + (1), *Alyssum montanum* + (22), *Mentha longifolia* + (11), *Dactylorhiza maculata* r (20), *Cynosurus echinatus* + (19), *Phlomis samia* + (22), *Moehringia trinervia* + (17), *Buglossoides purpurocaerulea* + (2), *Ceterach officinarum* + (8), *Ophrys scolopax* ssp. *cornuta* 1 (24), *Geranium silvaticum* + (16), *Plantago lanceolata* + (15), *Alliaria officinalis* 1 (18), *Chaerophyllum temulentum* + (20), etc.

Table 2. Plant-sociological units and respective site types in the beech zone of Mount Chortiatis.

Unit	Group of plant indices	Site quality
0^1	a (b) (c)	II
0^2	(a) b (c)	III
0^3	(b) (c)	IV
0^4	(b) C*	V

* The group of plant indices is written with a capital letter when the species belonging to this unit have an occurrence >50%; with a small letter when they have an occurrence 50–20% and with a small letter included in parentheses when they have an occurrence less than 20%.

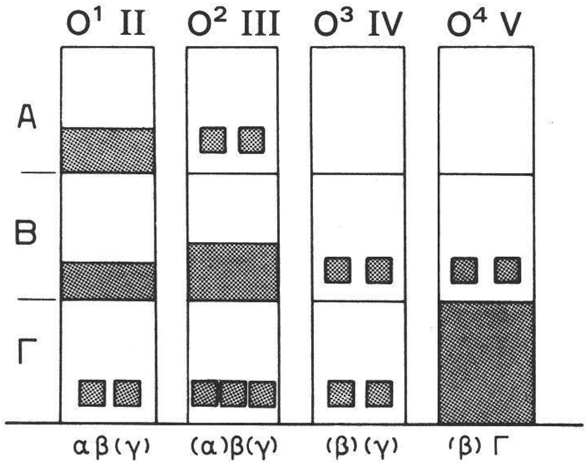

Fig. 2. Mean soil-coverage degree of plant-index groups in the plant-sociological units being separated.

Chortiatis, where the natural vegetation has been disturbed, the coefficient of similarity (Ellenberg 1956, Dierschke 1974, Smyris 1980) of the beech zone, in comparison with other vegetation zones, was found to be 32.09–42.5% (Karagiannakidou, 1983).

Unit 0^1. Plant-index groups a (b) (c). Site quality II

Spreading-Physiognomy: This unit is found on the N, NE and NW sides, covering a fairly large area of the highest peak, Kissos. The subvegetation is limited to the voids and in places where the canopy has been dispersed. The species of groups A and B are plentiful, whereas the species of group C are rare. As differentiating species of the other units of the beech zone we may consider those of group A, which do not appear in the other groups; however, as shown in Table 1, species of groups A and B dominate physiognomically in this unit. The shrubby species *Ilex aquifolium*, *Quercus dalechampii*, *Crataegus monogyna* ssp. *monogyna* often appear, while as accompanying species there are plenty of *Ptericium aquilinum*, *Poa nemoralis*, *Veronica chamaedrys* etc. Of the cryptogams, the bryophytes grow abundantly (Ganiatsas 1938).

Soil: The soil of type II belong to the brown-red forest soils is deep to very deep, slightly argillaceous to argillaceous-sandy with a relatively thick humic horizon, rich in nitrogen (N) and in acid, with a large depth of roots (about 1 m) and an intense biological activity (Table 3).

Table 3. Results of soil analysis in beech forests of Mount Chortiatis.

Phyto-sociological units	Soil horizons	Texture %			Classification	Sediment 1:1 Soil:water	Sediment 1:2,5 Soil:1NKCl	Classification	Organic substance	
		sand	clay	argil					Humus %	N %
0^1	A_1	65	27	8	Sand argillaceous	6.6	6.1	Slightly acid	10.32	0.374
	$2A_1$	30	44	26	Slightly argillaceous	6.0	5.0	Acid	3.03	0.098
	B_1	52	23	25	Slightly argillaceous	5.8	4.7	Acid	0.84	0.028
	B_2	49	39	12	Sand argillaceous	6.5	5.1	Acid	0.07	0.027
0^2	A_1	48	35	17	Argillaceous sandy	6.2	5.6	Slightly acid	13.42	0.309
	$2A_1$	52	36	18	Argillaceous sandy	6.2	5.6	Slightly acid	2.55	0.066
	B	41	44	15	Sand argillaceous	5.7	4.3	Strongly acid	0.2	0.003
0^3	A_1	60	27	13	Sand argillaceous	7.1	6.6	Neutral	9.80	0.147
	$2A_1$	51	35	14	Sand argillaceous	7.5	6.6	Neutral	3.47	0.048
	B	52	32	16	Argillaceous sandy	7.2	6.4	Slightly acid	1.75	0.017
0^4	A_1	56	30	14	Sand argillaceous	6.3	5.5	Acid	4.44	0.122
	$2A_1$	56	30	14	Sand argillaceous	6.2	5.4	Acid	2.00	0.060
	B	73	24	3	Sand argillaceous	6.5	5.2	Acid	0.53	0.042

The bedrock is of the magmatic course of Mt. Chortiatis (gneiss).

Stand description: Within this unit, the beech trees approach their ecological optimum. The beech stands are irregular, almost closed, where all forms appear; from those of same age up to group selection system. Trees have an average height of 12–15 m at an age of 47 years having grown after the fire of 1941 and after the uncontrolled felling during the German occupation. The coppice shoots are irregularly allocated and their bunches are non-uniform. Tree trunks are straight and free of branches up to a height of 10 m, are of medium size, with a complete dominance by small-diameter individuals. There is no natural regeneration and the subvegetation appears intense wherever the stands are slack. Beech trees have a coverage rate of 80–100%. The shrub floor presents a smaller coverage rate of 5–15% and the coverage rate of subvegetation is small, too (30–50%).

Unit 0^2. Plant-index groups (a) (b) (c). Site quality III

Spreading-Physiognomy: This unit appears on the N, NW and NE side of the mountain and covers a relatively small area on Kissos summit and a larger area on Kolosyrtis summit. The subvegetation appears intense where the canopy is broken off and where there are stands of an older age and voids.

From the plant-index groups the species of group B appear or occur in abundance, whereas some species of group C appear occasionally in the well-lit parts. Unit 0^2 differs from the previous group 0^1, in that no plants of group A occur in it. 0^2 also differs from the following two groups 0^3 and 0^4, because no species of the plant-index group B occur in them. Generally, plants of groups A and B are not in great need of high temperatures, but have high demands for moisture and soil fertility. In these groups the following species have the greatest abundance-coverage: *Cardamine bulbifera*, *Hedera helix*, *Polygonatum odoratum* etc. *Neottia nidus-avis, Geum urbanum*, etc., are also found in abundance here, while *Thymus sibthorbii*, *Hieracium bauhinii*, etc. are encountered occasionally wherever there is light.

Ilex aquifolium, *Rubus canescens*, *Rosa arvensis* often occur in the shrub floor. *Castanea sativa* is encountered at altitudes of 850–900 m, and in the upper floor it is mixing with beech.

This unit is characterized by the appearance of subvegetation within the voids and wherever the canopy is broken off. These places are quickly covered by *Pteridium aquilinum* and *Rubus canescens*. The appearance of sporadic xerophytic species of group C shows that the site conditions have deteriorated in many places.

Soil: The soil is deep to very deep, with a very thick humic horizon. It belongs to the brown-red forest soils and is sand-argillaceous, argillaceous-sandy, with an intense biological activity. Large amounts of organic matter, nitrogen and good natural properties have been measured (Table 3).

Stand description: Here also, the beech stands are dense, but fewer in comparison with those in 0^1. All structure forms are presented here; from those of same age up to the irregular group selection system. The quality of trunks is lower than in 0^1, the coppice shoots are 10 m high and irregularly allocated with a vague superiority by the thinner ones. The soil coverage on the upper floor ranges from 80–100%. On the shrub floor the coverage rate is kept low (5–15%) in contrast to the coverage rate by herbaceous vegetation, which is higher in relation to the previous unit.

Unit 0^3. Plant index groups (b) (c). Site quality IV

Spreading-Physiognomy: It occurs on smooth ridges of the E, W and SE sides and on the NE, NW sides which have been eroded. *Quercus frainetto* and *Q. petraea* sporadically appear on the upper floor. Among the shrubby species most abundantly found are: Ilex aquifolium, Juniperus communis ssp. *communis* and occasionally *Prunus* sp. *Pyrus amygdaliformis* etc.

Unit 0^3 is clearly different from the units 0^3, 0^2 and 0^4 because it lacks the plant-index groups; of these, group A is entirely absent while B and C may be characterized as newly appearing groups with a degree less than I (Athanasiadis 1978).

It may be characterized as an atypical unit the young age of which, along with its abundant litter, makes the growth of herbaceous vegetation difficult. On the contrary, the abundant occurrence of *Rubus canescens* and *Rosa arvensis* in the sunny spots, along with the sporadic appearance of *Mycelis muralis*, *Trifolium alpestre*, *Campanula trachelium*, encompass with the above its whole description. From the accompanying plants the following are encountered, however not abundantly: *Festuca heterophylla*, *Hieracium piloselloides*, *Veronica chamaedrys*, etc.

Soil: The soil of this unit is deep to medium deep, sand argillaceous with a relatively thick humic horizon, a weak loam concentration and an intense biological activity; it belongs to the brown-red neutral soils. The bedrock consists of schists and gneiss.

Stand description: As in unit 0^2, the stands here have the same structure, being closed, with an average height of 10 m at an age of 47 years. The individuals are thin with non-straight trunks. In many places the deforestation is so intense that it favours the growth of herbaceous grassplant vegetation which has within the voids a soil coverage rate of 80–100%. The shrub floor has a coverage rate of 15–30% where the growth of *Juniperus oxycedrus*, *Rubus* sp., *Crataegus monogyna* etc. is particularly favoured.

Unit 0^4. Plant-index groups (b) c. Site quality V

Spreading-Physiognomy: It occurs on the W and NW sides where the soil has been eroded. From the plant-indices all species of group C appear, while sporadically, very few species of group B are found. The plants of group C require warmer temperatures and less moisture than plants of groups A and B. 0^4 is distinguished from the other units by the abundance of plants in group C and by the absence of the other plant-indices. In the shrub floor the following species appear: *Juniperus oxycedrus* ssp. *oxycedrus*, *Quercus frainetto*, *Crataegus monogyna* ssp. *monogyna*, etc. Except for the accompanying species, which are abundant but with a small abundance-coverage (*Pteridium aquilinum*, *Poa nemoralis* etc.), there are plants of group B (*Geranium robertianum*, *Cardamine bulbifera* etc. see Table 1) which occur rarely with a scattered distribution.

Soil: The soil is shallow to medium deep, with a smaller depth and smaller thick humic horizon, less humus and nitrogen and a reduced biological activity; it belongs to the acid brown-red forest soils. The bedrock consists of schists and gneiss.

Stand description: The structure of the stands is varied, resembling the one in unit 0^3. Their qualitative composition is medium to bad, with a relatively smaller height and with more irregular trunks.

Discussion and conclusions

The beech species which compose the unmixed beech woods in Greece, are *Fagus orientalis*, *Fagus moesiaca* (two forms were identified, *spatulolepsis* and *tainiolepis*), and *Fagus silvatica*. The limits of the horizontal and vertical distribution of these three species in Greece cannot be drawn by a sharp line because the horizontal and vertical transition from one species to the other is taking place gradually; this phenomenon, which is related to the ecological environment, is determined by different factors, i.e. aspect etc. (Moulopoulos 1965, Mattfeld 1936). One distinctive site of *Fagus moesiaca* and *F. orientalis* with ecological demands has been separated (Grebenscikov 1938, Quezel et Pamukouǒlu 1969, Moulopoulos 1965). According to Dafis (1969) the beech forests in Greece can be vertically distinguished into three types of characteristic species: Fagetum submontanum (900–950 m, *F. orientalis* or *F. moesiacia* f. *spatulolepis*), Fagetum montanum (900–1600 m, *Fagus moesiaca* f. *tainiolepis*), and Fagetum subalpinum (1600–1800 m, *Fagus silvatica* or *Fagus moesiaca*). According to Raus (1980), this distinction of beech forests in Greece could become problematic without the assistance of additional characteristic species. In his opinion, a distinction of these very basic units from more independent associations in a broader basis of plant-sociological material was necessary. Thus, the associations of the Pindos and Voras ranges (Quezel et Contandriopoulos 1965, Quezel 1967, Smyris 1980), as well as their systematic position could further be considered, an opinion we have also agreed with. Strid in Mountain Flora of Greece (1986) distinguishes in *Fagus only* two subspecies: *F. silvatica* ssp. *silvatica* (incl. *F. moesiaca*) and *F. silvatica* ssp. *orientalis*. According to him, some individual trees in Greece, especially in the northeastern parts resemble ssp. *orientalis* in vegetative characters but never have delated cupula scales. Such trees (often called *F. moesiaca*) tend to grow at relatively low altitudes (200–1000 m) whereas the typical ssp. *silvatica* is mainly found in the western and central district and rarely below 1000 m. Sub-species *silvatica* and ssp. *orientalis* are in fact typical geographical races having a broad range of intermediates in the zone of contact.

The beech forests of Mt. Chortiatis above 800 m (Table 1, measurements 1–25) do not include beeches with characteristics of *F. orientalis*. *Fagus moesiaca* f. *tainiolepis* forms unmixed closed stands, 15 m high, in the best sites. The soil is characterized as acid brown-red and below a layer of 2–5 cm of decomposed litter there is a black humic horizon of 5–10 cm. The depth varies depending on the orographic condition of the site.

The herbaceous vegetation mainly consists of spring and numerous summer species which are found in well-lit places where favourable conditions are created (Table 1). In fact, in the slack stands at low altitudes (Kolosyrtis top), more undergrowths (substories) are encountered. On the contrary, at better sites, where the stands are dense (Kissos top) the herbaceous plants are limited to some spring and to a few shade species such as *Cardamine bulbifera*, *Galanthus elwesii* ssp. *minor*, *Cotyledon umbilicus*, *Arum maculatum*, *Platantherea chlorantha*, *Coeloglossum viride*, *Limodorum abortivum* etc. The growth of species with a horizontal creeping rooting system is also favoured (*Neottia nidus-avis*, *Cephalanthera longifolia*, *Listera ovata* etc., Karagiannakidou 1983). Various other bryophytes species, appear, too (Ganiatsas, 1938).

Depending on the soil moisture, the existing degradation, and the site humic form, we have encountered different forms of beech forests. Very humid conditions are absent in our region. A range of demanding species (see Table 1, measurements 1–20) is limited to generally good sites, but poor in bases. Due to the slackness of stands and the large degree of degradation, the site type of Fagetum nudum (Walter 1975) is absent from our region, but it is found in East Thessaly (Raus 1980).

A characteristic feature of the beech forests of the Chortiatis region is the relatively large contribution by the species Quercetalia pubescentis and Quercion frainetto-cerris, a fact which is also pointed out by Raus (1980) for the forests of East Thessaly.

The exploitation of the beech forests for wood is in the hands of the local authorities, and wood is taken mainly for fuel. The forest was burnt twice in the past. Therefore, instead of tall beech forests we find old stumps and low forests which have the potential to regenerate in a short time period.

The beech forests in Greece have not all been plant-sociologically investigated. A Fagus site research has been conducted in central and northwestern Greece by Dafis (1969) and Smyris (1980) in the district of the Voras. Horvat et al. (1974) described the following two forest associations of *Fagus moesiaca* in SE Europa: 1. Beech forests in rich calcareous soils (Galio-Fagetum moesiacum) and 2. Mountainous beech forests in acid soils (Luzulo-Fagetum moesiacum). Zoller et al. (1977) found that in the northern mountain ranges of Greece the following mid-european alliances of beech forests were encountered: (Cephalanthero-Fagion, Cardamine-Fagion, Galio odorati-Fagion, Luzulo-Fagion). For the beech forests of Eastern Thessaly (Raus, 1980) the alliances Doronico orientalis-Fagion moesiacae, *Fagus moesiaca*, *Quercus frainetto-Fagus*, *Vaccinium myrtillus-Fagus*, *Abies borisii regis-Fagus*, were distinguished. Smyris (1980) referring to beech forests of Voras confirms that the forest units of *Fagus silvatica* belong to the association Galio odorati-Fagetum montanum hellenicum and distinguishes in it one group rich in species and one poor.

By the analysis of Chortiatis vegetation in the beech zone we have found that 0^1 is distinguished from 0^2, as well as from the other two units, by the presence of differentiating plants of plant-index group A, such as: *Primula veris*, *Cystopteris fragilis*, *Listera ovata*, *Angelica silvestris*, *Stachys silvatica*, *Melica uniflora*. In comparison to 0^1, 0^2 does not include any independently differentiating species. Unit 0^3 (atypical unit) is very poor in demanding species and only a few individual species occur, such as: *Campanula trachelium*, *Cyclamen hederifolium*. The low number of demanding species is possibly due to the young age of the stands, the growth of which is impeded by the litter they create. Based on the worst soil conditions, 0^4 is mostly characterized as poor, since the species of group C found in it are more or less xerophytic which render it different from the other units. This can be explained by the fact that, on one hand, the reserves of nutrients available to this unit are lower, and, on the other, that the moisture conditions along with the natural properties of the soil, etc., mainly on the meridional slopes, are not favourable. In addition, the appearance of *Anthoxanthum odoratum*, *Thymus sibthorpii*, etc. in our region, confirms the view of Dafis (1969) that these species may be considered as indices of a drywarm environment.

Geographically differentiating species of the beech zone in the Chortiatis area, in relation to the units of beech of Central and NW Greece (Dafis 1969) are many, such as *Angelica silvestris*, *Ajuga reptans*, *Listera ovata*, *Digitalis lanata*, *Silene vulgaris* etc. In the region of Voras where Smyris (1980) conducted his research, the most prevalent species encountered is *Fagus silvatica*; on Chortiatis as well as in Central and NW Greece (Dafis 1969), the prevalent species is *Fagus moesiaca*. Comparing the species of the Chortiatis beech zone to the respective species of the beech zone of Voras, Central and NW Greece, we notice that on Chortiatis we have a decrease in demanding species, especially with respect to the area of Voras, and an increase of xerophytic species. This can be explained by the fact that the region of Chortiatis has a drier climate in comparison to that of Voras and the northern mountain ranges, a lower altitude, and is more influenced by man, being closer to populated areas.

From a plant sociological aspect, a large number of species are those typical of the association Luzulo-Fagetum (Oberdorfer 1957, Ellenberg 1963, Soo 1964, Horvat et al. 1974) and the Cardamino-Fagion, Galio odorati-Fagion, Cephalanthero-Fagion alliances (Zoller et al. 1977).

The soil research of the beech zone of our region, (Table 3) has also verified the close relationship between soil and vegetation. Wherever the demanding species appear, the soils are characterized by a higher availability of nutrients and better natural conditions. Moreover, the numbering of the forest types (II, III, IV, V) describes at the same time an ecological series with a decrease of nutrients. With respect to the content of N, the site qualities II and III are rich, whereas IV and V may be characterized as poorer. A similar relationship also occurs for organic matter. In comparison to the corresponding site qualities of Voras (Smyris 1980) the rates of N% are lower in our region; this is explained by the longer summer drought on Chortiatis which transiently destroys the microorganisms of the soil, in contrast to the region of Voras. With respect to the site qualities of Central and NW Greece (Dafis 1969) we have few differences, except that site quality I is entirely absent from Chortiatis. In our opinion, this is probably due to deterioration and soil degradation. The pH values of the beech zone soils, where our research was carried out, range from 5.5 to 6.1 not showing significant differences among the site qualities, and neither in relation to the depth of the soil. In addition, the pH values in the sites of *Fagus moesiaca* in Greece, range between 5–6, rarely dropping below 5 in very poor soil. Regel (1943) reports for Chortiatis (Fagetum ca. 900 m) a pH value from 6.0 to 6.5 and Alexandris (Panagiotopoulos 1979) in his soil study of the Chortiatis region characterizes them as acid brown-red forest soils with pH values 6.1 and 6.4.

I should like to thank Prof. S. Dafis for his help during the research stage, and Mr. Gr. Alexandris for the preparation of the figures. The English language was corrected by Dr. C. M. Cook and Prof. Dr. H. R. Hohl.

References

Alexiadis K. 1972. Natural and chemical analysis of the soil. Thessaloniki (Greek).

Athanasiadis N. 1978. Forest phytosociology. Thessaloniki (Greek).

Braun-Blanquet J. 1964. Pflanzensoziologie. Grundzüge der Vegetationskunde. Springer, Wien, New York.

Critchfield H. J. 1974. General climatology, 3rd ed. Prentice-Hall. Inc. Englewood Clitts N.J.

Dafis S. 1966. Standorts- und ertragskundliche Untersuchungen in Eichen- und Kastaniennieder-wäldern der nordöstlichen Chalkidiki. Aristotel. Univ. Thessaloniki, 120 S. Thessalokini (Greek).

Dafis S. 1969. Standortskundliche Untersuchungen in Buchenwäldern. Epist. Epet. Geopon. Dasol. Shol. Panepist. Thessalonikes 13: 1–48. Thessaloniki (Greek).

Dierschke H. 1974. Saumgesellschaften im Vegetations- und Standortsgefälle an Waldrändern. Scripta Geobot. 6. Goltze KG, Göttingen.

Ellenberg H. 1956. Aufgaben und Methoden der Vegetationskunde (in H. Walter (ed.): Einführung in die Phytologie, Bd. IV, Teil 1). Ulmer, Stuttgart.

Ellenberg H. 1963. Vegetation Mitteleuropas mit den Alpen (Einführung in die Phytologie von H. Walter, IV, 2). Ulmer, Stuttgart.

Ellenberg H. 1979. Indicator values of vascular plants in Central Europe. Scripta Geobot. 9. 2nd ed. Göttingen.

Ganiatsas K. 1938. Untersuchungen zur Flora des Chortiatis-Gebirges. Sc. Annals, Fac. Phy. & Math. Univ. Thessaloniki 5: 5–34 (Greek).

Grebenscikov D. 1938. On the occurrence of *Fagus orientalis* in Greece. Kew Bulletin Misc. Inform. 38–45.
Horvat I., Glavac V. und Ellenberg H. 1974. Vegetation Südosteuropas. Jena, 768 S.
Karagiannakidou V. 1983. Untersuchungen in der Querco-Fagetea-Zone des Chortiatis-Gebirges. (Diss.). Sci. Annals, Fac. Phys. & Math. Univ. Thessaloniki 22 (5): 1–161 (Greek).
Karagiannakidou V. 1988. Floristische Zusammensetzung und pflanzengeographische Analyse der Vegetationszonen des Massivs Chortiatis in Nordostgriechenland. Abstracta Botanica 12: 163–182.
Kockel F., Mollat H. und Walther H. 1977. Erläuterungen zur Geologischen Karte der Chalkidiki und angrenzender Gebiete 1:100 000 (Nord-Griechenland). Bundesanstalt für Geowissenschaften und Rohstoffe. Erl., 1195, 4 Abb., 5 Tab., 1 Taf., Hannover.
Mattfeld W. 1936. Die Buchen der Chalkidiki. Izv. Bulg. Bot. Druz. 7: 63–73.
Moulopoulos H. 1965. Die Buchenwälder Griechenlands. Epist. Epet Geopon. Dasol. Schol. Panempist. Thessaloniki (Greek).
Oberdorfer E. 1957. Süddeutsche Pflanzengesellschaften. Pflanzensoziologie 10. Jena, 564 S.
Panagiotopoulos N. 1979. Study of replanting of the large district of Thessaloniki (Greek).
Papamichos N. 1979. Forest edaphology. Thessaloniki (Greek).
Ponita N. et al. 1977. Ecologie Forestiera. Bucuresti.
Quezel P. 1967. A propos de quelques hêtraies de Macédoine grecque. Bull. Soc. Bot. France 114: 5–6, 200–210.
Quezel P. et Contandriopoulos J. 1965. A propos de la végétation des forêts de hêtres dans le Massif du Pinde. Bull. Soc. Bot. France 112: 5–6, 312–319.
Quezel P. et Pamukcuoğlu A. 1969. Etude phytosociologique des forêts d' *Abies equi-trojani* et de *Fagus orientalis* du Kaz Dag. Ann. Fac. Sci. Marseille ser. 2, 42: 145–151.
Raus Th. 1979. Die Vegetation Ostthessaliens (Griechenland). I. Vegetationszonen und Höhenstufen. Bot. Jahrb. Syst. 100: 564–601.
Raus Th. 1980. Die Vegetation Ostthessaliens (Griechenland). III. Querco-Fagetea und azonale Gehölzgesellschaften. Bot. Jahrb. Syst. 101: 313–361.
Regel C. 1943. Pflanzengeographische Studien aus Griechenland und Westanatolien. Bot. Jahrb. Syst. 73: 1–98.
Schlenker G. 1950. Forstliche Standortskartierung in Württemberg. Allg. Forstz. 40/41.
Soó R. 1964. Die regionalen Fagion-Verbände und Gesellschaften Südeuropas. Stud. biol. Acad. Sci. Hung. Budapest 1: 1–104.
Smyris P. 1980. Standortskundliche und waldbauliche Untersuchungen von naturnahen Buchenwäldern im Voras-Gebirge (Nordgriechenland). Diss. Göttingen.
Strid A. (ed.) 1986. Mountain Flora of Greece. I. Cambridge Univ. Press.
Strid A. and Tan K. (eds.) 1991. Mountain Flora of Greece. II. Edinburgh Univ. Press.
Tutin T. G. et al. 1964–1980. Flora Europaea Vol. 1–5. Cambridge Univ. Press.
Ulrich B. 1977. Der Boden als Teil des forstlichen Standorts. Ansprache, Klassifikation, Vergesellschaftung. Inst. für Bodenkunde und Waldernährung, Univ. Göttingen.
Walter H. 1975. Betrachtungen zur Höhenstufenfolge im Mediterrangebiet (insbesondere in Griechenland) in Verbindung mit dem Wettbewerbsfaktor. Veröff. Geobot. Inst. ETH, Stiftung Rübel, Zürich 55: 72–83.
Zoller H., Geissler P. & Athanasiadis N. 1977. Beiträge zur Kenntnis der Wälder, Moos- und Flechtenassoziationen in den Gebirgen Nordgriechenlands. Bauhinia 6: 215–255 + 14 Tab. und 5 Fig.