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WOOD DIVERSITY AND REGENERATION IN POST-INDUSTRIAL LANDSCAPE: CASE STUDY FROM SELECTED LOCATIONS

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ABSTRACT

Dendrological research investigating the influence of anthropogenic and natural factors on the dendroflora was carried out at six post-mining sites: the “Halda Ema” mine dump, part of the Terezie tailings, the slopes of the Petr Bezruč mine dump, the Mokroš wastepond, the Darkov Sea area and surroundings of Loucké ponds (Ostrava and Karviná regions). The reference area was a mixed deciduous forest in the Landek NNM in Ostrava. Our research findings confirm that anthropogenic and natural factors have a significant influence on the distribution and composition of woody flora in post-industrial sites. We noted significant differences in biodiversity between reclaimed areas and naturally regenerating areas, which points to the need for targeted management and conservation strategies to support the sustainable restoration of these landscapes. The highest levels of biodiversity were found at the "Halda Ema" mine dump, suggesting that site-specific characteristics are key to supporting species diversity. The results underline the importance of long-term monitoring and analysis of the influences that shape the woody flora in these areas, and emphasize the need to integrate ecological, social and economic aspects into the regeneration process. Variability in the biodiversity of woody plants between individual locations was revealed, with the greatest diversity at the "Halda Ema” dump and part of the Terezie tailings. Our study also reveals a higher prevalence of native plant species over invasive species in most of the monitored sites, which may reflect favorable ecological conditions or effective management strategies that prevent the spread of invasive species. These patterns, which agree with previous studies, suggest that ecological factors including habitat preference and human influence play a critical role in plant community dynamics. These findings expand our understanding of the process of landfill succession and the factors influencing biodiversity, reinforcing the importance of an integrated approach in ecological and environmental research to inform conservation and management practices.

Keywords: Dendroflora; Anthropogenic Factors; Natural Factors; Biodiversity; Reclaimed Areas.

1 INTRODUCTION

In an era increasingly focused on ecological sustainability and the restoration of degraded landscapes, it is essential to understand how various factors influence regeneration and biodiversity in post-industrial landscapes. This article focuses on dendrological research conducted at six post-mining sites: the “Halda Ema” mine dump, part of the Terezie tailings, slopes of the Petr Bezruč mine dump, the Mokroš wastepond, the Darkov Sea area, surroundings of Loucké ponds in the Ostrava and Karviná regions. The reference area was a mixed deciduous forest at the Landek National Natural Monument in Ostrava.

The main goal of this research is to analyze the composition and structure of the dendroflora, identify dominant and invasive species, and assess patterns of species diversity and the effectiveness of reclamation measures. The study combines field surveys, dendrological mapping, and data analysis to evaluate biodiversity and vegetation development at selected sites. The research focuses on the occurrence of native and invasive species at these locations.

The results of this study aim to provide a deeper understanding of the influence of anthropogenic and natural factors on the distribution and composition of woody flora, which is crucial for planning effective management and conservation strategies in post-industrial landscapes. This article contributes to the broader discussion on ecosystem restoration and biodiversity conservation, which are vitally important for ecological stability and sustainable development of our landscapes.

2 STUDY SITE AND METHODS

2.1 Field survey

The field survey was carried out at selected sites: the "Halda Ema" tailings complex (Slezská Ostrava), which was divided into three parts: the "Halda Ema" tailings complex itself (not recultivated), part of the Terezie tailings complex (partially recultivated), and the slopes of the Petr Bezruč tailings complex (recultivated). Furthermore, the location of the reclaimed area was chosen in the vicinity of the Mokroš wastepond (Horní Suchá), the recultivated area in the vicinity of the Darkov Sea area (Karviná-Darkov), the mine dumps in the area of Loucké ponds (Karviná-Louky) and the mixed deciduous forest in the area of the Landek National Natural Monument (Ostrava-Petřkovice) was chosen as a reference area. The field survey took place at selected locations: The mine dump complex "Halda Ema" (Slezská Ostrava), which was divided into three parts: the dump "Halda Ema" itself (unreclaimed), part of the Terezia mine dump (partially reclaimed), the slopes of the Petr Bezruč mine dump (reclaimed). Furthermore, the location of the reclaimed area in the vicinity of the Mokroš tailings pond (Horní Suchá), the reclaimed area in the vicinity of the Darkovské Sea (Karviná-Darkov), the floodplains in the area of Loucké ponds (Karviná – Louky) and the mixed deciduous forest in the territory of the Landek NNM were chosen as a reference area (Ostrava-Petřkovice).

2.2 Data Analysis

The Shannon Diversity Index (H') is a methodology for quantifying biodiversity, involving a calculation based on the relative abundance of species (pi) and their number in a sample. Data collection involves a field inventory of species and abundance of individuals, which allows the relative abundance of each species to be calculated and then the index itself. Higher values of the Shannon index indicate greater biodiversity, while lower values indicate less diverse or homogeneous areas. The results are used to identify areas of high biodiversity and to formulate conservation and mine dump management strategies to maintain their ecological value.

Heatmaps visualize the presence of woody plants at specific sites, with rows representing tree species and columns representing sites. Color intensity indicates the presence of a species, where darker color indicates its presence. Heatmaps, graphical displays of data with colors distinguishing values, are used in ecology to illustrate biodiversity or other phenomena. The data for the heatmap must be accurately acquired and structured, and QGIS software was used to create it.

2.3 Description of the area of interest

<u>LOCATIONS IN THE OSTRAVA REGION</u>

2.3.1 REFERENCE AREA – forest NNM LANDEK (Ostrava-Petřkovice)

The site is defined by the GPS coordinates (49° 0.87' N, 18° 0.26' 5.909" E). According to Kneblová et al. (2006), the Landek National Natural Monument is located in the Ostrava Basin in the Moravian-Silesian Region, more precisely in the cadastral territory of Ostrava-Petřkovice and Ostrava-Koblov. This area is characterized by its location above the confluence of the Ostravice and the Oder rivers, which are the main streams of the regional hydrological network. It is characterized as a wooded high plateau which slopes in various directions. The top part of this site reaches heights between 208 and 280 meters above sea level, with slopes oriented mainly to the south, northeast and northwest, see (Figure 1.).

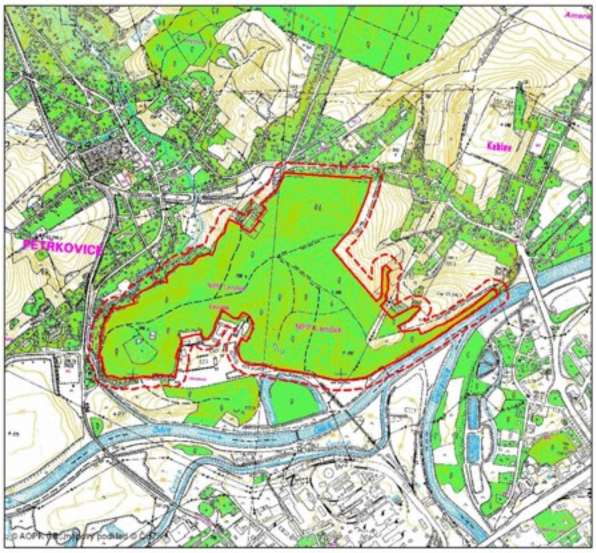

***Figure 1**. Areal image of the NNM Landek (modified by the author, 2024 according to www.geoportal.cenia.cz)*

2.3.2 Ema mine dump complex

- **”Halda Ema” mine dump (not recultivated)**
- **Part of the Terezie mine dump (partially reclaimed)**
- **Slopes of the Petr Bezruč mine dump (reclaimed)**

The site is bounded on the north and northwest by the former Petr Bezruč Mine, on the southwest by the Trojice Valley, separated by a road, and on the northeast and east by family houses with Na Najmanské, Vozačská, Miloše Svobody, Obvodní streets, with Na Najmanské Street forming the southern boundary (Lacková, 2012). The complex of the Ema and Terezie-Petr Bezruč and Trojice Walley is located in Silesian Ostrava. Due to the thermal activity of Ema, the Ema and Terezie mine dumps were evaluated separately as part of a dendrological survey, including slopes, plateaus and reclaimed and naturally successional parts. The survey covered the central unreclaimed part and the reclaimed areas in the southern and southeastern parts in the Trojice Valley, formed by the Trojice mine dump (Konicek, 2004), see Figure 2.

"Halda Ema" is the established name for this landfill and will therefore be displayed in the text in its original Czech designation.

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Figure 2. *Aerial image of the "Halda Ema" tailings complex (modified by the author, 2024 according to www.geoportal.cenia.cz)*

LOCATIONS IN THE KARVINÁ REGION

The Mokroš wastepond, the lake Darkov Sea and the Great Mill Pond are plotted on the map (Figure 3.) as the western and eastern subsidence basins. The current state of biota and ecosystems in the Karviná region, including these areas, is studied because of its zoological diversity, created by specific geomorphological evolution and history (Machacek, 2019). The emergence of subsidiary lakes and wetlands since the 1970s has transformed the areas into habitats for various species. According to Culek (1996), the biogeographical characteristics of the sites are part of the Polonia sub-province and extend across the Ostrava and Poodří bioregions, meeting the Podbeskydy bioregion of the Carpathian sub-province in the south. This unique combination of bioregions supports species diversity and reflects the transient nature of the local biota.

2.3.3 MOKROŠ WASTEPOND – reculctivated areas in the vicinity of the Mokroš wastepond (Horní Suchá)

Delineation of the site:

The location of the area is specified by GPS coordinates: 49° 49' 17.615" N, 18° 29' 20.16" E with a water surface elevation of 250 meters. The sedimentation basin is located at an elevation of 315 meters above sea level and is geographically positioned to the south-west of Karviná, as shown in Figure 3. The site is adjacent to the Darkov mine industrial complex and the Barbora operation (Polášek, 2004).

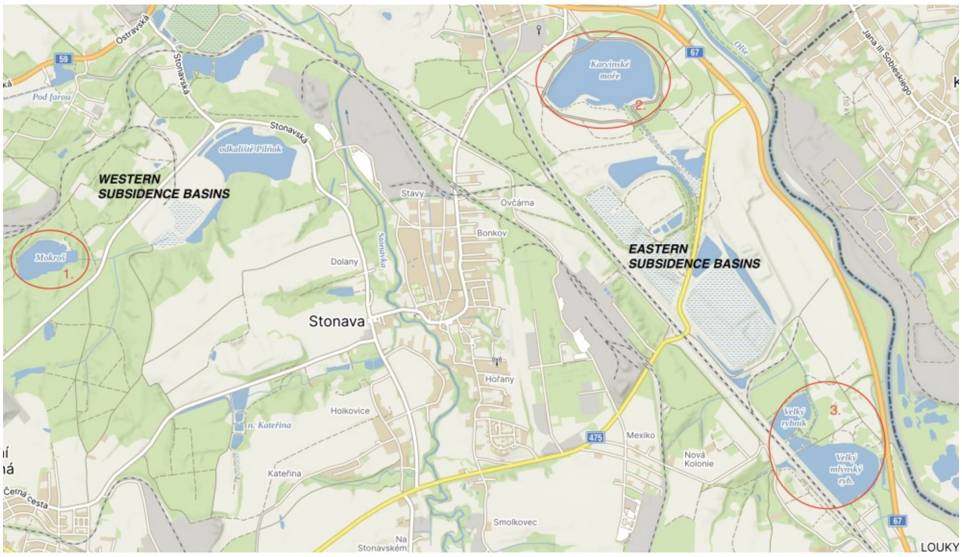

Figure 3. *Marking of sites in Karviná (Modified by author, 2024 according to: www.geoportal.gov.cz)*

The Mokroš sedimentation basin, presented in Figure 4., is located near the Barbora mine site in Karviná - Doly and is set in the landscape of the Solecký Brook valley. This reservoir is located in the Karviná region, Karviná district, Moravian-Silesian region (Polášek, 2008).

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***Figure 4**. Mokroš tailing pond, 2014 (Photo by the author, 2014)*

2.3.4 LAKE DARKOVSKÉ MOŘE (DARKOV SEA) - reclaimed areas around the Darkov Sea (Karviná-Darkov)

Delineation of the site:

GPS coordinates: (49° 50' 3.914" N, 18° 33' 0.406" E). The area developed as a result of water accumulation in a subsidence basin near the Darkov mine site, as shown in Figure 5. The Darkov Sea area is situated in the valley of the River Olše. The elevation of the study area extends from the water level to the tops of the mine dumps and agricultural land between 225 and 245 metres above sea level (Polášek, 2004).

***Figure 5.** View of the Darkov Sea (Photo by author, 2015)*

2.3.5 LOUCKÉ PONDS – landfills in the area of LouckÉ ponds (Karviná – Louky)

Delineation of the site:

The extinct core of the village of Louky nad Olší with its neighbouring ponds lies in the south of Karviná, in the part called Louky. This area together with the inhabited sectors (Zátiší, Podjedlí, Kempy, Pod pilou) forms the Karviná - Louky urban district. To the east, this part is bordered by the state border with Poland, with the Olše River defining the border, and to the north it borders the Karviná-Darkov district, which is relevant for visitors coming from Český Těšín. In the vicinity there are the villages Stonava and Albrechtice on the western side and Chotěbuz on the southern side (Burdová, 2014), see the map of the Louky nad Olší site (Figure 7.) and a photo of the view on Loucký Pond (Figure 6.).

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Figure 6. *View of Loucký Pond (Photo by author, 2014)*

Figure 7. *Map of the selected locality Louky nad Olší, the cadastral area Louky nad Olší is bordered in red (Modified by the author, 2024 according to: www.geoportal.gov.cz)*

3 RESULTS AND DISCUSSION

3.1 Differences in the number of tree species recorded at selected sites

Dendrological survey in the area of NNM Landek revealed differences in species diversity of trees between the analysed sites, see (Figure 8.): the Reference area Landek NNM, Ema mine dump, part of Terezie mine dump and Slopes of Petr Bezruč mine dump. The reference area showed the highest biodiversity, indicating its ecological value and well-preserved native vegetation. “Halda Ema” managed to achieve the second highest number of tree species, reflecting vegetation. “Halda Ema” managed to achieve the second highest number of tree species, reflecting its diversity. In contrast, part of the Terezie mine dump and the slopes of the Petr Bezruč mine dump had a lower number of species, which may indicate the influence of anthropogenic interventions or lower ecological heterogeneity. The results of the study underline the importance of biodiversity conservation, especially at reference sites, and the need for targeted management to promote species diversity in less diverse areas.

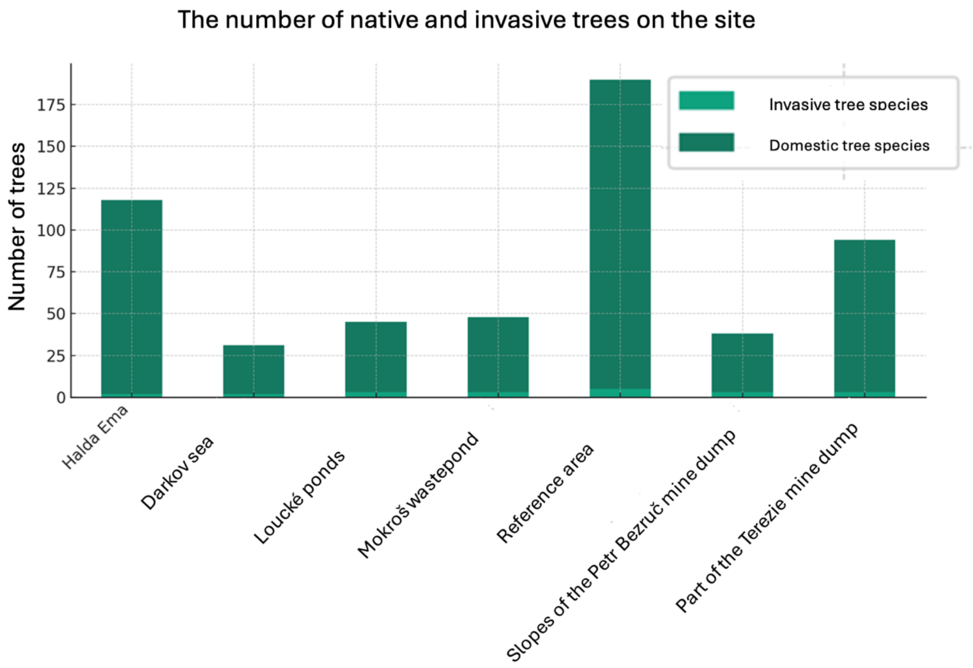

***Figure 8**. Number of tree species by location (Author, 2024)*

Graph (Figure 9) shows that some tree species are found only in one location, while others are widespread in several locations. For example, species such as *Alnus glutinosa* or *Fragaria vesca* are represented in several sites, which may indicate their greater ecological adaptability or wider spread.

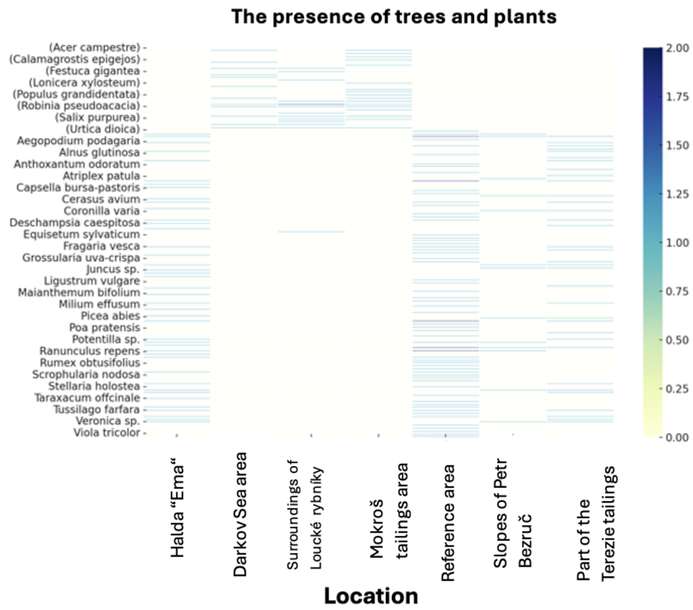

***Figure 9**. Presence of the same tree species on all sites (Author, 2024)*

3.1.1 Diversity of native tree species at selected sites

A biodiversity survey focused on native tree species in a particular region showed an uneven spread of these species among selected sites, such as the Reference Area, "Ema Halda", part of the Terezie tailings and the slopes of the Petr Bezruč tailings. The heatmap revealed differences in the presence of key species such as *Quercus robur* and *Fagus sylvatica*, indicating different adaptability of species to ecological conditions and their importance for the ecosystem. The results highlight the importance of protecting native tree species to maintain biodiversity and ecological stability, with some sites requiring special conservation measures due to lower diversity and negative impacts see (Figure 10).

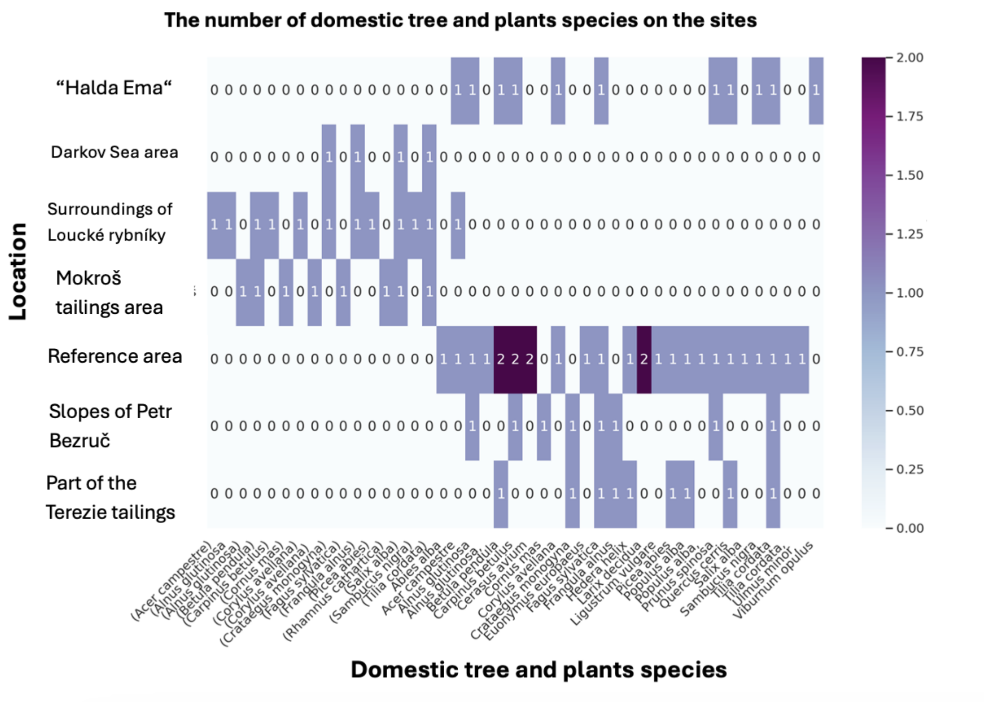

Figure 10. *Presence of native tree and plants species on all sites (Author, 2024)*

3.1.2 Spread of invasive tree species in dendrological research

The dendrological survey revealed the spread of invasive tree species such as *Acer negundo, Ailanthus altissima, Prunus serotina* and *Robinia pseudoacacia* on various natural sites. *Robinia pseudoacacia*, an adaptive species with a rapid spread, has seen the most significant expansion, raising concerns about negative impacts on native ecosystems.

Ailanthus altissima and *Acer negundo* show moderate levels of spread, while *Prunus serotina* has a more restricted spread, suggesting different degrees of invasion potential and effectiveness of management measures, see Figure 11.

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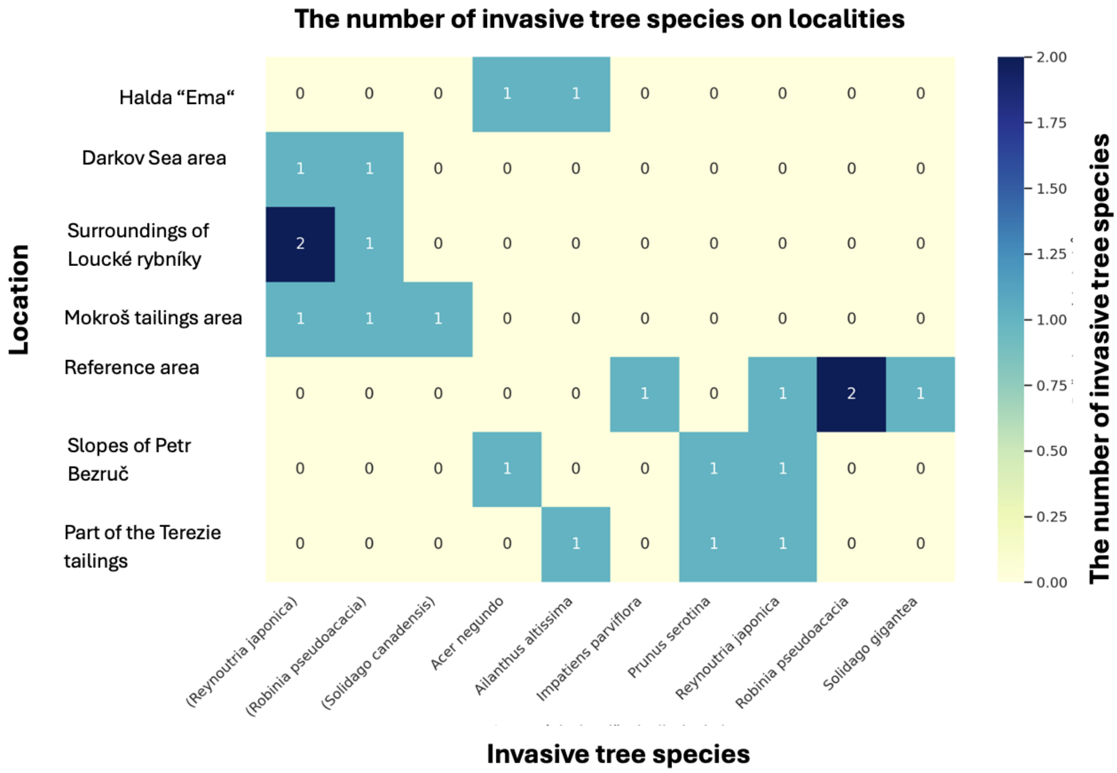

Figure 11. *Presence of invasive tree species at all selected sites (Author, 2024*

3.1.3 Distribution of invasive and native plant species across localities

The research indicates that the number of native plant species is higher than that of invasive species across most localities. Notably, the locality labeled "Mokroš tailings area" shows a significant concentration of native species, with 185 native plants recorded, the highest in the dataset.

Conversely, the "Halda Ema" locality exhibits the highest number of native plant species (116), but the lowest number of invasive species (only 2). This outcome could reflect effective protection measures or lower invasive pressures in this area.

The "Slopes of Petr Bezruč" and "Part of the Terezie tailings" show higher numbers of native plant species (35 and 91, respectively) compared to other studied localities, with a low count of invasive species (3 in both localities).

The remaining localities - Darkov Sea area, Surroundings of Loucké ponds and Reference area - have a relatively balanced presence of native plant species, with counts of 29, 42, and 45, respectively. The counts of invasive species in these areas are also low, ranging from 2 to 5 species. These data point to potential ecological factors, such as habitat preference or anthropogenic influences, that may be affecting the distribution of native and invasive plant species. A more in-depth analysis would require the examination of additional ecological and environmental variables to explain these distribution patterns.

The temperature map shows the distribution of domestic and invasive tree species in all monitored locations. Each cell represents the number of trees of a given type (domestic or invasive) at a specific location, with a color intensity corresponding to the size of this number. This type of visualization allows to identify quickly which locations do better with which tree types and allows for easy comparisons between locations, see graphs (Figure 12).

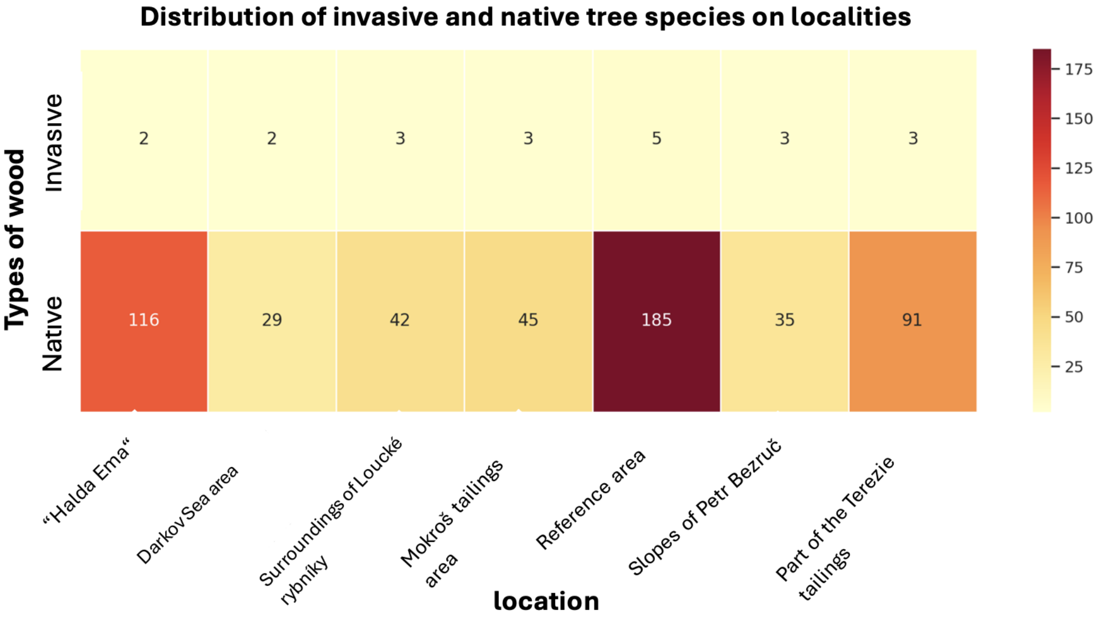

Figure 12. *Distribution of invasive and native tree species on localities (Author, 2024)*

3.1.4 Comparison of the occurrence of the number of all inventoried species of trees occurring at selected location vs. reference area

The analysis of tree species diversity showed significant differences between the reference area and various anthropogenically influenced sites (Ema mine dump, slopes of the Petra Bezruč mine dump, parts of the Terezie mine dump, the lake Darkovský moře, Loucké ponds, the Mokroš tailings). The reference area shows a higher species richness and the occurrence of native trees, which points to its important role in maintaining biodiversity and ecological stability. In contrast, anthropogenically influenced sites have reduced species diversity and a higher frequency of invasive or secondary species, reflecting the negative impact of human activities on these ecosystems, see in Figures 13, 14, 15, 16, 17, 18. As part of a study on the distribution and preferences of different tree species depending on specific environmental conditions, it was shown that ecological factors significantly influence the occurrence and prosperity of tree species. An example of such specific adaptations are the species Betula pendula and Salix spp., which show different preferences for environmental conditions, which is reflected in their distribution at two specifically monitored locations - on the Terezia slope and at Loucké ponds.

3.1.5 Influence of ecological factors on the spread of *betula pendula*

Betula pendula, commonly known as white birch, is characterized by a high degree of adaptability and the ability to thrive in different types of environments, but it especially prefers drier and light-saturated locations with a sufficient thermal regime. *Betula pendula* was found to be significantly more abundant at the site of the Terezia embankment than at other monitored locations. This location is characterized by its drier microclimate and higher temperatures, which is the result of the thermal activity of the soil. These conditions are ideal for white birch, as

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this species requires a well-sunlit habitat for its growth and development and is able to tolerate drier conditions better than many other domestic tree species (Jarvis, 1998).

3.1.6 Adaptation of salix spp. to wet locations

On the other hand, *Salix spp*., known as willows, are species with a high preference for moist to wet habitats. The location of Loucké ponds provides such conditions due to its proximity to bodies of water and a higher level of moisture in the soil. The results of the study showed that willows find ideal conditions for their growth here and are represented in greater numbers than in drier locations such as the Terezia dump. Willows are characterized by their rapid growth and ability to adapt to wet conditions, allowing them to dominate environments where many other species would have no chance of success (Jarvis, 1998).

3.1.7 Role of juvenile trees in the study

Special attention was paid to the juvenile stages of woody plants in the study, as young plants are often indicators of changes in the environment and their adaptation to specific ecological conditions can provide valuable information about the dynamics and potential changes in the vegetation of a given area. Monitoring the juvenile stages of woody plants thus contributes to a deeper understanding of the ecological processes that shape the vegetation cover in a given locality, and makes it possible to predict the possible development of vegetation in response to changes in the environment.

The results of this study underline how significantly ecological factors can influence the distribution and prosperity of different tree species in the natural environment. Adaptation to specific environmental conditions is a key factor that determines where and how well different tree species will thrive (Jarvis, 1998).

3.1.8 Robinia pseudoacacia

Robinia pseudoacacia, also known as white acacia, is an invasive species with high adaptability to different soil types and environmental conditions. This species prefers sunny sites with well-drained soil, which allows it to successfully spread over disturbed areas such as embankments. Its ability to fix nitrogen in the soil further supports its growth in poor, degraded habitats where other trees would have trouble rooting (Jarvis, 1998).

3.1.9 Quercus spp.

The *Quercus genera*, or oaks, are known for their ability to tolerate a wide range of soil and climate conditions, but some species prefer specific ecological niches. Oaks generally thrive in well-drained, deep soils and are able to withstand both drier and wetter conditions due to their deep root systems. This adaptability allows oaks to dominate many forest communities, providing them with significant ecological and biological value (Jarvis, 1998).

3.1.10 Acer spp.

The genus *Acer*, or maple, includes species with diverse demands on the environment. Some maples, such as *Acer pseudoplatanus* (honey maple), seek moist but well-drained soils in semi-shaded forest understory. Their ability to grow in a wide range of light conditions makes them flexible in colonizing different forest habitats. On the other hand, some invasive maple species, such as Acer negundo (ash maple), can spread rapidly in disturbed areas due

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to their high reproductive capacity and ability to tolerate a wide range of soil conditions (Jarvis, 1998).

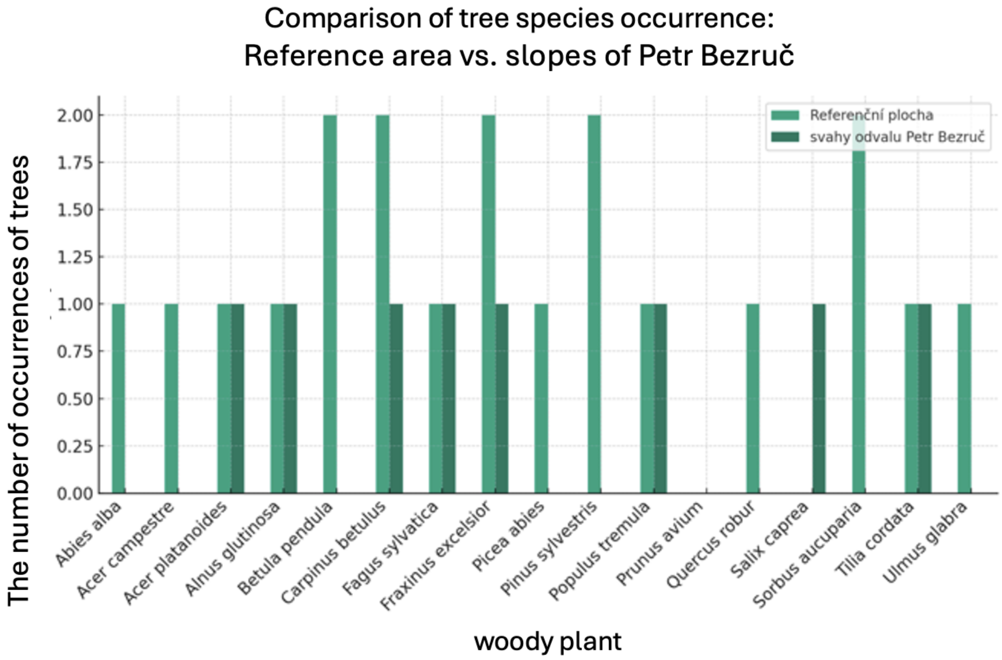

Figure 13. *Comparison of tree species: reference area vs. slopes of Petr Bezruč (Author, 2024)*

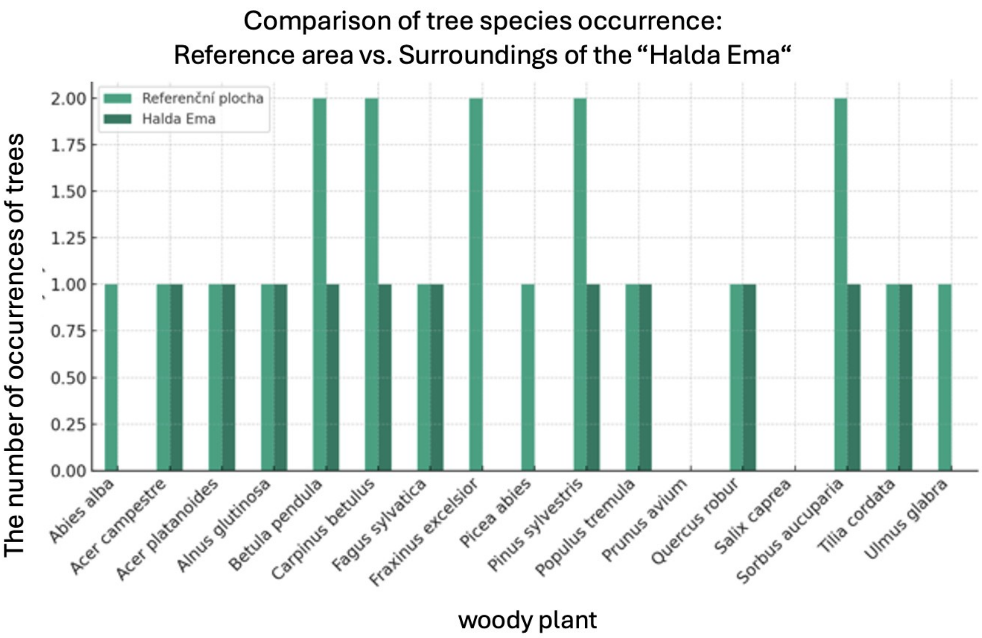

Figure 14. *Comparison of tree species occurrence: reference area vs. “Halda Ema“ (Author, 2024)*

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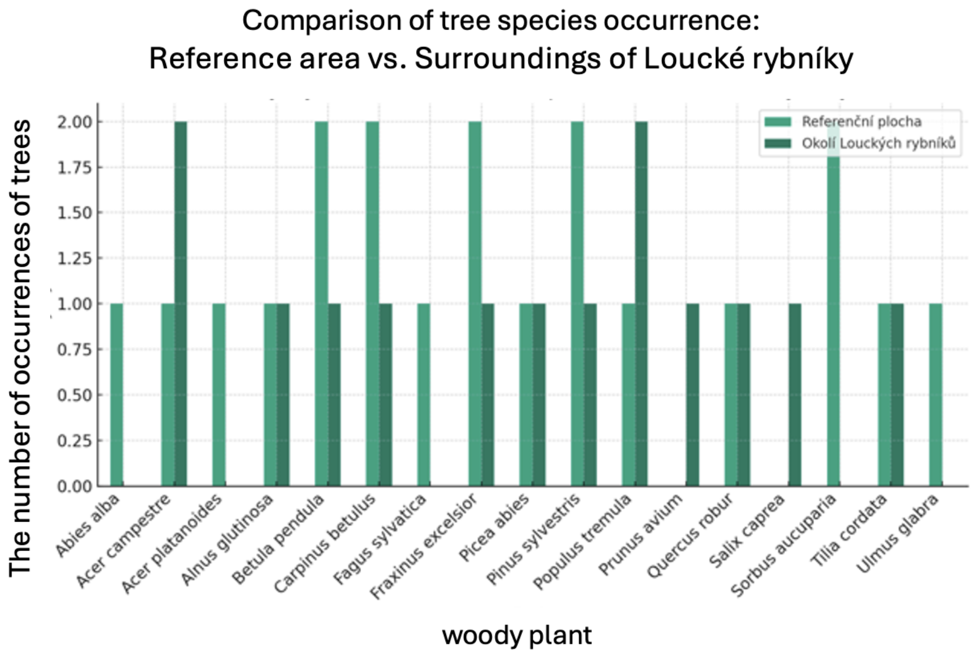

Figure 15. *Reference area vs. Surroundings of Loucké ponds (Author, 2024)*

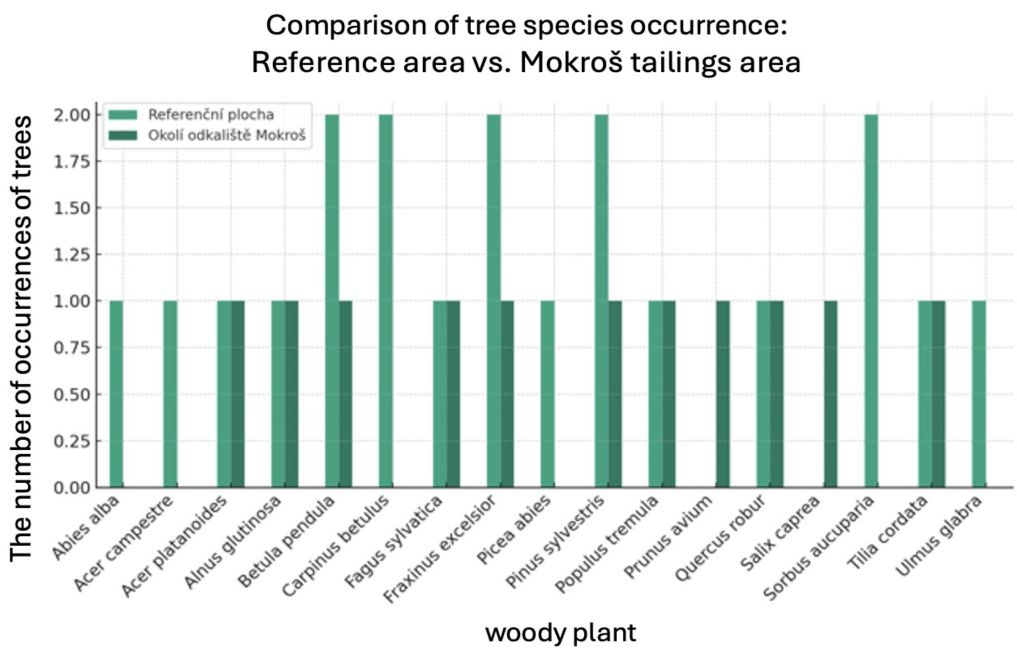

Figure 16. *Comparison of tree species occurrence: reference area vs. Mokroš tailings area (Author, 2024)*

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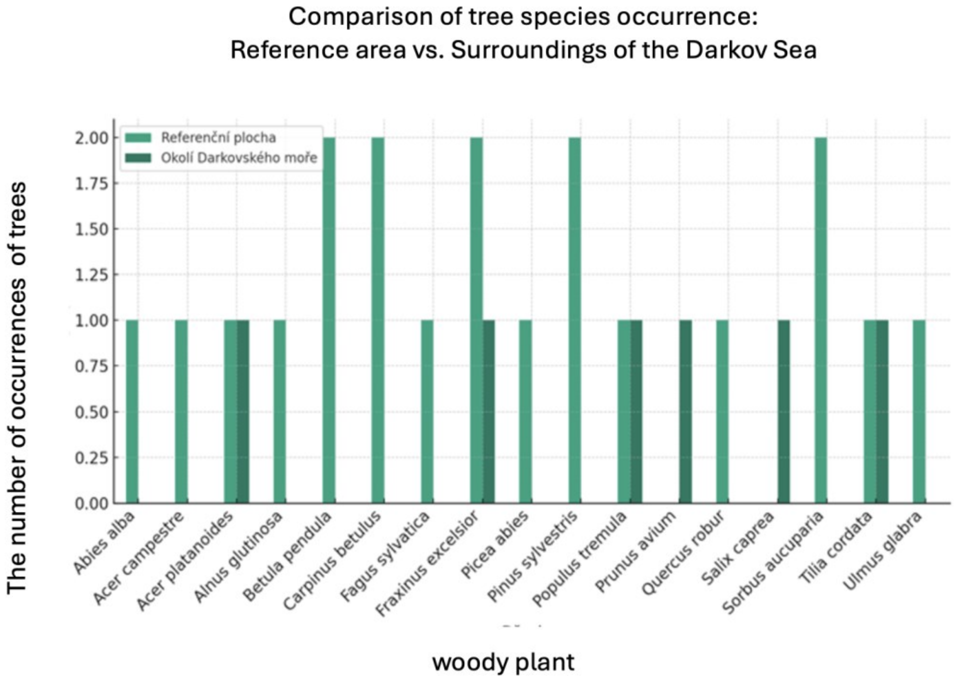

Figure 17. *Comparison of tree species occurrence: reference area vs. part of the Terezie tailings (Author, 2024)*

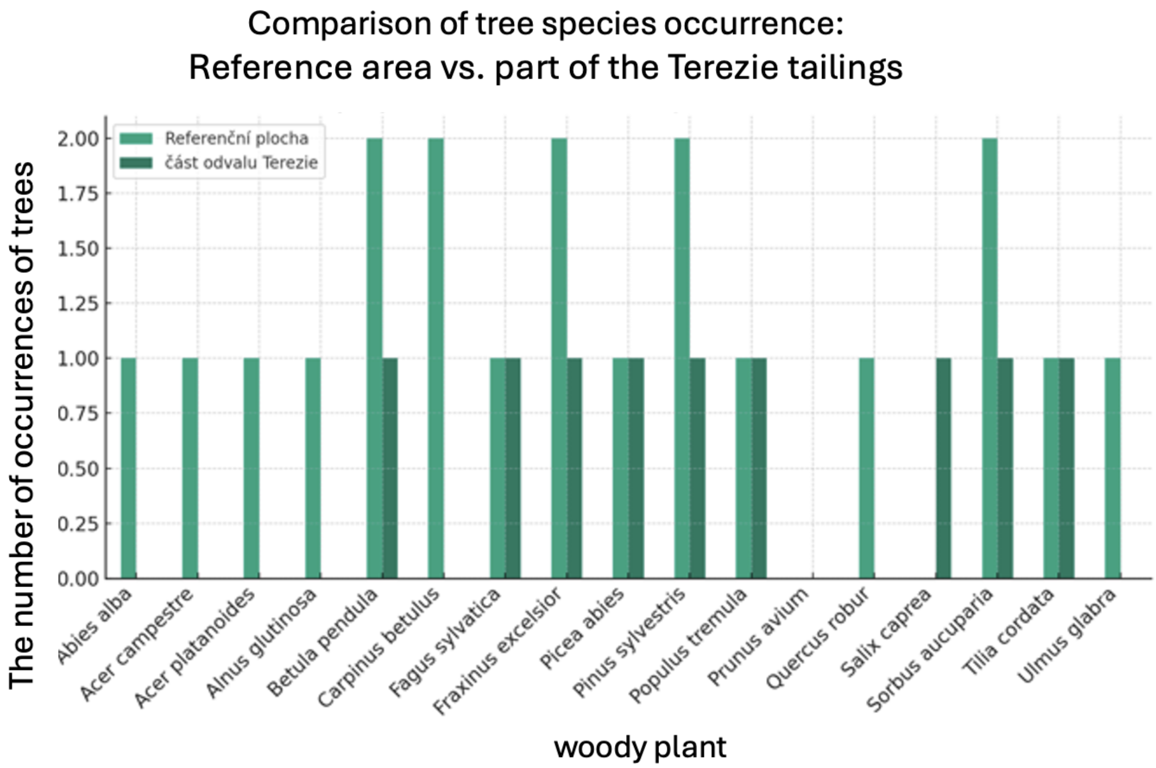

Figure 18. *Comparison of tree species occurrence: reference area vs. Darkov Sea area (Author, 2024)*

3.2 Spoil heap complex of the "Halda Ema"

The analysis shows (Figure 19) that the "Halda Ema" mine dump has a high density of diverse tree species, indicating considerable ecological richness. In contrast, the sites of the Terezie tailings and the slopes of the Petr Bezruč mine dump present a lower diversity of woody plants, but still provide important habitat for certain species. Thus, the results reveal variability in the distribution of woody plants, which may be a consequence of differences in microclimatic and soil conditions at individual sites.

These findings underline the importance of the Ema mine dump as a key ecosystem with high biodiversity that deserves further protection and study. At the same time, they point to the need for targeted management and conservation measures to maintain biodiversity in less diverse sites, such as part of the Terezie mine dump and the slopes of the Petr Bezruč mine dump.

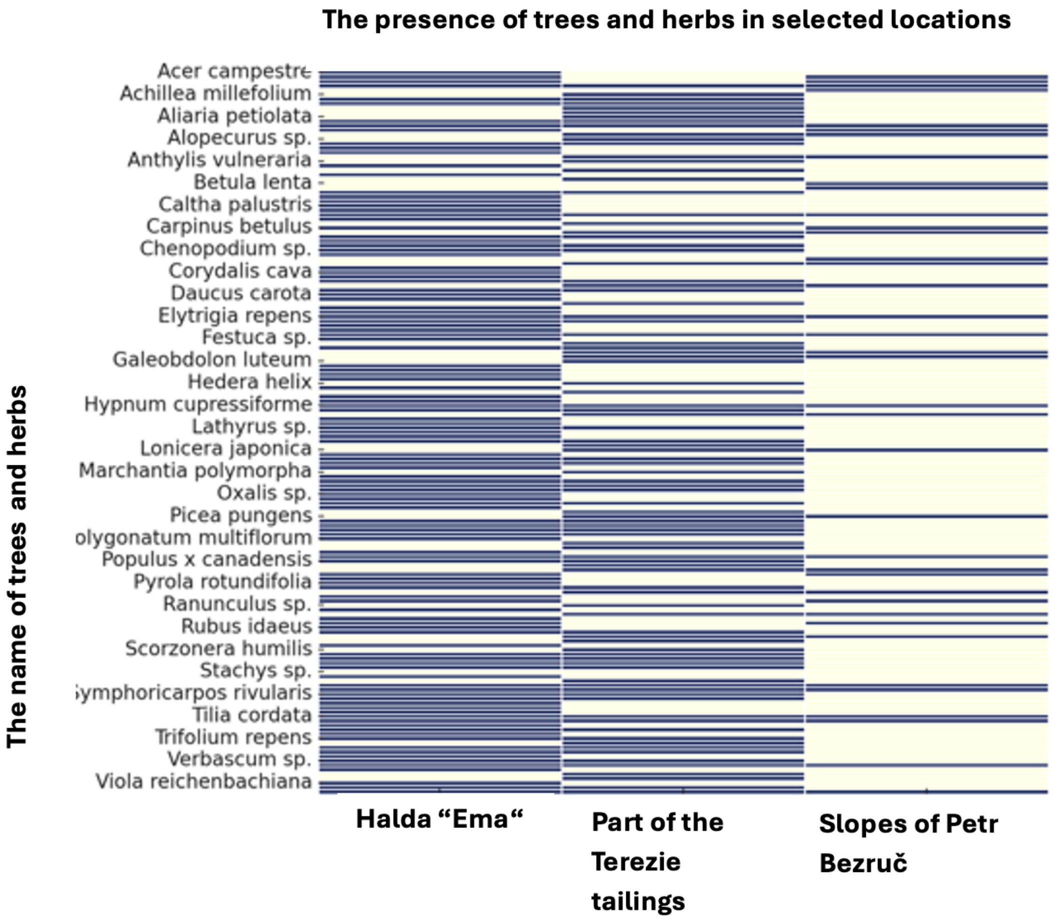

Figure 19. *The presence of trees in selected locations in the "Halda Ema" debris flow complex (Author, 2024)*

3.3 Discussion

In the study from Dvořáková (2008), she observed that successional processes on spoil heaps in Kladno could lead to the formation of stands with a high representation of *Calamagrostis epigejos*, which may inhibit further successional stages. Alternatively, there could be the development of communities dominated by *Tanacetum vulgare* and *Arrhenatherum elatius* or the growth of pioneer woody vegetation such as *Betula pendula* and *Populus spp.* This developmental trend is also confirmed by Vítková (2000) in her study on the spoil heaps of the Czech Lignite and Coal Works, where she describes formations dominated by *Arrhenatherum elatius* and *Calamagrostis epigejos*, which can achieve up to 90 % coverage and hinder further successional development. Furthermore, stages usually evolve gradually towards groves dominated by *Betula pendula* and *Populus tremula*. Felinks et al. (1998) describe similar stages with a high presence of Calamagrostis epigejos followed by the involvement of *Betula pendula* and *Robinia pseudacacia*.

Additionally, Dostálek and Čechák (1998) document successional stages on spoil heaps after uranium ore mining, where stands dominated by *Betula pendula* and *Picea abies* prevail, accompanied by other species such as *Salix caprea* and *Populus tremula*. Koutecká and Koutecký (2006), in their research on the Ostrava-Karviná region, distinguish two main directions of successional development: either the space is filled with *Calamagrostis epigejos*, which significantly slows down further successional processes, or pioneer woody species establish and create dense stands within 15 years. In later phases, typically in thirty-year-old stands, young individuals of species such as *Tilia*, *Acer*, and *Quercus* are often found. An example of advanced succession, where the young generation replaces pioneer woody species, has been recorded in sixty-year-old stands dominated by *Quercus*, *Acer*, and *Betula*.

These observations indicate that successional development on post-industrial sites can take various paths depending on the initial vegetation and other environmental factors that influence the speed and direction of ecological restoration.

4 CONCLUSION

Based on the analyses and observations, it can be concluded that anthropogenic and natural factors have a major influence on the distribution and composition of woody flora in post-industrial sites. The results of our research revealed significant differences in biodiversity between reclaimed and naturally evolving areas, highlighting the need for targeted management and conservation strategies to promote sustainable regeneration of these landscapes. The highest levels of biodiversity were recorded at the "Halda Ema" mine dump site, suggesting that the characteristics of individual sites are of key importance in supporting species diversity. Our findings underline the importance of long-term monitoring and analysis of the influences that shape the woody flora in these areas and highlight the need to integrate ecological, social and economic aspects into the regeneration process. These results reveal variability in tree biodiversity between sites, with "Halda Ema" mine dump and part of the Terezie mine dumps showing the greatest diversity. In conclusion, our study reveals a higher prevalence of native plant species over invasive ones across most localities. The Mokroš tailings area and "Halda Ema" mine dump exhibit particularly high counts of native species, suggesting favourable ecological conditions or effective management strategies that limit invasive species. While Slopes of Petr Bezruč and Part of the Terezie tailings also demonstrate higher native species presence with minimal invasive species, other localities maintain a balance of native flora. These patterns indicate the influence of habitat preferences and possibly human impacts on plant species distribution, warranting further investigation into underlying ecological and environmental factors.

In summary, our findings corroborate previous studies indicating a dominance of native over invasive plant species in successional development on spoil heaps. Consistent with Dvořáková (2008) and Vítková (2000), we observed locations like Mokroš tailings area and "Halda Ema" mine dump with substantial native flora, paralleling the early successional stages dominated by species such as Betula pendula. These patterns align with successional trends noted by Felinks et al. (1998) and Dostálek and Čechák (1998), where pioneer woody species precede the establishment of stands dominated by more mature trees, as seen in the advanced succession stages highlighted by Koutecká and Koutecký (2006). The general prevalence of native species suggests that ecological factors, potentially including habitat preference and anthropogenic impact, play a crucial role in plant community dynamics. This study enhances our understanding of plant succession on spoil heaps and the factors influencing biodiversity, reinforcing the importance of integrating ecological and environmental research to inform conservation and management practices.

REFERENCES

[1] BESTOVÁ, P. *Hodnocení krajinného rázu vrchu Landek a jeho význam pro Ostravu [Assessment of the landscape character of Landek Hill and its importance for Ostrava].* Ostrava, 2003. Diploma thesis. VSB-Technical University of Ostrava.

[2] BURDOVÁ, V. *Zaniklá obec Louky nad Olší v projektovém a tematickém vyučování [Defunct village Louky nad Olší in project and thematic education*]. Olomouc, 2014. Diploma thesis. Palacký University Olomouc. [acc. 2024-02-20]. Available at: https://theses.cz/id/wszas3/

[3] CULEK, M. *Biogeografické členění České republiky [Biogeographical division of the Czech Republic]*. Praha: Enigma, 1996. ISBN 80-853-6880-3.

[4] DOSTÁLEK, J. & ČECHÁK T. Vegetace na substrátech po těžbě uranové rudy [Vegetation on substrates from uranium mining]. *Zprávy České Botanické Společnosti*. 1998, vol. 33. pp. 187-196.

[5] DVOŘÁKOVÁ, H. *Sukcese vegetace na Kladenských haldách [Succession of vegetation on dumps around the town of Kladno]* Online, České Budějovice, 2008. Bc. Thesis. University of South Bohemia in České Budějovice. Available at: https:// https://botanika.prf.jcu.cz/thesis/pdf/DvorakovaH_Bc08.pdf. [acc. 2024-04-26].

[6] FELINKS, B. PILARSKI, M., & WIEGLEB, G. Vegetation survey in the former brown coal mining area of eastern Germany by integrating remote sensing and ground based methods. *Applied Vegetation Science*. 1998, vol 1, pp. 233-240. DOI:10.2307/1478953

[7] CENIA. *Ortofotomapy* [online]. Geoportal, 2024 [acc. 2024-02-11]. Available at: http://geoportal.cenia.cz

[8] Geoportal [online]. [acc. 2024-03-03]. Available at: http://www.geoportal.gov.cz.

[9] JARVIS, P. G. (Ed.). *European forests and global change: The likely impacts of rising CO2 and temperature*. Cambridge University Press, 1998.

[10] KNEBLOVÁ, I. et. al. *Plán péče o národní přírodní památku LANDEK (2008-2016) [Care plan for the national natural monument LANDEK (2008-2016)]*. Ostrava. 2008.

[11] KONÍČEK, P. *Studie vlivu odvalů a odkališť na složky životního prostředí- odval Ema. [Study of the influence of dumps and sludge ponds on the components of the environment - the Ema dump*]. Paskov. Studie. DIAMO s.p., 2004.

[12] KOUTECKÁ, V. & KOUTECKÝ, T. *Sukcese na antropogenních stanovištích hornické krajiny Ostravsko-Karvinského revíru [Succession in the anthropogenic habitats of the mining landscape of the Ostrava-Karvinsky district]. Zprávy České Botanické Společnosti.* 2006, vol. 41, Mater. 21, pp.117-124.

[13] KOUTECKÝ, T. Geobiocenózy hlušinových odvalů v Ostravsko-karvinském revíru [Geobiocenoses of tailings dumps in the Ostrava-Karvin area]. In: Neuhoferová, P. (ed): Problematika lesnické typologie IX. Typologické hodnocení antropogenně ovlivněných lokalit. Sborník referátů ze semináře 24. - 25-1.2007 v Kostelci n. C. l., ČZU v Praze a MZLU v Brně, Praha, Brno 2007.

[14] KOVÁŘ, P. *Natural recovery of human-made deposits in landscape (Biotic interactions and ore/ash-slag artificial ecosys- tems).* Praha: Academia, 2004.

[15] LACKOVÁ, E. *Hodnocení funkčního potenciálu území ovlivněných průmyslovou činností [Evaluation of the functional potential of areas affected by industrial activity].* Ostrava, 2012. Dissertation. VSB-Technical University of Ostrava.

[16] MACHÁČEK, M. *Vstupní biologické posouzení (vstupní analýza) z hlediska zájmů ochrany přírody: Pokračování hornické činnosti OKD, a. s., Dolu Darkov a ČSM v období 2021–2030 [Initial biological assessment (initial analysis) from the point of view of nature protection interests: Continuation of mining activities of OKD, a. s., Dolu Darkov and ČSM in the period 2021–2030*]. Jihlava: EKOEX, ekologické expertizy, poradenství a služby, 2019.

[17] NARDINI, A. et al., (1999): Competitive strategies for water availability in two Mediterranean Quercus species. *Plant, Cell and Environment*. 1999, vol. 22, pp. 109–116.

[18] ORCUTT, D. et al. *The physiology of plants under stress: Soil and biotic factors.* New York, 2000. ISBN 0-471-03152-6.

[19] POLÁŠEK, Z. *Úpravy pod hrází Mokroš: Komplexní biologický průzkum pro stavební záměr [Modifications under the Mokroš dam: A comprehensive biological survey for the construction plan*][OKD, a.s]. Havířov, 2008.

[20] STALMACHOVÁ, B. *Obnova Louckých rybníků metodou biologické regenerace krajiny[Restoration of Loucké ponds using the method of biological regeneration of the landscape]*. Projektová dokumentace. Ostrava, 1995.

[21] VÍTKOVÁ, M. Geobotanické poměry výsypek ČLUZ Nové Strašecí [Geobotanical conditions of landfills of the ČLUZ Nové Strašecí]. *Zprávy České Botanické Společnosti.* 1999, vol. 34, pp. 213-235.

[22] VOKŘÍNEK, P., (2003): NADACE LANDEK. Landek: Svědek dávné minulosti. 2. vyd. Český Těšín: FINIDR, 2003, 120 s. ISBN 80-866-8209-9.