Trees as a key element in the shaping of landscape and biodiversity of post-mining areas

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Summary

Post-mining land reclamation is a long-term and complex process, nevertheless, over time, it provides substantial benefits for environment, society and economy. To maximize the efficiency of the process and create the environment closest to natural, that will be suitable for local plants and animals, a method of rehabilitation of the area should be planned taking into consideration its specific environmental conditions. Dominant elements of the landscape of the „Ruda" quarry neighbourhood are monoculture fields and scattered farmhouses. Long-term intensive agricultural and mining activities left their mark on local biodiversity. When preparing the reclamation plans of this area, not only the compensation of environment losses resulting from mining activities, but also the initiation of the biodiversity and landscape development should be taken into account.

Planting trees and shrubs is one of the best ways of managing post mining areas. It supports local biodiversity and enriches the monotonous lowland landscape as well as positively affects the microclimate and habitat conditions by improving the soil conditions and mitigating erosion, water loose and nutrients flows.

Our project focuses on planting native, suited to the local environmental conditions, trees and shrubs species in forms of groves and avenues. The scheme of plantings was created in such a way so that woodlands and bushes form a new ecological niches that are attractive for fauna and flora as well as connect the area of Mineral Resources Mine "Ruda" with the rich ecosystem existing in the Odra valley, enabling the migrations of animals.

A series of field and laboratory studies preceded the preparation of the plan of plantings. The first stage was the complete inventory of flora and fauna in the mine and its surroundings and sampling of soil and water in order to recognize the local habitats conditions. Based on the results the best places and trees/shrubs species for plantings were chosen. The project meets the needs of a disturbed ecosystem and increases the potential of ecosystem services, as well as guarantees the high prosperity of plantings.

This project may become a base for further reclamation works in the "Ruda" quarry. The selection of trees and shrubs seedlings has been planned in order to maximize the chances for adaptation to local habitats. In addition to the detailed plan of plantings, we offer a range of affordable and simple solutions, which are designed to support the development of biodiversity in the post-mining lands e.g. building houses for insects or extend protection of habitats where protected species were spotted. In the future, in case of implementation, the project will lead to the enrichment of the local biodiversity and improvement of the ecosystems stability. Furthermore, it will positively affect the landscape aesthetics and the quality of life of the local community.

Acknowledgements

We would like to thank Dr. Ewa Szczęśniak for substantive assistance and cooperation in the field studies. We are also grateful Mr. Jaroslaw Wisniewski for providing a report on environmental impact assessment for the "Ruda" quarry and Mr. Jan Majchrzak for cooperation in the field studies and project creation.

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Meadow saffron *Colchicum autumnale* in "Ruda" mine

1. Introduction

Human activity have always been associated with an extreme transformation of the environment. Along with an economic development, the space management has been changed and the human impact on the environment has intensified. Mining activity became a necessity in the face of advancing development of civilization. In the post-mining areas we usually face quite strong alternation of the environment. The example is the area of “Ruda” quarry located in the vicinity of the river Oder. As a result of the current activities of the mine, the landscape is far from the panorama existing here in the past. However, the surrounding ecosystems have been changed not only under the influence of mining activities, also agriculture left its mark on the local nature. Monospecific large-area farmlands replaced the natural meadows and forests, and prevented the migration of plants and animals. In heavily modified landscape, still subjected to strong anthropopressure, groves planted in fields and along roadsides play an extremely important role for functioning of ecosystem (App. 1). In agricultural areas maintenance of high biodiversity depends largely on the presence of groups of trees and shrubs because they are refuges for fauna and flora associated with these open farmland areas. Also, they maintain the communication between fragmented habitats, allowing the movement of animals to distant feeding grounds. Even if they occupy relatively small area, their impact on biodiversity and ecosystem is significant, especially if they are arranged in the form of properly connected groups (Rademacher et al., 2010; Tyszko-Chmielowiec, 2012).

Preparation of a plan of plantings suited to local conditions and ensuring the success of reclamation process, both in the context of the natural and socio-economic needs, require detailed studies in the Mine and the surrounding area in order to identify both existing and potential environmental values. Only thorough analyses give the possibility of proper selection of plantings species and their location. In this way, highlighting of the existing natural values and elimination of potential hazards is possible. Therefore, present project was based on a field and laboratory research. The project was conducted by students and Ph. D students of two universities - the University of Wroclaw and the University of Environmental and Life Sciences under the supervision of environmental scientist, Dr. Ewa Szczęśniak and dr. hab. Zygmunt Kącki.

2. Objectives

The objective of present project was identification of existing and potential natural values of the area of “Ruda” quarry and proposing some practical solutions for the reclamation of post-mining areas in the environmentally friendly way.

The premise of the project was to use the results of an environmental inventory and chemical analyzes of soil and water to design the layout of plantings matching to the existing in the mine network and meeting the needs of the environment as well as to propose trees and shrubs species which would thrive in the local conditions.

The last of the goals was to develop some additional practical proposals that will support the development of biodiversity after the reclamation of the mine.

3. Study area

Sand and gravel pit “Ruda” (App. 2) has approx. 44 hectares and is located in the three villages: Ruda, Budziska and Turze, in the vicinity of Kuźnia Raciborska, in the south-western part of Silesia (Poland). The mine is located 1.3 km from the Oder River. Sand and gravel of fluvial sediments of the river created mine deposits. Next to the mining reservoir, there is a processing plant in which through sorting, crushing and separation of grains, sands and

aggregates are prepared for trade. Already the area of 21.3 ha transformed by mining operations was reconstructed. The majority of surrounding area is covered by monoculture fields and scattered meadows. The mine is located in the landscape park „Cysterskie Kompozycje Rud Wielkich".

4. Methods

Field research was conducted from March to July 2016. Fieldwork began with preliminary inspection of the mine and adjacent areas. On the basis of that investigation, in the immediate vicinity of the mine, the areas with valuable ecosystems (with special natural values - riparian forest, wet meadows) were selected. Within these places a detailed botanical, entomological and ornithological surveys were performed. Moreover, soil and water samples were collected for laboratory analysis. Based on the obtained results, plantings plan was prepared using AutoCAD 2015. Maps presenting the results of the inventory were prepared with Quantum GIS 2.12.3 Lyon (App. 3.).

During entomological inventory several methods were used. The first was making observations with an eye and caching insects using entomological nets at designated transect. Barber traps, containers buried in the ground (at one meter section of 10 meters) and hanging traps with the alluring substance (fermented vegetables) were also used.

Birds inventory took place between April and June, in the breeding season 2016. Observations were conducted throughout the day, with a particular emphasis on the early morning hours (sunrise), afternoon and night. All individuals seen or heard were counted and the distribution of species was recorded on a map. Additionally, the inventory of little owl *Anthene noctua* in villages in a radius of two kilometers from the quarry was carried out. It consisted of luring and listening watches in designated points (at distance of 500 m from each other) (Żmihorski 2005).

In order to identify and classify plant communities of special conservation value (wet meadows, riparian forest) 4 phytosociological relevés were collected. Surface relevé amounted to 25 m² in the case of meadow and 100 m² in the forest. Sampling points were selected preferentially and marked with a GPS receiver. Phytosociological relevés were made according to Braun- Blanquet method (1964).

An inventory of flora growing along the shoreline of the reservoir and simplified description of all trees and shrubs growing in the quarry along with close-up surveys of health status (Pacyniak and Smólski scale, 1973) was conducted. During the dendrological inventory basic dendrometric measurements were made. The trunk circumference at a height of 130 cm above the ground was measured using tape and the height with an accuracy of up to 0.5 m was measured using Suunto altimeter. Plant species were determined on the basis of the keys (Szafer et al. 1986; Rutkowski 2007; Seneta and Dolatowski 2008; Rothmaler 2010). The presence of invasive plant species (Tokarska-Guzik et al. 2012; Dajdok, Pawlaczyk ed. 2009) and the vascular plant species protected by law in Poland (Dz.U. 2014 poz. 1348, Dz. U. z 2014 r. Nr 0, poz. 1409) was noted.

Soil samples were collected from 25 sampling sites (App. 12) selected on the basis of the results of the above-mentioned inventories. About 0,5 kg of soil was taken from each sampling site (Bednarek et. al. 2004). Water samples were taken from 6 places directly from the reservoir at a depth of 0.5 m (PN-88/C-04632/04). Water pH was determined in the field with the pH-meter.

Prior to analysis, the soil samples were air dried and grounded in a mortar to pass a 2-mm sieve and were then homogenized. In such prepared samples pH in water and in KCl as well as content of chemical elements were determined: nitrogen content by Kjeldahl method using automatic steam distillation apparatus VAPODEST 40 by GERGARDT (Lityński et al. 1962), phosphorus content by flow injection analysis (FIA), content of bioavailable forms of alkaline cations (Na^+, Ca^{2+}, K^+, Mg^{2+}) by Pallman method using atomic absorption spectrophotometry (AVANTA PM GBC Scientific Equipment) with flame atomization (Bednarek et. al. 2004). The water samples were filtered prior to analysis. Concentrations of chemical elements was determined: phosphate content by flow injection analysis (FIA),

content of alkaline cations (Na^+, Ca^{2+}, K^+, Mg^{2+}) using atomic absorption spectrophotometry (AVANTA PM GBC Scientific Equipment) with flame atomization.

5. Results and Discussion

5.1. Environmental inventory

Landscape of the mine area was classified as agricultural type, with rivers and other water elements. The area is dominated by agricultural fields while meadows have a small share. Mining of natural aggregates caused the formation of an artificial water reservoir in excavation area. Natural succession process can be seen in many untreated shores of reservoir. The ecological niches for amphibians, birds and invertebrates related to aquatic ecosystems appeared in post-mining reservoir. Mining activities seem to result in an increase of biodiversity by creating new habitats (Rademacher et al. 2010). Despite of that, the environmental values of the site have been identified as mediocre, because it does not stand out in terms of natural, historical or recreational quality (Spałek et al. 2013).

The direction of the reclamation of the area should be based on the natural qualities of the specific ecosystems and only be supported by active reclamation activities. The results of research conducted by part of our group within the Mineral Resources Mine Nowogoród Bobrzański indicated that succession and soil seed bank play the crucial role of in the reclamation process (Swacha et al. 2015). Therefore, the inventory and the design of future plantings were planned having in mind the goal of linking the mine area with the Odra valley, where the richest and best preserved ecosystems (including alluvial forest) where found. Such planting scheme should enable more efficient natural colonisation by migration of plants and animals associated with aquatic and wetland ecosystems.

5.1.1. Entomological inventory

40 species of invertebrates were found during the inventory (App. 4). The most important seems to be the observation of praying mantis (*Mantis religiosa*) (App. 11), which is probably the first statement in this area. This insect is a protected species (Dz. U. 2014 poz. 1348). 149 specimens of the subfamily *Carabidae* and 5 species from the *Carabus* genera were caught using Barber traps. The presence of predatory beetles in this area indicates the existence of a rich food base in the form of other invertebrates. Moreover, due to the close proximity of the Oder River, this area has a high potential for the development of invertebrates, especially of the family of beetles *Carabidea*.

5.1.2. Ornithological inventory

In total, 56 birds species were noted: 44 species in the vicinity of “Ruda” quarry and 15 species in the Oder valley, in the area of floodplain forest and wet meadows (App. 5). Most of the recorded species were associated with aquatic ecosystems, for example Bluethroat *Luscinia svecica*, Black-headed gull *Chroicocephalus ridibundus*, Green sandpiper *Tringa ochropus*, Bank swallow *Riparia riparia*, Common tern *Sterna hirundo*, Wigeon *Anas penelope* and Sedge warbler *Acrocephalus schoenobaenus*. Birds living in an open areas, linked to the shelterbelts or shrubs were also observed. These includes: Red-backed Shrike *Lanius collurio*, Eurasian Hoopoe *Upupa epops* and European turtle dove *Streptopelia turtur*. Only two species occurred both in the mine area and the forest in the Oder valley (App. 5). One of the reasons for the differences in the species composition of the mine area and the river valley may be the fact that many species of birds living on the studied area of the river valley is associated with trees and shrubs, which are missing in proximity to the quarry. We failed to detect any stand of little owl *Athene noctua* that was expected since it is characteristic for open areas.

5.1.3. Botanical inventory

Vegetation

Non-forest, ruderal habitat communities and farmlands were dominant in the quarry area. Due to the dominance of agricultural fields and intensive farming activities, only the impoverished communities of agricultural weeds (*Stellarietea mediae* class) were found in the area.

In places where the humus layer was destroyed, a pioneer communities representing the class *Artemisietea vulgaris* developed. Different stages of their succession were observed which was connected with moving of the localization of mining activities. Locally, small groves build by shrubs (primarily by species of the genus *Salix)* were noted. At the western border of the mine area and along parts of the shoreline of the reservoir rush communities represented by Reed canary grass (Ass. *Phlaridetum arundinacea)*, Great Manna Grass (Ass. *Glycerietum maximae)*, Reed (Ass. *Phragmitetum australis)* and Cattail (Ass. *Typhetum latifoliae)* were found. Along the coastline, therophytes building communities of the class *Bidentetea tripartiti* were noted. The natural value of the area seems to be adversely affected by presence of grassland areas intensively used as meadows sown with grass mixtures.

In the immediate vicinity of the mine wet meadows representing order *Molinietalia caeruleae* with great burnet *Sanguisorba officinalis* and meadow saffron *Colchicum autumnale* were found (App. 11). The community was classified as valuable. While in close proximity of the Oder River a relatively narrow strip of another valuable community, riverside riparian willow forest represented by Ass. *Salicetum albo-fragilis,* was identified. It is the priority habitat nr 91E0 - riparian willow, poplar, alder and ash from Annex II of the Interpretation Manual of European Union Habitats (EUR28, 2007).

Flora

The presence of 82 species of vascular plants was recorded in the study area, along the shore of the reservoir mine ore. Flora of the area consists mainly of native species (App. 9). However, the occurrence of 16 invasive species was noted (App. 8). Anthropogenic ecosystems are particularly vulnerable to the invasion of alien species (Tokarska-Guzik et al. 2012). Large accumulation of invasive species have been observed along the coastline in the eastern and northern parts of the study area. Only Canadenian horseweed *Conyza canadensis* occurred in substantial quantities throughout almost the entire study area. A particular threat to native vegetation of the mine is knotweed *Reynoutria* sp. which creates several large clusters (App. 8).

One protected species was found - meadow saffron *Colchicum autumnale* (App. 11).

5.1.4. Dendrological inventory

In total, 300 trees and shrubs were inventoried in “Ruda” quarry area. Dendroflora was represented by 14 species (App. 10). Majority of trees were found in the northern and eastern parts of the shoreline of the reservoir. The remaining part of the mine lacks high vegetation (i.e. trees and shrubs). Among trees dominated were native species: alder (*Alnus glutinosa*) - 45.0% of the total number of specimens, the black poplar (*Populus nigra*) - 18.7%, and maple (*Acer platanoides*) - 5%. Other species of trees are present in small numbers. The shrub layer was rather poor. The most common was black lace (*Sambucus nigra*) - 0.7% share in total number of specimens. Among the inventoried trees and bushes, a large share - 27.3% had willows (*Salix alba, S. fragilis, S. caprea, S. purpurea, S. viminalis* + individuals hybrid). They occurred both in the form of trees and shrubs. Individual specimens of trees of foreign origin occurred in the quarry e.g. Black cherry *Prunus serotina* - 1.3%. The health status of the surveyed trees and bushes varied. The vast majority was completely healthy, but there were also trees with low health condition (App. 10).

5.1.5. Soil and water analyses

Soils in the quarry can be classified as sands and clays (PTG, 2008) (App 13). In all the study site soil pH was in ranges characterizing arable soils in Poland (Uggla, 1979). Reaction of soils from study sites 3, 15 and 22 was highly

acidic, in sites 14, 18-21, 23 and 25 acid, in study sites 1, 2, 4, 6-9, 11 and 17 slightly acidic, while in study sites 5 , 10, 12, 13 and 16 neutral (Mocek and Drzymała, 2010). Generally, the total nitrogen content (Annex) in all study sites was within the normal content in mineral soils in Poland (200-4000 mg/kg). In study site 15 only, the recorded content of nitrogen was relatively high (Lityński and Jurkowska, 1982, Mocek and Drzymała, 2010). Nitrogen content in soils from sites 1-8, 13, 17 and 25 were lower, while from sites 9-12, 14-15 and 19-24 higher than the average for agricultural soils (Dobrzański and Zawadzki, 1981; Uggla, 1979). The phosphorus contents were within the normal range for agricultural soils (Dobrzański and Zawadzki, 1981). Soils from most of the study sites (1-5, 11, 14, 15, 17-22, 24) can be classified as soils with very low abundance of phosphorus bioavailable for plants (<22 mg/kg). Soil from sites 6-8, 11, 16, 23 and 25 contained low amounts of phosphorus (22-44 mg/kg); soil from sites 9 and 13 the average amount, while study site 12 only was very rich in phosphorus (> 88 mg/kg) (Lityński and Jurkowska, 1982). Potassium content in the soils from Ruda quarry were within a wide range. The soils from all study sites were characterized by an average content of available potassium for plants (20-660 mg/kg) (Lityński and Jurkowska, 1982). Bioavaliable Mg in quarry soils was in wide ranges. Samples from the majority of study sites (1, 2, 4, 5, 9-21, 23-25) contained very high amounts of Mg (> 90 mg/kg). Soils from sites 6, 7 and 22 contained average amount of Mg and from site 8 low (<50 mg/kg) while from site 3 very low amount of Mg (<30 mg/kg) (Lityński and Jurkowska, 1982). Bioavaliable Ca contents were close to the average in Polish soils. Similarly, content of bioavaliable Na was in the range of natural content in all study sites except 6 and 7, where the content was relatively low (<7 mg/kg) (Lityński and Jurkowska, 1982).

The pH of the water from the mine reservoir ranged from neutral to slightly alkaline. Phosphorus and cations (Ca, Mg, K and Na) content was in the ranges of biogeochemical background - natural content in surface waters in Poland (PO_4 0.01-0.1 mg/l; Ca 3-110 mg/l; Mg 40 mg/l; K 20 mg/l; Na 30 mg/l) (Dojlido 1995; Gomółka and Szaynok 1997).

5.2. Planting plan

Location of plantings was based on the target surface and form of the mining reservoir (App. 2, 15). Due to the fact that the mine still operates, consequently the area is still subjected to dynamic changes, during creating the plan of plantings we took into account the planned expansion of the mine, that will be related to the extension of the operation and future reclamation works already started or planned (Spałek et al. 2013). The planned increase of mine production would result in the destruction of parts of the existing natural groves located along ditches and stream Młynówka Rudka, hence new trees should be planted in the proposed form, in areas that would not be disturbed in the future.

Plantings were designated in several different places in order to create mosaic of habitats in the landscape because such scheme will favor the migration of animals (Tyszko-Chmielowiec 2012). The network of trees and shrubs (e.g. wild rose, blackthorn) planted before at the edges of the water body (http://www.quarrylifeaward.com/quarries/poland/ruda) was supplemented. In order to facilitate the settlement of the mine by new species, the mine and the Oder valley were connected with line of trees (App. 15, Point 13, 15). Moreover, while choosing the locations of planting places we took into account the needs of birds and invertebrates, by creation of new ecological niches (App. 15, point 12, 14, App.16).

The selection of trees and shrubs species was based on native species, typical for field groves and river valleys, on dendroflora already existing in the area as well as analysis of habitat conditions (climate, soil characteristics). Native species are the most valuable for nature and environment pprotection as well as for increasing biodiversity, because they were able to create the most extensive relationships with local species of animals, plants and fungi (Tyszko-Chmielowiec, 2012). The results of chemical analyzes of soil were taken into account during the final selection of species, since plants absorb the majority of essential elements from the soil. The soil fertility and suitability for plantings is determined, among others, by the abundance of bioavailable forms of macroelements, but the availability of nutrients will depend also on such factors as the pH or the ratio between elements in the soil

(Dobrzański and Zawadzki 1981; Lityński and Jurkowska 1982), so these parameters were analysed during the research. Our proposal is the planting of several trees and shrubs species, as mixed communities prevail over monocultures in contribution to the development of biodiversity (Tyszko-Chmielowiec, 2012).

In the immediate vicinity of the reservoir, in the part where the exploitation of the deposit was already completed plantings of shrubs such as blackthorn *Prunus spinosa*, hawthorn *Crataegus monogyna*, gray willow *Salix cinerea* and trees such as wild cherry *Prunus avium*, oak *Quercus robur* and black alder *Alnus glutinosa* were planned (App. 15). The species chosen will create a habitat and feeding grounds for animals (App. 16). Some of the selected species are pioneer plants characterized by rapid growth, which will guarantee creation of new habitats in the near future. In addition, they transform and strengthen the soil structure, making it easier for other species to settle down. Such features help to speed up the natural overgrowing and to initiate succession leading to the creation of sustainable communities (App. 16).

In the western part of the quarry area (App. 15, Point 14), neighboring the part excluded from agricultural use, planting of shrubs blackthorn plum *Prunus spinosa*, gray willow *Salix cinerea* and hawthorn *Crataegus monogyna* was proposed. The aim was to create ecotone, a diverse and rich ecosystem, at the interface of the aquatic and field ecosystems. Again, selected species will provide food and shelter for animals (App. 16). But what's more, the compact nature of the designed plantings will form a natural barrier that will protect the reservoir, which is a refuge for animals, from nutrient runoff, noise and industrial dust coming from agricultural crops.

Row of oak *Querqus robur* located along the border of fields (App. 15, Point 15) has been planned to connect the mine with the riparian forest growing at the bank the Oder River, at distance of about 1.3 km southwest of the mine. The research showed that the riparian forest is the richest ecosystem in the area and could be a refuge for the development of species biodiversity in the mine. Such a scheme of plantings aims to create a migration corridor for animals and plants.

No plantings were proposed in the north part of the quarry area, due to the fact that, after the conclusion of mines operation, the reservoir will extend almost to the roadway, so there will be not enough space for afforestation. In the areas, deposition of earth masses left to natural succession was planned (App. 15). It is possible to create a gently sloping shoreline that would facilitate the overgrowth of communities of rushes there.

In addition to the plantings, the project goals may be supported by some other actions. The first one, building of houses for insects, may be began immediately after the completion of the implementation phase of the project. During the time when planted groves grow and develop, the establishment of houses for insects may have a positive impact on the growth of the population of pollinators as well as facilitate and speed up the process of natural habitats settlement. In addition, such houses can be an interesting educational objects.

An extremely important issue is the maintenance of semi-natural vegetation, which is the habitat of several species of meadow plants and insects, including Praying Mantis *Mantis religiosa,* whose natural habitats are sunlit glades and meadows. In "Ruda" quarry, this species was found at elevated edges of the reservoir in the western part of the area. The maintenance of these habitats should be ensured by the annual mowing.

Keeping a diverse coastline may also positively affect the biodiversity of post-mining area, as it allows the succession of wetland vegetation as many communities. Valuable communities, such as therophytes appearing on the banks of the periodically drying reservoirs and the various rushes and willow scrubs will find suitable habitats in these places. Other advantage of leaving the banks for natural overgrowing is strengthening them by the plants roots and hence prevention of soil erosion.

A very important action for protection of the local biodiversity would be removing the species characterized by particular potential of invasiveness to aquatic habitats i.e. knotweed *Reynoutria* sp. Removing whole plants (along with root) and mowing approx. 7-8 times a year may actually reduce the danger of the development of these species.

Another species that may be a threat to the species richness of the area is black cherry *Padus serotina*. The removal of individual specimens, especially the ones that produce fruits, will secure area from expansion. Most of the invasive species found in the area create slight threat for biodiversity, as they are pioneer plants, which would be repressed during the growth of vegetation associated with shoreline management and plantings.

6. Conclusions and Forecasts

We expect that the realization of present project will contribute significantly to the increase of biodiversity at all levels (from the genetic to the ecosystem level) in the mine and its surroundings (App. 17). New plantings and the implementation of other activities will transform the analysis area into a refuge for animals already inhabiting the area, as well as species, that could migrate through the created corridor between "Ruda" quarry and the riparian forest growing in flood terrace of the Oder River.

Trees and shrubs are essential for many rare animal species because they are safe nesting sites and feeding grounds (App. 16). Predatory mammals use them as a place of ambush and rest. The proposed planting species may provide food and shelter from predators to mammals of the family *Gliridae* (edible dormouse *Glis glis*, Hazel dormice *Muscardinus avellanarius*, Forest dormice *Dryomys nitedula*).

Communities of grasses and herbaceous plants are home to many insects, which in turn are food for larger animals, so even small natural habitats (microhabitats) feature high numbers of species. Proposed row of oaks *Quercus robur* will provide not only a valuable part of the agricultural landscape but also a refuge and breeding place for, among others, protected beetles: Cerambyx longicorn *Cerambyx cerdo*, *Osmoderma eremita*, green chafer *Protaetia speciosissima* and red click beetle rdzawego *Elater ferrugineus* (App. 16). An additional advantage of the proposed plantings is using melliferous species such as wild cherry *Prunus avium*, hawthorn *Crategus monogyna*, blackthorn *Prunus spinosa*, gray willow *Salix cinerea*. In agricultural areas such species will be benefit by increase the number of pollinators.

Also, the project has a real chance to enrich local avifauna. Avenues of trees, shrubs and groves in the agricultural landscape can be a hotbed of nearly 80 species of birds (App. 6) (Tryjanowski et al. 2009). Thanks to the planned plantings, new habitats that could be settled by some new species (e.g. Ortolan Bunting *Emberiza hortulana*, Middle Spotted Woodpecker *Leiopicus medius*, Common Kestrel *Falco tinnunculus*, long-eared owl *Asio otus*), currently not present in the area, will emerge. While species that already occur in the quarry (e.g. common blackbird *Turdus merula*, red-backed shrike *Lanius collurio*, Eurasian blackcap *Sylvia atricapilla*) will find new resources and may be able to increase in their number. Many species of birds and bats use groves as breeding sites (more than 30 species of birds), feeding grounds and resting places during both short flights and long-distance migrations. The most important reason for the existence of such a large disparity in the species number and composition of avifauna of the mine area and the river valley is the fact that in the vicinity of the "Ruda" quarry, in relation to the river valley the number of trees and shrubs is low.

It should also be noted that the groves are home to lichens and fungi. Many species of arboreal lichens finds in the groves their optimum environment. In deforested landscape, they are often the only habitat for forest species of fungi, so such places are extremely valuable to the maintenance of species richness.

During the inventory, in the northern part of the area a few years old plantings of maple *Acer platanoides* were found. Unfortunately, probably due to the differences in ecological requirements of the species (partial shade, fertile soil) and habitat conditions in the area (full sun, poor, sandy soil) the plantings are in poor condition - are characterized by an extremely slow growth and high mortality. Present plantings project, that is based on the analysis of site conditions will allow to avoid such situations in the future.

Our interdisciplinary conception will benefit in many ways. In addition to the enormous benefits to local biodiversity, that is essential for ecosystem services, and regulatory services in the form of maintaining the quality of water, air and prevention of soil erosion, the advantage will be creation of an aesthetic enrichment to the lowland, agricultural landscape. Also, the plantings will contribute to cultural functions of landscape – recreation, tourism and last but not least education.

1. Contestant profile

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2. Project overview

Title:	Trees as a key element in the shaping of landscape and biodiversity of post-mining areas
Contest:	Quarry Life Award 2016
Quarry name:	KSM Ruda
Prize category: (select all appropriate)	☐ Education and Raising Awareness ☑ Habitat and Species Research ☑ Biodiversity Management ☑ Student Project ☑ Beyond Quarry Borders

Project tags (select all appropriate):

This will be use to classify your project in the project archive (that is also available online)

Project focus:

- ☑Biodiversity management
- ☐Cooperation programmes
- ☐Education and Raising awareness
- ☐Endangered and protected species
- ☑Invasive species
- ☑Landscape management - rehabilitation
- ☑Rehabilitation
- ☑Scientific research
- ☐Soil management
- ☐Urban ecology
- ☐Water management

Flora:

- ☐Conifers and cycads
- ☐Ferns
- ☑Flowering plants
- ☑Fungi
- ☐Mosses and liverworts

Fauna:

- ☑Amphibians
- ☑Birds
- ☑Dragonflies & Butterflies
- ☐Fish
- ☑Mammals
- ☑Reptiles
- ☑Spiders
- ☑Other insects
- ☑Other species

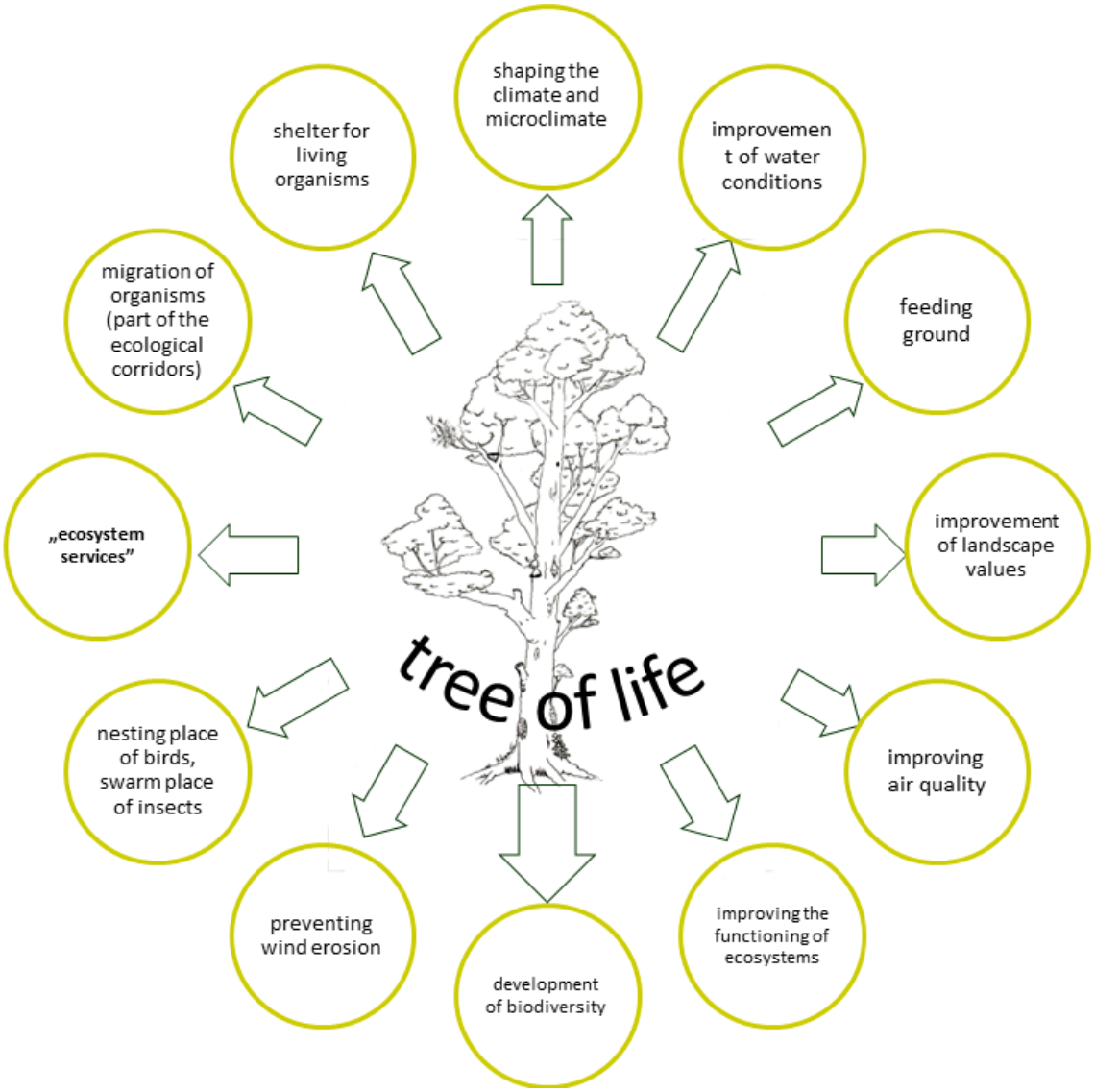
Habitat:

- ☐Cave
- ☐Cliffs
- ☑Fields - crops/culture
- ☐Forest
- ☑Grassland
- ☐Human settlement
- ☐Open areas of rocky grounds
- ☐Recreational areas
- ☐Screes
- ☑Shrubs & groves
- ☐Soil
- ☐Wander biotopes
- ☐Water bodies (flowing, standing)
- ☐Wetland

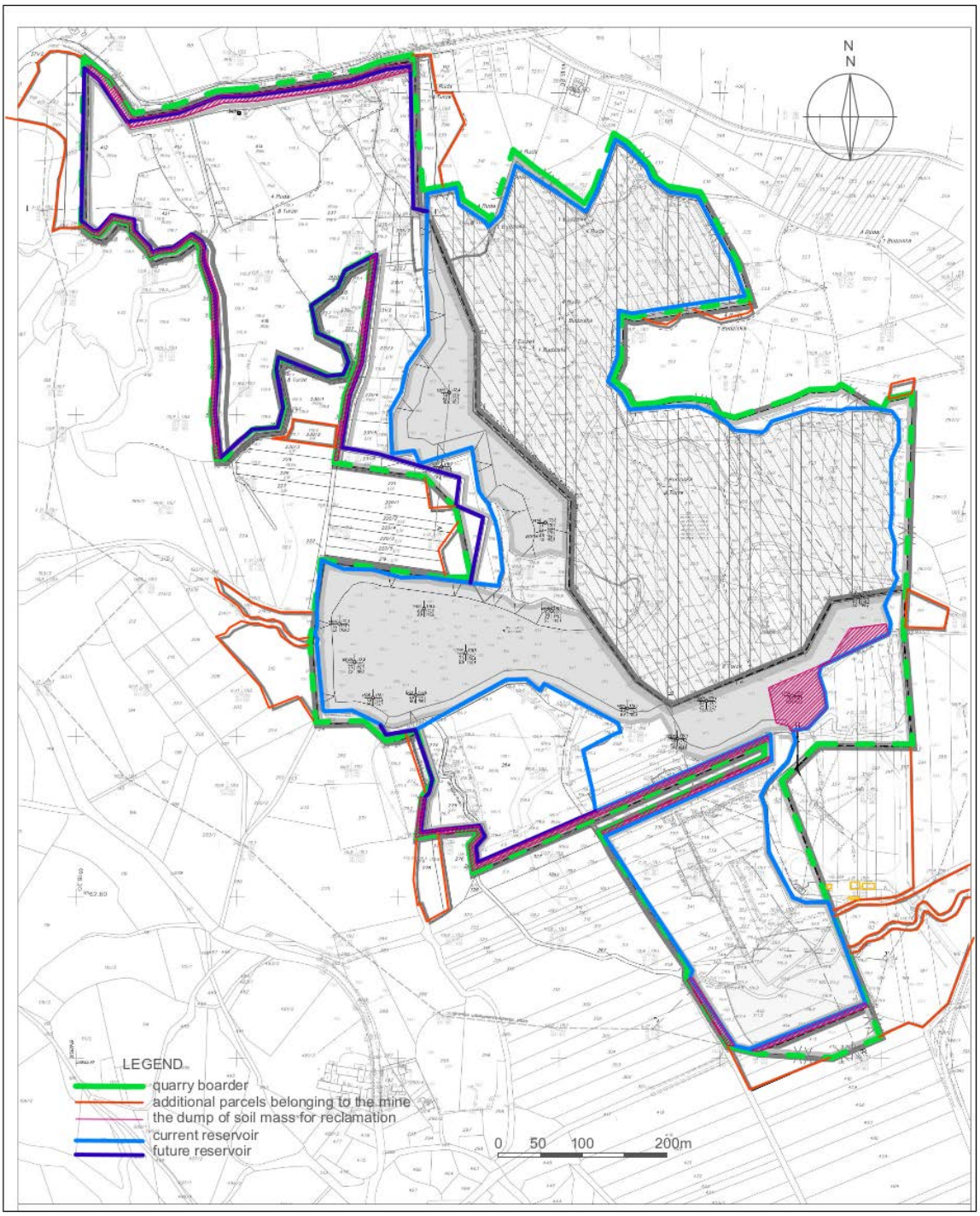
Stakeholders:

- ☑Authorities
- ☑Local community
- ☐NGOs
- ☐Schools
- ☑Universities

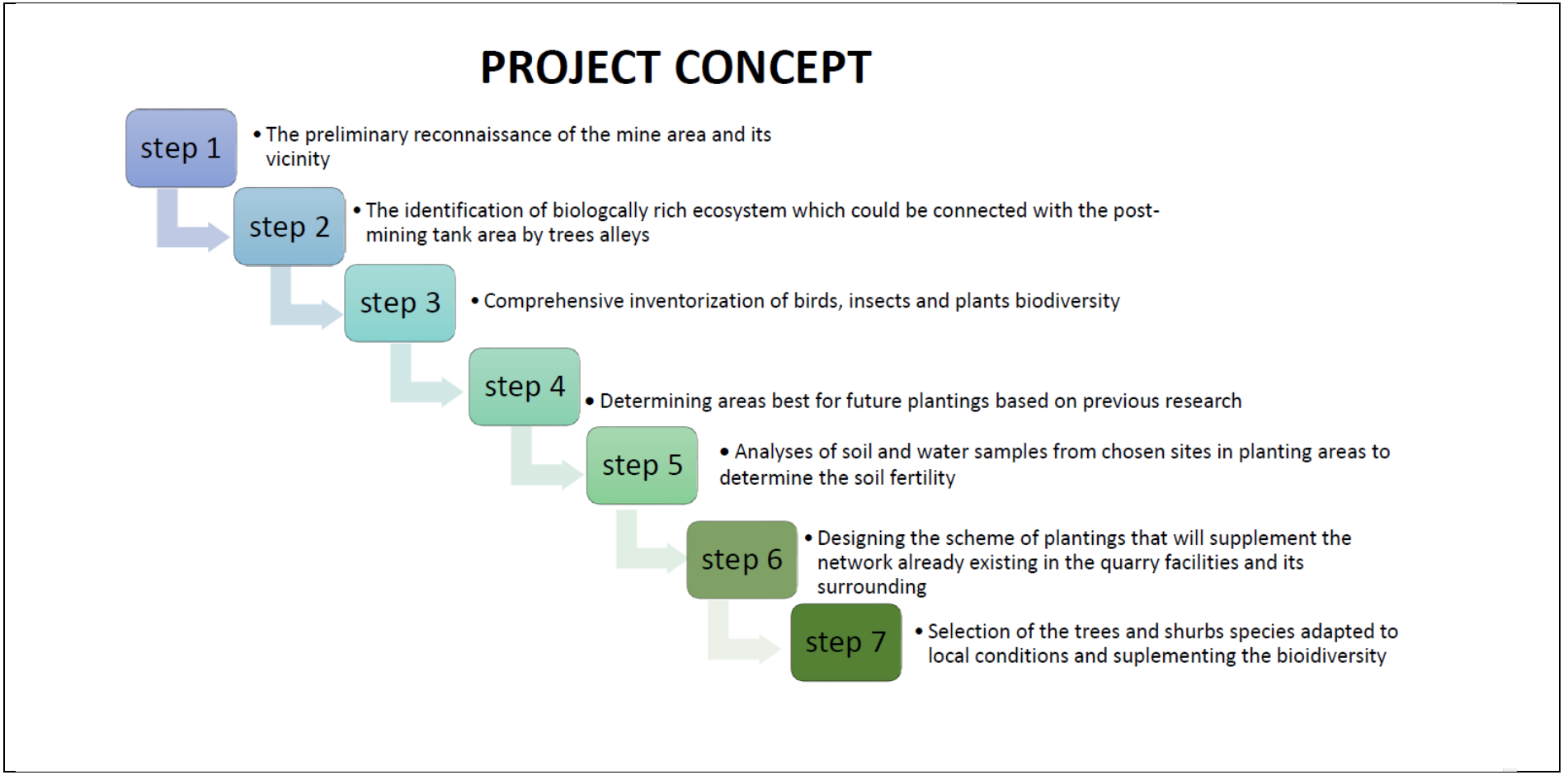
APPENDIX 1- THE ROLE OF TREES IN THE LANDSCAPE



APPENDIX 2-THE MAP OF „RUDA" QUARRY



APPENDIX 3- THE PROJECT CONCEPT

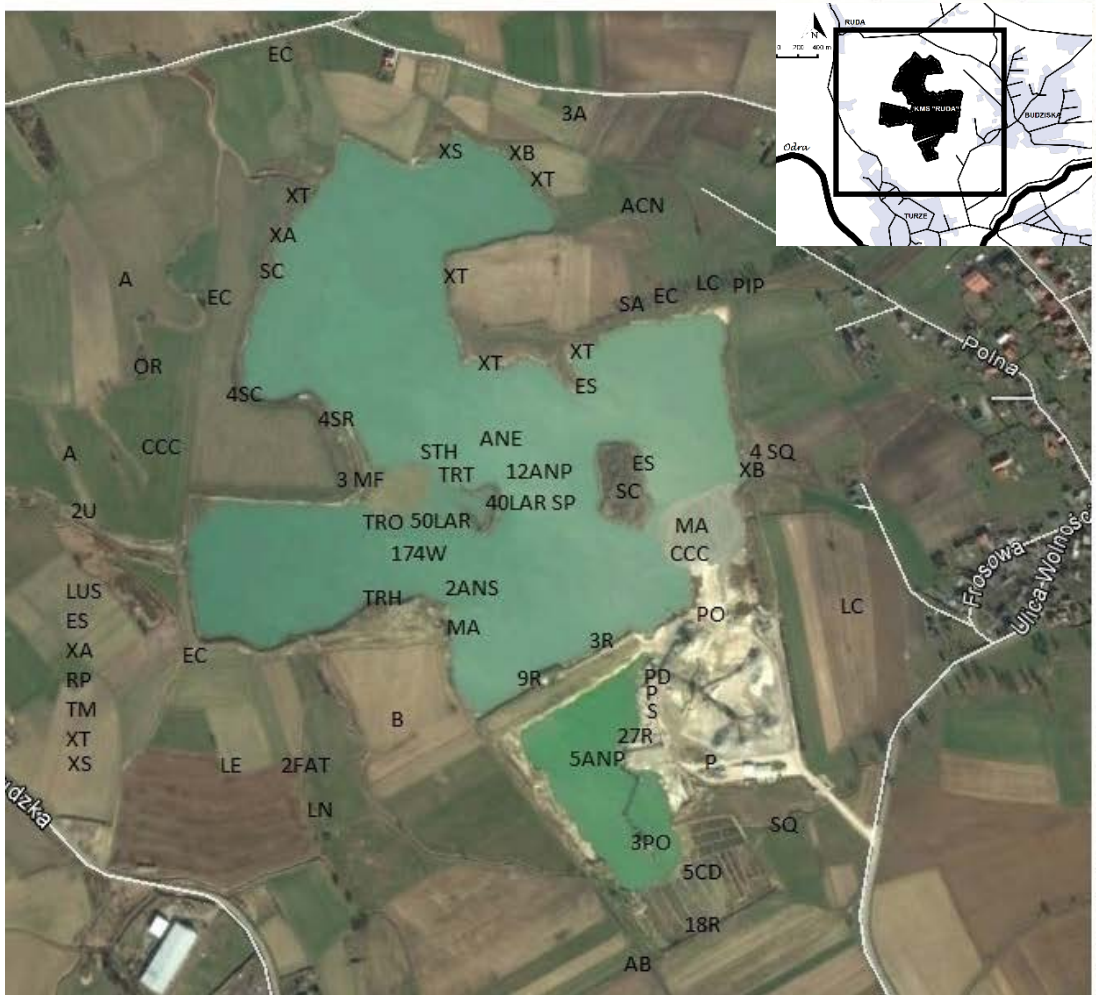


APPENDIX 4- THE LIST OF INSECT SPECIES FOUND IN THE QUARRY VICINITY AND IN THE ODER RIVER VALLEY

Nr.	Latin name
1	*Sympetrum vulgatum*
2	*Chorthippus biguttulus*
3	*Tettigonia viridissima*
4	*Gerris lacustris*
5	*Coccinella septempunctata*
6	*Cetonia aurata*
7	*Amphimallon solstitiale*
8	*Trypocopris vernalis*
9	*Bambus sp.*
10	*Polistes dominula*
11	*Piersi sp.*
12	*Gonepteryx rhamni*
13	*Inachis io*
14	*Vanessa atalanta*
15	*Vanessa cardui*
16	*Aglais urticae*
17	*Polygonia*
18	*Erebia sp.*
19	*Calopteryx virgo*

Nr.	Latin name
21	*Coenagrion puella*
22	*Forficula auricularia*
23	***Mantis religiosa***
24	*Gryllus campestris*
25	*Graphosoma lineatum*
26	*Chrysopa sp.*
27	*Panorpa communis*
28	*Agelastica alni*
29	*Cicindela hybrida*
30	*Cicindela campestris*
31	*Carabus cancellatus*
32	*Carabus violaceus*
33	*Agrypnus murinus*
34	*Cantharis fusca*
35	*Meloe proscarabaeus*
36	*Formica rufa*
37	*Ephemeroptera*
39	Diptera
40	Carabidae

APPENDIX 5- THE MAPS OF BIRD SPECIES DISTRIBUTION



Species found in the mine and its vicinity

Birds names abbreviations / Skróty nazw ptaków

1.	A	-	skowronek	Skylark	*Alauda arvensis*
2.	AB	-	makolągwa	Linnet	*Linaria cannabina*
3.	ACN	-	krogulec	Sparrow hawk	*Accipiter nisus*
4.	ANE	-	świstun	Widgeon	Anas penelope
5.	ANP	-	krzyżówka	Mallard	*Anas platyrhynchos*
6.	ANS	-	gęgawa	Greylag goose	*Anser anser*
7.	B	-	myszołów	Buzzard	*Buteo buteo*
8.	CCC	-	bocian biały	White stork	*Ciconia ciconia*
9.	CD	-	sieweczka rzeczna	Little-ringed plover	*Charadrius dubius*
10.	EC	-	potrzeszcz	Corn bunting	*Emberizia calandra*
11.	ES	-	potrzos	Reed bunting	*Emberizia schoeniclus*
12.	FAT	-	pustułka	Kestrel	*Falco tunnunculus*
13.	H	-	dymówka	Barn swallow	Hirundo rustica
14.	LAR	-	śmieszka	Black-headed gull	*Chroicocephalus ridibundus*
15.	LC	-	gąsiorek	Red-backed shrike	*Lanius collurio*
16.	LE	-	srokosz	Great grey shrike	*Lanius excubitor*
17.	LL	-	brzęczka	Savi's warbler	*Locustella luscinoides*
18.	LN	-	świerszczak	Grasshopper warbler	*Locustella naevia*
19.	LUS	-	podróżniczek	Bluethroat	*Luscinia svecica*
20.	MA	-	pliszka siwa	White wagtail	Motacilla alba
21.	MF	-	pliszka żółta	Yellow wagtail	Motacilla flava
22.	OR	-	wilga	Golden oriole	Oriolus oriolus
23.	P	-	mazurek	Tree sparrow	Passer montanus
24.	PD	-	wróbel domowy	House sparrow	Passer domesticus
25.	PIP	-	sroka	Magpie	Pica pica
26.	PO	-	kopciuszek	Black redstart	*Phoenicurus ochruros*
27.	R	-	brzegówka	Sand martin	*Riparia riparia*
28.	RP	-	remiz	European penduline tit	*Remiz pendulinus*
29.	S	-	szpak	Common starling	*Sturnus vulgaris*
30.	SA	-	kapturka	Eurasian blackcap	*Sylvia atricapilla*
31.	SC	-	cierniówka	Common white throat	*Sylvia communis*
32.	SQ	-	kląskawka	Common stonechat	*Saxicola torquata*
33.	SR	-	pokląskwa	Whinchat	*Saxicola rubetra*
34.	STH	-	rybitwa rzeczna	Common tern	*Sterna hirundo*
35.	TM	-	kos	Common blackbird	*Turdus merula*
36.	TRH	-	piskliwiec	Common sandpipper	*Loctitis hypoleucos*
37.	TRO	-	samotnik	Green sanpipper	*Tringa ochropus*
38.	TRT	-	krwawodziób	Common redshrank	*Tringa totanus*
39.	U	-	dudek	Hoopoe	*Upupa epops*
40.	W	-	czajka	Northern lapwing	*Vanellus vanellus*
41.	XA	-	trzciniak	Great reed warbler	*Acrocephalus arundinaceus*
42.	XB	-	trzcinniczek	Reed warbler	*Acrocephalus scirpaceus*
43.	XS	-	rokitniczka	Sedge warbler	*Acrocephalus schoenobaenus*
44.	XT	-	łozówka	March warbler	*Acrocephalus palustris*

green colour indicates common species for both - mine area and habitats near the river

Species found in the Oder river valley

Birds names abbreviations / skróty nazw ptaków

1.	AL	zimorodek	Common kingfisher	*Alcedo atthis*
2.	C	dzwoniec	Greenfinch	*Carduelis chloris*
3.	CU	kukułka	Common cuckoo	*Cuculus canorus*
4.	EI	trznadel	Yellowhummer	*Emberiza citrinella*
5.	KC	pierwiosnek	Common chiffchaff	*Phylloscopus collybita*
6.	LUsp	słowik	Nighttingale	*Luscinia sp.*
7.	MC	pliszka górska	Grey wagtail	*Motacilla cinerea*
8.	OR	wilga	Golden oriole	*Oriolus oriolus*
9.	PV	dzięcioł zielony	European green woodpecker	*Picus viridis*
10.	SA	kapturka	Eurasian blackcap	*Sylvia atricapilla*
11.	ST	turkawka	European turtle dove	*Streptopelia turtur*
12.	TF	śpiewak	Song thrush	*Turdus philomelos*
13.	TP	kwiczoł	Fieldfare	*Turdus pilaris*
14.	XT	łozówka	March warbler	*Acrocephalus palustris*
15.	Z	zięba	Common chafinch	*Fringilla coelebs*

green colour indicates common species for both - mine area and habitats near the river

APPENDIX 6 – THE LIST OF BIRDS SPECIES ASSOCIATED WITH TREES

Green colour indicates birds species which were not found in the mine area, but planting trees and shrubs in the form of alleys and clumps could provide them good habitat to live. Black colour indicates birds which were found in the mine area.

Nr.	English name	Latin name
1.	Goshawk	*Accipiter gentilis*
2.	Long tailed tit	*Aegithalos caudatus*
3.	Mallard	*Anas platyrhynchos*
4.	Tree pipit	*Anthus trivialis*
5.	Long eared owl	*Asio otus*
6.	Little owl	*Athene noctua*
7.	Buzzard	*Buteo buteo*
8.	Goldfinch	*Carduelis carduelis*
9.	Short- toed treecreeper	*Certchia brachydactyla*
10.	Common treecreeper	*Certhia familiaris*
11.	Greenfinch	*Chloris chloris*
12.	Hawfinch	*Coccothraustes coccothraustes*
13.	Stock dove	*Columba oenas*
14.	Wood pigeon	*Columba palumbus*
15.	Raven	*Corvus corax*
16.	Hooded crow	*Corvus cornix*
17.	Common cuckoo	*Cuculus canorus*
18.	Yellowhumm	*Cyanistes caeruleus*
19.	Great spotted woodpecker	Dendrocopos medius
20.	Middle spotted woodpecker	*Dendrocopos minor*
21.	Lesser spotted woodpecker	*Dendrocopus major*
22.	Black woodpecker	*Dryocopus martius*
23.	Corn bunting	*Emberizia calandra*
24.	Blue tit	*Emberizia citrinella*
25.	Ortolan	*Emberizia hortulana*
26.	Robin	*Erithaus rubecula*
27.	Kestrel	*Falco subbuteo*
28.	Chaffinch	*Fringilla coelebs*
29.	Eurasian jay	*Garrulus glandarius*
30.	Icterine warbler	*Hippolais icterina*
31.	Eurasian wryneck	*Jynx torquilla*
32.	Great tit	*Lanius collurio*
33.	Northern shrike	*Lanius excubitor*
34.	Common linnet	*Linaria cannabina*
35.	River warbler	*Locustella fluviatilis*
36.	Grasshooper warbler	*Locustella naevia*
37.	Woodlark	*Lullula arborea*
38.	Thrush nightingale	*Luscinia luscinia*

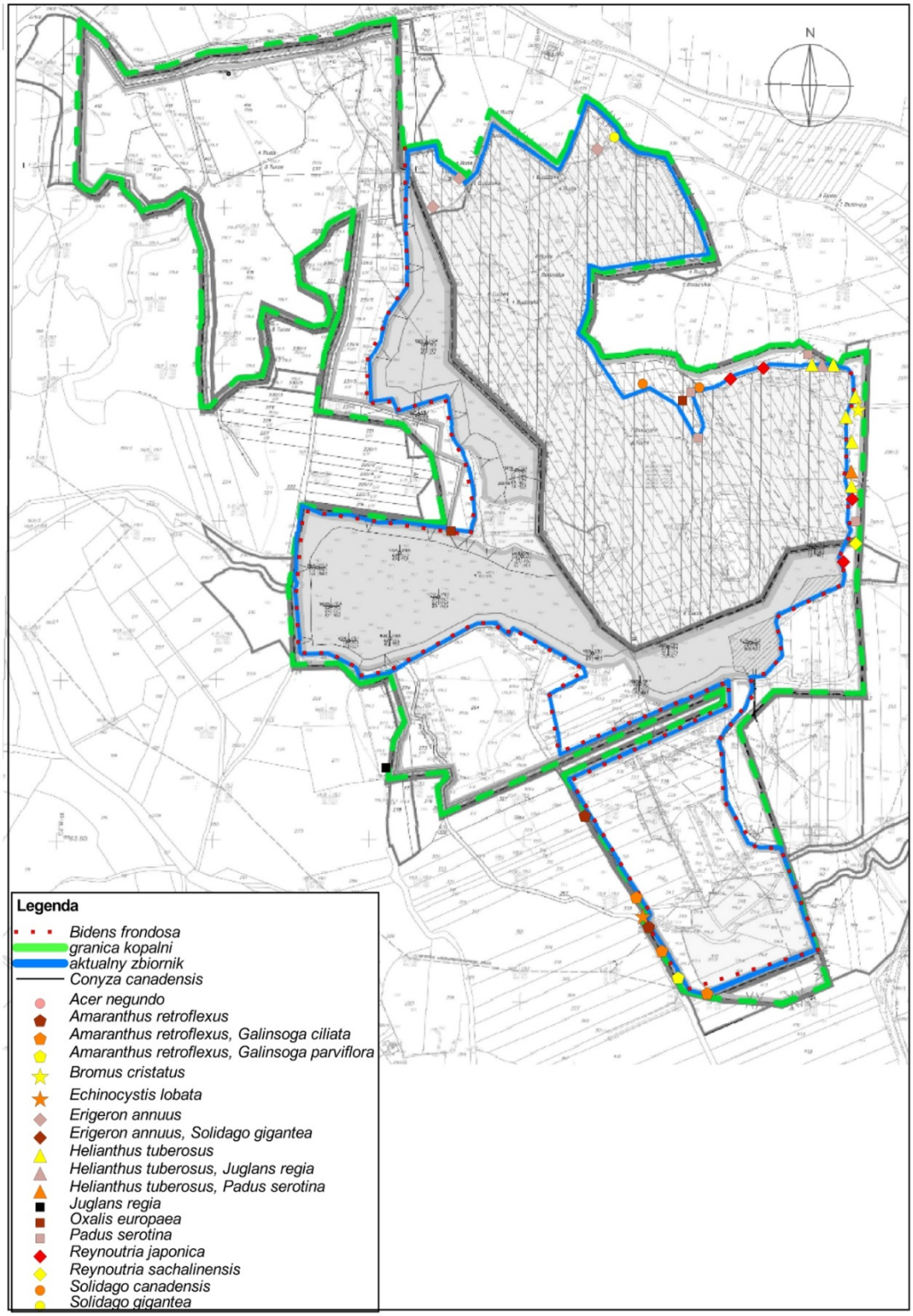
39.	Nightingale	*Luscinia megarchynchos*
40.	Spotted flycatcher	*Muscicapa striata*
41.	Golden oriole	*Oriolus oriolus*
42.	Red-backed shrike	*Parus major*
43.	House sparrow	*Passer domesticus*
44.	Eurasian treesparrow	*Passer montanus*
45.	Grey partridge	*Perdix perdix*
46.	Common pheasant	*Phasianus colchichus*
47.	Black redstart	*Phoenicurus ochruros*
48.	Common redstart	*Phoenicurus phoenicurus*
49.	Chiffchaff	*Phylloscopus collybita*
50.	Wood warbler	*Phylloscopus sibilatrix*
51.	Willow warbler	*Phylloscopus trochilus*
52.	Common magpie	*Pica pica*
53.	Willow tit	*Poecile montanus*
54.	Marsch tit	*Poecile palustris*
55.	Dunnock	*Prunella modularis*
56.	European penduline tit	*Remiz pendulinus*
57.	Whinchat	*Saxicola rubetra*
58.	European stonechat	*Saxicola rubetra*
59.	Serin	*Serinus serinus*
60.	Eurasian nuthatch	*Sitta euroropaea*
61.	Eurasian siskin	*Spinus spinus*
62.	Hoopoe	*Streptopelia decaocto*
63.	European turtle dove	*Streptopelia turtur*
64.	Towny owl	*Strix aluco*
65.	Starling	*Sturnus vulgaris*
66.	Blackcap	*Sylvia atricapilla*
67.	Garden warbler	*Sylvia borin*
68.	Common whitethroat	*Sylvia communis*
69.	Lesser whitethroat	*Sylvia curruca*
70.	Barred warbler	*Sylvia nisoria*
71.	Eurasian wren	*Troglodytes troglodytes*
72.	Common blackbird	*Turdus merula*
73.	Song thrush	*Turdus philomelos*
74.	Fieldfare	*Upupa epops*
75.	Collared dove	*Turdus pilaris*

APPENDIX 7- THE SYNOPTIC TABLE OF VALUABLE PLANT COMMUNITIES

Number of relevé - meadow	I	II	Medium coverage of the species (%)
Coverage of the herb layer (%)	100	85	
The number of species	27	23	
Galium verum	1	+	2,55
Festuca rubra	2		8,75
Dactylis glomerata	1	+	2,5
Anthoxantum odaratum	+	+	0,2
Arrhentherum elatius	+	+	0,2
Ranunculus auricomus	+		00,5
Achillea millefolium	+	+	0,2
Sanguisorba officinalis	+	1	2,55
Polygala vulgaris	+		00,5
Cerastium arense	+		00,5
Vicia cracca	+		00,5
Rumex acetosa	+	+	0,2
Carex hirta	+		0,2
Leucanthemum vulgare	+	+	0,2
Lathyrus pratensis	+	+	0,2
Ranunculus acris	+	+	0,2
Triforium pratense	+		00,5
Deschampsia caespitosa	+	+	0,2
Plantago lanceolata	+	+	0,2
Lotus uliginosus	+		00,5
Tanacetum vulgare	+		0,2
Centaurea oxylepis	+	+	00,5
Alopecurus pratensis	+		0,2
Polygonum persicaria	+		0,2
Pimpinella saxifraga	+		00,5
Equisetum arvense	+		0,2
Dianthus deltoides	+		0,2
Campanula patula		+	0,2
Dautus carota		+	0,2
Galium mollugo		+	0,2
Lotus corniculatus		+	0,2
Trifolium repens		+	0,2
Teifolium pratense		+	0,2
Holcus lanatus		+	0,2
Agrostis capillaris		+	0,2
Poa pratensis		+	0,2
Leontodon autumnalis		+	0,2

Number of relevé - forest	I	II	Medium coverage of the species (%)
Coverage of the herb layer (%)	95	90	
The number of species	14	19	
Urtica dioica	3	4	68,75
Impetiens grandulifera	1	+	2,55
Rubus sp.	1		2,5
Helacleum sphondylium	+		0,2
Dactylis polygama	+		0,2
Bromus inermis	+		0,2
Calystegia sepium	+		0,2
Cuscuta europaea	1		2,5
Aegopodium podagraria	1		2,5
Impatiens parviflora	+		0,2
Rubus ideaus	+		0,2
Galium aparine	+	+	00,5
Glechoma chederacea	+	1	2,55
Allaria petiolata	+	+	00,5
Phalaris arundinacaea		+	0,2
Geum urbanum		+	0,2
Ficaria verna		+	0,2
Anthriscus sylvestris		+	0,2
Helianthus tuberosus			0,2
Humulus lupulus		+	0,2
Poa nemoralis			0,2
Stachys sylvatica		+	0,2
Calystegia sepium			0,2
Rorippaamphibia	+		0,2
Pimpinella saxifraga	+		0,2
Equisetum arvense	+		0,2
Dianthus deltoides	+		0,2
Campanula patula		+	0,2
Dautus carota		+	0,2
Galium mollugo		+	0,2
Lotus corniculatus		+	0,2
Trifolium repens		+	0,2
Teifolium pratense		+	0,2
Holcus lanatus		+	0,2
Agrostis capillaris		+	0,2
Poa pratensis		+	0,2
Leontodon autumnalis		+	0,2

APPENDIX 8 – THE MAP OF PLANT INVASIVE SPECIES DISTRIBUTION



APPENDIX 9 - THE COASTLINE FLORISTIC LIST

Nr.	Latin name	Family
1.	*Achillea millefolium L.*	Asteraceae
2.	*Agrostis capillaris L.*	Poaceae
3.	*Alisma plantago-aquatica L.*	Alismataceae
4.	*Alopecurus pratensis L.*	Poaceae
5.	*Amaranthus retroflexus L.*	Amaranthaceae
6.	*Angelica sylvestris L.*	Apiaceae
7.	*Anthemis arvensis L.*	Asteraceae
8.	*Artemisia vulgaris L.*	Asteraceae
9.	*Berberis thunbergii DC.*	Berberidaceae
10.	*Betula pendula Roth*	Betulaceae
11.	*Bidens frondosa L.*	Asteraceae
12.	*Bromus carinatus Hooker &Arn.*	Poaceae
13.	*Calamagrostis epigeios (L.) Roth*	Poaceae
14.	*Calystegia sepium (L.) R. Br.*	Convolvulaceae
15.	*Carex acutiformis Ehrh.*	Cyperaceae
16.	*Carex gracilis Curt. = Carexacuta L.*	Cyperaceae
17.	*Carex species*	Cyperaceae
18.	*Centaurea cyanus L.*	Asteraceae
19.	*Cirsium arvense (L.) Scop.*	Asteraceae
20.	*Colchicum autumnale L.*	Colchicaceae
21.	*Convolvulus arvensis L.*	Convolvulaceae
22.	*Conyza canadensis (L.) Cronq.*	Asteraceae
23.	*Dactylis glomerata L.*	Poaceae
24.	*Deschampsia caespitosa (L.) Beauv.*	Poaceae
25.	*Elymus repens (L.) Gould*	Poaceae
26.	*Equisetum arvense L.*	Equisetaceae
28.	*Erigeron annuus (L.) Pers.*	Asteraceae
29.	*Erodium cicutarium (L.) L'Hér. ex Aiton*	Geraniaceae
30.	*Festuca rubra L.*	Poaceae
31.	*Galinsoga ciliata (Rafin.) S. F. Blake*	Asteraceae
32.	*Galinsoga parviflora Cav.*	Asteraceae
33.	*Galium aparine L.*	Rubiaceae
34.	*Galium palustre L.*	Rubiaceae
35.	*Glyceria maxima (Hartman) Holmberg*	Poaceae
36.	*Helianthus tuberosus L.*	Asteraceae
37.	*Holcus lanatus L.*	Poaceae
38.	*Iris pseudacorus L.*	Iridaceae
39.	*Juncus effusus L.*	Juncaceae
40.	*Juncus inflexus L.*	Juncaceae
41.	*Lolium perenne L.*	Poaceae
42.	*Lotus corniculatus L.*	Fabaceae

43.	*Lysimachia vulgaris L.*	Primulaceae
44.	*Lythrum salicaria L.*	Lythraceae
45.	*Oxalis europaea Jordan*	Oxylidaceae
46.	*Papaver rhoeas L.*	Papaveraceae
47.	*Phalaris arundinacea L.*	Poaceae
48.	*Phleum pratense L.*	Poaceae
49.	*Phragmites australis (Cav.)Tri.ex Ste.*	Poaceae
50.	*Pinus sylvestris L.*	Pinaceae
51.	*Plantago lanceolata L.*	Plantaginaceae
52.	*Plantago major L.*	Plantaginaceae
53.	*Poa annua L.*	Poaceae
54.	*Potentilla reptans L.*	Rosaceae
55.	*Reynoutria japonica Houtt.*	Polygonaceae
56.	*Reynoutria x bohemica*	Polygonaceae
57.	*Rosa species*	Rosaceae
58.	*Rubus species*	Rosaceae
59.	*Rumex acetosa L.*	Polygonaceae
60.	*Rumex obtusifolius L.*	Polygonaceae
61.	*Salix species*	Salicaceae
62.	*Sanguisorba officinalis L.*	Rosaceae
63.	*Scirpus sylvaticus L.*	Cyperaceae
64.	*Scutellaria galericulata L.*	Lamiaceae
65.	*Sisymbrium loeselii L.*	Brassicaceae
66.	*Solan umnigrum L.*	Solanaceae
67.	*Solidago canadensis L.*	Asteraceae
68.	*Solidago gigantea Aiton*	Asteraceae
69.	*Sparganium erectum L.*	Sparganiaceae
70.	*Taraxacum officinale Web. in Wigg.*	Asteraceae
71.	*Trifolium arvense L.*	Fabaceae
72.	*Trifolium repens L.*	Fabaceae
73.	*Typha latifolia L.*	Typhaceae
74.	*Urtica dioica L.*	Urticaceae
75.	*Vicia cracca L.*	Fabaceae

APPENDIX 10- THE LIST OF CURRENT TREE AND SHRUBS SPECIES

Nr.	Species	Trunk circumference [cm]	Height [m]	Health condition according to the Pacyniak and Smólski scale
1.	*Acer platanoides*	< 20	< 2	1-5
2.	*Alnus glutinosa*	190	17	1
3.	*Alnus glutinosa*	150	12,5	1
4.	*Alnus glutinosa*	190	16,7	1
5.	*Alnus glutinosa*	185	18	1
6.	*Alnus glutinosa*	163	18,5	1
7.	*Alnus glutinosa*	190	18,5	1
8.	*Alnus glutinosa*	154	18	1
9.	*Alnus glutinosa*	130	18	1
10.	*Alnus glutinosa*	125	18	1
11.	*Alnus glutinosa*	162	17,5	1
12.	*Alnus glutinosa*	164	13,5	1
13.	*Alnus glutinosa*	140	18,5	1
14.	*Alnus glutinosa*	138	17,5	1
15.	*Alnus glutinosa*	148	19	1
16.	*Alnus glutinosa*	221	19,5	1
17.	*Alnus glutinosa*	149	13	1
18.	*Alnus glutinosa*	153	12,5	1
19.	*Alnus glutinosa*	143	12	1
20.	*Alnus glutinosa*	175	15	1
21.	*Alnus glutinosa*	125	10,5	1
22.	*Alnus glutinosa*	154	17	1
23.	*Alnus glutinosa*	115	11	2
24.	*Alnus glutinosa*	84	8	3
25.	*Alnus glutinosa*	194	18	1
26.	*Alnus glutinosa*	190	18	4
27.	*Alnus glutinosa*	142	16,5	2
28.	*Alnus glutinosa*	163	15	1
29.	*Alnus glutinosa*	138	15	1
30.	*Alnus glutinosa*	225	16,5	1
31.	*Alnus glutinosa*	167	16,5	2
32.	*Alnus glutinosa*	158	12	1
33.	*Alnus glutinosa*	177	14	1
34.	*Alnus glutinosa*	95	10,5	3
35.	*Alnus glutinosa*	186	17	1
36.	*Alnus glutinosa*	208	17	2
37.	*Alnus glutinosa*	94	14,5	1
38.	*Alnus glutinosa*	77	14,5	1
39.	*Alnus glutinosa*	63	14,5	1
40.	*Alnus glutinosa*	96	14,5	1
41.	*Alnus glutinosa*	38	14	1
42.	*Alnus glutinosa*	80	14,5	1
43.	*Alnus glutinosa*	86	14,5	1
44.	*Alnus glutinosa*	42	14,5	1
45.	*Alnus glutinosa*	104	14,5	1
46.	*Alnus glutinosa*	45	13,5	1
47.	*Alnus glutinosa*	< 40	10	1
48.	*Alnus glutinosa*	68	15,5	1
49.	*Alnus glutinosa*	32	12,5	1
50.	*Alnus glutinosa*	85	11	1
51.	*Alnus glutinosa*	120	13	1
52.	*Alnus glutinosa*	87	12,5	1
53.	*Alnus glutinosa*	70	12	1
54.	*Alnus glutinosa*	73	12,5	1

55.	*Alnus glutinosa*	89	12,5	1
56.	*Alnus glutinosa*	98	13	1
57.	*Alnus glutinosa*	70	13	1
58.	*Alnus glutinosa*	68	13	1
59.	*Alnus glutinosa*	106	13	1
60.	*Alnus glutinosa*	202	13	2
61.	*Alnus glutinosa*	< 30	< 5	1
62.	*Betula pendula*	20	12,5	1
63.	*Malus* sp.	48	3	1
64.	*Populus nigra*	<25	0,5 -4	1
65.	*Populus nigra*	<70	06-mar	1
66.	*Populus nigra*	260	23,5	1
67.	*Prunus serotina*	< 25	< 5	1
68.	*Prunus serotina*	< 40	06-maj	1
69.	*Salix* sp.	< 70	06-mar	1
70.	*Salix* sp.	< 25	0,5-4	1
71.	*Salix* sp.	≤ 60	7	1
72.	*Salix* sp.	< 25	< 5	1
73.	*Salix* sp.	< 25	< 5	1
74.	*Salix* sp.	< 30	< 5	1
75.	*Sambucus nigra*	< 25	< 5	1
76.	*Sambucus nigra*	<20	<4	1
77.	*Sorbus acuparia*	< 25	14,5	1
78.	*Sorbus acuparia*	< 25	9,5	1
79.	*Quercus robur*	277	20	1
80.	*Quercus robur*	290	20,1	1

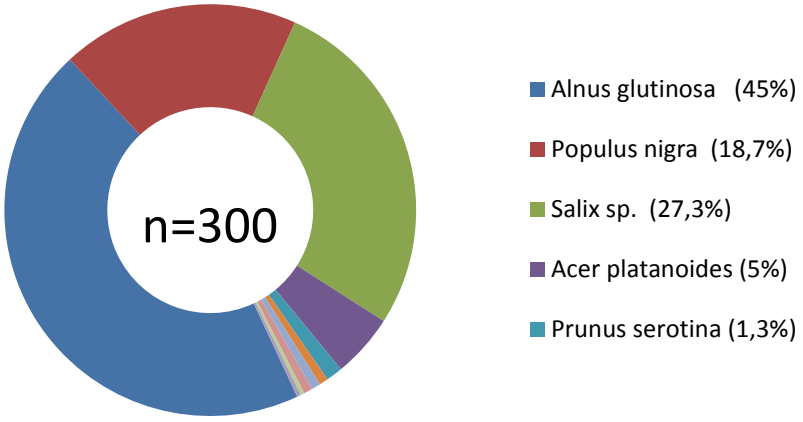
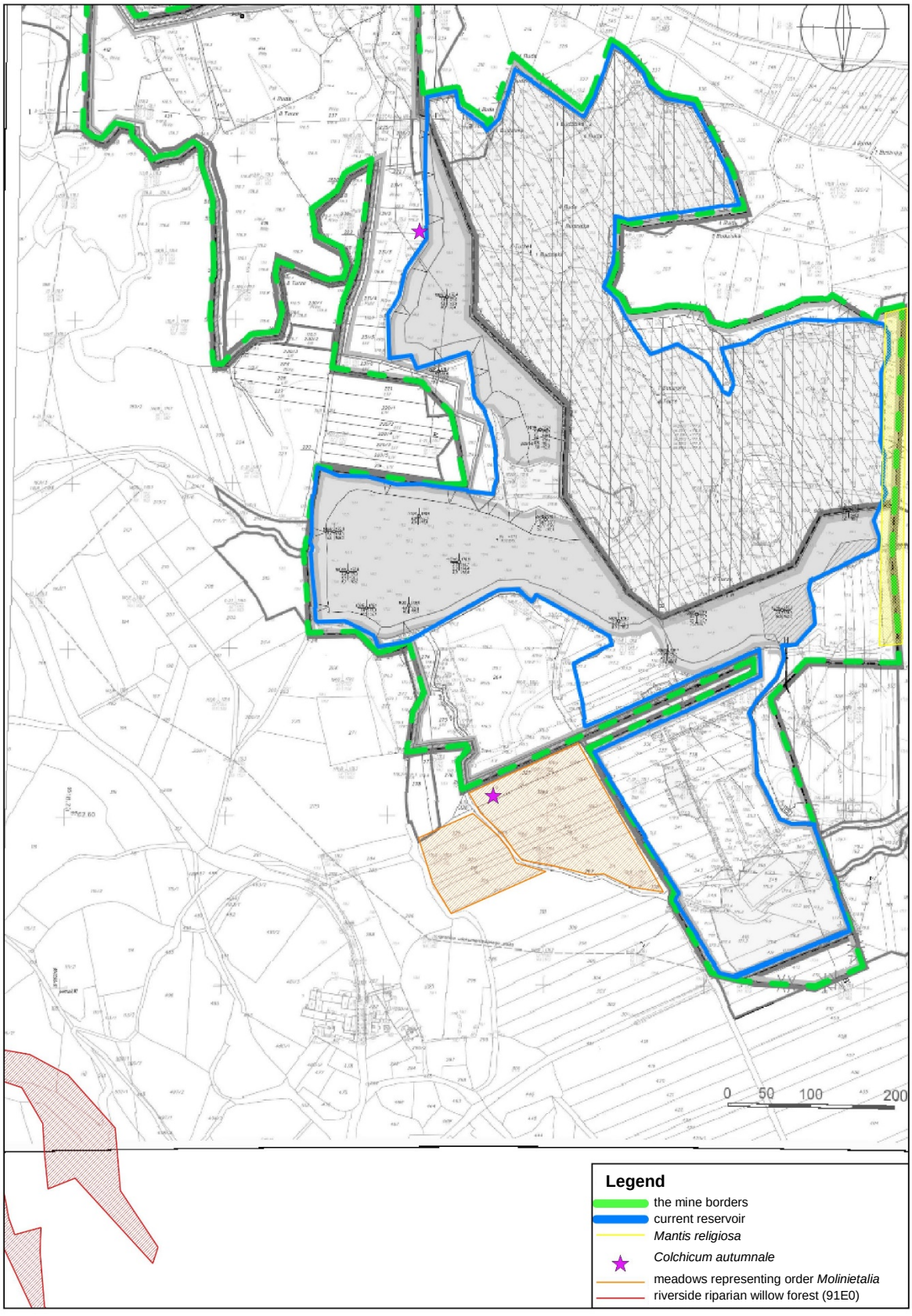
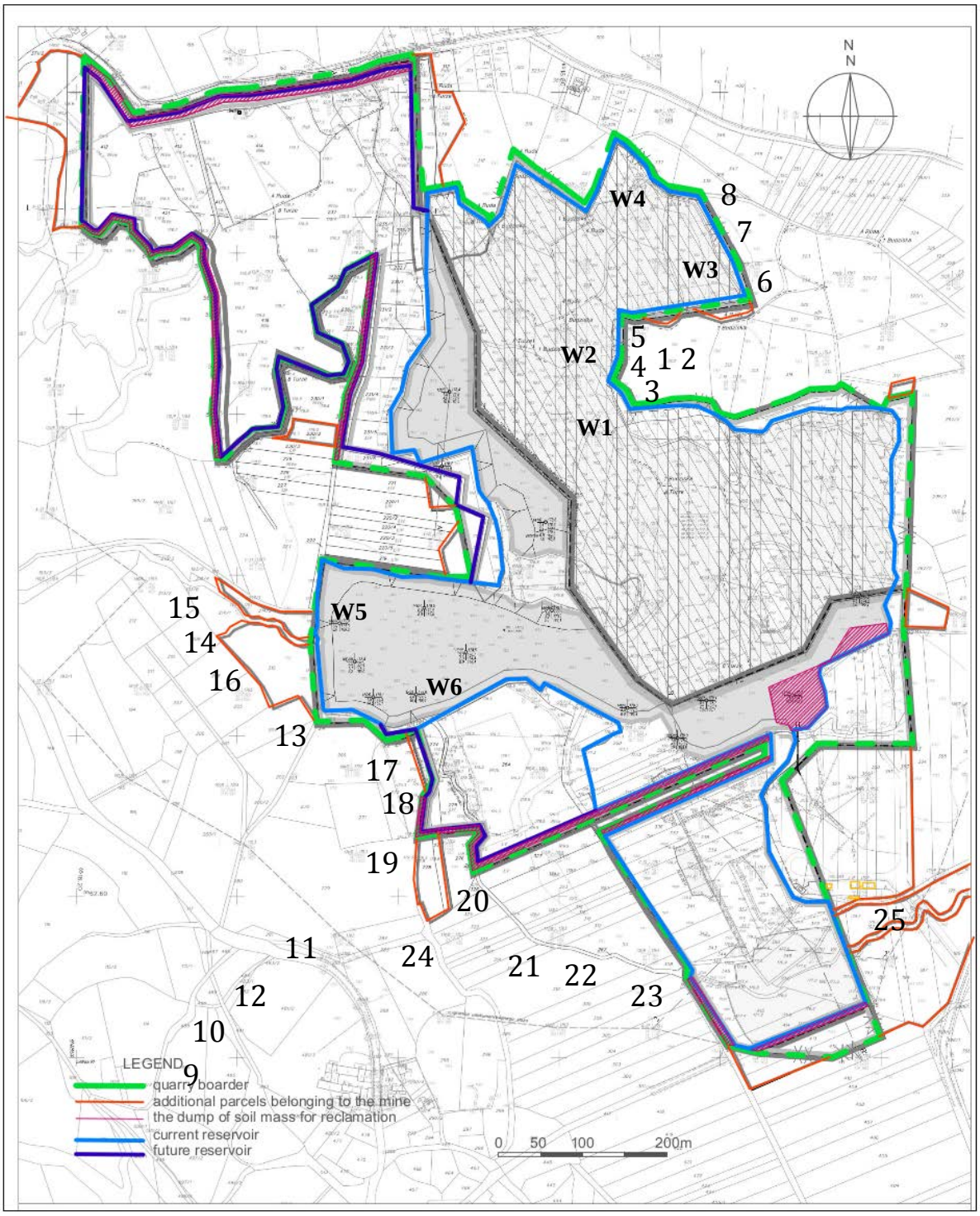


Fig. The percentage proportion of existing trees and shrubs species

APPENDIX 11- THE DISTRIBUTION MAP OF VALUABLE PLANT COMMUNITIES AND PLANT AND INSECTS SPECIES



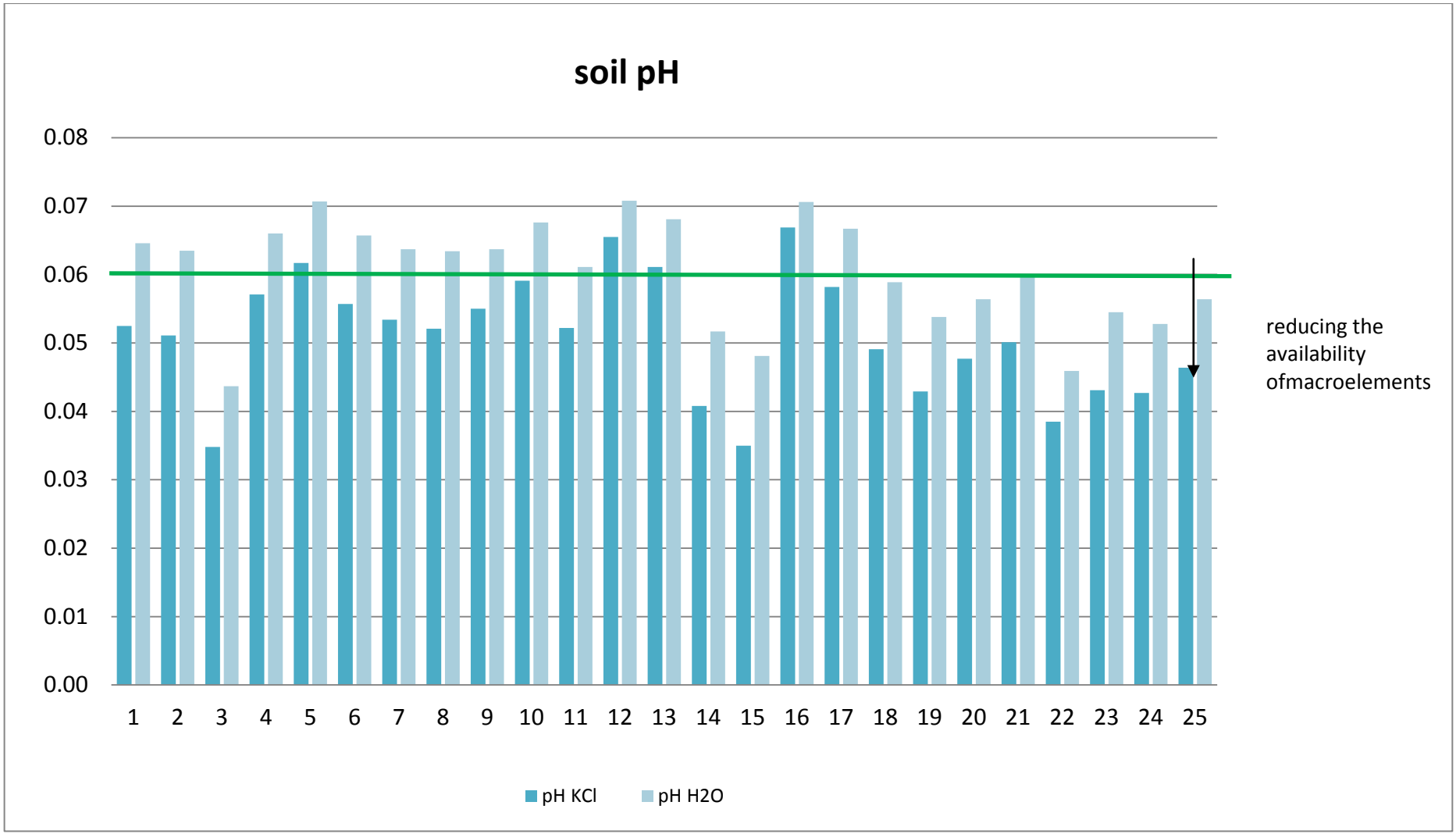
APPENDIX 12 – THE DISTRIBUTION MAP OF SOIL AND WATER SAMPLES

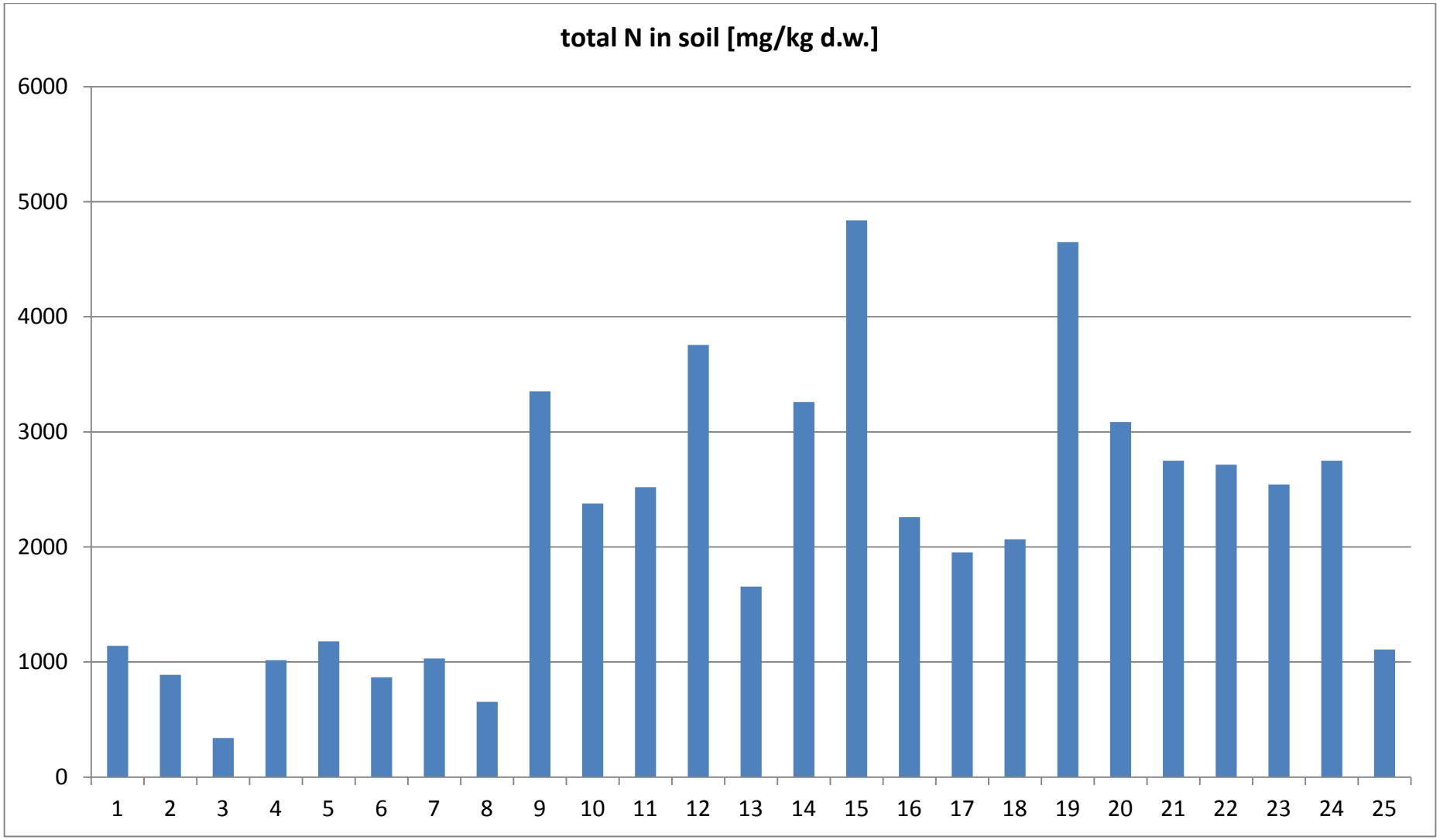


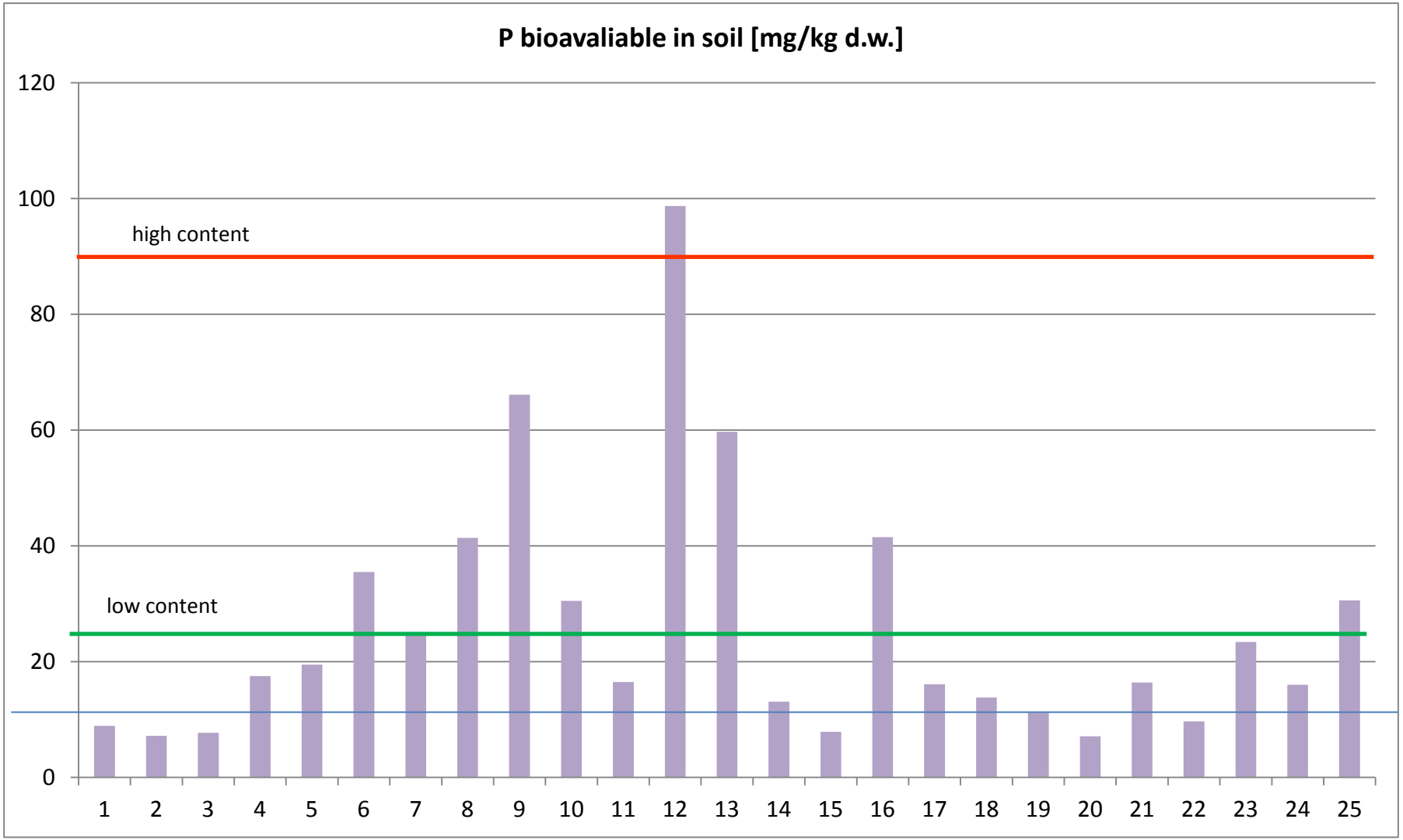
APPENDIX 13- THE TYPE, THE PH AND THE CONTENTS OF MACROELEMENTS IN SOIL FROM THE RUDA QUARRY

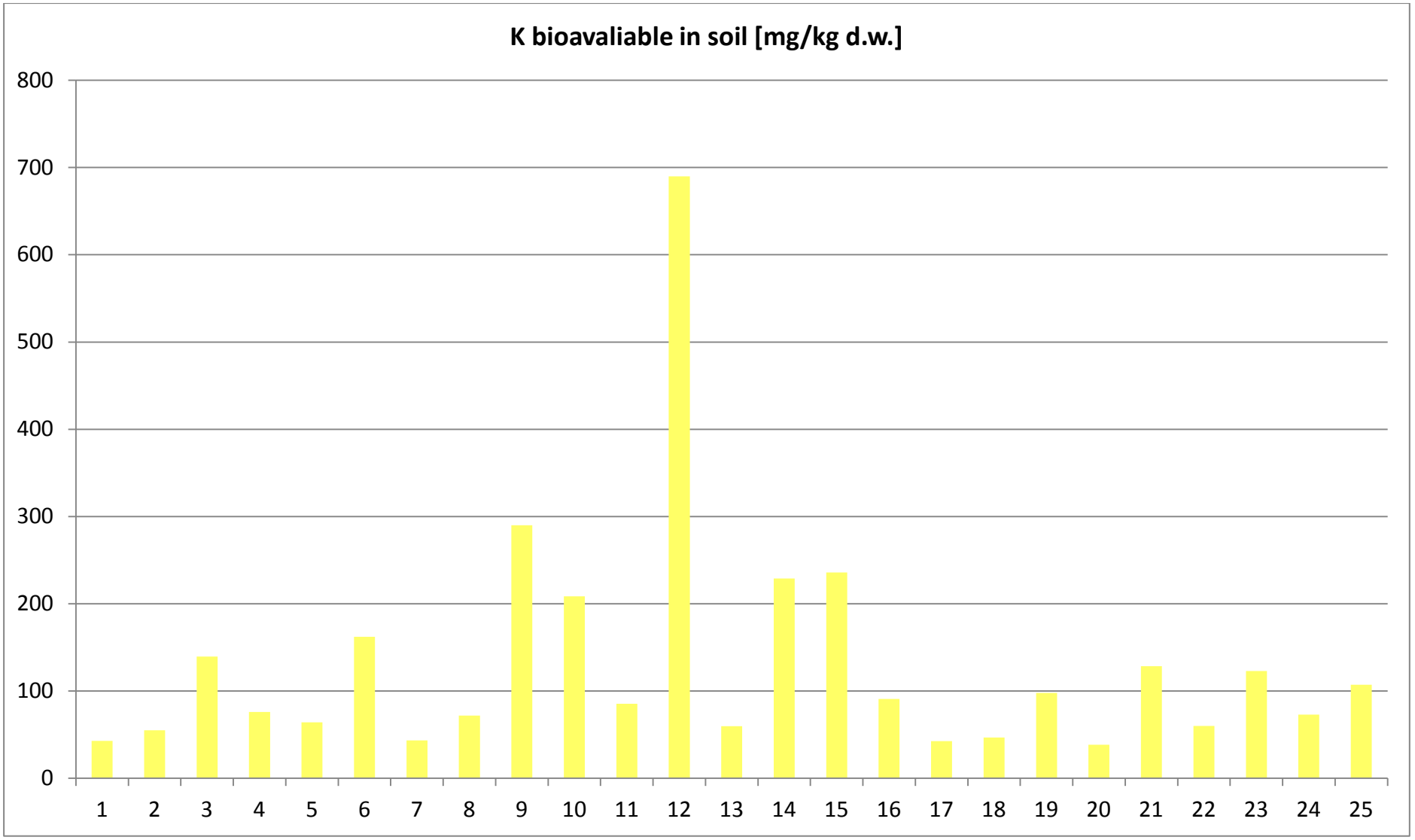
study site	textural group	pH KCl	pH H_2O	N [mg/kg]	P [mg/kg]	K [mg/kg]	Ca [mg/kg]	Mg [mg/kg]	Na [mg/kg]
1	scl	5.25	6.46	1141	8.9	43.0	1414	160.0	11.2
2	scl	5.11	6.35	889	7.2	55.1	1657	171.2	15.9
3	ls	3.48	4.37	340	7.7	139.4	82	17.6	89.8
4	scl	5.71	6.60	1016	17.5	76.1	1487	160.7	8.72
5	sc	6.17	7.07	1179	19.5	64.1	1827	138.5	10.2
6	sc	5.57	6.57	868	35.5	162.3	688	51.4	4.88
7	scl	5.34	6.37	1032	25.1	43.6	992	65.8	2.72
8	scl	5.21	6.34	655	41.4	71.8	594	31.8	8.60
9	scl	5.50	6.37	3353	66.1	290.1	2731	252.0	14.6
10	sc	5.91	6.76	2377	30.5	208.6	2320	231.6	13.2
11	scl	5.22	6.11	2519	16.5	85.3	2588	245.4	17.4
12	scl	6.55	7.08	3755	98.7	689.9	3294	328.4	56.5
13	sc	6.11	6.81	1656	59.7	59.6	2822	185.0	15.0
14	sc	4.08	5.17	3259	13.1	229.1	1922	218.8	26.6
15	scl	3.50	4.81	4838	7.9	236.0	746	101.8	9.12
16	scl	6.69	7.06	2260	41.5	91.0	3333	218.0	14.0
17	sc	5.82	6.67	1953	16.1	42.7	2638	241.6	14.8
18	sc	4.91	5.89	2066	13.8	46.8	1732	199.0	10.2
19	scl	4.29	5.38	4649	11.2	97.8	2121	235.0	34.2
20	ls	4.77	5.64	3086	7.1	38.6	1877	201.1	21.6
21	ls	5.01	5.98	2750	16.4	128.6	1518	178.6	13.6
22	ls	3.85	4.59	2715	9.7	60.0	330	52.7	28.2
23	ls	4.31	5.45	2544	23.4	122.9	720	163.6	23.6
24	scl	4.27	5.28	2750	16.0	72.9	1956	218.0	75.4
25	scl	4.64	5.64	1109	30.6	107.1	563	111.4	10.8

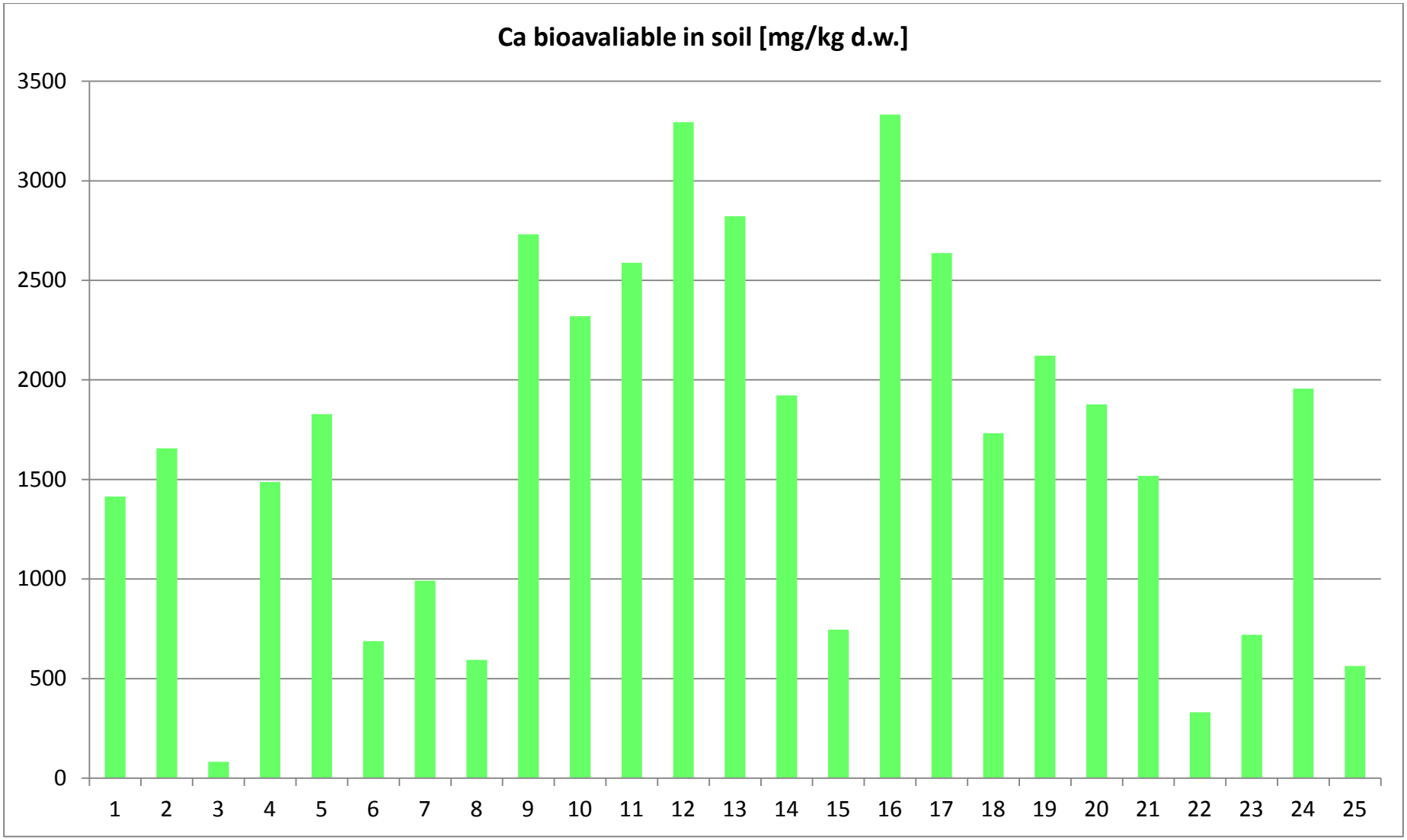
scl – sandy clay loam
sc – sandy clay
ps – loamy sand (PTG, 2008)

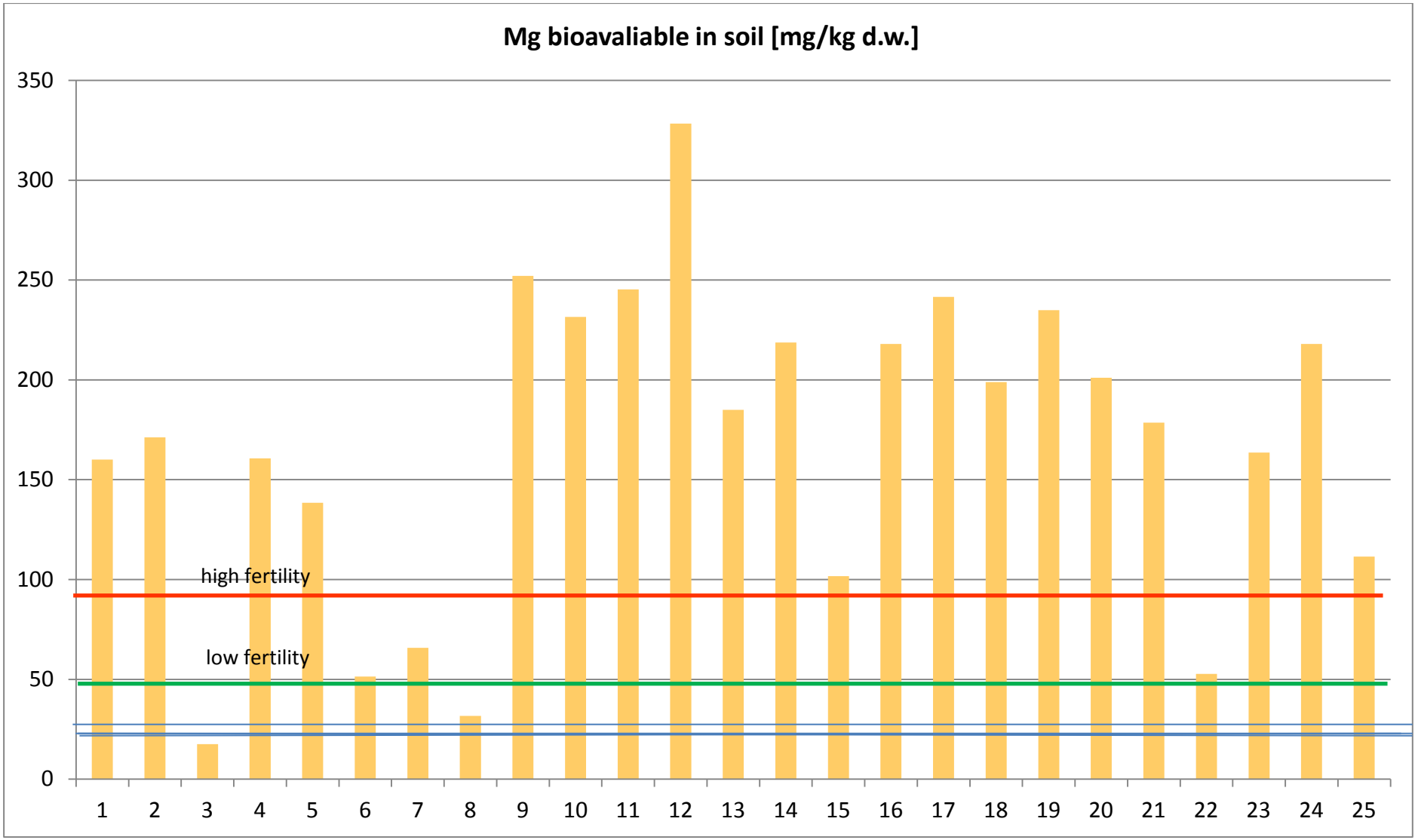

soil pH
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25
pH KCl
pH H2O
reducing the availability ofmacroelements

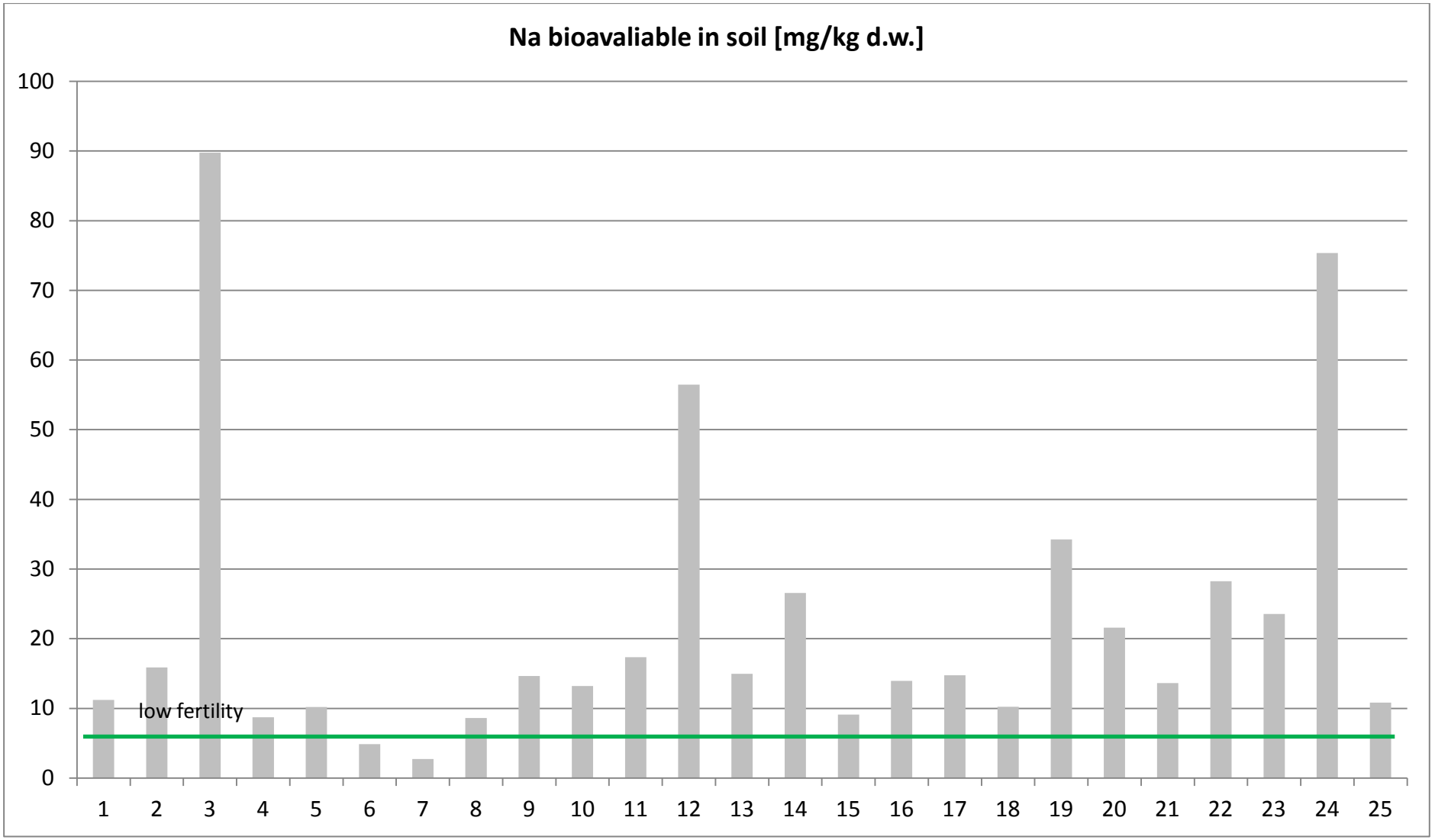

total N in soil [mg/kg d.w.]
6000
5000
4000
3000
2000
1000
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25


P bioavaliable in soil [mg/kg d.w.]
120
100
80
60
40
20
0
high content
low content
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25


K bioavaliable in soil [mg/kg d.w.]
800
700
600
500
400
300
200
100
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25

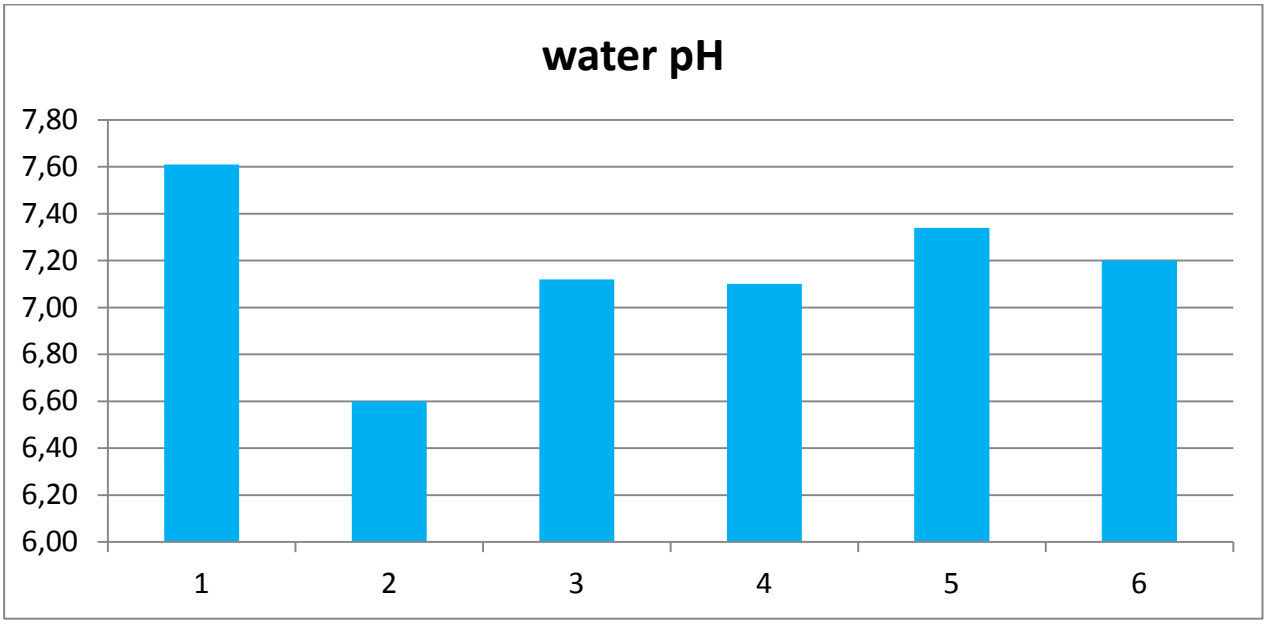

Ca bioavaliable in soil [mg/kg d.w.]
3500
3000
2500
2000
1500
1000
500
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25

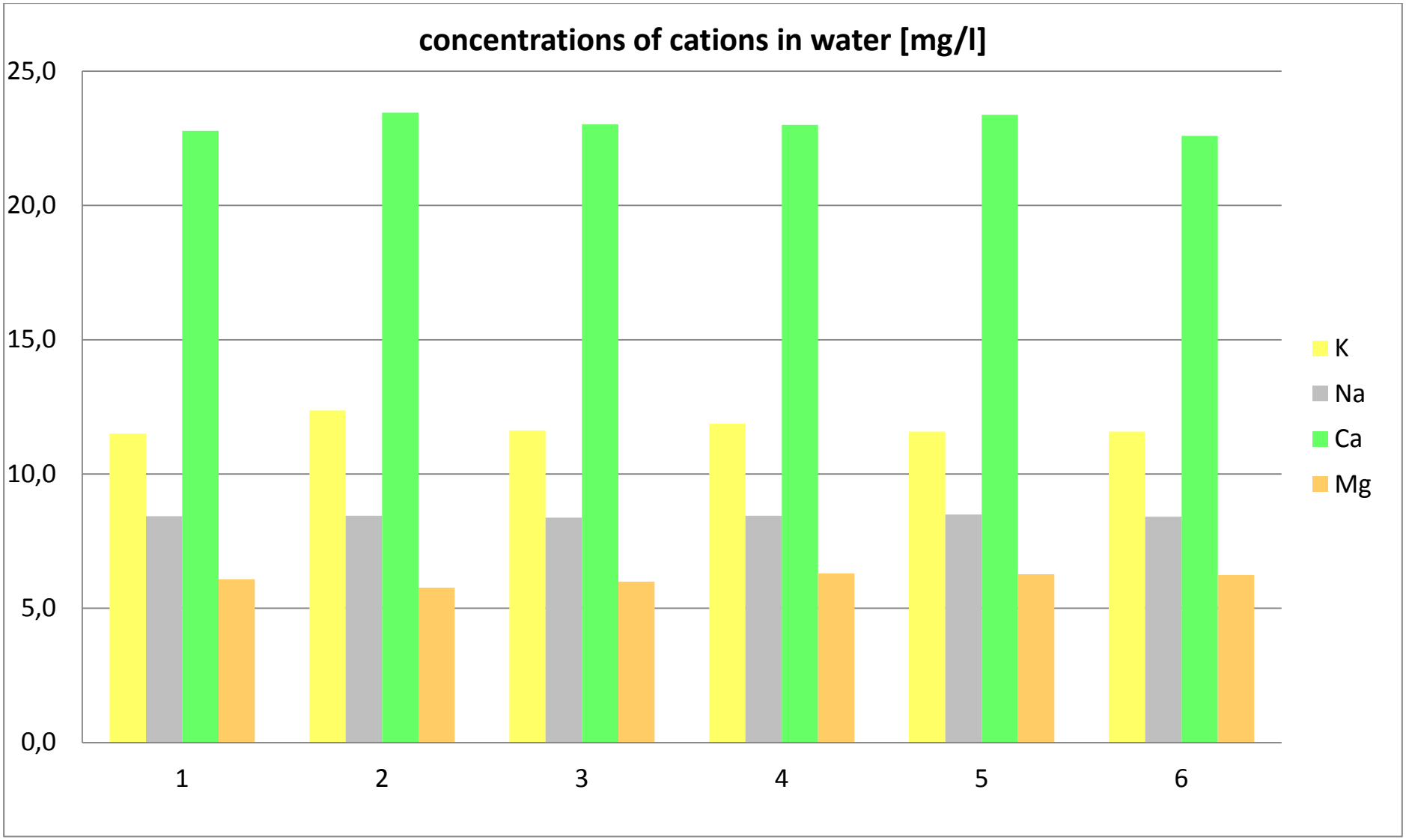

Mg bioavaliable in soil [mg/kg d.w.]
350
300
250
200
150
100
50
0
high fertility
low fertility
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25

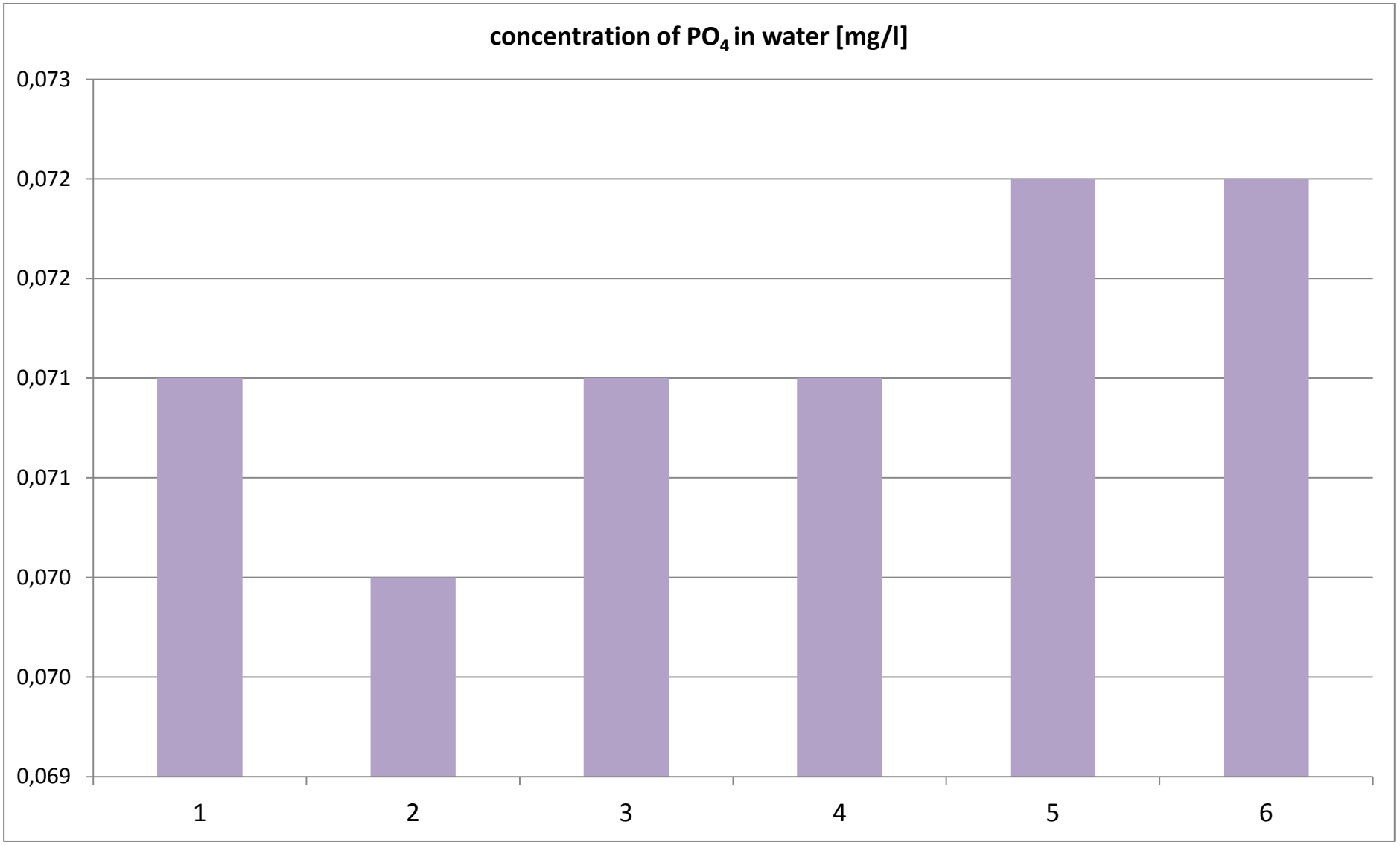

Na bioavaliable in soil [mg/kg d.w.]
100
90
80
70
60
50
40
30
20
10
0
low fertility
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25

APPENDIX 14- THE PH AND THE CONTENTS OF MACROELEMENTS IN THE WATER FROM THE RESERVOIR IN THE RUDA QUARRY

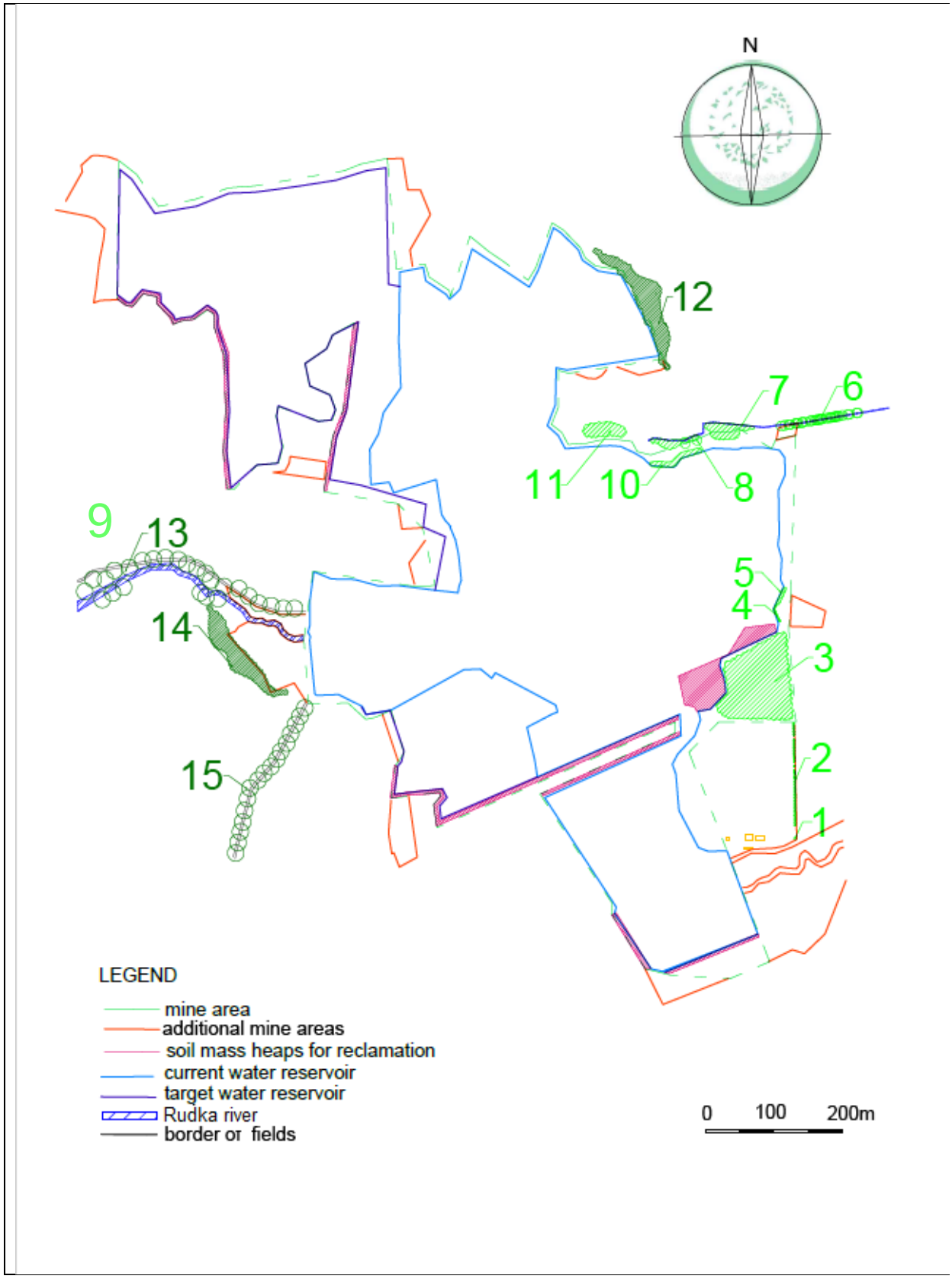
study site	pH	K [mg/l]	Na [mg/l]	Ca [mg/l]	Mg [mg/l]	PO_4 [mg/l]
w1	7.61	11.5	8.43	22.8	6.08	0.071
w2	6.60	12.4	8.45	23.5	5.77	0.07
w3	7.12	11.6	8.38	23.0	5.99	0.071
w4	7.10	11.9	8.44	23.0	6.30	0.071
w5	7.34	11.6	8.49	23.4	6.27	0.072
w6	7.20	11.6	8.41	22.6	6.25	0.072

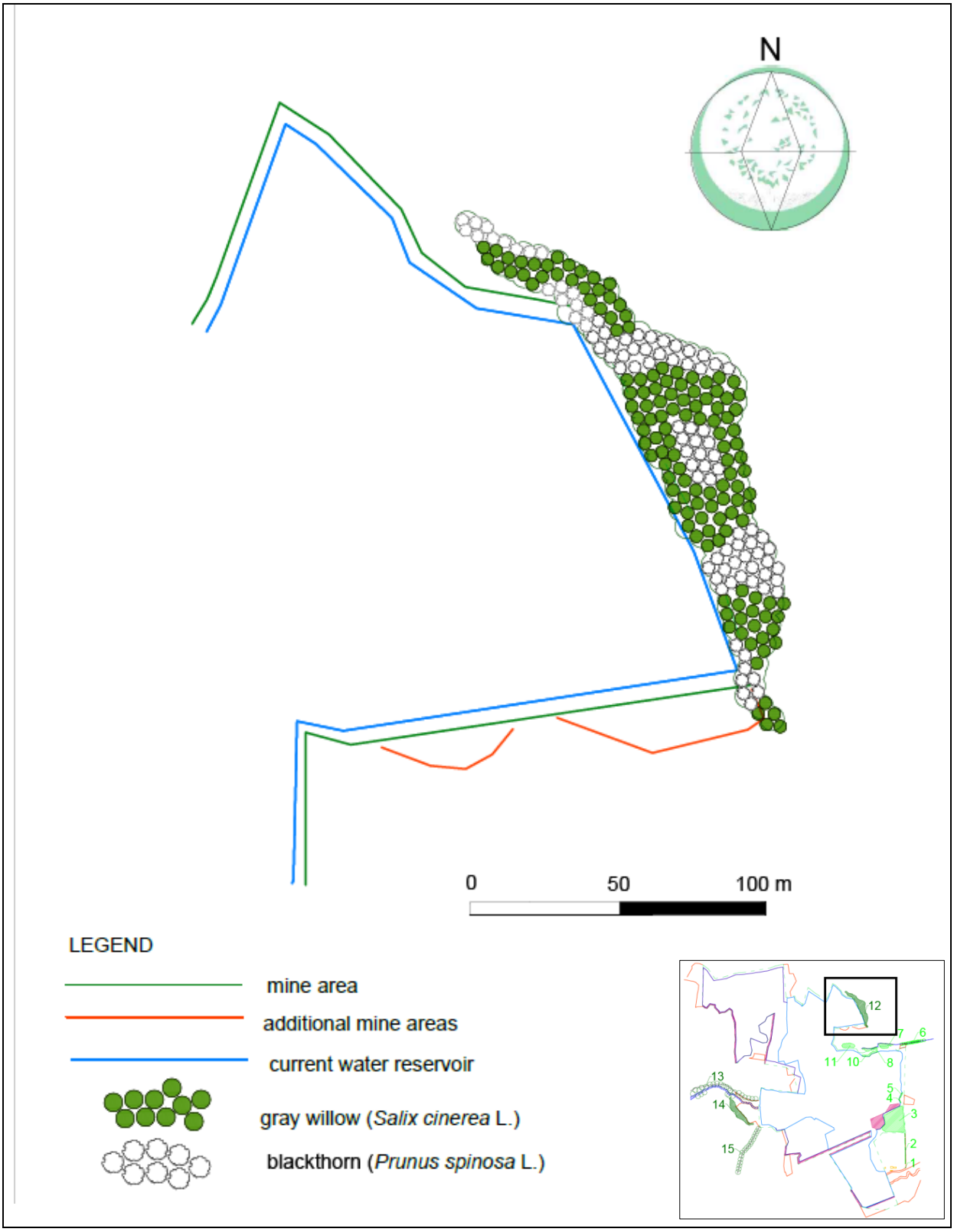


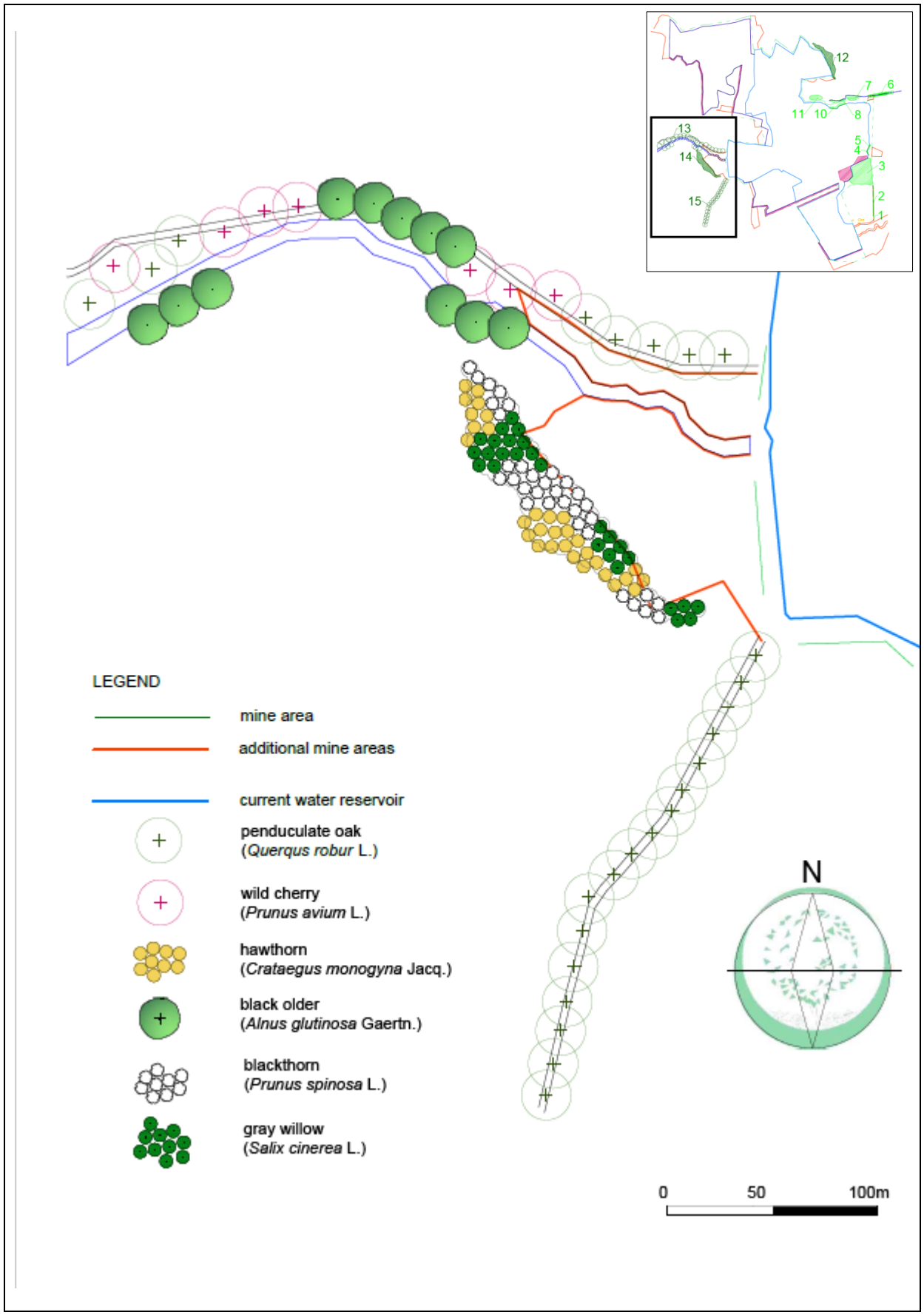

concentrations of cations in water [mg/l]
25,0
20,0
15,0
10,0
5,0
0,0
1
2
3
4
5
6
K
Na
Ca
Mg


concentration of PO4 in water [mg/l]
0,073
0,072
0,072
0,071
0,071
0,070
0,070
0,069
1
2
3
4
5
6

APPENDIX 15 – THE PLANTING PROJECT




N
0
50
100 m
LEGEND
mine area
additional mine areas
current water reservoir
gray willow (Salix cinerea L.)
blackthorn (Prunus spinosa L.)
12
7
6
11
10
8
13
5
4
14
3
15
2
1

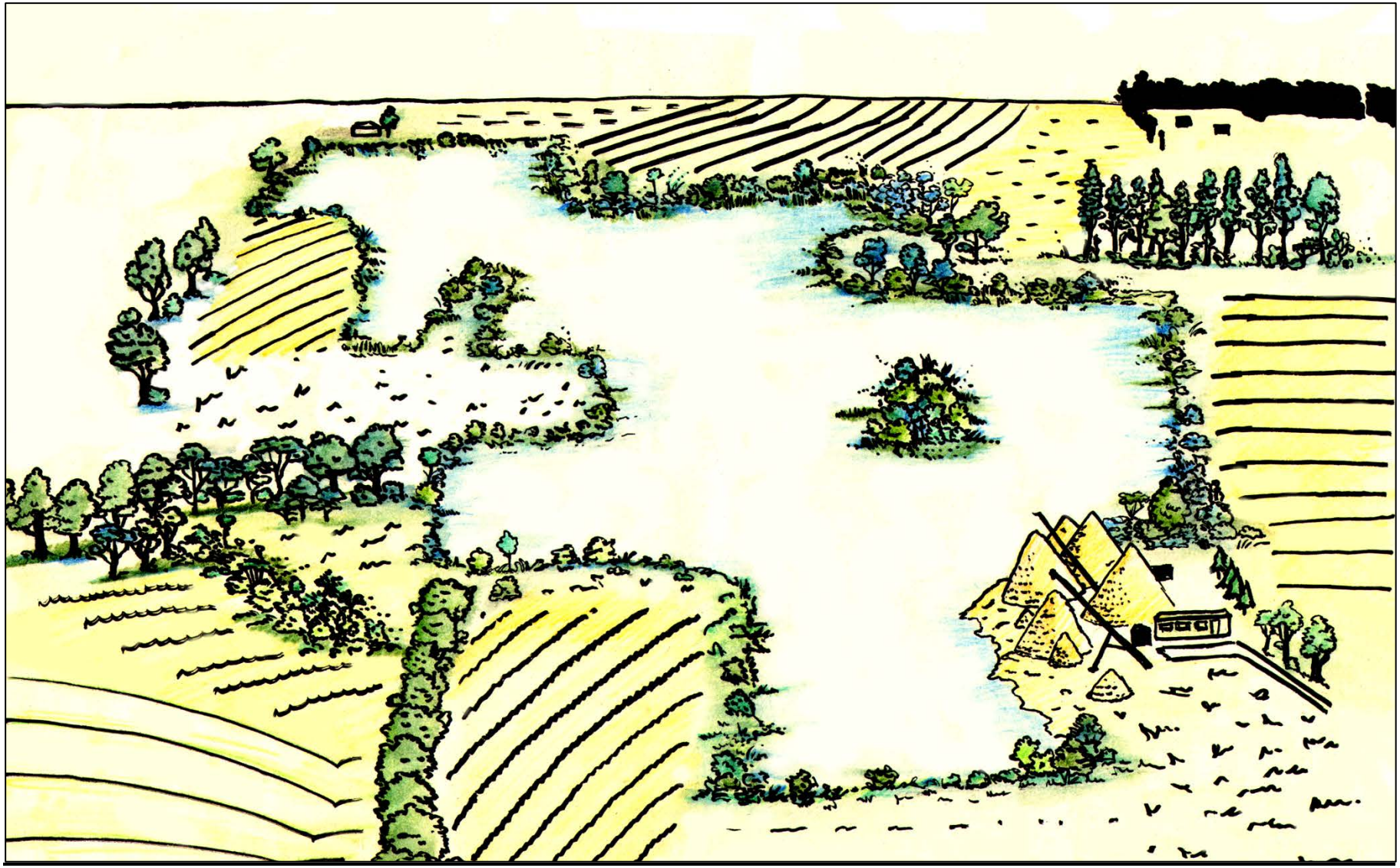

12
7
6
11
10
8
13
14
5
4
3
2
1
15
LEGEND
mine area
additional mine areas
current water reservoir
penduculate oak
(Querqus robur L.)
wild cherry
(Prunus avium L.)
hawthorn
(Crataegus monogyna Jacq.)
black older
(Alnus glutinosa Gaertn.)
blackthorn
(Prunus spinosa L.)
gray willow
(Salix cinerea L.)
N
0
50
100m

APPENDIX 16- THE ECOLOGICAL CHARACTERISTICS OF THE PROPOSED PLANTING

species name	habitat conditions	interspecies interactions	insects associated with the a plant species	birds associated with the a plant species	additional advantages
Prunus spinosa (blackthorn)	- pioneering tree, - dry or slightly moist soil, - soil with neutral or alkaline pH, - nutrient rich soil	- blackthorn creates habitat for small mammals and birds, - flowering blackthorn is a source of feed for pollinating insects, - fruits are feed for many species of birds, - caterpillars from more than 140 species of butterflies feed on a blackthorn leaves	- on blackthorn live butterfly's caterpillars from the families: Noctuidae, Geometridae, Lasiocampidae, Yponomeutidae and Lymantriidae - flowers provides nectar for many species of solitary bees	- blackthorn provides shelter and food for among others: shrikes, eurasian blackcaps, song thrushes and hawfinches	- blackthorn strengthen the rocky slopes, - as a pioneer species inhabits unused pastures and slopes
Crataegus monogyna (hawthorn monogyna)	- moist or slightly moist soil, - slightly acidic, neutral or alkaline soil, - soil moderately rich, fertile or very fertile	- fruit of hawthorn are a food for birds and rodents, - animals nailed to thorns of the hawthorn are the food base for a larger mammals, - an important species for pollinating insects and butterflies caterpillars feed on the leaves	- on the of hawthorn leaves fed butterfly caterpillars from the family Lasiocampidae - wasps (Hymenoptera) and flies (Diptera) are its pollinators	- in the crown of the hawthorn nest for example: red-backed shrike, song thrush and eurasian blackcap	
Salix cinerea (gray willow)	- moist soil, - soil moderately rich, fertile or very fertile	- willow bushes are a shelter for nesting birds, - willow's flowers provide nectar for a number of species of pollinating insects	- on the willow feed butterflies caterpillars from the Nymphalidae family	- bird species associated with aquatic ecosystems nest in willow bushes	
Prunus avium (wild cherry)	- fertile or moderately fertile soil with neutral pH	- the tree provides nectar for a number of species of pollinating insects - fruits are food for many species of birds	- the flowers are pollinated by bees (Hymenoptera) and flies (Diptera)	-fruits are food for birds: e.g. hawfinch, song thrush	
Quercus robur (english oak)	- fertile or moderately fertile soil - moist soil with neutral or acidic pH, - oak is resistant to pollutions	- oak acorns are food for birds, wild boars and forest dormouse, - butterflies caterpillars feed on the oak leaves, - mature oaks are shelter for birds, mammals and insects	- oak leaves are food for ca. 300 species of butterflies - in oak wood live few protected species of beetle, for example: Capricorn beetle *Cerambyx cerdo*, commonly known as great capricorn beetle	- acorns are food for hawfinch, jay and capercaillie, - oak hollows are home for large owls and woodpeckers	-oak bark is the best ground for the development of bryophytes and lichens

Alnus glutinosa (black alder)	- pioneering tree, - moist soil with neutral pH, - fertile or moderately fertile soil	- alder seeds are eaten by birds and mammals during the winter, - butterflies caterpillars feed on the alder leaves	- leaves are food for the beetles from Chrysomelidae family and for butterflies caterpillars	- alder is a place of feeding birds such as: redpoll and eurasian siskin	- black alder strengthens a soil and enriches it in nitrogen, - thanks to the dense root system, it stabilizes the edges of ponds and watercourses

APPENDIX 17 – THE VISUALIZATION OF PLANTING PROJECT



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