Assessment of the suitability of trees for brownfields reuse in the post-mining landscape

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Abstract. The post-mining landscape of Upper Silesian is deterioration of the original landscape caused by underground coal mining. There are huge ecosystems changes, which have been reclaimed by nature-friendly procedures. The aim of the work is to evaluate the suitability of selected trees for reuse of brownfields in this landscape and proposals for reclamation in the interest areas of Upper Silesian.

1. Introduction

The aim of this work is to evaluate the growth of trees in the areas affected by the mining of black coal. The areas on which the research is aimed are mainly mine dumps of Upper Silesia (figure 1). These post-mining landscapes themselves have been significantly affected by coal mining and subsequent piling of tailings (waste rock) from the pit to the delimited place of imposition. For the purpose of the research there were selected mine dumps of Ema, Heřmanice, Urx, together with the Barbora mine and František mine, as well as the post-mining landscape of Darkov Sea. Another area of interest are the stations of hygiene zone in the II. degree of protection of Bartovicky Forest waters. These habitats have been used as a reference area for fitness comparison of selected tree species. Reference area is located between intersections of mine dumps, which are selected for the purpose of research. In the surveyed areas are selected representatives of the most important tree species, including English oak *(Quercus robur)*, quaking aspen *(Populus tremula)*, birch *(Betula pendula)*, mazzard *(Cerasus avium)* and hawthorn *(Crataegus monogyna)*, black locust *(Robinia pseudoacacia)* [1].

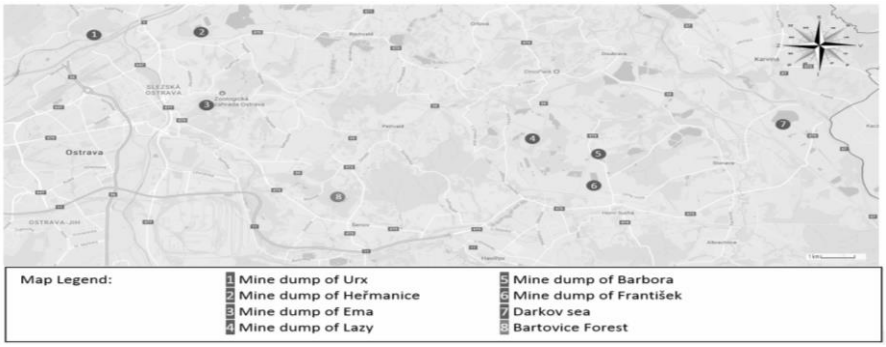

Figure 1. Map of selected areas with Map Legend (google.cz/maps - modified).

2. Methodology

Selection of habitats and species of juvenile stage trees represented take the form of stratified random sampling. Data collection at each selected site is being carried out by measuring the selected growth of a given tree, depending on the orientation towards the cardinal directions, the branch length, and the height at which the growth is located. Five representative growths are measured at each habitat/site. The collection of the data is mainly limited by weather conditions depending on the hazards associated with the working at heights. The selected habitat is marked and written first, before these data are collected. After that, five representative samples are selected at different tree heights and four measurements with different orientation on the cardinal directions. The fifth measurement is done on the tree terminal (growth peak). The length of each growth is measured in millimeters, followed by the total length of the branches in centimeters and followed by height from ground in meters at which the measurements were made. At the same time, the branches are marked with a marking spray, at the end of which branch the growth is measured, and the growth itself is marked by an arboretum mark with the designation of the cardinal direction and the order in which the growth is measured. After that, trunk perimeter is measured at a height of 130 centimeters from the ground.

The data are collected during the 2017 growing season. To accurate and safe measurements are used equipment for tree-lining and elevation work. The base of this equipment is an open or all-body seat with a protection and variable settings allowing the optimal distance from the tree trunk. In addition, static and dynamic ropes are used to protect and climb. The measurement itself is done by a tape measure, tape band and marker equipment. For successful and safe measurements are required three workers to measure, secure, and write data.

3. Selection of tree species

For research purposes, the most abundantly represented types of tree species that are in the maturity stage have been selected. Woods at this stage are characterized by generative reproduction. At this stage, the ideal growth of skeletal branches with other prolific overgrowth is typical.[2] In particular, the research areas include mainly these tree species: *Betula pendula, Robinia pseudoacacia, Cerasus Avium, Crataegus monogyna, Quercus robur* and *Populus tremula.*

Quaking aspen (*Populus tremula)*

In the Czech Republic it grows throughout the territory from the lowlands to the mountains, i tis the most widespread in the hilly areas. The aspen is a resistant pioneer tree, which first appears along with the birch on bare soils and clearings. It also grows in bright forests, pastures, abandoned pastures and forest ridges. It is resistant to frost and tolerant to soil reaction. It grows both on wet and dry soil, but mostly on sandy, rich in nutrients soil [3].

Birch (*Betula pendula)*

It appears in the Czech Republic plentifully up to altitude of about 1000m. Generally, it grows in Europe to the north to the Arctic Circle, to the south along the Pyrenees and the Apennines, to the east to the Lena River basin. Birches look for lighter forests and their edges, clearings, peat bogs, pastures, rocks, on the poorer, drier, even extremely acidic soils, bright habitats, while it is dying soon in the shade [4].

Black locust (*Robinia pseudoacacia)*

It comes from North America, eastern and central parts of the US, now extended all over the southern part of the North American continent. It was brought to Europe in the beginning of the 17th century, to Bohemia in 1710. It is cultivated in the mild belt of the whole world, it often runs wild, it spreads in many areas. It grows on the edge of forests, along roads, in alleys, around gardens and parks, near human settlements. It spreads to the natural communities of bright forests and shrubs, where it suppresses the original vegetation [5].

Mazzard (*Cerasus avium)*

It is spread across Europe, except in the southernmost regions. In our country it is rather abundantly widespread, throughout the territory of the republic. It is common in warmer areas and in lower

mesophyll positions. Thick trunk is smooth when young, usually grayish brown, dark brown in old age bark that peels off in various widths and transverse bands [6].

Upright Hawthorn (*Crataegus monogyna)*

The area of the species occupies almost the whole of Europe. The Slovak Republic is the most widespread species of hawthorn from planar to sub-mountain level. It has a wide ecological plasticity, so it can grow from extremely xerothermic habitats to flooded alluvial soils. It is part of shrub communities, the edges of deciduous forests, often creating separate monocenoses, mostly in agricultural landscapes. It is most commonly found on limestone subsoil, very rarely on acidic or very acidic soils, such as peat [7].

English Oak (*Quercus robur)*

Oak belongs to light-requiring species. In water requirements, two ecotypes are distinguished. The widespread ecotype, found especially in the floodplain forests, has considerable demands on water, and can withstand spring floods. Second ecotype has the ability to grow in shallow, heavily drying soils in the summer and can be found in forest-steppe localities. Bottom water must be within the roots reach. It is a tree heavy on soils and it grows best on deep, clay soils found in floodplain forests or less (figure 2) [8].

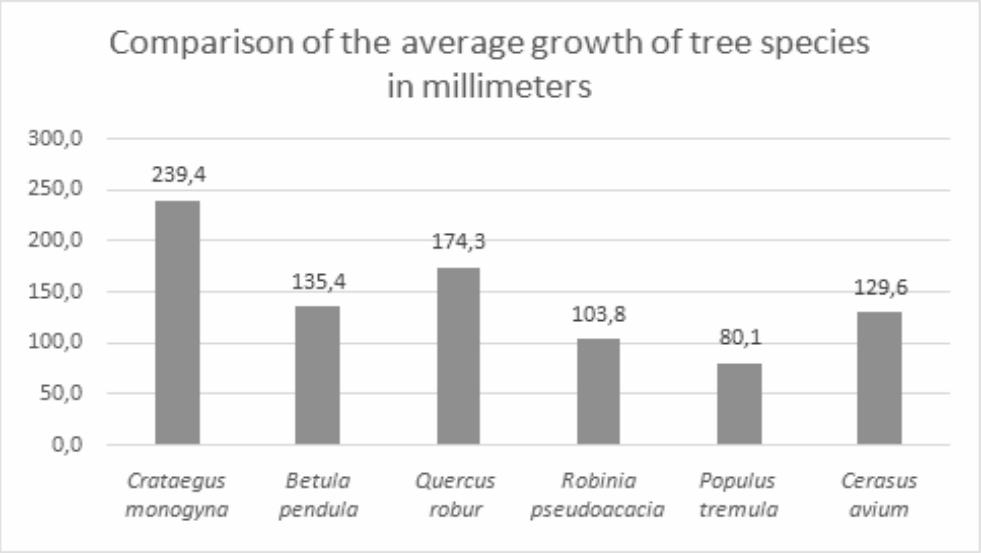

Figure 2. Comparison of the average growth of tree species in millimetres.

4. Results and discussion

The result of this research is the comparison of the fitness of juvenile stage trees occurring on the mine dumps of post-mining sites with the selected reference area of the Bartovice Forest. The available results show that dumps affect growth of individual trees. Selected tree additions grow into a shape of "fork", half of which withers in most cases. However, the average growth of post-mining sites is greater than the average growth of trees in the reference area. The largest average growth from habitats found on the mine dumps was measured during existing research at tree species *Crataegus monogyna*. Furthermore, according to the data gathered so far, the largest growth of wood species was in the mine dump Ema.

The lowest average growth was measured at tree species *Populus tremula*, which is considered as an optimal species for phytoremediation on industrial surfaces and on areas with bad air conditions (figure 3) [9]. Current research surprisingly indicates the inappropriate environment for the species *Populus tremula*. However, it's an original research which means there is no possibility to compare research data with others results. Research still continues and to complete the research is necessary collect more data and analyzes soil samples from sampling points on individual areas of interest.

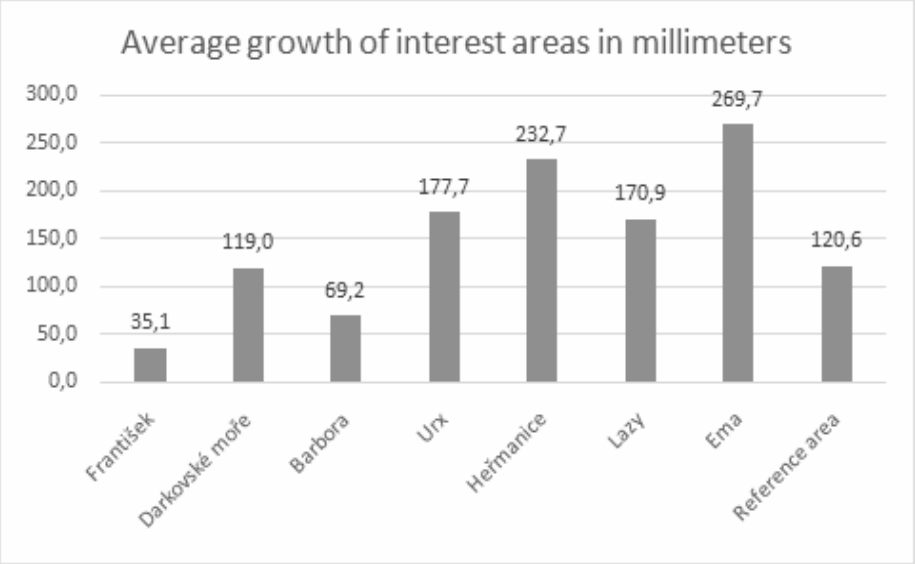

Figure 3. Average growth of interest areas in millimetres.

5. Conclusion

Research areas are characterized by the intensive deterioration of the original landscape elements and components caused by deep-scale coal mining. It is characteristic for significant changes in relief, changes in the water regime, changes in thermal and climatic conditions and extensive changes of ecosystems. However, the changes are not necessarily only negative. On the contrary, specific conditions which may suit certain plant species may be created at sites affected by mining. It is clear from the results that mine dump Ema is such an example. The largest growth of selected deciduous trees were found here, which means that some tree species complied more with habitat conditions at this site than on a reference area in the environment which wasn't directly affected by mining [1].

Acknowledgments

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