Ecological indicator based comparative study of tree of heaven (*Ailanthus altissima*) stands' herb layer

András DEMETER – Dominika FALVAI – Petra TRENYIK – Szilárd CZÓBEL

Department of Nature Conservation and Landscape Ecology, Faculty of Agricultural and Environmental Sciences, Szent István University, H-2100 Páter Károly u. 1. Gödöllő, Hungary. Email: demetex@gmail.com

Abstract: Tree of heaven (*Ailanthus altissima*) is one of the most dangerous and spread woody-stemmed invasive plant species in Hungary. By its nature it transforms its environment and reduces the biodiversity of the area. These processes can be observed studying species composition of habitats heavily infected by tree of heaven. In our research we studied the herb layered species composition of plant communities that were tree of heaven dominated in canopy in Fót, Gyermely, Makád and Tököl. After determining the species associated Borhidi's relative ecological indicators and Raunkiaer's life-forms have been applied and analysed for the distribution of the categories. Accordingly most of the species occurring in the herb layer of studied areas were herbaceous. In these stands disturbance tolerant species, generalists and weed species are common, but more, aggressive competitors also appear. These species are indicators of degraded and disturbed habitats however there was also a protected area (Fóti-Somlyó). Summing the indicators of relative temperature figures it can be stated that most of the species indicated the relative temperature demand of submontane broad-leaved forests. According to wetness requirement of the species, studied tree of heaven stands were semihumid. Looking at the relative nitrogen figures, species show a wide variety, but most of them indicate a moderately nutrient-rich, or richer habitat. On herb layer halflight plant species prevailed which indicates that these tree of heaven infected stands were less closed, allowing more light to come down to the herb layer. In continentality suboceanic and intermediate types dominated. The majority of the species is halophob, that does not tolerate the salty environment.

Keywords: tree of heaven, stands, herb layer, relative ecological values, life-form

Introduction

By development of transport, trade, industry and agriculture man dragged or immigrated more and more animal and plant species into areas far from these species habitats. These species often become successful invaders and by its strong spreading and environmental conversion activities threaten the ecosystem of the habitats. In our days invasive species connected conservational and economical losses are so huge, that to fight them became necessary (Csiszár 2012).

Mihók *et al.* (2014) during their research – in which they collected the currently most important questions of the Hungarian conservation – invasive species also came to the focus moreover tree of heaven has been highlighted. In 1998 in a workshop in Jósvafő this species was ranked among the 36 most dangerous species in Hungary (MÁT 2007). Tree of heaven is also on the list of Europe's 100 most dangerous invasive species compiled by DAISIE (Delivering Alien Invasive Species Inventories for Europe) (2006) and has the area of temperate and Mediterranean climate of the 5 continents (Kowarik & Böcker 1984).

Today tree of heaven can be found in a large part of Hungary, mostly on warmer hilly and plain areas (Udvardy & Zagyvai 2012), and it is present in a total of 12 different A-NER habitat types as one of the 3 most spread invasive plant species (Demeter *et al.* 2016). In Hungary it is receiving increasing attention, several publication has published about its spread, damage and potential usability. These have been summarized by Csiszár (2007) earlier and by Demeter and Czóbel (2016) last time. Most intensively Udvardy went in for ecological effects of the species. His results prove that tree of heaven transforms its environment and in these infected stands proportion of specialists is decreasing and proportion of competitors is increasing. It happens first because of allelopathic compounds releasing from its roots, and later by increasing shading than by the nitrogen enrichment effect of the large amount of falling leaves. In these stands nitrophilic, disturbance tolerant, shadow tolerant plant species appear with time (Udvardy 1997; 1998a; 1998b; 2004; Udvardy

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& Facsar 1995; Udvardy & Zagyvai 2012). In this article we study the herb layer of areas heavily infected by tree of heaven and we typify it based on Borhidi's (1995) ecological indicators of plant species found there.

Material and methods

For our research we looked for areas heavily infected by tree of heaven with different characteristics and a minimum of 70 % tree of heaven coverage in the canopy. Besides this we wanted the study areas not to be close to the roads in order to avoid the effect of this kind of disturbance on our results. Based on recommendation from the professionals of Pilisi Parkerdő a total of 21 quadrats have been marked out in four areas: Foti-Somlyó, Gyermely, Makád and Tököl in which investigations were conducted. The quadrats of Fót had southern and western exposure with 0-40° slope and altitudes of 179 to 199 m. Tree of heaven trees had an average height of 15 m, 3,5-14,2 cm average and 6-43 cm maximum stem diameters at breast height, seed and sprout origin estimated. The quadrats of Gyermely had southern and eastern exposure with 5-40° slope and altitudes of 183 m. Tree of heaven trees had an average height of 17-20 m, 15,4-24,9 cm average and 25-33,5 cm maximum stem diameters at breast height, seed origin estimated. The quadrats of Makád had eastern exposure with 0-2° slope and altitudes of 96 m. Tree of heaven trees had an average height of 16-18,5 m, 10,5-12,8 cm average and 14-22 cm maximum stem diameters at breast height, seed origin estimated. The quadrats of Tököl were flat and had altitude of 100 m. Tree of heaven trees had an average height of 7-9,5 m, 3-4,5 cm average and 4,8-8 cm maximum stem diameters at breast height, seed origin estimated. After choosing the study areas we marked the corners of the typically square shaped, 10 square meter sized quadrats visibly with colourful marker, than we recorded the GPS coordinates of their center. For this we used Garmin eTrex 20x. Thereafter we estimated % of coverage total and for each representing species for each layer in the quadrats. Exposure, gradient, typical height of the trees and estimated origin of tree of heaven stands have also been recorded for each quadrat. It was important to wait until tree of heaven is completely leafy so data recording has been carried out on 07.06.2016 in Fót, 06.07.2016 in Gyermely and on 20.07.2016 in Makád and Tököl. The data were organized and arranged in Microsoft Excel program. From Borhidi' ecological indicators SBT (Social Behaviour Type), TB (relative temperature figures), WB (relative moisture figures), NB (nitrogen figures), LB (light figures), KB (continentality figures), SB (salt figures) and Raunkier's life-form type have been assigned to the species occurred in our quadrats. After these – managing the different indicators separately – by summarizing data we could typify the vegetation of studied tree of heaven stands. Figures were prepared by SigmaPlot 8.0 program.

Results and discussion

SBT (Social behaviour type)

Plant species found in the studied areas could be classified to 10 groups (Figure 1.) From these, disturbance tolerant species (DT) and generalists (G) were represented with the highest number of species, but proportion of native weed species (W) in Fót and alien competitors (AC) in species poor Tököl was also significant.

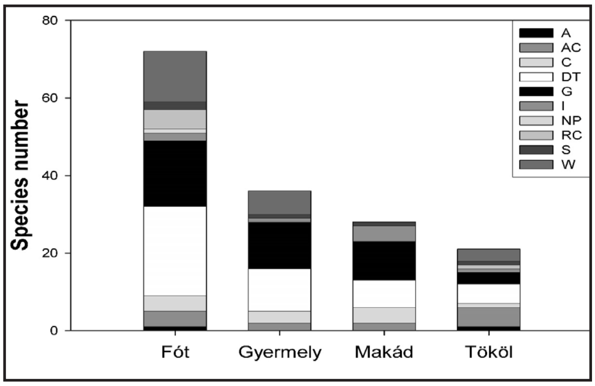

Figure 1. Distribution of Borhidi's social behaviour types of plant species occur in the studied sample areas Categories: A (Adventitious weeds); AC (Alien competitors); C (Natural competitors); DT (Disturbance tolerant plants of natural habitats); G (Generalists); I (Introduced crops running wild); NP (Natural pioneers); RC (Ruderal competitors of the natural flora); S (Specialists); W (Native weed species)

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TB (relative temperature figures)

The species represent 5 categories of relative temperature figures: from montane needle-leaved forest or taiga (TB_4) to submediterranean woodland and grassland (TB_8) (Figure 2.). Most of the species occurring on the studied areas indicated relative temperature demand of submontane broad-leaved forests (TB_6), the montane mesophilous broad-leaved forests (TB_5) furthermore thermophilous forest or woodlands (TB_7), thus they have middle or bigger temperature demand. These are followed by species of submediterranean woodlands and grasslands (TB_8). Relative temperature demand of montane needle-leaved forests or taigas (TB_4) is represented only by one species in Makád.

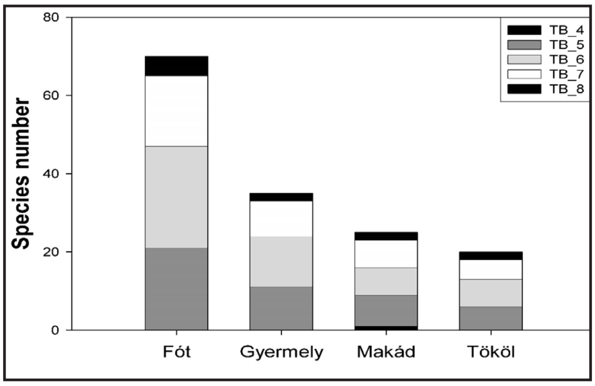

Figure 2. Distribution of Borhidi's relative temperature figures occurring on the studied sample areas. Categories: TB_4 (montane needle-leaved forest or taiga belt); TB_5 (montane mesophilous broad-leaved forest belt); TB_6 (submontane broad-leaved forest belt); TB_7 (thermophilous forest or woodland belt); TB_8 (submediterranean woodland and grassland belt)

WB (relative moisture figures)

Looking at relative moisture figures, types between xero-indicators (WB_2) and plants of wet soils (WB_9) were present. (Figure 3). Plants of semihumid habitats (WB_5) were dominant in 3 stands, but in Fót plants of semidry habitats (WB_4), plants of semihumid habitats (WB_5) and the xero-tolerants (WB_3) were present. Xero-indicators (WB_2) only here were found.

NB (nitrogen figures)

On the studied areas mostly categories between habitats very poor in N (NB_2) and hyperfertilized soils (NB_9) were found except for the area of Fót where 5 species were present indicating soils

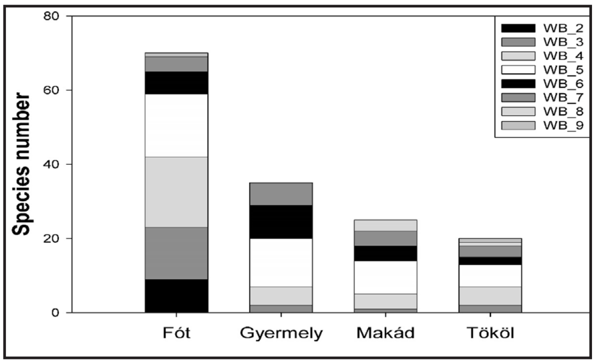

Figure 3. Distribution of Borhidi's relative moisture figures occurring on the studied sample areas. Categories: WB_2 (xero-indicators on habitats with long dry period); WB_3 (xero-tolerants, but eventually occuring on fresh soils); WB_4 (plants of semidry habitats); WB_5 (Plants of semihumid habitats, under intermediate conditions); WB_6 (plants of fresh soils); WB_7 (plants of moist soils not drying out and well aerated); WB_8 (plants of moist soils tolerating short floods); WB_9 (plants of wet, not well aerated soils)

extremely poor in mineral N (NB_1). This area has been proven to be diverse in relative nitrogen demand as all occurring categories were presented by more species, and no significant number of species in either could be observed. Most species (15) were plants of soils rich in mineral nitrogen (NB_7). In Gyermely and Tököl plants had mostly medium (NB_5) or higher relative N demand, and in Makád plants of submesotrophic habitats (NB_4) were rather typical.

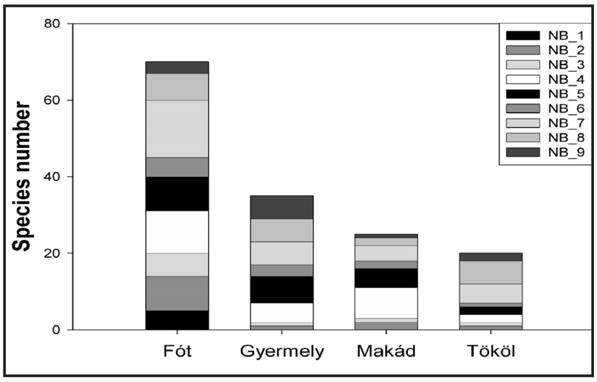

Figure 4. Distribution of Borhidi's nitrogen figures occurring on the studied sample areas. Categories: NB_1 (only in soils extremely poor in mineral nitrogen, plants); NB_2 (plants of habitats very poor in nitrogen); NB_3 (plants of moderately oligotrophic habitats); NB_4 (plants of submesotrophic habitats); NB_5 (plants of mesotrophic habitats); NB_6 (plants of moderately nutrient rich habitats); NB_7 (plants of soils rich in mineral nitrogen); NB_8 (N-indicator plants of fertilized soils); NB_9 (plants only on hyperfertilized soil, extremely rich in mineral nitrogen (indicating pollution, manure deposition)

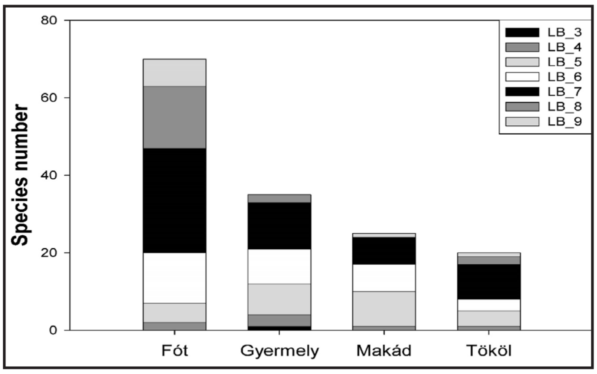

Figure 5. Distribution of Borhidi's light figures occurring on the studied sample areas. Categories: LB_3 (shadow plants; photosynthetic minimum under 5% relative light intensity, but survive more illuminated places); LB_4 (shadow-halfshadow plants; photosynthetic minimum between 5 and 10% rel. light intensity); LB_5 (halfshadow plants receiving more than 10% but less than 100% rel. light intensity); LB_6 (halfshadow-halflight plants; photosynthetic minimum between 10 and 40% rel. light intensity); LB_7 (halflight plants; mostly living in full light but also shadow tolerants); LB_8 (light plants; photosynthetic minimum above 40% rel. light intensity, less only in exceptional cases); LB_9 (full light plants of open habitats not receiving less than 50% of rel. light intensity)

LB (light figures)

In each area 6-6 relative category of light figures are present from the shadow plants (only in Gyermely) to the full light plants (Figure 5). In general it can be said that quadrats are characterized by halfshadow plant, halfshadow-halflight plant and halflight plant species.

KB (continentality figures)

Among groups characteristic for continentality we could find species between oceanic (only in Fót and Tököl) and continental (only in Fót and Makád) categories (Figure 6). In the highest proportion intermediate, oceanic-suboceanic and suboceanic species occurred.

SB (salt figures)

Regarding the salt resistance, studied areas showed a very similar picture (Figure 7). Total of 3 categories are present. Most of the species are considered as halophob, but we found on all of the four areas Beta- mesohaline species, furthermore salt tolerant plant species on Fót and Makád.

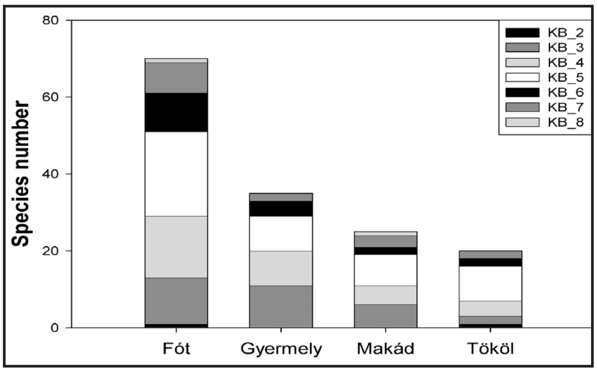

Figure 6. Distribution of Borhidi's continentality figures occurring on the studied sample areas. Categories: KB_2 (oceanic species, mainly in West Europe and western Central Europe); KB_3 (oceanic-suboceanic species, are in whole Central Europe); KB_4 (suboceanic species, mainly in Central Europe but reaching to East); KB_5 (intermediate type with slight suboceanic-subcontinental character); KB_6 (subcontinental, main area in eastern Central Europe); KB_7 (continental-subcontinental species main area in East-Europe); KB_8 (continental species reaching only eastern part of Central Europe)

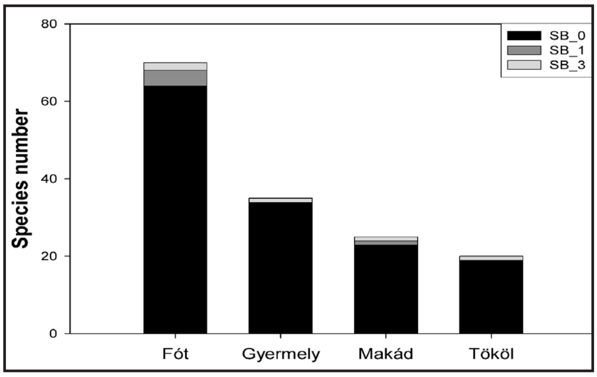

Figure 7. Distribution of Borhidi's salt figures occurring on the studied sample areas. Categories: SB_0 (Halophob species non occurring in salty or alkalic soils); SB_1 (salt tolerant plants but living mainly on non-saline soils); SB_3 (Beta-mesohalin plants living on soils of intermediate chloride content)

Life form

Species found on the studied areas could be classified to 12 life form categories (Figure 8). From these, on Fót hemikryptophyta and therophyta, on Gyermely hemikryptophyta and phanerophyta, on Makád phanerophyta, and on Tököl hemikryptophyta species were dominant. According to this, on Makád mostly woody- stemmed, and on the other three areas mostly herbaceous species could be found in the herb layer.

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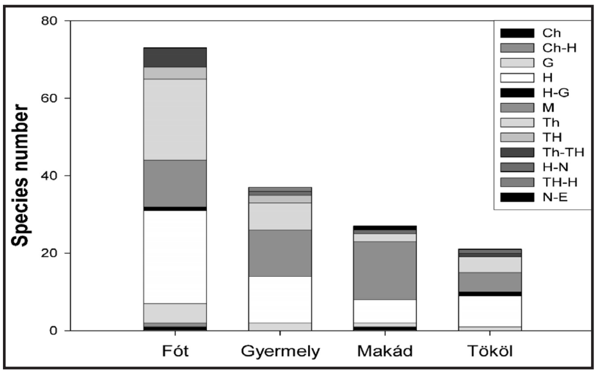

Figure 7. Distribution of Raunkiaer's life forms occurring on the studied areas. Categories: Ch (Chamaephyta); G (Kryptophyta); H (Hemikryptophyta); M (Phanerophyta); Th (Therophyta); TH (Hemitherophyta); E (Epiphyta)

Conclusions

Most of the examined ecological indicators (e.g. SBT, WB, NB, LB, KB, life forms) were represented in a significant number in most of the study areas, which may indicate the habitat transforming effect of spreading *Ailanthus altissima*. For example its falling foliage that increases N content of the soil (Csiszár 2012) can be one of the reasons why this many categories are represented in the studied stands.

In comparison of the studied areas based on the number of species (76) and occurring social behavior, continentality, relative nitrogen demand and life-form types, it can be concluded that the herb layer of Fóti-Somlyó proved to be much more diverse than the others, which is probably explained by this tree of heaven stocks' lower closure, by this habitats' more mosaic nature and by meeting of the highland and plain flora here. Most of the species being present here, are disturbance tolerant or generalist, halflight (according to this tree of heaven did not close above that), but shadow tolerant, with intermediate continentality, halophob herbaceous plants which indicate semidry or semihumid habitats that is rich in nutrients, and belongs to relative temperature demand of submontane broad-leaved forests. Regarding the number of occurring species (37) Gyermely area is the second one. We encountered here mostly generalists and disturbance tolerant, halflight but shadow tolerants with oceanic-suboceanic continentality, halophob herbaceous and woody-stemmed plants which indicate semihumid or fresh habitat that is richer in nutrients, and belongs to temperature demand of submontane broad-leaved forests.

Less species (28) than the above mentioned were found in Makád. On this sample area we found mostly generalist, halfshadow plants with intermediate continentality, halophob woody-stemmed plants which indicate semihumid habitat that is submesotrophic or richer in nutrients and belongs to temperature demand of submontane broad-leaved forests. From our sample areas this is the lowest, and the closest to Danube, which assumes more favorable hydrological circumstances. The latter is confirmed by the highest proportion of WB7's and WB8's categories.

The least number of species (21) was found in herb layer of Tököl area. The bigger part of these consists of disturbance tolerants and alien competitors, which are halflight plants, with mostly intermediate continentality, halophob herbaceous plants. They indicate semihumid or fresh habitat that is richer in nutrients and belongs to temperature demand of submontane broad-leaved forests.

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