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Review

The history of Austrian pine plantations in Hungary

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In Hungary the first experimental stands of Austrian pine (*Pinus nigra* Arn.) were planted at the end of the 19th century. In the beginning, soil preservation purposes dominated, later, in the 1950s and 70s, wood production received more attention. Recently, *Pinus nigra* stands cover 70300 hectares, that is 4.2% of the total forested area of Hungary. The extensive monocultures of this tree are causing several problems from a nature conservation point of view, of which occupying the habitat of native communities and impoverishment of the local flora and fauna are the most important. Therefore, stands of this tree should be transformed and occupied by natural vegetation types, at least when found in national parks or other nature conservation areas. *Fraxinus ornus* L. seems to be an appropriate native tree to replace the Austrian pine on dolomite hills, whereas on sandy soils *Populus alba* L. can be recommended.

Key words: History, afforestation, pine plantations, barren hillsides, *Pinus nigra*, ground stabilization

Introduction

In Hungary, the Austrian pine (*Pinus nigra* Arn.) planting started at the end of the 19th century, its main purposes being soil preservation and landscape protection. It was necessary to stop the soil erosion and landscape deterioration, which threatened the hillsides with degraded vegetation. *Pinus nigra* seemed to be a very good choice as being a rather drought resistant and heat tolerant tree (LEBOURGEOIS et al. 1998). It has a large but discontinuous distribution area ranging from Spain to Turkey, native stands close to the recent territory of Hungary being found in the border of the Eastern Alps (WENDELBERGER 1980). This area is shared by different subspecies – sometimes considered as separate species – that are often the subject of taxonomic and genetic studies (NIKOLIĆ and TUCIĆ 1983, SCALTSOYIANNES et al. 1994, AGUINAGALDE et al. 1997, LIBER et al. 1999). In Hungary, *P. nigra* ssp. *nigra* and *P. nigra* ssp. *laricio* received more attention in afforestation (VEPERDI 1990–1991).

Alongside landscape protection aims, wood production was only a secondary purpose in the first few decades. Later, however, when the success of Austrian pine planting ex-

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ceeded all expectations, wood production became an increasingly important consideration and it was promoted by certain political trends, too.

The current animosity to Austrian pine plantations began to form only in the 1970s. By this time the pasturing has almost completely stopped in the mountainous areas resulting in the regeneration succession of the vegetation on the grassy hillsides. In some places even spontaneous shrub-growth began and so the erosion-preventing role of the Austrian pine became less important. At the same time, nature conservation-oriented botanists began to worry about alien plants that – in some cases – proved to be spreading aggressively (CSONTOS 1984, 1986a, b; BALOGH et al. 1994; PRISZTER 1997; UDVARDY 1998a, b; BAGI 1999; TAMÁS 1999–2000). Of the vituperations against alien species, quite a lot were accounted for by the Austrian pine.

Trailing behind the change of mentality in the related sciences, the forestry trade chose at this time to decide on a large scale planting programme. KERESZTESI (1966) wrote that the total area of Austrian pine stands was 21000 hectares and indicated that the directives proposed increasing them to 80000 hectares. We will see that in spite of all objections the forestry trade managed to fulfil this plan.

As an excuse, however, we must note that the protests were phrased almost exclusively in verbal discussions and apart from ZÓLYOMI's early work (ZÓLYOMI 1955) the botanists delayed for an unduly long time providing well-founded objections, like scientific publications (CSONTOS and LŐKÖS 1992). This situation began to change in the middle of the 1990s when ANDRÁS HORÁNSZKY and his associates started to publish their results concerning pine plantations of the Budai Hills (HORÁNSZKY 1996, JÁRÓ 1996, NAGY 1996, TÖRÖK and TÓTH 1996).

So a real dialogue started and the number of studies aimed at the clarification of the Austrian pine stands' botanical status has been growing in the past few years (TAMÁS and CSONTOS 1998, MIHÓK 1999, CSONTOS et al. 2001). Nevertheless, there was no publication dealing with the history of planting of Austrian pine stands in Hungary.

The history of planting and changes in its appreciation

The thought of planting Austrian pine stands was first discussed by PODHRADSZKY (1866). Early on there were proposals to use this tree in the afforestation of barren dolomite hills (PODHRADSZKY 1866, SZÉKELY 1868). It did not take long, however, for the species to appear in the forestation plans of the sandy areas of the Great Hungarian Plain (PAUSINGER 1879, KALLINA 1880) for which purpose it was considered to be better suited than the black locust that was introduced into Hungary around 1750. So, at this time most of the Austrian pine stands were planted in the sandy regions between the rivers Danube and Tisza (KISS 1913, 1920, 1927, 1931) and this is the area where their proportion is still the greatest (Fig. 1).

To prevent the devastation of over-grazed areas, Austrian pine stands were planted mainly in the Croatian karst at the beginning (NYITRAY 1913) but then it was used more and more on the barren dolomite hillsides in Trans-Danubia. The planting of this Mediterranean species proved to be a great success from a forestry point of view, as vigorous stands grew on the sandy areas and hillsides that had been treeless until then. The long term objective was – as is clear from the publications of the experts of the time (PODHRADSZKY 1866; SZÉKELY 1868; KISS 1931, 1944) – to exploit the soil-improving effect of the Austrian

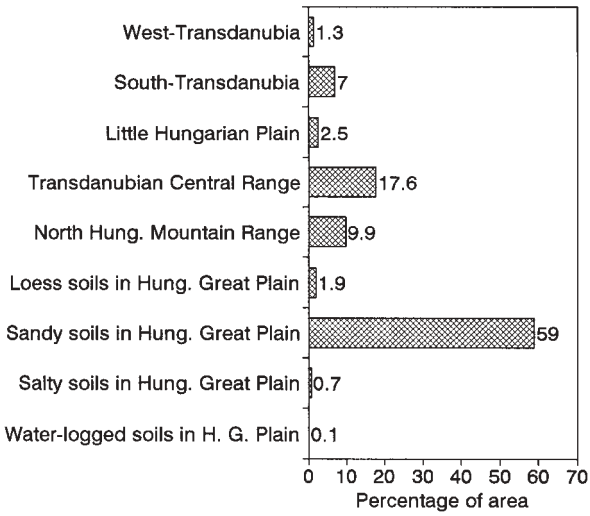

Fig. 1. Percentage share of Austrian pine stands in the main forestry districts of Hungary, drawn from the data of SZABÓ (1997).

pine's rich pine-litter and following a relatively short time to log the pines and re-plant the areas with more valuable tree species.

There was a new wave of Austrian pine planting in the years after World War II (HÉDER 1951). At this time the main purpose, however, was to produce wood as an industrial raw material. But its high resin content and knotty wood structure made the Austrian pine a much less valuable wood than *Pinus silvestris* L. or *Picea abies* (L.) Karst. (DÉRFÖLDI 1966, MÁRKUS 1987).

A serious disadvantage of pine planting is that it causes certain intractable ecological and nature conservation problems. The natural Austrian pine stands are quite open, and mixed with several deciduous species (e.g. *Fraxinus ornus* L., *Carpinus orientalis* Mill., *Ostrya carpinifolia* Scop.) and have a well-developed shrub-layer and herb-layer (FEKETE 1959, POLDINI 1969, HORVAT et al. 1974, KARRER 1985, ELLENBERG 1988, HODA 1993). In contrast the Austrian pine stands in Hungary are closed and monodominant. The usual planting density is 8–12000 individuals per hectare (KOVÁCS and VEPERDI 1990–91) from which almost completely monodominant stands develop. When the actual tree species composition of different Hungarian forest types were surveyed, Austrian pine stands proved to be the most monodominant with an 89.5 percent share of *Pinus nigra* in their canopy (SZABÓ 1997).

Not surprisingly under the canopy of these plantations the available light is very low. KERTÉSZ (1982) detected 7–9% relative irradiation in the ground layer of an old stand planted on sandy soil. According to my measurements in a 38-year-old stand on a south facing dolomite slope 9.46% relative irradiation was found on average, with 5.5% and 38.0% minimum and maximum values, respectively. From randomly selected localities 74 percent of the measured points fell into the class of 5–10% relative irradiation, whereas values above 20% were obtained from measurements at sporadically occurring sun flecks (Fig. 2).

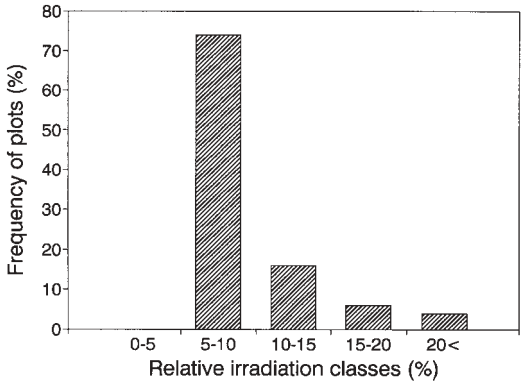

Fig. 2. Distribution of the relative irradiation values in a 38-year-old *Pinus nigra* stand detected at 20 cm above the litter layer. Measurements were carried out on a south-facing dolomite slope in the Budai hills (47° 37.629'N; 18° 51.267'E; alt.= 275 a.s.l.) under clear sky conditions at noon, 27 August, 2002.

The most generally recognized nature conservation problem related to the Austrian pine is caused by the stands planted on dolomite slopes. The original vegetation developing on a dolomite bed rock is quite diverse both floristically and phytosociologically and often preserves endemic or relict species (DRASKOVITS 1967, ISÉPY and CSONTOS 1996). This phenomenon was explained in details by ZÓLYOMI (1942, 1987). The establishment of Austrian pine stands influenced the following phytosociological units of the dolomite vegetation complex: Festucetum glaucae, Festuco-Brometum erecti, Chrysopogono-Caricetum humilis and Cotineto-Quercetum pubescentis (HÉDER 1951, JÁRÓ 1996), that is afforestation happened not only in »barren« grassy communities but areas covered by shrubs or poorly developed scrub forests as well. The listed original communities were usually bright. The species of the dolomite vegetation did not adapt to low-light conditions (DRIN 1984), though certain differences among species regarding their light preference occur. For instance, *Paronychia cephalotes* (M. B.) Bess., *Dianthus plumarius* ssp. *regis-stephani* (Rapaics) Baksay and *Linum dolomiticum* Borb. prefer the most open grasslands, whereas *Dianthus giganteiformis* Borb., *Dictamnus albus* L. and *Coronilla coronata* Nath. are characteristic in scrub forests (ZÓLYOMI 1958, TÖRÖK and PODANI 1982). Species inhabiting this vegetation complex easily disappear when the shading effect increases (BÓDIS 1993, KELEMEN 1997). The light-absorbing effect of the pinewoods is much stronger than that of the scrub forests. As a result the understorey vegetation becomes quite sparse, as was found in many case studies (BORHIDI 1956, BÓDIS 1993, CSONTOS et al. 1996, HORÁNSZKY 1996, MIHÓK 1999). The re-establishment of locally extinct grassland species is difficult as many of them have short-term persistent seed bank (CSONTOS 2001), or can not tolerate the strong raw humus layer accumulating under Austrian pine stands (FEICHTER and STAFFLER 1996). An impoverishment of the animal communities can be demonstrated as well (LOKSA 1988, NAGY 1996, TÖRÖK and TÓTH 1996, MAGURA et al. 1997). The possible candidates to inhabit pine stands may originate from shady habitats like ground-layer of beech forests. However, these plants owe their success to the period from autumn to spring when beech forests have plenty of light (DRASKOVITS 1975). They fail in pine stands where shady conditions prevail all the year.

HÉDER (1954) and BORHIDI (1956) considered the appearance of scrub forest shrubs in the developing pine stands as a sign that pine plantations help the succession from grasslands towards *Cotineto-Quercetum pubescentis*. The shrub growth they detected was not significant (according to BORHIDI 1956 the shrub cover never exceeded 10 percent of the total area) and when one considers the fact that some of the Austrian pine stands were planted in scrub forest habitats, the positive evaluation of this phenomenon becomes questionable. What seems to be a much more significant effect is the decimation or total disappearance of the herbaceous plants.

The unfavourable effects on the original vegetation would have been much less significant if the pines were planted mixed with some deciduous tree species. The problems inherent in monocultures were recognised quite early from the viewpoint of forest protection and the experts warned about these at the same time the first experimental stands were created (TÓTHI SZABÓ 1880, NYITRAY 1913). For example, TÓTHI SZABÓ (1880) wrote the following: »Taking into consideration the imminent threat of fire that can do great damages to pure pine stands, and taking into consideration the numerous insect pests of these trees, when a massive gradation of certain insects may destroy whole forests, the Austrian and Scotch pines should not be planted in themselves only but when it is possible for these trees to be planted mixed with Turkey oak, other oaks, tree of heaven or black locust.« However, his advice was generally not taken; this is indicated by HÉDER's study (1954) on the renewal of the ageing monocultures planted around 1900. He thinks that the strength of the 40–50 year old stands decreases rapidly in those habitats where the soil is thin and in this status a few litter-fires or a lengthy drought may start a quick process of decay. To avoid this he proposes renewal with various deciduous trees. The primary function of the forests planted in the barren dolomite hills was protection against soil erosion (BABOS 1954, ROTT 1955, SZODFRIDT and TALLÓS 1966). For this purpose a mixed forest would serve better than a pine monoculture, because it is much more resistant to extreme weather. Due to their crown, thick and tight even in winter, pines are more prone to damage caused by storms. Additionally, in closed stands most of the winter precipitation evaporates from the crown without reaching the soil, therefore drought also affects them more severely (PAPP 1966). It is strange that in spite of the awareness of these problems the pine forests planted between 1950 and 1970 were still monocultures. The pine planting programme of the 1970s further increased the area of the Austrian pine stands (see also KERESZTESI 1966).

As a result the area of our Austrian pine plantations has increased gradually (Fig. 3) and now these make up 4.2 percent (70300 hectares) of all forested areas in Hungary (SZABÓ 1997). Then, beginning in the early 1990s a new, formerly only rarely observed fungal pest – *Sphaeropsis sapinea* Dyko et Sutton – started to destroy the pine shoots in ever increasing numbers in these forests. The sudden epidemic is probably due to the abundant cone forming resulting from the ageing of the stands, as it was determined that the cones are the pines' most susceptible parts regarding this infection (KOLTAY 1998a, KOLTAY and NAGY 1999). Knowing the stands' age distribution (Fig. 4) it is predictable that in one or two decades time *Sphaeropsis* damages may become more severe.

Poor site conditions are another factor responsible for the susceptibility of *Pinus nigra* to *Sphaeropsis* disease, as was reported by DIMINIĆ (1996, 1999). It is notable that this fungus was found as endophyte in healthy trees and could turn to serious pathogen due to abiotic stress (DIMINIĆ and JURC 1999). In the north Serbian plantations, *Scirrhia pini* Funk

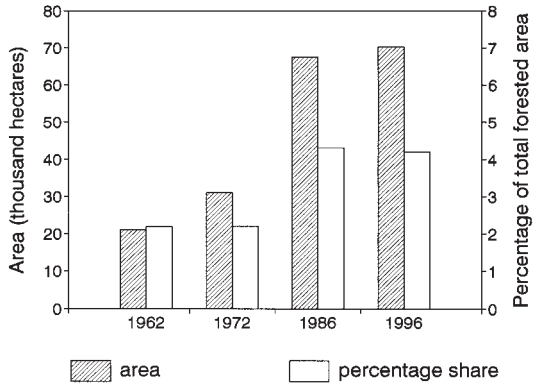

Fig. 3. Changes in the area covered by Austrian pine during the latest decades according to the data of KERESZTESI (1966), DANSZKY (1973) and SZABÓ (1997).

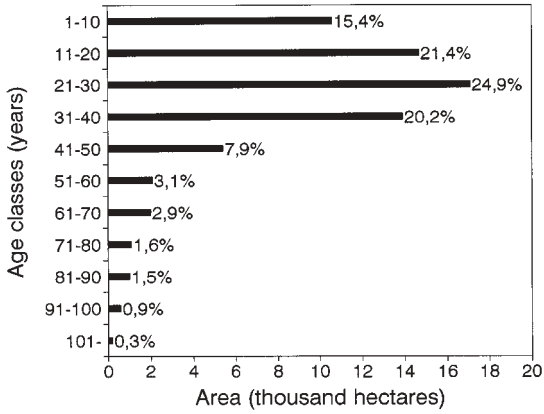

Fig. 4. Age distribution of Austrian pine stands in Hungary. Drawn from the data of SZABÓ (1997).

et Parker was found to be the most dangerous fungus (KARADŽIĆ 1989, KARADŽIĆ and ZORIĆ 1994). The situation is made worse by the increasing woodworm-infestation of the stressed Austrian pine stands; for example the six-toothed woodworm (*Ips sexdentatus* Boern) became increasingly frequent in the Hungarian plantations in the past few decades (KOLTAY 1998b, CSÓKA and KOVÁCS 1999). Fire damaged pine stands can also be more susceptible to woodworm attack (FERNÁNDEZ and COSTAS 1999). The susceptibility of the Austrian pine to various pests is increased when large even-aged stands live in a habitat that is not optimal for the species' development. Unfortunately, most of the Hungarian stands are grown in suboptimal habitats: 90.9 percent of them are in areas with a medium or poor wood producing ability (SZABÓ 1997).

It is important to note in relation to the current standing of Austrian pine that according to a recent survey supported by the Hungarian Nature Conservation Agency the objective is to turn Austrian pine monocultures into forests mixed with deciduous trees, and on the areas with a high level protection the final goal is the total removal of the pine (KESZTHELYI et al. 1995).

Many poor wood producing areas where the Austrian pine was planted (dolomite hillsides and sandy steppes) have a potentially high nature conservation value. One could think that the replacement of the Austrian pine stands can easily and quickly be done here. However, this is not so because the relevant forestry plans are acting against this trend. The intention is to maintain the forests planted in these areas for soil protection purposes for as long as possible (VEPERDI 1993), which may mean that these stands will be logged only when reaching the age of 90 or 100 years. Now, the average age of the pine stands planted with such a purpose is 70.6 years (SZABÓ 1997). Regarding further pine stands belonging to the poor wood production category KOVÁCS and VEPERDI (1990–91) propose lengthening the logging age, which is 50 years now. Because of the poor potential of the habitat, no quality wood production is possible in these areas, so in order to increase the quantity at least, no thinning is done, and so the stands remain practically in their original – planting – density for long times (SOLYMOS 1978). According to VEPERDI (1988–89, 1990–91) this planting density is optimal when done on a network with a mesh between 1×1 and 2×2 metres, which produces a 3–9 times higher tree density than is found in a native stand (VALTCHEV and NIKOLOV 1993). From these facts it is quite clear that if forestry considerations continue to dominate then we will find thick, dark Austrian pine stands in these areas for a long time yet.

Summary

The first experimental Austrian pine stands were planted in Hungary at the end of the 19th century with the purpose of stopping soil erosion on steep slopes and binding quick ground. This South European species met the expectations very well so planting with wood-production purposes was started as well. One of the big planting »booms« occurred in the 1950s but the alien programme of the 1970s resulted in establishing the species in even bigger areas. These new stands differ from the indigenous stands of southern Europe in their tightly closed canopy, with the result that only a few extremely tolerant species of the original vegetation can survive in them. From a nature conservation point of view this is one of the main arguments against the Austrian pine stands. Further frequently mentioned objections are derived from the monocultural character of these stands: a very low diversity, susceptibility to pests and a high risk of fire. Talking about pure Austrian pine stands we must know that these were planted in spite of the fact that many forestry experts warned against this practice because of the dangers inherent in monocultures and proposed planting of mixed forests.

Today the transformation of monocultures should not be delayed any longer, especially in the nature reserves. Using the system of DOBROSI and SZABÓ (1999) in order to put the planted stands into a better category (mixed stand) the ratio of native tree species should be increased to 33 percent. This objective can be achieved in dolomite habitats if Austrian pine stands are mixed with *Fraxinus ornus* L. This species is naturally present in the indigenous Austrian pine stands in southern Europe (FEKETE 1959, POLDINI 1969, HODA 1993). Showing its considerable plasticity, manna ash often mixes naturally with the planted pine stands in Hungary (KALAPOS and CSONTOS 2003, CSONTOS et al. 2001). We must promote this process by opening up the closed Austrian pine stands. Finally, pineless stands can also be created on the dolomite hills, as BORISZLAVSZKY (1887) claims that *Fraxinus ornus* can

form even pure stands in this habitat. In sandy soils, *Populus alba* L. seems to be the best suited native species to implement a similar transformation of the species ratio (see also MAGYAR 1961).

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References

AGUINAGALDE, I., LLORENTE, F., BENITO, C. 1997: Relationships among five populations of European black pine (*Pinus nigra* Arn.) using morphometric and isozyme markers. Silvae Genetica 46, 1–5.

BABOS, I., 1954: Magyarország táji erdőművelésének alapjai. Mezőgazdasági Kiadó, Budapest.

BAGI, I., 1999: A selyemkóró (*Asclepias syriaca* L.) Egy invazív faj biológiája, a védekezés lehetőségei. Kitaibelia 4, 289–295.

BALOGH, L., TÓTHMÉRÉSZ, B., SZABÓ, T. A., 1994: Patakkísérő invázív gyomok (*Helianthus*, *Humulus*, *Impatiens*, *Reynoutria*, *Rubus*, *Sambucus*, *Solidago* és *Urtica*) állományainak számítógépes elemzése Szombathely térségében. Berzsenyi Dániel Tanárképző Főiskola Tudományos Közleményei 9, Természettudományok 4, 73–99.

BÓDIS, J., 1993: A feketefenyő hatása nyílt dolomit sziklagyepre. I. Texturális változások. (Effect of black pine on dolomite rock grasslands. I. Textural changes.) Bot. Közlem. 80, 129–139.

BORHIDI, A., 1956: Feketefenyveseink társulási viszonyai. (Zönologische Verhältnisse unserer Schwarzföhrenwälder). Bot. Közlem. 46, 275–285.

BORISZLAVSZKY, J., 1887: A virágos kőris (*Fraxinus ornus* L.), meg a sziklás hegyoldalak. Erdészeti Lapok 26, 497–500.

CSÓKA, GY., KOVÁCS, T., 1999: Xilofág rovarok. Agroinform Kiadó, Budapest.

CSONTOS, P., 1984: Az *Impatiens parviflora* DC. vadállókövi (Pilis) állományának cönológiai és ökológiai vizsgálata. Abst. Bot. 8, 15–34.

CSONTOS, P., 1986a: Dispersal and establishment of *Impatiens parviflora*, an introduced plant, in a hardwood forest. Abst. Bot. 10, 341–348.

CSONTOS, P., 1986b: Phytosociological description of a hilly country stand of *Impatiens parviflora* DC. Stud. Bot. Hung. 19, 115–118.

CSONTOS, P., 2001: A természetes magbank kutatásának módszerei. Scientia Kiadó, Budapest.

CSONTOS, P., HORÁNSZKY, A., KALAPOS, T., LÖKÖS, L., 1996: Seed bank of *Pinus nigra* plantations in dolomite rock grassland habitats, and its implications for restoring grassland vegetation. Annls hist.-nat. Mus. natn. hung. 88, 69–77.

CSONTOS, P., LÖKÖS, L., 1992: Védett edényes növényfajok térbeli eloszlás-vizsgálata a Budai-hegység dolomitvidékén – szünbotanikai alapozás természetvédelmi területek felméréséhez. Bot. Közlem. 79, 121–143.

CSONTOS, P., TAMÁS, J., KALAPOS, T., 2001: Correlation between age and basal diameter of *Fraxinus ornus* L. in three ecologically contrasting habitats. Acta Bot. Hung. 43, 127–136.

DÉRFÖLDI, A., 1966: Fenyveseink használata. In: KERESZTESI, B. (ed.), A fenyők termesztése, 487–499. Akadémiai Kiadó, Budapest.

DIMINIĆ, D. 1996: Gljiva *Sphaeropsis sapinea* (Fr.) Dyko et Sutton na borovima sjevernojadranskog podrucja. Sumarski list br. 11/12, 463–468.

DIMINIĆ, D. 1999: The presence of fungus *Sphaeropsis sapinea* on pines in Croatia. In: Forster, B., Knizek, M., Grodzki, W. (eds.) Methodology of forest insect and disease survey in Central Europe. Proc. IUFRO Workshop, Sion-Chateauneuf, Switzerland, 189–193.

DIMINIĆ, D., JURC, M. 1999: Some aspects of *Sphaeropsis sapinea* presence on Austrian pine in Croatia and Slovenia. Phyton (Austria) 39, 231–234.

DOBROSI, D., SZABÓ, G., 1999: Természetvédelmi erdők kezelési problémái. Erdészeti Kutatások 89, 225–234.

DRASKOVITS, R., 1967: A *Linum dolomiticum* Borb. cönológiai viszonyai. Bot. Közlem. 54, 193–201.

DRASKOVITS, R., 1975: Light intensity studies in beechwoods of different age. Acta Bot. Acad. Sci. Hung. 21, 9–23.

DRIN, I., 1984: Antropogén hatások a Nagyszénás vegetációjában – Tájidegen fafaj és rendszeres taposás hatása a Nagyszénás délkeleti lejtőjén kialakult másodlagos gyepre. MSc theses, L. Eötvös University, Budapest.

ELLENBERG, H., 1988: Vegetation ecology of central Europe. Cambridge University Press, Cambridge.

FEICHTER, A., STAFFLER, H. 1996: Zum Schutz des Lebensraumes: Die Aufforstungen am Vinschgauer Sonnenberg. Forstw. Cbl. 115, 246–255.

FEKETE, G., 1959: Angaben zur Zönologie der moesischen Schwarzföhrenwälder. Acta Bot. Acad. Sci. Hung. 5, 327–347.

FERNÁNDEZ, M. M. F., COSTAS, J. M. S. 1999: Susceptibility of fire-damaged trees (*Pinus pinaster* and *Pinus nigra*) to attacks by *Ips sexdentatus* and *Tomicus piniperda* (Coleoptera: Scolytidae). Entomol. Gener. 24, 105–114.

HÉDER, I., 1951: A dolomit és mészkő kopárfásítások egyes főbb irányelvei. Erdészeti Tudományos Intézet Évkönyve 1, 65–90.

HÉDER, I., 1954: Dolomit és mészkőkopárokra telepített erdők hatásvizsgálata és a kiöregedő állományok felújítása. Erdészeti Kutatások 1954, 87–101.

HODA, P. 1993: A geobotanical survey of the black pine (*Pinus nigra* Arn.) forests in Albania. Annali Bot. 51, 77–92.

HORÁNSZKY, A., 1996: Növénytársulástani, erdőgazdálkodási és természetvédelmi kérdések a Kis- és Nagy-Szénáson. Természetvéd. Közlem. 3/4, 5–19.

HORVAT, I., GLAVAČ, V., ELLENBERG, H., 1974: Vegetation Südosteuropas. Gustav Fischer Verlag, Stuttgart.

ISÉPY, I., CSONTOS, P. 1996: Comparison of 24 grassland communities in the Carpathian-Basin with the emphasis on their role in nature conservation. Proc. Conf. »Research, Conservation, Management«, Aggtelek-Jósvafő, Hungary, 1, 309–317.

JÁRÓ, Z., 1996: Ökológiai tanulmányok a Kis- és Nagy-Szénáson. Természetvéd. Közlem. 3/4, 21–53.

KALAPOS, T., CSONTOS, P., 2003: Variation in leaf structure and function of the Mediterranean tree *Fraxinus ornus* L. growing in ecologically contrasting habitats at the margin of its range. Plant Biosyst. 137. 73–82.

KALLINA, K., 1880: Az erdei- és feketefenyő ültetése kosarakban, futóhomok-területen (*Pinus sylvestris* et *austriaca*). Erdészeti Lapok 19, 31–37.

KARADŽIĆ, D. 1989: *Scirrhia pini* Funk et Parker. Life cycle of the fungus in plantations of *Pinus nigra* Arn. in Serbia. Eur. J. For. Path. 19, 231–236.

KARADŽIĆ, D., ZORIĆ, R. 1994: Najvaznije parazitske i saprofitiske gljive cetina crnog i belog bora u kulturama na Deliblatskoj pescari. Proc. Congress Deliblatski Pesak, Pancevo, 511–520.

KARRER, G., 1985: Waldgrenzstandorte an der Thermenlinie (Niederösterreich). Stapfia 14, 85–103.

KELEMEN, J. (ed.), 1997: Irányelvek a füves területek természetvédelmi szempontú kezeléséhez. A KTM Természetvédelmi Hivatalának Tanulmánykötetei 4., Természet BÚVÁR Kiadó, Budapest.

KERESZTESI, B. (ed.), 1966: A fenyők termesztése. Akadémiai Kiadó, Budapest.

KERTÉSZ, M., 1982: A fénymintázat és a növényzet kapcsolatának vizsgálata egy páfrányokban gazdag fenyvesben. MSc theses, L. Eötvös University, Budapest.

KESZTHELYI, I., CSAPODY, I., HALUPA, L., 1995: Irányelvek a természetvédelem alatt álló erdők kezelésére. A KTM Természetvédelmi Hivatalának Tanulmánykötetei 3. Published by KTM, Budapest.

KISS, F., 1913: Az alföldi homokterületek erdősítésénél követendő újabb eljárások. Erdészeti Lapok 52, 296–318.

KISS, F., 1920: Az Alföld fásításának kérdéséhez. Erdészeti Lapok 59, 275–294.

KISS, F., 1927: A feketefenyő ültetése. Erdészeti Lapok 66, 249–254.

KISS, F., 1931: Az Alföldfásítás gyakorlati kérdéseihez. Erdészeti Lapok 70(3), 210–243.

KISS, F., 1944: Harc az elemi csapásokkal a Duna-Tisza közti homokterületeken. Erdészeti Lapok 83, 101–108.

KOLTAY, A., 1998a: A feketefenyő hajtáspusztulását okozó *Sphaeropsis sapinea* Dyko & Sutton gomba biológiájának vizsgálati eredményei. Erdészeti Kutatások 88, 251–271.

KOLTAY, A., 1998b: Health condition of Hungarian pine forests. Proc. IUFRO Workshop. Ustron-Jaszowiec (Poland), 133–137.

KOLTAY, A., NAGY, L., 1999: Feketefenyő klónok fogékonysága a *Sphaeropsis sapinea* és *Dothistroma septospora* kórokozók fertőzésével szemben. Erdészeti Kutatások 89, 151–162.

KOVÁCS, F., VEPERDI, G., 1990–91: A feketefenyő fatermése és erdőnevelési modellje. Erdészeti Kutatások 82/83, 328–344.

LEBOURGEOIS, F., LÉVY, G., AUSSENAC, G., CLERC, B., WILLM, F. 1998: Influence of soil drying on leaf water potential, photosynthesis, stomatal conductance and growth in two black pine varieties. Ann. Sci. For. 55, 287–299.

LIBER, Z., PAVLETIĆ, Z., NIKOLIĆ, T., FULGOSI, H. 1999: DNA polymorphisms in Austrian and Dalmatian black pine. Wiss. Mitt. Niederösterr. Landesmuseum 12, 53–62.

LOKSA, I., 1988: Fenyvesítés hatása a természetközeli faunára (Nagy-Szénás). Final report of the project »A telepített fenyőállományok hatása természetvédelmi területek termőhelyére«, Budapest.

MAGURA, T., TÓTHMÉRÉSZ, B., BORDÁN, Z. 1997: Comparison of the carabid communities of a zonal oak-hornbeam forest and pine plantations. Acta Zool. Acad. Sci. Hung. 43: 173–182.

MAGYAR, P., 1961: Alföldfásítás II. Akadémiai Kiadó, Budapest, 622 pp.

MÁRKUS, L., 1987: A fenyvesek ökonómiai vizsgálata. In: BONDOR, A. (ed.), A fenyő termesztése és hasznosítása, 180–199. Mezőgazdasági Kiadó, Budapest.

MIHÓK, B., 1999: Telepített feketefenyves állományok természetvédelmi szempontú vizsgálata dolomiton. Természetvéd. Közlem. 8, 49–65.

NAGY, B., 1996: Orthopteroid rovarok rekolonizációs viszonyai megnagyobbított feketefenyő tisztásokon. Természetvéd. Közlem. 3/4, 55–63.

NIKOLIĆ, D., TUCIĆ, N. 1983: Isoenzyme variation within and among populations of European black pine (*Pinus nigra* Arnold). Silvae Genetica 32, 80–89.

NYITRAY, O., 1913: A karszterdősítés. In: FEKETE, L. and BLATTNY, T. (eds), Az erdészeti jelentőségű fák és cserjék elterjedése a magyar állam területén, 766–768. Joerges Ágost özvegye és fia, Selmecbánya.

PAPP, L., 1966: A fenyők jelentősebb betegségei, károsítói, és az ellenük való védekezés. In: KERESZTESI, B. (ed.), A fenyők termesztése, 428–441. Akadémiai Kiadó, Budapest.

PAUSINGER, J., 1879: Homokkötési munkálatok a deliblati pusztán. Erdészeti Lapok 18, 649–655.

PODHRADSZKY, A., 1866: Előhegyeink kopár déloldalainak, tisztásainak s vizmosásainak legbiztosb és legolcsóbb erdősitéséről. Erdészeti és Gazdászati Lapok 5, 22–32.

POLDINI, L. 1969: Le pinete di pino austriaco nelle Alpi carniche. Bolletino Della Societa' Adriatica di Scienze – Trieste 57, 3–65.

PRISZTER, SZ., 1997: A magyar adventívflóra kutatása. Bot. Közlem. 84, 25–32.

ROTT, F., 1955: A balatonkörnyéki fásítások irányelvei. Az erdő 4, 483–494.

SCALTSOYIANNES, A., ROHR, R., PANETSOS, K. P., TSAKTSIRA, M. 1994: Allozyme frequency distributions in five European populations of black pine (*Pinus nigra* Arnold). Silvae Genetica 43, 20–30.

SOLYMOS, R., 1978: Erdőnevelés. In: KERESZTESI, B., SOLYMOS, R. (eds), A fenyők termesztése és a fenyőfagazdálkodás (2nd edition), 236–277. Akadémiai Kiadó, Budapest.

SZABÓ, P. (ed.), 1997: Magyarország erdőállományainak főbb adatai 1996. Országos adatok. Állami Erdészeti Szolgálat, Budapest.

SZÉKELY, M., 1868: A feketefenyű (*Pinus austriaca*) mívelésének és terjesztésének hasznairól. Erdészeti Lapok 7, 205–210.

SZODFRIDT, I., TALLÓS, P., 1966: A feketefenyvesek kultúr erdőtípusai. In: KERESZTESI B. (ed.), A fenyők termesztése, 105–106. Akadémiai Kiadó, Budapest.

TAMÁS, J., 1999–2000: Az invazív fajok terjedésének törvényszerűségei egy magyarországi esettanulmány kapcsán – a betyárkóró. Bot. Közlem. 86/87, 169–181.

TAMÁS, J., CSONTOS, P., 1998: A növényzet tűz utáni regenerálódása dolomitra telepített feketefenyvesek helyén. In: CSONTOS, P. (ed.), Sziklagyepek szünbotanikai kutatása, 231–264. Scientia Kiadó, Budapest.

TÖRÖK, J., TÓTH, L., 1996: A Nagy-Szénás természetvédelmi terület madárfaunájának minőségi és mennyiségi vizsgálata. Természetvéd. Közlem. 3/4, 65–70.

TÖRÖK, K., PODANI, J. 1982: A numerical analysis of karstic bush forests of Gerecse Hills, Hungary. Documents phytosociologiques N. S. vol. 6, 339–354.

TÓTHI SZABÓ, S., 1880: Az erdei és fekete fenyő (*Pinus sylvestris* et *austriaca*) elterjedése és a befásítási ügy Somogymegyében. Erdészeti Lapok 19, 415–422.

UDVARDY, L., 1998a: Spreading and coenological circumstances of the tree of heaven (*Ailanthus altissima*) in Hungary. Acta Bot. Hung. 41, 299–314.

UDVARDY, L., 1998b: Classification of adventives dangerous to the Hungarian natural flora. Acta Bot. Hung. 41, 315–331.

VALTCHEV, V., NIKOLOV, V. 1993: Production primaire d'un écosystéme forestier á *Pinus nigra* de la reserve »Tchervenata Stena«, en Bulgarie. Belg. Journ. Bot. 126, 164–174.

VEPERDI, G., 1988–89: Feketefenyő ültetési hálózati kísérlet dél-alföldi homoktermőhelyen. Erdészeti Kutatások 80/81, 123–132.

VEPERDI, G., 1990–91: Arid homoktermőhelyek *Pinus nigra* Arn. fafajjal történő hasznosítása Magyarországon. Erdészeti Kutatások 82/83, 391–397.

VEPERDI, G., 1993: A Duna-Tisza közi feketefenyő ültetési hálózati és erdőnevelési vizsgálatának újabb eredményei. CSc theses, Hung. Acad. Sci., Budapest.

WENDELBERGER, G., 1980: Streuvorkommen der Schwarzföhre (*Pinus nigra* Arn.) am Alpenostrand. Acta Bot. Acad. Sci. Hung. 26: 209–221.

ZÓLYOMI, B., 1942: A középdunai flóraválasztó és a dolomitjelenség. Die Mitteldonau--Florenscheide und das Dolomitphänomen. Bot. Közlem. 39, 209–231.

ZÓLYOMI, B., 1955: Hozzászólások és zárszó a fásítási ankét előadásaihoz. Az erdő 4, 494–496.

ZÓLYOMI, B., 1958: Budapest és környékének természetes növénytakarója. In: Pécsi, M. (ed.), Budapest természeti képe, 511–642. Akadémiai Kiadó, Budapest.

ZÓLYOMI, B., 1987: Coenotone, ecotone and their role in preserving relic species. Acta Bot. Hung. 33, 3–18.