The Vegetation of Aladag-Sultan Serisi Forests in Bolu/Turkey

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Untersuchungen zur Vegetation der Sultan-Serisi-Wälder in der Provinz Bolu/Türkei

1 Introduction

Turkey comprises a great variety of natural habitats, ranging from Mediterranean, Aegean and Black Sea beaches to towering coastal and interior mountains, from deeply incised valleys to expansive steppes, from fertile alluvial plains to arid, rocky hillslopes (Kaya & Raynal, 2001). Due to this climatic and topographical diversity, a rich natural plant habitat reflected in a rich flora and source of biodiversity are found. Its richness is expressed by both the total number of species and especially the number of endemics, of which there are ca. 3,000 (Ekim, 1995; Ekim et al., 2000). (This compares with a total of ca.12,000 species of vascular plants and ca.1,750 endemic species in Europe despite having a land area fifteen times larger) (Colak & Rotherham, 2006).

In the north of Anatolia, the mountain ranges running parallel to the Black Sea create a barrier for rain clouds moving inland and they cause abundant rainfall on the mountain slopes facing the coast. During summer period, cool and humid air mass forms over the Black Sea. This air mass, which is forced to rise up the slopes of the Northern Anatolian mountains, loses much of its moisture through precipitation and leads to fog formation. Therefore, humid forests are found on the northern slopes while subhumid and semiarid forests are common on the slopes facing south. For example, *Pinus sylvestris* L. forests are found on the slopes facing south in the upper parts of the Northern Anatolian mountains due to decreasing precipitation and direct sun radiation and subhumid black pine and dry oak are found at the lower altitudes of southern slopes. On the other hand, a humid-temperate broad-leaved deciduous forest belt including oak (*Quercus* sp.), lime (*Tilia* sp.), alder (*Alnus* sp.), maple (*Acer* sp.) etc. at lower altitudes and *Fagus orientalis* Lipsky. and *Abies bornmuelleriana* Mattf. forests are found on upper part of northern slopes (Atalay, 2002; Mayer & Aksoy, 1998).

Akman et al. (1983) classified forest communities of the Semen mountains which comprise Aladag mountain as *Abies nordmanniana* subsp. *bornmuelleriana-Fagus orientalis, Abies nordmanniana* subsp. *bornmuelleriana-Pinus sylvestris, Pinus sylvestris-A. nordmanniana* subsp. *bornmuelleriana, Quercus petraea* subsp. *iberica-Viola suavis, Carpinus betulus-Scaligera tripartita, Pinus nigra* subsp. *pallasiana-Ligustrum*

Summary

In this study, the vegetation of Sultan Serisi-Bolu, which is located on northern slopes of Aladag mountain in the West Blacksea region of Anatolia, was analysed. Characteristics of climate, soil and vegetation of the area show differences among altitudinal-climatic zones. Notably, elevation gradients create varied climates along with resultant soil differentiation which promotes the diversification of plant communities.

A large part of the study area is covered by *Abies bornmuelleriana*-dominated forest, mostly mixed with *Fagus orientalis* and *Pinus sylvestris*. At lower altitudes, subhumid *Pinus nigra* and dry *Quercus* sp. forests are found. Fog formation and abundant rainfall on the upper part (over 1300 m) of the study area create favourable conditions for *A.bornmuelleriana* forests.

Three forest communities and seven subcommunities were described and presented in a synoptic constancy table.

Key words: *Abies bornmuelleriana,* Bolu, Aladag, Euro-Siberian, forest community.

Zusammenfassung

In dieser Studie wird die Vegetation der Sultan-Serisi-Wälder am Nordabhang des Aladag-Gebirges in der Provinz Bolu analysiert, die in der westlichen Schwarzmeerregion Anatoliens liegen. Klima, Boden und Vegetation zeigen deutliche Unterschiede zwischen einzelnen höhenklimatischen Zonen. Entlang von Höhengradienten bewirken die Klimaunterschiede Differenzierungen in der Bodenentwicklung, beides bewirkt die Diversifikation der Pflanzengesellschaften. Ein großer Teil des Untersuchungsgebietes ist Waldgebiet und wird von *Abies bornmuelleriana* dominiert, oft in Mischung mit *Fagus orientalis* und *Pinus sylvestris.* In tieferen Lagen gedeihen subhumide *Pinus niga-* und trockene *Quercus sp.*-Wälder. Nebelformationen und reichlich Niederschläge bewirken in den höheren Lagen über 1300 m Seehöhe ideale Bedingungen für *Abies bornmuelleriana*-Wälder.

Drei Waldgesellschaften sowie sieben Untergesellschaften wurden für das Untersuchungsgebiet ausgewiesen und mittels synoptischer Konsistenztafeln beschrieben. Die Pflanzengesellschaften wurden identifiziert und mittels Zusammensetzung der Arten, Ökologie und Verteilung charakterisiert.

Schlagworte: *Abies bornmuelleriana*, euro-sibirische Vegetationszone, Waldgesellschaften, Bolu, Aladag-Gebirge.

vulgare communities and grassland community as *Festuca varia-Viola gracilis* community.

Forest ecosystems comprise three main characteristics – structure, composition and function –, which are influenced by climate, soil, disturbances and topography. Disturbances, both anthropic and natural, shape forest systems by changing their composition, structure and functional processes (DALE et al., 2001). Indeed, over-exploitation, illegal cuttings, overgrazing and mismanagement activities have destroyed and still destroy the structure and natural

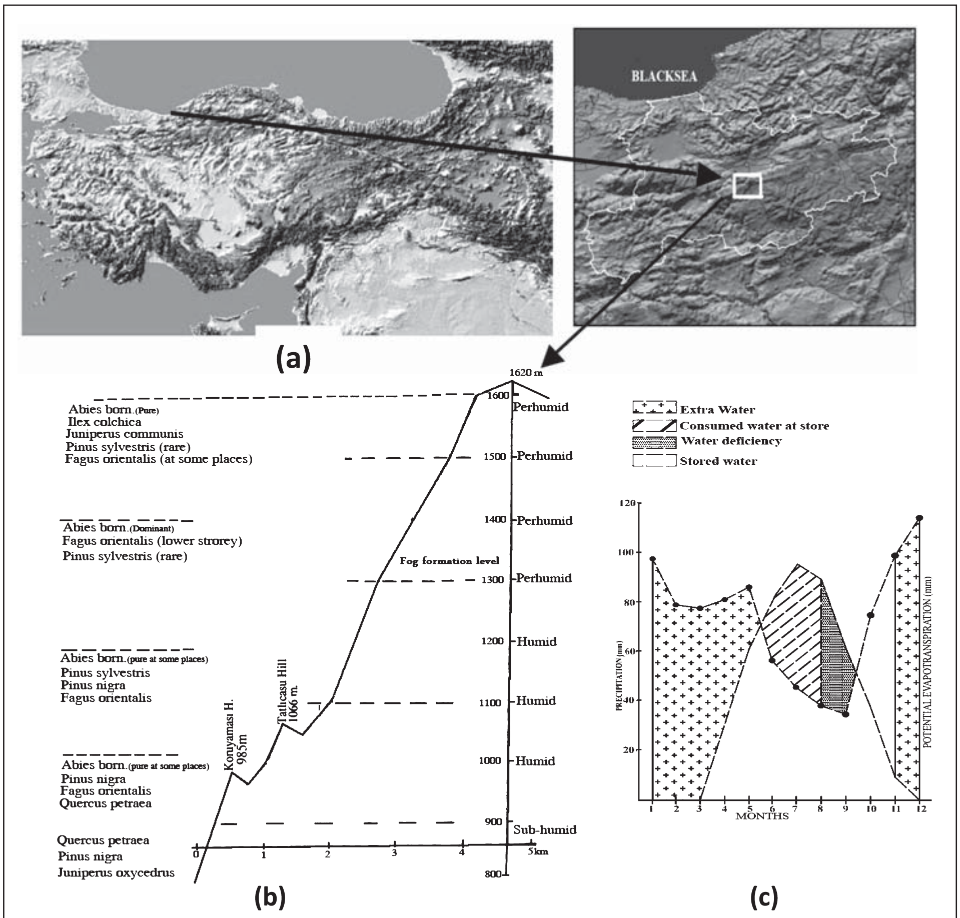


Figure 1: (a) Location of the study area in Northwest Turkey. (b) Cross-section of the northern slopes of Aladag mountain (Sultan Serisi) according to altitudinal-climatic zones (KANTARCI, 1980). (c) Water balance graphic of the region (TOSUN, 2003)

Abbildung 1: a) Lage des Untersuchungsgebietes im Nordwesten der Türkei. b) Querschnitt des Nordhanges des Aladag-Gebirges (Sultan Serisi) mit höhenklimatischen Zonen (KANTARCI 1980). c) Klimadiagramm der Region (TOSUN 2003) composition of forests in Turkey. In particular, some economically important trees (*P. nigra, P. sylvestris* etc.) in mixed forests have been intensively harvested, irrespectively of forest tree composition. Consequently, natural tree composition has changed in favour of shade tolerant plants in pure and mixed stands. For this reason, forest structure seems to be the heritage of historical events (climatic changes, fires, drought, management systems) and their consequences which continue to influence the region.

This study analyses the vegetation types and structure of the northern slopes of Aladag mountain (Sultan Serisi). It is based on the vegetation study that was carried out in 1978.

2 Material and Method

2.1 Study area

Aladag mountain is part of the Köroglu mountain ranges which extend along east-west direction. The study area is located in the south of the Bolu on the northern slopes of Aladag mountain in the West Black Sea region of Anatolia, approximately at the latitudes of 40°37'30''–40°41'30''N and the longitudes of 31°29'31''–31°38'18''E. The altitude of the research area varies between 830 m and 1,610 m.

The great part of the study area which has eruptive main rock is composed of andesites. However, elevation gradients create varied climates along with resultant soil differentiation which promote the diversification of plant communities and growth rate of the trees.

The study area shows transitional features between Euro-Siberian and Irano-Turanian phytogeographic regions and it is in the extreme south of the western sector of the Euxine province of the Euro-Siberian region (Akman & Yurdakulol, 1981).

Kantarci (1979) classified the study area into four altitudinal-climatic zones according to the landforms, altitude, climate and tree development. These zones are lower slopes (900–1100 m), middle slopes below fog formation level (1100–1300 m), middle slopes above fog formation level (1300–1500 m) and upper slopes (1500–1620 m) (Figure 1).

2.2 Climate

The meteorological data were collected from the observation stations of Bolu (742 m) and Serif Yüksel Research Forest (1,550 m) (Table 1).[1] Some climatic data of Bolu meteorology station were calculated per 100 m increase (Table 2).

Kantarci (1979) stated that fog formation is a common event from 1,300 m upwards on the northern slopes of the Bolu mountains. Therefore, the northern slopes of the study area above 1,300 m (upwards from Gölcük lake) have a considerably different climate due to frequent rainfall and fog formation compared to that of the southern slopes of the Bolu mountain at the same time of the day.

According to Thornthwaite method indicated with $B4C_2$'rb_2' symbols which means a location, it has been found that the climate type of Şerif Yüksel Research Forest "shows close characters to oceanic climate that is humid, microthermal, no or little water deficiency" (Figure 1c) and Bolu station exhibits a transitory character between Mediterranean climate with a very cold, less rainy winter and oceanic climate (Tosun, 2003).

2.3 Method and Data Analysis

The study is based on the analysis of 76 unpublished relevés, provided by H. Aksoy in 1978. The relevés were carried out according to the Braun-Blanquet (1932) method.

Input and editing of vegetation data was performed by TURBOVEG database (Hennekens & Schaminée, 2001). Then the data were exported to JUICE 7.0 and classified using the two-way indicator species analysis (TWINSPAN) (pseudospecies cut levels 0, 5, and 25) (Hill, 1979), under JUICE software (Tichy, 2002). Diagnostic, constant and dominant species of every vegetation unit, which are each defined in fidelity, relative frequency and cover threshold respectively, were extracted from synoptic table analysis in JUICE (Chytry et al., 2002).

Unconstrained ordination was used to find major gradients in species composition and thus describe the general pattern in species distribution along the gradients. The dataset was subjected to detrended correspondence analysis (DCA) with down-weighting of rare species (minimum weight was set to 7 %), using CANOCO 4.5 (Ter Braak & Šmilauer, 2002). Sample plots corresponding to different aspects were marked by different symbols and altitude was plotted onto the resulting DCA ordination diagram.

Stand structural characteristics of the study area and stand profiles were taken from Caliskan (1982).

[1] Temperature values were calculated based on 0.5 °C decrease for every 100 m increase. Precipitation values were calculated according to Schneider Formula (Yh = Yo ± 54 h) (ERINC, 1968).

	ANNUAL		Summer Months (VI+VII+VIII+IX)		January	
	BOLU	Şerif Yüksel	BOLU	Şerif Yüksel	BOLU	Şerif Yüksel
mean temperature (°C)	10.2	5.7	18	13.6	0.7	-3.8
precipitation (mm)	533.6	882.6	126.5	174.1	53.7	97.6
relative humidity (%)	73	81.6	69.5	77.5	77.5	88.4

Table 1: Some Climatical Data of Bolu (742 m) and Şerif Yüksel Research Forest Meteorology Station (1,550 m)
Tabelle 1: Ausgewählte Klimaparameter der Meteorologischen Stationen Bolu und Şerif Yüksel Versuchswald

Elevation (m)	Temperature (°C)					Precipitation (mm)				
	Annual	Summer months (VI+VII+VIII+IX)				Annual	Summer months (VI+VII+VIII+IX)			
1600	5.9	12.7	15.2	15.4	15.4	990.8	89.9	63.9	56.5	68.6
1300	7.4	14.2	16.7	16.9	13	828.8	76.4	50.4	43	55.1
1100	8.4	15.2	17.7	17.9	14	720.8	67.4	41.4	34	46.1
742 (mean)	10.2	17	19.5	19.7	15.8	533.6	51.8	25.8	18.4	30.5

Table 2: Temperature and precipitation changes with respect to altitude (Kantarci, 1979)
Tabelle 2: Änderung von Temperatur und Niederschlag in Bezug auf Höhenstufen

3 Results

3.1 Ordination Analysis

Indirect gradient analysis (DCA) of the entire data set (76 relevés; 261 taxa) revealed three major groups which were also determined using classification methods (Figure 2). Even though a single one of the environmental factors cannot explain the overall variability, altitudinal differences seem to explain a great part of the distribution and variability of forest plant communities, as for example precipitation increase and temperature decrease with increasing altitude.

3.2 Classification of the Vegetation

Three communities and seven sub-communities were identified from the classification of 76 relevés. Diagnostic, dominant and constant species of the communities were given in a percentage synoptic table (see App. 1).

***Festuca drymeja-Abies bornmuelleriana* community**
- *Pinus sylvestris-Pinus nigra* sub-community
- *Galium odoratum* sub-community
- Typical sub-community

***Juniperus oxycedrus-Pinus nigra* community**
- *Buxus sempervirens* sub-community
- Typical sub-community

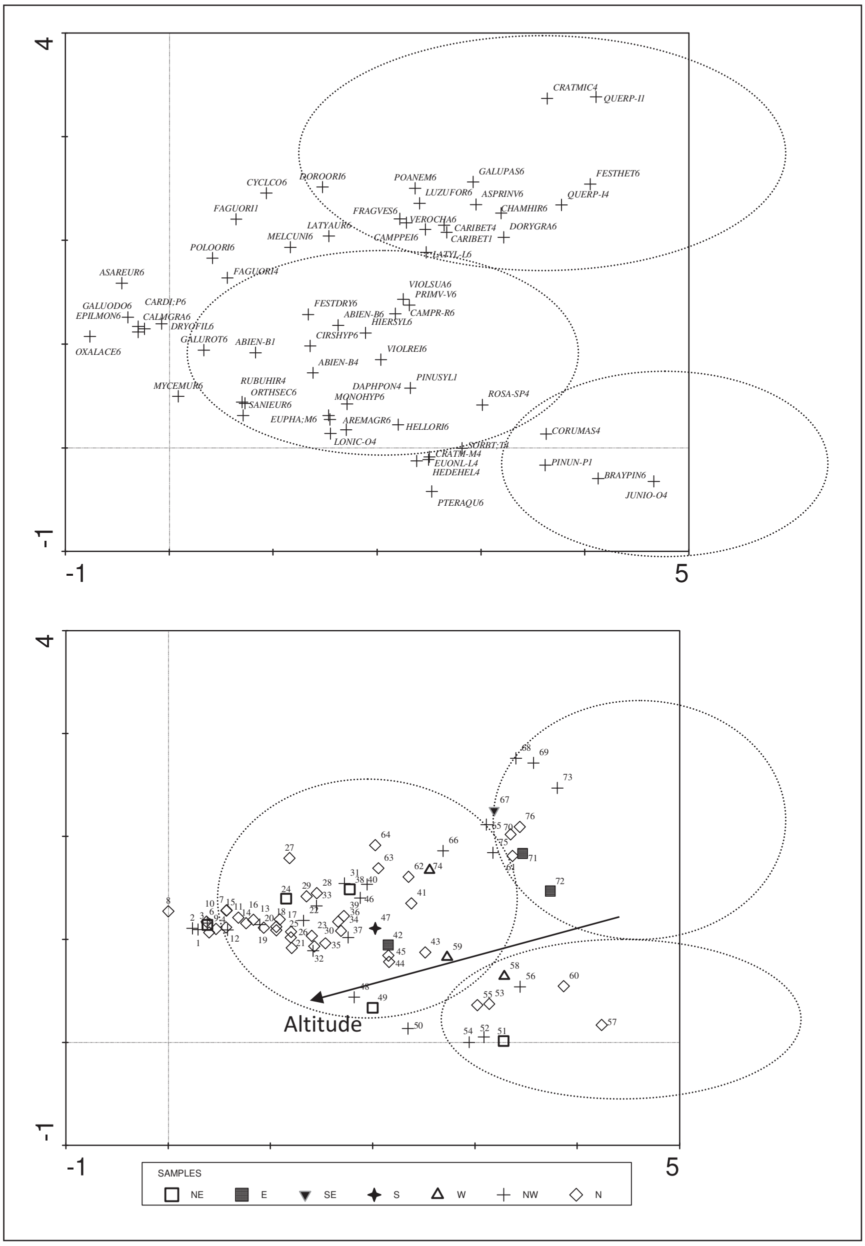
***Crataegus microphylla-Quercus petraea* community**
- *Fagus orientalis* sub-community
- Typical sub-community

3.2.1 Festuca drymeja-Abies bornmuelleriana community

The sample plots show a clear dominance of A. *bornmuelleriana* in tree layer. This community prevails on northern

Figure 2: Detrended correspondence analysis (DCA) diagram of species and vegetation plots with altitude passively projected onto the ordination (The numbers at the end of species name represents layer, i.e. 1: tree layer, 4: shrub layer, 6: herb layer)

Abbildung 2: Diagramme einer „Detrended Correspondance“-Analyse (DCA) bezüglich Artverteilung und Vegetationsgruppierung nach Seehöhe (die Nummern am Ende des Artnamens codieren die Vegetationsschicht, z.B. 1: Baumschicht, 4: Strauchschicht, 6: Krautschicht)



slopes of the Aladag mountain at an altitude of 900 m to 1,600 m. The great part of the study area is covered with A. *bornmuelleriana*-dominated forest plant community with scattered F. *orientalis* distribution.

The characteristics which differentiate the community are the floristic richness and the number of hydrophilous species (Table 3). Although the herb layer is floristically rich, the shrub layer is rather poor with respect to the number of species.

Three sub-communities were identified according to their floristic and ecologic structure in this community. At lower elevations of (900–1,400 m) of its distribution, A. *bornmuelleriana* and F. *orientalis* mixed forests were identified as a typical sub-community. As a second sub-community, *P. nigra* and *P. sylvestris* admix with A. *bornmuelleriana* and F. *orientalis* were identified (Figure 3b). At higher elevations (1,200 m–1,610 m), a third sub-community which prevails with a rich herbacous flora is *Galium odoratum* sub-community (Figure 3a) (see App. 1).

3.2.2 Crataegus microphylla-Quercus petraea community

At lower altitudes (830–1,000 m) on relatively dry site conditions, a *Q. petraea*-dominated plant community appears in the form of degraded coppice forest mixed with deciduous species, i.e. *C. betulus, F. orientalis, A. campestre.* Fo-

Number of relevés: 50 **Threshold fidelity value for diagnostic species:** 60 (65) **Threshold frequency value for constant species:** 60 (90) **Threshold frequency value for dominant species with cover up to 60:** 0 (100)	
Diagnostic species	***Fagus orientalis 65.9;*** *Calamintha grandiflora [6] 63.2,* ***Cardamine impatiens var. pectinata*** *73.6, Epilobium montanum 61.7, Festuca drymeja 64.5, Galium odoratum 61.7,* ***Galium rotundifolium 87.1, Orthilia secunda 67.4***
Constant species	***Abies nordmanniana subsp. bornmuelleriana 100,*** *Fagus orientalis 62; Daphne pontica 84,* ***Rubus hirtus 94;*** *Cirsium hypoleucum 64, Euphorbia amygdaloides var. amygdaloides 80, Fragaria vesca 80, Lathyrus aureus 80, Lathyrus laxiflorus subsp. laxiflorus 86, Luzula forsteri 66, Melica uniflora 78, Monotropa hypopithys 64, Poa nemoralis 64, Polygonatum orientale 62, Sanicula europaea 68, Veronica chamaedrys 80, Viola reichenbachiana 84, Viola suavis 84*
Dominant species	*Abies nordmanniana subsp. bornmuelleriana 78, Fagus orientalis 2, Pinus nigra subsp. pallasiana 2; Buxus sempervirens 2, Fagus orientalis 4, Rubus hirtus 4; Galium rotundifolium 2, Oxalis acetosella 16*

Table 3: Diagnostic, dominant and constant species of *Festuca drymeja-Abies bornmuelleriana* community (species exceeding higher fidelity or frequency threshold value (in bracket) are displayed in bold style)

Tabelle 3: Diagnostische, dominierende und konstante Arten der *Festuca drymeja-Abies bornmuelleriana*-Gesellschaft (Arten, die höhere Schwellenwerte bezüglich Stetigkeit oder Häufigkeit überschreiten, sind fett dargestellt)

rest stands where *F. orientalis* becomes dominant were determined as a sub-community and areas in which *F. orientalis* is less frequent were determined as a typical community.

Differential species of this community are *Crataegus microphylla* and *Q. petraea* (Table 4). The shrub layer is rich in species, composed of thermophilous and mesophilous species *(A. campestre, C. microphylla, Sorbus torminalis, Rosa sp., Mespilus germanica, Cornus mas, Euonymus latifolius).*

3.2.3 Juniperus oxycedrus-Pinus nigra community

P. nigra forests form the northern borders of the Bolu mountains in the north-west region of Turkey. *P. nigra* forests are not a common forest type of Aladag mountain and are found from sub-montane to montane zone (800–1,000 m) in a transition zone between oceanic and semi-arid climates. The shrub layer is species-rich, composed of *Buxus sempervirens, Ligustrum vulgare, Crataegus monogyna, Corylus colurna, Crataegus monogyna, Crataegus microphylla, Sorbus torminalis, Rosa sp., Cornus mas, Euonymus latifolius, Daphne pontica* (Table 5).

Concerning the riverside distribution of this community, Buxus sempervirens covers understorey with high cover values, was identified as *Buxus sempervirens* sub-community and samples which were characterized by *Juniperus oxycedrus* as a typical community. In this community, forest stands are commonly single-storied and *Quercus petraea* is found commonly in shrub layer (Figure 4) (see App. 1).

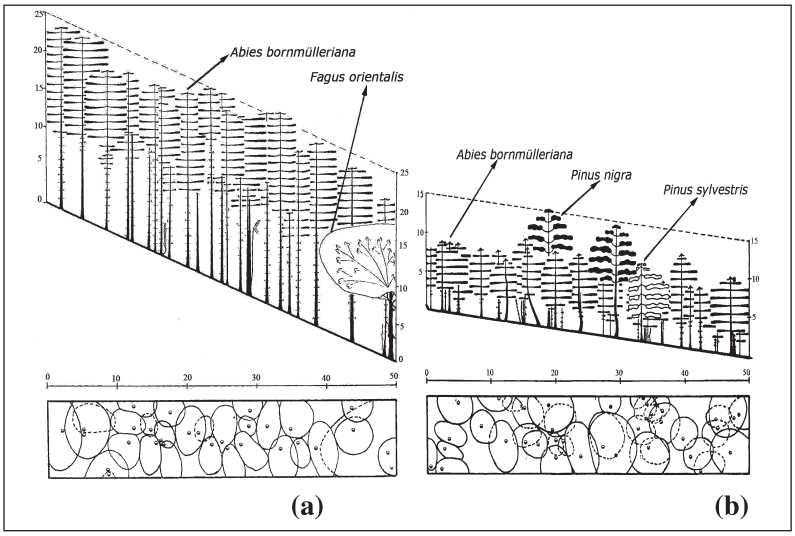


Figure 3: (a) Forest stand profile of *Festuca drymeja-Abies bornmuelleriana* community (Altitude: 1,510 m, aspect: N-NE, inclination: 23°), (b) *Pinus sylvestris-Pinus nigra* sub-community (Altitude: 980 m, aspect: S-SE, inclination: 7°) (CALISKAN, 1982)

Abbildung 3: Bestandsaufrisse (Caliskan 1982)
a) der *Festuca drymeja-Abies bornmuelleriana*-Gesellschaft (Seehöhe 1510 m, Exposition N-NO, Hangneigung 23°). b) *Pinus nigra-Pinus sylvestris*-Untergesellschaft (Seehöhe 980 m, Exposition S-SO, Hangneigung 7°)

Number of relevés: 14 **Threshold fidelity value for diagnostic species:** 60 (70) **Threshold frequency value for constant species:** 60 (90) **Threshold frequency value for dominant species with cover up to 80:** 0 (90)	
Diagnostic species	***Quercus petraea subsp. iberica 91.4; Crataegus microphylla 71.7***
Constant species	*Quercus petraea subsp. iberica 64, Rosa species 79;* ***Asperula involucrata 100,*** *Chamaecytisus hirsutus 64,* ***Festuca heteropphylla 93, Fragaria vesca 93,*** *Lathyrus aureus 79,* ***Lathyrus laxiflorus subsp. laxiflorus 100, Luzula forsteri 93,*** *Poa bulbosa 64,* ***Poa nemoralis 93, V eronica chamaedrys 93,*** *Viola reichenbachiana 71, Viola suavis 79*
Dominant species	*Fagus orientalis 14, Quercus petraea subsp. iberica 57*

Table 4: Diagnostic, dominant and constant species of *Crataegus microphylla-Quercus petraea* community (Species exceeding higher fidelity or frequency threshold value (in brackets) are displayed in bold style)

Tabelle 4: Diagnostische, dominierende und konstante Arten der *Crataegus microphylla-Quercus petraea*-Gesellschaft (Arten, die höhere Schwellenwerte bezüglich Stetigkeit oder Häufigkeit überschreiten, sind fett dargestellt)

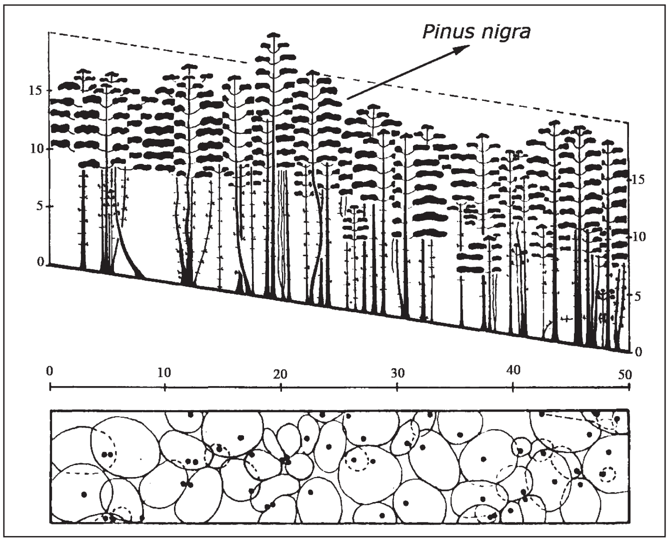


Figure 4: Forest stand profile of *Juniperus oxycedrus-Pinus nigra* community (Altitude: 940 m, aspect: N-NW, inclination: 9°) (CALISKAN, 1982)

Abbildung 4: Bestandsaufriss (Caliskan 1982) der *Crataegus microphylla-Quercus petraea*-Gesellschaft (Seehöhe 940 m, Exposition N-NW, Hangneigung 9°)

Number of relevés: 12 **Threshold fidelity value for diagnostic species:** 50 (55) **Threshold frequency value for constant species:** 70 (90) **Threshold frequency value for dominant species with cover up to 80:** 0 (100)	
Diagnostic species	***Pinus nigra subsp. pallasiana 59.4;*** Clematis vitalba 54.4, ***Lonicera nummulariifolia subsp. nummularii 55.7, Pinus nigra subsp. pallasiana 57.3, Quercus pubescens 62.5;*** Briza media 54.4, ***Dactylis glomerata subsp. glomerata 58.7, Festuca valesiaca 55.7,*** Pilosella hoppeana subsp. pilisquama 51.7, Pinus nigra subsp. pallasiana 53.2, Teucrium chamaedrys subsp. chamaedrys 53.8
Constant species	*Cornus mas 75, Juniperus oxycedrus subsp. oxycedrus 75, Rosa species 75; Asperula involucrata 83, Brachypodium pinnatum 75,* **Dorycnium graecum 92,** *Festuca heteropphylla 75,* **Lathyrus laxiflorus subsp. laxiflorus 92,** *Viola reichenbachiana 75, Viola suavis 75*
Dominant species	*Pinus nigra subsp. pallasiana 42; Buxus sempervirens 8, Quercus petraea subsp. iberica 8*

Table 5: Diagnostic, dominant and constant species of *Juniperus oxycedrus-Pinus nigra* community (Species exceeding higher fidelity or frequency threshold value (in brackets) are displayed in bold style).

Tabelle 5: Diagnostische, dominierende und konstante Arten der *Juniperus oxycedrus-Pinus nigra*-Gesellschaft (Arten, die höhere Schwellenwerte bezüglich Stetigkeit oder Häufigkeit überschreiten, sind fett dargestellt).

4 Discussion

Syntaxonomy aims at relating vegetation units to a wider geographical background. It is generally expressed by a hierarchical system of syntaxa (BERGMEIER & DIMOPOULUS, 2001). In order to classify vegetation units in a hierarchical system, a regional elobaration of relevés is needed in Northwest Turkey. However, AKMAN et al. (1983) state that forest formations in which *Abies* sp. dominates can be put into the order *Fagetalia sylvaticae*, and *P.nigra* forests, which form a zone around Anatolia, into the order *Quercetalia pubescentis. Quercus petraea*-dominated forests can, from the phytosociological point of view, be put into the order *Querco-Carpinetalia orientalis* in Northwest Anatolia. The abundance of species belonging to the Fagetalia sylvaticae order in the Black Sea region shows the influence of central Europe on the forestal vegetation in the area.

Forest types of the study area can be arranged along different climatic zones and changing ecological conditions with altitudinal gradient. *A.bornmuelleriana* covers most of the study area and becomes dominant in the middle and upper altitudinal-climatic zones. *P.nigra* and *Q. petraea* communities are found only in lower slopes.

Although *A.bornmuelleriana* has a large distribution in the study area, at lower limits of the *Festuca drymeja-Abies bornmuelleriana* community (approximately between 900 and 1,300 m.), stand structure characteristics change considerably in addition to species composition. In this community, overstorey height varies between 17 and 26 m and the mean stand height is 22 m. On the other hand, at lower altitudes in the *Pinus sylvestris-Pinus nigra* sub-community, mean overstorey height varies between 8 and 15 m and mean stand height is 9.8 m (CALISKAN, 1982). KANTARCI (1979) showed that mean stand height and diameter at breast height of *A.bornmuelleriana* forests are higher in upper altitudinal-climatic zones and decrease in lower zones respectively. It was stated that these development changes on higher elevations seem to be related to the soil characteristics in addition to humidity. This is due to the fact that the amount of nitrogen increases while the amount of exchangeable cations in the soil content decreases along altitudinal gradient (KANTARCI, 1979).

High precipitation, high atmospheric humidity and low temperature above 1,300 m (in the fog formation zone) are some of the site characteristics which create favourable conditions for *A. bornmuelleriana. A.bornmuelleriana* in fog formation zone has little or no deformed stems compared to those at lower altitudes. While natural regenerations of *A.born-muelleriana* in the *Festuca drymeja-Abies bornmuelleriana* community were seen under open canopy closures, they were observed under both closed canopies and gaps in the *Pinus sylvestris-Pinus nigra* sub-community. However *P. nigra* and *P. sylvestris* regenerations were only seen under canopy gaps.

In the *Juniperus oxycedrus-Pinus nigra* community, forest stands are commonly single-storied and only 2 % of pines are found in the understorey layer. Mean stand height is 16.6 m and diameter at breast height varies between 20 and 58 cm. Nearly half the trees in the stand have stem deformations.

Human-induced disturbances (i.e. inappropriate silvicultural operations, excessive harvesting, unplanned exploitation and grazing etc.), which have an effect on forest structure and composition, may change the sustainability of pure and mixed stands. It is known that unplanned exploitation of economically important trees changed forest composition, in favour of shade tolerant species (*A. bornmuelleriana*), in mixed stands. As a result of this situation, more vulnerable and unproductive forests have developed on lower altitudes where *A.bornmuelleriana* does not show good development.

However, human influence on communities which are close to settlement areas (villages, mountain pastures) is more prominent than in other communities. Oak forests in the form of degraded coppice have also occurred as a result of irregular exploitation around settlements for fuel wood. Grazing indicators such as *Juniperus oxycedrus* occur at lower altitudes, mostly under pine forest. An experiment carried out in France on an area with secondary matorral of *Juniperus thurifera,* invaded by *Quercus pubescens*, has shown that goats prefer scrub below two meters in height, except junipers (BENSETTITI et al., 2005).

Typical *P. nigra*-dominated forest communities, which are found out of the sites where deciduous trees show good development, are admixed with oaks in secondary stand layer. Other trees that admix are *Carpinus betulus, Acer campestre* and *Sorbus torminalis.* Species mentioned here and some more species listed in the vegetation table (App. 1), i.e. *Pteridium aquilinum, Rubus hirtus, Viola suavis, Viola reichenbachiana, Euphorbia amygdaloides, Sanicula europaea, Hedera helix, Brachypodium sylvaticum,* indicate that these sites are not too dry. In Central Europe, these species are largely missing in primary Pinus (*nigra* and *sylvestris*) communities. If found in pine communities, those are usually secondary communities, i.e. pine stands on site types. There the potential natural vegetation would be dominated by *Fagus, Quercus* or *Carpinus.*

Vegetation sampling of this area was carried out in 1978. In this long term, it is possible to see the results of forest use and demographic pressures on forest structure and composition. Further studies will give detailed information about the changes in vegetation structure.

App. 1: Percentage synoptic table of Aladag-Sultan Serisi forests. High constancy values are set dark. J.o-Pn = *Juniperus oxycedrus-Pinus nigra* community, B.s = *Buxus sempervirens* sub-community, Typ. = Typical, C.m-Q.p = *Crataegus microphylla-Quercus petraea* community, F.o = *Fagus orientalis* sub-community, *F.d-A.b* = *Festuca drymeja-Abies bornmuelleriana* community, *P.s-P.n* = *Pinus sylvestris-Pinus nigra* sub-community, G.o = *Galium odoratum* sub-community

Anhang 1: Prozentuale Übersichtstabelle der Sultan-Serisi-Wälder. Hohe Konstanzwerte sind dunkel unterlegt. Abkürzungen: J.o-Pn = *Juniperus oxycedrus-Pinus nigra*-Gesellschaft, B.s = *Buxus sempervirens*-Untergesellschaft, Typ. = Typical, C.m-Q.p = *Crataegus microphylla-Quercus petraea*-Gesellschaft, F.o = *Fagus orientalis*-Untergesellschaft, F.d-A.b = *Festuca drymeja-Abies bornmuelleriana*-Gesellschaft, P.s-P.n: *Pinus sylvestris-Pinus nigra*-Untergesellschaft, G.o: *Galium odoratum*-Untergesellschaft

Group No.		1	2	3	4	5	6	7
No. of relevés		12	9	5	3	16	16	18
Community		J.o-Pn		C.m-Q.p		F.d-A.b		
Sub-community		B.s	Typ.	Typ.	F.o	P.s.-P.n	Typ.	G.o
Altitude Layer		830–990 m		880–970 m		910–1610 m		
Abies nordmanniana s. bornmuelleriana	*Tree*	**75**	25	22	**60**	**100**	**100**	**100**
Abies nordmanniana s. bornmuelleriana	*Shrub*	**50**	**63**	22	20	**100**	**100**	**100**
Abies nordmanniana s. bornmuelleriana	*Herb*	**50**	**63**	33	40	**95**	**90**	**90**
Pinus sylvestris	*Tree*	**50**	25	11	.	**100**	.	.
Pinus sylvestris	*Shrub*	.	.	11	.	42	.	.
Pinus nigra s. pallasiana	*Tree*	**100**	**100**	**78**	.	**63**	10	.
Pinus nigra s. pallasiana	*Shrub*	**50**	**75**	22	.	21	.	.
Pinus nigra s. pallasiana	*Herb*	25	**75**	22	.	11	.	.
Quercus petraea s. iberica	*Tree*	.	13	**100**	**100**	11	.	.
Quercus petraea s. iberica	*Shrub*	**50**	**75**	**89**	20	47	.	.
Fagus orientalis	*Tree*	.	13	11	**100**	47	**70**	**71**
Fagus orientalis	*Shrub*	.	25	11	40	**74**	**100**	**95**
Mespilus germanica	*Shrub*	.	13	22	**100**	26	10	5
Carpinus betulus	*Shrub*	**50**	38	22	**100**	47	**50**	5
Carpinus betulus	*Tree*	**50**	.	44	**80**	11	40	10
Cornus mas	*Shrub*	**100**	**63**	44	**80**	21	20	5
Acer campestre s. campestre	*Shrub*	**75**	38	44	**60**	37	10	.
Acer campestre s. campestre	*Herb*	.	.	.	40	.	.	.
Sorbus torminalis v. torminalis	*Shrub*	**75**	25	33	40	**58**	40	.
Sorbus torminalis v. torminalis	*Tree*	.	13	11	40	32	10	.
Acer campestre s. campestre	*Tree*	25	38	.	40	16	10	.
Buxus sempervirens	*Shrub*	**100**	.	.	.	5	10	.
Buxus sempervirens	*Herb*	**75**	.	.	.	5	10	.
Quercus pubescens	*Tree*	.	25	.	.	.	.	.
Quercus pubescens	*Herb*	.	13	.	.	.	.	.
Taxus baccata	*Shrub*	25	.	.	.	5	10	.
Acer platanoides	*Tree*	.	.	.	.	.	10	19
Taxus baccata	*Herb*	.	.	.	.	5	10	.
Quercus robur s. pedunculiflora	*Tree*	.	.	.	.	5	.	.
Acer trautvetteri	*Tree*	.	.	.	.	.	.	5
Acer trautvetteri	*Shrub*	.	.	.	.	.	.	5
Fraxinus angustifolia s. angustifolia	*Tree*	.	.	.	.	.	.	10
Ulmus glabra	*Tree*	.	.	.	.	.	.	5
Populus tremula	*Tree*	.	.	.	.	.	.	5

Asperula involucrata	*Herb*	**100**	**75**	**100**	**100**	**79**	**60**	10
Rosa species	*Shrub*	**100**	**63**	**89**	**60**	**63**	40	14
Festuca heteropphylla	*Herb*	**75**	**75**	**100**	**80**	11	10	.
Dorycnium graecum	*Herb*	**100**	**88**	**67**	40	**53**	10	14
Juniperus oxycedrus s. oxycedrus	*Shrub*	**100**	**63**	**67**	.	11	.	.
Brachypodium pinnatum	*Herb*	**100**	**63**	**56**	20	32	.	.
Helleborus orientalis	*Herb*	**100**	**50**	33	**80**	42	40	**62**
Dactylis glomerata s. glomerata	*Herb*	**100**	**50**	22	.	16	.	.
Iris sintenisii	*Herb*	**100**	**50**	33	40	26	.	.
Quercus pubescens	*Shrub*	**100**	38	11	.	.	.	.
Anthemis tinctoria v. discoidea	*Herb*	**75**	**50**	33	20	5	.	.
Trifolium campestre	*Herb*	**75**	**50**	**56**	20	.	.	.
Polygala supina	*Herb*	**75**	**50**	44	.	32	.	.
Chamaecytisus hirsutus	*Herb*	25	**88**	**89**	20	**68**	30	5
Teucrium chamaedrys s. chamaedrys	*Herb*	**50**	**50**	11	.	5	.	.
Trifolium pannonicum s. elongatom	*Herb*	.	**50**	11	20	.	.	.
Galium paschale	*Herb*	.	**63**	**67**	40	47	30	5
Campanula persicifolia	*Herb*	25	38	**56**	20	37	**50**	29
Platanthera chlorantha	*Herb*	25	13	44	20	21	.	.
Muscari neglectum	*Herb*	.	25	22	40	5	.	.
Sorbus torminalis v. torminalis	*Herb*	.	25	33	40	11	10	.
Poa angustifolia	*Herb*	.	38	22	20	16	.	.
Pteridium aquilinum	*Herb*	**100**	13	.	40	37	30	29
Pyracantha coccinea	*Shrub*	**100**	25	11	.	16	10	.
Pilosella hoppeana s. pilisquama	*Herb*	**100**	38	11	20	16	.	.
Digitalis ferruginea s. ferruginea	*Herb*	**100**	25	11	20	**63**	20	.
Brachypodium sylvaticum	*Herb*	**75**	38	11	40	26	10	5
Lonicera nummulariifolia s. nummularii	*Shrub*	**75**	38	11	.	.	.	.
Festuca valesiaca	*Herb*	**75**	38	11	.	.	.	.
Lathyrus digitatus	*Herb*	**75**	25	33	.	11	.	.
Euphorbia nicaeensis s. glareosa v. la	*Herb*	**75**	13	11	.	.	.	.
Briza media	*Herb*	**100**	13	.	.	5	.	.
Clematis vitalba	*Shrub*	**100**	13	.	.	5	.	.
Orobanche anatolica	*Herb*	**75**	.	.	.	.	.	.
Carex flacca s. flacca	*Herb*	**75**	13	22	.	11	.	.
Cornus sanguinea s. sanguinea	*Shrub*	**75**	.	.	20	.	10	.
Carex muricata	*Herb*	**75**	.	22	40	.	10	.
Euonymus latifolius s. latifolius	*Shrub*	**75**	25	33	40	47	40	19
Ligustrum vulgare	*Shrub*	**75**	.	.	.	16	.	.
Primula vulgaris s. vulgaris	*Herb*	**75**	13	33	**80**	21	30	48
Crataegus monogyna s. monogyna	*Shrub*	**75**	25	11	.	**63**	30	5
Salvia forskahlei	*Herb*	**50**	38	11	40	37	.	10
Trifolium medium v. medium	*Herb*	**50**	38	44	40	11	.	.
Pyrola chlorantha	*Herb*	**50**	25	.	.	37	20	.
Calamintha nepeta s. nepeta	*Herb*	**50**	13	.	.	11	.	.
Campanula glomerata s. hispida	*Herb*	**50**	25	11	.	.	.	.
Galium verum s. verum	*Herb*	**50**	38	22	.	5	.	5
Cerinthe minor s. auriculata	*Herb*	**50**	.	.	.	.	.	.
Crataegus tanacetifolia	*Shrub*	**50**	.	.	.	.	.	.
Lithospermum purpurocaeruleum	*Herb*	**50**	25	11	.	11	10	.
Laser trilobum	*Herb*	25	25	11	.	.	10	.
Argyrolobium biebersteinii	*Herb*	25	38	11	.	16	.	.
Lonicera etrusca v. etrusca	*Shrub*	25	25	11	.	.	.	.
Viburnum lantana	*Herb*	25	13	11	.	.	.	.
Sanguisorba minor s. minor	*Herb*	25	25	.	.	.	.	.
Onobrychis armena	*Herb*	25	13	.	.	.	.	.
Helianthemum nummularium s. lycaonicum	*Herb*	.	13	11	.	.	.	.
Polygala anatolica	*Herb*	.	13	11	.	.	.	.
Aristolochia pallida	*Herb*	.	13	11	.	.	.	.
Trifolium arvense v. arvense	*Herb*	.	25	.	.	.	.	.

Saponaria glutinosa	*Herb*	.	25	.	.	.	.	.
Crataegus microphylla	*Shrub*	.	25	**78**	**100**	11	20	.
Sedum pallidum v. pallidum	*Herb*	25	38	**67**	40	11	.	.
Poa bulbosa	*Herb*	.	25	**78**	40	5	.	.
Pilosella piloselloides s. piloselloid	*Herb*	.	38	**67**	20	26	.	.
Cyclamen coum v. coum	*Herb*	.	.	22	**80**	42	20	**52**
Doronicum orientale	*Herb*	.	.	22	40	47	40	29
Aremonia agrimonoides	*Herb*	**50**	25	11	40	**58**	40	38
Cephalanthera rubra	*Herb*	.	38	44	20	11	10	.
Carex species	*Herb*	.	13	22	40	.	.	.
Moenchia mantica s. mantica	*Herb*	.	.	22	40	5	.	.
Genista lydia v. lydia	*Herb*	25	25	22	.	5	.	.
Trifolium repens v. repens	*Herb*	.	13	33	.	.	.	.
Vicia cracca s. cracca	*Herb*	.	13	33	.	.	.	.
Silene italica	*Herb*	.	25	33	20	11	.	.
Aira elegantissima s. elegantissima	*Herb*	.	.	22	20	.	.	.
Veronica chamaedrys	*Herb*	**50**	**63**	**100**	**80**	**95**	**70**	**71**
Poa nemoralis	*Herb*	.	**63**	**89**	**100**	**58**	**70**	**67**
Festuca drymeja	*Herb*	.	13	22	**60**	**95**	**90**	**86**
Lathyrus aureus	*Herb*	25	13	**67**	**100**	**68**	**100**	**81**
Hedera helix	*Shrub*	**100**	**50**	22	40	**63**	**100**	29
Rubus hirtus	*Shrub*	**75**	38	22	40	**89**	**90**	**100**
Galium rotundifolium	*Herb*	.	.	.	20	**79**	**90**	**100**
Daphne pontica	*Shrub*	**100**	25	44	**80**	**79**	**80**	**90**
Euphorbia amygdaloides v. amygdaloides	*Herb*	**75**	38	33	40	**74**	**70**	**90**
Cardamine impatiens v. pectinata	*Herb*	.	.	.	.	21	**70**	**100**
Sanicula europaea	*Herb*	**75**	13	11	40	42	**50**	**100**
Galium odoratum	*Herb*	.	.	.	.	11	10	**100**
Calamintha grandiflora	*Herb*	.	.	.	.	16	20	**95**
Mycelis muralis	*Herb*	25	.	.	.	21	40	**90**
Epilobium montanum	*Herb*	.	.	.	.	16	20	**90**
Monotropa hypopithys	*Herb*	**75**	25	22	.	**68**	**60**	**62**
Orthilia secunda	*Herb*	25	13	.	.	**74**	**80**	**71**
Cirsium hypoleucum	*Herb*	25	25	22	**60**	**63**	**60**	**67**
Melica uniflora	*Herb*	25	13	33	**80**	**79**	**60**	**86**
Polygonatum orientale	*Herb*	.	.	33	40	37	**60**	**86**
Dryopteris filix-max	*Herb*	25	.	.	.	21	**50**	**86**
Moehringia trinervia	*Herb*	.	.	11	20	11	40	**71**
Cardamine bulbifera	*Herb*	25	.	.	.	16	30	**71**
Actaea spicata	*Herb*	.	.	.	.	5	.	**67**
Asarum europaeum	*Herb*	.	.	.	20	11	.	**81**
Mercurialis perennis	*Herb*	.	.	.	.	5	.	**62**
Oxalis acetosella	*Herb*	.	.	.	.	.	.	**67**
Myosotis sylvatica s. rivularis	*Herb*	.	.	.	.	26	.	**57**
Galeobdolon luteum s. montanum	*Herb*	.	.	.	.	11	.	**57**
Viola odorata	*Herb*	.	.	.	.	5	10	**52**
Lonicera caucasica s. orientalis	*Shrub*	.	13	22	.	**63**	**70**	38
Hieracium sylvularum	*Herb*	25	38	22	.	**53**	40	24
Hordelymus europaeus	*Herb*	.	.	.	.	.	.	48
Polystichum aculeatum	*Herb*	.	.	.	.	.	30	43
Lapsana communis s. intermedia	*Herb*	.	.	.	.	5	.	43
Valeriana alliariifolia	*Herb*	.	.	.	.	5	.	38
Polypodium vulgare s. vulgare	*Herb*	.	.	.	.	11	30	5
Asplenium adiantum-nigrum	*Herb*	.	.	.	.	.	40	5
Epilobium lanceolatun	*Herb*	.	.	.	.	11	30	10
Luzula luzulina	*Herb*	.	.	.	.	.	.	38
Ranunculus brutius	*Herb*	.	.	.	.	5	.	29
Neottia nidus-avis	*Herb*	.	.	.	.	.	.	24
Epipogium aphyllum	*Herb*	.	.	.	.	.	.	29
Geranium robertianum	*Herb*	.	.	.	.	.	.	38

Urtica dioica	*Herb*	.	.	.	.	5	10	33
Ilex colchica	*Shrub*	25	.	.	.	5	.	29
Chelidonium majus	*Herb*	.	.	.	.	5	20	38
Scrophularia scopolii v. scopolii	*Herb*	.	.	.	.	5	.	19
Veronica officinalis	*Herb*	.	.	.	.	.	.	24
Dryopteris dilatata	*Herb*	.	.	.	.	5	.	24
Rumex obtusifolius s. subalpinus	*Herb*	.	.	.	.	.	.	19
Trachystemon orientalis	*Herb*	.	.	.	.	11	.	33
Acer platanoides	*Shrub*	.	.	.	.	.	10	19
Saxifraga rotundifolia	*Herb*	.	.	.	.	.	20	19
Galeobdolon luteum s. luteum	*Herb*	.	.	.	.	.	10	10
Moneses uniflora	*Herb*	.	.	.	.	11	20	29
Hypericum bithynicum	*Herb*	.	.	.	.	11	.	14
Carex depressa s. transsilvanica	*Herb*	.	.	.	.	11	.	14
Silene vulgaris v. vulgaris	*Herb*	.	.	.	.	.	.	29
Atropa belladonna	*Herb*	.	.	.	.	.	.	14
Circaea alpina	*Herb*	.	.	.	.	.	.	10
Ajuga reptans	*Herb*	.	.	.	.	.	.	10
Sorbus aucuparia	*Shrub*	25	.	.	.	.	.	14
Sambucus nigra	*Herb*	.	.	.	.	.	.	10
Fragaria vesca	*Herb*	**50**	**75**	**89**	**100**	**89**	**70**	**76**
Lathyrus laxiflorus s. laxiflorus	*Herb*	**100**	**88**	**100**	**100**	**95**	**100**	**71**
Luzula forsteri	*Herb*	25	**88**	**100**	**80**	**74**	**60**	**62**
Viola suavis	*Herb*	**100**	**63**	**67**	**100**	**95**	**90**	**71**
Viola reichenbachiana	*Herb*	**100**	**63**	**56**	**100**	**79**	**90**	**86**
Campanula rapunculoides s. rapunculoid	*Herb*	.	**75**	44	40	**63**	**70**	43
Corylus colurna	*Shrub*	**75**	13	11	20	11	30	19
Ruscus hypoglossum	*Herb*	.	.	.	.	.	10	10
Staphylea pinnata	*Herb*	.	.	.	.	.	10	10
Galium aparine	*Herb*	.	.	.	.	.	20	.
Epipactis helleborine	*Herb*	25	13	.	.	5	.	.
Phleum phleoides	*Herb*	.	25	22	.	.	.	.
Juniperus oxycedrus s. oxycedrus	*Herb*	.	13	11	20	.	.	.
Dorycnium pentaphyllum s. herbaceum	*Herb*	.	13	11	20	.	.	.
Koeleria cristata	*Herb*	.	13	.	20	.	.	.
Luzula campestris	*Herb*	.	13	.	20	5	.	.
Coronilla varia s. varia	*Herb*	.	13	11	.	5	.	5
Chamaecytisus supinus	*Herb*	.	13	.	.	.	.	.
Potentilla recta	*Herb*	.	13	.	.	.	.	.
Stachys byzantina	*Herb*	25	.	.	.	.	.	.
Anacamptis pyramidalis	*Herb*	25	.	.	.	.	.	.
Frangula alnus s. pontica	*Shrub*	25	.	.	.	.	.	.
Himantoglossum caprinum	*Herb*	25	.	.	.	.	.	.
Crataegus pentagyna	*Shrub*	25	.	.	.	.	.	.
Scabiosa columbaria s. columbaria v. c	*Herb*	.	13	.	.	.	.	.
Inula salicina	*Herb*	.	13	.	.	.	.	.
Jurinea consanguinea	*Herb*	.	13	.	.	.	.	.
Teucrium polium	*Herb*	.	13	.	.	.	.	.
Festuca rubra s. pseudorivularis	*Herb*	.	13	.	.	.	.	.
Colutea cilicica	*Shrub*	.	13	.	.	.	.	.
Salvia tomentosa	*Herb*	.	13	.	.	.	.	.
Lotus corniculatus v. corniculatus	*Herb*	.	13	.	.	.	.	.
Hieracium racemosum	*Herb*	.	13	.	.	.	.	.
Trifolium pratense v. pratense	*Herb*	.	13	.	.	.	.	.
Carex halleriana	*Herb*	.	13	.	.	.	.	.
Fritillaria species	*Herb*	25	.	22	.	.	.	.
Trifolium hybridum v. anatolicum	*Herb*	.	.	11	.	.	.	.
Euphorbia stricta	*Herb*	.	.	11	.	.	.	.
Trifolium physodes v. physodes	*Herb*	.	.	11	.	.	.	.
Campanula lyrata s. lyrata	*Herb*	.	.	11	.	.	.	.

Trifolium hybridum v. hybridum	*Herb*	.	.	11	20	.	.	.
Ventenata dubia	*Herb*	.	.	11	20	.	.	.
Oenanthe pimpinelloides	*Herb*	.	.	.	20	.	.	.
Ranunculus constantinopolitanus	*Herb*	.	.	.	20	.	.	.
Platanthera bifolia	*Herb*	.	.	.	20	.	.	.
Draba muralis	*Herb*	.	.	.	20	.	10	.
Trifolium ochroleucum	*Herb*	.	.	.	20	5	.	.
Scutellaria species	*Herb*	.	.	11	.	11	.	.
Luzula species	*Herb*	.	.	.	.	11	.	.
Arabis hirsuta	*Herb*	.	13	11	.	5	.	.
Pinus sylvestris	*Herb*	.	.	11	.	5	.	.
Dianthus cibrarius	*Herb*	.	13	.	.	5	.	.
Hypericum montbretii	*Herb*	.	13	.	.	5	.	.
Hieracium sabaudum	*Herb*	.	.	.	.	5	.	.
Sorbus umbellata v. umbellata	*Shrub*	.	.	.	.	5	.	.
Rumex acetosella	*Herb*	.	.	11	.	5	.	.
Prunella vulgaris	*Herb*	.	.	.	.	5	.	5
Pyrola minor	*Herb*	.	.	.	.	5	.	5
Juniperus communis s. alpina	*Shrub*	.	.	.	.	5	.	.
Cardamine hirsuta	*Herb*	.	.	.	.	5	10	.
Myosotis ramosissima s. ramosissima	*Herb*	.	.	11	20	11	20	.
Origanum vulgare s. vulgare	*Herb*	.	.	.	20	.	10	.
Pyrola rotundifolia	*Herb*	.	.	.	.	.	10	.
Geranium lucidum	*Herb*	.	.	.	.	5	10	.
Arabis turrita	*Herb*	.	.	.	.	.	10	.
Asplenium trichomanes	*Herb*	.	.	.	.	.	10	.
Cystopteris fragilis	*Herb*	.	.	.	.	.	10	.
Cerastium fontanum s. triviale	*Herb*	.	.	.	.	.	10	.
Geum urbanum	*Herb*	.	.	.	.	.	.	10
Laurocerasus officinalis	*Shrub*	.	.	.	.	.	.	10
Circaea lutetiana	*Herb*	.	.	.	.	.	.	10
Thelypteris dryopteris	*Herb*	.	.	.	.	.	.	5
Peucedanum aegopodioides	*Herb*	.	.	.	.	.	.	5
Heracleum sphondylium s. ternatum	*Herb*	.	.	.	.	.	.	5
Salvia glutinosa	*Herb*	.	.	.	.	.	.	5
Aristolochia pontica	*Herb*	.	.	.	.	.	.	5
Fraxinus angustifolia s. angustifolia	*Shrub*	.	.	.	.	.	.	5
Asperula taurina s. taurina	*Herb*	.	.	.	.	.	.	5
Athyrium filix-foemina	*Herb*	.	.	.	.	.	.	5
Verbascum species	*Herb*	.	.	.	.	.	.	5

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