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The Woody Flora of Bulgaria: A Review

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Abstract: This review presents a brief survey of the Bulgarian dendroflora. The country is situated in the transition zone between the continental and Mediterranean climate and, therefore, considerable habitat diversity exists on its territory. About 370 species – trees, shrubs and sub-shrubs – have been established up until today. An overview of the species' diversity, woody formations and their distribution is presented. The data show that Bulgaria is characterised by a relatively rich dendroflora that needs appropriate close-to-nature management and measures for its conservation.

Abstract: Diese Studie liefert eine kurze Übersicht über die taxonomische Struktur der bulgarischen Gehölzflora. Bulgarien liegt in einer Übergangszone zwischen der kontinentalen und mediterranen Klimazone und verfügt deshalb über eine grosse Artenvielfalt. 370 Spezies – Bäume, Sträucher und Untergehölz – wurden bisher gezählt. Eine Übersicht über diese Artenvielfalt, die Waldformationen und ihre Verbreitung wird in dieser Studie vorgestellt. Die Daten zeigen auf, dass Bulgarien über eine relativ reichhaltige Gehölzartenvielfalt verfügt, die Massnahmen für eine naturnahe Bewirtschaftung und Artenschutz erforderlich machen.

Bulgaria occupies the central and eastern part of the Balkan Peninsula *(Figure 1).* The combination of southern latitudes (41–43°) and variable relief, including high mountains (up to 2925 m) results in a great variety of plant habitats. They range from sub-Mediterranean ecosystems in the southern part of the country and along the Black Sea Coast, to typical temperate and boreal formations and to sub-alpine and alpine ecosystems above the alpine timber line.

One consequence of so many different co-existing habitats is the rich Bulgarian flora. Today, it consists of about 3500–3600 higher plant species, incl. *Pterydophyta* and *Equisetophyta* (Kozhuharov, 1992) – more than are found in other European countries with considerably larger territories.

According to the official data, the woody plants of Bulgaria consist of about 370 species – trees, shrubs, and sub-shrubs (fruticose plants). This is an approximate number, as there is controversy about the taxonomic status of certain units – whether or not they can be classed as units. The arboreal species belong to 123 genera and 49 families *(Table 1).* Please note that we rely on the interpretation of the authors of ‹Flora of the Republic of Bulgaria› vol. I–X (1963–1995), and particularly, of the recently published ‹Handbook for the identification of Bulgarian plants› (Kozhuharov, 1992) rather than presenting our own taxonomic interpretation.

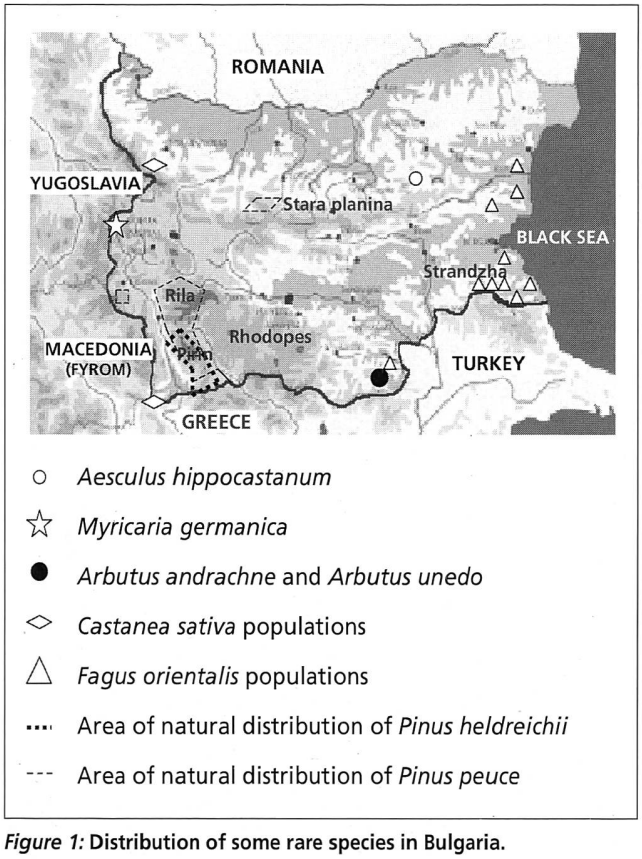

Figure 1: **Distribution of some rare species in Bulgaria.**
Abbildung 1: Verbreitung einiger seltener Spezies in Bulgarien.

The gymnosperms consist of 16 species (4.34% of all arboreal species) and belong to 6 genera and 4 families. The highest species' diversity is attained by the angiosperms (95.66% of all species).

The most frequent families are *Rosaceae,* including 17 genera and 118 species, *Fabaceae* (12 genera, 50 species), *Salicaceae* (2 genera, 22 species). It should be pointed out, however, that in the ‹Flora of RB› (loc.cit.), some critical genera have been interpreted in a strictly taxonomical way, and a species' status was given to some taxa which were not considered as species by other authors. In other words, there is no general agreement among the taxonomists concerning certain critical issues and thus, concerning the species' number.

Recently, some new arboreal species of the Bulgarian flora have been discovered. These are *Arbutus andrachne* L. and *Arbutus unedo* L. (Velčev *et al.,* 1989), *Crataegus x media* Bechst. (Vakarelov, 1988), and *Myricaria germanica* (L.) Desv. (Gussev & Dimitrov 1997). These findings show that the process of studying the Bulgarian dendroflora has still not been completed.

The main systematic groups consist of different numbers of species. Their peculiarities can be summarised as follows:

Gymnosperms

Although they are not conifers, two species belonging to the family of *Ephedraceae (Ephedra distachya* L. and *E. fragilis* Desf.) should be mentioned. They are sporadically distributed and therefore are important from a conservation point of view.

Even though not numerous, the conifers play an important role in the forest ecosystems, especially within mountainous regions, because they occupy large territories, thus influencing the local environment. Three families are represented in the Bulgarian flora – *Pinaceae* (genera *Pinus, Abies* and *Picea), Cupressaceae* (g. *Juniperus)* and *Taxaceae* (g. *Taxus).* The representatives of the *Pinaceae* family are considered to be the

most important ones. Five pine species grow naturally in Bulgaria. The most widespread tree species is Scots pine *(Pinus sylvestris* L.), occupying one third of the territory of coniferous forests. It should be mentioned that a certain amount of its territory is attributed to artificial stands, planted mainly as reconstruction measures and against soil erosion on deforested and destroyed land. The Austrian black pine *(Pinus nigra* Arn.) is the second most common. According to the classification of FUKAREK (1958), it belongs to the eastern group, and in Bulgaria, it includes varieties such as *austriaca, poiretiana, pallasiana* and *gočensis* (DOBRINOV *et al.*, 1982). However, this classification still has to be improved. The black pine is mainly found in the Pirin mountains and the Western Rhodopes, but it also occurs in other mountains. The mountain dwarf pine *(Pinus mugo* Turra) can be found in the highlands, more than 1800 m above sea level *(Figure 2).* It belongs to ssp. *mugo* (YURUKOV, 1988), which is characterised by a shrubby and prostrate growth form and differs from the western ssp. *uncinata* (Ram.) DC., which displays a monocormic and erect growth form. *P. mugo* forms compact mountain belts above the alpine timber line in the Rila and Pirin mountains, but it can also be found in the remaining high mountains within small, isolated spots. Single individuals of this species reach 2700 m above sea level. DOBRINOV & YAGDZIDIS (1971) found some evidence of a putative introgressive hybridisation between *P. sylvestris* and *P. mugo.* Some recent studies of FILIPPULA *et al.* (1992), CHRISTENSEN (1987a,b), NEET-SARQUEDA (1994) showed that this hypothesis should be carefully tested. Note, however, that Bulgarian *Pinus mugo* ssp. *mugo* differs from *P. mugo* ssp. *uncinata* from the Alps (CHRISTENSEN, 1987a) and, therefore, such a hybridisation can easily be recognised by habitual differences. Some progeny tests partly supported this hypothesis (GAGOV & ZHELEV, 1996), but no special study has been completed up until now.

Special attention should be given to two endemic pines: *Pinus peuce* Griseb., a Balkan endemic, and *Pinus heldreichii* Christ. (syn. *P. leucodermis* Ant.), called Balkan sub-endemic, occurring also in several isolated stands in Southern Italy (MORGANTE & VENDRAMIN, 1991). Both species grow in high

Figure 2: **Natural distribution of some rare species in Bulgaria.**
Abbildung 2: Natürliche Verbreitung einiger seltener Spezies in Bulgarien.

Table 1: **The diversity of the Bulgarian woody plants.**
Tabelle 1: Artenvielfalt bulgarischer Gehölzpflanzen.

Family	Genera	No of species
1	2	3
Gymnospermae		
Ephedraceae	*Ephedra*	2
Pinaceae	*Abies, Pinus, Picea*	7
Cupressaceae	*Juniperus*	6
Taxaceae	*Taxus*	1
Angiospermae		
Aceraceae	*Acer*	7
Anacardiaceae	*Cotinus, Pistacia, Rhus*	3
Aquifoliaceae	*Ilex*	2
Araliaceae	*Hedera*	1
Asclepiadaceae	*Cionura, Periploca*	2
Asteraceae	*Artemisia, Otanthus*	2
Berberidaceae	*Berberis*	1
Betulaceae	*Alnus, Betula, Carpinus, Corylus, Ostrya*	9
Brassicaceae	*Iberis, Mathiola*	5
Caprifoliaceae	*Lonicera, Sambucus, Viburnum*	8
Caryophyllaceae	*Saponaria*	1
Celastraceae	*Euonymus*	3
Chenopodiaceae	*Atriplex, Kochia, Camphorosma*	3
Cistaceae	*Cistus, Fumana, Helianthemum, Rhodax*	7
Cornaceae	*Cornus*	2
Elaeagnaceae	*Hippophäe*	1
Empetraceae	*Empetrum*	1
Ericaceae	*Arbutus, Arctostaphylos, Bruckenthalia, Calluna, Erica, Rhododendron, Vaccinium*	12
Euphorbiaceae	*Andrachne*	1
Fabaceae	*Astragalus, Astracantha, Caragana, Cercis, Chamaecytisus, Chamaespartium, Colutea, Coronilla, Corothamnus, Genista, Lembotropis, Ononis*	50
Fagaceae	*Castanea, Fagus, Quercus*	19
Globulariaceae	*Globularia*	2
Hippocastanaceae	*Aesculus*	1
Hypericaceae	*Hypericum*	3
Lamiaceae	*Hyssopus, Salvia, Satureja, Thymus, Teucrium*	12
Liliaceae	*Asparagus, Smilax*	4
Loranthaceae	*Arceutobium, Loranthus, Viscum*	3
Oleaceae	*Fraxinus, Jasminum, Ligustrum, Phyllirea, Syringa*	8
Platanaceae	*Platanus*	1
Ranunculaceae	*Clematis*	4
Rhamnaceae	*Frangula, Rhamnus, Paliurus*	6
Rosaceae	*Amelanchier, Amygdalus, Cotoneaster, Crataegus, Dryas, Eriolobus, Laurocerasus, Malus, Mespilus, Potentilla, Prunus, Pyracantha, Pyrus, Rosa, Rubus, Sorbus, Spiraea*	~118
Salicaceae	*Populus, Salix*	22
Santalaceae	*Comandra, Ozyris*	2
Saxifragaceae	*Ribes*	5
Scrophulariaceae	*Veronica*	3
Solanaceae	*Solanum*	1
Staphylleaceae	*Staphyllea*	1
Tamaricaceae	*Myricaria, Tamarix*	3
Thymeleaceae	*Daphne*	5
Tiliaceae	*Tilia*	4
Ulmaceae	*Celtis, Ulmus*	5
Verbenaceae	*Vitex*	1
Violaceae	*Viola*	1
Vitaceae	*Vitis*	1
Total:		**~370**

mountains, roughly at an altitude between 1300 and 2000 m above sea level *(Figure 1).* A remarkable characteristic of both species is their tolerance of the severe ecological conditions. According to MITCHELL (1996), *P. peuce* can grow healthily under a great variety of site conditions, including industrially polluted areas. Even though the trees originally described by Grisebach were not large in height, in the Bulgarian mountains, these trees reach up to 40 m in height and 1.2 m in diameter under optimal conditions (DELKOV, 1992; VIDAKOVIĆ, 1991). Therefore, it is considered a very important species for the restoration of forests near the alpine timber line.

The other species, *P. heldreichii,* inhabits the calcareous soils in the Pirin mountains as well as the neighbouring smaller mountains called Slavyanka *(Figure 1).* It is also a tolerant species and shows a remarkable longevity: the oldest individual alive is estimated to be more than 1300 years old. This species is often divided into two taxa with a species rank: *P. leucodermis* and *P. heldreichii.* Recent studies (e.g. BOSCHERINI *et al.,* 1994; GAUSSEN *et al.,* 1993) showed that the reasons for such a taxonomic treatment are rather dubious and that it is more acceptable to consider them as varieties of a single species.

The silver fir *(Abies alba* Mill.) has its most south-easternly distribution in Bulgaria, growing mainly in the mountains within the western part, but it also appears in some isolated stands in the eastern part. In Greece, it is replaced by *Abies cephalonica* Loud. An intermediate form, *Abies borisii-regis* Mattf., grows in the south-western part of Bulgaria and in Northern Greece. It is described as a separate species by MATTFELD (1925, 1930). The Bulgarian botanists attributed a subspecies status to this taxon. STEBBINS (1950) proposed the hypothesis that *A. borisii-regis* is an introgressive hybrid between *A. alba* and *A. cephalonica.* This hypothesis has been widely accepted for a long period, but some recent unpublished data, based on an isozyme survey (F. Bergmann & V. Gagov, pers. comm.) cause some doubt regarding the introgressive origin of this taxon.

Taking into consideration that the populations of the silver fir in Bulgaria persisted during the last glaciation periods and gave rise to the subsequent re-colonisation, some of them are considered to be of relic origin.

Picea abies (L.) Karst. also grows in Bulgaria in the southernmost area of its natural range in Europe. Among the conifer trees, it occupies second place after Scots pine regarding the total area of distribution in the country.

The English yew – *Taxus baccata* L. is sparsely distributed in almost all mountainous regions, in small groups only, and is, therefore, a protected species. Its importance is due to the fact that it could be an evolutionary link between the European and West-Asian populations.

The *Cupressaceae* family is represented by a single genus, *Juniperus,* consisting of 6 species. Among them, *Juniperus excelsa* M.B. should be mentioned. This species can be found in two small localities in Bulgaria *(Figure 2).* As it has the characteristics of a tree, it is different from the other Bulgarian shrubby species of the genus.

Angiosperms

The angiosperms represent a much larger group. We shall focus on the most important species that form large communities and play a significant ecological role.

The representatives of the family of *Fagaceae* occupy the largest area of all tree species. They inhabit a great variety of sites with different climatic conditions. The European beech *(Fagus sylvatica* L.) holds the first position, represented by two subspecies: ssp. *sylvatica* and ssp. *moesiaca* – distributed roughly above and below 1000 m a.s.l. respectively (STOJANOFF, 1932). Sometimes the second taxon is even considered a separate species. Recent studies, employing biochemical markers (e.g. GÖMÖRY *et al.,* 1999) revealed that the Balkan populations of common beech are well differentiated from those of Central Europe, but a species rank appears too high. There are some beech woods that are even more differentiated, as for example in Calabria, but they are denoted as *F. sylvatica.* Therefore, the conclusion of the authors (GÖMÖRY *et al.,* 1999) was that a subspecies' status is the most appropriate for the Balkan common beech.

A different situation is given in the case of *Fagus orientalis* Lipsky, occurring in the eastern part of the country *(Figure 1).* It occupies the eastern part of the Balkan mountains (Stara planina) and the Strandzha mountains. GÖMÖRY *et al.* (1999) have shown that *F. sylvatica* and *F. orientalis* are fairly well differentiated, even though some transitional putative introgression zone could be detected. The shift of genes occurs from *F. orientalis* to *F. sylvatica,* but not in the opposite direction. Such an asymmetric hybridisation was recently reported also for other closely related species of *Fagaceae* (BACILIERI *et al.,* 1996).

The second genus of the family, *Castanea,* represented by *C. sativa* Mill., has a sporadic distribution in the south-western part of the country *(Figure 1).* The genetic structure and differentiation of Bulgarian populations remain to be studied. There is a knowledge gap about the geographic variation of the species, since the population structure and differentiation of the Italian as well as of the Turkish chestnut are already known, at least at the level of allozyme markers (VILLANI *et al.,* 1994, 1999). Therefore, such a study of the Bulgarian populations will be of particular interest.

Oaks *(Quercus* spp.) occupy the largest area of all broadleaved genera. They can be found in sub-Mediterranean areas *(Q. pubescens* Willd., *Q. coccifera* L., *Q. thracica* Stef. et Ned.), in the wet valleys of Strandzha *(Q. hartwissiana* Stev.), in the plains and hills and mountain slopes *(Q. robur* L., *Q. cerris* L., *Q. frainetto* Ten.) up to the conifer zone *(Quercus petraea* (Matt.) Liebl.). The taxonomy of Bulgarian oaks is quite complicated, as is the taxonomy of oaks itself. GANCHEV & BONDEV (1966) applied a narrow species frame and, therefore, their list contains more species than ever reported before. According to STEFANOFF (1943b, 1944), the oaks in Southern Europe and the Mediterranean region are currently undergoing a process of evolutionary changes, expressing a trend to xerophylisation related to the changing climatic conditions.

Apart from the change in the climatic and edaphic conditions, influencing the variation by causing directional selection, population genetic factors are also thought to play a significant role in the oaks' evolution. This is due to the fact that many stands are fragmented, small stands are at least partly isolated, and the gene flow among them is reduced. Such fragmentation may trigger off stochastic processes, such as random drift, and thus the species' evolution. This statement could be true especially for *Q. robur,* but its validity requires experimental verification.

Therefore, the variation within the oak species is extremely high, resulting in many intraspecific taxa and, hence, in many taxonomic complications. Our task is not to solve the problems of oak taxonomy in this paper and, therefore, no detailed discussion will be provided. We would like, however, to outline the great variety of Bulgarian oaks and their significant role in the formation of the environment.

The predominant oak formations in Bulgaria consist of a very specific mix of *Quercus cerris* and *Quercus frainetto.* These species usually occupy dryer and moderately rich habi-

tats in the hills and plains, sometimes on low mountain slopes. In the driest and poorest habitats, *Quercus pubescens* appears to be a successful oak species, as it survives under drought stress, but shows poor growth. *Quercus petraea* (Matt.) Liebl. s.l. climbs the southern slopes of the mountains, growing in pure stands and in mixtures with other broad-leaved trees and in some cases even with pines *(P. nigra* and *P. sylvestris).* Our recent study based on allozyme markers (Gömöry *et al.,* in press.) revealed that in Eastern Europe, *Q. petraea* stands are more differentiated than those of *Q. robur.* Indeed, according to the classification of Bondev & Ganchev (1966) and Schwarz (1993), *Q. petraea* is divided into three narrower species: *Q. dalechampii* Ten., *Q. polycarpa* Shur and *Q. petraea* (Matt.) Liebl. If we accept such a taxonomic concept, we must point out that *Q. dalechampii* predominates in the western and central part of Bulgaria, while *Q. polycarpa* is situated in the eastern part, and *Q. petraea* s. str. is localised mostly on rocky and poorer habitats.

A very specific representative of the so-called «Euxinean» flora (named after *Pontus Euxinus,* the Latin name of the Black Sea) along the Black Sea Coast is *Quercus hartwissiana.* This species, growing also in the Caucasus and in adjacent territories, occurs in Bulgaria only in the Strandzha mountains, in the river valleys *(Figure 2).*

There are also some endemic species of a very limited distribution: *Q. thracica* (SE Bulgaria), *Q. mestensis* Bond. et Ganc. (SW Bulgaria), and a new species, found by Dončev & Busov (1980), still not officially published and preliminarily called *Q. protoroburoides* by its authors .

Finally, the common oak *(Q. robur),* which is so important for the countries of Western and Central Europe, grows in Bulgaria mainly in the plains and near the larger rivers. Unfortunately, many of its habitats were destroyed in the past and converted into agricultural land. Therefore, this very important species can be found nowadays in some scarce, small and partially isolated populations. Some of the larger localities of the species in Eastern Bulgaria are protected. We believe that this species is currently undergoing a genetic erosion, consisting of reduced genetic diversity, due to fragmentation of its metapopulation.

The «satellites» of the oaks consist of many other broad-leaved species. We would like to mention the elm *(Ulmus)* species, some ash *(Fraxinus),* maple *(Acer)* and lime *(Tilia)* species and many other small trees. Some of these species *(Fraxinus oxycarpa* Willd., *Tilia tomentosa* Moench.) also form pure stands, but more often, they grow in different mixtures with other broad-leaved species.

Relatively rich in species is the genus *Acer,* consisting of 7 native species in Bulgaria. *Acer hyrcanum* Fisch. et Mey. and *Acer tataricum* L. penetrate from Asia, which is not the case in other parts of Europe. Also the Balkan endemic *Acer heldreichii* Orph. can be found in the highest parts of the mountainous forests. The habitats of this species are normally the mesic forests, dominated by beech, mostly between 1000 m a.s.l. and the upper timber line. *Acer monspessulanum* L. is typical for Southern Europe and the Mediterranean region. The remaining species are more common and can be found almost all over Europe: *A. platanoides* L., *A. pseudoplatanus* L. and *A. campestre* L.

The numerous shrubs and less known forest trees can hardly be commented on here, but, in our opinion, two numerous families should be mentioned: *Rosaceae* and *Fabaceae.*

As mentioned above, the *Rosaceae* family is largely represented *(Table 1).* Even though the number of species in some critical genera could be questioned (for example *Rubus, Rosa),* this is a very rich family. These critical genera usually include species that grow in isolated populations and have particular modes of reproduction: apomyxis, clonal propagation etc. The nature of variation in these genera is not fully understood and, therefore, the taxonomic decisions are difficult. Apart from these genera, the other most numerous are *Sorbus* (8 spp.), *Prunus* (7 spp.), *Crataegus* (6 spp.) and *Pyrus* (4 spp.). The remaining genera contain 1–3 species. More interesting taxa are *Pyrus elaeagrifolia* Pall. ssp. *bulgarica* (Kh. et Sah.) Vâlev (endemic subspecies), *Crataegus laciniata* Ucria and *Eriolobus trilobata* Roem. They all occupy extremely dry habitats and are well adapted to such conditions. We should also mention *Spiraea salicifolia* L., represented in one single site within the Western Rhodopes in the whole Balkan Peninsula.

The *Fabaceae* family is numerous, but mainly consists of shrubs. The only exception is *Cercis siliquastrum* L. – a small tree in the eastern part of the country. The genera *Chamaecytisus* and *Genista,* consisting of 20 and 13 species respectively, are small shrubs. They are interesting from a conservation and phytosociological point of view, especially some endemics: *Ch. frivaldszkyanus* (Deg.) Kuzm., *Ch. kovacevii* (Vel.) Rothm., *Ch. neiceffii* (Urum.) Rothm., *Genista rumelica* Vel. and some others.

Other interesting rare species and endemics of *Fabaceae* are *Astracantha aitosensis* (Ivanich.) Podl., *Astragalus physocalix* Fisch. and *Caragana frutex* Lam. The genus *Astracantha* has recently been separated from the genus *Astragalus* (Pavlova, 1988) and includes the species of the former *Tragacantha* section.

The third numerous family is *Salicaceae.* Apart from the four poplar species *(P. alba* L., *P. nigra* L., *P. tremula* L. and *P. cansecens* (Ait) Sm.), there are 18 willow species in Bulgaria. Several of them, *Salix alba* L., *S. fragilis* L., *S. triandra* L., *S. elaeagnos* Scop., *Salix purpurea* L., form large riparian communities, while *S. caprea* L. mainly grows in the mountains. There are several other willows, of which some are especially interesting: *S. retusa* L., *S. herbacea* L. and *S. reticulata* L., which are small shrubs growing in the high mountains, above the alpine timber line.

Many other families within the Bulgarian dendroflora are represented by one species only. Some of them are: *Platanaceae (Platanus orientalis* L.), *Staphylleaceae (Staphyllea pinnata* L.), *Verbenaceae (Vitex agnus-castus* L.), *Violaceae* (a most interesting small sub-shrub *Viola delphinantha* Boiss., a Balkan endemic), *Hippocastanaceae (Aesculus hippocastanum* L.) *(Figure 1).* The last species is also a Balkan endemic; its origins, however, are not very well known, as this species has been cultivated in many European countries since the Roman times.

Relic centres of plant diversity

According to Turill (1928), the species diversity in the Balkans is higher than in any other comparable European area. One reason for this is the survival of old florae, including many tertiary species that persisted the quaternary ice ages (Polunin, 1980). Indeed, during the last ice age, the mean temperatures in July were probably about 5 °C lower than today (Kutzbach & Guetter, 1986), and there was almost no ice cover during the last ice age (Thiede, 1974; Denton & Hughes, 1981; Dawson, 1992). Hence, during the last glaciation period, the greatest diversity existed in the middle to high altitudes and probably under more humid climatic conditions (Willis, 1994). Therefore, sites with relic flora and vegetation can still be found on Bulgarian territory today. It is not possible to review all the glacial refugia and relic centres, but most of them are located within the mountainous areas (Bozilova & Tonkov, 2000) mainly within the higher parts of Rila, Pirin and Stara planina.

Among the arboreal species are relic species mentioned above, such as *Pinus peuce* and *P. heldreichii, Rhododendron myrtifolium* Schott et Kotschy, *Salix herbacea, Salix reticulata, Empetrum nigrum* L., *Corylus collurna* L. Many herbaceous species indicate the relic character of these habitats.

Another example is the Strandzha (or Strandja) mountains. They differ from the previously mentioned mountains in many respects: altitude, climatic and other environmental factors. The relic origin of the forests in this area is related to their closeness to and influence by the Black Sea. These forests will be subject to a more detailed comment further on in this study.

Influences of other floristic regions

Due to very specific geographic factors, the Bulgarian flora is subject to different floristic influences. One can distinguish between the Mediterranean influence, the eastern (or oriental) influence, and in some cases the influence of the Middle European mountain flora.

The contemporary situation of plant formations results from the effects of many factors – climatic, edaphic (and combined) migration pathways before and after the glaciation periods. However, some peculiarities are outlined below:

The oriental floristic elements, penetrating into Bulgaria from the east and south-east, can be divided into two conditional groups: The first group includes species originating from the Ponto-Caucasian region. These are mainly relic species characterised by a higher demand of soil and air humidity. They grow mainly in Strandzha and Eastern Stara planina. This influence can be identified not only by the composition of the arboreal species, but also by the character of plant communities. For example, *Fageta orientalis* can be observed in the Strandza mountains, but also in the Caucasus. Many of the characteristic plant species in the communities also indicate this influence on the vegetation: *Quercus hartwissiana, Rhododendron ponticum* L., *Daphne pontica* L., *Ilex colchica* Pojark., *Vaccinium arctostaphylos* L., *Trachystemon orientale* D. Don., *Cyclamen coum* Mill., *Scilla bithynica* Boiss., *Senecio othonnae* M.B. and many others.

The second group of species is related to drier habitat conditions: they sometimes come from the steppes of Middle Asia, and sometimes from the semi-arid zones of the Near East. Some characteristic plants belonging to the two groups are listed below and the conditional groups are given in parentheses:

Acer hyrcanum Fisch. et Mey. (I)
Acer tataricum L. (II)
Crataegus laciniata Ucria(II)
Daphne pontica L. (I)
Eriolobus trilobata Roem. (II)
Fagus orientalis Lipsky (I)
Fraxinus pallisae Willm. (I)
Ilex colchica Pojark. (I)
Juniperus excelsa M.B. (II)
Quercus hartwissiana Stev. (I)
Rhododendron ponticum L. (I)
Vaccinium arctostaphylos L. (I)

Another floristic centre that influences the Bulgarian dendroflora is the Mediterranean centre. This influence is usually prevented by the high mountains situated in the southern part of the country. However, in the plain (lowland) areas of Southern Bulgaria, it is very well expressed. Here, many of the species penetrating from this region find their northern limits of natural distribution, at least on the Balkan Peninsula (STEFANOFF, 1943a). These species are found in formations of transitional character, which can be recognised not only by the arboreal plants, but also by the species, characterising and differentiating the vegetation syntaxa. It is not possible to list all the Mediterranean elements, but the following are the most characteristic ones:

Arbutus andrachne L.
Arbutus unedo L.
Arceutobium oxycedri M.B.
Asparagus acutifolius L.
Cercis siliquastrum L.
Cionura erecta (L.) Griseb.
Cistus incanus L.
Cistus salviifolius L.
Jasminum fruticans L.
Lonicera etrusca Santi
Ozyris alba L.
Paliurus spina-Christi Mill.
Periploca graeca L.
Phylliraea latifolia Mill.
Pistacia terebinthus L.
Quercus coccifera L.

Some species have a natural distribution both in the Orient and in the Mediterranean region *(Platanus orientalis, Castanea sativa* and others), so they can be classified in both groups.

The third influence can be traced in the mountain flora. It is influenced by the high mountains of Central Europe (Alps, Carpathians) and the plants penetrating from there have been described by STEFANOFF (1943a) as «elements from the mountain centre». This phenomenon is related to the glaciation periods and the migration of the vegetation in direction from north to south and from higher to lower altitudes and vice versa. The influence is represented by typical mountainous inhabitants such as: *Daphne blagayana* Freyer *(Figure 2), Salix herbacea, Rhododendron myrtifolium (Figure 2), Dryas octopetala* L., *Vaccinium uliginosum* L. and some other species. It is less expressed by vegetation features than the previous two centres, which is mainly due to the high percentage of endemics in the highest parts of the Bulgarian mountains. For example, a significant part of plant communities in the highlands is dominated by endemics, such as *Sesleria comosa* Vel., *Chamaecytisus absinthioides* (Jka) Kuzm., *Festuca riloensis* (Hayek) Markgr.-Dannb., and many others (BONDEV, 1991).

The vertical distribution of the woody vegetation

The vegetation distribution in the Balkans and particularly in Bulgaria is affected by many factors such as climate, altitude, soil, anthropogenic pressure, and the vegetation zones are a result of their combined effect (WILLIS, 1994). According to POLUNIN (1980), the vegetation can be classified on a broadest scale as: *i)* Mediterranean plant communities and *ii)* Central European (Continental) plant communities. This classification is, however, too general to provide any definite impression of the vegetation. Moreover, it concerns the whole Balkan Peninsula.

Indeed, the woody formation distribution in Bulgaria is affected by many factors, but usually, three vertical belts can be distinguished. But even within these three belts, there are substantial differences among the different regions of Bulgaria.

The lowermost vertical belt is called the oak zone and includes the plant formations of roughly up to 800 m in altitude. As indicated by the name, the majority of woody formations here are dominated by oaks. However, even within this zone, some subdivisions could be made. It is not possible to provide a detailed classification nor is it an objective of this review. Further information on this topic is given in BONDEV (1991) and HORVAT *et al.* (1974). We shall thus only briefly present the most important woody formations classified informally and according to our personal view.

Without doubt, the first group will be the oak formations. All but one oak species of Bulgaria are within this altitude range. The picture of distribution is more complicated, because a large number of these formations have been converted into agricultural land during the last millennia. The oak forests, therefore, occupy the land less suitable for agricultur-

al purposes. The main types of oak formations are *Querceta dalechampii, Querceta cerris* and a very specific mix of *Q. cerris* and *Q. frainetto.* The last formation probably occupies the largest area in the planes, while *Querceta dalechampii* can be found on the southern mountain slopes. The composition of these forests seldom consist of oaks only, but includes a large set of other broad-leaved species: *Fraxinus excelsior* L., *Carpinus betulus* L., *Tilia tomentosa* Moench., *Sorbus torminalis* (L.) Crantz, *S. domestica* L., *Acer campestre, Ulmus minor* Mill. and numerous other species. In the north-eastern part, there are even some pure formations of *Fraxinus excelsior* and *Tilia tomentosa.* It has already been mentioned that *Q. robur* today persists in relatively few and small stands only. When speaking of oak zones, special attention should be given to the Strandzha mountains *(Figure 1, 2).* It has been mentioned above that this low mountain range is a centre of relic flora and vegetation. Moreover, this is the site where the most well conserved oak forests grow in Bulgaria. We did already comment on the fact that the character of the flora and vegetation is similar here to the areas of the Black Sea Coasts of the Caucasus and North-Eastern Asia Minor. The predominant forest formations in Strandzha are oak formations. Here, we can see communities of *Q. polycarpa, Q. cerris* and *Q. frainetto,* together with other oaks. *Quercus hartwissiana* has a limited distribution along the river coasts, opened to the Black Sea. Interestingly, in Strandzha, oak formations are situated above beech formations. This is because the upper part of the canopy here is dried by western winds and, therefore, the beech (here *Fagus orientalis)* looks for the more humid areas further down the slopes. The formations of oriental beech differ significantly from *F. sylvatica* formations. A very typical forest type is *Fagus orientalis* with an understorey of *Rhododendron ponticum* – this unique type only exists in Bulgarian and Turkish Strandzha. *Rhododendron ponticum* represents an interesting case. This species is considered as very aggressive in some West European countries, characterised by high air humidity (Milne & Abbott, 2000), but in Bulgaria, it hardly survives outside of its natural habitats, which are limited to Strandzha.

And, last but not least important in this belt, we would like to mention the formations occupying the river banks. They are somewhat distinct and specific. In this vegetation belt, they can be more easily distinguished than in higher altitudes. There are two reasons for this fact: first, at higher altitudes, the rivers are smaller and have therefore less influence on the vegetation, and second, the air and soil humidity at higher altitudes tends also to be higher and, therefore, no such contrasts exist between the riparian banks and the adjacent lands, as in the lowermost belt.

Special attention should be given to flooded riparian forests. Today, most of these formations are changing, mainly due to anthropogenic pressure, including drainage, correction of river beds, and agricultural activities. Therefore, these relic forests only persist in several places, the most typical ones along the rivers close to the Black Sea Coast. These formations consist of *Q. robur, Fraxinus oxycarpa, Fraxinus pallisae* Wilm., *Ulmus minor, Ulmus laevis* Pall. and others, connected by a dense «network» of woody climbers: *Smilax excelsa* L., *Periploca graeca* L., and *Hedera helix* L. They are considered to be very fragile ecosystems and are subject to special attention and measures for conservation.

Further riparian formations are the large poplar and willow riparian communities *(Populetalia),* mainly occurring along the Danube river. Unfortunately, many places here have lost their natural character, as a result of of the intensive cultivation of fast growing, but uniform poplar and willow cultivars. Still, some isolated spots of natural riparian forests exist here and they are usually protected.

Very typical of riparian ecosystems in the sub-Mediterranean region are the woods dominated by *Platanus orientalis (Figure 2).* These formations probably reach their northern limit of distribution in Bulgaria. Such riparian formations occur in three localities in the southern part of the country and they usually consist of *Platanus orientalis* mixed mainly with *Alnus glutinosa* (L.) Gaertn., sometimes with *Populus alba* or different *Salix* species. *Plataneta orientalis* also climbs the slopes of the mountains in the southern parts up to about 800 m, but always close to small rivers. These formations in the lowlands are composed of ruderal riparian plant communities, but on the mountain slopes, the communities form a transition to beech and chestnut communities.

Last to be mentioned in the lowermost zone are the formations growing on drier and poorer sites, often subjected to a Mediterranean climatic influence. They consist of communities of *Q. virgiliana* Ten. and *Q. pubescens,* together with *Carpinus orientalis* Mill., *Fraxinus ornus* L., *Syringa vulgaris* L., sometimes *Pinus nigra* (natural or planted). Apart from these oak formations in the sub-Mediterranean zone, we can see light communities composed by drought-resistant species, and a great many shrubs. Apart from *Quercus pubescens* and *Carpinus orientalis,* also *Juniperus excelsa, Phylliraea latifolia, Quercus coccifera, Pistacia terebinthus, Ozyris alba, Paliurus spina-Christi* Mill., *Cistus incanus* L., *Jasminum fruticans* L., *Rhus coriaria* L. grow here. The southern influence can also be recognised by numerous other plants growing in these formations that place them into the group of sub-Mediterranean or transitional formations: *Asparagus acutifolius* L., *Bisserula pelecinus* L., *Ruscus aculeatus* L., *Euphorbia myrsinites* L., *Ziziphora capitata* L., *Cnicus benedictus* L., *Hippocrepis ciliata* Willd., *Scandix australis* L., *Dracunculus vulgaris* Schott, *Romulea bulbocodium* (L.) Sebast. et Mauri.

The second vertical belt, situated roughly between 800 and 2000 m, is composed exclusively of coniferous and beech forests. The higher we go, the lower is the diversity of plant formations. Indeed, the number of species seems to be less diverse here than in the lower belt. But the most valuable forest stands are also situated in this belt. Even though it could generally be classified as a belt of beech and conifers, there are also some horizontal differences. For example, the northern slopes of Stara planina are occupied mainly by beech, while the Rila-Rhodopes massif is a typical coniferous zone. From a phytosociological point of view, the beech forests do not differ significantly from the analogous forests in Central Europe. They are sometimes referred to as *Fageta moesiacae* (Horvat *et al.,* 1974), but as discussed above, *F. moesiaca* is quite similar to the common beech. Beech forests are sometimes mixed with *Carpinus betulus,* sometimes with *Quercus dalechampii* or with conifers, but the predominant part of them are almost pure stands. *Q. dalechampii* forms also large pure or mixed stands on the southern slopes of the mountains.

The coniferous formations can be subdivided into mesophyte and xero-mesophyte ones. The first group, no doubt, should include Norway spruce and silver fir. Both species reach their southernmost European distribution limit in the Balkans, and are therefore highly specialised regarding the habitat selection, growing in most cases under rather mesophyte conditions. They sometimes grow in a mixture with beech, and these mixed spruce-fir-beech ecosystems are considered to be among the most productive sites in Europe.

Pines dominate the other group of conifer formations. The formations of *Pinus sylvestris* and *Pinus nigra* are large and are situated mainly in Rila, Pirin and the Rhodopes, even though they occur also in other mountainous regions. *P. nigra* is more sensitive to frosts and, therefore, the formations of this species occupy lower altitudes. This species is capable of grow-

ing on calcareous soils, and sometimes directly on the rocks. A very interesting, even though not common combination can be seen in the Central Rhodopes, where black pine and Norway spruce grow together in mixed stands on calcareous soil. This community requires special attention, because the two species are, if not a pure contrast, however, significantly different in their habitat preferences.

The calcareous terrains can hardly be subjected to zonation (PAVLOV, 1998), and, therefore, some plant communities can be found in more than one vertical belt (like *Pinus nigra).* Moreover, the riparian vegetation is difficult to classify, but we would like to mention that this belt mainly contains the formation of *Alnus glutinosa* and *Alnus incana* Moench., often mixed with *Salix caprea.* In open places, the secondary formations of *Populus tremula* and *Betula pendula* Roth. may also appear.

Finally, very specific formations can be seen in this zone, especially in Rila and Pirin. They consist of the two endemic pines: *Pinus peuce* and *Pinus heldreichii.* These communities are called «quasi-boreal» forests, differing from typical boreal ones to the ediphicator species. While *Pinus peuce* formations can be found in several mountains, and they often mix with Norway spruce, or occasionally with Scots pine, the *Pinus heldreichii* formations are situated only on two mountains *(Figure 1)* and exclusively on calcareous soils. Due to the unique character of these endemic plant communities, the majority of them are protected.

The highest vertical belt, situated above 1800–2000 m, is considered as forestless, even though many arboreal species grow there. The *Pinus mugo* formation *(Pineta mugi)* occupies the land between 2000 and 2500 m in Rila and Pirin, and is represented by some small, isolated spots in other mountainous areas. In the communities, the main species is combined with *Alnus viridis* (Chaix) DC, *Salix waldsteiniana* Willd., *Juniperus sibirica* Burgsd., *Bruckenthalia spiculifolia* (L.) Rchb. and other species. *Pinus mugo* resources are currently not exploited and, therefore, it is expected that the area of these formations will increase.

Apart from *Pineta mugi,* some other arboreal formations can also be seen in high mountainous areas. The most widespread species is *Junipereta sibiricae.* On some places it is of secondary origin, after removing *Pinus mugo* either for charcoal wood, or for releasing pastures (YURUKOV, 1988). Other communities are the Ericoid communities, consisting of different *Vaccinium* species, *Arctostaphylos uva-ursi* L.(Spreng.), *Bruckenthalia spiculifolia,* and *Empetrum nigrum* L., and the small willow groups *(Salix reticulata, Salix herbacea),* accompanied sometimes by *Dryas octopetala,* climbing the highest part of the mountains. Only the grassland alpine communities are above them.

Threats to arboreal plant diversity

This topic requires special study, but we consider the habitat destruction and fragmentation as the most important threat to the Bulgarian dendroflora. This is, of course, too general a factor, as it could be due to many different reasons: overexploitation, changing the water regime of the ecosystems, forest fires, converting the forests into agricultural fields, converting the high uneven-aged forests into more uniform coppice forests, environmental pollution, etc. Habitat fragmentation in nature usually leads to decrease in the genetic diversity. The reasons can be traced to the limited gene flow among populations, and the stochastic processes in small and isolated populations, such as genetic drift, founding events, bottleneck effects, etc. It seems that the common oak, one of the most important tree species, is subject to genetic erosion at a higher extent, since many of its stands have been converted into agricultural land and nowadays, the species persist in patchy and relatively small, isolated populations. Some other species also seem to be affected similarly by genetic erosion, which, in almost all cases, is due to habitat fragmentation. Up until today, no special studies have been performed to test these processes. The studies on population structure of several species, such as *Pinus sylvestris, P. mugo, Fagus sylvatica, Quercus petraea,* showed that the level of genetic diversity in these species falls within the values reported generally for these tree species (e.g. HAMRICK *et al.,* 1992), but a more profound study on fine-scale diversity has still not been completed.

Habitat destruction can also lead to the physical extinction of a species. An example is *Salix rosmarinifolia* L., which does not exist in Bulgarian flora anymore since the drainage of the marshlands, where its only habitat used to be.

A total of 78 arboreal species are listed in the Red Data Book of Bulgaria (VELČEV, 1984), and 29 species are protected by the law. Many of the virgin forests or localities of rare plants are protected in national parks, nature reserves and protected sites. This helps to conserve their gene pools. Some of the species are stored in *ex situ* collections. All these measures are necessary, but dynamic and effective conservation requires much more.

Evidently, such a diverse picture could hardly be demonstrated with a few words, and therefore, our objective was to mark some milestones and to provide general, even though incomplete information. Any other task would be unrealistic for the purpose of such a review. We hope we succeeded (at least partly) to provide some general impressions.

In conclusion, we would like to point out once again the richness of the Bulgarian dendroflora. Even though some ecosystems have been destroyed and have changed their virgin composition, there are still many well-preserved forests that should be managed for the conservation of their typical characteristics, and hence – their originality. Such sustainable management and conservation could be a contribution to the conservation of global biodiversity and will be of international importance. This is an important issue, because the forests are complex ecosystems, providing habitats for many other living organisms, not only trees.

Summary

Bulgaria is situated in South-Eastern Europe, where the ecological conditions are extremely variable due to the combination of southern latitude and variable relief, including high mountains. Therefore, the flora of Bulgaria, and particularly the arboreal flora is very rich, amounting to 370 species.

This review represents a brief survey of the taxonomic structure of the dendroflora, the main groups, their importance and distribution. Some peculiarities such as endemism, conservation, vulnerability and effects of other floristic regions are discussed in brief. The most typical woody plant formations are presented. This review highlights the diversity of Bulgarian dendroflora and vegetation and points out that special measures for close-to-nature management are necessary to conserve such diversity.

Zusammenfassung

Die Holzflora Bulgariens: ein Überblick

In Bulgarien (Südosteuropa) sind die ökologischen Bedingungen auf Grund der südlichen Lage und des variablen Geländes mit Ebenen und hohem Gebirge sehr unterschiedlich. Aus diesen Gründen ist die Flora Bulgariens und vor allem die Baumflora sehr artenreich und verfügt über ungefähr 370 Spezies.

Diese Studie soll eine kurze Übersicht über die taxonomische Struktur der Gehölzflora, ihrer Hauptgruppen, ihrer Bedeutung, Stellung und Verteilung liefern. Einige Besonderheiten wie die Endemizität, der Artenschutz, die Schadenanfälligkeit und die Wirkung anderer floristischer gehölzgeographisch interessanter Regionen werden diskutiert. Auch die typischsten Formationen der Gehölzpflanzen werden kurz vorgestellt. Diese Übersicht soll die Diversität der bulgarischen Gehölzflora und Vegetation beleuchten und ein Plädoyer sein für den Schutz dieser Diversität sowie die Notwendigkeit spezieller Massnahmen für eine naturnahe Forstwirtschaft herausstreichen.

Übersetzung: TAMARA BRÜGGER

Résumé

Une revue de la flore ligneuse de Bulgarie

La Bulgarie est située au sud-est de l'Europe. Dans ce pays, les conditions écologiques sont extrêmement variables en raison de l'action combinée de la latitude méridionale et du relief changeant, hautes montagnes comprises. De ce fait, la flore bulgare est très riche, ce qui est tout particulièrement valable pour la flore arborescente (environ 370 espèces).

Cette revue donne un aperçu de la structure taxonomique de la flore ligneuse et aborde les groupes principaux, leur importance et leur répartition. Certains aspects particuliers comme l'endémisme, la conservation, la vulnérabilité et les influences d'autres régions floristiques sont brièvement discutés. Les formations les plus typiques sont présentées, mettant en évidence la diversité de la flore et de la végétation ligneuse. Les auteurs soulignent en conclusion que des mesures d'aménagement et de conservation proches de l'état naturel sont nécessaires pour préserver une telle diversité.

Traduction: JEAN-PIERRE SORG

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