Hungarian University of Agriculture and Life Sciences (MATE)

EFFECTS OF FEEDING PLACES FOR HUNTING PURPOSES ON VEGETATION, SEED BANK AND SOIL IN THE MÁTRA MOUNTAINS

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1. Background and objectives

The effects of wild game feeding, and especially supplementary feeding, have already been widely investigated, but mostly the animal species and their populations have been in the focus (Inslerman et al. 2006; Richardson 2006; Milner et al. 2014). In general, the effects on natural vegetation have received less attention, even though healthy and species-rich undergrowth plays a primary role in the functioning of natural forest ecosystems and in providing the natural food supply for ungulates (Riggs et al. 2004). Most studies have examined species important to agriculture and forestry, primarily the browsing of shrubs and seedlings, as well as its spatial and temporal changes (Milner et al. 2014), while changes in herbaceous vegetation have been less researched (Rinella et al. 2012), these feeding grounds are typically only mentioned as potential sources of exotic species (Kosowan & Yungwirth 1999; Spurrier & Drees 2000). In addition, significant number of the related studies were published in North American and Northern European areas, and here, too, only the effects of winter supplementary feeding were examined (Inslerman et al. 2006; Milner et al. 2014).

In our country, literature on similar topics only occurs sporadically. Some research examining game preserves mention feeding places as weedy areas that strongly affected by degradation (pl. Heltai & Sonkoly 2009; Bleier et al. 2006), but none of them focused on the examination of weeds and/or invasive plant species that spread around bait sites until recently. In fact, in Europe, this type of game feeding is not only centuries old, but also presumably of Hungarian origin. Aldo Leopold, researching the history of game feeding, was the first on the continent in Hungary to mention this method in addition to supplementary feeders at the end of the 1700s, when the aim is to improve the hunting opportunities through grains placed for wild boar ("*grain-baiting of wild boars to decoy them within range of blind"*) (Leopold 1933). Since then, shooting of wild boars at feeding grounds has been very popular on the continent and has become a very popular and widely used practice, especially in Eastern and Central Europe (Apollonio et al. 2010). This is also true in Hungary: in the Hungarian colloquial language, the so-called locations known as *bait sites* are very widespread throughout the country, and they are typically used quite intensively (Nagy 2004). Diverse and usually a very large amounts of feed are dumped on these sites, which – knowing the significant weed seed content of different forage (Wilson et al. 2016; Gervilla et al. 2019) – represents growing threat to the surrounding natural habitats. In addition, the process is extremely complex, as it is not only about the addition of external propagule sources, thus the direct influence of below- and above-ground vegetation. The increased amount of litter caused by the remaining forage and the increased density of animals (Malo et al. 2000), as well as the regular disturbance caused by animals (Barrios-Garcia & Ballari 2012) can change the nutrient content and main physical and chemical parameters of the soil. In addition, the anthropogenic disturbances associated with feeding activity, as well as the changed animal behaviour (e.g. Arnold et al. 2018), and the indirect and direct effects of various seed dispersal mechanisms (Blossey & Gorchov 2017) must also be taken into account. Moreover, taking into account that the introduction of anthropogenic sources into the natural environment necessarily means the risk of introduction of alien species (Auffret 2011), such sites can even be potential focal points of a biological invasion (Spurrier & Drees 2000; MacDougall & Turkington 2005). This can be particularly significant from the point of view of our country, considering that the spread of invasive species is the greatest problem in our natural habitats today (Kézdy et al. 2018). And since it is well known that prevention is the most important thing in the case of invasions, it is therefore particularly important to find all possible hotspots of spread (Mihály & Botta-Dukát 2004).

That is why I set out to investigate the effects of feeding places for hunting purposes (i.e. the so-called bait sites) on the vegetation, the soil seed bank and the soil in the Mátra Mountains. At the beginning of the research, several people warned me that this topic is not worth dealing with from a scientific point of view: cooperation with hunters is difficult, positive relationship between wildlife management and nature conservation may not even exist, it is only a local problem, weed species will not spread into the forest, so it is not only unnecessary, but also worthless to deal with this problem. This landscape-destroying sight can only be encountered during a nature walk, but there is no other significance worthy of scientific attention. In my case, the problem started like this. When I visited mountainous areas in Hungary, I often noticed that next to the high-stands, where there were once beautiful grasslands, a high abundance of weeds, and often a significant amount of unpleasant-smelling of diverse food residues spoil the view. It does not suit in natural habitats, and particularly unacceptable in protected areas. And although it sometimes happens that hunters mow the area for better visibility, the problem is still present throughout the country, and considering the huge amount and variety of forage used – added to which most of the time this is done with vehicles – so it is inevitable that alien and/or invasive species and weed species enter the natural environment. Then, these species can spread further either along road networks or through animal or human seed dispersal.

I started the research during the preparation of my master's dissertation. Based on the results of this, it can be said that bait sites can change typically local, but significantly their environment, and weed species can even appear in very large abundance at these locations (Rusvai 2018; Rusvai et al. 2022).

At that time, I only examined the vegetation, but my doctoral research, considering the many factors mentioned previously, includes not only the investigation of the vegetation, but also the examination of the soil seed bank and some soil parameters, as well as different zonal habitat types. Besides, the assessment of abandoned bait sites of different ages, and the regeneration processes that may occur at these sites were also among the goals, in order to explore the effects of feeding as an extremely complex process as comprehensively as possible.

The main questions of the study were the following:

1. Will the weed infestation be detectable at bait sites over a long period, and will the interannual changes be typical in every year, according to the fact that in August, more weed species are usually present with a greater cover at the bait sites?
2. Do the main meteorological factors play a role in the degree of weed infestation in each year, does precipitation or does higher or lower temperature affect the number and/or cover of weed species?
3. What effect would bait sites have over several years on some physical and chemical parameters of the soil and on the soil seed bank?
4. Does the level of weed infestation differ in individual altitude zones; are the bait sites located in the beech forest less weedy than the ones in the lower more favourable climate turkey oak–sessile oak zone?
5. What happens to baits sites after their cessation, does spontaneous regeneration occur, if so, at what rate, for how long and to what extent do weed species appear in the below and above-ground vegetation after abandonment?

2. Materials and methods

The research had three large units: I.) Long-term study in the turkey oak–sessile oak zone, during which I examined the vegetation of three forest and three clearings in May and August 2016, 2018, 2019 and 2020, and in addition, in 2019, soil seed bank and laboratory soil samples were also taken, and a similar examination was also conducted in reference habitats (one forest, one clearing). II.) Examination of bait sites located in beech forest: 3 baits in beech forest were examined in May and August 2020 and 2021, and a soil seed bank sampling was also made in 2020. III.) Examination of abandoned bait sites: in May and August 2019 and 2020, the vegetation of 3 abandoned baits of different ages (1, 8 and 10 years) were surveyed and in 2019 soil seed bank was also investigated.

During the research the following methods were used:

1.) Vegetation survey: the above-ground vegetation was investigated using the transect method. The transects were set out from the centre of the baits in 4 directions, closing an angle of 90° to each other. 22-22 1x1 meter tangential quadrats were placed on each of them, in which a percentage cover estimation was carried out in May and August of each year. In addition, in order to be able to compare with the control habitats (as well as to compare above- and below-ground vegetation), vegetation was surveyed in one year in a circle with a radius of 2 m in the centre of the baits, while in reference habitats, vegetation was recorded separately in 5 similar sampling units. 2.) Soil seed bank sampling: soil was sampled in 12 plots of 10cm×10cm×5cm at the centre of all bait sites, randomly located in a circle with a radius of 2 m in the centre of the baits (total 6000 cm3/bait). At control sites, the 12 samples were taken randomly. In the same units, a separate coenological recording was also made in order to compare above- and below-ground vegetation. Then, seedling emergence method was used. 3.) Examination of soil parameters: after cleaning the surface of plant material, 10-10 samples of approximately 100 cm3 from the top 0-10 cm layer of the soil from the centre of the baits and control areas (random sampling) (r=2m) were taken. In the case of the baits, samples along the vegetation transects was also taken, from all quadrats (100 cm3/quadrat). After drying, cleaning, and sieving the samples, the laboratory analysis performed at the Department of Soil Science and Agrochemistry of SZIE. The soil pH, salinity, available nitrogen, phosphorus, and potassium content of the samples, as well as the organic carbon content (SOC) were determined, all in accordance with the Hungarian standard MSZ-08-0210: 1977. In addition, in May 2019, the soil moisture content and compaction were also measured in each sampling unit using the Eijkelkamp Penetro Viewer Vs. 6.08, which is also often used in national practice (Böröczky et al. 2021).

3. Results and discussion

The results were evaluated by the three mentioned research units. Based on the 4 years of investigation ***in the long-term study*** at forest and clearing bait sites, it was proven that feeding can cause locally but significant degradation in natural habitats. Accordingly, the hypothesized disturbance gradient could be detected in all years: the cover of degradation indicator species was the highest in the centre of the baits, further their density and number of species decreased, while the number and cover of natural species increased. However, the spatial extent of this was different at each bait types. As expected, bait sites located in the clearing proved to be the most degraded. In this case, the area of the baits was typically characterized by continuous weed cover until 5-8 meters, while in the forest sites, the bare, litter-free soil surface was dominated with only a few weeds. The phenomenon is presumably due to the higher sensitivity of open habitats to invasions (Pauchard et al. 2009) and the specific environmental needs of weed species (Pinke & Pál 2005). There was also a significant difference between the vegetation of the examined periods: in August, more weed species were present at all sites, with a higher cover, although climatic factors also played a significant role in the extent of this and in the species composition. Confirming the results of Jánoska (2006), I was able to make the observation that the degree of degradation increased in drought years, while in rainier periods some regeneration processes could also be observed. In addition, many other factors may have influenced the extent of weed cover, including unique habitat characteristics and other anthropogenic disturbances, like the decreasing wild boar population due to the spread of ASP and the slightly reduced hunting intensity due to restrictions caused by Covid-19. Meanwhile, based on the results of the soil seed bank examination, it can be said that the baits and their control sites were well separated, but there was no significant difference between the two bait types. On average, the seed bank of the baits located in clearing proved to be more infected with weed seeds, but due to the large statistical standard deviation, there was usually no significant difference between the two habitats, and the highest weed seed density was detected in a forest site. This clearly indicates the importance of using forage contaminated with weed seed, which in this way can be significant, regardless of the habitat type and the above ground weed infestation. The vegetation-seed bank similarity, on the other hand, well reflected the habitat characteristics and the impact of disturbance: in general, the similarity was the highest in clearings and even in the more heavily disturbed bait sites, while it was lower in forest areas, as proven by many national results (Csontos 2001; Kiss 2016). Regarding the persistence of the seeds, long-term persistent species were dominant at all sites, but they were usually present in a higher proportion at more disturbed bait sites than in control areas (Csontos 2001; Kiss 2016). Regarding the soil parameters, it can be said that similar to what Jánoska (2006) experienced in wild boar preserves, the effect of feeding on soil physical parameters - although a small degree of compaction and drying was observed at all locations - was less significant than expected, while the chemical properties of the soil changed significantly. Soil pH, for example, was changed to alkaline condition as a result of the high amount of remained forage on the surface, while the quantity of the main nutrients (N, P, K) increased significantly. The degree of degradation is clearly indicated by the fact that values detected in some heavily used sites were similar to those of organic fertilizers (Hoffmann et al. 2006). The effects were the most significant in the centre of all sites and according to the disturbance gradient, they decreased along the transects parallel to the degradation of the vegetation. The salinity was the highest at baits located in forest, mainly due to the placing of salt blocks on the ground. Their effect has also clearly been shown in the form of sparser vegetation (Ramakrishna & Viraraghavan 2005; Hon et al. 2020) and lower seed density (Gul et al. 2013; Valkó et al. 2014). In summary, it can be said that bait sites located in clearings proved to be the most degraded, where the composition and extent of weed infestation were similar to those experienced by Kochjarová et al. (2023) at hunting facilities in Slovakia, while at forest sites it was less detectable. However, the weed seed content of soil could be significant regardless of the habitat type and the level of above ground degradation, as a consequence of which is that in case of a possible disturbance or the opening of the canopy during forestry activities, similar changes to clearings can also occur in forests due to the high density of weed seeds in the soil (Davis & Pelsor 2001).

Based on the ***examination of the bait sites located in beech forest***, it can be said that contrary to expectations, the level of weed infestation was very similar to the feeding places located in the turkey oak–sessile oak zone, the differences were mainly due to habitat characteristics. In general, fewer weed species with a smaller abundance appeared at these locations, but considering the proportion of weeds, baits located in beech forest proved to be more degraded. Moreover, presumably because of the lower game density, the germination and the relatively large cover of cultivated plants was typical in these locations, while in the other forest type, only a few weed species appeared and most of them were natural weed species. In addition, it is worth mentioning that similar to what was observed in the surroundings of the Slovakian feeding grounds (Kochjarová et al. 2023), even in the mountainous environment of the beech zone, at an altitude of 900m above sea level, species such as thorn apple (*Datura stramonium* L.) and southern wood-sorrel (*Oxalis dillenii* Jacq.) were also detectable, which clearly indicates the role of climate change (Kueffer et al. 2013) and the importance of disturbances in the establishment of alien species (Rejmánek et al. 2013).

Environmental factors proved to be important in this case as well, including different moisture and soil conditions, as well as other anthropogenic effects (e.g. placement of green waste near one of the bait), which also affected the vegetation. In the seed bank, as in the vegetation, there was almost no detectable difference compared to the other forest type, and most of them were of habitat origin. Although, in this case the beech seed bank proved to be more infected, which clearly indicates the role of forage contaminated with weed seeds. Vegetation-seed bank similarity and persistence also did not differ significantly between the two habitat types, but the presence of disturbance was clearly detectable. Overall, regarding the two forest types, it can be said that although environmental factors played a major role in the development of above- and belowground vegetation, the similar weed density in the seed bank clearly indicates the importance of anthropogenic effects (Möst et al. 2015).

Based on the ***examination of the abandoned bait sites***, it was clearly demonstrated that the cover of degradation indicator species decreased significantly over time, and most of them were no longer field species, but natural weeds and nitrophilous plants. However, the number of weed species generally did not change. Moreover, the once presumably abundant segetal species could also be found even on the oldest abandoned site. This is consistent with what has been experienced during old-field succession processes in Hungary (e.g. Csecserits et al. 2007), as well as with the results of a research examining the effects of abandoned sheep corrals (Hődör 2013). The temporal changes observed at current bait sites, whereby the cover and number of weed species typically increased at the end of summer, were also typical in these locations, but were no longer as significant as at present baits, which is a good indication of the higher stability of these habitats, and the lack of regular disturbances (Kratz et al. 2003). Climatic factors, on the other hand, played a significant role in this case as well. Similar to the results of Jánoska (2006) and to what was observed at current bait sites included in the long-term study, the cover of weed species increased slightly in these locations during periods of drought, while in wetter years a higher density of natural species was observed. Meanwhile, the results of the seed bank experiment clearly proved that weed seeds introduced into the soil during feeding can be detected in the soil even after several years, and even some species, such as thorn apple (*Datura stramonium* L.), were found in significant density even after nearly a decade. Thus, considering the high amount of weed seeds in the seed bank and the significant nutrient content in the soil (Klemmedson & Tiedemann 1994), regeneration after the abandonment of bait sites may take several decades (Bossuyt & Hermy 2001; Plue et al. 2008).

4. Conclusions and recommendations

On the whole, it can be said that although weed invasion typically extends to the intermediate environment of the bait sites, valuable habitat patches can also be destroyed (e.g. Bíró 1998; Molnár 2014). In addition, thanks to the repeated supply of diaspores, the presence of species of external origin remains local, but constant (Kochjarová et al. 2023), which in addition to the high persistence of weed seeds (Baskin & Baskin 1985), represents significant danger for the surrounding natural habitats. Considering the contributing factors of nutrient enrichment due to forage, the increased amount of urine and waste (Malo et al. 2000; Smit & Putman 2011), the persistent weed seeds introduced with contaminated feed (Livingston & Allesis 1968; Kivilaand & Bandurski 1981), , digging and trampling due to a higher concentration of animals (Barrios-Garcia & Ballari 2012), increasing environmental impacts caused by wild populations increasing as a result of feeding, and the other effects of seed dispersal mechanisms and other disturbances, potential influencing factors, bait sites can even be focal points of a biological invasion (Spurrier & Drees 2000, Davis & Pelsor 2001; MacDougall & Turkington 2005).

The presence of non-native species was detectable at all locations, and although in many cases they were only able to appear in the soil seed bank, they can also establish in the above-ground vegetation under favourable conditions, as they regarded as *'sleeper cells'* (Gioria et al. 2014). In addition, significant changes in habitat conditions and the seed bank can even promote the establishment of other alien species, which in this way can even lead to secondary invasions (according to the so-called "*invasional meltdown hypothesis*"; Simberloff & von Holle 1999). According to some research, in the case of species with invasive behaviour, if they already reach 30% in the seed bank, the chance of their establishment is significant (Dairel & Fidelis 2020). And considering that in this case the seeds of weed species showing invasive characteristics in the vegetation were often able to reach a share of over 90% in the seed bank, there is little chance of natural species becoming established.

In addition, taking into account that almost all ecosystems in Europe are susceptible to invasion (Hulme 2007), and since there is a very large number of bait sites in the country (Nagy 2004), they can also serve as major infection hotspots in a network. Thus, although, weed infestation typically remains local, and the light-demanding weed species that become abundant in small clearings are presumably not expected to spread to neighbouring forest areas (Burst et al. 2017), spreading via the road network and other ways their effect in suitable habitat patches (e.g. disturbed clearings, open forest patches, unclosed regeneration patches) may even occur further away (Sukopp 1962; Kleijn & Sutherland 2003). The reality of this assumption is indicated by the fact that, for example, in Slovakia, where feeding activities take place in a similar way and to the same extent, the number of non-native plant species in the national parks is increasing every year, and some researchers mention these hunting facilities as one of the main sources of alien plants (Kochjarová & Blanár 2018). In addition, the regeneration of these sites is clearly quite limited: the presence of weeds and alien species in the seed bank clearly shows that in the event of a possible new disturbance, the previously abundant species, or even other invasive species, may appear again on open and disturbed, nutrient-rich habitats (Davis & Pelsor 2001; Devlaeminck et al. 2005).

The listed processes can be further aggravated by climate change (Van der Putten et al. 2016), as well as the consequent weakening of forest health (Milad et al. 2011), which, combined with often inadequate forest management methods and other anthropogenic effects, can lead to the opening of forests (Dale et al. 2001). In this way it can promote the spread of weed species and invasive species and also the strong degradation of the affected communities (Kueffer et al. 2013) in more closed forest areas (Laurence & Yensen 1991; Martin et al. 2009) and other valuable habitat patches as well (Rejmánek et al. 2013).

All in all, it can be said that the least environmental damage would be the prohibition or significant limitation of bait sites in nature conservation areas. However, in national circumstances, this can probably only be achieved in several stages, as a result of a longer process. Taking this into account, my recommendations are the following:

1. It is necessary to modify the relevant legal rules and sectoral plans, especially regarding the clarification of the term '*bait site'*, which can form the basis of further regulations. In this way, I recommend the following:
    - restrictions on the *placement of bait sites* should appear at least at the regulation level: their establishment in a protected natural area should always be subject to a permission. Related to this, according to the experience of Stergar & Jerina (2017), I recommend that bait sites should be placed in the least vulnerable habitats, in this case rather in forest areas, because according to my observations and results, they cause less degradation in these habitats. It is recommended to protect small forest clearings, as they often represent valuable habitat patches, where even a small disturbance can lead to changes in plant species diversity and composition. If possible, it would be worthwhile to mention these suggestions in nature conservation management plans, Natura 2000 maintenance

plans, and wildlife management plans in connection with non-protected natural areas at least at the recommendation level.

- determination of the *number of bait sites*: the maximum number of feeding places that can be created per area unit must be named. In Slovakia, for example, it is stated in a decree that one bait site can be established for every 300 ha of hunting area (344/2009 Coll. implementing the Act on hunting; http1). In this way, the number of these hunting facilities could be maximized in our country as well, thereby the distribution of degrading sources affecting the natural environment would also be more favourable. According to the results of some research, this is also more advantageous from the point of view of forest damage (Månsson et al. 2015), and the control of possible pollutions would also be much simpler this way.

- regulation of the *amount of forage*: one of the possible ways could be the regulation included in the decision issued during the control of African swine fever (http2), according to which the amount that can be placed is determined with reference to a specific location and period (10-15 kg forage/bait per week). In Slovakia, according to a similar restriction, a maximum of 30 kg of grain or 100 kg of fleshy feed can be unloaded in a month (http1), which in our country could be an obtainable goal if extended to a national level and for an indefinite period.

- the requirement of regular removal of *remaining forage* at bait sites is also recommended, as our hunting law currently only has a point regarding the removal of the remaining hay in connection with winter feeding. In Slovakia, this is also included in the legislation. According to 274/2009. Section 61 (2) of the Hunting Act, unused feed must be removed in all cases after feeding, and it is also emphasized here that spoiled or unhealthy forage and its remains must be removed from feeding facilities and their surroundings.

- further limitation of the *quality of the forage*: regarding this issue, the use of weed-free fodder, which is a common method in some areas of North America, could be one of the possible solutions (Clark 2003). However, the national implementation of this is not relevant in terms of its significant financial and other aspects. Ground or pelleted feeds that may still be usable could also reduce the chance of release propagules of foreign origin, however, their usage is also very expensive, and even these may also contain viable weed seeds (Cash et al. 1998; Sheeley et al. 2000), moreover, it has been proven that their application generally does not reduce forest damage either (Priesmayer et al. 2014). Some researchers (e.g. Edenius et al. 2014; Felton et al. 2017) recommend the use of feed materials similar to the natural food composition of animals (e.g. leftover wood, bales made from leaves), but presumably these would not solve the problem either, and they are also not easy to produce, it can even be harmful to the nature. Therefore, I recommend restrictions that include the range of materials that can be used and the methods of their placement in a slightly more detail than the current national regulations, similar to the Slovakian example, where the related restrictions can be found in many national and regional veterinary and human health documents (http1).

2. In addition, I recommend the build of a *database* and system that, in addition to the registration of bait sites, would also make compliance with the rules more controllable. The best solution is perhaps the Slovakian example, where recently, due to public opinion and media pressure, an internet application was created, with the help of which anyone can check whether the feeding place they find is operating legally (http3). However, this first requires the registration of bait sites and the creation of a national map database, which could be implemented through the requirement of announcement for all hunting organizations.
3. In the future, it would be advisable to pay more attention to the enforcement of the legislation. It is typical that some of the restrictions are ignored during the operation of bait sites (e.g. placement of blocks of salt at feeding places directly on the soil surface, use of large amounts of mixed food waste, lack of mowing). Thus, in the absence of an appropriate control system, as well as environmental education, any new rules that may be introduced will not be effective either. That is why, in the future, more effective cooperation and frequent consultations between experts in nature conservation and wildlife management would be necessary.
4. Finally, I recommend further research, which may also help to understand the mechanisms of the degradation affecting other landscapes and habitat types of the country, caused by bait sites. In addition, it would be worthwhile to plan more comprehensive studies that focus on the role of bait sites in changes at local and landscape level as well, regarding the spread and establishment of invasive and weed species.

5. Overview of new scientific results

My new scientific results are summarised in the following points:

1.) It has been proven that due to the contamination of the feed used, the weed seed content of the soil seed bank can be significant regardless of the habitat type and the level of above-ground degradation, and the weed species can be present in considerable density at the bait sites even after nearly a decade of abandonment.

2.) I found that many physical and chemical parameters of the soil – especially compaction, soil pH and nutrient content – also change during the operation of the bait sites, and this was mainly detected at the heavily degraded clearing sites, in the central part affected by the spreading of feed.

3.) In the case of the bait sites that were abandoned, I proved that similar to old-field succession processes, the abundance of weeds decreased significantly over time, but the number of weed species typically did not change, and the presence of segetal weed species was detectable even after almost a decade.

4.) It could be shown at all sites that based on several years, the vegetation changed along a disturbance gradient away from the centre of the baits: the cover of degradation indicator species was the highest in the centre of the baits, further their density and number decreased, while the number and cover of natural species increased, which tendency was less evident at the sites of the two zonal forest types (cherry-oak, beech) with almost equally sparse weed cover, while it was clearly visible at the strongly degraded clearing sites.

5.) The well-known seasonal changes in field weed vegetation also proved to be true in the case of bait sites: the increase in the number and coverage of weed species at the end of summer, resulting from their life-form, was generally detectable in all years and locations, however, the degree of it was significantly influenced by weather factors: the degree of degradation was more significant in drought years, while some regeneration processes were also observed in wetter periods.

6. Publications related to the topic of the dissertation

6.1. Publications in international peer-reviewed journals

In a foreign-language, impact factor journal:

Rusvai K., Wichmann B., Saláta D., Grónás V., Skutai J., Czóbel Sz. (2022): Changes in the Vegetation, Soil Seed Bank and Soil Properties at Bait Sites in a Protected Area of the Central European Lower Montane Zone. Sustainability. 14(20): 13134. https://doi.org/10.3390/su142013134

Rusvai K., Saláta D., Falvai D., Czóbel Sz. (2022): Assesment of weed invasion at bait sites in a Central European lower montane zone. Perspectives in Plant Ecology, Evolution and Systematics. Vol. 55. 125667. https://doi.org/10.1016/j.ppees.2022.125669

Demeter A., Saláta D., Tormáné Kovács E., Szirmai O., Trenyik P., Meinhardt S., **Rusvai K.,** Verbényiné Neumann K., Schermann B., Szegleti Zs., Czóbel Sz. (2021): Effects of the Invasive Tree Species Ailanthus altissima on the Floral Diversity and Soil Properties in the Pannonian Region. Land. 10: 1155. https://doi.org/10.3390/land10111155

In a foreign language, non-impact factor journal:

Rusvai K., Czóbel Sz., Kispál L. (2019): Assessment of weed invasion at bait sites in the Mátra Landscape Protection Area. Columella – Journal of Agricultural and Environmental Sciences. 6(2): 37–44. DOI: 10.18380/SZIE.COLUM.2019.6.2.37

In a Hungarian language, non-impact factor journal:

Rusvai K., Czóbel Sz. (2021): A vadászati célú etetőhelyek gyomfertőzöttsége a Mátrai Tájvédelmi Körzetben. Erdészettudományi Közlemények. 11(1–2): 1–11. https://doi.org/10.17164/EK.2021.001

Rusvai K., Czóbel Sz. (2021): A vadászati célú etetőhelyek gyomfertőzöttsége a Mátrai Tájvédelmi Körzetben. Erdészeti Lapok. CLVI. évf. 3. szám. 94–97.

Rusvai K., Czóbel Sz. (2020): Gyomos szórók – avagy miért nem elégséges a kaszálás? Magyar Vadászlap, XXIX. évfolyam 7. szám: 24–25.

Rusvai K. (2020): Gyomos szórók: valóban lokális a probléma? Hunor II. évfolyam 4. szám: 10–12.

Rusvai K., Czóbel Sz. (2019): Az erdei tisztásokon kialakított szórók növényzetének és magkészletének degradációja a Mátrai Tájvédelmi Körzetben. Gyepgazdálkodási Közlemények. 17(2): 31–38.

Rusvai K. (2019): VIII. Tájökológiai Konferencia. Tájökológiai Lapok 17(2): 303–305.

Rusvai K. (2019): 28. EVS Kongresszus. Tájökológiai Lapok 17(2): 311–314.

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