ACTA UNIVERSITATIS AGRICULTURAE ET SILVICULTURAE MENDELIANAE BRUNENSIS

Volume 63 157 Number 5, 2015

http://dx.doi.org/10.11118/actaun201563051453

STYLIZATION: A METHOD FOR PRESERVING THE CHARACTER OF CLIMATE SENSITIVE HABITATS. A CASE STUDY OF ACIDOFREQUENT MIXED FORESTS

Ákos Bede-Fazekas[1,2], Imelda Somodi[2]

[1] Department of Garden and Open Space Design, Faculty of Landscape Architecture, Corvinus University of Budapest, Villányi út 29-43, H-1118 Budapest, Hungary

[2] MTA Centre for Ecological Research, Institute of Ecology and Botany, Alkomány u. 2-4, H-2163 Vácrátót, Hungary

Abstract

BEDE-FAZEKAS ÁKOS, SOMODI IMELDA. 2015. Stylization: a Method for Preserving the Character of Climate Sensitive Habitats. A case Study of Acidofrequent Mixed Forests. *Acta Universitatis Agriculturae et Silviculturae Mendelianae Brunensis*, 63(5): 1453–1458.

Stylization is a common method of ornamental plant use that imitates nature and evokes the scenery. This paper discloses a not yet proposed aspect of stylization, since the method offers the possibility of preserving the physiognomy of those habitats that seem to vanish due to future climate change. In addition, novelty of the method is founded also on that vulnerability of the Hungarian habitats has been examined by the researchers only from the botanical and ecological point of view so far and not in terms of its landscape design value.

In Hungary, acidofrequent mixed forests appear to be highly sensitive to climate change according to ecological models. We are going to discuss the methodology of stylization of climate sensitive habitats and briefly refer to acidofrequent mixed forests as a case study. Those coniferous and deciduous tree species of the studied habitat that are water demanding are proposed to be substituted by drought tolerant ones with similar characteristics, and an optionally expandable list of these taxa is presented. Based on this the authors suggest experimental investigations of those of the proposed taxa for which the higher drought tolerance is based on observations only.

Keywords: climate change, ornamental plant, dendrology, adaptation

INTRODUCTION

Stylization and Climate Change

Stylization is a method of ornamental plant use usually applied in artificial (mainly urban) open spaces and garden design based on aesthetic consideration. Among others, a well-known example of stylization of the character of distant landscapes is the Mediterranean garden. There are, however, very few suggestions for the stylization of native habitats of Hungary (poplar-juniper steppe woodlands and downy oak scrub woodlands; Schmidt (2003)). The character of some of the native habitats has a value that is not exceeded by the often evoked Mediterranean, Alpine and humid subtropical habitats in any way. From a novel point of view, stylization of natural or semi-natural habitats can sometimes serve as a method for preserving the physiognomy of the plant associations that may be affected by the climate change of the 21st century.

Climate change might affect species and communities in several ways including phenological and genetic change, horizontal and altitudinal shift of the distribution range and the change of its scale, and the disintegration of the complex net of relationships among the communities (Kovács-Láng *et al.*, 2008; Czúcz, 2010; Peñuelas *et al.*, 2013). Different habitats are not affected in the same way by the changing climate. Some (particularly zonal) woodland habitats in Hungary might probably be highly sensitive to climate change (Czúcz, 2010; Czúcz *et al.*, 2011; Kelemen *et al.*, 2013).

According to the results of regional climate models, the mean and, even more so, maximum temperature might increase in Hungary. The mostly affected season is the summer. In addition, precipitation seasonality may significantly change in the future, and therefore the climate is projected to be considerably drier.

According to four climate models, based on the scenario SRES A2, in the period of 2035–2065 the mean temperature of the warmer half-year will increase more (1.8–2.9 °C) than that of the colder half-year (1.5–2.3 °C). In the warmer half-year the amount of precipitation is predicted to rather decrease ((–14.2%)–(+0,4%)), while in the colder half-year it is predicted to increase or decrease ((–3.3%)–(+7.0%)) (Czúcz, 2010).

Acidofrequent Mixed Forests

Most of the forests of Hungary are deciduous. Those forests that are mixed with coniferous species are edaphic and classified accordingly. The General National Habitat Classification System (Á-NÉR) distinguishes calcareous Scots pine forests (N2) and acidofrequent mixed forests, also known as acidofrequent coniferous forests (N13) (Bölöni *et al.*, 2011). We are going to overview the distribution, species composition, and the possibilities of stylization of acidofrequent mixed forests as a case study. The habitat category N13 includes the associations of *Bazzanio-Abietetum* (fir-spruce forests), *Aulocomnio-Pinetum* (pine-oak forests with a thick moss layer), and *Genisto nervatae-Pinetum sylvestris* (acidofrequent pine-oak forests) (Borhidi, 2007). The native distribution of these associations is localized in the southern part of Western Transdanubia (Vendvidék, Őrség, and the western part of Felső-Kemeneshát and Kerka Valley).

Acidofrequent mixed forests typically occur at acidic bedrock (always free from lime), usually pseudogley, gritty, clayey loam (Bölöni *et al.*, 2008). Although they are not zonal associations (Tímár, 2002), the climate is typically balanced, and the amount of precipitation is high.

The studied habitat subtypes share the following characteristics: mixed upper tree layer (containing both deciduous and coniferous species), herb layer rich in acidofrequent species, and rich moss layer. The physiognomy and species pool of the subtypes are strongly determined by the dominant coniferous species that can be Norway spruce (*Picea abies* (L.) H. Karst.) or Scots pine (*Pinus sylvestris* L.). The upper tree layer of the monodominant Scots pine forests is usually very open. Under the upper tree layer one can usually find a deciduous, more or less closed lower tree layer. If the soil is richer in nutrients, the upper tree layer is mixed with deciduous tree species as well, while the lower tree and shrub layers are sparse. Species with climax character (e.g. *Quercus petraea* (Matt.) Liebl., *Qu. robur* L.) and pioneer species (*Betula pendula* Roth, *Populus tremula* L.) mix in the tree layer. A common subtype of mixed pine forests is a *Pinus sylvestris* dominated forest with mostly shade tolerant deciduous tree species (*Fagus sylvatica* L., *Carpinus betulus* L.) in the lower layer (Bölöni *et al.*, 2011). In addition to the aforementioned species *Quercus cerris* L. and *Sorbus aucuparia* L. can occur (Kárpáti and Terpó, 1971).

The herb layer of acidofrequent pine forests is diverse. In the subtype of open heaths with mosses of the *Polytrichastrum* genus, light demanding and acidofrequent, xerophilous species are typical (chiefly *Calluna vulgaris* (L.) Hull, and some other chamaephyta, nanophanerophyta plants). In the typical pine forest subtype one can commonly find mesophilous species that are sporadic in the subtype with greater deciduous ratio (Bölöni *et al.*, 2011). The herb layer is also rich in acidofrequent species (Czóbel, 2007). The development of the moss layer is typically inversely related to the cover of leaf-litter, and is often high (up to 60%; Bölöni *et al.*, 2011).

The tree structure of spruce forests is very diverse too. The cover of Norway spruce is commonly 40–70%, the species is intermingled mainly with deciduous trees (*Acer pseudoplatanus* L., *Fagus sylvatica*, *Carpinus betulus*, and *Alnus glutinosa* (L.) Gaertn.) or in some case with Scots pine (Bölöni *et al.*, 2011). *Alnus glutinosa* is commonly found in the bottom of the valleys (Kárpáti and Terpó, 1971). Other subordinated species can be *Castanea sativa* Mill., *Alnus viridis* (Chaix) DC., and *Sorbus aucuparia*.

The undergrowth of the natural spruce forests is very diverse, since it is the mixture of the undergrowth of mesophilous deciduous forests, the species of acidophilous forests, and that of the humid riverine woodlands (Bölöni *et al.*, 2007).

The shrub layer of the subtypes can be discussed jointly. This layer is often missing or if not, then it is dominated by the species characteristic for deciduous forests. Besides the growing saplings one can often find *Crataegus laevigata* (Poir.) DC., *Daphne mezereum* L., *Rubus* spp., *Frangula alnus* Mill., *Betula pubescens* Ehrh., *Salix cinerea* L., and *S. aurita* L.. *Alnus viridis* occurs as a subordinate species in the Vendvidék; *Juniperus communis* L. can occur in the forest fringe and in open stands (Bölöni *et al.*, 2011). The shrub layer of the oak-pine mixed forests is relatively rich (*Ligustrum vulgare* L., *Rosa gallica* L.) (Kárpáti és Terpó, 1971). The presence of *Sambucus nigra* L. is typical in the spruce forests (Bölöni *et al.*, 2007). One can find a more detailed review of the acidofrequent mixed forests provided by Pócs (1960), Pócs (1968), and Borhidi (2007).

MATERIALS AND METHODS

Stylization as a Plant Application Method

According to Schmidt (2003) one can influence the character of a garden and evoke the atmosphere of a certain landscape deliberately by stylizing a plant association found to be typical in that landscape. The method is about evoking the character (forms, color dynamics, volume and space proportions, and other characteristics) of the vegetation of an association/habitat/landscape at different locations, at different times, under different climatic conditions, using primarily ornamental plants. The archetypes of stylization for someone searching for particular and novel things are typically the foreign, distant landscapes and unusual associations. In addition to the plants of landscapes distant in the space, distance in time might also be interesting for some associations. For example those, the current distribution range of which is likely to decrease due to climate change. In that case, stylization serves as a method for preserving the character of the habitat as a memento.

Hence stylization is not bound to the original location of the habitat and therefore does not aim at contributing to habitat restoration. Due to the tightness of the available space and the high number and nearness of artificial elements, these plant assemblages are not to be handled as the occurrence of the given association. Stylization has only garden and open space design and dendrological significance. For stylization, garden architecture methods are applied instead of restoration techniques usually used in natural environment. Although the two approaches differ from each other in terms of both their methods and their aims, stylization can utilize the experience accumulated during habitat reconstructions and the knowledge amassed by ecologists. For example, during stylization in built environment it is proposed to apply as many native species as possible. In the course of stylization one should try to select non-invasive species, i.e. which are not going to invade spontaneously the surrounding natural habitats. Whenever one would like to apply species previously not extensively planted one should review the European experiences about their spontaneous occurrence since they were introduced there. We can harm our natural habitats by planting unknown species that can have an invasive character without careful consideration.

Stylization of Climate Sensitive Habitats

The stylization of climate sensitive habitats is closely bound to the ecological ornamental plant application approaches. Stylization can be seen as a nature-imitating plant application which evokes the scenery rather than an ecological plant application which assists the processes and functions observed in the nature. It would be impossible to review the huge literature of the topic here, for ecological plant applications are well summarized by Dunnett and Hitchmough (2004).

In the course of stylization characteristic species of the original association are planted or replaced by taxa with similar appearance compared to the original species (Schmidt, 2003), at a different location and a different time. The design is materialized almost always in built environment. Forming a plant cluster confusingly similar to the original habitat is not the aim of stylization; its objective is rather to evoke the atmosphere and the impression and revive memories. A detailed ornamental planting design which specifies the species can only be given once the location is selected. In the course of stylization of a climate sensitive habitat of Hungary one should find some stand forming taxa that look similar to, but are more drought tolerant than characteristic to the model habitat. We mention, however, that some of these plant species might be frost sensitive or have other features that limits the possibility of their application. Since stylization is often, but not always, carried out in urban environment, one should take the special soil conditions into consideration. Although soil replacement before planting is a method often proposed by landscape architects, it is extremely expensive in case of planting large trees. Hence, more alkaline/calcareous, drier, compacted and therefore more airless soils might provide planting environment not suitable for all the taxa. Thus experimental research of the proposed taxa whose environmental demands are only partially known is highly recommended. Besides the appearance of the taxa, this paper considers only the drought tolerance. The proposed taxa are more drought tolerant than the evoked ones. This information is based on empirical knowledge (if other source is not mentioned), literature, or inspection of the distribution ranges.

According to predictive vegetation models climate sensitivity of acidofrequent mixed forests is predicted to be considerable. The results of the regression tree model of Czúcz (2010) showed that among native habitats the most sensitive one is the acidofrequent mixed forest, with a sensitivity of 97% and a 100% dominance of climatic variables. A new model was run by the authors to affirm this result. The original model was built by Somodi *et al.* (2009), and now we project it to a prediction period centered for 2050 and to the entire territory of Hungary.

RESULTS AND DISCUSSION

Climate Sensitivity of Acidofrequent Mixed Forests

We selected from the numerous habitats found in Hungary the acidofrequent mixed forests that is in all likelihood greatly affected by climate change. We have confirmed the climate sensitivity of the studied habitat by a Boosted Regression Tree (BRT; Elith *et al.*, 2008) model based on the GCM HadCM3 (IPCC Data, 2010).

According to the model results and the supplementary knowledge, acidofrequent mixed forests are very sensitive habitats and their native distribution is expected to retract in the future.

Preservation of the habitat or the assurance of the optimal conditions for natural succession towards other habitats is the task of nature conservation. Since the habitat will not be self-sustainable in its current Hungarian distribution range, its stands will probably transform even if human action only allows for natural processes. Traditional land use may delay the retraction of acidofrequent mixed forests but in the case of a considerable climate change, as it is predicted to happen in the future, conservation by land use might become impossible, too. By the method of stylization the character can be preserved as a memento in the form of plantings in open spaces and gardens of built environment.

Stylization of Acidofrequent Mixed Forests

The main result of our research is the conceptual innovation that expands the current aims of stylization. This chapter is going to demonstrate the possibility of stylizing acidofrequent mixed forests in terms of evoking the character of this climate sensitive habitat in built environment and drier climate. Through the case study of the studied habitat, our study demonstrates that stylization could be used as a method of preserving the character of vanishing habitats.

The character of the studied habitat is determined chiefly by the tree species forming the canopy layer but the presence/absence of the shrub layer and the character of the undergrowth are significant, too. In the case of the spruce forests, the lying and standing dead wood are remarkable visual elements (Bölöni *et al.*, 2011) that are partially evocable. The two most important species of the tree layer are Scots pine and Norway spruce. Scots pine has wide climatic tolerance (Gencsi and Vancsura, 1997) and is only slightly sensitive to climate change (Bartha and Zagyvai, 2014). Anyway, in order to increase the dendrological diversity of the garden one might want to apply other species. It seems to be obvious to apply black pine (*Pinus nigra* J. F. Arnold) that is viable in Hungary. There are serious counter-arguments, however, such as its invasiveness (Mihály and Botta-Dukát, 2004) and its different crown structure and bark color. Several other species from the genus can, however, be mentioned as the potential evoker of *Pinus sylvestris*, such as the highly similar Japanese red pine (*Pinus densiflora* Siebold & Zucc.) that has an expressive common name in Hungarian: 'Scots pine of Japan', pitch pine (*Pinus rigida* Mill.), Japanese black pine (*Pinus thunbergii* Parl.) and Chinese red pine (*Pinus tabuliformis* Carriere) that are more similar to the black pine, and Monterey pine (*Pinus radiata* D. Don). Several other species from the Far East and America will probably be applicable under the future climatic conditions, though some of them have remarkably longer needles than those of the Scots pine and therefore can reflect the character of the original species to a lower degree. The typical character of the Mediterranean pines differs from that of the Scots pine. From them, Turkish pine (*Pinus brutia* Ten.) seems to be the most applicable.

In the case of the Norway spruce, however, the necessity to replace the tree species arises, since it is more sensitive to the change of the climate (Theurillat and Guisan, 2001). The character of the Norway spruce is well evoked by the Caucasian spruce (*Picea orientalis* (L.) Link), the Serbian spruce (*Picea omorika* (Pancic) Purk.) that has a slightly slimmer form and bluer foliage, or the dragon spruce (*Picea asperata* Mast.), the foliage of which is considerably bluer. All the three species are more drought-tolerant than the Norway spruce (Gencsi and Vancsura, 1997). In addition, the application of Koyama's spruce (*Picea koyamae* Shiras.) can also be proposed from this genus, though its crown has a different color and structure compared to the Norway spruce. Besides the spruces, we should mention the Douglas fir (*Pseudotsuga menziesii* (Mirb.) Franco) that has similar characteristics but might also have difficulties to tolerate the future climate, and some drought-tolerant fir species like the Algerian fir (*Abies numidica* de Lannoy ex Carriere) and the Taurus fir (*Abies cilicica* (Antoine & Kotschy) Carriere).

Not all the subordinated species can be replaced by more drought-tolerant taxa with similar characteristics. The pioneer-like species (*Betula pendula* and *Populus tremula*) are also present in southern, warmer and more arid locations than the Carpathian Basin (EUFORGEN, 2009a; EUFORGEN, 2009b). In the course of stylization one will probably be able to apply these species without any problems. Nevertheless, for perpetuating the character of the climax and successional species it is worthwhile to look for similar species that are more drought-tolerant. Naturally these can only partly evoke the character of the original habitat. Instead of *Quercus petraea* and *Qu. robur* one can apply species such as the pubescent oak (*Quercus pubescens* Willd.) that has a size commensurable with the typical garden spaces (but it is more symmetrical and larger when planted than the specimens found in nature), Algerian oak (*Quercus canariensis* Willd.), or perhaps the Turkey oak (*Quercus cerris*). In addition some American oak species could be applied. We should also mention the chestnut-leaved oak (*Quercus castaneifolia* C. A. Mey.), that also evokes the sweet chestnut (also present in the original habitat). The predicted future climate will, however, probably not have a negative effect on the sweet chestnut. *Fagus sylvatica* may be replaced by the oriental beech (*Fagus orientalis* Lipsky) that has a slightly lighter bark and is, based on its distribution range, presumably more drought-tolerant than its native relative (Kandemir and Kaya, 2009). However, there is no introduction experience with the species in Hungary. The character (bark pattern and color, branch and trunk structure, fruit, plasticity) of *Carpinus betulus* is reflected by the oriental hornbeam (*Carpinus orientalis* Mill.) that has weaker growth and smaller leaves. A good alternative to *Acer pseudoplatanus* is Heldreich's maple (*Acer heldreichii* Orph. ex Boiss.) and velvet maple (*Acer velutinum* Boiss.). Although its leaf shape differ from both of the species and is not to be planted in very dry soil, Italian alder (*Alnus cordata* (Loisel.) Duby) can replace *Alnus glutinosa* and *Alnus viridis*, since it originates from warmer climatic conditions than Hungary's and it can even tolerate moderate drought (Tóth, 2012). Instead of *Sorbus aucuparia* one can plant Japanese rowan (*Sorbus commixta* Hedl.) or one of the hybrid species of the *S. aucuparia* – *S. aria* transition, e.g. Borbás' rowan (*Sorbus borbasii* Jav.) and hybrid service tree (*Sorbus* × *thuringiaca* (Nyman) Schonach).

The character of the shrub and herb layer can be evoked more easily, since in these layers the species have less importance, the sizes and quantities might be more relevant instead. Due to the established phytoclimate, some species of the shrub and herb layer of the original habitat may also be planted in the stylized habitat. Ferns might probably cause the greatest challenge, while narrow-leaved plants similar to sedges will easily be replaced. Most of the chamaephytes of heaths will be applicable in the future climate in Hungary. One should, naturally, take their soil demands into consideration. The dense moss coverage that is typical in the habitat can be attained by lawn-mowing with low stubble height but only in the watered or shaded parts of the garden.

CONCLUSION

Stylization of climate sensitive habitats is a novel method of garden and open space design in Hungary. According to our research, the acidofrequent mixed forest habitat might considerably be affected by the climate change predicted for the 21st century. Its natural stands are expected to retract in the future or they might vanish from the territory of Hungary. Even if stylization is not a method that could protect natural stands, it can preserve the character of the habitat. Some of the species typically found in acidofrequent mixed forests will be applicable in the course of stylization, while we provided a profuse species list for the substitution of the other ones.

In this paper we briefly discussed the method of stylization and studied acidofrequent mixed forests as a case study. Stylization that is a method of ornamental plant use usually applied in open space and garden design has been studied in terms of its aims, its ecological relations and its process. In addition we have discussed stylization from a novel point of view: stylization of climate sensitive habitats. After summarizing the predicted climate of Hungary and the climate sensitivity of acidofrequent mixed forests, proposal of stylization of the selected habitat has been provided. Although the environmental demands of some of the proposed taxa are not well known and the list of these taxa is optionally expandable, the paper presented a commonly used method in a novel aspect, and therefore provides a conceptual innovation for landscape architecture.

Acknowledgement

Ákos Bede-Fazekas was supported by the TÁMOP Operative Project [4.2.1/B-09/1/KMR-2010-0005], Imelda Somodi by the by the Hungarian Scientific Research Fund (OTKA) grant [PD-83522]. The authors would like to express gratitude to Bálint Czúcz.

REFERENCES

BARTHA, D. and ZAGYVAI, G. 2014. Jelenlegi társulások sérülékenysége, lehetséges alternatívák. In: BIDLÓ, A., KIRÁLY, A. and MÁTYÁS, C., *Agrárklíma: Az előrevetített klímaváltozás hatáselemzése és az alkalmazkodás lehetőségei*. Sopron: Nyugat-magyarországi Egyetem Kiadó.

BORHIDI, A. 2007. *Magyarország növénytársulásai*. Budapest, Hungary: Akadémiai Kiadó.

BÖLÖNI, J., MOLNÁR, Z., KUN, A. and BIRÓ, M. 2007. *Általános Nemzeti Élőhely-osztályozási Rendszer.* Vácrátót, Hungary.

BÖLÖNI, J., MOLNÁR, Z. and KUN, A. (eds.). 2011. *Magyarország* élőhelyei. *A hazai vegetációtípusok leírása* és *határozója*. ÁNÉR 2011. Vácrátót, Hungary: MTA ÖBKI.

BÖLÖNI, J., MOLNÁR, Z., BIRÓ, M. and HORVÁTH, F. 2008. Distribution of the (semi-)natural habitats in Hungary II.: Woodlands and shrublands. *Acta Botanica Hungarica*, 50(Suppl.): 107–148.

CZÓBEL, S. 2007. Fás társulások (erdők). In: TUBA, Z., SZERDAHELYI, T., ENGLONER, A. and NAGY, J. (eds.), *Botanika III. Növényföldrajz., Társulástan., Növényökológia*. Budapest, Hungary: Nemzeti Tankönyvkiadó.

CZÚCZ, B. 2010. *Az éghajlatváltozás hazai természetközeli élőhelyekre gyakorolt hatásainak modellezése*. Ph.D. thesis. Budapest, Hungary: Corvinus University of Budapest.

CZÚCZ, B., GÁLHIDY, L. and MÁTYÁS, C. 2011. Present and forecasted xeric climatic limits of beech and sessile oak distribution at low altitudes in Central Europe. *Annals of Forest Science*, 68(1): 99–108.

DUNNETT, N. and HITCHMOUGH, J. 2004. *The Dynamic Landscape: the ecology, design and* *management of naturalistic urban planting*. London, United Kingdom: E. & F. N. Spon.

ELITH, J., LEATHWICK, J. and HASTIE, T. 2008. A working guide to boosted regression trees. *Journal of Animal Ecology*, 77(4): 802–813.

EUFORGEN. 2009a. *Distribution map of silver birch (Betula pendula)*. [online]. Available at: www.euforgen.org/distribution_maps.html. [Accessed: 2013. 11. 20.].

EUFORGEN. 2009b. *Distribution map of aspen (Populus tremula)*. [online]. Available at: www.euforgen.org/distribution_maps.html. [Accessed: 2013. 11. 20.]

GENCSI, L. and VANCSURA, R. 1997. *Dendrológia. Erdészeti növénytan II*. Budapest, Hungary: Mezőgazda Kiadó.

IPCC DATA. 2010. *IPCC Data Distribution Center*. [online]. Available at: www.ipcc-data.org. [Accessed: 2010. 01. 01.].

KANDEMIR, G. and KAYA, Z. 2009. *EUFORGEN Technical Guidelines for genetic conservation and use of oriental beech (Fagus orientalis)*. Roma, Italy: Bioversity International.

KÁRPÁTI, Z. and TERPÓ, A. 1971. *Alkalmazott növényföldrajz*. Budapest, Hungary: Mezőgazdasági Kiadó.

KELEMEN, K., MAG, Z., ASZALÓS, R., BENEDEK, Z., CZÚCZ, B., GÁLHIDY, L., KOVÁCS, B., STANDOVÁR, T. and TÍMÁR, G. 2013. Hazai erdők jövője a klímaváltozás tükrében. *Természettudományi Közlöny*, 144(1): 7–10.

KOVÁCS-LÁNG, E., KRÖEL-DULAY, G. and CZÚCZ, B. 2008. Az éghajlatváltozás hatásai a természetes élővilágra és teendőink a megőrzés és kutatás területén. *Természetvédelmi Közlemények*, 14(1): 5–39.

MIHÁLY, B. and BOTTA-DUKÁT, Z. 2004. *Biológiai inváziók Magyarországon*. Özönnövények. Budapest, Hungary: TermészetBÚVÁR Alapítvány Kiadó.

PEÑUELAS, J., SARDANS, J., ESTIARTE, M., OGAYA, R., CARNICER, J., COLL, M., BARBETA, A., RIVAS-UBACH, A., LLUSIÀ, J., GARBULSKY, M., FILELLA, I. and JUMP, A. S. 2013. Evidence of current impact of climate change on life: a walk from genes to the biosphere. *Global Change Biology*, 19(8): 2303–2338.

PÓCS, T. 1960. Die zonalen Waldgesellschaften Südwestungarns. *Acta Bot. Acad. Sc. Hung.*, 6(1): 75–105.

PÓCS, T. 1968. *A magyarországi tűlevelű erdők cönológiai és ökológiai viszonyai*. Thesis. Budapest and Eger, Hungary.

SCHMIDT, G. 2003. Stilizált növénytársulások a kertben. In: SCHMIDT, G. (ed.), *Növények a kertépítészetben*. Budapest, Hungary: Mezőgazda Kiadó.

SOMODI, I., CZÚCZ, B., PEARMAN, P. and ZIMMERMANN, N. E. 2009. Magyarország potenciális vegetációtérképének modellezése. In: TÖRÖK, K., KISS, K. T., KERTÉSZ, M. (eds.), *Válogatás az MTA* Ökológiai és *Botanikai Kutatóintézet kutatási eredményeiből 2009*. ÖBKI *Műhelyfüzetek*. Vácrátót, Hungary: MTA ÖBKI.

THEURILLAT, J.-P. and GUISAN, A. 2001. Potential Impact of Climate Change on Vegetation in the European Alps: A Review. *Climatic Change*, 50(1): 77–109.

TÍMÁR, G. 2002. *A Vendvidék erdeinek értékelése új nézőpontok alapján*. Ph.D. thesis. Sopron, Hungary: University of West Hungary.

TÓTH, I. 2012. *Lomblevelű díszfák, díszcserjék kézikönyve*. Budapest, Hungary: Tarkavirág Kereskedelmi és Szolgáltató Kft.

Contact information

Ákos Bede-Fazekas: bede-fazekas.akos@okologia.mta.hu
Imelda Somodi: somodi.imelda@okologia.mta.hu