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ΕΛΛΗΝΙΚΟΣ ΓΕΩΡΓΙΚΟΣ ΟΡΓΑΝΙΣΜΟΣ "ΔΗΜΗΤΡΑ"

Institute of Mediterranean Forest Ecosystems
and Forest Product Technology

Conservation of priority forests and forest openings in "Ethnikos Drymos Oitis" and "Oros Kallidromo" of Sterea Ellada
LIFE11 NAT/GR/1014 - "ForOpenForests"

ACTION A.5
Determination of vegetation composition and structure in the mountain grasslands (6210*, 6230*)

DELIVERABLE A.5.1
Mountain grassland composition, structure, and ecology in Mt. Oiti and Mt. Kallidromo

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Ινστιτούτο Μεσογειακών και Δασικών Οικοσυστημάτων

Διατήρηση δασών και ανοιγμάτων προτεραιότητας στον "Εθνικό Δρυμό Οίτης" και στο "Όρος Καλλίδρομο" της Στερεάς Ελλάδας
LIFE11 NAT/GR/1014 - "ForOpenForests"

ΔΡΑΣΗ Α.5
Καθορισμός της σύνθεση και της δομής της βλάστησης των ορεινών λιβαδιών (6210*, 6230*)

ΠΑΡΑΔΟΤΕΟ Α.5.1
Σύνθεση, δομή και οικολογία της βλάστησης των ορεινών λιβαδιών στα όρη Οίτη και Καλλίδρομο

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Table of Contents

SUMMARY

The aim of Action A.5 is the establishment of the base status of the target mountain grassland habitats of Mt. Oiti and Mt. Kallidromo and its relation to ecological factors. The target habitat on Mt Oiti is habitat type 6230*, species rich *Nardus* grasslands, on siliceous substrates in mountain areas. The target habitat on Mt Kallidromo is habitat type 6210, semi-natural dry grasslands and scrubland facies on calcareous substrates (*Festuco-Brometalia*), considered priority if it is an important orchid site. Habitat type 6210 is closely related to habitat type 62A0, eastern sub-Mediterranean *Scorzoneretalia villosae* grasslands. The two habitat types which belong to different orders of the same vegetation class, *Festuco-Brometea*, are not always clearly separated and, a large scale, european level comparative study of the *Festuco-Brometea* is needed for the determination of the most appropriate syntaxonomic model. A total of 8 transects (100 plots) were established at 6 localities of Mt. Oiti and a total of 17 transects (190 plots) were established at 6 localities of Mt. Kallidromo and soil properties of most of the localities were also studied. A total of 254 plant species were identified in the grasslands, 119 on Oiti and 179 on Kallidromo, mostly dry and wet grassland species and also mountain heath species. Synanthropic vegetation species occured mainly on Kallidromo where the invasive species *Xanthium spinosum*, the only alien identified in the grasslands, was also found. Vegetation analysis resulted in 13 vegetation groups, clearly clustered in the higher altitude plots of Oiti and of Gkioza on Kallidromo (groups 1 to 8) and in the lower altitude plots of the other Kallidromo grasslands (groups 9 to 13). Vegetation groups 1, 2, 5, 6, and 7 (Livadies, Alykaina, Greveno, Zapantolakka, and possibly Tourkos) were assigned to habitat type 6230 including transitions to oro-Mediterranean scrub and 6210 grasslands. Vegetation group 3 represents scrub intrusion in the grasslands of Mt. Oiti. Vegetation group 4 at Tsamadaiika was assigned to habitat type 6210 but was also close to habitat type 6230, possibly due to the fact that the substrate is flysch with extended limestone intercalations. Vegetation group 8 (Gkioza) was assigned to habitat type 6210 and hosts the rare species *Orchis pallens*. The position of vegetation group 10 (Souvala, Nevropoli, Isomata, Mourouzos, Mouriza) was not clear but most probably fits in habitat type 62A0. Vegetation groups 12 and 13 were assigned to habitat type 62A0, including transition to wet grasslands of habitat type 6420. Vegetation group 9 (Souvala, Mouriza) was assigned to habitat type 6420, including transition to aquatic *Phragmito-Magnocaricetea* commgroupities. Vegetation group 11 was found at the canal of Souvala and was assigned to habitat type 6420. The vegetation groups with higher species richness were the ones of dry grasslands or of transition to dry grasslands, especially vegetation groups 8, 5, and 10. Evenness, that is the comparative cover of species was generally high, 0.7 and above, and was highest in Oiti plots which represent transition to other vegetation groups or habitats (vegetation groups 4, 5, 6, and 7). Altitude, parent rock (including the water related alluvial substrates), and grazing affect significantly the floristic composition of mountain grasslands. Vegetation group 1 is ecologically clearly separated from all others while vegetation group 8 is clearly separated from all other Kallidromo grasslands. The analysis of the detailed soil propery data showed that altitude, pH, basic element content (exchangable Mg, Ca, base saturation), parent rock, and available Fe and Mn were the factors affecting most the plot and species data.

ΠΕΡΙΛΗΨΗ

Σκοπός της δράσης Α.5 είναι ο καθορισμός της αρχικής κατάστασης των ορεινών λιβαδιών που αποτελούν στόχους του προγράμματος στα όρη Οίτη και Καλλίδρομο και η σχέση αυτής της κατάστασης με οικολογικούς παράγοντες. Ο οικότοπος στόχος στο όρος Οίτη είναι ο τύπος οικοτόπου 6230*, πλούσια σε *Nardus* λιβάδια σε πυριτικά υποστρώματα σε ορεινές περιοχές. Ο οικότοπος στόχος στο όρος Καλλίδρομο είναι ο τύπος οικοτόπου 6210, ημι-φυσικά ξηρά λιβάδια σε ασβεστολιθικά υποστρώματα (*Festuco-Brometalia*), ο οποίος θεωρείται προτεραιότητας εάν αποτελεί σημαντική περιοχή για τις ορχιδέες. Ο τύπος οικοτόπου 6210 συνδέεται στενά με τον τύπο οικοτόπου 62Α0, ανατολικά, υπο-Μεσογειακά λιβάδια των *Scorzoneretalia villosae*. Οι δύο τύποι οικοτόπων που ανήκουν σε διαφορετικές τάξεις της ίδια κλάσης βλάστησης, της *Festuco-Brometea* δεν είναι πάντα εύκολο να διακριθούν μεταξύ τους και απαιτείτε μεγάλης κλίμακας συγκριτική μελέτη σε επίπεδο Ευρώπης προκειμένου να καθοριστεί το καταλληλότερο συνταξινομικό μοντέλο. Συνολικά εγκαταστάθηκαν 8 διατομές (100 δειγματοεπιφάνειες) σε 6 θέσεις του όρους Οίτη και 17 διατομές (190 επιφάνειες) 6 θέσεις του όρους Καλλίδρομο.Στις ίδιες θέσεις μελετήθηκαν οι ιδιότητες του εδάφους. Στο σύνολο των ορεινών λιβαδιών αναγνωρίστηκαν 254 είδη φυτών, 119 είδη στην Οίτη και 179 είδη στο Καλλίδρομο και στην πλειοψηφία τους ήταν είδη ξηρών και υγρών λιβαδιών και είδη ορομεσογειακών θαμνώνων. Τα είδη της συνανθρωπικής βλάστησης ήταν περισσότερα στο Καλλίδρομο, όπου εντοπίστηκε και το *Xanthium spinosum*, το μοναδικό επιγενές είδος των λιβαδιών. Η ανάλυση της βλάστησης κατέληξε σε 13 ομάδες βλάστησης που διαφοροποιήθηκαν καθαρά σε δύο μεγάλες ομάδες, τις δειγματοεπιφάνειες των μεγαλύτερων υψομέτρων της Οίτης (ομάδες βλάστησης 1 έως 8) και της κορυφής Γκιόζα του Καλλιδρόμου και τις δειγματοεπιφάνειες χαμηλότερων υψομέτρων του Καλλιδρόμου (ομάδες βλάστησης 9 έως 13). Οι ομάδες βλάστησης 1, 2, 5, 6 και 7 (Λιβαδιές, Αλύκαινα, Γρεβενό, Ζαπαντόλακκα και ίσως Τούρκος) αντιστοιχούν στον τύπο οικοτόπου 6230, συμπεριλαμβανομένων και των μεταβατικών ζωνών προς τους ορο-Μεσογειακούς θαμνώνες και τα ξηρά λιβάδια του τύπου 6210. Η ομάδα βλάστησης 3 αντιπροσωπεύει την εισβολή θαμνώνων στα ορεινά λιβάδια της Οίτης. Η ομάδα βλάστησης 4, στα Τσαμαδαΐικα, αντιστοιχίστηκε στον τύπο οικοτόπου 6210 αλλά έχει επίσης σχέσεις με τον οικότοπο 6230, πιθανώς λόγω το ότι το υπόστρωμα στη θέση αυτή είναι φλύσχης με ενστρώσεις ασβεστολίθου. Η ομάδα βλάστησης 8 (Γκιόζα) αντιστοιχεί στον οικότοπο 6210 και φιλοξενεί το σπάνιο είδος ορχιδέας *Orchis pallens*. Η θέση της ομάδας βλάστησης 10 (Σουβάλα, Νεβρόπολη, Ισώματα, Μουρούζος, Μουρίζα) δεν ήταν καθαρή αλλά πιθανότατα αντιστοιχεί στον τύπο οικοτόπου 62Α0. Οι ομάδες βλάστησης 12 και 13 αντιστοιχούν στον οικότοπο 62Α0, συμπεριλαμβανομένων των μεταβατικών ζωνών προς τα υγρά λιβάδια του τύπου οικοτόπου 6420. Η ομάδα βλάστησης 9 (Σουβάλα, Μουρίζα) αντιστοιχεί στον τύπο οικοτόπου 6420, συμπεριλαμβανομένης της μετάβασης προς τις υδρόβιες κοινότητες των *Phagmito-Magnocaricetea*. Η ομάδα βλάστησης 11 εντοπίστηκε μόνο στο κανάλι της Σουβάλας και αντιστοιχεί στον τύπο οικοτόπου 6420. Οι ομάδες βλάστησης με τη μεγαλύτερη αφθονία ειδών ήταν εκείνες των ξηρών λιβαδιών ή των μεταβατικών ζωνών προς ξηρά λιβάδια, ιδιαίτερα οι ομάδες βλάστησης 8, 5 και 10. Η ομοιομορφία, ως προς τη σχετική κάλυψη των ειδών σε κάθε δειγματοεπιφάνεια, ήταν γενικά υψηλή, 0,7 και μεγαλύτερη, και έφτασε τις ανώτατες τιμές στις δειγματοεπιφάνειες της Οίτης που αντιπροσωπεύουν μετάβασης προς άλλες ομάδες βλάστησης ή οικοτόπους (ομάδες 4, 5, 6 και 7). Το υψόμετρο, το μητρικό πέτρωμα (συμπεριλαμβανομένων και των αλλουβιακών υποστρωμάτων) και η βόσκηση

επηρεάζουν σημαντικά τη χλωριδική σύνθεση των ορεινών λιβαδιών. Η ομάδα βλάστησης 1 διαχωρίζεται καθαρά από οικολόγική άποψη από όλες τις υπόλοιπες, ενώ η ομάδα βλάστησης 8 διαχωρίζεται καθαρά από τις άλλες ομάδες βλάστησης του Καλλιδρόμου. Η ανάλυση των δεδομένων των ιδιοτήτων του εδάφους έδειξε ότι το υψόμετρο, το pH, η περιεκτικότητα σε βασικά στοιχεία (ανταλάξιμο Mg, Ca, κορεσμός σε βάσεις), το μητρικό πέτρωμα και τα διαθέσιμα Fe και Mn ήταν οι παράγοντες με σημαντικότερη επίδραση την κατανομή των ειδών και των επιφανειών.

Mountain grassland species, May to July 2013, photo P. Delipetrou.

1. Introduction

The aim of Action A.5 is the establishment of the base status of the target mountain grassland habitats of Mt. Oiti and Mt. Kallidromo and its relation to ecological factors. The target habitat on Mt Oiti is habitat type 6230*, species rich *Nardus* grasslands, on siliceous substrates in mountain areas. The target habitat on Mt Kallidromo is habitat type 6210, semi-natural dry grasslands and scrubland facies on calcareous substrates (*Festuco-Brometalia*), considered priority if it is an important orchid site.

Habitat type 6230 includes closed, dry or mesophile, perennial *Nardus* grasslands with highly varied vegetation (EUR28 2013). In Europe, *Nardus stricta* grasslands are typically assigned to the class *Calluno-Urticetea* (=*Nardetea strictae*) (Mucina 1997, Rodwell et al. 2002, Rivas-Martínez et al. 2002). In Greece, *Nardus stricta* grasslands of habitat type 6230 are represented by plant communites of the greek endemic order of oro-Mediterranean chionophilous swards *Trifolietalia parnassi* Quézel 1964 (with a unique alliance, *Trifolion parnassi* Quézel 1964) which belongs to class *Juncetea trifidi* Hadač 1946 (Quézel 1964, Papastergiadou et al. 1997, Rodwell et al. 2002). On Mt. Oiti this grassland type was first identified and studied by Karetsos (2002) who described four plant associations, all assigned to the alliance *Trifolion parnassi*: *Nardus stricta* comm., *Trifolium hybridum* com., *Poa timoleontis* comm., and *Potentilla pedata* comm. These grasslands develop on flat or of small inclination areas on flysch. The former two associations develop on soils that are temporarily inundated or waterlogged and retain their humidity throughout the year. They are considered "climax" communities based on the assumption that due to their edaphological and hydrological conditions, they would not be succeeded by pre-forest or forest formations (Karetsos 2002). The latter two associations develop on better drained soils and present indications of transition to the oro-Mediterranean calcifilous grassland and scrub of the class *Daphno-Festucetea* Quézel 1964.

Habitat type 6210 includes dry to semi-dry calcareous grasslands of the class *Festuco-Brometea* and is formed on the one hand by steppic or subcontinental grasslands (order *Festucetalia valesiacae*) and on the other by the grasslands of more oceanic and sub-Mediterranean regions (order *Brometalia erecti* with the primary xerophytic alliance *Xerobromion* and the secondary mesophytic alliance *Mesobromion*) (EUR28 2013). Habitat type 6210 had been interpreted as including the whole class *Festuco-Brometea* (Biondi et al. 2012). It must be noted that the name *Brometalia erecti* W. Koch 1926 which has recently been used to encompass the meso-xerophytic alliances of the *Festuco-Brometea* in a single European mesophytic order was proposed for rejection as *nomen ambiguum* to be substituted by *Brachypodietalia pinnati* Korneck 1974 (Dengler et al. 2006, Mucina et al. 2009, Di Pietro et al. 2015). Also, Mucina et al. (2009) proposed the name *Artemisio albae-Brometalia erecti* (Biondi & *al.* 1995) Ubaldi 1997 for the xerophytic alliances of the former *Brometalia erecti* s.l.

Habitat type 6210 is closely connected to and may coexist with habitat type 62A0 which includes *Festuco-Brometea* sub-Mediterranean grasslands of the order *Scorzoneretalia villosae* developing in areas of lesser continentality and a greater Mediterranean element (EUR28 2013). Habitat type 62A0 was included in Annex I Dir. 92/43/EEC in 2002 as one of the ammendments for 10 accession countries (EUR25 2003). Terzi (2015) in a review of the *Scorzoneretalia villosae* delimited the (up to then) distribution of the order from the eastern and northern Adriatic coast including the southeastern part of the pre-Alps (Italy, Slovenia, Croatia, Bosni & Herzegovina, Montenegro, Albania) excluding communities from Serbia, Kosovo, the former Jugoslavic Republic of Macedonia and Bulgaria. His scheme This scheme refers to a classical interpretation of the class, with geographically defined orders and with the *Scorzoneretalia villosae* lying between the western suboceanic *Brometalia erecti* and the eastern sub-continental *Festucetalia Valesiacae*.

Unfortunatelly, the two habitat types which belong to different orders of the same vegetation class, *Festuco-Brometea*, are not always clearly separated. The problem of several co-existing but inconsistent concepts of subdivision is particularly prominent in the class *Festuco-Brometea* while there is a long standing debate regarding the southern and eastern limits of the *Scorzonetetalia villosae* (=*Scorzonero-Chrysopogonetalia*) (Apostolova et al. 2014). There is ambiguity as to whether *Festuco-Brometea* should be divided in geographically vicariant orders (the traditional concept, as e.g. in Royer 1991) or in ecologically distinct orders (e.g. Mucina et al. 2009, Dengler et al. 2012). In his review of the *Scorzoneretalia villosae*, Terzi (2015) noted that the floristic similarities of the *Scorzoneretalia villosae* with Balkan associations of the *Bromion erecti* might suggest that the *Scorzoneretalia villosae* could be moved to the *Brachypodietalia pinnati*. Further, Di Pietro et al. (2015) argued that many species of the *Scorzonerion villosae* (the alliance representing the mesophilous wing of the *Scorzoneretalia villosae*) are shared with the *Brachypodietalia pinnati* and that the two orders could be united under either the name *Scorzoneretalia villosae* (the earliest name) or the name *Brachypodietalia pinnati* (as a conserved name). Evidently, a large scale, european level comparative study of the *Festuco-Brometea* is needed for the determination of the most appropriate syntaxonomic model. Whichever this model may be, habitat types 6210 and 62A0 have a legal status and the delimitation of protected sites has been based on their presence. Thus, changes in the legal interpretation of these habitat types may have serious repercussions, especially since habitat type 6210 is considered a priority one in certain cases while habitat type 62A0 is not priority.

Finally, it must be noted that the recent "Rule based system for in situ identification of Annex I habitats" (Bunce et al. 2012) does not make the distinction of these habitats much easier since they retain common indicator species, not readily distinguisable environmental qualifiers, and mapping rules not applying to all records of the habitats (e.g. 62A0 is given only for altitudes below 300 m).

In Greece, up until recently, it was considered that habitat type 6210 was represented by grasslands of the endemic Mediterranean order *Astragalo-Potentilletalia* (Papastergiadou et al. 1997, Vrahnakis 2010, Fotiadis et al. 2014), found only in the central and southern parts of the Balkans (Čarni et al. 2000). According to Pirini (2014), in the Balkan Peninsula, *Festuco-Brometea* is represented by *Scorzonero-Chrysopogonetalia* (=*Scorzoneretalia villosae*) which includes the sub-Mediterranean grasslands of the north-western sector of the Dinarids, by *Festucetalia valesiacae* extending from eastern Central Europe through the eastern and south-eastern Balkans, and by *Astragalo-Potentilletalia*, which includes the sub-Mediterranean/sub-continental lowland to montane grasslands of the south-central Balkans (Bergmeier et al. 2009, Redzic 2010).

Nevertheless, the recent official Annex I habitat type list per country published at some point after 2011 (http://bd.eionet.europa.eu/activities/Reporting/Article_17/reference_portal) does not include 6210 in the habitats present in Greece, apparently after advice from the national authorities. However, the presence of the *Scorzoneretalia villosae* in Greece had not been substantiated in any scientific publication or other literature at the time which resulted in confusion regarding the assignement of certain vegetation units to habitat 6210. This is evident in a recent work from Prespa presented at the 11th European Dry Grassland Meeting: habitat type 6210 was cited in the abstract (Vrahnakis et al. 2014a) but was replaced by habitat type 62A0 in the finally presented poster (Vrahnakis et al. 2014b). This was the first published record of habitat 62A0 - *Scorzoneretalia villosae* from Greece, although the relevant table of the poster cited the syntaxa *Festuco-Brometalia*: *Festucion valesiacae* and *Astragalo-Potentilletalia*: *Saturejo-Thymion* (?) and *Saturejion montanae* (?).

The field work for action A.5 took place in 2013 and the study was planned so as to include all types of mountain grasslands found in the project sites without pre-assigning them to a certain habitat type.

Grazed grassland in Mouriza (Mt. Kallidromo) with *Colchicum autumnale*, September 2013, photo P. Delipetrou

2. Study of soil properties

2.1. Methodology

Collection of soil samples

Soil sampling took place at the localities of the grassland vegetation transects (section 3). The collection sites are shown in Table 1 and in Figures 3 – 15. In total, 15 samples were collected from Mt. Kallidromo and 10 from Mt. Oiti.

Litter was removed and the organic layer, which was very thin in all sampling localities, was collected together with the mineral soil to a depth of 20 cm. All samples were labelled in the field (pit numbers 1 to 25) and transported to the laboratory.

Table 1. Soil sampling localities.

Pit number	Mountain	Locality	Vegetation Transect
1	Kallidromo	Nevropoli	N2
2	Kallidromo	Nevropoli	N2
3	Kallidromo	Nevropoli	N1
4	Kallidromo	Nevropoli	N1
5	Kallidromo	Panagia-Dremata	K2
6	Kallidromo	Panagia-Dremata	K2
7	Kallidromo	Isomata	K4
8	Kallidromo	Isomata	K4
9	Kallidromo	Mouriza-pond	
10	Kallidromo	Mouriza	K3
11	Kallidromo	Mourouzos	K7
12	Kallidromo	Mourouzos	K7
13	Kallidromo	Gkioza	K1
14	Kallidromo	Gkioza	K1
15	Kallidromo	Gkioza	K1
16	Oiti	Greveno-pond	
17	Oiti	Greveno	G
18	Oiti	Livadies 2	L2
19	Oiti	Livadies-pond	
20	Oiti	Livadies	L
21	Oiti	Livadies	L
22	Oiti	Livadies	L
23	Oiti	Alykaina-pond	
24	Oiti	Alykaina	A
25	Oiti	Tourkos	TR

Sample pretreatment and analysis

All soil samples were air dried and passed through a 2 mm sieve before analysis. All soil concentrations are expressed on an air-dry basis. For the determination of total organic C and total N subsamples were pulverized by a ball mill so as to reach clay dimensions.

The texture of soils was determined by the hydrometer method. The $CaCO_3$ content was determined by a calcimeter. The pH of soils (1:2.5 soil: water ratio) was measured by a glass electrode. Cation exchange capacity (CEC) of the samples was determined by the Na-acetate method (Bower et al. 1952). Organic C was measured by wet oxidation with $K_2Cr_2O_7$ (Walkley

1946). The conductivity of the soil solution (1:5 soil: water ratio) was measured electrometrically and the results were multiplied by 6.4 (BAI 1984).

Exchangeable base cations (Ca, Mg, K and Na) were extracted with 1 M ammonium acetate, pH 7, and their concentrations were determined by atomic absorption spectrometry. Cation Exchange Capacity (CEC) was determined with the sodium acetate method (Bower et al. 1952). Base saturation (%) was calculated as the percentage of the sum of base cations over the CEC. Available trace elements were extracted with a solution of pH 7.3 containing 0.005 M diethylenetriaminepentaacetic acid (DTPA), 0.1 M triethanolamine, and 0.01 M calcium chloride (Lindsay and Norvell, 1978) and their concentration was measured with atomic absorption spectrometry. Available P was extracted with deionized water in a soil to water ratio 1:10 (Olsen and Sommers, 1982) and its concentration was measured with ICP atomic emission spectrometry.

2.2. Results and Discussion

The average values, ranges and coefficients of variation for the soil properties in both mountains are presented in Table 2. The results of all analyses are presented in Table 3.

With regard to the nature of the parent material, slight differences were found from the geology of the area depicted in Figures 3 to 15. So, the parent material of pit 1 (Nevropoli) is flysch, the parent material of pits 3 and 4 (Nevropoli) is colluvial rock derived from hard limestones and the parent material of pits 24 (Alykaina) and 25 (Tourkos) is dolomite. The latter were classified as such based on the high concentrations of exchangeable Mg found during the analysis. The importance of the parent material on defining soil functions was stressed by Kooijman et al. (2005). Oyonarte et al. (2008) found that for the mountainous forest ecosystems in the Mediterranean zone lithology is more important than plant cover with regard to soil physical and chemical properties. In Greece, hard limestones, including limestone marbles, cover 32% of the total land area (Nakos 1979). Due to their mode of formation soils derived from hard limestones are usually contained in pockets of the parent rock reaching down to varying depths whilst the rock is very commonly exposed at the surface. One characteristic of the rocks in the area is the colluvial formation that exists along with the hard limestone landscape. That colluvial material has slided down from slopes as a result of gravitational forces from higher portions of slopes and accumulated at their feet. Tertiary deposits occupy 21% of the area of Greece and an appreciable percentage of the soils developed on this material is alkaline in reaction and rich in bases especially Ca. Flysch rocks cover 9% of the area of Greece. Soils from flysch are usually acid in reaction and moderately to sufficiently supplied with base cations (Ca, Mg, K).

The topography of the grassland area covered by the soil sampling does not correspond to a mountainous relief. It could be considered as a plain formed by the deposits of the surrounding areas either in the alluvial or in the colluvial form. So, apart from the nature of the parent material, the way of formation has greatly influenced the physical and chemical properties of the soils. An important property that changed is the total soil depth. Usually, soils developed on hard limestones are shallow.

Table 2. Summary of properties of soil samples in grasslands of Mt. Oiti and Mt. Kallidromo.

		Mt. Oiti			Mt. Kallidromo		
Property and abbreviation		**Average**	**Range**	**CV[1] (%)**	**Average**	**Range**	**CV[1] (%)**
pH		5.53	4.99-6.47	7.24	6.55	5.34-7.57	8.74
Organic C (%)	OrganicC	4.34	2.36-6.78	37	4.66	2.13-8.28	38.9
Total N (g/kg)	TotalN	4.05	2.87-5.60	26.1	4.16	2.10-8.19	40
C/N	CtoN	10.6	8.04-14.0	23	11.4	7.67-15.2	18.6
Sand (%)	Sand	55.5	48.4-63.8	9.4	53.8	34.0-68.0	20.4
Clay (%)	Clay	15.7	6.88-22.9	31.9	20.1	11.6-30.7	31.6
Silt (%)	Silt	28.8	16.7-44.4	26.6	26.1	17.2-46.4	30
Conductivity (μS/cm)	Cond	290	184-648	48.9	761	376-1162	35.8
Exch. Ca (meq/100 g)	Ca	6.04	2.05-12.2	59.5	20.5	8.40-37.8	47.5
Exch. Mg (meq/100 g)	Mg	2.8	0.50-10.2	138	5.19	1.58-11.3	60.8
Exch. K (meq/100 g)	K	0.59	0.36-0.95	36.8	0.9	0.33-1.61	41.2
Exch. Na (meq/100 g)	Na	0.08	0.05-0.09	18.6	0.1	0.07-0.17	27
CEC (meq/100 g)	CEC	17.4	6.94-34.7	43.3	29.1	17.3-57.6	37.4
BS (%)	BaseSat	55.1	18.3-98.7	54.1	98	48.9->100	52
Available P (mg/kg)	Av_P	0.72	0.19-2.23	78.2	0.56	0.16-1.25	59.4
Available Mn (mg/kg)	Av_Mn	19.3	4.00-76.0	112	58.7	15.0-116	53.2
Available Fe (mg/kg)	Av_Fe	213	72-434	59.5	85.1	24.0-46.3	54.4
Available Cu (mg/kg)	Av_Cu	1.46	0.66-2.74	56.6	1.85	0.92-3.14	42.3
Available Zn (mg/kg)	Av_Zn	0.62	0.24-0.98	39	1.98	0.44-3.52	51

[1]Coefficient of variation

In our case, plants do not face such problem. Another property to be influenced is the texture. The area of Kallidromo mostly has soils formed on hard limestones. Usually the hard limestones give rise to heavy soils, whereas here the average texture of the Kallidromo soils is sandy clay loam. Only three pits, 9, 11 and 12, at the area of the ponds Mourouzos and Mouriza, had soils with relatively high clay content and that was due to the fine soil material around the ponds. None of the soils sampled from the Oiti mountain had a high clay content (Tables 2 and 3). The average texture of the soils of Oiti was found to be sandy loam.

Only the pH of soils derived from tertiary deposits in the mountain of Kallidromo had high values and one of them (pit number 5 at Panagia-Dremata) had a 7% percentage of $CaCO_3$.

Soils derived from hard limestones can be slightly acidic, whereas soils developed on colluvial rocks from hard limestones have a high weathering rate (Papamichos 1984) and therefore $CaCO_3$ has more active surfaces. This is the reason that pit numbers 3 and 4 (Nevropoli) have soils with a higher pH. Apart from pH all the other soil properties had high coefficients of variation (Table 2). This finding clearly shows the non-uniformity of non-agricultural soils even if they are formed from the same parent material. The soils collected from Mt. Oiti had, as expected, lower pH values than those from Mt. Kallidromo as most of their soils were derived from flysch.

Table 3. Properties of soil samples in the grasslands of Mt. Oiti and Mt. Kallidromo.

Pit No	Parent material	Sand (%)	Clay (%)	Silt (%)	pH	Organic C (%)	Total N (g/kg)	C/N	Conductivity (μS/cm)	Exch. Ca	Exch. Mg	Exch. K	Exch. Na	CEC	Base saturation (%)	Avail. P	Avail. Mn	Avail. Fe	Avail. Cu	Avail. Zn
										(meq/100g)						(mg/kg)				
1	Flysch	63.8	14.2	22	5.34	4.41	3.5	12.6	472	10.4	2.08	0.61	0.08	18.9	70.2	1.25	72	132	1.3	2.46
2	Hard limestone	63.1	15.6	21.2	5.82	3.23	2.45	13.2	378	8.4	1.58	0.79	0.07	17.3	62.3	0.399	86	74	0.92	2.02
3	Colluvial rock	57.1	23.6	19.2	6.92	3.31	2.45	13.5	960	26	1.67	0.77	0.08	26	>100	0.386	72	54	2.06	1.4
4	Colluvial rock	57.1	19.6	23.2	6.79	5.83	3.85	15.2	1162	25.5	2.08	1.28	0.11	29.8	97.2	0.501	80	86	2.38	2.88
5	Tertiary deposits	58.6	19.1	22.4	7.57	3.39	3.5	9.68	1120	37.8	4.25	0.66	0.1	21	>100	0.711	20	24	1.12	0.62
6	Tertiary deposits	57.1	25.6	17.2	6.91	3.55	3.15	11.3	1056	32.2	9.33	0.33	0.17	57.6	73	0.236	32	54	2.78	0.62
7	Hard limestone	63.1	17.6	19.2	6.79	4.49	4.2	10.7	708	25.8	11.3	0.46	0.1	19.4	>100	0.967	50	126	3.02	1.12
8	Hard limestone	68	12.4	19.6	6.92	2.13	2.1	10.1	376	36.4	9.83	0.49	0.09	26.5	>100	0.271	22	50	1.12	0.44
9	Hard limestone	34	30.7	35.3	6.83	2.6	2.8	9.29	680	19.4	5.5	0.97	0.1	29.8	87	0.164	90	158	3.14	1.86
10	Hard limestone	57.1	11.6	31.2	6.1	6.23	4.55	13.7	684	10.7	2.92	0.79	0.09	19.8	73.3	0.305	116	80	1.4	3.38
11	Hard limestone	42	30.7	27.3	6.52	3.7	4.83	7.67	572	15.5	5	1.61	0.09	33.6	66	0.612	60	188	2.48	2.04
12	Hard limestone	39.1	28.9	32	6.35	6.94	5.11	13.6	1018	18.4	4.42	1.15	0.11	35.1	68.5	0.527	94	76	2.36	3.52
13	Hard limestone	53.1	16.2	30.7	6.85	8.28	8.19	10.1	909	18.8	7.67	0.97	0.12	45.9	60.1	1.18	32	44	1.44	3.3
14	Hard limestone	58.8	16.9	24.4	5.8	7.01	6.65	10.6	457	9.2	3.5	1.36	0.14	29	48.9	0.517	15	82	1.02	2.12
15	Flysch	34.8	18.9	46.4	6.81	4.81	5.11	9.41	869	13.4	6.67	1.28	0.12	27.6	77.8	0.385	40	48	1.22	1.94
16	Flysch	52.8	22.9	24.4	6.47	2.36	2.94	8.04	221	8.8	1.92	0.43	0.08	14.8	76.1	0.771	76	222	2.52	0.9
17	Flysch	55.1	16.2	28.7	5.81	4.33	5.25	8.26	214	3.8	0.72	0.92	0.07	14.8	37.3	0.631	11.8	96	0.68	0.44
18	Flysch	63.8	16.2	20	5.53	6.54	4.76	13.7	358	2.05	0.53	0.41	0.09	16.7	18.4	0.334	26	332	0.66	0.48
19	Flysch	63.1	20.2	16.7	4.99	6.78	4.83	14	368	5.25	1.08	0.43	0.09	6.94	98.7	0.414	4	376	2.16	0.98
20	Flysch	48.8	6.88	44.4	5.41	6.07	5.6	10.8	216	3.9	0.64	0.56	0.07	20.5	25.3	0.553	22	172	1	0.6
21	Flysch	58.4	10.9	30.8	5.53	2.68	3.01	8.9	195	5.8	0.92	0.43	0.05	12.5	57.6	0.613	24	86	1.02	0.38
22	Flysch	56.4	14.9	28.8	5.24	3.79	3.15	12	184	2.15	0.5	0.36	0.05	16.7	18.3	0.194	4.9	72	0.66	0.24
23	Flysch	48.4	20.9	30.8	5.38	3.81	2.87	133	218	5.05	1.5	0.95	0.09	13.1	57.7	2.23	5.2	434	2.74	0.82
24	Dolomite	54.4	10.9	34.8	5.29	4.18	4.55	9.18	648	11.4	10	0.64	0.09	23.3	94.9	0.704	6.5	176	1.04	0.6
25	Dolomite	54.4	16.9	28.8	5.63	2.86	3.5	8.16	284	12.2	10.2	0.74	0.09	34.7	66.8	0.742	12.2	166	2.12	0.78

The conductivity of the soil solution in both mountains was not high (Table 3). According to BAI (1984) there must be at least a value of 2000 μS/cm for some sensitive to salinity plants to start having problems. Also the concentrations of exchangeable Na of the soil samples had low values (in comparison with the CEC values) and therefor there is no problem with sodicity. The ESP percentage (the percentage of Na with regard to the CEC) was much lower than the value of 15% (the threshold for sodicity).

In order to enable the comparison of the soil properties of the sampled areas with the threshold values of nutrients, values indicative of nutrient deficiencies for agricultural plants are presented in Tables 4 and 5. In any case, this comparison must be interpreted with caution as wild plants are capable of coping with infertile soils. Still, that is an indication of nutrient fertility. The threshold values were taken from BAI (1984) for organic C, total N, CEC and exchangeable cations, from Nelson (1982) for P and from Martens and Lindsay (1990) for micronutrients. In this respect, regarding organic C only one sample, pit number 8 (Isomata), had a value of 2.13 % which is considered low. There was no indication of deficiency regarding the absolute magnitudes of N, exchangeable Ca, Mg and K. However, in soils of high pH the ratio of Ca/Mg should not be above 5 as there could be a competition for take up between Ca and Mg in favor of the Ca (BAI 1984). In our soils this happens for the pits 3 and 4 (Nevropoli) and for the pit 5 (Panagia-Dremata) in the mountain of Kallidromo. An interesting case is the existence of dolomite rocks, a mixture of $CaCO_3$ and $MgCO_3$, in the area of the pit numbers 24 (Alykaina) and 25 (Tourkos) in the mountain of Oiti. This conclusion was drawn from the high concentrations of exchangeable Mg in comparison with exchangeable Ca. It must be mentioned that according to the Institute of Geology and Geological Exploration (IGME) 1:50000 map these two areas are within the zones of flysch and limestones, respectively. However, in the Greek landscapes different rocks intermingle very often with the main rock depicted in geological maps.

The percentage of base saturation (BS) was over 100% only in the samples of Kallidromo (Table 2). This finding is in accordance with those found by Nakos (1979). Soils on hard limestones and tertiary deposits can give high values of BS, sometimes higher than 100. In contrast, soils derived from flysch, as in the case of Mt. Oiti, have always lower values.

The ratio of C/N is not high and considered satisfactory for non-agricultural soils.

Table 4. Critical values of nutrients according to literature. Organic C is expressed in %, total N in g/kg, Cation Exchange Capacity (CEC), exchangeable Ca, Mg and K, in meq/100g, available P in mg/kg.

Organic C	Total N	CEC	Exch. Ca	Exch. Mg	Exch. K	P
2	1	5.0	0.8	0.20	0.20	0.13

Table 5. Critical values of available micronutrients (mg/kg) according to literature.

Fe	Mn	Zn	Cu
4.80	0.22	0.80	0.53

The magnitude of CEC of all samples was above the value of 5 meq/100 g. Only one sample, the pit number 19 (Livadies pond), had a low CEC (6.94 meq/100 g).

Only two soil samples had a low value of available P, the numbers 9 and 22 (App.3). Still these values were not below the critical value of Table.7.

Based on the threshold values (Table 5), there were no indications of deficiencies regarding the concentrations of the available Fe, Mn and Cu, either.

However, some samples were found to have Zn concentrations below the limit. These were the pit numbers 5, 6, 17, 18, 20, 21, 22 and 24 (Panagia-Dremata, Greveno, Livadies, Alykaina). The two samples from Mt. Kallidromo came from soils derived from tertiary deposits having a high pH. The dependence of Zn availability on soil pH has also been found by other studies (Kiekens 1995). Regarding the samples from Mt. Oiti, the pH of the soils in this mountain is not high and the low amounts of Zn can be attributed to the nature of the parent material. As mentioned above, the threshold limits have been set for agricultural plants and not for plants in the wild. The rooting systems of plants can excrete organic acids the anions of which can chelate micronutrients bound to Mn or Fe oxides. In order to determine whether a nutrient deficiency actually exists for the typical grassland species, the only way is the *ex situ* application of fertilizers. If the nutrient supposedly in scarcity is applied to the plant and its growth rate increases, then this is a proof of nutrient deficiency. Pit number 18 (Livadies 2) is of particular interest as the plant *Nardus stricta*, typical of habitat 6230*, is abundant there.

Finally, pits 3 and 4, adjacent to the pond of Nevropoli, have an unfavorable Ca/Mg ratio. These soils were derived from colluvial limestone rocks and have a high pH. It seems that the plants in this locality can cope with the Mg take up.

Left: Grassland transect K1 at Gkioza (Mt. Kallidromo), July 2013, photo I. Dimitriadis

Right: *Orchis pallens* at Gkioza (Mt. Kallidromo), May 2013, photo P. Delipetrou

3. Vegetation composition and structure

3.1. Methodology

Field work

Vegetation structure and flora composition of the grasslands were studied by transects at selected localities of Mt. Oiti and Mt. Kallidromo in 2013 (Figures 1 and 2). Sampling took place in July which is the season when most of the typical grassland species are identifiable in both mountains. However, it must be noted than at any season some species may not be identifiable or even visible, so field recording included the typical species but not the entire floristic composition of the grasslands. The localities were selected so as to cover both the transition to temporary pond vegetation (transects were established at all the termporary pond localities) and the transition to woodland scrub (transects were established at localities with evident *Juniperus nana-Abies cephalonica* expansion). Also, there was an effort to cover the variety of grasslands on both mountains. A total of 8 transects (100 plots) were established at 6 localities of Mt. Oiti and a total of 17 transects (190 plots) were established at 6 localities of Mt. Kallidromo (Table 6, Figures 3 to 14). It must be noted that: a) no transects were established at the area of Louka because all flora species had been grazed to the ground and were not identifiable by July; and b) the transects at the area of Souvala were originally established for the study of the supposed temporary ponds of the site but as it turned out the vegetation of this locality consisted of different wet and dry grassland types.

Table 6. List of vegetation transects at the mountain grasslands.

Mountain	Locality	Altitude, m	Bioclimate	Vegetation Transect	Length m
Oiti	Alykaina	1917-1925	Mountain Mediterranean/Oro-Mediterranean	A	150
Oiti	Greveno	1896-1897		G	100
Oiti	Livadies	1812-1821		L	250
Oiti	Livadies 2	1804-1810		L2	100
Oiti	Tourkos	1704-1712	Mountain Mediterranean	TR	100
Oiti	Tsamadaiika	1400-1435	Supra-Mediterranean/ Mountain Mediterranean	TS	110
Oiti	Zapantolakka	1406-1415		Z1	50
Oiti	Zapantolakka	1399-1409		Z2	50
Kallidromo	Gkioza	1288-1296		K1	150
Kallidromo	Isomata	994-1005	Supra-Mediterranean	K4	50
Kallidromo	Isomata	998-1010		K6	50
Kallidromo	Mouriza	1070-1072		K3	75
Kallidromo	Mourouzos	1070-1074		K7	100
Kallidromo	Nevropoli	976-985		N1	50
Kallidromo	Nevropoli	975-983		N2	50
Kallidromo	Souvala	1022-1025		S1	90
Kallidromo	Souvala	1020-1024		S2	100
Kallidromo	Souvala	1016-1020		S3	110
Kallidromo	Souvala	1017-1021		S4	180
Kallidromo	Souvala	1017-1022		S5	140
Kallidromo	Souvala	1019-1024		S6	150
Kallidromo	Souvala	1018-1021		S7	140
Kallidromo	Souvala	1016-1021		S8	100
Kallidromo	Souvala	1017-1021		S9	60
Kallidromo	Panagia-Dremata	777-790	Meso-Mediterranean/Supra-Mediterranean	K2	150

The transects had a length of 50 – 250 m, depending on the topography, variety of grassland and transition to other vegetation units at each locality. During field work, the transects were marked on the ground by measuring tapes and sampling was made at 1x1 vegetation plots delimited using a wooden frame and systematically placed along the transects every 10 m. In each plot, total plant cover as well as the cover-abundance (Braun-Blanquet 9-grade scale) of each plant present in the plot were recorded. Samples of plants were collected if necessary for identification (if possible samples were taken outside the 1x1 plot, otherwise the plants were not uprooted).

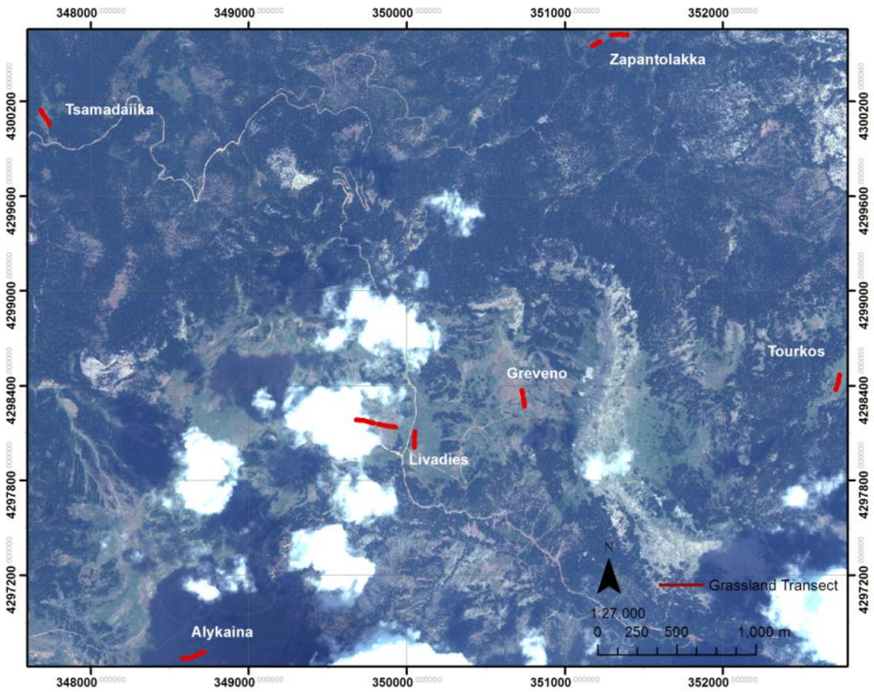

Figure 1. Grassland transects on Mt. Oiti.

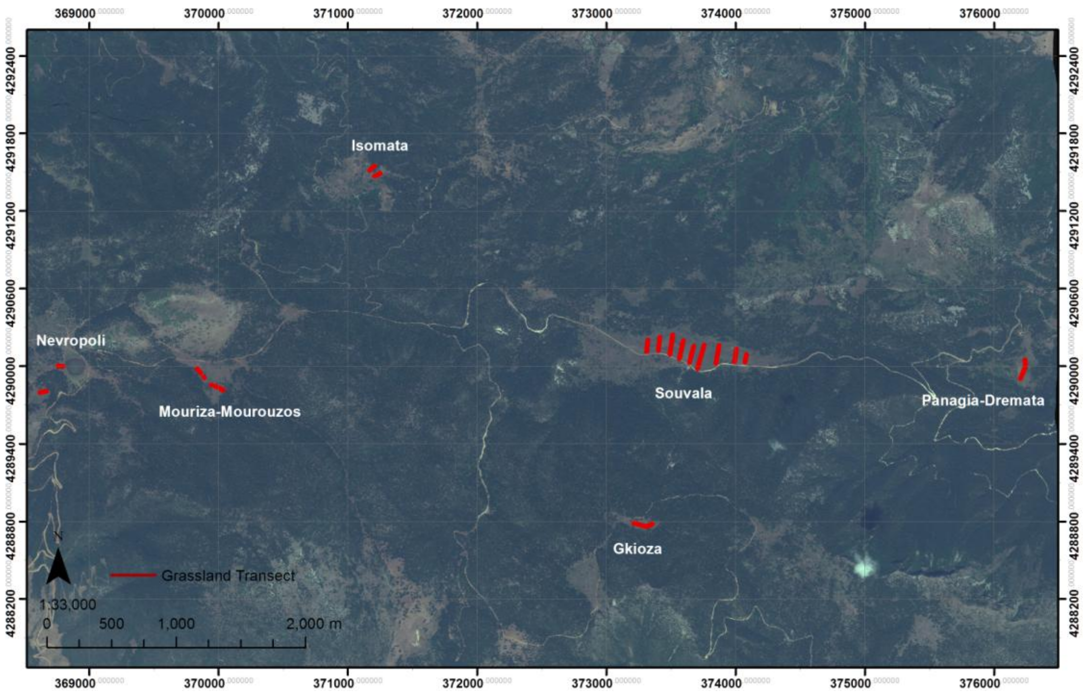

Figure 2. Grassland transects on Mt. Kalldromo.

Data process and analysis

Plant samples were dried, identified and mounted on herbarium sheets. *Festuca* species were identified by an expert, B. Foggi (Dipartimento di Biologia vegetale, Università degli studi di Firenze, Italy). After the end of the project, the specimens will be deposited at the herbarium of the Botanical Museum of the National and Kapodistrian University of Athens (Faculty of Biology). The field data of the vegetation plots were corrected after plant identification and recorded in a TURBOVEG (© 1998-1999 Hennekens S.) database customised for the needs of the project.

Life forms and chorological data are according Dimopoulos et al. (2013). Life forms follow the Raunkiaer system: T = Therophytes (annual herbs); H = Hemicryptophytes (biennial and perennial herbs); G = Geophytes (perennial herbs); C = Chamaephytes (perennial subshrubs and small shrubs); P=Phanerophytes (perennial tall shrubs and trees). Chorological categories are as follows: END = Greek endemic; Bk = Balkan; BI = Balkan-Italian; BC = Balkan-C European; BA = Balkan-Anatolian; EM = E Mediterranean; Me = Mediterranean; Meu = Mediterranean-European; MA = Mediterranean-Atlantic; MS = Mediterranean-SW Asian; Eu = European; ES = European-Siberian; EA = European-SW Asian; Pt = Paleotemperate; Ct = Circumtemperate; ST = Subtropical-Tropical; Bo = Boreal; AA = Arctict-Alpine; Co = Cosmopolitan; [S-Am.] = Alien-S American.

Analysis of the vegetation data was made with the hierarchical classification method Two-way indicator species analysis (TWINSPAN) by the softwasre package JUICE (© Ver. 7.0, Lubomír Tichý, 1999-2010). This type of analysis discriminates vegetation units (different species assemblages), so it is suitable for the identification of differences in flora composition between and within grassland localities. Fidelity of the species to vegetation units was assessed using the phi coefficient (φ) which ranges from -1 to +1, with greater values indicating that the species and the vegetation unit co-occur more frequently than would be expected by chance, and is independent of the total number of relevés in the dataset (Chytrý et al. 2002). Fidelity was taken into account only for species with significance 0.05 calculate by the Fischer's exact test. The threshold value for the identification of diagnostic species was 50 ($\phi \geq 0.5$), for constant species 70 (frequency ≥ 70%), and for dominant species 50 (cover in plot ≥ 50%).

The exploration of the major patterns of the species data, and their relation to environmental variables was made by unimodal ordination techniques (Detrended Correpondence Analysis-DCA and Canonical Correspondece Analysis-CCA) by the software packages Canoco 4.5 (© ter Braak & Smilauer 1997-2002 Biometris-Wageningen, ter Braak & Smilauer 1998) and CanoDraw 4.0© (ter Braak & Smilauer 1999-2002 Biometris-Wageningen). The response of the species to ecological variables was also explored by Generalized Additive Models (GAM) or Generelized Linear Models (GLM) with the above software. Only species with significant ($P<0.05$) goodness of fit based on the F statistic were used in the diagrams.

Biodiversity indices were used in order to assess the floristic composistion of the plots. Species diversity consists of two different aspects of species relative abundance: the actual number of species included in any particular sample, and the evenness of the distribution of individuals between the species encountered. Different metrics, differing in the extent at which they are influenced by the above aspects were applied to the plot data. Diversity at species level was determined by the Shannon-Wiener index H' ($H' = -\Sigma p\text{i} \ \ln P\text{i}$, where Pi is the relative abundance of each species in the plot, minimum value 0, maximum value=$\log_2 N_0$) and the related equatability or evenness index $Rs = H'/\ln N_0$ (where N_0=total species number in the plot, values 0 – 1), a parameter of species competition (Krebbs 1999, Li & Kräuchi 2004). In addition, Hill's indices (calculated by CanoDraw) were used. These are N_0 (species richness, i.e. number of species), N_1 (exponential of Shannon-Weiner Index) and N_2 (reciprocal of Simpson's Index $D = \Sigma Pi^2$, minimum value 1, maximum value=N_0). N_1 is more sensitive to the number of species recorded in the sample, where as N_2 is more sensitive to the evenness of the distribution of individuals between species.

Grassland transect L at Livadies (Mt. Oiti), July 2013, photo I. Dimitriadis

Area of grassland transect L2 at Livadies (Mt. Oiti) , May 2013, photo I. Dimitriadis

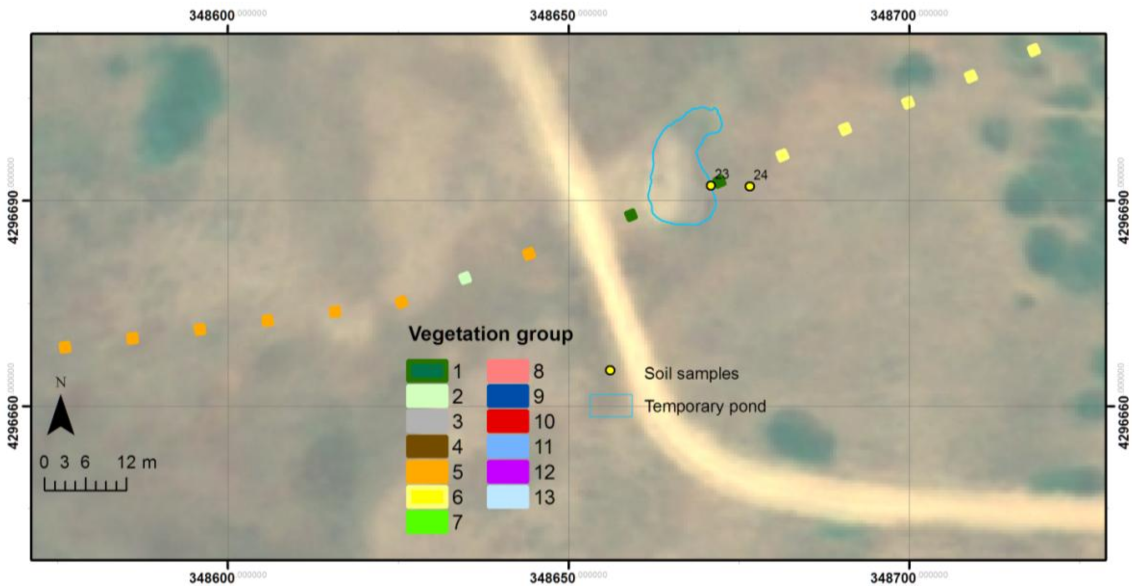

Figure 3. Oiti, Alykaina grassland transect (A).

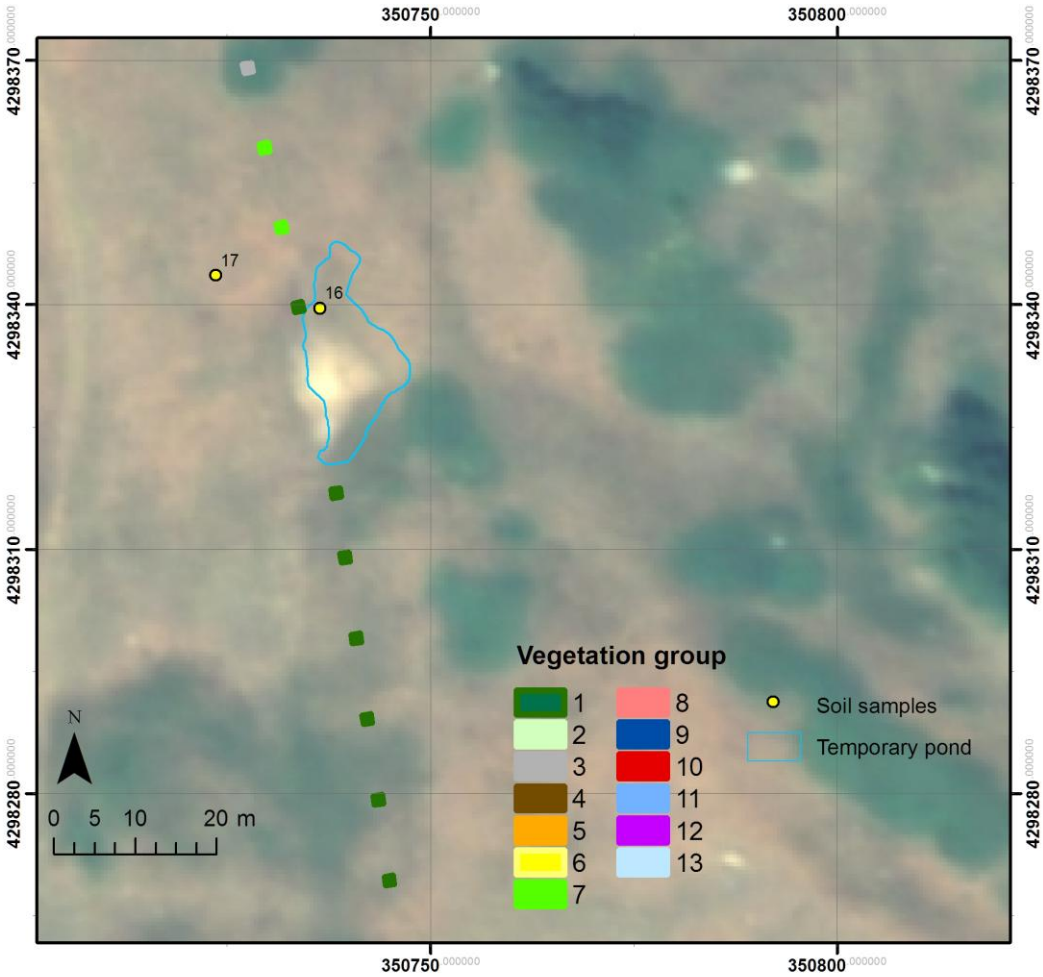

Figure 4. Oiti, Greveno grassland transect (G).

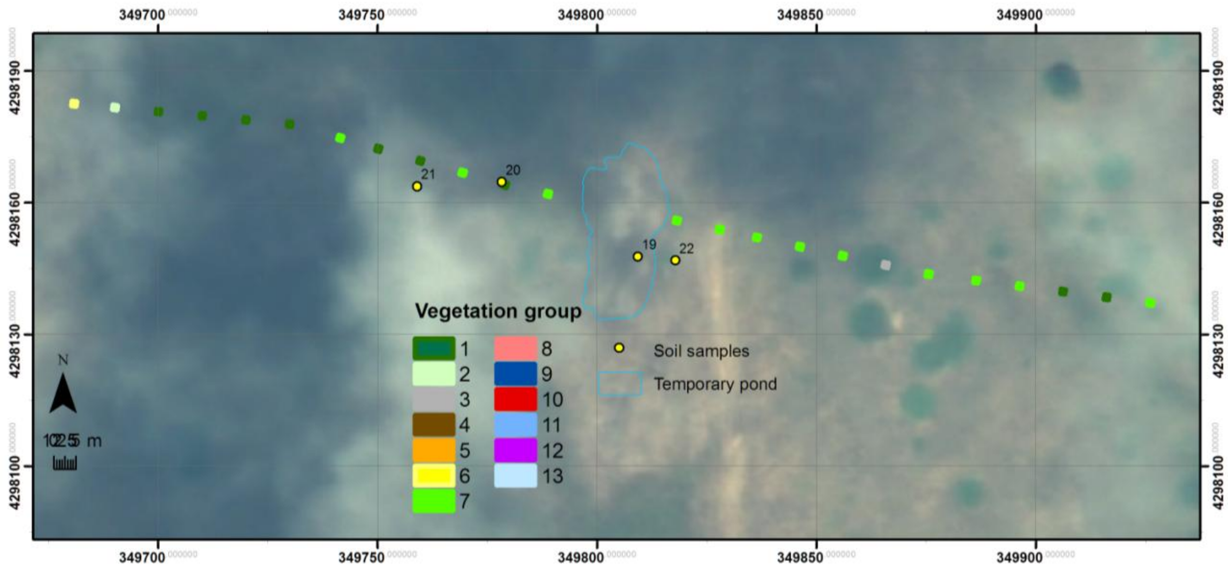

Figure 5. Oiti, Livadies grassland transect (L).

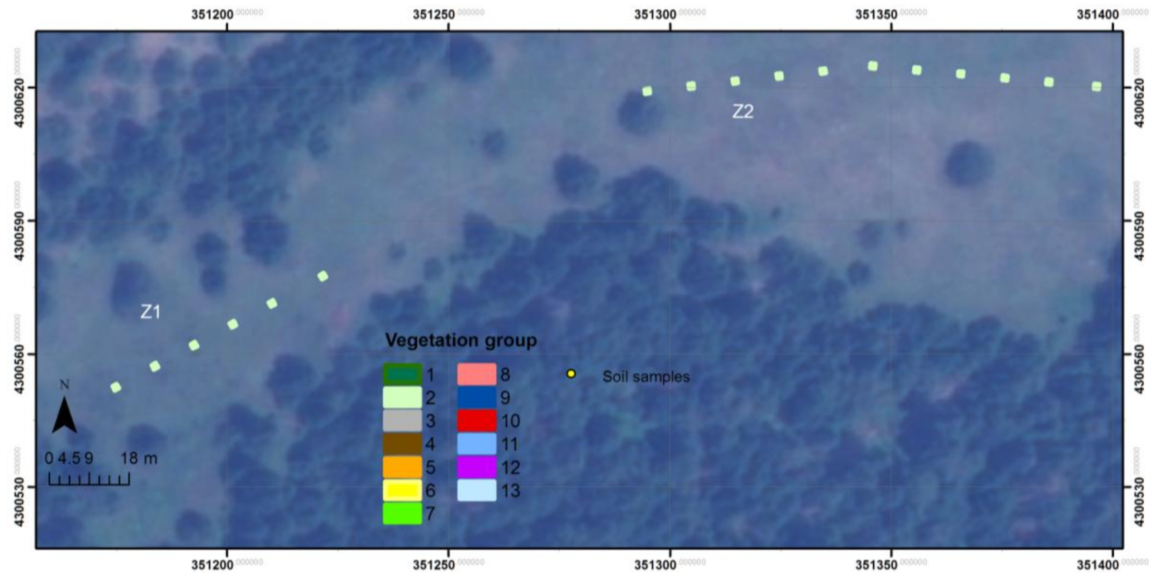

Figure 6. Oiti, Zapantolakka grassland transects (Z1, Z2).

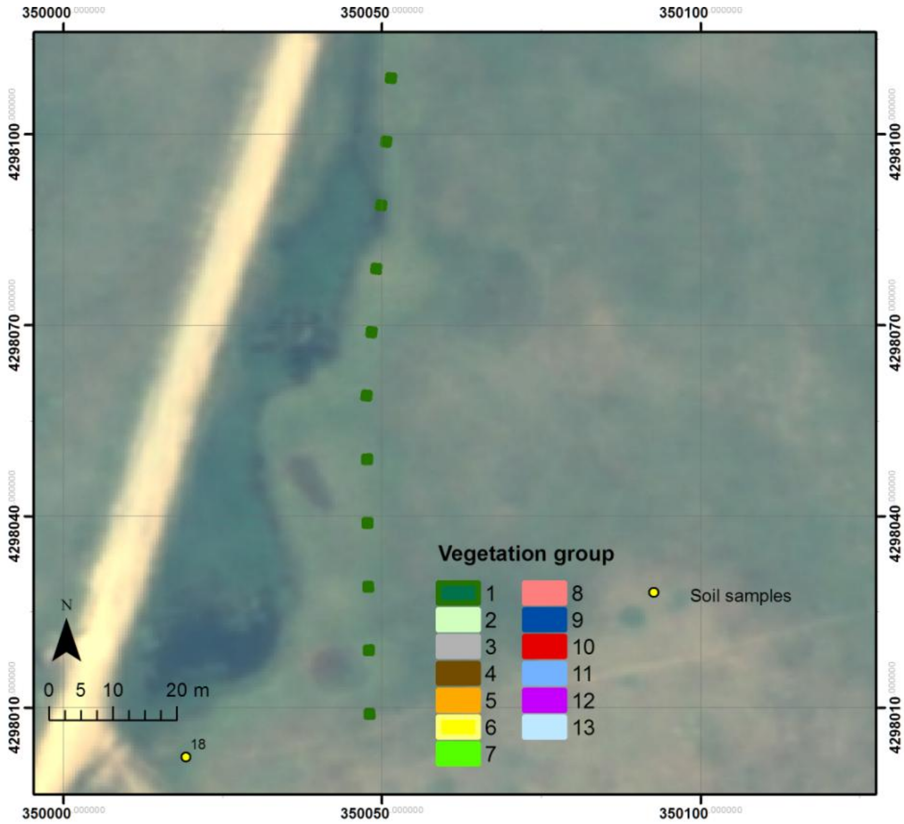

Figure 7. Oiti, Livadies 2 grassland transect (L2).

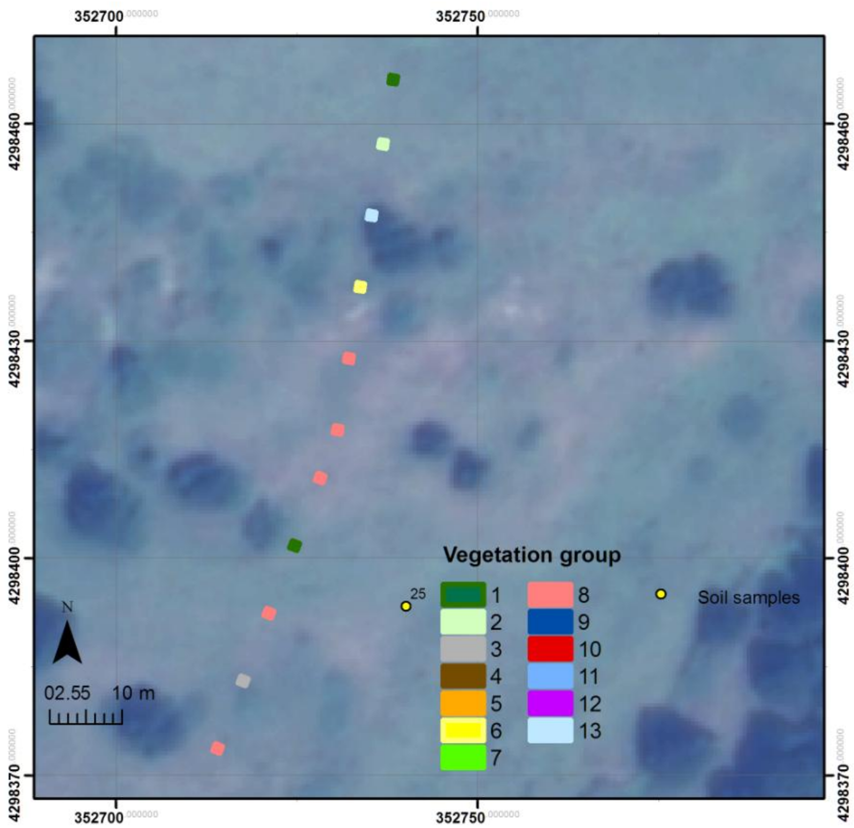

Figure 8. Oiti, Tourkos grassland transect (TR).

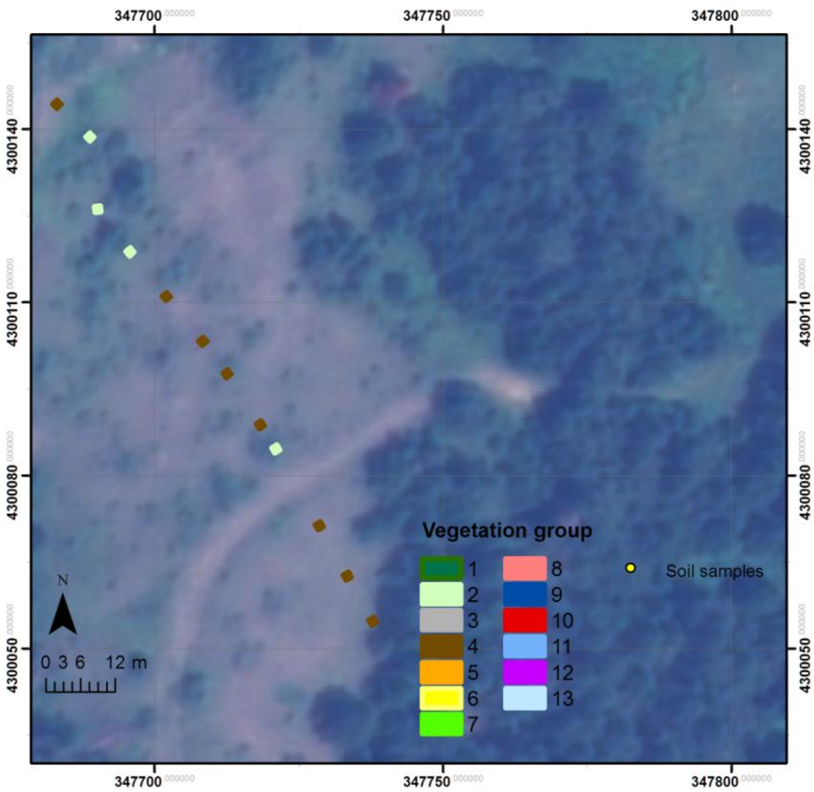

Figure 9. Oiti, Tsamadaika grassland transect (TS).

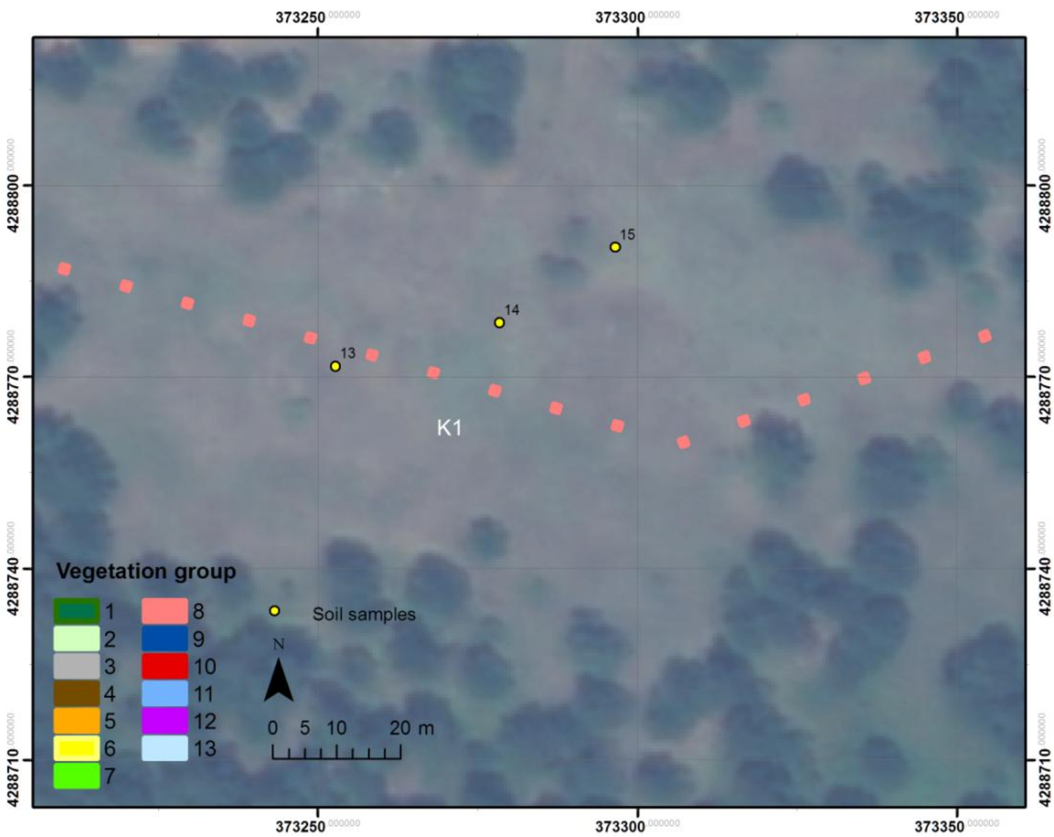

Figure 10. Kallidromo, Gkioza grassland transect (K1).

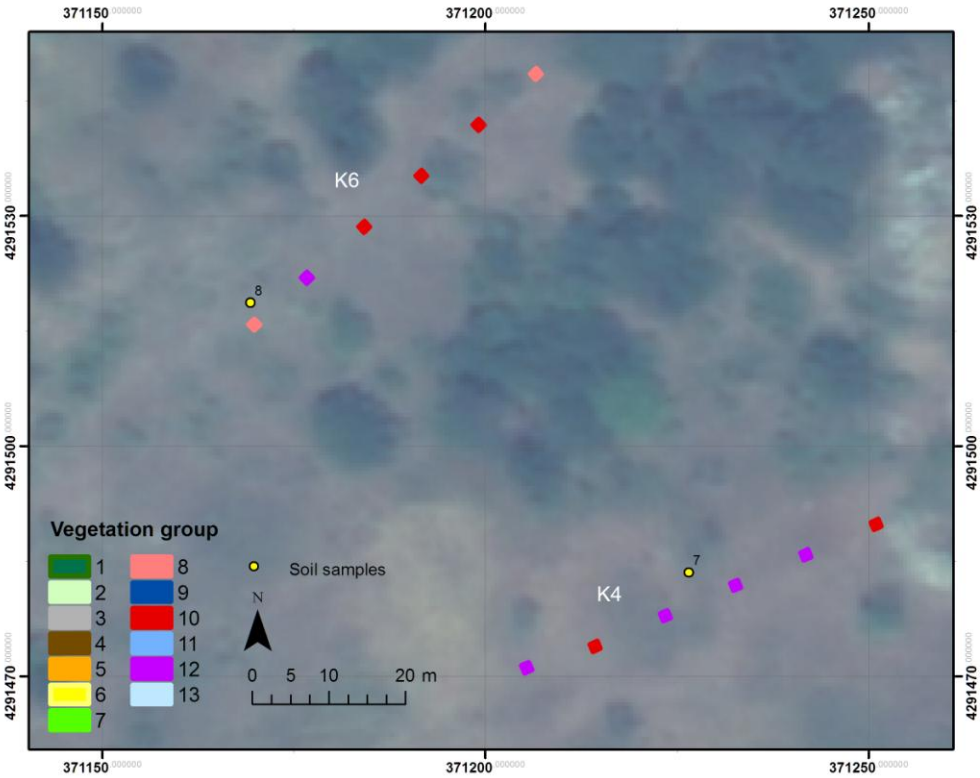

Figure 11. Kallidromo, Isomata grassland transects (K4, K6).

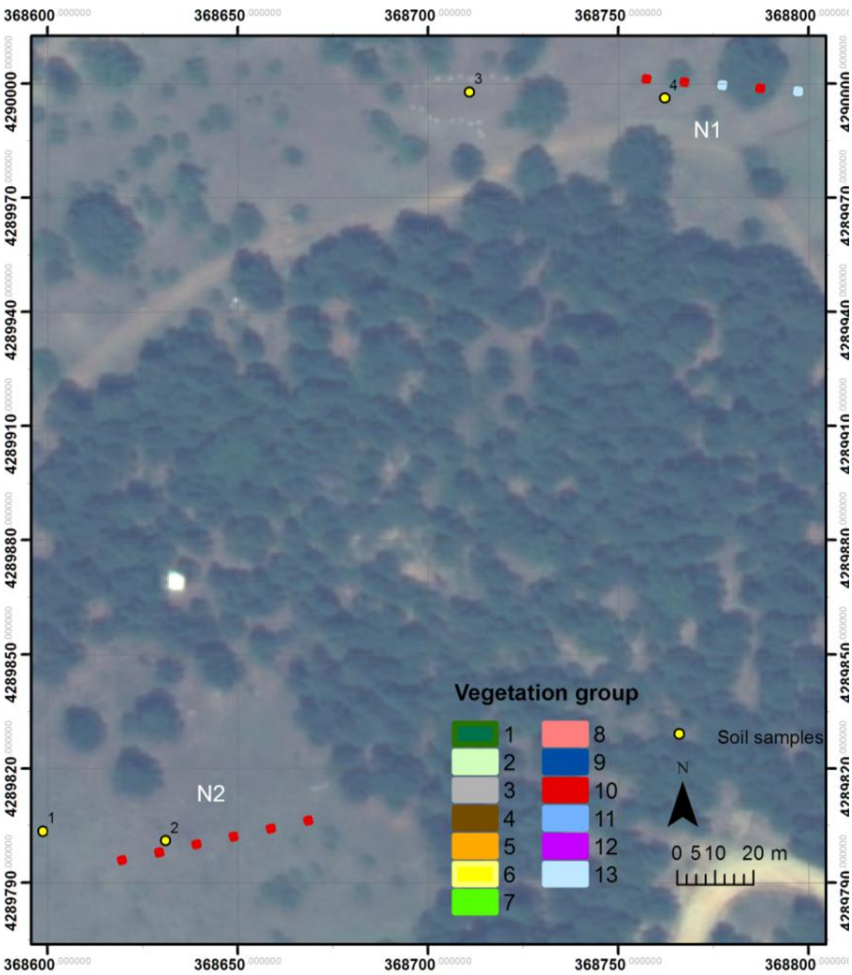

Figure 12. Kallidromo, Nevropoli grassland transects (N1, N2).

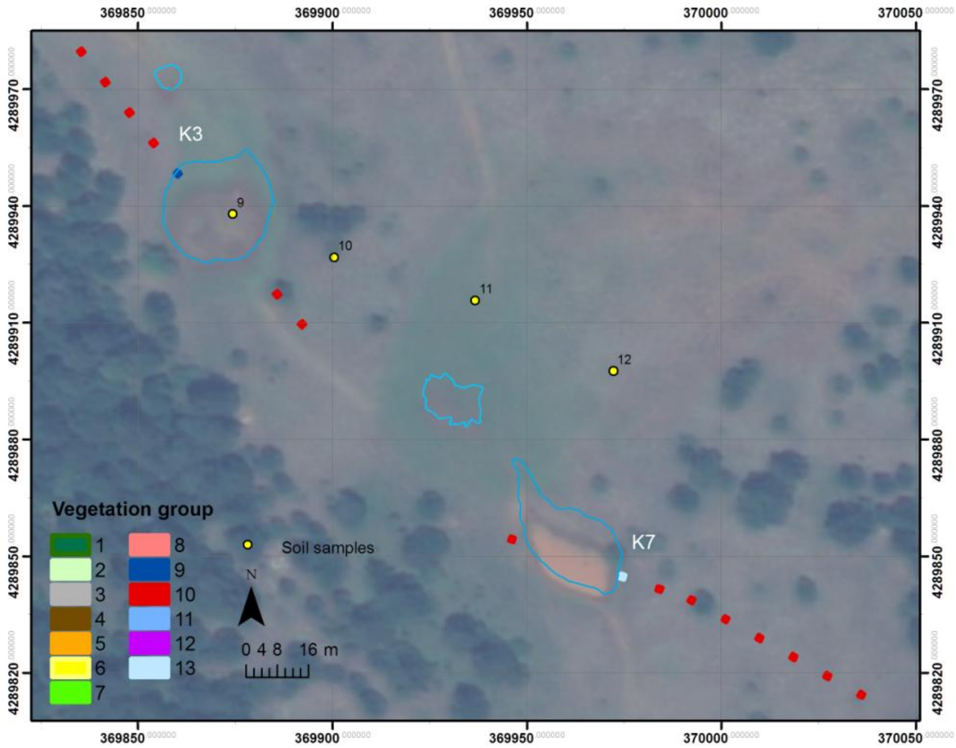

Figure 13. Kallidromo, Mouriza and Mourouzos grassland transects (K3, K7).

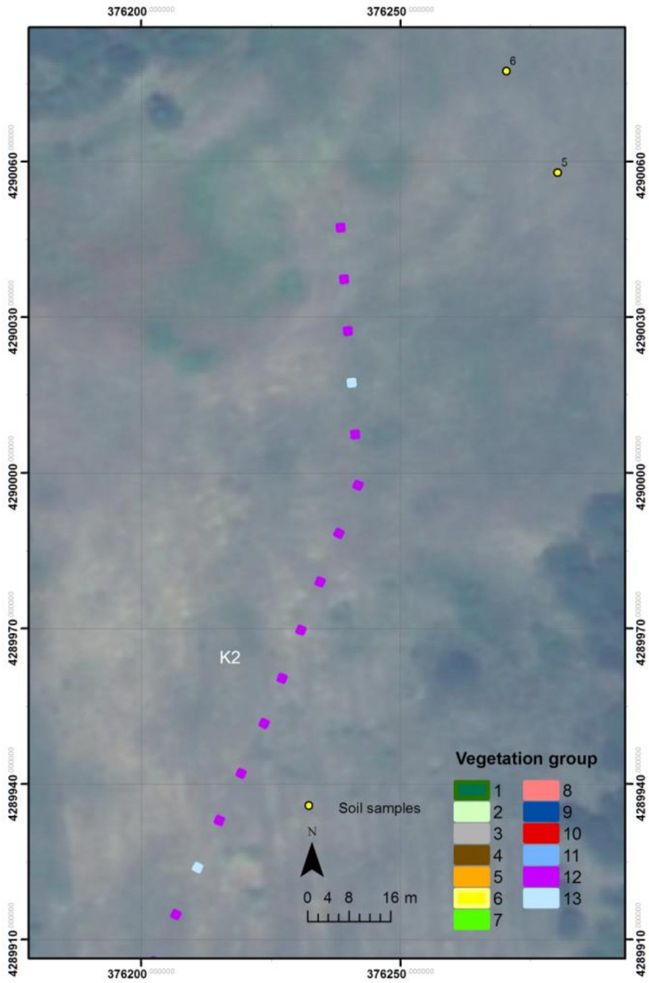

Figure 14. Kallidromo, Panagia-Dremata grassland transect (K2).

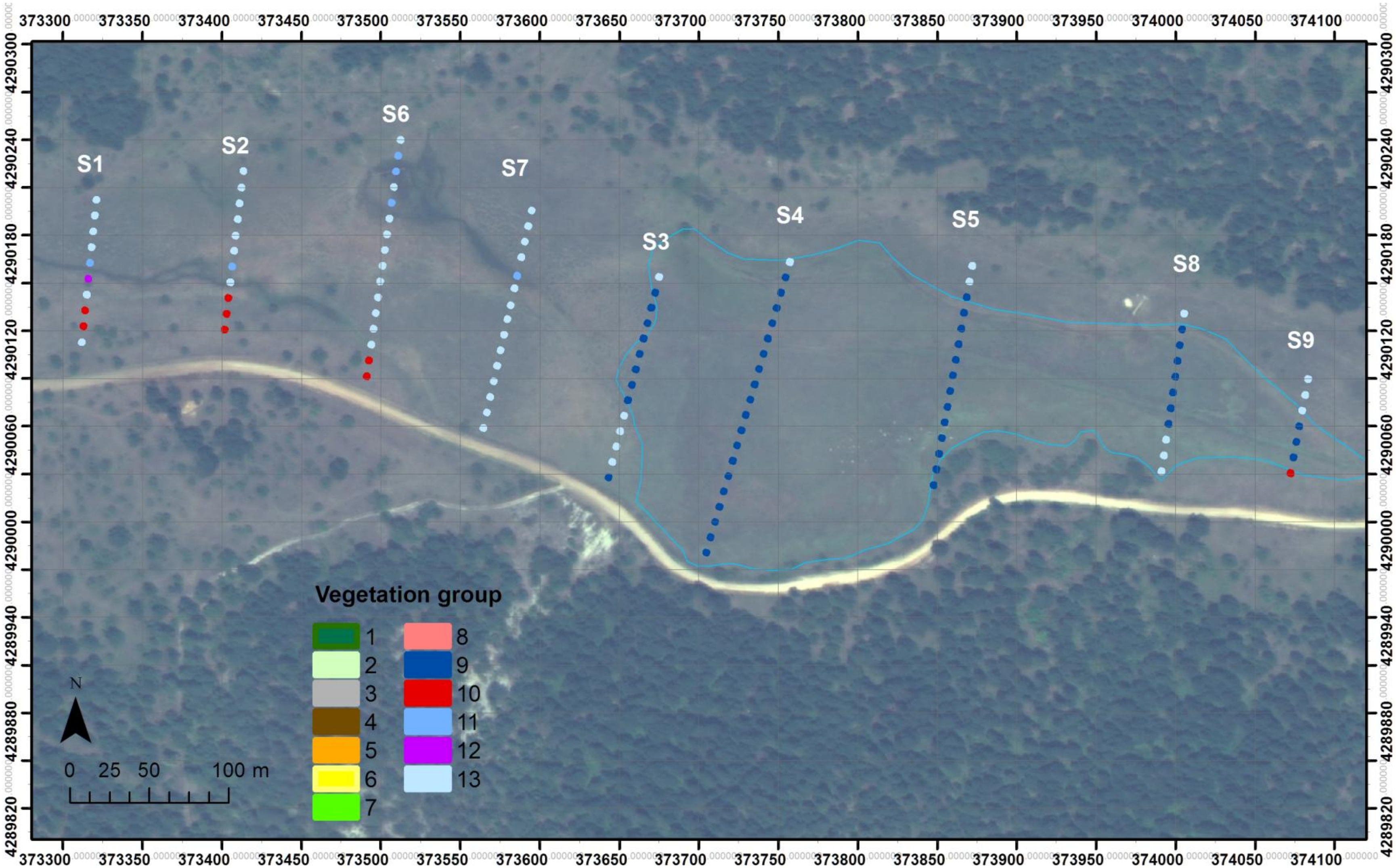

Figure 15. Kallidromo, Souvala grassland transects (S1 to S9).

3.2. Description of flora composition and vegetation groups of the mountain grasslands in Mt. Oiti and Mt. Kallidromo

A total of 254 plant species were identified in the grasslands, 119 on Oiti and 179 on Kallidromo, mostly dry and wet grassland species and also mountain heath species (Table 8). Synanthropic vegetation species occured mainly on Kallidromo where the invasive species *Xanthium spinosum*, the only alien identified in the grasslands, was also found.

The life form spectrum of the mountain grassland vegetation is presented in Figure 16a. More than 92 % of the species were herbs and the most prominent life form was the hemicryptophytic, as expected for high altitude ecosystems. Therophytes were mainly dry grassland and synanthropic species and were more frequent on Mt. Kallidromo. Chamaephytes and phanerophytes were few and in fact occurred at plots representing transition to mountain scrub and forest.

The chorological spectrum is presented in Figure 16b. In general, the restricted distribution species such as the greek endemics and balkan endemics as well as the Mediterranean taxa represented a lower percentage in the mountain grassland flora than in the general Greek flora (data on the Greek flora as in Dimopoulos et al. 2013). On the contrary widespread species, especially European and Eurasiatic species, represented a higher percentage in the mountain grasslands than in the general flora. This was also noted by Karetsos (2002) for the flora of Mt. Oiti. Notably, five species with distribution in N Eurasia at (boreal) or above (arctic -alpine) the high montane timberline were identified: *Juncus articulatus*, *Luzula multiflora*, *Phleum alpinum*, *Luzula spicata*, and *Veronica serpyllifolia*.

The above general patterns of life forms and chorology varied between the two mountains and between the vegetation units. This variation is presented per vegetation unit below.

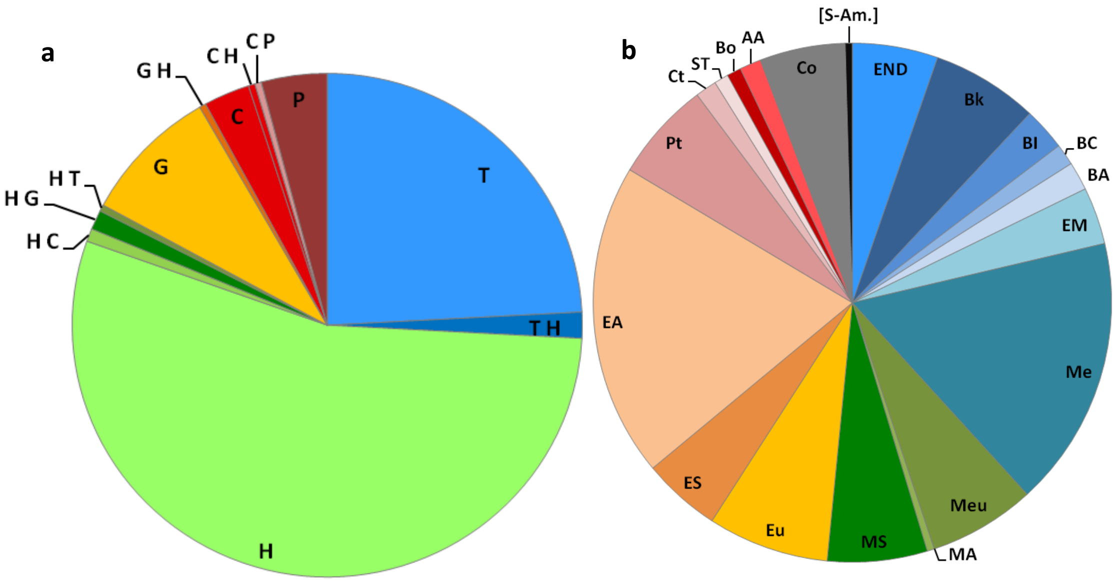

Figure 16. a: Life form spectrum of the mountain grassland species; **b**. Chorological spectrum of the mountain grassland species.

The mountain grasslands of Mt. and Mt. Kallidromo were clustered in 13 vegetation groups (Table 7). It must be stressed that these groups do not represent vegetation units in a strict phytosociological sence, but are rather species assemplages representing the spatial distribution of flora species in the grassland areas, including the transition to or intrusion of scrub and forest and the transition to wet grassland or temporary pond vegetation. The hierarchical classification tree is illustrated in Figure 17 and the synoptic classification table, including the flora list in the grasslands is shown in Table 8. Each vegetation group is described in detail below and the spatial distribution of the vegetation groups at each locality is presented in Figures 3 to 15.

The classification analysis separated the plots in two large groups, mainly based on altitude (Figure 17). The first group includes high altitude grasslands on Oiti (vegetation groups 1 to 7), which correspond to habitat type 6230 and its transition to drier grassland types or scrub, and on Kallidromo (vegetation group 8) which corresponds to habitat type 6210 and its transition to scrub. The second group (vegetation groups 9 to 13) includes grasslands on Kallidromo which correspond to either wet grasslands of habitat type 6420 or dry grasslands of habitat types 6210 or 62A0 and the transitions among them.

Table 7. Vegetation groups in the mountain grasslands of Mt. Oiti and Mt. Kallidromo.

	Vegetation Groups	Vegetation type	Distribution
1	*Nardus stricta-Centaurea nervosa subsp. promota*	6230	Oiti: Livadies, Livadies 2, Greveno, Alykaina, Tourkos
2	*Poa timoleontis-Galium verum*	6230 transition to 4060/4090 or *Festuco-Brometea*	Oiti: Zapantolakka, Tsamadaiika, Alykaina, Livadies, Tourkos
3	*Juniperus communis subsp. nana*	4060	Oiti: Livadies, Greveno, Tourkos
4	*Plantago holosteum-Hieracium piloselloides*	6210 (or 6230 transition to *Festuco-Brometea*)	Oiti: Tsamadaiika
5	*Festuca dalmatica-Plantago argentea*	6230 transition to *Festuco-Brometea*	Oiti: Alykaina
6	*Koeleria lobata-Poa variegata*	6230 transition to 4060/4090	Oiti: Alykaina, Tourkos, Livadies
7	*Hieracium hoppeanum-Plantago holosteum*	6230 and 6230 transition to 4090	Oiti: Livadies
8	*Festuca jeanpertii subsp. achaica-Achillea crithmifolia*	6210, 6210 transitionn to 4060	Kallidromo: Gkioza, Isomata; Oiti: Tourkos
9	*Mentha pulegium-Potentilla reptans*	6420: *Plantaginetalia majoris* and transition to *Phragmito-Magnocaricetea*	Kallidromo: Souvala, Mouriza
10	*Festuca valesiaca-Eryngium campestre*	6210/62A0+synanthropic	Kallidromo: Souvala, Nevropoli, Isomata, Mourouzos, Mouriza
11	*Juncus inflexus*	6420: *Plantaginetalia majoris*	Kallidromo: Souvala (canal)
12	*Hordeum bulbosum-Agrostis gigantea* (*Ononis spinosa*)	62A0, 62A0 transition to 6420	Kallidromo: Panagia, Isomata, Souvala
13	*Plantago lanceolata-Lotus corniculatus* (*Ononis spinosa*)	62A0, 62A0 transition to 6420	Kallidromo: Souvala, Panagia, Nevropoli, Mourouzos Oiti: Tourkos

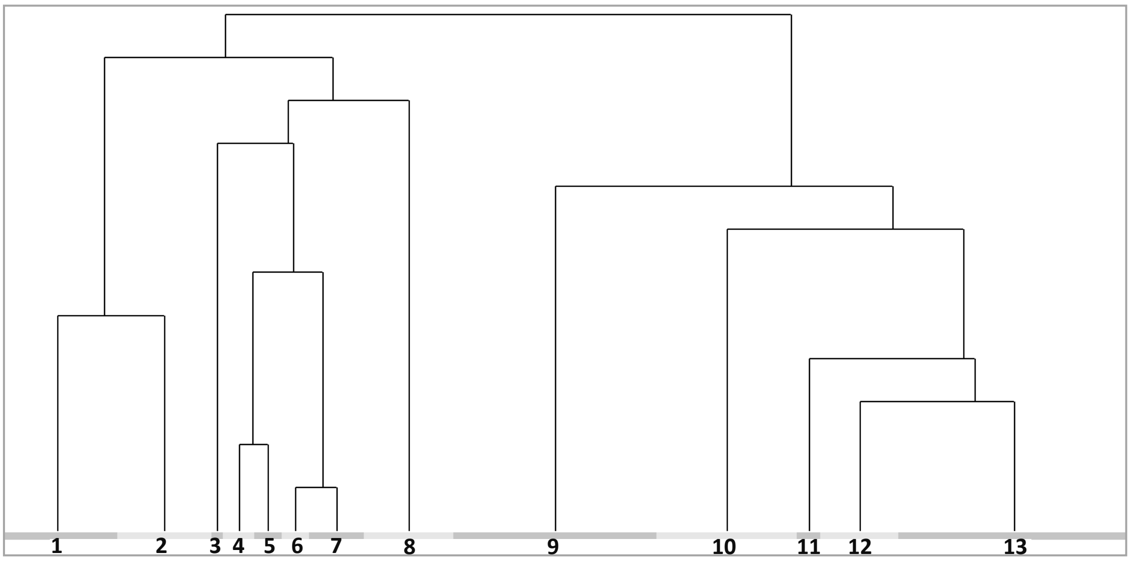

Figure 17. Hierarchical classification tree of vegetation units in the mountain grasslands of Mt. Oiti and Mt. Kallidromo.

Vegetation group 1: 6230 - *Nardus stricta-Centaurea nervosa* subsp. *promota*

Diagnostic species: *Centaurea nervosa* subsp. *promota, Nardus stricta, Trifolium hybridum*

Constant species: *Centaurea nervosa* subsp. *promota, Galium verum*

Dominant species: *Centaurea nervosa* subsp. *promota, Deschampsia cespitosa, Nardus stricta*

Vegetation group 1 occurs only on high altitude (above 1700 m) flyschs of Mt. Oiti at soils which remain waterlogged after the snow melts and are more acidic. This vegetation group corresponds to the typical form of habitat 6230 and is most representative at the locality Livadies 2. Both *Centaurea nervosa* subsp. *promota* (a greek endemic high altitute species) and *Nardus stricta* (a species with distribution in temperate Eurasia) are diagnostic of the *Juncetea trifidi* Greek endemic order *Trifolietalia parnassi*. Besides, the participation of the *Juncetea trifidi* species *Luzula multiflora*, *Luzula spicata*, *Rumex acetosella*, *Dianthus tymphresteus*, *Bellardiochloa variegata* (=*Poa variegata*), and *Phleum alpinum* is notable in this group. The participation of wet grassland species such as *Trisetum flavescens* and *Plantago lanceolata* is notable, and especially *Trifolium hybridum* appears with high frequency. Another two species, *Plantago argentea* and *Galium verum*, present significant contancy in both vegetation group 1 and 2. *Plantago argentea* is considered diagnostic of xerophytic *Festuco-Brometea* orders (*Scorzoneretalia villosae*, *Brometalia erecti*) in Europe while *Galium verum* is considered diagnostic of mesophytic *Festuco-Brometea* grasslands (e.g., Terzi 2015, Chytrý & Tichý 2003). However, in Greece *Plantago argentea* has been listed in the diagnostic species of the order *Juncetea trifidi*: *Trifolietalia parnassi* (Quezél 1964, Karetsos 2002). *Galium verum* on the other hand apparently participates in a range of mountain grassland communities in Greece and in Europe, for example *Mollinio-Arrhenatherea* in Italy (Allegreza & Biondi 2011), *Koelerio-Corynephoretea* and *Daphno-Festucetea* in the Greek Prespes National Part (Fotiadis et al. 2014) and has been recorded with high frequency in acidophilous *Brachypodietalia pinnati* communities in Aar in Germany (Becker et al. 2012). Its association to the *Nardus stricta* grasslands has been registered not only on Oiti, where it has been included in the diagnostic species of the *Trifolion parnassi* association *Nardus stricta-Luzula spicata* (Karetsos 2002), but also in Monte Perdido in Spain where it was differential of *Nardus stricta* communities. As whole, vegetation group 1 corresponds to the associations *Nardus stricta-Luzula spicata* ass. Quézel 1964 and *Trifolium hybridum* comm. identified by Karetsos (2002) on Oiti.

It must be noted that two of the plots clustered in this group at the locality of Tourkos occur on dolomite. As noted in section 1, different rocks may intermingle with the parent rock locally but this may not be the case in Tourkos. The dominance of *Centaurea nervosa* and the participation of *Juncetea trifidi* species leave no doubt as to the assignment of the plots to vegetation group 1. Since vegetation group 8 (habitat type 6210) is the dominant one at Tourkos locality, these two plots may represent locally wetter patches of *Festuco-Brometea* communities which at higher altitudes are close to the class *Juncetea trifidi* (Micevski 1971).

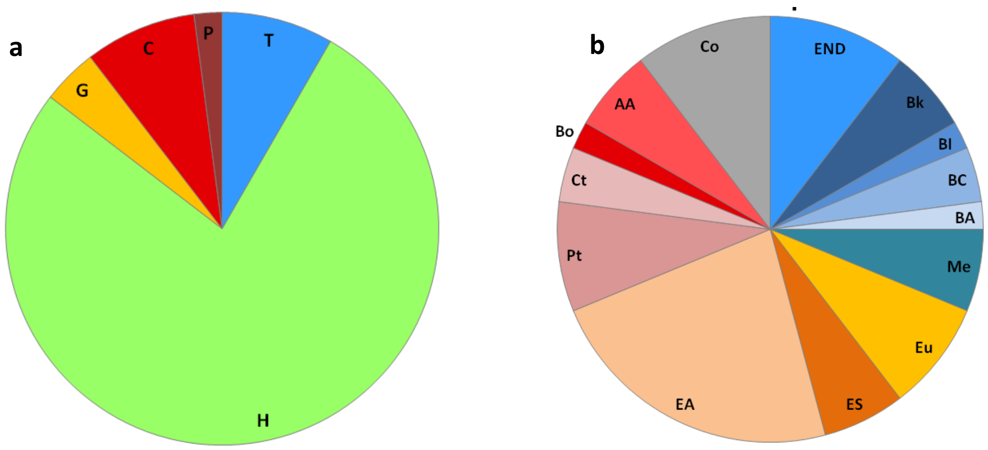

Figure 18. Vegetation group 1, **a**: life form spectrum; **b**. chorological spectrum.

The life form spectrum shows that hemicryptophytes are dominant and the presence of other life forms is sporadic. The only phanerophyte is the shrub *Juniperus communis* subsp. *nana* appearing in one plot in Livadies and indicating scrub intrusion. The increased chamaephytic element reflects species of the *Daphno-Festucetea*. Regarding chorology, the endemic and balkan element is more prominent than in the mountain grasslands as a whole, however Mediterranean species were much fewer. Also, this group includes all the 3 arctic-alpine and one of the two boreal species identified in the mountain grasslands. The increased participation of cosmopolitan species is due to the increased wet grassland element.

Vegetation group 2: 6230 transition to *Festuco-Brometea* or 4060/4090 - *Poa timoleontis-Galium verum*

<u>Diagnostic species</u>: *Achillea setacea, Poa timoleontis, Potentilla recta*

<u>Constant species</u>: *Galium verum*

<u>Dominant species</u>: *Achillea setacea, Galium verum, Helictotrichon pubescens, Hieracium hoppeanum s.l., Juniperus foetidissima, Poa timoleontis*

Vegetation group 2 was recorded mainly on flyschs at the lower altitudes of Oiti (1400 – 1435 m) at the localities Zapantolakka, where it presents the unique vegetation group identified, and Tsamadaiika. Only three plots were recorded at the higher altitudes of Livadies, Alykaina, and Tourkos. As a whole, this community is characterised by a series of species usually considered as diagnostic of the class *Festuco-Brometea* (e.g. *Eryngium amethystinum*, *Prunella laciniata*, *Potentilla recta*, and *Hieracium hoppeanum* s.l.) and by sporadic presence of

Juncetea trifidi (e.g. *Alopecuros gerardii*, *Edraianthus parnassicus*, and *Luzula spicata*) and other wet grassland species (e.g. *Trisetum flavescens*).

The diagnostic species *Poa timoleontis* and *Achillea setacea* were identified only in Zapantolakka. *Achillea setacea*, a member of the *Achillea millefolium* aggregation, is considered a diagnostic species of the alliance *Festucion valesiacae*, apparently calcifuge, in the Czech Republic (Chytrý 2007, Danihelka 2001, Vassilev et al. 2012) but occuring both on limestone and schist in Greece (Strid & Tan 1991). *Poa timoleontis*, on the other hand, is generally considered diagnostic of the class *Daphno-Festucetea* in Greece (e.g. Mucina 1997, Κοκμοτός 2008), but it has also been identified as diagnostic of *Trifolietalia parnassi* associations in Mt. Vermion (association with *Alopecuros gerardii-Phleum alpinum*) and Mt. Oiti (*Poa timoleontis* comm.) (Χοχλιούρος 2005, Karetsos 2002). The cases of *Plantago argentea* and *Galium verum* are discussed in vegetation unit 1. Another two species with high frequency in Zapantolakka, *Armeria canescens* and *Trifolium alpestre* have been considered as diagnostic of both xerophytic *Festuco-Brometea* alliances (e.g. Terzi 2015, Chytrý 2007, Papademetriou et al. 1998), and the *Juncetea trifidi* alliance *Trifolion parnassi* (Quezél 1964, Karetsos 2002). Especially *Trifolium alpestre* is also considered a *Trifolio-Geranietea* fringe vegetation species (Mucina 1997). A third species with high frequency in Zapantolakka, *Trisetum flavescens*, commonly considered diagnostic of the class *Molinio-Arrhenatheretea*, has also been included in the *Juncetea trifidi* in Greece (Χοχλιούρος 2005). Taking into account all the above, the presence of *Alopecuros gerardii* and other *Juncetea trifidi* species, and the flysch substrate, the grasslands of Zapantolakka may be considered as a transitional state between the chionophilous grasslands of habitat 6230 and the *Festuco-Brometea* grasslands. The increased presence of scrub and forest species, including saplings of *Juniperus foetidissima*, indicates that the forest is expanding in the currently ungrazed grassland.

The four plots at the locality Tsamadaiika which are differentiated by the constant presence of *Brachypodium pinnatum*, a typical *Brachypodietalia pinnati* (=*Brometalia erecti*) species, constitute a different case. The plots in question were either under shrubs or close to a stream and seem to represent a more humid facies of vegetation group 4. As discussed under vegetation group 4, the substrate of the locality may not be purely flysch. Here, the presence of *Juncetea trifidi* species is rare and the commuinty seems to have closer affinities to the *Festuco-Brometea* grasslands, so the plots could be assigned to habitat type 6210.

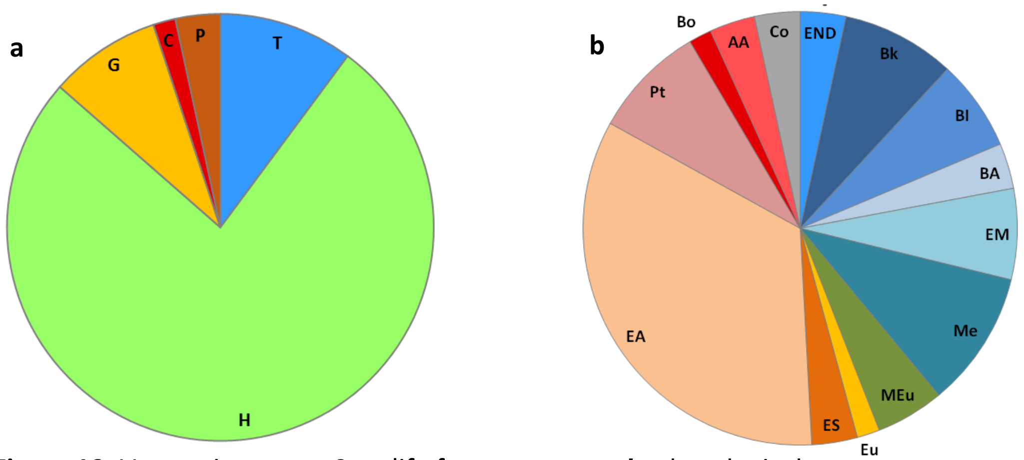

Figure 19. Vegetation group 2, **a**: life form spectrum; **b**. chorological spectrum.

Finally, the high altitude plots at Livadies, Tourkos, and Alykaina which are differentiated by the wet grassland species *Helictorichon pubescens* and *Trisetum flavescens*, represent facies of vegetation groups 1 (Livadies, Tourkos) and 5 (Alykaina) indicating transition to mesic *Festuco-Brometea* grasslands. *Helictotrichon pubescens* is considered diagnostic of the class *Molinio-Arrhenatheretea* (Mucina 1997, Rivas-Martinez et al. 2002) but is also known to differentiate *Brometalia erecti* communities in Europe (Simwell 1971, Rūsiņa 2009, Becker et al. 2012).

The life form spectrum of vegetation group 2 is similar to the one of vegetation group 1. Regarding chorology, vegetation group 2 has a less prominent greek endemic element than vegetation group 1 and a more prominent Balkan and Mediterranean element, but the most prominent element is the European-SW Asian (c. 40 %) which is higher than the ones of both vegetation group 1 and the general grassland chorological spectrum.

Vegetation group 3: 4060 - *Juniperus communis* subsp. *nana*

Diagnostic species: *Juniperus communis* subsp. *nana*
Constant species: *Juniperus communis* subsp. *nana*
Dominant species: *Juniperus communis* subsp. *nana*

This vegetation group corresponds to habitat 4060, mountain scrub with *Juniperus communis* subsp. *nana*. It represents scrub intrusion in the mountain grasslands.

Vegetation group 4: 6210 (or 6230 transition to *Festuco-Brometea*) - *Plantago holosteum-Hieracium piloselloides*

Diagnostic species: *Euphrasia liburnica, Hieracium piloselloides, Plantago holosteum*
Constant species: *Plantago holosteum*

Vegetation group 4 was recorded only in Tsamadaiika. This site is located in an area where the main geological substrate is flysch with extended limestone intercalations. *Plantago holosteum* is a species considered diagnostic of *Thero-Brachypodietea* dry grasslands (Mucina 1997) but in the balkans (Redžić et al. 2013, Aćić et al. 2015) and in E Europe (Bernhardt & Kropf 2006, Terzi 2015) it has been identified as diagnostic of dry *Festuco-Brometea* communities (*Brometalia erecti*: *Xerobromion*, *Halacsyetalia sendtneri*, *Scorzoneretalia villosae*). In Greece, *Plantago holosteum* has been identified as diagnostic of *Thero-Brachypoetea* dry grasslands in Makedonia (Bergmeier et al. 2009, Fotiadis et al. 2014). However, the species has also been considered as diagnostic of the alliance *Trifolion parnassi* (Quézel 1964, Χοχλιούρος 2005) and identified as diagnostic of the drier aspect of *Trifolion parnassi* communities on Oiti (Karetsos 2002). *Hieracium piloselloides* is also considered a *Festuco-Brometea* species either of the *Scorzoneretalia villosae* or of the xerophytic *Brometalia erecti* (Maccherini et al. 1998, Alegro 2003, Biondi & Galdenzi 2012). *Euphrasia liburnica* on the other hand is a balkan endemic which has been identified as diagnostic of alpine grassland *Elyno-Sesleretea* communities in Croatia and Slovenia (Surina 2005, Surina & Surina 2010). *Thymus longicaulis* also participates with significant constancy in vegetation group 4. It is a Mediterranean species, diagnostic of *Festuco-Brometea* (Mucina 1997, Terzi 2015) and in the Balkans it has also been recorded as diagnostic of the orders *Scorzoneretalia villosae* (Horvat et al. 1974), *Halacsyetalia sendtneri* (Aćić et al. 2015), and *Brometalia erecti* (Foggi et al. 2014) and especially of the alliance *Cirsio-Brachypodion pinnati* (Vassilev et al. 2012). However, on Oiti it is often abundant in *Daphno-*

Festucatea communities and it has been identified as diagnostic of the *Trifolion parnassi Potentilla pedata* comm. (Karetsos 2002). The presence of *Festuco-Brometea* species and especially of xerophytic vegetation species (i.e. *Festucetalia valesiacae*, *Xerobromion*) is constant in this group while the presence of *Juncetea trifidi* is sporadic but there is significant presence of *Daphno-Festucetea* and thermophilous dry grassland species. Considering the above and taking into account the *Brachypodium pinnatum* wet aspect of the grassland in Tsamadaiika (vegetation group 2), vegetation group 4 has greater affiliations to the *Festuco-Brometea* grasslands than to the *Juncetea trifidi* grasslands and could be assigned to habitat type 6210. Alternatively, due to the presence of *Juncetea trifidi* species and based on their syntaxonomical position on Oiti (Karetsos 2002), the Tsamadaiika grassland could be considered a transitional form of habitat 6230 towards the *Festuco-Brometea*.

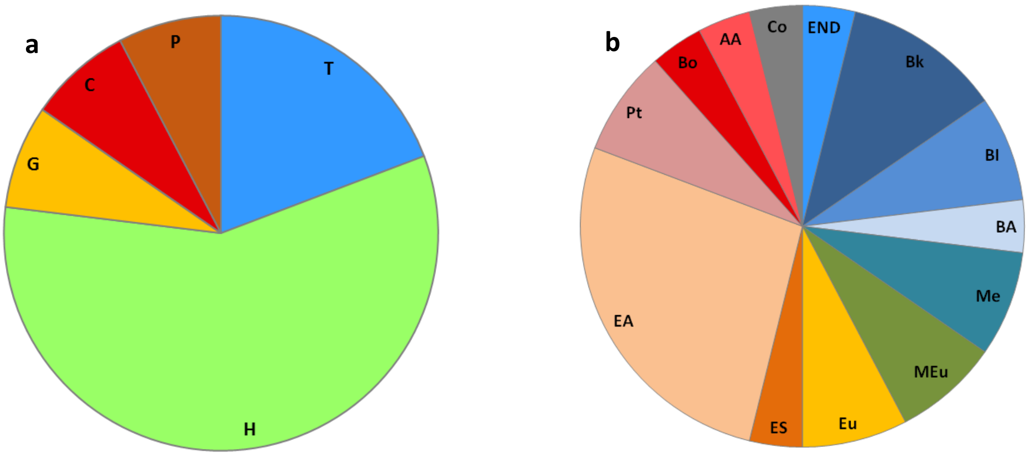

Figure 20. Vegetation group 4, **a**: life form spectrum; **b**. chorological spectrum.

The life form spectrum of vegetation group 4 is characterised by a higher participation of therophytes compared to groups 1 and 2. Regarding the chorological spectrum, the greek endemic element is even lower than the one of group 2, but the balkan element is even more pronounced. The Mediterranean element and European-SW Asian element are also lower than in group 2, but the latter is still increased compared to the general grassland pattern.

Vegetation group 5: 6230 transition to *Festuco-Brometea* - *Festuca dalmatica-Plantago argentea*

<u>Diagnostic species</u>: *Achillea species, Centaurea triumfettii, Festuca dalmatica**,** Poa bulbosa, Trifolium phleoides*

<u>Constant species</u>: *Festuca dalmatica, Plantago argentea, Poa bulbosa, Trisetum flavescens*

Vegetation group 6 was recorded only at the locality of Alykaina where limestone intercalations appear on the main flysch substrate. The participation of *Juncetea trifidi* species (*Dianthus tymphresteus*, *Rumex acetosella*, *Anthemis tinctoria* subsp. *parnassica*) is constant in all the plots as is the constancy of species such as the *Plantago argentea*, *Trisetum flavescens*, *Trifolium alpestre*, and *Armeria canescens* which present an affiliation to the *Juncetea trifidi*, as discussed above. However, the presence of *Festuco-Brometea* and other dry grassland species is equally prominent. *Festuca dalmatica* has been identified as a diagnostic species of *Astragalo-Potentilletalia* communities (Aćić et al. 2015) or of communities intermediate between *Cirsio-Brachypodion pinnati* and the more xerothermic *Festucion valesiacae* and *Saturejion montanae* (Vassilev et al. 2012). *Centaurea triumfettii* is usually considered as diagnostic of *Festucetalia valesiacae* communities but also included in *Brometalia erecti* or *Scorzoneretalia villosae* (Horvat et al. 1974, Todorova & Tzonev 2010, Terzi 2015). On the other hand, *Poa bulbosa* is included in the diagnostic species of the *Festuco-Brometea* by Terzi (2015), however it is usually considered typical of the *Thero-Brachypodietea* or *Poetea bulbosae* (Mucina 1997, Rivas-Martinez et al. 2002). Vegetation group 5 is close to vegetation group 4 due to the presence of *Anthemis tinctoria* subsp. *parnassica*, the high constancy of *Thymus longicaulis* and *Plantago argentea* and the presence of the dry grassland and forest species, *Arenaria serpyllifolia* and *Silene italica*. But it is characterised by higher constancy of *Juncetea trifidi* species and by a high constancy of *Trisetum flavescens*. Taking into account all the above and the fact that the locality of Alykaina is affected by snow cover and adjacent to the 6230 vegetation group 1, vegetation group 5 is considered a transitional vegetation of the habitat 6230 towards *Festuco-Brometea* communities.

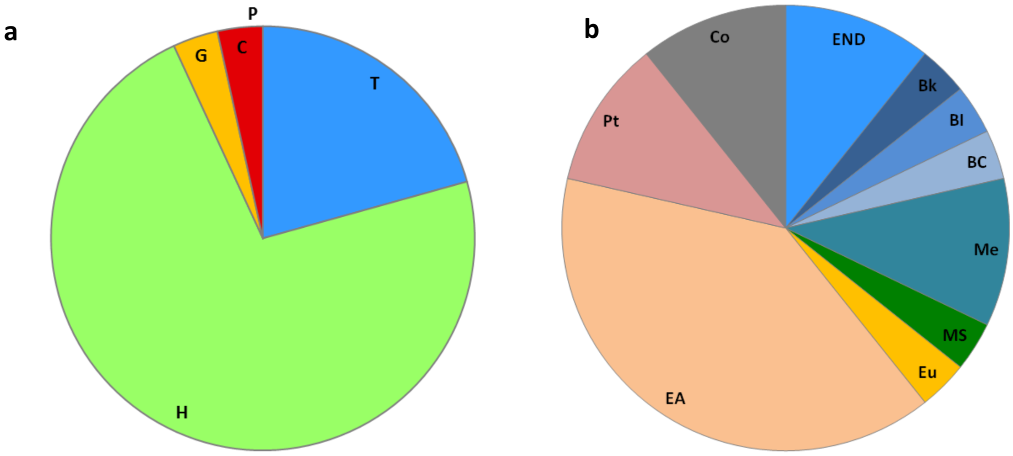

Figure 21. Vegetation group 5, **a**: life form spectrum; **b**. chorological spectrum.

The life form spectrum shows the dominance of hemicryptophytes and also an increased percentage of therophytes due to the participation of *Thero-Brachypodietea* species. The chorological spectrum shows increased participation of Paleotemperate and Cosmopolitan species compared to vegetation groups 1 to 4. European-SW Asian and Mediterranean species are also increased as in vegetation group 2. The increased participation of Cosmpopolitan species (3 species) reflects the synanthropic vegetation species which occur with high frequency probably due to the fact that the area of Alykaina is grazed.

Vegetation group 6: 6230 transition to 4060/4090 - *Koeleria lobata-Poa variegata*

<u>Diagnostic species</u>: *Astragalus sempervirens, Koeleria lobata, Poa variegata* (valid name = *Bellardiochloa variegata*)

<u>Constant species</u>: *Koeleria lobata, Poa variegata*

<u>Dominant species</u>: *Secale montanum* (valid name = *Secale strictum* subsp. *strictum*)

Vegetation group 6 was recorded at high altitudes in the area of Alykaina (most of the plots) where dolomites intercalate with flysch and also in Livadies and Tourkos (one plot each). It is characterised by high constancy of *Juncetea trifidi* species, among which the diagnostic *Bellardiochloa variegata*, and by high constancy of *Daphno-Festucetea* species, among which the diagnostic *Astragalus sempervirens*. On the contrary, the presence of *Festuco-Brometea* and other dry grassland species is reduced. *Koeleria lobata* is typically included in the *Festuco-Brometea* (e.g., Mucina 1997, Foggi et al. 2014), but in Greece and especially on Oiti it has also been identified as differential in *Daphno-Festucetea* communities (Karetsos 2002, Korakis & Gerasimidis 2010, Fotiadis et al. 2014). Due to the above and taking also into account both the high altitude and the adjacent 6230 plots, vegetation group 6 is assigned to habitat 6230 as a transitional form to the oro-Mediterranean scrub of habitats 4060 and 4090. Indeed, as it was evident in the field and in the satellite images (Figures 3, 5, and 8), vegetation group 6 has been recorded at a zone where scrub cover begins to increase.

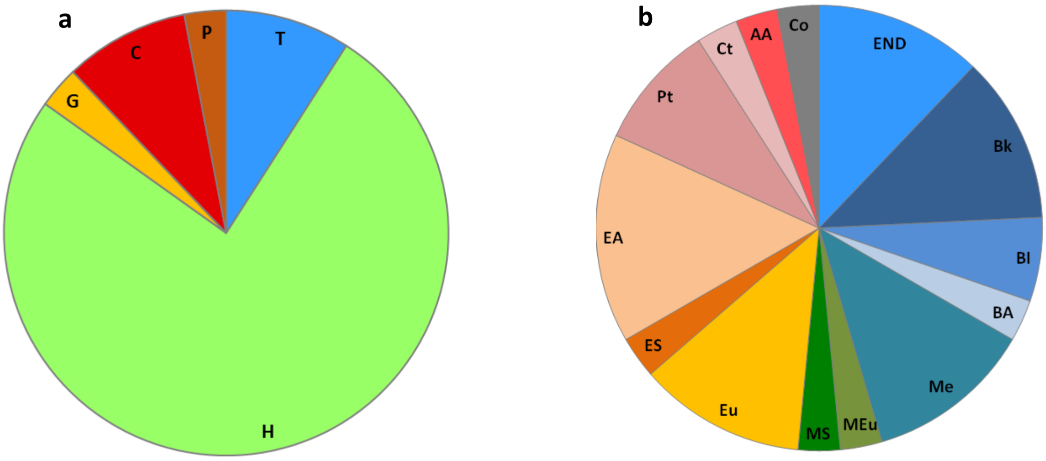

Figure 22. Vegetation group 6, **a**: life form spectrum; **b**. chorological spectrum.

The life form spectrum is similar to the one of vegetation group 1. The chorological spectrum however shows an increased participation of greek endemic, Mediterranean and Balkan species and a decreased particpation of European-SW Asian and Eurasiatic species compared to vegetation group 1. The former increase is mainly due to the high participation of species of the greek endemic class *Daphno-Festucetea*.

Vegetation group 7: 6230 and 6230 transition to 4090 - *Hieracium hoppeanum-Plantago holosteum*

Diagnostic species: *Anthemis cretica ssp. columnae, Hieracium hoppeanum s.l., Minuartia recurva*

Constant species: *Hieracium hoppeanum s.l., Plantago holosteum, Poa bulbosa*

Vegetation group 7 was recorded only at the high altitudes of Livadies and Greveno, on flysch, in contact with vegetation group 1. This vegetation group is characterised by the constant presence of a several *Juncetea trifidi* species (e.g., *Dianthus tymphresteus*, *Phleum alpinum*, *Centaurea nervosa* subsp. *promota*) and mesophilous grassland species (e.g., *Anthemis cretica* subsp. *columnae*, *Anthoxanthum odoratum*) and by frequent participation of *Daphno-Festucetea* species (*Astragalus thracicus*, *Astragalus sempervirens*, *Festuca jeanpertii* subsp. *achaica*). Except from certain of the characteristic species, the presence of *Festuco-Brometea* species is sporadic. Regarding the characteristic species, *Minuartia recurva* is considered diagnostic of the class *Juncetea trifidi* (Mucina 1997) while the case of *Plantago holosteum* and its affiliation to the alliance *Trifolion parnassi* is discussed in vegetation group 4. *Hieracium hoppeanum* is a variable species with several subspecies and the plants of Oiti have been identified as *Hieracium hoppeanum* subsp. *pilisquamum* (Karetsos 2002) whose valid name is *Pilosella leucopsilon* subsp. *pilisquama* (Dimopoulos et al. 2013). It is generally considered diagnostic of the meso-xerophytic *Festuco-Brometea* communities (Mucina 1997, Pirini et al.

2014, Dimitrov 2015, Vassilev et al. 2012). However, it has also been identified as a dianostic species of *Juncetea trifidi* communities in Romania (Ştefan et al. 2002) and of *Nardus* rich grasslands in the Alps (Lüth et al. 2011) and on Oiti (Karetsos 2002). Taking into account the above, vegetation group 7 represents *Juncetea trifidi* communities of habitat 6230, at patches drier than the ones of vegetation group 1 and also at the transition zones from habitat 6230 to oro-Mediterranean scrub (habitat 4090).

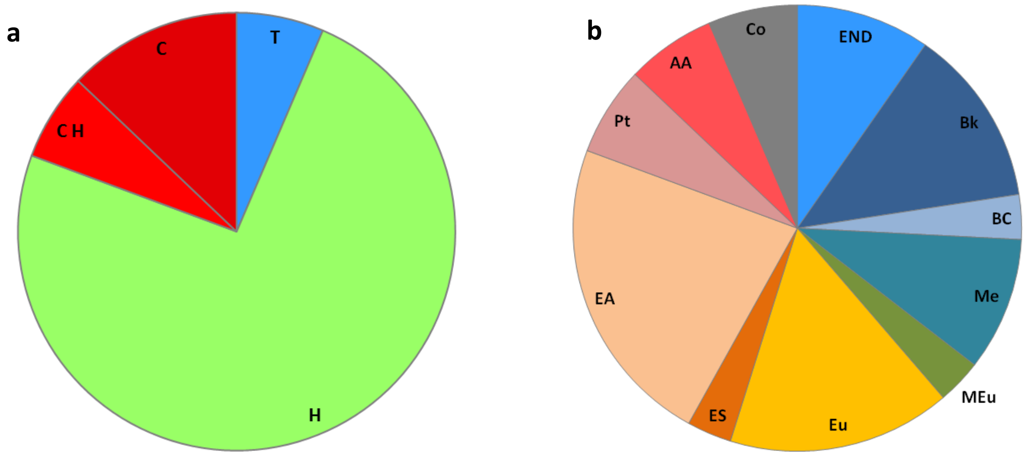

Figure 23. Vegetation group 7, **a**: life form spectrum; **b**. chorological spectrum.

The life form spectrum is similar to the ones of vegetation groups 1 and 2 regarding the dominance of hemicryptophytes but shows a somewhat higher participation of chamaephytes. The chorological spectrum is also similar to the one of vegetation group 1.

Vegetation group 8: 6210 - *Festuca jeanpertii* subsp. *achaica-Achillea crithmifolia*

<u>Diagnostic species</u>: *Achillea crithmifolia, Festuca jeanpertii* subsp. *achaica, Hieracium gaudryi, Leontodon cichoriaceus, Potentilla laciniosa*

<u>Constant species</u>: *Festuca jeanpertii* subsp. *achaica*

<u>Dominant species</u>: *Festuca jeanpertii* subsp. *achaica, Hieracium gaudryi, Thymus longicaulis*

Vegetation group 8 was recorded on hard limestone at the sites of Gkioza (most plots of the group) and Isomata in Kallidromo and on dolomite at the site of Tourkos on Oiti. All sites are grazed and are within the *Abies cephalonica* zone. This vegetation group is characterised by high frequency and number of *Festuco-Brometea* species, by significant but lower numbers and low frequency of thermophilous dry grasslands species, and by few mesophilous grassland *Molinio-Arrhenatheretea* species, mainly *Plantago lanceolata*.

Festuca jeanpertii subsp. *achaica* is the diagnostic species with the highest constancy. It is a greek endemic of moderate to high altitudes considered characteristic of the oro-Mediterranean srcub communities of the *Daphno-Festucetea* (Mucina 1997) and has been identified as diagnostic in *Stipo-Morinion* communities which are supposed to represent the impact of burning and summer grazing on the *Abies cephalonica* forest formations (Karetsos 2002, Maroulis 2005, Κοκμοτός 2008). This fact as well as the participation of other *Daphno-Festucetea* species, such as *Marrubium velutinum*, *Astragalus thracicus* and *Poa thessala*, (mainly at Tourkos) and of forest and scrub species, such as *Pteridium aquilinum* and *Juniperus oxycedrus* (mainly at Gkioza and Isomata), indicates that these grasslands may indeed be the result of forest degradation and also that lack of grazing and grazing management promotes the recovery of the scrub and forest. It must be noted that the diagnostic species *Leontodon* *cichoriaceus* (which was recorded only in the transect of Gkioza but is known to occur at other grasslands as well both in Oiti and Kallidromo) is a Mediterranean geophyte, usually found in mountain juniper or deciduous scrub and forest in Greece (e.g. Χοχλιούρος 2005, Korakis & Gerasimidis 2010) and recorded as typical of *Festuco-Brometea* grasslands only in Tuscany (Foggi et al. 2014).

The main species common in Tourkos and Gkioza are the characteristic *Thymus longicaulis* along with *Nepeta nuda*, *Galium verum*, and *Trifolium arvense*. The affiliations of *Thymus longicaulis* and of *Galium verum* to *Festuco-Brometea* grasslands have been discussed in vegetation groups 4 and 1, respectively, and they are better considered as diagnostic of the class. *Trifolium arvense* is a widespread dry grassland annual, common in *Thero-Brachypodietea* (=*Helianthemetalia guttati*) communities and also occasionaly identified as diagnostic in *Festuco-Brometea* syntaxa (e.g. Aćić et al. 2015). On the other hand, *Nepeta nuda* is a polymporphic European-SW Asian species which in Greece occurs in montane and subalpine meadows and forest clearings (Strid & Tan 1986). It is considered a xerothermic generalist in Pannonian *Festucetalia valesiacae* steppe grasslands (Kovács 2011, Illyés & Bölöni 2007) and has never been affiliated to *Scorzoneretalia villosae* communities. However, in the Greek mountains of Elikon, Oiti, and Parnassos it has been identified as diagnostic of *Trifolietalia parnassi* communities (Κοκμοτός 2008, Karetsos 2002, Quézel 1964) and indeed participated in vegetation groups 1 and 5. Notably, both *Festuca jeanpertii* s.l. and *Nepeta nuda* are diagnostic in *Astragalo-Brometea* thorn cushion steppe vegetation in Turkey (Kurt et al. 2006).

Vegetation group 8 in Gkioza is differentiated by the participation of the diagnostic species *Achillea crithmifolia*, *Hieracium gaudryi*, and *Potentilla laciniosa*, and also by significant contancy of *Prunella laciniata*. In addition, another three species were recorded at the locality of Gkioza flowering earlier (in May) but were not present (or not identified due to the season) in the transect: *Phleum montanum*, *Stipa capillata*, *Salvia argentea*, and the rather rare orchid *Orchis pallens*. *Hieracium gaudryi* subsp. *gaudryi* is a rare high altitude greek endemic plant (Dimopoulos et al. 2006) which occurs both on limestone rocks and rocky grasslands and there is no data regarding its syntaxonomic affiliations. *Achillea crithmifolia* is a balkan-central european (Balkan-Pannonian) species and central Greece is the southermost limit of its distribution (Dimopoulos et al. 2006, Strid & Tan 1986). It has been identified as diagnostic of the *Astragalo-Potentilletalia* alliances in Serbia (e.g. Aćić et al. 2015) and of the order *Festucetalia valaesiacae* in Bulgaria (Tzonev 2009) or its alliances in France (Barbéro & Loisel 1971). It has also been recorded among the characteristic species of subcontinental grasslands with submediterranean element (*Stipio pulcherrimae-Festucetalia pallentis*) communities in Romania (Sanda et al. 2008) and *Hungary* (Boridi 2003). *Achillea crithmifolia* has not been recorded in *Scorzoneretalia villosa*e syntaxa and is supposed to indicate an ecological context different from the one of this order (Terzi 2015). *Potentilla laciniosa* has been identified as diagnostic of the class *Astragalo-Potentilletalia* in Greece and the south Balkans (Bergmeier et al. 2009, Ćušterevska et al. 2011) and also of the order *Festucetalia valesiacae* (Todorova & Tzonev 2010), but has also never been affiliated to the order *Scorzoneretalia villosae*. *Phleum montanum* is also diagnostic of the order *Festucetalia valesiacae* (Tzonev 2013). The fourth *Festuco-Brometea* species of Gkioza which is considered typical of continental steppe vegetation (Ceng & Nakamura 2007, Suzuki et al. 2012) and not affiliated to the *Scorzoneretalia villosae* is *Stipa capillata*. It has been identified as diagnostic of *Festucetalia* *valesiacae* and *Stipo-Festucetalia* in Romania (Dengler et al. 2012), *Festucion valesiacae* in Czechia (Chytrý 2007) and of *Astragalo-Potentilletalia* in Greece (Pirini et al. 2014). Finally, *Salvia argentea* is Mediterranean species, occurring occasionaly at the grasslands of Kallidromo and considered typical of the submediterranean-subcontinental steppes in Bulgaria (Vassilev & Apostolova 2014) but also considered typical of *Scorzoneretalia villosae* grasslands in Italy (Terzi et al. 2010).

Vegetation group 8 in Tourkos is differentiated by the presence of *Bromus cappadocicus*, *Eryngium amethystinum*, *Plantago argentea*, *Plantago holosteum*, *Potentilla pedata*, *Achillea setacea*, *Trisetum flavescens* (most of which are characteristic in vegetation groups 1 to 6) and by the occassional participation of several *Juncetea trifidi* and *Daphno-Festucetea* species. On the other hand, the two plots at Isomata are mainly connected to vegetation group 8 due to the rare presence of *Potentilla laciniosa*, otherwise they are characterised by *Festuca valesiaca* and other species of the vegetation groups 9 to 13.

In total, vegetation group 8 is undoubtely a *Festuco-Brometea* grassland which, based on the characteristic taxa (Table 8), seems more affiliated to *Festucetalia valesiacae* continental steppe communities or to the southern Balkan *Astragalo-Potentilletalia* ones than to the *Scorzoneretalia villosae* submediterranean communities. The species participating in this group (but not as characteristic) and considered by Terzi (2015) as diagnostic of the order *Scorzoneretalia villosae* are *Eryngium amethystinum*, *Plantago argentea*, *Plantago holosteum*, and *Festuca valesiaca*. The first three occur only in Tourkos and their affiliations to other high altitude vegetation units in Greece have already been discussed. The latter is only present at Isomata. One more species, *Prunella laciniata* which occurs sporadically in Gkioza, has been identified by Terzi (2015) as diagnostic of the alliance *Scorzonerion villosae* but it has also been identified as diagnostic in *Brometalia erecti/Brachypodietalia pinnati* alliances or assocations (e.g. Szafer 1966, Dengler et al. 2012).

Based on the above vegetation group 8 is assigned to habitat 6210. At Gkioza, it represents the high altitude submediterranean grasslands of Kallidromo, at the borders of supra- and mountain-Mediterranean bioclimate, still within the *Abies cephalonica* zone and maintained due to grazing. At Tourkos, it represents a transitional state among *Juncetea trifidi* and *Festuco-Brometea* grasslands. At Isomata, it is a facies of vegetation group 10 grasslands.

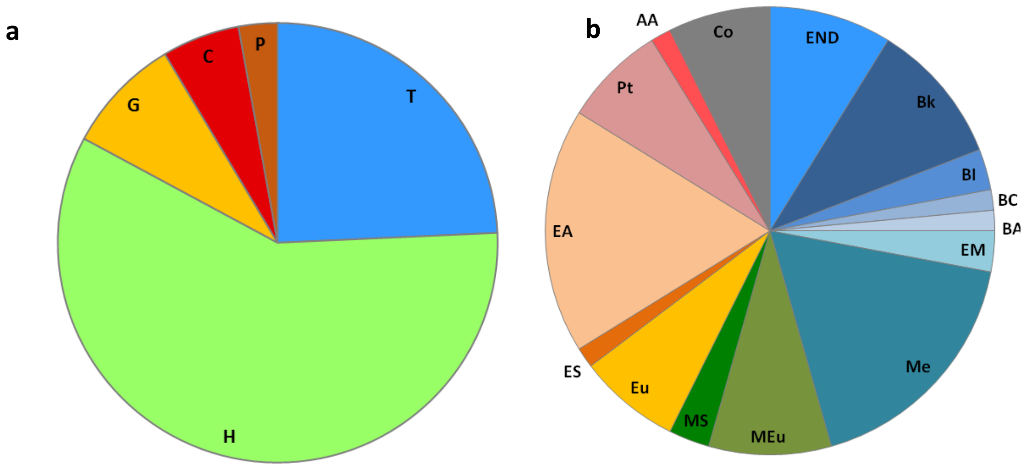

Figure 24. Vegetation group 8, **a**: life form spectrum; **b**. chorological spectrum.

The life form spectrum of vegetation group 8 is quite similar to the ones of vegetation groups 4 and 5. It shows a dominance of hemicryptophytes but has an increased percentage of annuals reflecting the increased participation of thermophilous dry grassland species. The chorological spectrum shows an increased participation of greek endemic, Mediterranean and Balkan species and a decreased particpation of European-SW Asian and Eurasiatic species similar to the one of vegetation group 6.

Vegetation group 9: 6420: *Plantaginetalia majoris* transition to *Phragmito-Magnocaricetea* - *Mentha pulegium-Potentilla reptans*

<u>Diagnostic species</u>: *Eleocharis palustris, Mentha pulegium*
<u>Constant species</u>: *Mentha pulegium*
<u>Dominant species</u>: *Convolvulus arvensis, Cynodon dactylon, Eleocharis palustris, Mentha pulegium, Plantago lanceolata, Potentilla reptans*

Vegetation group 9 is the main vegetation type at the deeper parts of the lake deposits of Souvala and was also recorded at one plot in Mouriza, adjacent to the pond. These sites are seasonally innundated wetlands under spring to summer heavy trampling and grazing. Vegetation group 9 is characterised by constancy and dominance of a series of hygrophilous species of the class *Molinio-Arrhenatheretea*, several of them considered diagnostic species of the eutrophic soil communities of the order *Plantaginetalia majoris*, i.e. *Potentilla reptans*, *Cynodon dactylon*, *Juncus inflexus*, *Carex divisa*, *Trifolium fragiferum*, *Carex otrubae* (Mucina 1997, Rivas-Martínez et al. 2002). Also, there is significant constancy of the pioneer nitrophilous grassland species *Convolvulus arvensis* and *Elytrigia repens*.

The diagnostic but not constant species *Eleocharis palustris* and also *Veronica anagallis-aquatica* are characteristic of *Phragmito-Magnocaricetea* helophytic communities and indicate longer periods of inundation. The diagnostic species *Mentha pulegium* is the unique representative of the class *Isoëto-Nanojuncetea* in this group and indicates late spring to summer inundation. Thus, part of the plots could be assigned to the order *Nano-Cyperetalia* which signifies communities of habitat 3170. However, *Mentha pulegium* is known to participate in *Phragmito-Magnocaricetea* communities (e.g. Landucci et al. 2013) and to occur at seasonally inundated habitat settings other than temporary ponds such as roadsides, ditches, and exposed river banks (e.g. Sarika 2005, Šumberová 2013).

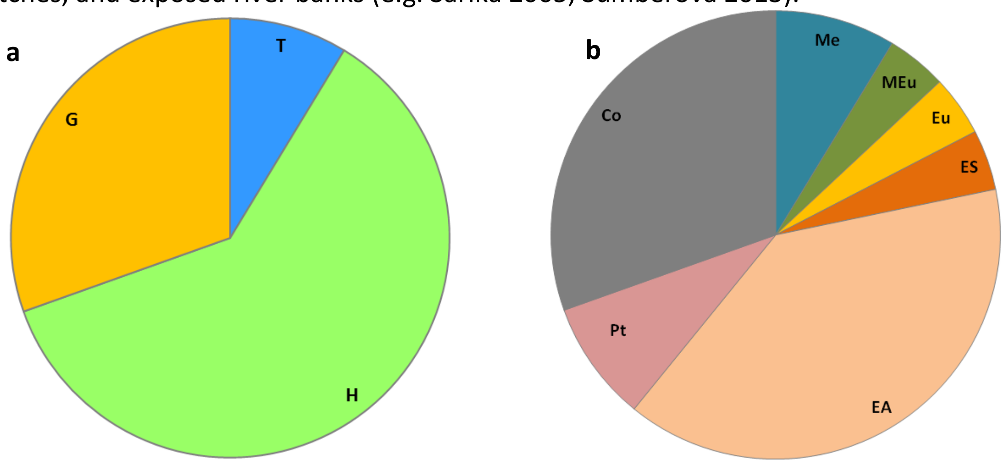

Figure 25. Vegetation group 9, **a**: life form spectrum; **b**. chorological spectrum.

It must be noted that while the transect samplings took place in July, a series of exploratory vegetation plots took place in early June, when part of the lake was flooded, in the area of transect S3 and between transects S3 and S7 close to the canal. In these plots, at the area of vegetation group 9, the dominant species were *Eleocharis palustris* and the *Molinio-Arrhenatheretea* species *Ranunculus sardous*, and *Oenanthe silaifolia* (the latter was rare in July possibly due to heavy grazing). Furthemore, in early May the area of transect S4 close to the road is flooded and the aquatic *Phragmito-Magnocaricetea* species *Ranunculus trichophyllus* dominates. This indicates a temporal and seasonal succesion between aquatic and wet grassland communities.

The life form spectrum of vegetation group 9 is characterised by dominance of hemicryptophytes, an elevated percentage of geophytes (mostly stoloniferous grasses,) and a total lack of woody plants. The chorological spectrum is also very different from the one of all the other vegetation groups, except group 11, in the lack of species with restricted distribution (e.g. endemic and balkan) and the increased participation of species with wide distribution, especially the European-SW Asian and Cosmopolitan species. The prevalence of species with wide distribution is a well known phenomenon in wetlands in the Mediterranean as well as world wide and it is supposed to be related to both the autecology and the (sometimes) synanthropic character of the plants (e.g., Barrett et al. 1993, Jacobs & Wilson 1996, Santamaria 2002, Fraga i Arguimbau 2008).

Vegetation group 10: 6210/62A0+synanthropic - *Festuca valesiaca-Eryngium campestre*

Diagnostic species: *Centaurea solstitialis, Eryngium campestre, Festuca valesiaca, Hypochaeris cretensis*

Dominant species: *Aegilops lorentii* (valid name = *Aegilops biuncialis*)*, Bromus hordeaceus, Festuca polita, Lotus corniculatus*

Vegetation group 10 was the main grassland type at altitudes 975 – 1075 m at the sites Nevropoli, Mourouzos, Mouriza, and Isomata (transect K6) on hard limestone and it was also recorded at the drier (elevated parts) of Souvala. All the sites are under heavy grazing except from Isomata where grazing is of medium intensity. This vegetation group is characterised by distinctive presence of *Festuco-Brometea* species (*Prunella laciniata* and *Festuca valesiaca* with high constancies), of thermophilous grasslands species (*Cynosurus echinatus* and *Hypocaheris cretensis* with high constancies), and of mesophilous grassland *Molinio-Arrhenatheretea* species (*Plantago lanceolata* and *Hordeum bulbosum* with high constancies), and a series of synanthropic vegetation species (*Eryngium campestre* and *Bromus hordeaceus* with high constancies and also the alien *Xanthium spinosum*).

The diagnostic species *Festuca valesiaca* is a European-SW Asian species considered as diagnostic of both the continental steppes of the *Festucetalia valesiacae*: *Festucion valesiace* (e.g. Chytrý 2007, EUR28 2013, Aćić et al. 2015) and the submediterranean grasslands of the *Scorzoneretalia villosae* (e.g. Horvat et al. 1974, Terzi 2015). In Greece it has been identified as differential in *Festuco-Brometea* grasslands (Fotiadis et al. 2014), and included in the diagnostic species combinations placed within the order *Astragalo-Potentilletalia* (Bergmeier et al. 2009, Pirini et al. 2014) and the order *Festucetalia valesiacae* (Papademetriou et al. 1988). The diagnostic species *Hypochaeris cretensis* is a Mediterranean hemicryptophyte widely distributed in Greece where it occurs at various grasslands, including scrub openings and synanthropic ones, from thermo-Mediterranean to supra-Mediterranean climate (e.g., Chronopoulos et al. 2005, Κοκμοτός 2008, Pirini et al. 2014, Kougioumtzis et al. 2015). In Europe it has also been recorded as differential or mostly as companion of various grassland types in various bioclimates, including *Festuco-Brometea* and *Nardetea strictae* grasslands (e.g. Tomaseli et al. 2003, Carni & Matevski 2005, Delbosc et al. 2015, Julve 2015, Blasi & Biondi 2015).

Two thistles, with morphological defences to grazing, are also included in the diagnostic species: *Centaurea solstitialis* and *Eryngium campestre*. *Centaurea solstitialis* is a Mediterranean species typically included in the synanthropic vegetation of the class *Artemisietea vulgaris* (e.g. Rivas-Martínez et al.), although it may participate in grasslands of other types (Fotiadis et al. 2014). *Eryngium campestre* is a European-SW Asian species, widespread in Greece and occuring in grasslands, phrygana and ruderal habitats (Dimopoulos et al. 2013). In Europe, it is usually considered one of the character taxa of the *Festuco-Brometea* (e.g., Mucina 1997, Maccherini et al. 1998, Aeschimann et al. 2004, Sopotlieva & Apostolova 2007, Chytrý 2007, EUR28 2013). On the other hand, in Spain (Rivas-Martínez et al.), in Sicily (Brullo & Marcenò 1985), and in NW France (Catteau & Duhamel 2014) it is considered a character species of the *Artemisietea vulgaris* order *Onopordetalia acanthii*. As Brandes & Jesske (2013) pointed out, the ecological niche of the species exceeds the *Festuco-Brometea* grasslands since it is frequently found at disturbed ruderalised places and a connection with a single class sould only be valid within local scale if ever. Indeed, in Greece it has been identified as diagnostic of the *Astragalo-Potentilletalia* (Pirini et al. 2014) or of various thermophilous dry grasslands, including both the *Festuco-Brometea* and the synanthropic *Stellarietea mediae* (Fotiadis et al. 2014). Similarly, Matevski et al. (2008) recorded the species in scrub as well as in synanthropic and *Festuco-Brometea* grassland and in Czechia it is included in the diagnostic species of both the *Festucion-valesiacae* grasslands (Chytrý 2007) and the *Salvio nemorosae-Marrubietum peregrini* synanthropic vegetation of the class *Artemisietea-vulgaris* (Láníková 2009).

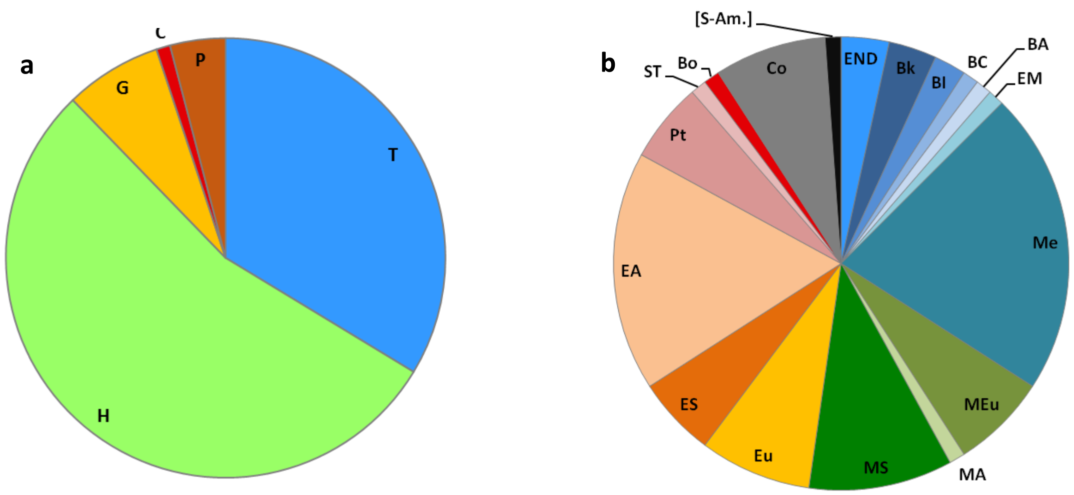

Figure 26. Vegetation group 10, **a**: life form spectrum; **b**. chorological spectrum.

As a whole (table 8), vegetation group 10 includes five character species of the *Scorzoneretalia villosae* and the *Scorzonerion villosae* (Terzi 2015), namely *Festuca valesiaca*, *Prunella laciniata*, *Ononis spinosa*, *Potentilla recta*, and *Plantago argentea* but also shows affiliations to other *Festuco-Brometea* syntaxa, notably of the *Astragalo-Potentilletalia*. It shares with the *Scorzonerion villosae* the high participation of ingressive mesophilous grassland species (Terzi 2015). However, unlike this alliance, it is also characterised by high participation of ingressive thermophilous grassland species, a feature shared with *Astragalo-Potentilletalia* grasslands and with the thermo-xerophytic grasslands of the *Scorzoneretalia villosae* (Pirini et al. 2014, Aćić et al. 2015, Terzi 2015). The high participation of synanthropic grassland species apparently reflects the effects of heavy grazing. Taking into account the above and its distribution at lower altitudes compared to vegetation group 8, vegetation group 10 seems to have an intermediate position and may be assigned either to the *Astragalo-Potentilletalia* or the *Scorzoneretalia villosae*, that is to habitat 6210 or to habitat 62A0.

The life form spectrum of vegetation group 10 is also characterised by dominance of hemicryptophytes but the participation of therophytes is higher than in vegetation groups 1 to 8, reflecting the lower altitude and the high participation of thermophilous grassland species. The chorological spectrum, compared to vegetation group 8, is characterised by higher participation of Mediterranean, Mediterranean-European, and Mediterranean-SW Asian species but a much lower participation of endemic and balkan species.

Area of grassland transect K2 at Panagia (Mt. Kallidromo), June 2013, photo I. Dimitriadis

Vegetation group 11: 6420: *Plantaginetalia majoris - Juncus inflexus*

<u>Diagnostic species</u>: *Juncus articulatus, Juncus inflexus*
<u>Constant species</u>: *Juncus inflexus*
<u>Dominant species</u>: *Juncus inflexus*

Vegetation group 11 was recorded only at Souvala at plots located at the canal traversing the wetland. The dominant diagnostic species *Juncus inflexus* as well as most of the other participating species are characteristic of the class *Molinio-Arrhenatheretea*. As in vegetation group 9, several of them are considered diagnostic species of the eutrophic soil communities of the order *Plantaginetalia majoris*, i.e. *Juncus inflexus*, *Potentilla reptans*, *Trifolium* *fragiferum*, *Carex otrubae* (Mucina 1997, Rivas-Martínez et al. 2002). There is also sporadic participation of nitrophilous synanthropic vegetation species. The diagnostic species *Juncus articulatus* is considered as diagnostic of either the class *Isoëto-Nanojuncetea* (Mucina 1997) or the permanently moist grasslands of the order *Molinietalia caeruleae* of the *Molinio-Arrhenatheretea* (Rivas-Martínez et al. 2002). Thus, vegetation group 11 represents a wet grassland of the habitat 6420.

The life form spectrum is similar to the one of vegetation group 9 with dominance of hemicryptophytes and increased participation of geophytes. The chorological spectrum is also similar to the one of vegetation group 9, with increased participation of widespread species, for the same reasons.

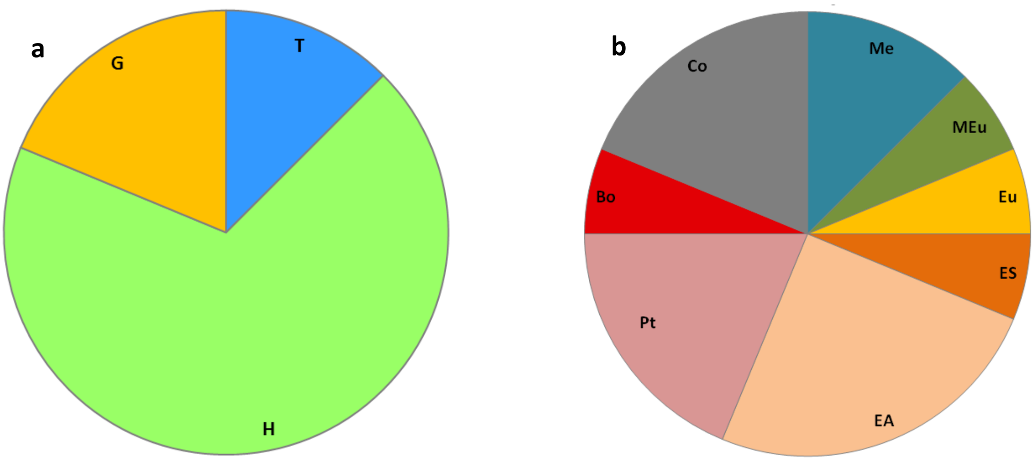

Figure 27. Vegetation group 11, **a**: life form spectrum; **b**. chorological spectrum.

Vegetation group 12: 62A0, 62A0 transition to 6420 - *Hordeum bulbosum-Agrostis gigantea (Ononis spinosa)*

<u>Diagnostic species</u>: *Agrostis gigantea, Avena barbata, Carex flacca, Convolvulus betonicifolius, Dactylis glomerata, Hordeum bulbosum, Mentha spicata* subsp. *condensata, Ononis spinosa, Xeranthemum cylindraceum*

<u>Constant species</u>: *Agrostis gigantea, Hordeum bulbosum*

<u>Dominant species</u>: *Hordeum bulbosum, Ononis spinosa*

Vegetation group 12 was the main vegetation type at Panagia, on tertiary deposites, and at Isomata (transect K4) on hard limestone and was also recorded at one plot (close to the canal) at Souvala. Notably, at both Panagia and Isomata vegetation group 12 occurs close to wet grasslands developing along water flows. It is characterised by distinctive presence of *Festuco-Brometea* species, of *Molinio-Arrhenatheretea* species, and of synanthropic vegetation species.

The diagnostic and dominant species *Ononis spinosa* (70 % of the plots) as well as another two species which participate with low frequency, *Prunella laciniata* and *Dorycnium pentaphyllum* subsp. *herbaceusm*, are considered diagnostic of the order *Scorzonerion villosae* (Horvat 1974, Terzi 2015). *Ononis spinosa* is also the main species which differentiates vegetation groups 12 and 13 from vegetation group 10. Another two species with significant frequency are *Galium verum* and *Carex flacca* which are considered characteristic of mesophilous *Festuco-Brometea* communities (Terzi 2015). On the other hand, the diagnostic species *Xeranthemum cylindraceum*, a Mediterranean-European annual which in Greece occurs in temperate to submediterranean grasslands (Dimopoulos et al. 2013), is considered diagnostic of the

Festuco-Brometea grasslands (Mucina 1997) or of *Helianthemetea guttati* grasslands (Rivas-Martínez et al. 2002).

The mesophilous grassland *Molinio-Arrhenatheretea* series of species includes the diagnostic and constant species *Agrostis gigantea* and *Hordeum bulbosum*, and the diagnostic species *Mentha spicata* subsp. *consensata*. *Agrostis gigantea* although typically considered a *Molinio-Arrhenatheretea* species (e.g. *Rivas-Martínez* et al. 2002), has also been identified as diagnostic of *Cirsio-Brachypodion pinnati* associations in Central Europe (e.g. Novák 2007, Dengler et al. 2012). On the other hand, Blasi et al. (2009) identified a *Molinio-Arrhenatheretea Hordeum bulbosum* association in mown and grazed meadows in central Italy with distinct participation of *Festuco-Brometea* and *Helianthemetea guttati* species, a in vegetation group 12. However, unlike vegetation group 12, the *Festuco-Brometea* species in these grassland were neither diagnostic nor constant except from *Trifolium campestre* and *Eryngium capestre* which however have multiple syntaxonomic affinities.

In conclusion, vegetation group 12 represents mesophilous grasslands either of the *Festuco-Brometea* (habitat type 62A0) or of the *Molinio-Arrhenatheretea*. It is probably better interpeted as a *Festuco-Brometea* grassland and its transition to *Molinio-Arrhenatheretea*.

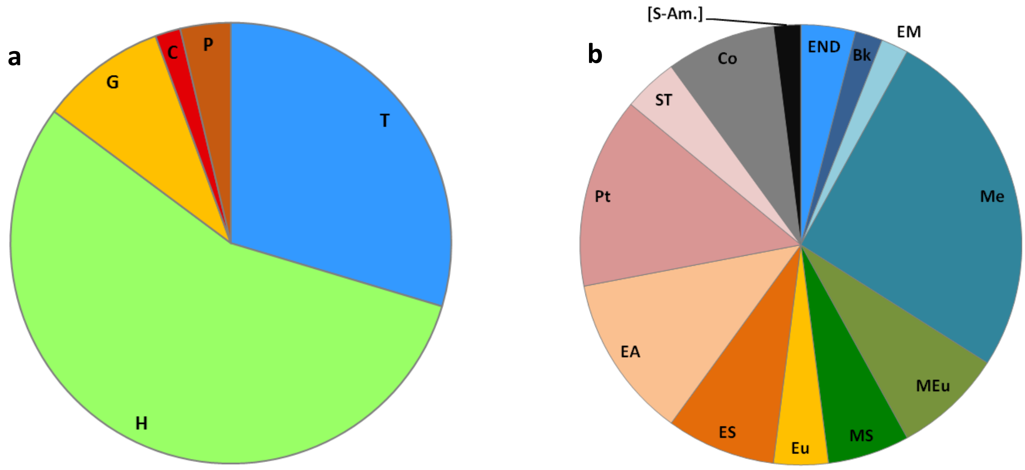

Figure 28. Vegetation group 12, **a**: life form spectrum; **b**. chorological spectrum.

The life form spectrum of vegetation group 12 is similar to the one of vegetation group 10 with dominance of hemicryptophytes and significant participation of therophytes. The chorological spectrum is also similar to that of vegetation group 10, especially regarding the prominent Mediterranean element, but differs in the decreased participation of European-SW Asian species in favours of the more widespread Paleotemperate species.

Vegetation group 13: 62A0, 62A0 transition to 6420 - *Plantago lanceolata-Lotus corniculatus (Ononis spinosa)*

<u>Diagnostic species</u>: *Lotus corniculatus*

<u>Constant species</u>: *Plantago lanceolata*

<u>Dominant species</u>: *Agrostis gigantea, Carex distans, Elymus repens, Lolium rigidum, Ononis spinosa, Plantago lanceolata, Prunella laciniata*

Vegetation group 13 was the main vegetation type at the alluvial part of Souvala and was also recorded at few plots at Panagia, Nevropoli (close to the pond), and Mourouzos (adjacent to the pond). Only one plot was at Tourkos grassland on Oiti. This group is very similar to vegetation group 12. It is differentiated due to the high frequency of the diagnostic species *Lotus corniculatus* (a mesophilous *Festuco-Brometea* species), the higher frequency and dominance of *Plantago lanceolata*, the larger number of *Molinio-Arrhenatheretea* and synanthropic vegetation species, and the lower number of dry grassland species. It seems that vegetation group 13 is a more mesophilous version of vegetation group 12.

Regarding the syntaxonomy and assignment to a habitat type, following the same rationale as for vegetation group 12, vegetation group 13 represents mesophilous grasslands either of the *Festuco-Brometea* (habitat type 62A0) or of the *Molinio-Arrhenatheretea*. It is could be interpeted as a *Festuco-Brometea* grassland and its transition to *Molinio-Arrhenatheretea* or vice-versa.

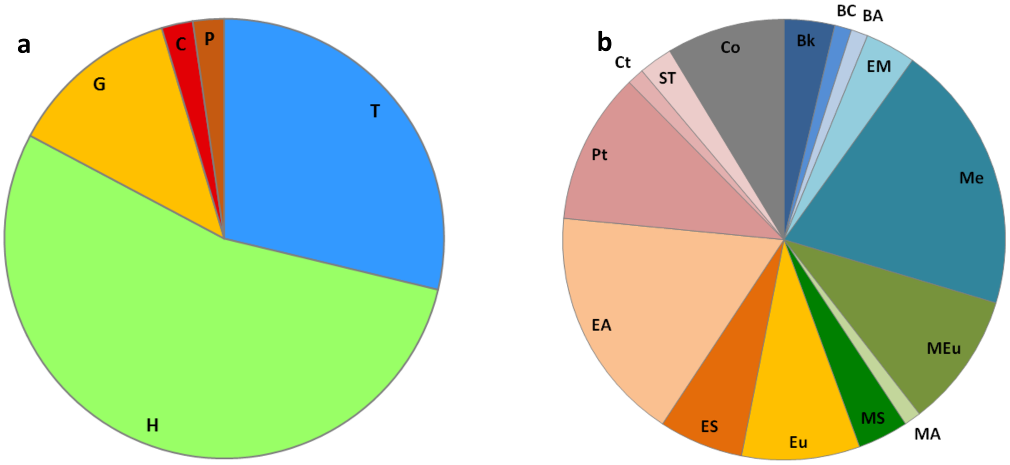

Figure 29. Vegetation group 13, **a**: life form spectrum; **b**. chorological spectrum.

The life form spectrum and the chorological spectrum are also similar to the ones of vegetation group 12. The chorological spectrum differs in the lower participation of Mediterranean species and the higher participation of more widespread European and Eurasiatic species, a fact apparently reflecting the larger participation of wetland *Molinio-Arrhenatheretea* species.

Souvala wetland (Mt. Kallidromo), June 2013, photo I. Dimitriadis

Table 8. Syntaxonomic table of mountain grassland vegetation units on Mt. Oiti and Mt. Kallidromo with percentage frequency and fidelity index phi (superscript, only values significant to the 0.05 level are shown).

Vegetation class		Vegetation unit (group)	1	2	3	4	5	6	7	8	9	10	11	12	13
		No. of plots	31	24	3	8	7	7	14	23	52	36	6	20	59
Oromediterranean chionophilous grassland (*Juncetea trifidi*)		*Euphrasia minima*	$6^{24.5}$	.	.	.	.	.	.	.	.	.	.	.	.
		Carex ovalis	$6^{24.5}$	.	.	.	.	.	.	.	.	.	.	.	.
		Nardus stricta	$35^{58.0}$	.	.	.	.	.	.	.	.	.	.	.	.
		Centaurea nervosa ssp. promota	$71^{75.1}$	.	.	.	.	.	14	.	.	.	.	.	.
		Luzula multiflora	$19^{27.8}$	4	.	12	.	.	.	.	.	3	.	.	.
		Luzula spicata	$23^{20.8}$	4	.	12	.	.	$36^{37.1}$	.	.	.	.	.	.
		Dianthus tymphresteus	$35^{19.2}$	8	.	.	$57^{37.8}$	14	$50^{31.7}$	4	.	.	.	.	.
		Poa variegata	$16^{8.1}$	.	.	.	.	$71^{65.7}$	$21^{13.6}$	.	.	.	.	.	.
		Rumex acetosella	$26^{13.8}$	4	.	.	29	$43^{29.6}$	$36^{23.0}$	4	.	.	.	.	.
		Phleum alpinum	$29^{23.3}$	8	.	.	.	14	$43^{38.4}$	4	.	.	.	.	.
		Anthemis tinctoria ssp. parnassica	.	.	.	$25^{15.7}$	14	$57^{47.7}$	7	.	.	.	.	$15^{5.7}$	2
		Silene roemeri	.	$8^{9.6}$	.	.	.	$29^{44.7}$	.	.	.	.	.	.	.
		Herniaria parnassica	3	.	.	.	.	.	$14^{32.4}$	.	.	.	.	.	.
		Minuartia recurva	.	.	.	.	.	.	$36^{58.2}$	.	.	.	.	.	.
		Hypericum barbatum	.	.	.	.	.	14	$14^{23.8}$	.	.	.	.	.	.
		Dianthus viscidus	.	.	.	$25^{32.6}$	.	.	.	.	.	11	.	.	$12^{12.5}$
		Alopecurus gerardii	.	$17^{39.5}$	.	.	.	.	.	.	.	.	.	.	.
		Edraianthus parnassicus	6	$33^{42.8}$	.	.	.	.	.	13	.	.	.	.	.
Oromediterranean grassland and scrub (*Daphno-Festucetea*, **Elyno-Sesleretea*)		*Poa timoleontis*	.	$54^{69.2}$	.	.	.	.	.	4	.	.	.	.	.
		Stachys germanica ssp. heldreichii	.	$21^{44.2}$	.	.	.	.	.	.	.	.	.	.	.
		Astragalus sempervirens	$10^{7.0}$	.	.	.	.	$43^{52.8}$	7	.	.	.	.	.	.
		Juniperus communis ssp. nana	3	.	$100^{85.9}$	.	.	$29^{17.6}$	.	.	.	.	.	.	.
		Cerastium candidissimum	.	.	.	.	.	$14^{36.5}$	.	.	.	.	.	.	.
		Secale montanum	.	.	.	.	$14^{23.8}$	$14^{23.8}$	.	.	.	.	.	.	.
		Poa thessala	.	.	.	.	.	14	.	$9^{15.2}$	.	.	.	.	.
		Centaurea affinis ssp. pallidior	.	$12^{14.5}$	.	.	.	14	.	$17^{22.3}$	.	.	.	.	.
		*Euphrasia liburnica**	.	$12^{13.0}$	.	$38^{50.5}$	.	.	.	.	.	.	.	.	.
		*Minuartia verna**	.	.	.	.	.	14	.	$9^{15.2}$	.	.	.	.	.
		Campanula spatulata	10	4	.	$38^{41.1}$	.	14	.	4	.	.	.	.	.
		Astragalus thracicus	3	.	.	25	.	$29^{19.3}$	$50^{40.7}$	13	.	.	.	.	.
		Festuca jeanpertii ssp. achaica	16	.	.	.	14	$43^{22.1}$	$43^{22.1}$	$83^{54.0}$	.	.	.	.	.
		Marrubium velutinum	.	.	.	.	14	.	.	$17^{28.0}$	.	.	.	.	.
		Minuartia attica	.	.	.	.	.	.	.	$13^{34.9}$	.	.	.	.	.
		Juniperus foetidissima	.	4	.	.	.	.	.	.	.	.	.	.	.
		Paronychia albanica	.	4	.	.	.	.	.	.	.	.	.	.	.
		Rhinanthus pubescens	3	.	.	.	.	.	.	.	.	.	.	.	.
		Festuca polita	.	.	.	.	.	.	.	.	.	$11^{17.9}$	.	$15^{25.7}$	2
		Ranunculus psilostachys	.	.	.	.	.	.	.	4	.	$6^{15.9}$	.	.	.
Temperate grassland (*Festuco-Brometea*)	br/ap/DF	*Koeleria lobata*	.	.	.	.	.	$86^{92.0}$	.	.	.	.	.	.	.
	fv/ap	*Hypericum rumeliacum ssp. apollinis*	.	.	.	.	.	$14^{30.6}$	.	.	.	.	.	5	.
	bm	*Festuca nigrescens*	$6^{24.5}$	.	.	.	.	.	.	.	.	.	.	.	.
	sv/ap	*Chrysopogon gryllus*	.	4	.	.	.	.	.	.	.	.	.	.	.
	bm	*Brachypodium pinnatum*	.	$17^{39.5}$	.	.	.	.	.	.	.	.	.	.	.
	fv	*Erysimum cuspidatum*	.	$17^{39.5}$	.	.	.	.	.	.	.	.	.	.	.
	Fv/**JT**	*Hieracium cymosum*	3	.	.	.	.	.	$14^{32.4}$	.	.	.	.	.	.
	sv/fv	*Centaurea triumfettii*	.	4	.	.	$43^{60.7}$	.	.	.	.	.	.	.	.
	br/ap	*Festuca dalmatica*	$13^{4.3}$	.	.	.	$86^{79.0}$	.	14	.	.	.	.	.	.
	FB	*Achillea species*	.	.	.	.	$29^{51.9}$	.	.	.	.	.	.	.	.
	fv/br/**JT**	*Trifolium alpestre*	.	$38^{31.1}$	.	25	$43^{36.8}$	.	.	.	.	.	.	.	.
	FBm	*Hieracium piloselloides*	.	8	.	$50^{63.5}$	.	.	.	.	.	.	.	.	.
	sv/bx/**JT**	*Plantago holosteum*	3	.	.	$88^{58.6}$	.	29	$71^{45.6}$	4	.	.	.	.	.
	FB/**JT**	*Hieracium hoppeanum s.l.*	6	$58^{43.6}$	.	.	.	.	$79^{62.2}$	.	.	.	.	.	.
	fv	*Achillea setacea*	6	$54^{62.7}$	.	.	.	.	.	9	.	.	.	.	.
	sv/bx/fv	*Potentilla recta*	3	$58^{50.5}$	.	25	.	.	.	.	.	11	17	.	.
	FBx/**JT**	*Armeria canescens*	23	$62^{38.7}$	.	$62^{38.7}$	14	14	.	.	.	17	.	.	.
	FB/bm/DF	*Thymus longicaulis*	10	25	33	$62^{27.4}$	$57^{23.7}$	29	14	$65^{29.2}$	.	.	.	.	.
	sv/bx/**JT**	*Plantago argentea*	$45^{17.7}$	$33^{9.2}$	.	$62^{30.1}$	$86^{46.7}$	14	7	13	.	3	.	.	2
	sv/br/DF	*Eryngium amethystinum*	.	$38^{39.8}$	.	.	.	14	.	$22^{20.1}$	.	.	.	.	.
	FBm/**JT**	*Nepeta nuda*	3	$21^{14.0}$	.	.	$43^{37.7}$	.	.	$35^{29.0}$	.	.	.	.	.
	fv/ap	*Potentilla pedata*	$29^{19.7}$	12	.	.	29	14	14	$22^{12.4}$	.	.	.	.	.
	FBm/**JT**	*Galium verum*	$71^{30.0}$	$83^{38.2}$	33	12	.	.	7	17	.	11	.	$55^{19.4}$	$42^{11.1}$
	FB/br/PB	*Poa bulbosa*	13	4	.	.	$100^{52.9}$	29	$86^{43.1}$	26	.	22	.	15	3
	fv	*Cerastium glomeratum*	6	.	.	12	$29^{27.2}$	14	.	9	.	8	.	.	.
	FB/MA/**JT**	*Lotus corniculatus*	23	.	.	.	.	14	7	.	8	11	.	.	$61^{50.6}$

Vegetation class		Vegetation unit (group)	1	2	3	4	5	6	7	8	9	10	11	12	13
		No. of plots	31	24	3	8	7	7	14	23	52	36	6	20	59
	FB/TB	*Medicago sativa ssp. falcata*	.	$17^{22.4}$	.	.	.	.	.	$17^{23.6}$	.	.	.	5	2
	FBx/TB	*Trifolium campestre*	.	4	.	25	.	.	.	.	.	$36^{39.8}$	.	.	3
	fv/DF	*Phleum montanum*	.	.	.	$25^{40.1}$	.	.	.	.	.	3	.	.	$7^{7.4}$
	sv/br	*Prunella laciniata*	3	21	.	.	.	.	.	22	.	$53^{44.5}$	.	5	12
	sv/fv/ap	*Festuca valesiaca*	.	.	.	.	.	.	.	4	.	$58^{68.0}$	.	.	7
	fv/DF	*Teucrium chamaedrys*	.	.	.	.	.	.	.	4	.	.	.	.	.
	ap	*Erysimum crassistylum*	.	.	.	.	.	.	.	4	.	.	.	.	.
	ap/DF	*Acinos alpinus*	.	.	.	.	.	.	.	$13^{34.9}$	.	.	.	.	.
	FB	*Leontodon cichoriaceus*	.	.	.	.	.	.	.	$35^{57.4}$	.	.	.	.	.
	ap/DF	*Bromus cappadocicus*	.	.	.	.	.	.	.	$17^{40.3}$	.	.	.	.	.
	br	*Allium vineale*	.	.	.	.	.	.	.	$13^{34.9}$	.	.	.	.	.
	FB	*Hieracium gaudryi*	.	.	.	.	.	.	.	$61^{68.3}$	.	14	.	.	.
	fv/ap	*Achillea crithmifolia*	.	.	.	.	.	.	.	$48^{60.7}$	.	8	.	.	2
	FB	*Sanguisorba minor*	.	.	.	.	.	.	.	$17^{32.4}$	.	3	.	5	.
	ap	*Potentilla laciniosa*	.	.	.	.	.	.	.	$35^{52.7}$	.	6	.	.	.
	ap	*Dianthus gracilis*	.	.	.	.	.	.	.	$22^{27.0}$	.	$28^{36.1}$	.	.	.
	FBx/ap	*Teucrium capitatum*	.	.	.	.	.	.	.	4	.	.	.	.	.
	sv/br	*Filipendula vulgaris*	.	.	.	.	.	.	.	.	.	.	.	.	$3^{17.7}$
	sv/br	*Ononis spinosa*	.	.	.	.	.	.	.	.	.	8	.	$70^{54.9}$	$63^{48.1}$
	FB/TB	*Xeranthemum cylindraceum*	.	.	.	.	.	.	.	4	.	6	.	$70^{64.3}$	$29^{21.3}$
	FBm	*Carex flacca*	.	.	.	.	.	.	.	4	.	.	.	$45^{61.0}$	2
	FB	*Festuca species*	.	.	.	.	.	.	.	.	.	6	.	15	$14^{19.7}$
	fv	*Achillea pannonica*	.	.	.	.	.	.	.	.	.	$6^{15.3}$	.	5	.
	sv	*Dorycnium pentaphyllum ssp. herbaceum*	.	.	.	12	.	.	.	.	.	.	.	5	.
	FB	*Leontodon species*	.	.	.	.	.	.	.	.	.	$6^{19.4}$	.	.	2
	FB/AV	*Tragopogon species*	.	.	.	.	.	.	.	4	.	$6^{15.9}$	.	.	.
	FB	*Hieracium species*	.	.	.	.	.	.	.	.	.	3	.	.	.
Mesic and wet eutrophic grassland (*Mollinio-Arrhenatheretea*), **Isoeto-Nanojuncetea*, ***Phragmito-Magnocaricetea* ***also in *Juncetea trifidi*		*Trifolium hybridum*	$61^{57.7}$	4	.	.	14	14	7	.	.	.	.	.	.
		*Trisetum flavescens****	6	$38^{19.5}$	.	.	$71^{47.8}$	14	.	17	.	$25^{9.1}$	.	10	.
		Plantago lanceolata	26	.	.	.	.	.	29	$65^{23.0}$	$58^{18.2}$	$69^{25.7}$	33	20	$78^{31.1}$
		Ranunculus polyanthemoides	.	.	.	.	.	.	$7^{25.7}$	.	.	.	.	.	.
		*Anthoxanthum odoratum****	29	12	.	.	.	.	$50^{30.4}$	$43^{25.0}$	.	3	.	.	$41^{22.6}$
		Anthemis cretica ssp. columnae	.	.	.	.	.	.	$50^{69.3}$	.	.	.	.	.	.
		Dactylis glomerata	3	4	.	.	14	14	.	4	.	3	.	$55^{51.9}$	.
		Ranunculus neapolitanus	.	.	.	.	.	.	.	.	.	.	.	5	.
		Agrostis gigantea	3	4	.	.	.	.	.	.	25	6	17	$75^{51.7}$	$47^{28.5}$
		Mentha spicata ssp. condensata	.	4	.	.	.	.	.	.	.	6	.	$45^{57.6}$	2
		Hordeum bulbosum	.	.	.	.	.	.	.	.	.	$33^{21.7}$	.	$85^{70.5}$	17
		Phleum pratense	.	4	.	.	.	.	.	.	.	6	.	10	$15^{22.4}$
		*Mentha pulegium**	.	.	.	.	.	.	.	.	$71^{78.6}$	3	.	.	5
		*Lotus angustissimus**	.	$25^{38.0}$	.	.	.	.	.	.	.	$11^{14.1}$	.	.	2
		Galium palustre	.	.	.	.	.	.	.	.	$6^{19.8}$	.	.	.	2
		Lactuca saligna	.	.	.	.	.	.	.	.	.	.	.	.	2
		Trifolium resupinatum	.	.	.	.	.	.	.	.	.	.	17	.	$8^{13.7}$
		Rumex conglomeratus	.	.	.	.	.	.	.	.	2	.	17	.	5
		Carex distans	.	.	.	.	.	.	.	.	.	.	17	.	$14^{21.5}$
		Juncus compressus	.	.	.	.	.	.	.	.	$19^{40.4}$	.	.	.	2
		Potentilla reptans	.	.	.	.	.	.	.	.	$62^{37.0}$	39	33	25	$41^{20.3}$
		Bromus racemosus	.	.	.	.	.	.	.	.	.	3	.	.	.
		Trifolium repens	3	4	.	.	.	.	.	.	.	.	$33^{48.9}$	.	2
		Juncus inflexus	.	.	.	.	.	.	.	.	2	.	$100^{98.1}$	.	2
		Asteriscus aquaticus	.	.	.	.	.	.	.	.	2	.	.	.	2
		Juncus thomasii	.	.	.	.	.	.	.	.	4	.	.	.	2
		Lolium perenne	.	.	.	.	.	.	.	.	.	8	.	15	$27^{34.7}$
		Trifolium physodes	.	.	.	.	.	.	.	$9^{21.9}$	2	3	.	.	.
		Trifolium lappaceum	.	.	.	.	.	.	.	.	.	.	.	.	2
		Barbarea vulgaris	.	.	.	.	.	.	.	.	.	.	.	5	.
		Cynodon dactylon	.	.	.	.	.	.	.	.	$23^{41.5}$	.	.	.	5
		Oenanthe silaifolia	.	.	.	.	.	.	.	.	6	.	.	.	$12^{26.2}$
		Verbena officinalis	.	.	.	.	.	.	.	.	.	.	.	.	2
		Carex divisa	.	.	.	.	.	.	.	.	$10^{21.6}$	.	.	.	7
		Barbarea sicula	.	.	.	.	.	.	.	.	.	.	.	.	2
		Ranunculus species	$10^{30.0}$	.	.	.	.	.	.	.	.	.	.	.	.
		Veronica serpyllifolia	$10^{30.0}$	.	.	.	.	.	.	.	.	.	.	.	.
		Helictotrichon pubescens	.	4	.	.	.	.	.	.	.	.	.	.	.
		Festuca rubra	$23^{46.1}$	.	.	.	.	.	.	.	.	.	.	.	.
		Deschampsia cespitosa	$16^{38.8}$	.	.	.	.	.	.	.	.	.	.	.	.

Vegetation class	Vegetation unit (group)	1	2	3	4	5	6	7	8	9	10	11	12	13
	No. of plots	31	24	3	8	7	7	14	23	52	36	6	20	59
	Trifolium fragiferum	.	4	.	25	29	.	.	9	13	22	17	.	$25^{13.2}$
	Lotus pedunculatus	.	.	.	$12^{34.1}$	.	.	.	.	.	.	.	.	.
	*Cynosurus cristatus****	13	.	.	.	14	.	.	.	.	.	.	.	$29^{34.8}$
	Arrhenatherum elatius	.	.	$33^{38.7}$	.	$29^{32.3}$	.	.	.	.	.	.	.	.
	Juncus articulatus	.	.	.	.	.	.	.	.	.	.	$33^{56.2}$	.	.
	Dasypyrum villosum	.	.	.	.	.	.	.	.	.	.	.	5	.
	Ranunculus sardous	.	.	.	.	.	.	.	.	$29^{30.2}$	.	17	.	$24^{23.7}$
	*Eleocharis palustris***	.	.	.	.	.	.	.	.	$42^{63.5}$	.	.	.	.
	*Veronica anagallis-aquatica***	.	.	.	.	.	.	.	.	$15^{37.9}$	.	.	.	.
	Rorippa sylvestris	.	.	.	.	.	.	.	.	2	.	.	.	.
	Carex otrubae	.	.	.	.	.	.	.	.	$15^{17.7}$	.	$33^{45.0}$	.	.
	Bellis perennis	.	.	.	.	.	.	.	.	.	$8^{27.8}$	.	.	.
Mediterranean grassland and steppes (*Thero-Brachypodietea-Tuberrarietea guttatae, Lygeo-Stipetea, Poetea bulbosae*)	*Trifolium arvense*	.	17	.	$62^{43.5}$	.	14	.	$70^{49.7}$	.	.	.	.	.
	Cerastium brachypetalum	.	.	.	.	.	.	$7^{25.7}$	.	.	.	.	.	.
	Veronica arvensis	3	.	.	.	.	.	$14^{32.4}$	.	.	.	.	.	.
	Bupleurum gracile	.	.	.	.	.	.	.	$26^{42.6}$	.	3	.	5	.
	Linum trigynum	.	.	.	.	.	.	.	.	.	.	.	$10^{30.5}$	.
	Crepis species	.	.	.	.	.	.	.	4	.	3	.	5	.
	Crucianella angustifolia	.	.	.	.	.	.	.	4	.	.	.	5	3
	Hypochaeris cretensis	.	.	.	.	.	.	.	.	.	$39^{55.5}$	.	.	7
	Thlaspi perfoliatum	.	.	.	.	.	.	.	$13^{28.7}$	.	.	.	.	5
	Trifolium striatum	.	.	.	.	.	.	.	.	.	3	.	.	2
	Trifolium pallidum	.	.	.	.	.	.	.	.	.	6	.	$15^{31.1}$	.
	Torilis nodosa	.	.	.	.	.	.	.	.	.	3	.	5	.
	Hedypnois cretica	.	.	.	.	.	.	.	.	.	3	.	.	3
	Alyssum chalcidicum	.	.	.	.	.	.	.	.	.	.	.	.	$3^{17.7}$
	Petrorhagia species	.	.	.	.	.	.	.	.	.	$8^{27.8}$	.	.	.
	Parentucellia latifolia	.	.	.	.	.	.	.	4	.	$8^{21.6}$	.	.	.
	Plantago lagopus	.	.	.	.	.	.	.	.	.	3	.	.	.
	Taeniatherum caput-medusae	.	.	.	.	.	.	.	.	.	3	.	.	.
	Aegilops lorentii	.	.	.	.	.	.	.	.	.	3	.	.	.
	Medicago truncatula	.	.	.	.	.	.	.	.	.	3	.	.	.
	Colchicum species	.	.	.	.	.	.	.	.	.	3	.	.	$8^{23.7}$
	Bupleurum glumaceum	.	.	.	.	.	.	.	.	.	$22^{37.8}$	.	.	8
	Linum bienne	.	.	.	.	.	.	.	9	.	$8^{16.7}$	.	.	2
	Alyssum alyssoides	.	.	.	.	.	.	.	.	.	3	.	.	.
	Fumana species	.	.	.	.	.	.	.	4	.	$19^{37.9}$	.	.	.
	Anthemis species	.	.	.	.	.	.	.	.	.	$6^{19.4}$	.	.	2
	Allium species	.	.	.	.	.	.	.	.	.	3	.	.	2
	Helianthemum species	.	.	.	.	.	.	.	.	.	3	.	.	2
	Salvia verbenaca	.	.	.	.	.	.	.	.	.	6	.	.	3
	Arenaria leptoclados	.	4	.	.	.	.	.	4	.	6	.	.	.
	Trifolium scabrum	.	.	.	.	.	.	.	$26^{40.2}$	.	$11^{14.3}$	.	.	.
	Muscari species	.	.	.	.	.	.	.	$13^{34.9}$	.	.	.	.	.
	Vicia species	.	4	.	.	.	.	.	.	.	.	.	.	.
	Arenaria serpyllifolia	.	.	.	$38^{37.5}$	$43^{44.0}$	.	.	.	.	.	.	.	.
	Trifolium phleoides	.	.	.	.	$43^{64.0}$	.	.	.	.	.	.	.	.
	Cynosurus echinatus	.	.	.	.	14	.	.	$30^{15.9}$	.	$64^{45.3}$	.	$50^{33.1}$	2
	Vulpia species	.	.	.	.	.	.	.	.	.	$8^{27.8}$	.	.	.
	Rumex tuberosus	.	.	.	.	.	.	.	.	.	$22^{45.7}$	.	.	.
	Bupleurum semicompositum	.	.	.	.	.	.	.	4	.	.	.	.	2
	Stachys graeca	.	.	.	.	.	.	.	.	.	.	.	5	.
	Triticum baeoticum	.	.	.	.	.	.	.	.	.	.	.	.	$3^{17.7}$
	Allium guttatum	.	.	.	.	.	.	.	.	.	.	.	.	$10^{30.8}$
	Scabiosa species	.	.	.	.	.	.	.	4	.	.	.	.	.
	Poa species	.	.	.	.	.	.	.	.	.	.	.	.	2
	Erophila verna	.	4	.	.	.	.	.	.	.	.	.	.	.
	Anthemis arvensis ssp. cyllenea	.	.	.	.	.	.	.	4	.	.	.	.	.
	Avellinia species	.	.	.	.	.	.	.	4	.	.	.	.	.
	Scleranthus annuus	.	.	.	.	.	.	.	$9^{28.4}$	.	.	.	.	.
	Trifolium species	.	.	.	.	.	.	.	.	.	$11^{17.9}$	17	.	.
	Ranunculus gracilis	3	4	.	.	.	.	.	.	.	.	.	.	.
	Galium melanantherum	.	.	.	.	.	.	.	.	.	3	.	.	.
Synanthropic nitrophilous and semi-nitrophilous grassland	*Stachys germanica*	.	.	.	.	.	14	.	4	.	.	.	.	3
	Lotus species	.	.	.	.	.	.	.	.	.	.	.	5	2
	Aegilops geniculata	.	.	.	.	.	.	.	4	.	$19^{28.7}$	.	10	3

Vegetation class	Vegetation unit (group)	1	2	3	4	5	6	7	8	9	10	11	12	13
	No. of plots	31	24	3	8	7	7	14	23	52	36	6	20	59
(*Stellarietea mediae, Artemisietea vulgaris*)	*Rumex pulcher*	.	.	.	.	.	.	.	.	.	3	.	10 $^{26.4}$	.
	Cichorium intybus	.	.	.	.	.	.	.	.	.	11 $^{12.2}$	.	30 $^{42.2}$	3
	Carduus species	.	.	.	.	.	.	.	.	.	8 $^{14.2}$	.	15 $^{28.7}$	.
	Daucus carota	.	.	.	.	.	.	.	.	.	.	.	15 $^{37.4}$	.
	Eryngium campestre	.	.	.	.	.	.	.	.	.	67 $^{73.5}$	.	5	7
	Xanthium spinosum	.	.	.	.	.	.	.	.	.	3	.	5	.
	Lolium rigidum	.	.	.	.	.	.	.	.	.	.	.	10	12 $^{22.9}$
	Bromus squarrosus	.	.	.	.	.	.	.	.	.	3	.	.	2
	Cirsium creticum	.	.	.	.	.	.	.	.	.	.	17	.	8 $^{13.7}$
	Centaurea solstitialis	.	.	.	.	.	.	.	.	.	33 $^{53.2}$	.	.	3
	Poa compressa	.	.	.	.	.	.	.	.	.	6	.	.	8 $^{20.7}$
	Notobasis syriaca	.	.	.	.	.	.	.	.	.	.	.	.	15 $^{37.7}$
	Sherardia arvensis	.	.	.	.	.	.	.	.	.	6 $^{22.7}$	.	.	.
	Bellardia trixago	.	.	.	.	.	.	.	.	.	.	.	.	2
	Cirsium vulgare	.	8	.	.	.	.	.	4	.	3	.	5	34 $^{42.9}$
	Avena species	.	.	.	.	.	.	.	.	.	3	.	.	.
	Chondrilla juncea	.	.	.	.	.	.	.	.	.	3	.	.	2
	Avena barbata	.	.	.	.	.	.	.	.	.	.	.	45 $^{65.6}$	.
	Bromus species	.	.	.	.	.	.	.	.	.	.	.	5	.
	Lotus ornithopodioides	.	.	.	.	.	.	.	.	.	36 $^{49.7}$	.	5	7
	Polygonum arenastrum	.	.	.	.	.	.	.	.	.	3	.	.	.
	Onopordum illyricum	.	.	.	.	.	.	.	.	.	3	.	.	2
	Bromus intermedius	.	.	.	.	.	.	.	.	.	3	.	5	8 $^{18.8}$
	Marrubium peregrinum	.	.	.	.	.	.	.	.	.	6 $^{22.7}$	.	.	.
	Geum urbanum	.	4	.	.	.	.	.	.	.	.	.	.	.
	Bromus sterilis	.	.	.	.	.	.	.	.	.	3	.	.	.
	Tolpis species	.	.	.	.	.	.	.	.	.	14 $^{36.0}$	.	.	.
	Cruciata laevipes	.	4	.	.	.	.	.	.	.	.	.	.	.
	Verbascum mallophorum	.	4	.	.	.	.	.	.	.	.	.	.	.
	Bromus hordeaceus	.	.	.	.	57 $^{39.8}$	.	.	17	.	53 $^{36.0}$	.	15	15
	Convolvulus arvensis	.	.	.	.	43	.	.	.	60 $^{43.2}$	17	.	10	22
	Carthamus lanatus	.	.	.	.	.	.	.	.	.	3	.	.	.
	Convolvulus betonicifolius	.	.	.	.	.	.	.	.	.	3	.	55 $^{70.8}$	.
	Elymus repens	.	.	.	.	.	.	.	.	2	11	17	20	22 $^{20.9}$
	Echium italicum	.	.	.	.	.	.	.	.	.	11 $^{32.2}$	.	.	.
	Carduus pycnocephalus	.	.	.	.	.	.	.	.	.	3	17 $^{36.1}$	.	.
	Lepidium hirtum ssp. nebrodense	.	.	.	.	.	.	.	4	.	3	.	.	.
	Verbascum species	.	.	.	.	.	.	.	.	.	3	.	.	.
Other vegetation types (forest and scrub vegetation mainly *Quercetea pubescentis* and also *Quercetea ilicis*)	*Sedum amplexicaule ssp. tenuifolium*	.	.	.	.	.	.	14 $^{36.5}$	.	.	.	.	.	.
	Brachypodium sylvaticum	.	.	.	.	.	.	.	.	.	.	.	5	2
	Pyrus spinosa	.	.	.	.	.	.	.	.	.	.	.	5	.
	Crataegus species	.	.	.	.	.	.	.	.	.	.	.	.	2
	Lonicera implexa	.	.	.	.	.	.	.	.	.	.	.	5	.
	Prunus cocomilia	.	.	.	.	.	.	.	.	.	.	.	.	2
	Prunus prostrata	.	.	.	.	.	.	.	.	.	3	.	.	.
	Pteridium aquilinum	.	.	.	.	.	.	.	30 $^{46.6}$	.	8	.	.	.
	Rosa gallica	.	.	.	.	.	.	.	.	.	.	.	.	2
	Scrophularia heterophylla	.	.	.	.	.	.	.	4	.	.	.	.	.
	Digitalis ferruginea	.	4	.	.	.	.	.	.	.	.	.	.	.
	Sedum species	3	.	.	.	.	.	.	4	.	.	.	.	.
	Abies cephalonica	.	.	.	12	.	.	.	4	.	6	.	.	.
	Juniperus oxycedrus	.	12 $^{15.5}$	.	12	.	.	.	13 $^{16.4}$	.	3	.	.	.
	Silene italica	.	.	.	25 $^{30.3}$	29 $^{35.5}$	.	.	.	.	.	.	.	.
	Digitalis leucophaea	.	4	.	.	.	.	.	.	.	.	.	.	.
	Carum graecum	.	25 $^{48.5}$	.	.	.	.	.	.	.	.	.	.	.
	Quercus species	.	.	.	.	.	.	.	.	.	3	.	.	.
	Helleborus cyclophyllus	.	4	.	.	.	.	.	.	.	.	.	.	.

Festuco-Brometea species diagnostic role (literature): FB=*Festuco-Brometea*, FBx= *Festuco-Brometea* xerophytic , FBm= *Festuco-Brometea* mesophytic, ap=*Astragalo-Potentilletalia*, br=*Brometalia erecti/Brachypodietealia pinnati*, bx=*Brometalia erecti* xerophytic, bm=*Brometalia erecti* mesophytic, fv=*Festucetalia valesiacae/Festucion valesiacae/Saturejion montanae* etc, sv=*Scorzoneretalia villosae/Scorzonerion villosae* etc, AV=*Artemisietea vulgaris*, DF=*Daphno-Festucetea*, MA=*Molinio-Arrhenatheretea*, TB=*Thero-Brachypodietea*.


Grassland transect TR at Tourkos (Mt. Oiti), July 2013, photo I. Dimitriadis


Grassland transect TS at Tsamadaiika (Mt. Oiti), July 2013, photo I. Dimitriadis


Area of grassland transects Z1 and Z2 at Zapantolakka (Mt. Oiti), July 2013, photo P. Delipetrou

Biodiversity indices

The biodiversity indices per plot are presented in Annex II. A synopsis per vegetation unit is presented in Table 9. The vegetation groups with higher species richness (as assessed by total species numbers and the Shannon index H) were the ones of dry grasslands or of transition to dry grasslands, especially vegetation groups 8, 5, and 10. Evenness (as assessed by the Rs index), that is the comparative cover of species was generally high, 0.7 and above, and was highest in Oiti plots which represent transition to other vegetation groups or habitats (vegetation groups 4, 5, 6, and 7). Evenness was quite low only in the *Juniperus nana* subsp. *nana* dominated plots (vegetation group 3) and the *Juncus inflexus* plots in the canal of Souvala (vegetation group 11).

Table 9. Descriptional statistic of biodiversity indices per vegetation group.

Vegetation	N0 Number of species			Shannon H			Rs evenness		
group	min	max	mean	min	max	mean	min	max	mean
1	2	13	8	0.50	2.22	1.41	0.35	0.90	0.70
2	6	14	10	0.81	2.31	1.59	0.42	0.93	0.70
3	1	3	2	0.00	0.57	0.23	0.00	0.52	0.22
4	4	12	8	0.98	2.36	1.60	0.63	0.99	0.77
5	9	15	11	1.29	2.27	1.84	0.59	0.86	0.77
6	5	17	8	1.03	2.50	1.61	0.58	0.93	0.79
7	3	13	9	0.67	2.13	1.63	0.60	0.89	0.77
8	5	20	12	0.84	2.53	1.73	0.43	0.87	0.70
9	2	9	5	0.17	2.01	1.00	0.15	0.95	0.66
10	6	19	13	0.55	2.74	1.89	0.30	0.97	0.75
11	2	7	5	0.45	1.23	0.78	0.32	0.76	0.54
12	7	16	11	0.75	2.35	1.44	0.36	0.85	0.61
13	2	19	10	0.34	2.59	1.54	0.43	0.93	0.70

A similar but not identical picture is presented when the indices N1 (species richness) and N2 (species evenness) are used (Figure 30). The dry grassland vegetation groups 8, 10, 12 and 13 (6210, 62A0) show high variation in both indices and also score the highest values in both. Notably, the latter three are also the ones with the higherst numbers of thermophilous grassland and synanthropic species.

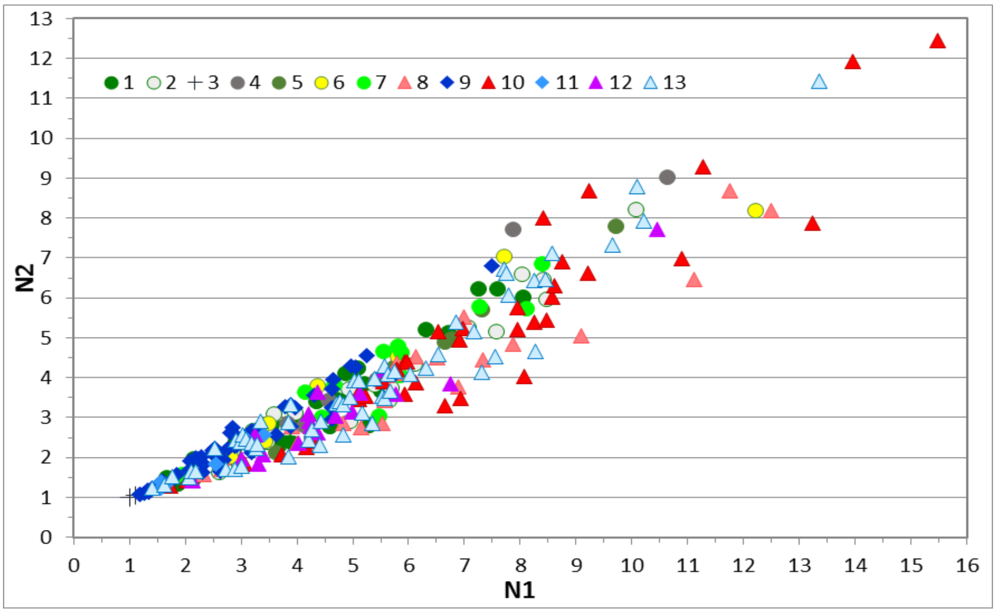

Figure 30. Biodiversity indices N1 and N2 per plot per vegetation unit.

3.3. Ecological factors affecting the composition and structure of the mountain grasslands in Mt. Oiti and Mt. Kallidromo

The exploratory indirect multivariate analysis DCA of the grassland plot data (290 plots) using altitude, grazing intensity, and parent rock as environmental variables (predictors) indicated a strong unimodal response in the 1st (lengths of gradient 8.421) and the 2nd (lengths of gradient 7.075). The results of the DCA are shown in Figures 31 (plot data), 32 (species data), 33 (focus on Kallidromo data), and Table 10.

The high altitude plots of vegetation groups 1 to 8 are clearly separated from vegetation groups 9 to 13 along the 1st ordination axis indicating different ecological niches related to altitude and the flysch substrate on the one hand and grazing and water-related substrates on the other (Figure 31). Vegetation groups 1 (6230) and 4 (4060) are separated from vegetation groups 2, 3, 5, 6, 7 and 8 along the 2nd ordination axis apparently depicting differences in substrate (flysch vs. limestone-dolomite) and possibly water content. The latter vegetation groups are closely related apparently due to transitional plots (grassland to scrub, dry to humid) and only the plots of vegetation group 8 at Gkioza (6210) are positioned apart. The plots of Mt. Kallidromo (Figures 31 and 33) are separated in three groups along the 1st ordination axis at increasing grazing and water level: vegetation group 8 at high altitudes, vegetation groups 10, 11, and 12 at lower altitudes and on tertiary/colluvial/alluvial substrate, and vegetation groups 9 and 11 on alluvial substrate and in the lake/canal.

In the species data graph (Figure 32), the typical *Juncetea trifidi* species such as *Nardus stricta*, *Luzula multiflora*, *Luzula spicata*, *Centaurea nervosa*, *Carex ovalis*, *Phleum alpinum*, and *Herniaria parnassica* are set apart at the areas of vegetation groups 1 and 2. The *Festuco-Brometea* species span the area of vegetation groups 3 to 8 and 10, 11 and 13. *Galium verum* lies at an intermediate position, while *Achillea crithmifolia* is positioned within vegetation group 8 and *Ononis spinosa* within vegetation groups 10, 11, and 12. The wet grassland and swamp species appear at the one hand within vegetation group 1 and scattered at the area of vegetation groups 3 to 7 (high altitude, chionophilous and mesic grasslands), and on the other hand in the areas of vegetation groups 9, 11, and 13 (grazing, mesic and wet grasslands).

Table 10. DCA results for the grassland plot data (290 plots).

Axes	1	2	3	4
Eigenvalues	0.8	0.56	0.48	0.374
Lengths of gradient	8.421	7.075	4.861	3.599
Species-environment correlations	0.942	0.388	0.586	0.75
Cumulative percentage variance				
of species data	5.2	8.8	11.9	14.3
of species-environment relation	23.3	25.7	0	0
Sum of all eigenvalues (total inertia)				15.531
Sum of all canonical eigenvalues				3.037

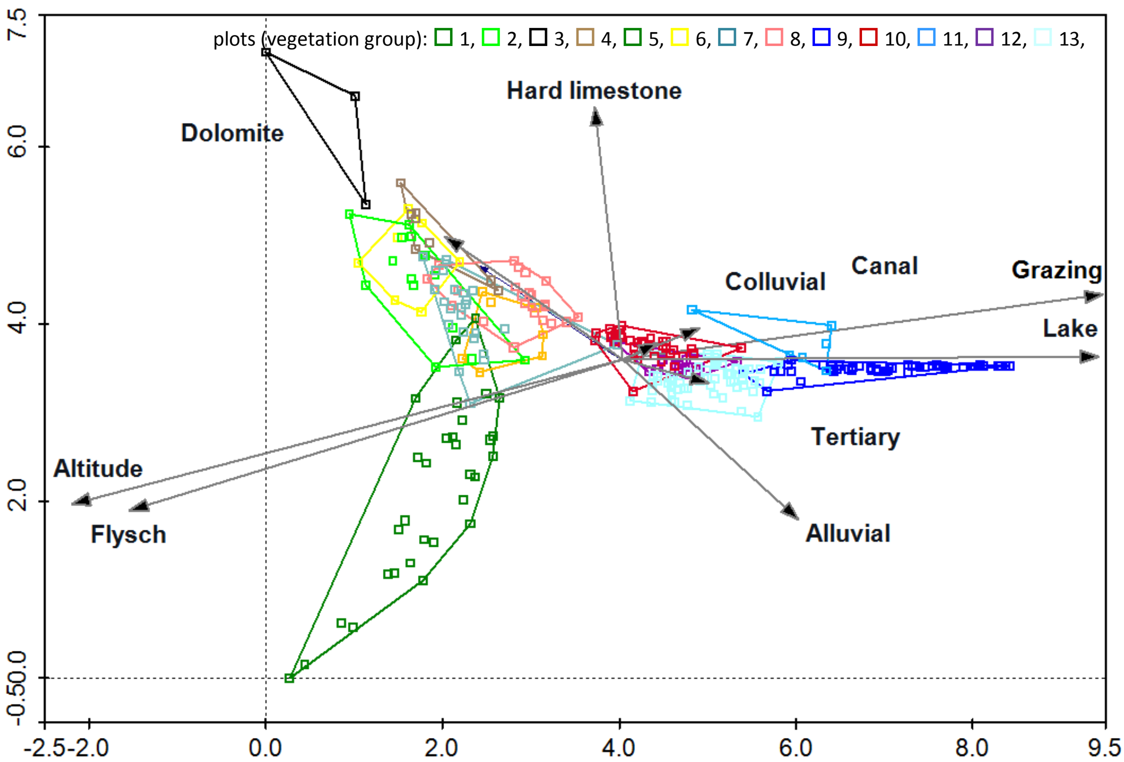

Figure 31. DCA of mountain grassland plots, plot data, axes 1 and 2, symmetric Hill scaling (species points at the centre of their niche in the diagram, plot distances are ecological distances).

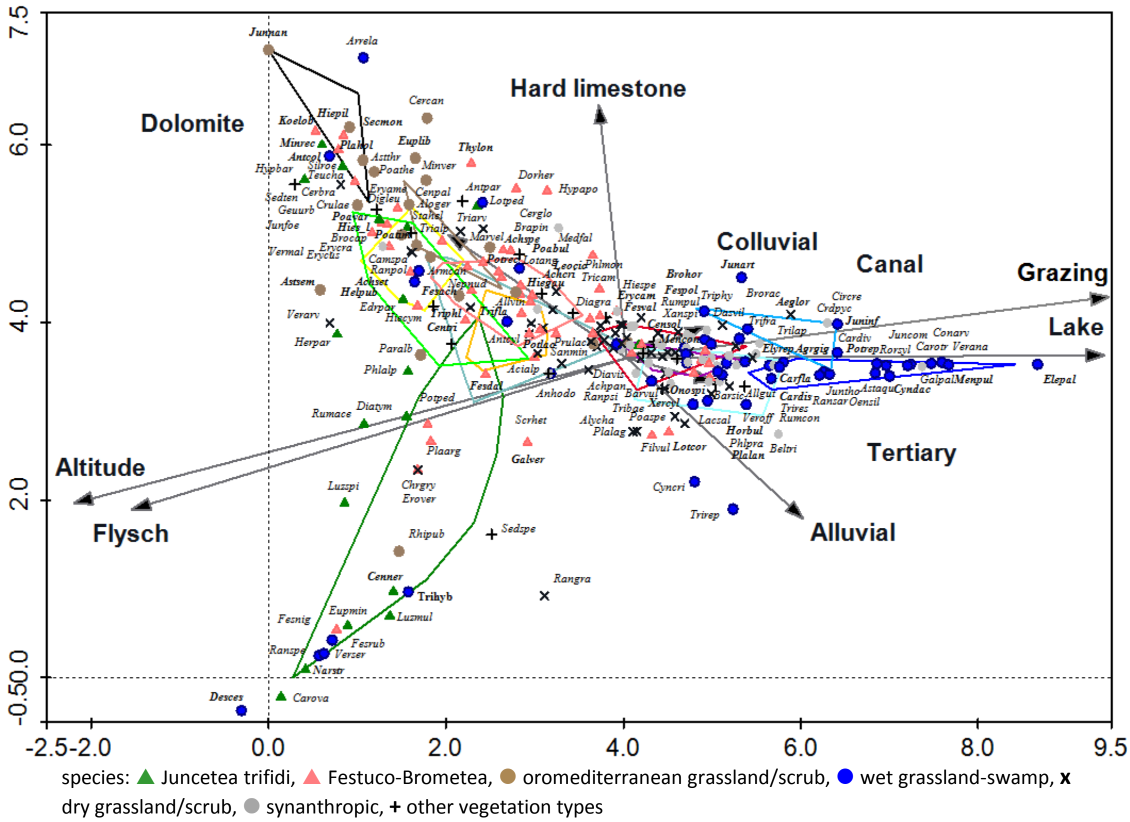

Figure 32. DCA of mountain grassland plots, species data, axes 1 and 2, symmetric Hill scaling (species points at the centre of their niche in the diagram, plot distances are ecological distances).

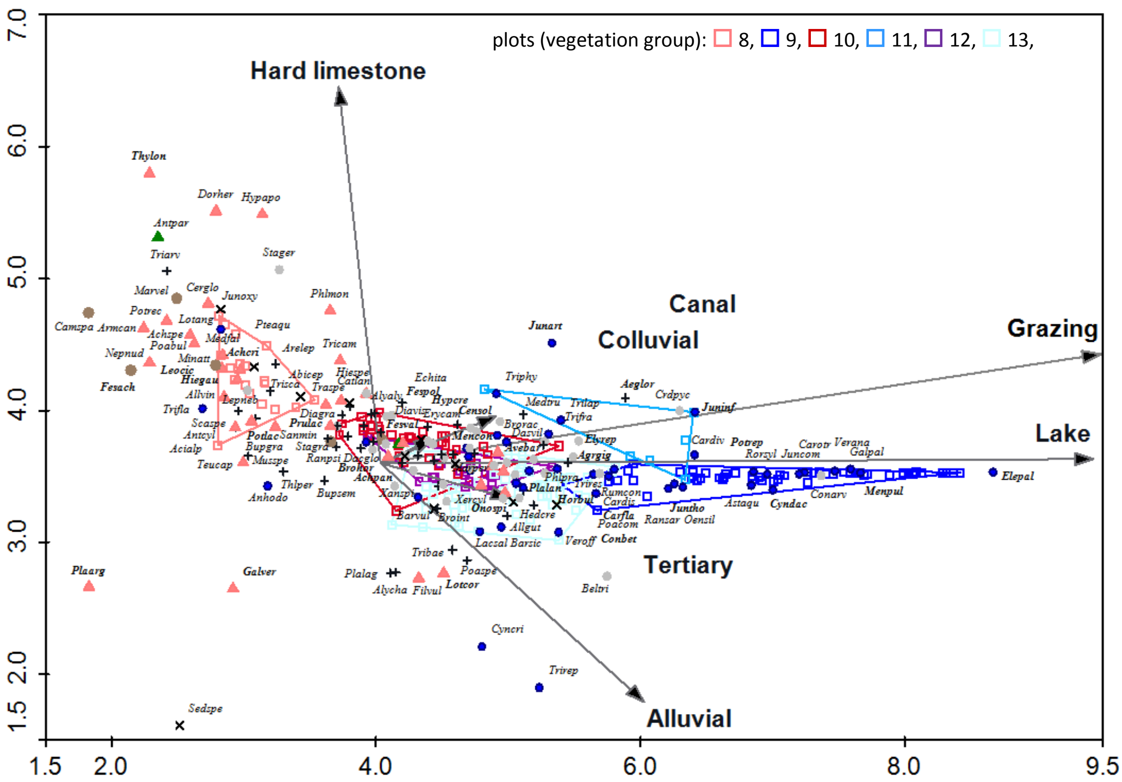

Figure 33. DCA of mountain grassland plots, only Kallidromo plots shown, axes 1 and 2, symmetric Hill scaling (species points at the centre of their niche in the diagram, plot distances are ecological distances).

An exploratory indirect multivariate analysis DCA was applied to the part of grassland plot data for which detailed soil data were available (131 plots) using altitude, grazing intensity, the whole set of soil analysis data (Table 3) as environmental variables (predictors) indicated a strong unimodal response in the 1st (lengths of gradient 7.287) and the 2nd (lengths of gradient 4.902) axes which is of suitable size for using CCA (ter Braak 1994).

The environmental variables explaining better the sample and species data were selected with manual forward selection so that the maximum number of the least correlated variables (as indicated by the values of the variable inflation factor which were < 20) with the higher explanatory values (as indicated by Lambda A which is the variance explained for conditional effects) were selected. It must be noted that certain variables was expectedly correlated, from example sand, silt and clay content was expected to be correlated when all three of the were fitted together and the same goes for C content and the ration C to N and for altitude and flysch (which was mainly recorded at the higher altitudes of Oiti). The variance that each of the 27 environmental variables explained singly (Lamda 1) when it was used as the only environmental variable in the model is shown in table 11. The explanatory value (Lambda A) of the 12 variables selected and included in the model is shown in table 12. The results of the CCA model with the selected variables are shown in Figure 34 and Table 13. The CCA model explains a significant 34 % of the grassland data. Altitude, pH, basic element content (exchangable Mg, Ca, base saturation), parent rock, and available Fe and Mn were the factors affecting most the plot and species data.

The 1st ordination axis clearly represents altitude while sand content and grazing change along the 2nd ordination axis. Vegetation groups 1 and 2 appear at higher altitude (and flysch), higher Av_Fe, and sand content and lower pH, with the plots at Livadies being clearly separated from all others. Vegetation groups 10, 12, and 13 of Mt. Kallidromo lie at increasing pH, conductivity, and clay content values and are ordered along increasing sand and decreasing grazing, Av_Mn and Mg values from vegetation group 12 to vegetation groups 10 and 13. The plots of vegetation group 8 (Gkioza) are separated at lower sand and higher grazing, Av_Mn and Mg values. The plots of Tourkos lie at an intermediate position regarding altitude, pH and Av_Fe and are negatively related (clay, content, conductivity) or not related (grazing, sand) to the other factors.

Table 11. Marginal effects of environmental variables. Explained variance (Lambda 1) of each variable when used singly. Environmental variable abbreviations as in Table 2.

Variable	Lambda1	Variable	Lambda1
Altitude	0.77	TotalN	0.46
Ca	0.71	OrganicC	0.45
pH	0.69	Silt	0.44
Base_sat	0.69	Av_P	0.44
Tertiary	0.63	K	0.44
Flysch	0.62	CtoN	0.4
Av_Zn	0.61	Clay	0.37
Cond	0.6	Mg	0.37
grazing	0.59	Av_Cu	0.36
Av_Mn	0.58	Alluvial	0.33
Hard lim	0.57	Colluvia	0.33
Av_Fe	0.57	Sand	0.33
CEC	0.51	Dolomite	0.32
Na	0.49		

Table 12. Conditional effects of environmental variables in order of their inclusion in the model. Lambda A: additional variance explained by each variable; P: significance level from the Monte Carlo permutation test carried out when the variable was added to the model. Environmental variable abbreviations as in Table 2.

Variable	LambdaA	P
Altitude	0.77	0.002
grazing	0.57	0.002
Av_Fe	0.44	0.002
pH	0.37	0.002
Alluvial	0.33	0.01
Colluvia	0.32	0.002
CtoN	0.29	0.002
Cond	0.27	0.002
Av_Mn	0.22	0.002
Clay	0.18	0.002
Mg	0.17	0.002
Sand	0.15	0.012

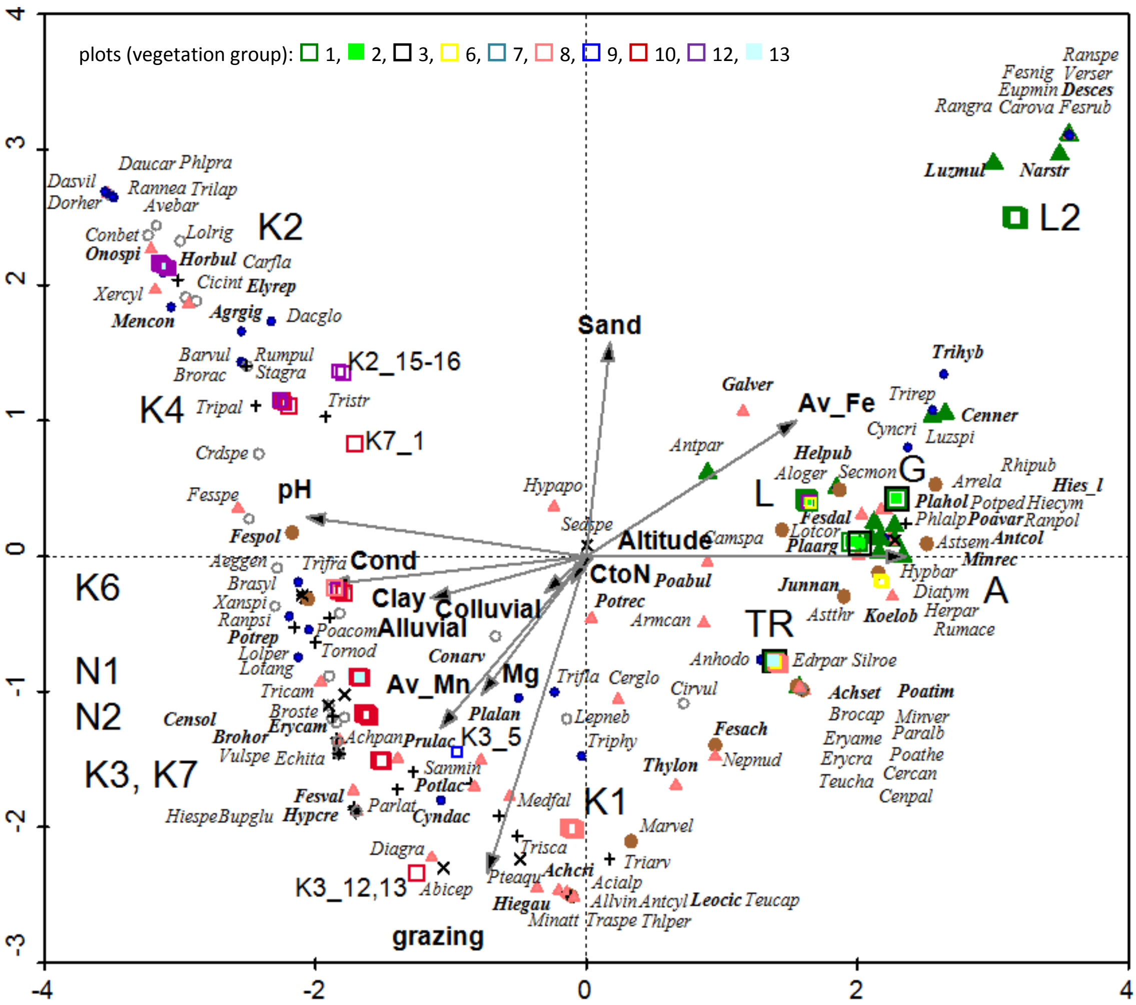

Figure 34. CCA of 131 mountain grassland plots, axes 1 and 2, symmetric Hill scaling (species points at the centre of their niche in the diagram, plot distances are ecological distances).

Table 13. CCA results for the mountain grassland data (131 plots).

Axes	1	2	3	4
Eigenvalues	0.788	0.645	0.516	0.448
Species-environment correlations	0.986	0.956	0.938	0.919
Cumulative percentage variance				
of species data	6.5	11.9	16.2	19.9
of species-environment relation	19.3	35.1	47.8	58.8
Sum of all eigenvalues (total inertia)				12.063
Sum of all canonical eigenvalues				4.079
Monte Carlo permutation test				
significance of 1st canonical axis	0.002			
significance of all canonical axes	0.002			

4. Literature

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Juniperus nana intrusion in mountain grasslans of Mt. Oiti, Livadies (up, May 2013) and Alykaina (down, September 2013), photo I. Dimitriadis