XI. SUBCONTINENTAL SUBMEDITERRANEAN DRY DECIDUOUS FORESTS OF SOUTHEAST EUROPE – QUERCETALIA CERRIS

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The xerophilous deciduous forests of the eastern half of Southeast Europe are placed into the order of *Quercetalia cerris*. The recognition of this order is justified, since toward east these xerophilous oak forests form a gradually broadening zone with increasing diversity. This pattern results from climatic influences. To the east, the oceanic climate is diminishing, and the submediterranean climate is associated with more pronounced continentality causing high summer temperatures and long summer droughts. In the west, the xerophilous character of the vegetation is restricted in space due to the strong oceanic climate (Borhidi 2003).

Aceri tatarici-Quercion Zólyomi et Jakucs 1957

The xerothermic forests of the northeastern mountain range of Hungary and the plains under subcontinental climate are classified into the alliance of *Aceri tatarico-Quercion*. The dry forests on the Hungarian Plain once may have been very widespread, but deforestation decimated their stands that became fragmented and isolated from one another.

XI.1 *Convallario-Quercetum roboris* Soó (1937) 1958

Syn.: *Quercetum roboris convallarietosum* (*convallariosum*) 1937, 1943, Aszód 1935; *Convallarieto-Quercetum* Soó 1957; *Convallario-Quercetum tibiscense* Soó 1957; *Quercetum roboris tiliosum argenteae* 1937 p.p.; *Quercetum roboris tibiscense convallariosum* vel *umbrosum* Soó 1937; *Quercetum roboris convallarietosum* Soó 1943, Balázs 1943; *Querceto-Convallarietum tibiscense* Soó et Zólyomi 1951.

Habitat characteristics and zonality

In the Nyírség, the closed oak forests have developed in slight depressions on top of the sand dunes high above the floodplain. Their habitat is only little influenced by groundwater. The bedrock is slightly acidic fluvial sand that was deposited by the Tisza. However, Balázs (1943) also reported this association in the vicinity of Nagykároly and Erdőd on hard alluvial deposits. The stands of this forest occur on humus-rich, clayey brown forest soil, or reddish brown forest soil.

It could be considered a zonal association as the closed forest of Nyírség; however, Jakucs (1981) classified it into the forests primarily influenced by bedrock, and therefore it is regarded an intrazonal association.

Scientists have a different view of the development of the closed oak forests. Hargitai (1940) regarded these oak forests as the climax community of the successional series on sand starting from the moss-lichen stage. At that age, two subassociations of this association were distinguished: *festucetosum sulcatae* and *convallarietosum*. The two subassociations were later put on the rank of association with respective names of *Festuco rupicolae-Quercetum roboris* Soó (1937) 1958, and *Convallario-Quercetum roboris* Soó (1937) 1958. Further developing the idea of Hargitai (1940), Soó (1962) considered the closed oak forest (*Convallario-Quercetum roboris*) as the climax association of the successional series, which develops from the open oak forest (*Festuco rupicolae-Quercetum roboris*) as shown on his figure.

According to Fekete (1992), Soó (1962) with his model has moved away from reality, as the presence of closed forests on sand „may only be understood by the extra availability of edaphic water". Recent studies and observations show that the closed oak forests have probably developed from oak-ash-elm gallery forests as a result of gradual drying of their habitats. Along the rivers, this process may be witnessed spatially in the form of successive occurrence of these associations with a transitional zone between them (Kevey 1993). Horánszky (1998, 2000), however, questions the validity of this model based on the distance from rivers. Oak-ash-elm gallery forests rich in Fagetalia species may have developed far from rivers if the local soil moisture conditions are conducive (see Zólyomi 1934, Járai-Komlódi 1958, 1959). The loss of extra groundwater in these habitats may have led to the development of closed oak forests (*Convallario-Quercetum roboris*) by ecological succession. This model is supported by phytosociological relevés of closed forests on sand and oak-ash-elm gallery forests made by Soó (1937, 1943) in the Nyírség. Also, the two associations are in contact at several locations even today (for example, Debrecen „Halápi-erdő", „Nagy-erdő", „Monostori-erdő", Újfehértó „Ángliusi-erdő"). The occasional occurrence of old specimens of *Ulmus laevis* and *Padus avium* in closed oak forests (*Convallario-Quercetum roboris*) also supports the model. The successional relations of these associations are also accepted by Borhidi (*ex verb.*) and Fekete (1999). Thus, the successional development of the closed forests of the Nyírség on sand may be interpreted with particular reference to their habitat being influenced in the past by rivers or the tributaries of the Tisza. This relationship validates the inclusion of this association into the present study.

Physiognomy

The closed oak forests of Nyírség have been studied by Soó (1937, 1938a, 1943) and Horánszky (1998). The canopy of this association is dense with 65–80 %

cover, and the height may reach 30 meters. The dominant tree is *Quercus robur*, but *Tilia tomentosa* may form a consociation. Other tree species most frequently mixed with them are *Betula pendula* and *Populus tremula*. The trees of the lower canopy layer mainly fill the treefall gaps. Their height varies between 8 and 20 meter, and their cover may approach 40 %.The shrub layer is moderately or well developed, its cover ranges from 40 to 70 %, and its height is 2-4 meters. Common shrub species are *Corylus avellana, Crataegus monogyna* and *Ligustrum vulgare*. Of the xerothermic species *Acer tataricum, Euonymus verrucosa, Prunus spinosa* and *Rhamnus cathartica* occur here. The herbaceous layer is often pronounced (60–95 %), although in some stands it may cover only 10-12 %. The most abundant species are *Convallaria majalis* and *Polygonatum latifolium*. Other species such as *Agropyron caninum, Lithospermum purpureo-coeruleum, Poa nemoralis, Salvia glutinosa* and *Stachys sylvatica* may locally become abundant. At some places *Corydalis cava* forms an early spring aspect.

Species composition

The closed oak forests on the Tisza plain, essentially those of Nyírség are best documented in the works of Soó (1937, 1943). The weighted proportions of the species characteristic of the hardwood gallery forests (*Alnion incanae*: 4.3 %) and mezophilous deciduous forests (*Fagetalia*: 8.7 %) are lower than that of the oak-hornbeam forests (*Circaeo-Carpinetum*), but that of the dry oakwoods (*Quercetea pubescentuis-petraeae* s.l.: 27.9 %) is greater. These data indicate that the closed oak forests are less influenced by groundwater than the oak-hornbeam forests.

There are, however, closed oak forests on sand in the Nyírség that are transitional to oak-hornbeam forests or oak-ash-elm gallery forests. These are mostly dominated by *Salvia glutinosa* and *Stachys sylvatica*, and harbor fewer species characteristic of dry oakwoods (*Quercetea pubescentis-petraeae*: 15.7–16.7 %). The weighted proportions of species of the mezophilous deciduous forests (*Fagetalia* 13.9–15.2 %) and hardwood gallery forests (*Alnion incanae* 7,5–7.7 %) are, in turn, higher. Their successional relationship to oak-ash-elm gallery forests is indicated by the presence of some species characteristic of hardwood gallery forests (*Alnion incanae*): *Carex brizoides, Cephalaria pilosa, Equisetum* × *moorei, Frangula alnus, Fraxinus angustifolia* ssp. *pannonica, Padus avium, Ribes rubrum, Ulmus laevis, Viburnum opulus*, etc.

Comparison of closed oak forests on sand occurring in the different regions is difficult because typical stands have only been found in Nyírség. Their considerable species are: *Artemisia pontica, Bulbocodium vernum, Campanula rotundifolia, Centaurea triumfettii* ssp. *axillaris, Cephalanthera rubra, Crocus variegatus, Dictamnus albus, Digitalis grandiflora, Equisetum moorei, Gymnocarpium dryopteris, Iris aphylla* ssp. *hungarica, Iris arenaria, Listera ovata, Melampyrum bihariense, Melampyrum nemorosum* ssp. *debreceniense, Muscari botryoides,*

Ophioglossum vulgatum, Platanthera bifolia, Platanthera chlorantha, Primula veris, Pulsatilla pratensis ssp. *hungarica, Pyrola rotundifolia, Scilla kladnii, Scilla vindobonensis, Thalictrum aquilegiifolium, Tilia tomentosa*. The vegetation samples of Balázs (1943) were collected from the forests of the edge of the Szatmár plain whose soil is not sandy. Consequently, these forests are less typical, although several notable species have been reported here that also occur in the Nyírség: *Digitalis grandiflora, Genista ovata* ssp. *transsylvanica, Gladiolus imbricatus, Listera ovata, Melampyrum bihariense, Melampyrum nemorosum* ssp. *debreceniense, Muscari botryoides, Oenanthe banatica, Platanthera bifolia, Platanthera chlorantha, Primula veris*. The most important of them is *Genista ovata* ssp. *transsylvanica* with Dacic distribution. In the relevés of Margóczi and Makra (ined.) recorded on the Bereg plain, *Listera ovata*, whereas in the material of Tuba (ined.) collected in the Bodrogköz, *Rosa gallica* and *Epipactis helleborine* agg. occurred. In the dry oakwoods of the Sajó river area, the following species were recorded by Ujvárosi (1941): *Dianthus collinus* ssp. *glabriusculus* var. *debreceniensis, Epipactis helleborine* agg., *Neottia nidus-avis, Phlomis tuberosa, Platanthera chlorantha, Thalictrum aquilegiifolium.*

The forest stands of the floodplains occurring in gradually drying habitats exhibit an even closer relationship to oak-ash-elm gallery forests (*Fraxino pannonicae-Ulmetum*). Based on their xerophilous character, these stands are identified with closed oak forests on sand. The weighted proportin of characteristic species differs slightly among regions (Szatmár plain: Balázs 1943, Bereg plain: Margóczi and Makra ined., Bodrogköz: Tuba ined., area of the Sajó river: Ujvárosi 1941). The stands studied in the Bodrogköz (Tuba ined.) are particularly noteworthy, since their species composition is the most similar to that of the oak-ash-elm gallery forests. This is indicated by the relatively high proportions of species characteristic of marshes (*Cypero-Phragmitea* s.l.: 5.5 %), willow gallery forests (*Salicetea purpureae* s.l.: 11.6 %), and hardwood gallery forests (*Alnion incanae*: 9.7 %). These data provide further support to the supposed successional relations of oak-ash-elm gallery forests to dry oakwoods.

Convallario-Quercetum roboris of Nyírség is replaced by the vicariant *Polygonato latifoliae-Quercetum roboris* in the Danube-Tisza Interfluve and South-Mezőföld (Borhidi in Borhidi and Kevey 1996), from which it is distinguished by the presence of the following species: *Digitalis grandiflora*, Iris aphylla* ssp. *hungarica*, Melampyrum bihariense*, Melampyrum nemorosum* ssp. *debreceniense*, Platanthera chlorantha*, Pulsatilla pratensis* ssp. *hungarica*, Scilla kladnii**.

Distribution of closed oak forests on sand on the Tisza plain

The closed oak forests on sand (*Convallario-Quercetum roboris*) once were the dominant forest association in the Nyírség. As a result of deforestation and the

spread of black locust plantations, only few typical, natural remnants of this forest type are known today. Soó (1943) observed it at the following locations: Bátorliget „Fényi-erdő"; Debrecen „Nagy-erdő"; Hajdúbagos „Hosszúpályi felé levő erdő"; Mikepércs „Pac-erdő"; Nyírábrány–Szentannapuszta „Bagaméri-erdő"; Nyíregyháza „Városi-erdő"; Nyírtelek–Királytelek „Uradalmi-erdő"; Sáránd „a községtől ÉK-re levő erdő"; Tornyospálca „Pálca-erdő". Horánszky (1998) reported it from the vicinity of Nyíracsád, whereas László Papp and I studied it at the following locations: Debrecen–Haláp „Álló-hegy"; Debrecen–Józsa „Monostori-erdő"; Újfehértó „Ángliusi-erdő". Its stands at Bodrogköz (Tuba ined.) have developed on young alluvial deposits, and therefore more closely resemble the oak-ash-elm gallery forests. Beyond the state borders Balázs (1943) reported closed oak forests close to Nagykároly (Carei) and Erdőd (Arded) in the Szatmár plain on alluvial, hard soil. Similar stands were observed in the vicinity of Békés, Békéscsaba, Doboz, Sarkad, Gyula and Bélmegyer in the area of the Körös rivers. The stands studied by Margóczi and Makra (ined.) at the Bereg plain (Vámosatya „Bockereki-erdő"), Tuba (ined.) at the Bodrogköz, and Ujvárosi (1941) in the area of the Sajó river (Sajólád „Kemely-erdő") are best regarded as closed oak forest-like stands developed from oak-ash-elm gallery forests.

XI.2 *Galatello-Quercetum roboris* Zólyomi et Tallós 1967

Syn.: *Querceto-Festucetum sulcatae pseudovinetosum* Soó 1950; *Quercetum roboris tibiscense festucosum* Máthé 1933 p.p.; *Querceto-Ulmetum* Máthé 1936 p.min.p.; *Quercetum roboris festucetosum pseudovinae* Soó 1934; *Querceto-Festucetum sulcatae pseudovinetosum* Soó 1950; *Pseudovineto-Quercetum roboris* (Máthé 1933) Soó 1958; *Acereto tatarici-Quercetum petraeae-roboris pseudovinetosum* (*tibiscense*) Zólyomi 1957; *Galatello-Quercetum roboris festucetosum sulcatae* Zólyomi et Tallós 1967; *Galatello-Quercetum roboris peucedanetosum officinalis* Tallós et Tóth B. 1968.

Habitat characteristics and zonality

The relic stands of the alkali steppe oakwoods are typically found at the transitional zone between the abandoned floodplain of rivers and the slightly higher reliefs covered with loess. These habitats still have been influenced by groundwater. In terms of their water regime, they are characterized by the extremes. On the one hand, the clearings are often under water in the spring. On the other hand, the water disappears by summer, the soil dries out, and – through the capillary action – the process of salinization begins during the arid period. As a consequence, the soil is poor in nutrients, has been salinized, but the salts accumulate in the deeper layers only. These processes may take place only in areas of continental climate, which characterizes only the forest-steppe zone of the Hungarian Plain.

Thus, the alkali steppe oakwoods are classified into the edaphic, intrazonal forest associations.

In terms of the origin of the alkali oakwoods, Molnár (1989) hypothesizes that these woods have developed from hardwood gallery forests (*Fraxino pannonicae-Ulmetum*). According to his model, the habitat of the hardwood gallery forests along the rivers became gradually drier as the river changed its course and moved away from the forests. Floods reached the forests more and more infrequently while salinization of the soil began. As a consequence, the canopy of these forests opened up, small clearings developed, and the species composition changed, and eventually these forests have developed into alkali oakwoods (*Galatello-Quercetum roboris*). Indirect evidence to this model is that the two forest associations are in direct contact at several locations even today.

Physiognomy

The alkali oakwood (*Galatello-Quercetum roboris*) is a mosaic of clearings with salinized soils and patches of woods – a characteristic of forest steppe vegetation (Molnár *et al.* 2000a). Forestry practices, however, may have altered this original physiognomy by creating even-aged plantations. Today the alkali oakwoods are mostly restricted to the edges of the closed forests and the tiny patches of woods on the clearings (for example, Bélmegyer „Szolga-erdő"). Due to the unfavorable soil conditions, the canopy is very loose (10-40 %), and the trees – mostly *Quercus robur,* but also *Acer campestre, Fraxinus angustifolia* ssp. *pannonica, Pyrus pyraster* and *Quercus cerris* whose nativity is questioned in this habitat – are low (12–15 m). A lower and also very loose canopy layer may also be observed that consists of low-growth trees. Here *Acer campestre, Acer tataricum, Pyrus pyraster* and *Ulmus minor* are frequent, whereas *Malus sylvestris* and *Quercus pubescens* are found occasionally. The shrub layer is very dense with 70–90 % cover and 2–4 m height. It primarily consists of *Crataegus monogyna* and *Prunus spinosa*. Other species, such as *Acer tataricum, Ligustrum vulgare* and *Rhamnus catharticus* are also frequent, while species characteristic of the forest-steppes (*Prunus tenella, Prunus fruticosa* and *Rosa gallica*) are rare. The shrubs separate the woods from the clearings (*Peucedano–Asteretum sedifolii*) forming a continuous mantle. The spread of the shrubs may also be observed at most locations; that is, the woody vegetation is gradually creeping on the clearings. Among the species, *Quercus robur* is often found indicating the very first step in the successional development of the alkali oakwood (*Galatello-Quercetum roboris*).

The cover of the herb layer varies greatly depending on light availability. Frequent and abundant species, some of them becoming locally dominant, are as follows: *Agropyron caninum, Agropyron repens, Alliaria petiolata, Alopecurus pratensis, Corydalis cava, Dactylis glomerata, Festuca pratensis, Festuca*

rupicola, Festuca valesiaca, Ficaria verna, Lithospermum purpureo-coeruleum, Peucedanum officinale, Poa nemoralis, Poa pratensis, Polygonatum latifolium, Scilla vindobonensis, Viola cyanea. With the presence of *Corydalis cava, Ficaria verna, Gagea lutea* and *Scilla vindobonensis*, an early spring aspect is also present.

Species composition

In the first half of the 20th century, Máthé (1933, 1936, 1938) and Soó (1938b) studied the phytosociological and habitat characteristics of the alkali oakwoods. However, their publications do not include phytosociological relevés. Later Zólyomi and Tallós (1967) published a synthetic table, then Tallós and Tóth (1968) gave a detalied table of this association. They distinguished two subassociations: the canopy layer of the *festucetosum sulcatae* (= *peucedanetosum officinalis*) is low and open, whereas that of the *polygonatetosum latifoliae* is taller and more closed. The species composition of the former is characteristic of the forest steppes, but that of the latter is more similar to the species composition of the hardwood gallery forests (*Fraxino pannonicae-Ulmetum*). These two subassociations may also be identified in the tables published by Molnár (1989).

The weighted proportions of species characteristic of marshes (*Cypero-Phragmitea* s.l.) and meadows on peaty soil (*Molinio-Juncetea* s.l.) in the alkali steppe oakwoods (*Galatello-Quercetum roboris*) are similar to those in the oak-ash-elm forests (*Fraxino pannonicae-Ulmetum*). On the other hand, the proportion of species characteristic of xerophilous grasslands (*Festuco-Bromea* s.l.: 7.6–10.9 %) is much higher in the alkali steppe oakwoods.

The co-occurrence of higrophilous and xerophilous species may seem contradictory at first. However, the higrophilous species apparently may establish themselves in this habitat because of the frequent water cover in the spring. How can then the xerophilous species successfully survive despite the spring water cover? A partial explanation may be that „the large negative water potential of the alkali soils cause physiological drought" (Kevey 1995). For further support of this idea, physiological and ecological studies are certainly needed. Nevertheless, the occurrence of species characteristic of steppes makes the alkali steppe oakwoods somewhat similar to forest steppe oakwoods on loess (*Aceri tatarico-Quercetum roboris*) (see Molnár 1989). Relative to the oak-ash-elm forests (*Fraxino pannonicae-Ulmetum*), the dry character of their habitat is indicated by the significantly smaller proportion of species characteristic of softwood (*Salicetea purpureae* s.l.: 0.4–2.9 %) and hardwood (*Alnion incanae*: 2.4–3.1 %) gallery forests, and mezophilous forests (*Querco-Fagetea*: 8.2–16.1 %, *Fagetalia*: 0.8–2.6 %). Species characteristic of xerophilous oak forests (*Quercetea pubescentis-petraeae* s.l.: 21.7–37.6 %) are much more frequent, however. The most notable feature of this association is the presence of salt tolerant species (*Puccinellio-Salicornea* s.l.: 4.2–5.4 %): *Artemisia pontica, Artemisia santonicum, Aster*

sedifolius, Festuca pseudovina, Juncus gerardii, Limonium gmelini ssp. *hungaricum, Melandrium viscosum, Peucedanum officinale, Ranunculus pedatus, Rumex pseudonatronatus*.

The comparison of the species composition of the alkali steppe oakwoods occurring in various regions was not possible due to the availability of only synthetic tables in some instances. The location of the remaining 40 relevés is known, but their grouping is unnecessary, since this association is found only in a few localities on the Tisza plain. Its considerable species are: *Aster linosyris, Aster sedifolius, Artemisia pontica, Artemisia santonicum, Campanula rapunculus, Carduus crispus, Carex melanostachya, Centaurea triumfettii, Cerasus fruticosa, Doronicum hungaricum, Hesperis sylvestris, Iris spuria, Juncus gerardii, Limonium gmelini, Lycopus exaltatus, Melica altissima, Melica transsylvanica, Peucedanum officinale, Phlomis tuberosa, Podospermum canum, Pulmonaria mollis, Rosa gallica, Rumex pseudonatronatus, Saxifraga bulbifera, Scilla vindobonensis, Vicia pisiformis, Viola montana.*

Distribution of alkali steppe oakwoods on the Tisza plain

Alkali steppe oakwoods almost exclusively occur on the Tisza plain, the phytogeographical region of Crisicum. The only exception is the fragment discovered recently near the village of Iván, on the southern part of the Lesser Plain. All other stands occur at the following locations: Alattyán „Berki-erdő"; Békéscsaba „Fácános-erdő", „Hajlás-erdő", „Pósteleki-erdő"; Bélmegyer „Fás-erdő"; Berettyóújfalu „Malom-füzes"; Doboz „Madárfoki-erdő", „Papholt-erdő"; Egyek „Ohati-erdő"; Görbeháza „Bagotai-erdő", „Fenyves-erdő"; Gyula „Gelvács", „Kutyahelyi-erdő", Hencida „Csere-erdő", „Miklós-erdő"; Hortobágy „Malomházi-erdő"; Jászdózsa „Pap-erdő"; Kerecsend „Kerecsendi-erdő"; Kisújszállás „Nagy-erdő"; Konyár „Határ-erdő"; Körösladány „Ladányi-erdő"; Mezőcsát; Tiszacsege „Berzsenyes morotva"; Tiszadob „Sóskuti-legelő"; Tiszaigar–Tiszaörs „Körtvélyesi-legelő"; Tiszaszentimre „Körtvélyesi-legelő"; Tiszaug „Bokros-puszta"; Újszentmargita „Tilos-erdő" (see Máthé 1933, 1936, 1938, Soó 1938b, Zólyomi and Tallós 1967, Molnár 1989, Horváth *et al.* 1999, Molnár *et al.* 2000b). Many of the above stands are only fragments.

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