COMPARISON OF ENVIRONMENTAL CHARACTERISTICS AND ECOLOGICAL VALUE BETWEEN TECHNICAL RECLAMATION AND SPONTANEOUS SUCCESSION ON POST-MINING AREAS IN CZECH REPUBLIC:

From point of view of *Rana dalmatina*

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PRESENTATION

I am Victor Martinez Bolea who studies Environmental Sciences at the University of Zaragoza and I am the author of this project.

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This project has been made within interchange program Erasmus; between Polytechnic University College belonging at the University of Zaragoza and Faculty of Environmental Sciences which depends of Czech University of Life Sciences Prague.

Idea about this project was conceived during December of 2011, when Ing. Jiří Vojar Ph.D. offered me collaborates with his research group which worked and studied about post-mining areas, ecological restoration and amphibians since 15 years ago. Proposal was presented to the Polytechnic University College and after being accepted, Jose Manuel Nicolau was choosed as speaker. While obviously, Jiří Vojar was designated project´s director.

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Then, first three months of 2012 was used to learn all necessary about coal mining, ecological restoration and amphibian ecology. Field work was carried out during two first weeks of April. Later, last weeks of April, May and June was done analysis of data and redaction the project. Finally, 6th of July was presented this project.

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ABSTRACT

Due to decline of coal mining in Europe we found many post-mining areas in which we must carry out ecological restoration. At present, there are two main options; one hand, traditional technical reclamation and, other hand, innovative spontaneous succession. We compare both methods in order to know how environmental characteristics of resultant ponds are in each case. In addition, we analyze habitat preferences of Rana dalmatina under situations with high and poor abundance of clutches. Study area is North Bohemian Brown Coal Basin where we took data; then carry out statistical analysis. We found on spontaneous succesion areas a higher proportion of smaller shallow ponds, with gentle shore slopes, partial insolation of water surface and partial vegetation cover which characteristics are suitable for European amphibians. Also, when abundance of clutches is low the environmental characteristics of ponds as depth, vegetation cover, surrounding environment and status of reclamation are more important than with these levels are high. We conclude ponds on spontaneous succession have more suitable characteristics for amphibians (Rana dalmatina) than does technical reclamation; thus represent a wonderfull potential for nature conservation. Lastly, we want remember that there is a general decline in amphibian abundance so we must try to generate them the better environmental features for this situations.

KEYWORDS:

Coal mining, post-mining areas, spoil banks, ecological restoration, technical reclamation, spontaneous succession, amphibians, Rana dalmatina, Czech Republic and North Bohemian Coal Basin

1. INTRODUCTION

The general goal of this project is compare the ecological value between reclaimed and successional post-mining areas (PMA)*. The reason is that despite the many advantages of spontaneous succession which known, rigorous technical reclamation of spoil banks still dominates in the Czech Republic (HODAČOVÁ and PRACH, 2003). One hand, technical reclamation has predominated during the end of the last century because of the fact that has kept an inheritance of communist approach of ecological restorarion in PMA. Thus, this has lead to a more uniform environment and a terrain is totally planned homogeneously. Other hand, spontaneous succession should be considered as a reasonable alternative to technical reclamation of spoil heaps in the area, providing more diverse vegetation cover (HODAČOVÁ and PRACH., 2003) and diversity animal (NICHOLS., 2003. RATHKE and BRÖRING, 2005) than technical reclamation sites.

We work in North Bohemian coal basin in Czech Republic but also we want know the situation in other areas around the world. First, we analyze ponds on spontaneous succession and on technical reclamation spoil banks, in order to know main differences of ponds under the influence of these two ecological restoration methods. Then, we work about abundances of Rana dalmatina (Agile frog in English; rana ágil in Spanish) clutches, so that we can analyze the ponds characteristic more important with different levels of clutches abundance. In addition, we can known habitat preferences of them when there is high abundance and, on the contrary, when this levels are poor. All this will allow carry out a effective conservation management.

¿Why we study Rana dalmatina? Because this specie, as all amphibians, is a great indicator of environmental features, since it is very sensitive to environmental changes. Summarizing, goals of this project are the next:

1.) To compare the environmental characteristic (size, depth, vegetation, slope, shine, water quality, etc.) of ponds on reclaimed and unreclaimed PMA.

2.) Analyzing data on abundance between the year 2008 with highest and the year 2012 with poorest of Rana dalmatina to assess the population dynamic of this species on specific environment of spoil bank.

3.) To compare population abundances and habitat preferences of Rana Dalmatina in the years aforementioned.

** PMA= post-mining area; next, we will abbreviate*

1.1. BACKGROUNDS

1.1.1 COAL MINING

The industrialisation of Europe in the eighteenth and nineteenth centuries was based on coal. During these centuries of development, open-cast mining caused total destruction of original ecosystem in the coal areas and changes in the surrounding areas (SKLENIČKA and LHOTA, 2002; DOLEŽALOVÁ et al., 2008). In the last decades of XXI century, there was an overall decline of coal mining that affected different coal regions of Europe. The impact of this crisis has given like result scars on the landscape, unemployment and reduction in the quality of the environment.

We can found two general types of mining: one hand, underground mining and another hand, surface mining. Next, is showed these two methods obtained of Kentuchy Geological Survey, University of Kentuchy.

- UNDERGROUND MINING

The modes of underground mining are: drift, slope and shaft mining, also now the actual methods include longwall and room and pillar mining. Drift mines enter horizontally into the side of a hill and mine the coal within the hill. Slope mines usually begin in a valley bottom, and a tunnel slopes down to the coal to be mined. Shaft mines are the deepest mines; a vertical shaft with an elevator is made from the surface down to the coal (Figure 1).

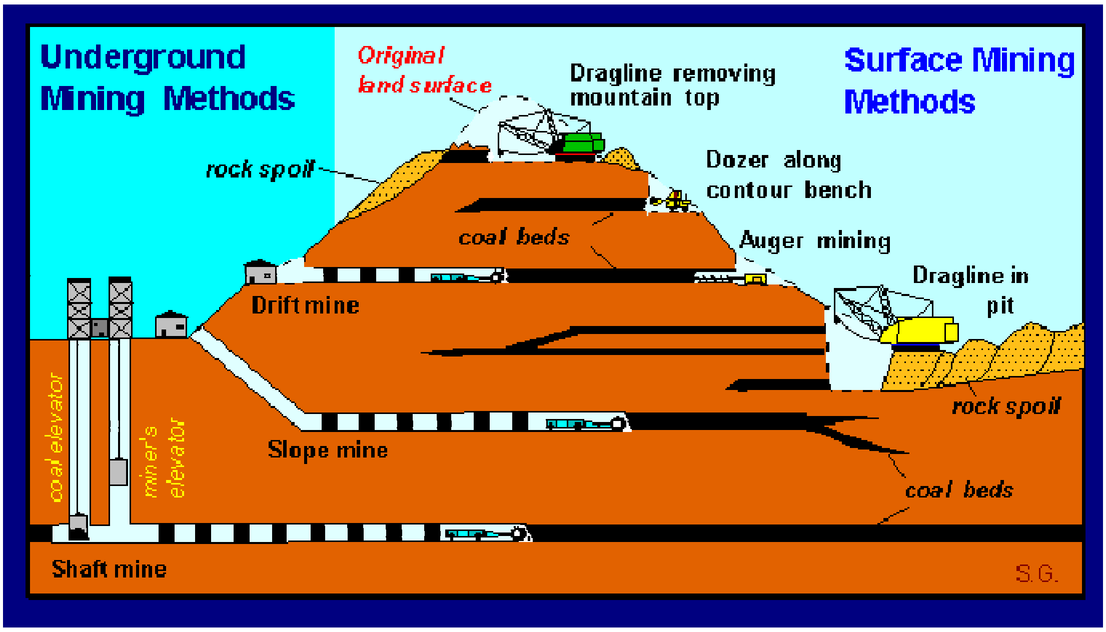


Figure 1: Methods of mining **Source:** Kentuchy Geological Survey

In room and pillar mining, the most common type of underground coal mining, coal seams are mined by a "continuous miner" that cuts a network of "rooms" into the seam. "Pillars" composed of coal are left behind to support the roof of the mine. Each "room" alternates with a "pillar" of greater width for support. Using this mining method normally results in a reduction in recovery of as much as 60 percent because of coal being left in the ground as pillars.

Longwall mining is another type of underground mining. Mechanized shearers are used to cut and remove the coal at the face of the mine. After the coal is removed, it drops onto a chain conveyor, which moves it to a second conveyor that will ultimately take the coal to the surface. This method of mining has proven to be more efficient than room and pillar mining, with a recovery rate of nearly 75 percent, but the equipment is more expensive than conventional room and pillar equipment, and cannot be used in all geological circumstances.

- SURFACE MINING

Surface-mining methods include area, contour, mountaintop removal, and auger mining. Area mines are surface mines that remove shallow coal over a broad area where the land is fairly flat. Huge dragline shovels commonly remove rocks overlying the coal. After the coal has been removed, the rock is placed back into the pit. Contour mines are surface mines that mine coal in steep, hilly, or mountainous terrain. A wedge of overburden is removed along the coal outcrop on the side of a hill, forming a bench at the level of the coal. After the coal is removed, the overburden is placed back on the bench to return the hill to its natural slope. Mountaintop removal mines are special area mines used where several thick coal seams occur near the top of a mountain. Large quantities of overburden are removed from the top of the mountains, and this material is used to fill in valleys next to the mine. Auger mines are operated on surface-mine benches; the coal in the side of the hill that can't be reached by contour mining is drilled out.

- COAL MINING

According to OKD, the most important mining company in Czech Republic, in worldwide; the coal is the second most utilized raw material in terms of energy in the world, right after oil. Around three quarters of this quantity is used in power plants – though different sources vary considerably in this respect. Retaining the current level of consumption, the known stock of all coal types would last for some 300 years (Table 1).

Country	Verified stock (Bill. t.)	Annual production (Bill. t.)	Annual consumption (Bill. t.)
China	125*	1,6	1,5
India	90	0,43	0,45
Russia	270	0,25	0,29
USA	270	1,06	1,07
* The propable stock is around 4 trillion of tons			

Table 1: World producers and consumers of coal **Source:** OKD

The problem of current utilization of coal in power plants is the low efficiency of its conversion to electricity (around 40 percent is stated with modern units) and the pollution produced. The developed countries therefore are making a substantial effort in development of new methods of conversion of coal to electricity.

In the EU member states the coal is a traditional and one of the most abundant domestic sources of energy. Nowadays the hard coal is imported to an increasing extent because internal exploitation in the EU is unprofitable due to high cost of labour and safety measures. Sale of domestic hard coal is mostly subsidized by European governments and mining is gradually being reduced. Part of this fact is also due to the hypothesis according to which emissions of carbon dioxide are the cause of global warming. Although also, the European countries want get more energetic self-sufficiency and as result of it, phasing down of coal mining is being replaced with support for development of clean methods of producing electricity from coal.

European Association for Coal and Lignite (EURACOAL) indicates that in Czech Republic the coal is the only significant indigenous energy resource. The country’s coal resources have been estimated at some 2.4 billion tonnes and cover about 500 km2 (ŘEHOUNEK et al., 2010). Brown coal, which accounts for more than 70 % of these resources, is mainly produced in north-western Bohemia, whilst hard coal is mined in northern Moravia. Hard coal is exported in significant quantities to Slovakia, Austria and Poland (Figure 2).

Figure 2: Mining areas in CR **Source:** EURACOAL

Mining of other resources have been rather rare, if we do not consider historical mining. Here, we focus on spoil heaps after coal mining, because they are fairly more extensive and their formation continues until the present. The area of coal spoil heaps is around 270 km2 and approximately the same area is heavily impacted by mining in other ways.

1.1.2. ECOLOGICAL RESTORATION

Restoration is defined as the return of an ecosystem to a close approximation of its condition prior to disturbance. In restoration, ecological damage to the resource is repaired. Both the structure and the functions of the ecosystem are recreated. Merely recreating the form without the functions, or the functions in an artificial configuration bearing little resemblance to a natural resource, does not constitute restoration. The goal is to emulate a natural, functioning, self-regulating system that is integrated with the ecological landscape in which it occurs. (NATIONAL RESEARCH COUNCIL, 1992)

It is easy to believe that restoration should only have one aim, that of restoration in a narrow sense - to put back faithfully what was there before. But this has led to endless problems. Should it be what was there just before the area was damaged - which may be a cultural landscape heavily influenced by humans beings, or should it be what was there before human beings started to modify it?

From the historical perspective, four developmental phases in mining – restoration relationships can be distinguished: the oldest phase is natural succession (spontaneous colonisation without reclamation), followed by a clean up planting phase (biological reclamation using plantations but without other technical terrain improvements), an agricultural-productive phase (improvement of soil conditions, preference for planting production tree species, a high proportion of agricultural fields) and, finally, the current ecological phase (a landscape-ecological concept aimed at achieving high biodiversity on the levels of taxa, communities and ecosystems) (HENDRYCHOVÁ, 2008).

Then, now there is a transition between agriculture/productive phase and ecological phase. In the Czech Republic, there is an effort by scientists, non-governmental organizations and occasionally even mining companies themselves to increase the proportion of near-natural restoration measures in PMA, but it has been often limited by legislative barriers. During a lot years, technical approaches have been lead to establishment of uniform communities with low natural and even economic value. (ŘEHOUNKOVA et al., 2011)

- TECNICHAL RECLAMATION

In 1854, the General Mining Act was the first official document that included rules for mining in relation to the land. The Act included an injury compensation requirement and a requirement that the land must be returned to its original function after exploitation mining (ŠTÝS, 2001).

A definite obligation to carry out such restoration was written into the Mining Act of 1957. In accordance with the current Act on Protection and Utilization of Mineral, measures restoration successes are based in (HENDRYCHOVÁ, 2008): similar diversity and community structure in comparison with reference sites, also is important the presence of indigenous species. Moreover, physical environment must have enough capacity to sustain viable populations which guarantee the presence of functional groups necessary for long-term stability. From the visual point of view, reclamation area should integrate with surrounding landscape correctly. When it is established, must be control about potential threats so that to short-term ecosystem can be adapted to natural disturbances and as final goal, get be self-sustainables.

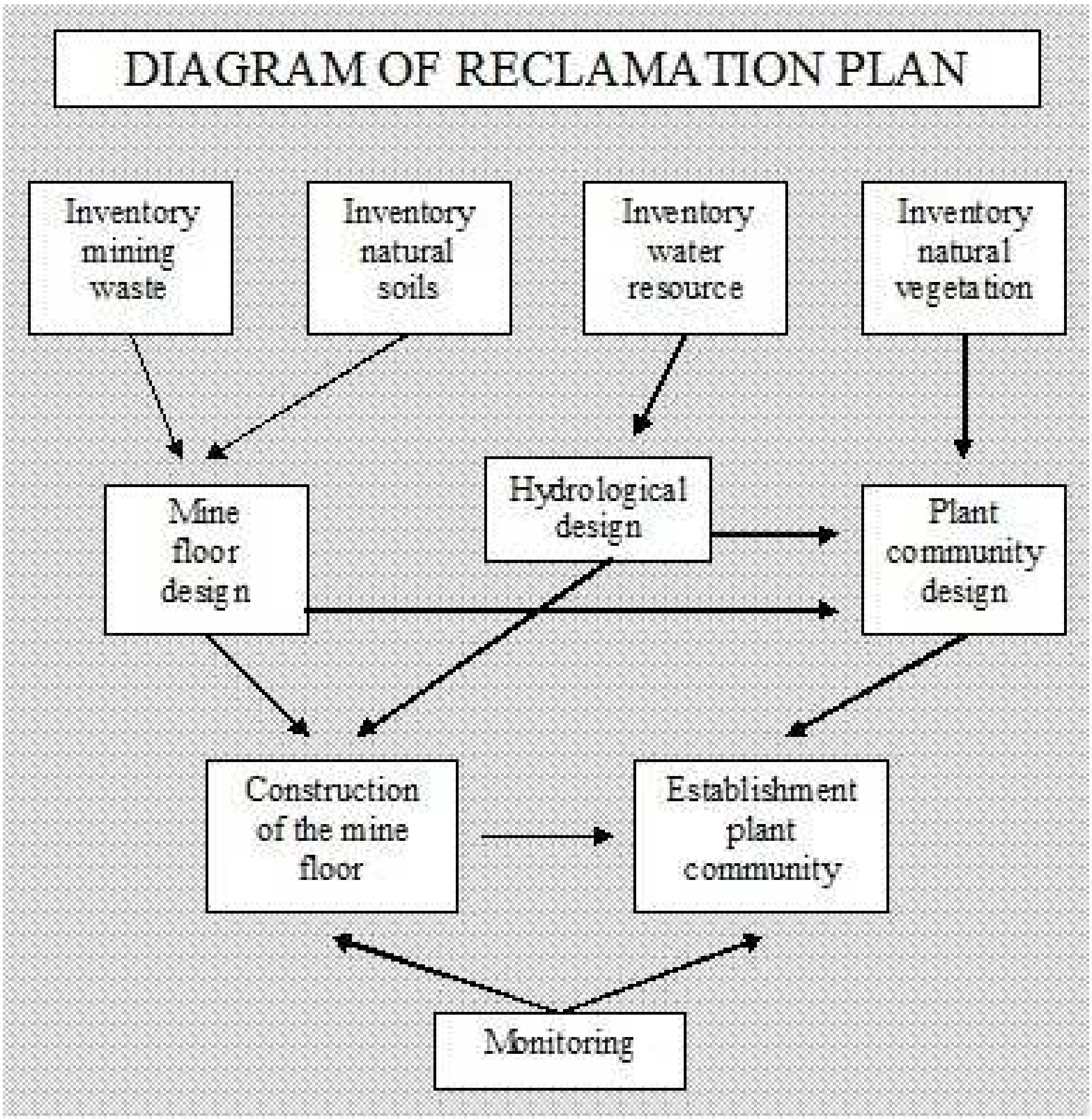


Figure 3: Diagram of reclamation plan **Source:** Own elaboration

Czech legislation distinguishes two types of mining sites regarding their size and importance of the resource. The first type is larger areas where strategic resources such as coal are extracted. Starting to mine is done according to special mining laws, which bind the creation of a financial reserve during the mining time for the future reclamation of the site after finishing the mining process. The second type is smaller mining sites with locally used resources (i.e. sand and stone). For such sites, rules are less strict (ŘEHOUNKOVA et al., 2011).

General scheme of restoration process can include the following seven succesive key steps which keep decisive relations between them (HOBBS AND NORTON, 1996):

1.) Identification of the processes that led to degradation
2.) Suggesting nomination of procedures to stop degradation
3.) Setting realistic objectives for a restoration project
4.) To design easily measurable parameters documenting the recovery process
5.) To design concrete restoration measures
6.) Application of these measures to the project and its practical implementation
7.) Monitoring (Figure 3).

For PMA, where degradation has already taken place, the relevant steps are those starting with the third in the sequence, "setting realistic objectives for a restoration project". Choosing main goals of technical reclamation in PMA depends of the mining company that operated this area. Generally, companies of open-cast mining want filling quickly the pit to get that area come back to be integrated immediatly with its surroundings from the landscape point of view, and even, if possible, restore the uses agricultural or pasture prior to mining. For this, the most important is the recovery of soil cover which had to be prepared separately from the rest of the material mined during the productive period.

Ecological restoration in PMA, in particular, faces the problem that the slow reconstitution of the humus layer on bare soils slows down microbial and faunal recovery (KAPPES et al., 2012).Reclamation techniques such as topsoil transfer, topsoil structuring, and afforestation with the aim at the accumulation of organic matter and thus the restoration of species assemblages and ecosystem functioning (TOPP et al. 2001, 2010). Soil improvement can consist in:

- Application of additives such as floury mould, marl loams, bentonites in the form of mould and rock improvements
- Spreading and defraying organic materials as composts with an adjusted proportion between carbon and nitrates
- Fertilizing crop rotation (with the use of legumes and grass over a six-year or eight-year cycle).

In Czech Republic; agricultural, aquatic and afforestation improvements are usually applied in reclamation plans. However, forests with non-productive functions are currently the most common land-use in PMA landscapes. In addition, species composition of the communities in reclaimed forest stands is strongly influenced by age (i.e. the species that were best available when the stands was planted) and also each region reflects different approaches. In the past, afforestation was with the species available at the time while nowdays, it is do with species suitables with the pedological conditions and with climatic area, and also with the particular phytogeographic region (HENDRYCHOVÁ, 2008). Also is important the role of animals in many ecological processes taking place in ecosystemas (i.e., nutrient cycles, aeration and acceleration of soil development, pollination, predation and pest control, seed dispersal, food availability, etc.). The life cycles of animals can bring changes of abiotic and biotic variants, so animals would also be good tool for evaluating restoration (HENDRYCHOVÁ, 2008).

According to Ministry of the Environment of the Czech Republic there are differents types of approach for technical reclamation depending of future use (Figure 4). Next, the main are described:

- Agricultural reclamation: the use of this type of reclamation is based on the Act on Protection of the Agricultural Land Fund and on the obligation to strip and store the cultivated surface layers of the soil. The technological process depends of type of agriculture: arable area or grassland (meadow or pasture) or any other type of agricultural reclamation. The reclamation crop rotation practices are applied for a period of 2 to 6 years.

- Afforestation: this type of reclamation is a priority where the many specific protective functions of forests are desired. Its implementation has two major stages: the preparation stage, including planting (1 to 3 years), and the cultivation stage (6 to 8 years). The trees/shrubs that are used for reclamation include an approved mix of endemic species and also species suitable for the slopes in the area being reclaimed.

- Hydrological reclamation: this involves the formation of a new water regime in the reclaimed landscape, based on construction and technical measures. The ponds resultants of this reclamation will be analyze and compare later.

- Other reclamations: functional and recreational greenery. Unlike conventional agricultural reclamation or afforestation, this approach uses scattered greenery, which is one of important landscaping features. The purpose is to develop parks, engineered landscapes or suburban greenery, to include recreational and sports grounds in the landscape, to cultivate the areas surrounding industrial premises, dumps etc. Riparian greenery along water streams and in the littoral zones around the lakes in the flooded residual pits is an important landscape feature. Roadside tree planting, groves in fields, bushes on spoil bank slopes exposed to erosion, etc. are also designed for reclaimed landscape.

Finally, we like remember that in many cases these techniques are mixed, for example there are areas with afforested and hydrological reclamation.

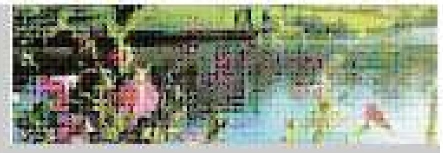
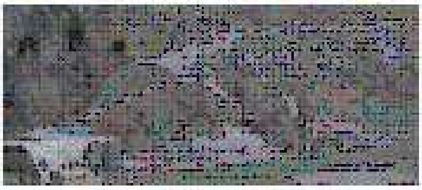
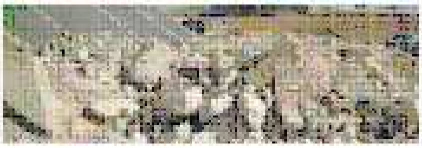
TYPES OF RECLAMATION			
TYPES OF USE		CHARACTERISTICS	NECESSARY ASPECTS
AGRIULTURAL		- Fruit tree - Cereal - Grapevine - Grazing land - Grassland	- Smooth slopes - Drainage system - Fertile soil - Species selection
FORESTAL		- Wood exploitation - Increase diversity - Anti-erosion	- Moderate slopes - Fertile soil - Drainage system - Species selection
HÁBITAT NATURAL		-Natural recuperation of the environment - Creation of new habitat - Reserves (flora and fauna)	- Fertile soil - Drainage system - Modelling shore and pit
RECREATIONAL ACTIVITIES	 	- Trekking - Nature contact - Species observatory - Climb - Hunting - Fishing - Nautical sports - Mining museum	- Stability slope - Good properties of soil - Access - Closeness to the urban areas - Fitting out of the pit - User safety
TWON PLANNING		- Urbanizations - Parks and green spaces - Auditorium - Churches - Wineries	
INDUTRIAL		- Industrial park - Parking - Fish farm	- Smooth slopes - Good properties of soil - Access - Closeness to the urban areas - Infrastructure - Fitting out of the pit - User safety
WASTE DUMP		- Waste dump	

Figure 4: Types of technical reclamation **Source:** Own elaboration (tranlate to www.larioja.org)

SPONTANEUOS SUCCESSION

Most of the heaps have the potential to be reclaimed by spontaneous succession (PRACH et al. 2008), which can be regarded as habitats with high species diversity and as sites that are home to many threatened species (DOLEŽALOVÁ et al., 2012). However, reality is not like this; because in the extensive central European coal mining districts, especially in the post-Communist countries, technical reclamation has dominated or has even been considered the only possible way to reclaim spoil banks (HODAČOVÁ and PRACH., 2003). As result for example we can found, more than 80% of the post-mining landscape of Lower Lusatia in Germany is currently being recultivated for forest or agriculture and only 15% is reserved for nature development. In the case of Czech Republic, this proportion reserved for nature development reaches less than 5% (ŠÁLEK et al, 2010).

The root of the ecological importance of spontaneously developed post-mining areas should be sought in the specific environment arising there – early-successional sites, variety of oligotrophic ponds without intensive fish management, forest steppes and open forests. Such habitats have been decreasing throughout Europe over the past several decades due to intensive farming, forestry management, industry and urban development (DOLEŽALOVÁ et al., 2012). The spontaneous succession is beneficial where environmental site conditions are not very hard, and there are no expected negative influences, such as landslides, erosion, contamination of water or soil, or negative aesthetic perception (PRACH et al., 2008). Spontaneous succession has advantages over technical restoration especially for the following reasons:

- Colonizing species will be well adapted to the local site conditions and it reduces care of them (KOVÁR, 2004).
- The ecological and nature value of spontaneously colonized sites is usually higher than that of technically restored sites (HODAČOVÁ and PRACH, 2003).
- Seral stages often provide refugia for wildlife, more often than technically restored sites (BENKEWITZ et al. 2002).
- Last but not least, spontaneous succession is cheap.

A disadvantage is the slow progress toward a target stage under certain circumstances, especially if a disturbed site is large and transport of diaspores of desirable species is limited by distance. It is also the case if a site is surrounded by extensive vegetation dominated by ruderal or alien species, instead of vegetation composed by desirable species (PRACH et al., 2008). The best place for spontaneous succession is a site small and surrounded by natural vegetation and that site conditions are not principally altered by the initial disturbance (PRACH AND PYSEK, 2001).

All this indicates that the unassisted processes of natural colonisation can be very powerful and deliver fully developed and functional ecosystems within 100 years. This applies not only to the vegetation, but also to the soil. But this does not always occur. In some sites, although colonisation does take place, it is slow, so that within a time span of 50 or even 100 years vegetation establishment is not complete either in species composition or growth and cover (BRADSHAW, 2000).

Spontaneous succession on degraded area has a series of known processes. These can be divided into those that are primarily biological in origin and those that are primarily physical, although there is a considerable interconnection between them (BRADSHAW, 2000) (Figure 5).

Biological processes		Physical processes	
Time (year)	Process	Time (year)	Process
1–50	1. Immigration of appropriate plant species	1–100	1. Break up of compacted surfaces by frost or periodic drought
1–50	2. Establishment of appropriate plant species	1–1000	2. Accumulation of fine material by rock weathering
1–10	3. Surface stabilisation and accumulation of fine mineral materials by plants	1–1000	3. Decomposition of soil minerals by weathering
1–100	4. Accumulation of nutrients by plants from soil minerals	1–100	4. Improvements of soil available water capacity
1–100	5. Accumulation of nitrogen by biological fixation and from atmospheric inputs	1–1000	5. Release of mineral nutrients from soil minerals
1–20	6. Immigration of soil flora and fauna supported by accumulating organic matter	10–10000	6. Leaching of mobile materials from surface to lower layers
1–20	7. Changes in soil structure and function due to plant, soil micro-organism and animal activities	100–10000	7. Formation of distinctive horizons in the soil profile
10–1000	8. Reduction in toxicities by accumulation of organic matter and leaching		

Figure 5: Biological and physical processes in spontaneous sucession **Source:** Bradshaw, 2000

Establishment of appropriate species can has troubles due to frost and other factors which may be serious. This can be mitigated by spreading some protective material, such as organic mulch (BRADSHAW, 2000). Usually, the first species in appear in spontaneous succession is conditioned by:

- Adaptation to long distance dispersal
- They live in adjacent habitats
- They were already present as seeds
- They are strategist "r"

A very necessary element in nearly all spontaneous succession is the stabilisation of the surface and the accumulation of fine materials due to vegetation activity. So, early plant colonists have an important role; particularly when it is fine textured and where there are hard erosion by wind and rain. All this is important in producing a stable soil of satisfactory texture, particularly retaining water adequately (BRADSHAW, 2000).

Next important attributes of plants is their ability to capture the soil for nutrients, accumulate them in their biomass, and then transfer them in organic matter to the soil, from where they are then readily available to other plants by organic matter decomposition. By this, the potential of the soil to support growth improve considerably over time and with the vegetal establishment. The problem for spontaneous succession is lack of nitrogen but also these sites can be very important for some species adapted to the low nutrient conditions. Because nitrogen is not stored in soils in the form of a mineral but only in organic matter, and because it is the element required in the largest amount by plants. With the arrival N-fixing species, either legumes or other species, such as Alnus, with symbiotic N-fixing microorganisms, appear in the succession, development accelerates. Progress of many natural primary successions is linked with the arrival of such species and where development is slow it can be associated with their non-arrival. By this, is more suitable try to introduce legumes species (Ulex and Cytisus) than fertiliser anually, because this is expensive and ineffective methods (BRADSHAW, 2000).

Another problem to face by the spontaneous succession is acidity and heavy metals. The colonisation by acid or metal tolerant species or populations is a slow process. But if extreme acidity can be reduced by application of even a small amount of lime or other neutralising material, acid tolerant plants will be more successful (BRADSHAW, 2000).

Spontaneous succession in productive sites is usually fast in the sense of rapid formation of continuous vegetation cover. However, it must often be enhanced by technical improvement in low-productivity sites to reach the targets. In lowproductivity sites, where vegetation cover is sparse and forms slowly, the threat of erosion is usually higher than in high productivity sites. So, spontaneous succession should be used in reclamation whenever possible. But we need to examine and understand the factors that may be limiting these processes and how they may be overcome (PRACH et al. 2008).

1.1.3. GENERAL DIVERSITY ON SPOIL BANKS

As mentioned above, post mining area are very suitable places for fauna and flora diversity, whether in technical reclamation areas or in spontaneous succession areas. But in this last, one of the most significant features of a community is its variability in time. Changes in species composition, number of species and densities of populations show up with repeated fluctuations, or the community gradually develops during succession (VOJAR, 2006).

Species diversity should increase in connection with specialization of spatial and trophic niches (ODUM, 1977). Over time, during this process there is an increase in the size of the organisms, the length and complexity of their life and interspecies, which are attributes that limit the number of species (VOJAR, 2006).

FLORA DIVERSITY

The physical structure and chemical composition of the populations of plants that are established, combined with the specifity of many trophic relationships, strongly influence the potential for restoration of animal and microbial communities (DAVY, 2002)

Ecological restoration usually demands the deliberate re-establishment of plant species and subsequent management of them to direct or suppress successional processes. This is true whether the establishment is aimed immediately at creating the target communities or whether it is designed to accelerate succession towards them. The achievement of spatial and temporal heterogeneity, both biotic and abiotic, on the same scales as reference sites would be an informative criterion for success. The ability to remove or control invasive, alien species is as important as the ability to establish desirable ones. The damage and destruction that necessitate restoration work, and the potential for world-wide dissemination of propagules, create many unbridled opportunities for catastrophic invasions (DAVY, 2002).

Community development and composition together represent only one facet of ecosystem structure and function. The restoration of plant community composition is inextricably bound up with the restoration of ecosystem function and needs to be considered in parallel with all of the processes that comprise ecosystem function. Similarly, we recognise that a plant community will interact with the communities of all other organisms present. The restoration is likely to be more successful and more rapid if the population dynamics of as many as possible of the species introduced, and their interactions with other species (negative and positive), are already understood in similar habitats.

Restoration ecology, although arguably in its infancy, has been exceedingly successful in highlighting how little such information exists in the majority of cases (DAVY, 2002). Then until now, there have been no many studies which comprehensive comparison in disturbed areas of the effects of the two restoration methods on the conservation potential of the sites (TROPEK et al., 2010). Next, we show more important conclusions of them.

In Meirama mine spoil banks the colonization by navite plant species were very fast, and such species typically account for more than 75% of cover from about the sixth or seventh year onwards (BLANCO et al., 1991). The unusual speed of these processes at Meirama compared with other lignite mines is probably attributable to the absence of toxic components in the spoil bank and a high rainfall (GALÁN, 1997).

We can found, in a study (North Bohemian Brown Coal Basin) that tree cover was on average very similar on succesion and reclamation (56% versus 68%), but successions had nearly twice the herb cover (63% versus 37%). In addition, of major interest was only the endangered Tetragonolobus maritimus (dragon’s teeth) included on the Red List for the Czech Republic we have found this species on unreclaimed slopes of the former Saxonia Mine (HENDRYCHOVÁ et al., 2011). Also, results indicate that spontaneous succession provides more diverse vegetation cover than technical reclamation. The technical reclamation usually starts when the dumped material is more or less stabilized, usually 5 to 8 years after the dumping event. This coincides with the time when spontaneous succession approaches the stages when perennials start to dominate and gradually form a rather compact vegetation cover approximately in the 15th year of succession (HODAČOVÁ and PRACH, 2003).

Other study based in old quarries in Czech Republic, where the colonization of spontaneously developed habitats within by high numbers of threatened and habitat-specialized species indicates that spontaneous succession is an effective tool for biodiversity conservation. These patterns were consistent in vascular plant. The vegetation development is slower under spontaneous succession than under reclamation when are difficult, for example; habitats of open rocks, sparse grasslands and scrub. Technical reclamation invariably involves inputs of topsoil, nutrients and plant diaspores. These conditions favour first, fast-growing ruderal vegetation from buried seeds, and ultimately the establishment of competitive species. While in spontaneous succesion with slow develop favor to vegetation heterogeneous, which finally will result increasing of herbivores species diversity (TROPEK et al., 2010).

FAUNA DIVERSITY

The establishment of animal communities on mine spoils is typically dependent on the establishment of native plant communities (GALÁN, 1997). The positive correlation between diversity of plants and arthropods is clear, in accordance a general principles of succession (VOJAR, 2006).

In the beginning a usual process, a little number of species dominate with around 90% of prevalent in diversity; as is showed in north Bohemian spoil banks for the specie *Apodemus sylvaticus* (BEJČEK, 1981). Later, in early or middle stages usually are obvious some kind of transition toward a more diversity and without dominant species (MARGALEF, 1963). Finally, in mature stages the species are more specialized and the diversity decreased is clear, also dominant species come back to appear (VOJAR, 2006).

Usually, the results show to species diversity never return to pre-disturbance levels or levels similar to around areas. It can be probably attributable to the fact that, in many animal communities, there are likely to be species which require microhabitats that arise only after a very long period, such as fallen tree trunks (GALÁN, 1997). One hand, as suggested in one study of copper mine spoils in Australia which declares to require at least 80 years for full reclamation of pre-disturbance species diversity (HALLIGER, 1993). Other hand, there are a study of BECJECK (1981), which compares species diversity of small mamals on four unreclaimed spoil banks of ages 2-4, 7-9, 13-15 and 19-21 years. The highest value of diversity was found on locations 13-15 years. So, species diversity is culminates in middle seral stages as says MARGALEF (1963).

First, for microrganisms a large interdisciplinary project presented by ALLEN (2002) was iniciated in the autumn of 1981 to study the applicability of succession theory to restoration of an open-pit coal mine in western Wyoming. Several groups of organisms were targeted for assessment and the general hypothesis was that the invasion and establishment of soil micro-organisms is a limiting factor in the recovery of soil processes, which, in turn, can limit the establishment of acceptable plant diversity and productivity. The microbial composition was dramatically altered by the mining and topsoil storage. The implications from these experiments are clear. The microbial component of a restored site is complex and dependent on the treatment practices that disturb the ecosystem, the care with which the topsoil is handled and the location and retention of a diverse source area.

Microbes are not the same everywhere. They are easily the most diverse elements of any ecosystem and do not always recover from a disturbance no matter what the time-frame. Help from inoculation efforts may help in some aspects of restoration. However, just as plant production requires a diversity of plants to maintain sustainability, so do the functions that are catalysed by the soil micro-organisms. As these functions are numerous, recognition of the importance and care to manage them is a crucual step in a real restoration effort.

For those terrestrial invertebrates, one hand, the diversity and the numbers of invertebrates was always generally higher on spoil heaps under the spontaneoussuccession, we conclude that these sites provide better ecological conditions than most silviculturally reclaimed spoil heaps. This is especially due to differences within habitat characteristics (microtopography, microclimate, wet regime), diverse vegetation cover, complex it of food webs or nutrient cycles (more species at higher levels of food chains or with demands on organic litter) (HENDRYCHOVÁ et al., 2008).

The last year, HENDRYCHOVÁ et al. (2011) carried out a study about terrestial invertebrates in North Bohemian Brown Coal Basin which obtained the some principal conclusions about differents groups of invertebrates in post mining areas. For isopods group, species richness on reclamations and successions was also similar, but successions achieved higher species evenness. Also for Millipedes group, there is not too much difference but only in succesion you can found xerophilic species *(Kryphioiulus occultus* and *Brachyiulus bagnalli*) and an Atlantic species (*Rossiulus vilnensis*). The next group is centipedes that in successions had greater abundances and numbers of species than did reclamations. Also, it included one steppe element (*Lithobius muticus*). As for bugs, although these seem unlikely to be affected by type of post-mining management, more diverse and abundant communities prevailed on successions. Species richness there was more than twice greater than on reclamations. In addition for the carabid beetles the species living exclusively on reclamations were very abundant also in the surrounding landscape, with one exception being the scarce *Licinus depressus*. Finally, the last group was the carrion beetles preferring open sites on reclamations as well as successions.

As for aquatic invertebrates, in lakes and ponds, an understanding of the roles of certain invertebrates, such as Daphnia spp., has been exploited in biomanipulation, and in some cases used to augment prey availability to fish through species introductions or nutrient additions. Invertebrates are often considered to be relatively resilient to perturbation, but some invertebrates are poor colonisers. For instance, many of the large mussels that are endangered are dependent on particular fish to disperse their larvae, fish that may also be in peril. The aquatic insects vary in their capacity to disperse, from strong flyers such as dragonflies, to weak flyers such as some of the stoneflies, which will affect colonisation by oviposition. These differences between species mean that not all species will respond on the same temporal scale, and recolonisation rates will depend upon the proximity of "seed" populations. Theory predicts that a diverse ecosystem is less sensitive to perturbation by virtue of having some alternative pathways or species that can compensate for each other thus maintaining ecosystem functions.

For fishes, these have a massive potential for reproduction, indeterminate and plastic growth and ability to exploit a variety of foodstuffs with relatively standard body form and gut design.

As for birds, is known that in Most spontaneous succesion is better for sparrowhawks than thecnical reclamation. In addition, the dominant species, including warblers, robins and blackbirds, were the same in both habitat types, suggesting that this common feature did not motivate the sparrowhawks in their preference for natural succesion (ŠÁLEK et al, 2010).

In the case of mammals, a study about rodents and shrews in Lower Lusatia of Germany which is border with North Bohemian Brown Coal Basin, declares; one hand, the first pioneer rodent specie is Apodemus silvatycus. Other hand, shrews were recorded in all study sites. Then, distances between suitable habitats are no barrier for recoloniziation of spoil banks (RATHKE et al., 2005).

AMPHIBIAN DIVERSITY

Conservation of amphibians is a very important need due to the considerable sensitiveness of this animal class to environment changes and the worldwide decline of their abundance (VOJAR, 2006). These are relatively less mobile than other vertebrates, with movements (i.e., dispersal or migration) of up to a few kilometers for anurans, and less than 250 m for most salamanders. Indeed, physiological constraints (water balance and temperature regulation) prevent them from venturing far from moist habitats (MAZEROLLA, 2003). Long-term studies are needed to untangling the causes of fluctuations in population size because amphibians are very influenced by habitat variables and human influence. As a result, short-term studies can be a problem (DOLEŽALOVÁ et al., 2008). For MAZEROLLE (2003); amphibians, when engaging in movements across disturbed habitats, to depend more strongly on landscape variables than in past environments. Taking into consideration the complex life cycles of amphibians, we analyzed habitat selection at three scales, i.e., the characteristics of the pond, its surroundings, and the density of ponds in the surroundings and the distance of the pond from the source of colonization (DOLEŽALOVÁ et al., 2008).

Suitable ponds characteristics in Central European for amphibians usually are middle-sized (about 500 m2), stable water bodies with a depth allowing development of partial vegetation cover. Very large and deep ponds are unsuitable for amphibians due to intensive fish management and could even represent barriers for them. Very small and shallow ponds, on the other hand, are often threatened by desiccation, and due to restricted size and suboptimal conditions they often host small populations. Also about surrounding environment, amphibians prefer forest steppe or forest habitats during their terrestrial period (DOLEŽALOVÁ et al., 2012).

Amphibian populations on spoil banks of the Meirama opencast lignite mine in northwest Spain were studied and censured during 7 years (1988 - 1994). The pioneer colonists identified in this study were *Rana perezi* and *Alytes obstetricans* in the third year of sampling (GALÁN, 1997). *Rana perezi* is a species with broad habitat requeriments with a similar ecology as the *Rana ridibunda*, which is common in spoil banks of Czech Republic soon after they have been filled (VOJAR, 2006). Following colonization by these pioneer species, others arrive in rapid succession, and high levels of species diversity are soon reached. The first individuals of all amphibian species detected within the first four years were juveniles. Until fifth year was not detected eggs or larvaes, when were found of *Discoglossus galganoi* and *Bufo calamita* (GALÁN, 1997). This specie, along with *Bufo viridis*, is also in Czech conditions one of the first, with clutches registered already in the initial seral stage (VOJAR, 2006).

1.1.4. RANA DALMATINA

Scientific classification of Rana Dalmatina is:

Kingdom → Animalia
Phylum → Chordata
Class → Amphibia
Order → Anura
Family → Ranidae

Species authority: Bonaparte, 1840

Red List Category: Least Concern

Figure 6: Rana dalmatina **Source:** www.naturfoto.cz

This species is widely distributed in much of Europe and northern Turkey (Figure 7). Within Europe it is widespread, but it is restricted to Álava, Burgos and Navarra Provinces in Spain, the southeast coastline of Sweden and the islands of Denmark, and it is absent from Portugal, the British Isles (except the island of Jersey, where a small population is present). In addition, there is a need to confirm the presence of this species in Poland, where it is supposed to occur in the southeast. In the former Soviet Union, it is known only from the Transcarpathian Plain (including adjacent foothills and mountain slopes) of the Ukraine. In Turkey this species is found in Turkish Thrace and northern parts of Anatolia; further studies are needed to determine the distributions of Rana dalmatina and Rana macrocnemis along the southern Black Sea coastline. It occurs from sea level to elevations 1,700 meters (UICN).

Figure 7: Range map of Rana Dalmatina **Source:** UICN

It is found in glades and open sites within light deciduous woodland (oak, beech, hornbeam etc.), and less frequent in meadows and thickets. It generally it does not occur in pasture, arable areas or coniferous forests. It spawns in small wetlands (pools, ponds and marshes, ditches) within forests and at their edges. High levels of larval mortality have been recorded. It is generally threatened by the drainage and eutrophication of breeding sites, also replacement of deciduous forest habitat with unsuitable coniferous species. It is locally threatened by road mortality during breeding migrations (UICN).

2. METHODS

2.1. STUDY AREA

Northern Bohemian Brown Coal Basin is located among the foothills of the Krušné hory; along the national border with Germany (Saxony), in the vicinity of the towns of Kadaň, Chomutov, Most, Teplice and Ústí nad Labem.

Figure 8: Spoil banks in North Bohemian brown coal basin **Source:** Supervisor, Jiri Vojar

Area is under the influenced of continental climate due to geographical latitude, height above sea level and distance from the ocean. As a result, average temperature differences between seasons are very huge, with very cold winters (-3ºC) and hot summers (24ºC). Also the basin is the area with lowest level of precipitation (400 mm) of whole country; the majority of rainfalls are in summer months (Figure 9).

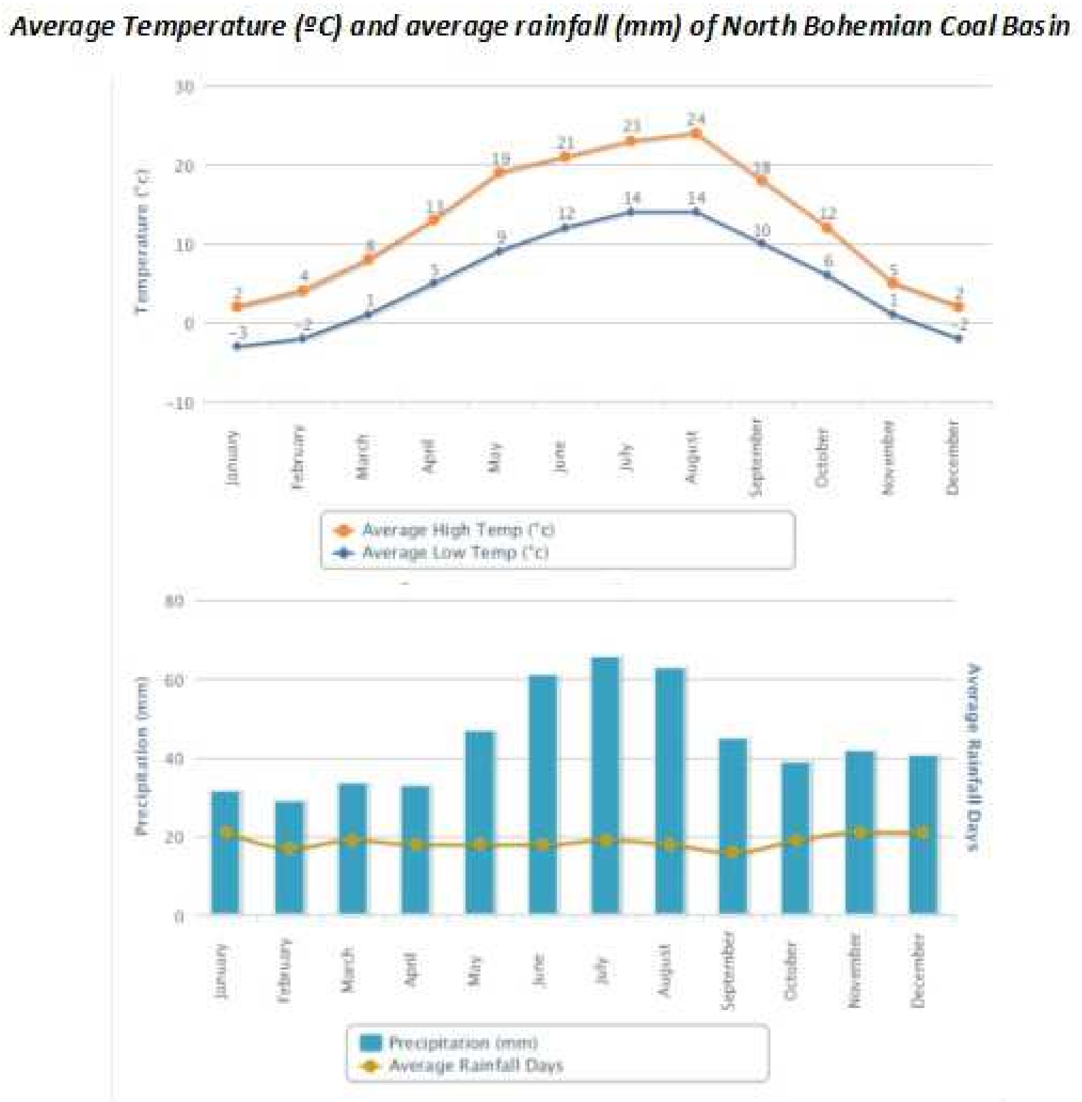


Figure 9: Average temperature (ºC) and average rainfall (mm) of North Bohemian Coal Basin

Source: www.worldweatheronline.com

2.2. POND LOCATION AND DESCRIPTION

Field work began in Spring, during first days of April. First, North Bohemian Brown Coal Basin was divided in the different spoil banks. The study was carried out on 17 large spoil banks in the North Bohemian brown coal basin in the Czech Republic, situated between the towns Ústí nad Labem and Kada on an area of about 2500 km2 (Picture 8). The study area is the largest mining site in the Czech Republic and one of the largest in all of Europe. Several spoil banks contained both successional and technically reclaimed areas. Thus, we distinguished 14 technically reclaimed areas and 6 areas without technical reclamation with a total area of 84.3 km2.

With the use of orthophoto maps (Portal of Public Administration, 2011) in ArcGIS 9.2 (ESRI, 2007) and field surveys, we registered each spoil bank and we described the characteristics: reclamation status (spontaneous vs. technically reclaimed), type of reclamation (e.g. agricultural, forest), area of spoil bank, total area of water habitats, the ratio of water habitats area and spoil bank area, mean area of water habitats, total number of water habitats, and the number of water habitats per hectare of spoil bank. In the case of the same spoil bank has different reclamation status, each section was described separately (see Table 2 for details).

Name of spoil bank (SB)	Recl.	Area SB (ha)	Area WH (ha)	Ratio WH/SB (%)	Mean area WH (m^2)	*n* WH	*n* WH per ha SB
Technically reclaimed							
Březno	T,F,A	231.36	1.61	0.70	4025	4	0.02
Čepirohy	T,A,F	496.77	9.66	1.94	2476	39	0.08
Hornojiřetínská – TR	T,F,H	351.28	16.37	4.66	20.46	8	0.02
Kopistská – TR	T,A,G	119.94	4.74	3.95	23.70	2	0.02
Lochočice	T,A,F	847.81	2.13	0.25	3045	7	0.01
Malé Březno	T,F,A	306.62	1.35	0.44	2257	6	0.02
Merkur	T,F,A	100.45	3.97	3.95	2333	17	0.17
Pokrok	T,F,A,G	289.39	5.28	1.83	5285	10	0.03
Prunéřov	T,F,A	261.31	4.67	1.79	6672	7	0.03
Radovesická – TR	T,A,F	1483.00	14.34	0.97	4216	34	0.02
Růžodolská – TR	T,F,G	952.99	33.52	3.52	4410	76	0.08
Střimická	T,F,A	743.55	16.98	2.28	14.15	12	0.02
Velebudická	T,F,A	729.32	1.32	0.18	1644	8	0.01
Žichlice	T,F	103.35	0	0.00	0	0	0.00
Technically unreclaimed							
Albrechtická	F,S	89.85	0.24	0.26	91	26	0.29
Hornojiřetínská – TU	F,S	352.71	33.40	9.47	1380	242	0.69
Kopistská – TU	F	359.06	14.64	4.08	438	334	0.93
Radovesická – TU	S	57.34	5.42	9.45	888	61	1.06
Růžodolská – TU	F,S	31.28	1.76	5.61	1463	12	0.38
Teplická	F	519.31	23.58	4.54	12.41	19	0.04

Table 2: Description of spoil banks (SB). TR = technically reclaimed part of spoil bank, TU = technically unreclaimed part; Recl. = type of reclamation, T = technical, F = forest, A = agricultural, H = hydrological, G = grass stands, S = successional (without cultivated forest stands) – in case of multiple types of reclamation, the order indicates the proportion of reclamation types on the spoil bank; area SB = total area of spoil bank in hectares; area WH = total area of water habitats in hectares; rat. WH/SB = the ratio of total water habitat area to total spoil bank area expressed as a percentage; mean area WH = mean area of water habitats in m^2; n WH = number of water habitats on spoil bank; n WH per ha SB = number of water habitats on spoil bank per hectare of spoil bank.

First, using orthophoto maps, GPS navigations and the systematic field search, we discovered 924 water bodies in total, 694 on successional and 230 on technically reclaimed spoil banks. Later, in the field we registered the different characteristics in the location card as you can see in picture 11. A summary of all variables is presented in table 3:

- Pond features: area, maximum depth, shore slope, insolation of water surface, coverage by littoral vegetation.
- Type of prevalent surrounding terrestrial environment and the status of reclamation.
- Connectivity with other ponds in the surrounding area.

Variable (unit)	Range of levels	Levels
Maximun depth (m)	<0.5	1
	0.5-1.5	2
	>1.5	3
Shore slope (º)	<30	1
	30-55	2
	>55	3
Insolation (%)	<5	1
	5-75	2
	>75	3
Vegetation cover (%)	<5	1
	5-75	2
	>75	3
Surrounding environment	Initial successional stages	1
	Arable lands	2
	Grasslands	3
	Forest steppes	4
	Forests	5
Technical reclamation	Reclaimed	2
	Unreclaimed	1

Table 3: Description of assessed habitat features

Area in smaller ponds was measured directly in the field by tape line, but if these were large ponds recognizable from orthophotos maps, their area was determined with ArcGIS. To avoid errors and subjectivity of different persons, we designated pond characteristics (depth, slope, insolation, vegetation cover, etc) as variables on an ordinal scale (Table 3).

Depth was measured using a ruler. For shore slope, we considered the prevalent slope of banks under the water surface directly affecting the occurrence of littoral vegetation. The intensity of insolation was stated as the ratio of the water surface area not shaded by trees and shrubs growing around the pond to the total water surface area. To avoid errors due to the sun's changing position during the day, we determined this variable only in the middle of the day, i.e. between 10:00 a.m. and 3:00 p.m. We regarded as littoral vegetation any aquatic, emerged and submerged vegetation, as well as submerged grasses and branches of trees along pond edges.

LOCALIZATION CARD

Name: Date and time:

Coordinates GPS:

Climate

Clouds: no semi clouded drizzle rain

Size

Area:___m² GIS: (you mark if is enough big to measure by GIS)

< 50 m² 500 m² 2.000 m² >5.000 m²

Depth

Maximum: (3 categories: (< 0.7),(1,5 – 2.5),(>2.5)m) Average: (3 categories: (< 0.5),(0.5 – 1.5),(>1.5)m)

Littoral (vegetation)

Area (cover vegetation):_ %

Without (< 5 %) Partly (5 – 75%) Full (> 75%)

Slope

Little (< 22º) Medium (22 – 45º) Big (> 45º)

Shine

Without Partly Total

Water quality

pH: Conductivity: Eutrophication: yes/no

Fish

Presence: yes probably no

Environmental problems

Contamination Glide land Desertification Others:_

Surrounding

Meadow Shrub Forest

Human intervention

Technical reclamation: yes/no Forest reclamation: yes/no

Rana Dalmatina

Nº Method

Clutches Stage:

Adults (sight, sound)

Other species

Specie Nº Method

Figure 10: Location card **Source:** Own elaboration

Prevalent surrounding terrestrial environment was described within a vicinity of 150 m and classified according to five types of environment differing mainly by vegetation type and cover (Table 2).

For the pond connectivity varaible, we used ArcGIS for creating buffer zones around the ponds with 300 m of distance. The distance of 300 m corresponds to the common dispersion ability of Central European amphibians.

2.3. SIGNIFICANCE OF ENVIRONMENTAL FACTORS

Study consisted in take data of Radovesická and Růžodolská spoil banks of 2012, the year poorest abundance of Rana dalmatina and compare with data of 2008, the year with highest abundance researched on the past studies. To do this, we select the ponds recorded in both years (n=114); these spoil banks are under spontaneous succesion, forest reclamation and thecnical reclamation.

Following, we compare the significance of variables in both years. The variables are the next: maximun depth, vegetation cover, shore slope, insolation, surrounding environment and status of reclamation. These variables are divided in different levels (Table 3).

Finally, we compare number the number of ponds and number the clutches for each year and each level of environmental factor.

2.4. STATISTICAL ANALYSIS

First, for analyze the environmental characteristic (size, depth, vegetation, slope, shine, etc.) of ponds on reclaimed and unreclaimed PMA we compare the ratio of water habitat area to total spoil bank area. In addition to the number of ponds per hectare of spoil bank between reclaimed (n = 14) and spontaneous succession (n = 6) spoil bank sections, were compared by generalized linear models (GLM) using R statistical software. A separate model was computed for each response variable. We used the status of reclamation of spoil bank, as the explanatory variable. GLM was use to test the differences in habitat features of water bodies between reclaimed and spontaneous succession spoil banks sites as well.The variable of pond area was logarithmically transformed and the linear model (LM) was used. The remainder of the variables were managed as categorical variables divided in levels (Table 3) .To analyze the obtained frequencies; we used log-linear models with Poisson distribution of the response variable. To test the significance of each variable in the model, we used Chi-squared deletion tests for the models with Poisson distribution of the response variable.

Later, for analyze the significance of variables in both distant years (2008 and 2012) we compared also by generalized linear models (GLM) using R statistical software. A separate model was computed for each response variable. We used the abundance each year, as the explanatory variable. GLM was use to test the differences in significance of environmental factors in the year with highest abundance and the year with poorest abundance of Rana dalmatina. Also as before, variable of pond area was logarithmically transformed and the linear model (LM) was used and the other variables were managed as categorical variables divided in levels (Table 3). To analyze the obtained frequencies, we used log-linear models with quasi-Poisson distribution of the response variable. Later, to test the significance of each variable in the model, we used F tests for the models with quasi-Poisson distribution.

3. RESULTS

3.1. COMPARISON THE ENVIRONMENTAL CHARACTERISTIC OF PONDS ON RECLAIMED AND UNRECLAIMED PMA

ENVIRONMENTAL CHARACTERISTIC:

The ratio of water habitat area to total spoil bank area and the number of ponds per hectare of spoil bank in spontaneous succession than on reclaimed sites of spoil banks (ratio: df = 1, F = 10.82, p = 0.004; pond number: df = 1, F = 47.33, p < 10−5). Water bodies occupied from 0.00% to 4.66% (median = 1.81%) of the area on reclaimed sections and from 0.26% to 9.47% (5.08%) of the area on successions. The number of ponds per hectare of spoil bank varied on reclaimed parts from 0.00 to 0.17 (0.02) and on successions from 0.04 to 1.06 (0.53).

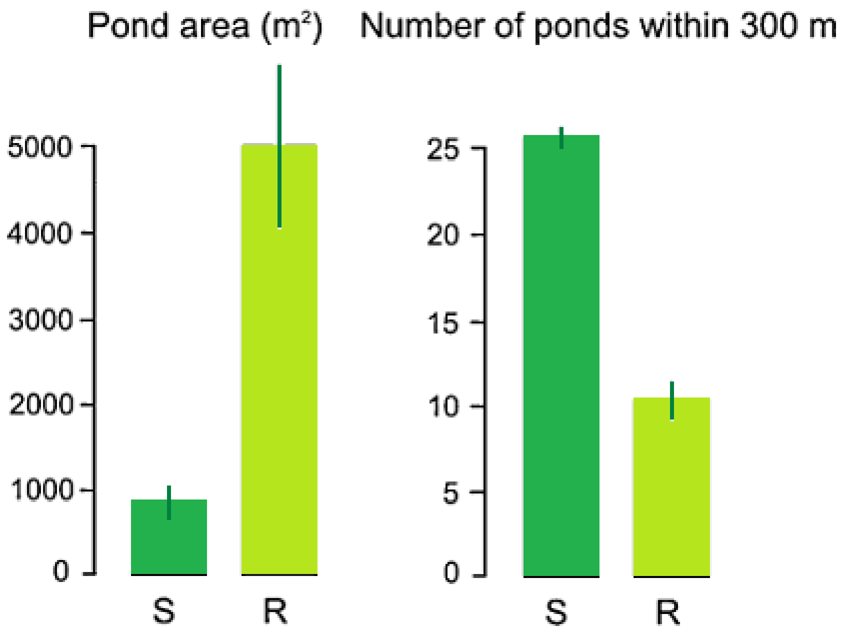


Figure 11: Differences in pond area and number of ponds inside of 300 m on technically reclaimed (R) and spontaneous (S) spoil bank sites. Vertical lines represent 95% confidence intervals of the mean.

Area of water bodies arising on spontaneous succession sites of spoil banks were significantly smaller than on reclaimed sites. On the other hand, the number of ponds within 300 m was much higher on successional sites than on reclaimed sites (Figure 11).

Log-linear analyses of pond numbers belonging to a particular level of a given variable, and reclamation status revealed highly significant differences among observed frequencies in all variables.

Variable	*df*	F	*p*	Result
Pond area				
Bank	1	76.68	$p < 10^{-6}$	
Rec	1	20.98	$p < 10^{-5}$	S < R
Bank:rec	1	15.25	$p = 10^{-4}$	
Number of ponds				
Bank	1	306.68	$p < 10^{-6}$	
Rec	1	21.99	$p < 10^{-5}$	S > R
Bank:rec	1	56.18	$p < 10^{-6}$	

Table 4: Results of analyses of differences in pond area and the number of ponds within 300 m on technically reclaimed (R) and successional (S) spoil bank sites. Bank = spoil bank specificity, Rec = reclamation status (successional vs. technically reclaimed), Bank:rec = interaction between mean variables. In the case of pond area, LM was used; for the number of ponds, GLM with quasi-Poisson distribution was used.

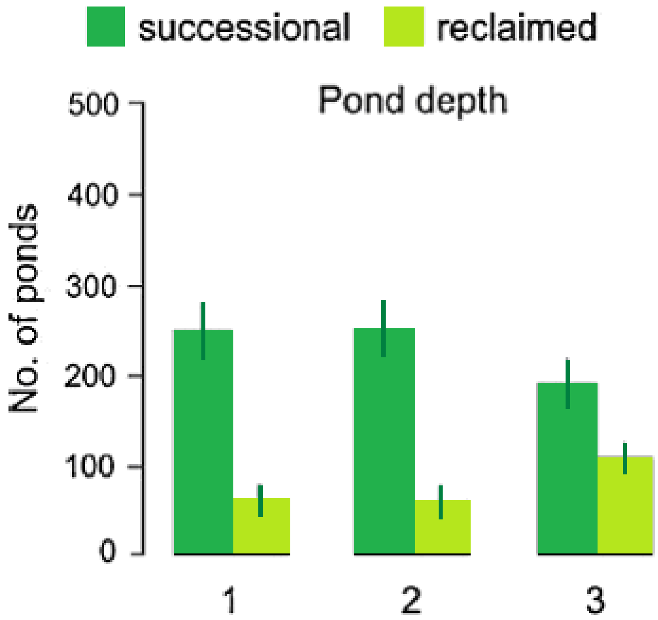


Figure 12: Number of ponds according to the pond depth and the reclamation status (successional vs. technically reclaimed). 1 = (<0.5m), 2 = (0.5 -1.5m) and 3 = (>1,5m)

Results show that technically reclaimed parts of spoil banks are deeper ponds, while on spontaneous succesion sites prevailed shallow and medium-depth ponds (Figure 12). Ponds with gentle shore slopes are considerably predominate on spontaneous succesion sites, where less than just 5% of ponds there in the steepest level. While in reclaimed sites these are around 25% (Figure 13 and table 5).

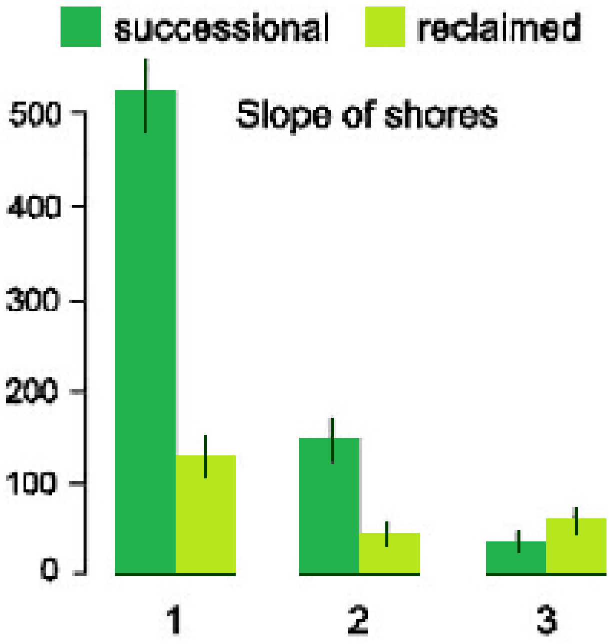


Figure 13: Number of ponds according to the slope of shores and the reclamation status (successional vs. technically reclaimed). 1 = (< 30º), 2 = (30 -55º) and 3 = (55º)

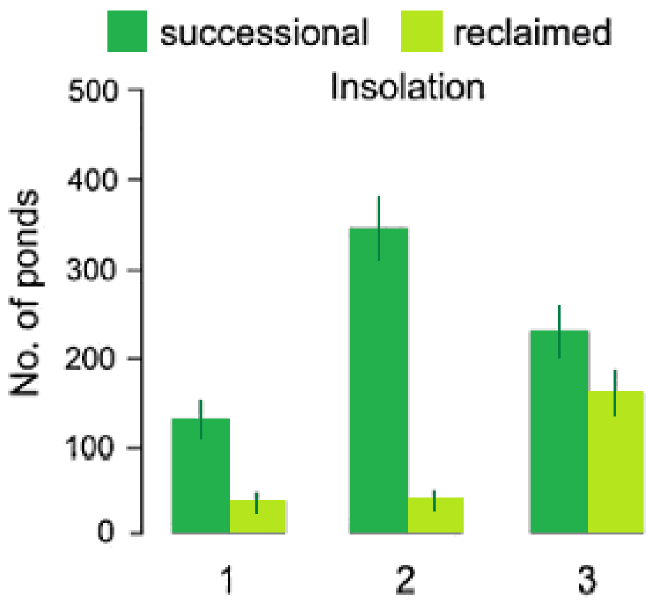


Figure 14: Number of ponds according to the insolation and the reclamation status (successional vs. technically reclaimed). 1 = (< 5%), 2 = (5-75%) and 3 = (>75%)

As for insolation of water surface, whereas on reclaimed sections the majority of ponds were fully insolation; in spontaneous succesion sections ponds with partially insolation prevailed (Figure 14 and table 5).

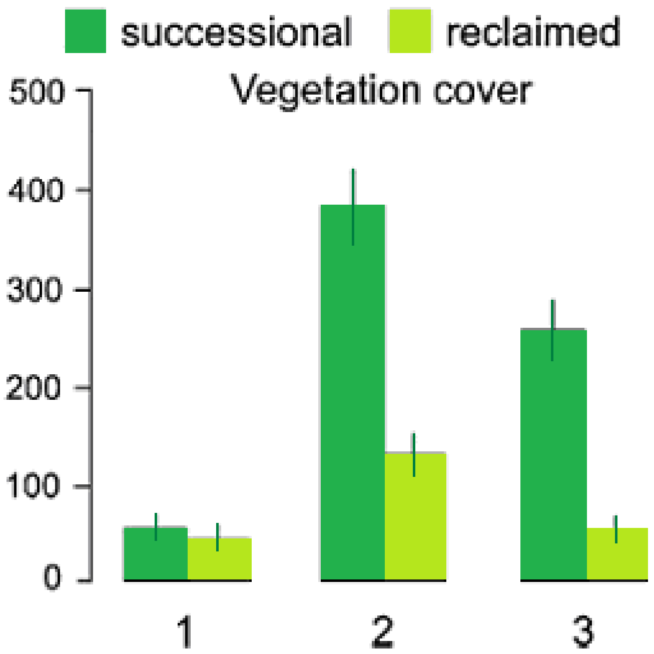


Figure 15: Number of ponds according to the vegetation cover and the reclamation status (successional vs. technically reclaimed). 1 = (< 5%), 2 = (5-75%) and 3 = (>75%)

Both reclaimed and unreclaimed spoil banks partially vegetated ponds predominated, but on spontaneous succesion sites the proportion of fully vegetated ponds was significantly higher than on reclaimed sites (Figure 15). As surrounding environment, on spontaneous succesion sites prevailed forests and forest-steppe, while other landscape types were rare or practically absent. However, on reclaimed spoil banks this had a more balanced ratio of landscape types in pond surroundings (Figure 16).

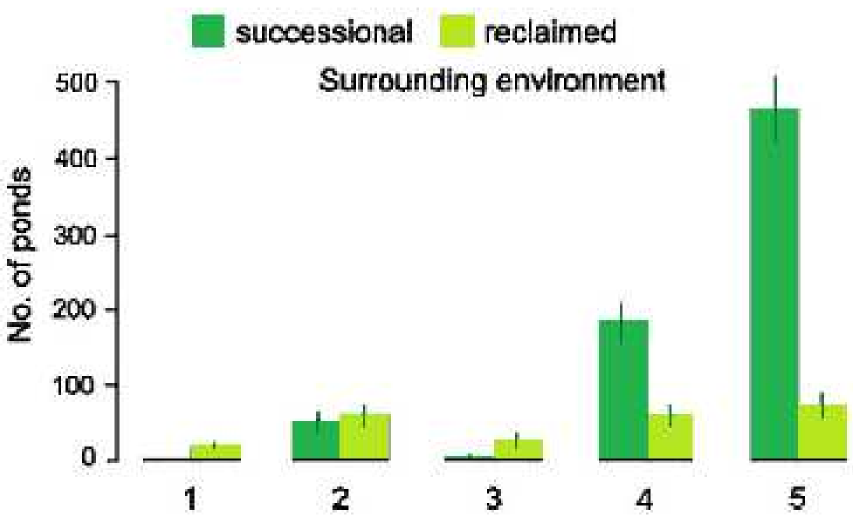


Figure 16: Number of ponds according to the surrounding environment and the reclamation status (successional vs. technically reclaimed). 1 = Initial successional stages, 2 = Arable lands, 3 = Grasslands, 4 = Forest steppes and 5 = Forests

The next table represents the number of ponds and percentage of the different variables in the two reclamation status (successional and reclaimed):

Variable		**Pond numbers (%)**					***df***	***p***
		1	**2**	**3**	**4**	**5**		
Maximun depth	S	252 (36.3)	253 (36.5)	189 (27.2)			2	$< 10^{-6}$
	R	63 (27.4)	60 (26.1)	107 (46.5)				
Shore slope	S	515 (74.2)	145 (20.9)	34 (4.9)			2	$< 10^{-6}$
	R	129 (56.1)	45 (19.6)	56 (24.3)				
Insolation	S	127 (18.3)	342 (49.3)	225 (34.4)			2	$< 10^{-6}$
	R	34 (14.8)	37 (16.1)	159 (69.1)				
Vegetation cover	S	54 (7.8)	381 (54.9)	259 (37.3)			2	$< 10^{-6}$
	R	45 (19.6)	131 (56.9)	54 (23.5)				
Surrounding environment	S	0 (0.0)	3 (0.4)	48 (6.9)	180 (25.9)	463 (66.7)	4	$< 10^{-6}$
	R	17(7.3)	25(10.9)	58 (25.2)	58 (25.2)	72 (31.3)		

Table 5: Log-linear frequency analysis of pond numbers according to reclamation status (R – reclaimed, S – successional) and the particular level of the given variable (numbers from one to five). Only the interactions between particular variables and the reclamation status are presented as the results of the analyses. The percentages in parentheses represent pond ratios within a particular reclamation status and the level of the given variable. For an explanation of the levels of variables (see Table 3).

3.2. SIGNIFICANCE OF ENVIRONMENTAL FACTORS WITH DIFFERENT LEVELS OF ABUNDANCE AND HABITAT PREFERENCES OF RANA DALMATINA

In the whole of ponds (n=114) researched during the two years we could see the great difference existing between both. A total 1436 clutches were counted in 2008, which is the year with highest abundance. On the contrary, almost ten times less clutches (n=165) were registered in the same areas (Radovesická and Růžodolská spoil banks) in the poorest abundance year, year 2012 (TABLE 6).

Variable	**Year**	**Number of clutches**
Number of clutches	2008	1436
	2012	165

Tabla 6: Number of clutches of each year (2008 and 2012)

Obviously, not in all studied ponds there were presence of clutches of Rana dalmatina. In 2008, year researched with highest abundance of them, showed that ponds half had presence of clutches. While in 2012, only a little more of a quarter of ponds counted with presence of them (Table).

Variable	Year	Total ponds	Ponds with presence	Ponds with presence/ Total ponds
Number of ponds with presence of Rd	2008	114	56	49.12 %
	2012		34	29.82 %

Tabla 7: Ponds with presence of clutches of Rana Dalmatina to total ponds researched in Radovesická and Růžodolská spoil banks to both years (2008 and 2012)

Variable	*df*	F	*p*	Result
Pond area				
2008	1	8.86	$p < 10^{-2}$	2008 > 2012
2012	1	3.48	$p < 0,05$	
2008:2012	1	5.37	$p < 0,05$	
Maximun depth				
2008	2	5.20	$p < 10^{-2}$	2008 < 2012
2012	2	10.65	$p < 10^{-4}$	
2008:2012	2	4.13	$p < 0,05$	
Vegetation cover				
2008	2	4.63	$p < 0,05$	2008 < 2012
2012	2	7.06	$p < 10^{-2}$	
2008:2012	2	1.28	$p < 0,5$	
Shore slope				
2008	1	9.47	$p < 10^{-2}$	2008 > 2012
2012	1	10.65	$p < 0,05$	
2008:2012	1	11.88	$p < 10^{-3}$	
Insolation				
2008	2	0.40	$p < 0,5$	2008 = 2012
2012	2	2.41	$p < 0,5$	
2008:2012	2	0.90	$p < 0,5$	
Surrounding environment				
2008	1	5.07	$p < 0,05$	2008 < 2012
2012	1	9.55	$p < 10^{-2}$	
2008:2012	1	6.16	$p < 0,05$	
Status of reclamation				
2008	1	1.97	$p < 0,5$	2008 < 2012
2012	1	16.24	$p < 10^{-3}$	
2008:2012	1	0,08	$p < 0,5$	
Conectivity (300 m)				
2008	1	1.11	$p < 0,5$	2008 = 2012
2012	1	0,04	$p < 0,5$	
2008:2012	1	7,28	$p < 0,05$	

Tabla 8: Results of analyses of differences in enviromental variables (pond area, maximun depth, shore slope, insolation, surrounding environment, status of reclamation and connectivity in 300 metres) on year with highest (2008) and year with poorest abundance (2012) abundance. In the case of pond area, GLM with quasi-Poisson distribution was used.

First, pond area is significance in 2008, the year with highest abundance of clutches. While for 2012, the year with poorest abundance of clutches, also can be considered as variable significant but less than 2008. As for maximum depth, it was high significant both 2008 and 2012. Although in the year with the poorest abundance of clutches, maximum depth was more significant (Table 8).

Vegetation cover also was significant in both years. But like in maximum depth, the year 2012 vegetation cover was more significant than in the year with highest abundance of clutches. For shore slope, the interpretation of data showed that both 2008 and 2012 this variable was significant. It is worth highlighting that in 2008 this variable had more valor of significance (Table 8).

Next, we worked the insolation variable, which showed that was insignificant variable both in 2008 as in 2012. As for variable surrounding environment, this variable was significant both year with the highest abundance as year with the poorest abundance, but was more significant in this last (table 8).

Status reclamation was highly significant for the year 2012, with the poorest abundance; while when the abundance was the highest (2008) this variable wasn´t significant. Last, the variable which measures the connectivity between ponds inside the distance of 300 metres wasn't significant any year (Table 8).

Variable		Number of ponds with presence (%)					d*f*	*p*
		1	2	3	4	5		
Maximun depth	2008	4 (7.14)	31 (55.36)	21 (37.50)			2	$< 10^{-6}$
	2012	1 (2.94)	14 (41.18)	19 (55.88)				
Vegetation cover	2008	3 (5.36)	33 (58.93)	20 (35.71)			2	$< 10^{-6}$
	2012	0 (0.00)	27 (79.41)	7 (20.59)				
Shore slope	2008	43 (76.78)	13 (93.33)				1	$< 10^{-6}$
	2012	28 (82.35)	6 (17.65)					
Insolation	2008	1 (1.78)	20 (35.71)	35 (62.50)			2	$< 10^{-6}$
	2012	0 (0.00))	10 (29.41)	24 (70.59)				
Surrounding environment	2008				23 (41.07)	33 (58.93)	1	$< 10^{-6}$
	2012				19 (55.88)	15 (44.12)		
Status of reclamation	2008	22 (39.29)	34(60.71)				1	$< 10^{-6}$
	2012	8 (23.53)	26 (76.47)					

Tabla 9: Log-linear frequency analysis of pond numbers with presence of clutches according to year (2008 – highest level of abundance, 2012 – poorest level of abundance) and the particular level of the given variable (numbers from one to five). Only the interactions between particular variables and the reclamation status are presented as the results of the analyses. The percentages in parentheses represent pond ratios within a particular reclamation status and the level of the given variable. For an explanation of the levels of variables (see Table 3).

Last table showed ponds number with presence of clutches of Rana dalmatina and percentage in each year (2008 and 2012) and each the particular level of the given variable. For maximum depth we could observed that first level (<0, 5) appear in a few ponds, while the other two levels showed in similar shape (Table 9).

The first level (<5 %) of vegetation cover also was poor, on the opposite the level two (5-75%) was predominant in this variable for both years. In case of shore slope, the level three (>55º) did not appear represented. The, level one (<30) is more frequent than level 2 (30-55º) (Table 9).

As in other variables in the case of insolation, level one (<5%) was highly poor. Then, level predominant was the level three which represented the fully insolation. Furthermore, variable of surrounding environment only showed two of their levels: forest steppes and forest. Last, status of reclamation was divided in unreclaimed as level one and reclaimed as level two (Table 9).

Variable		Number of clutches (%)					*df*	*p*
		1	2	3	4	5		
Maximun depth	2008	53 (3.69)	1094 (76.18)	289 (20.12)			2	$< 10^{-6}$
	2012	1 (0.60)	91 (55.15)	73 (44.24)				
Vegetation cover	2008	12 (0.84)	996 (69.36)	428 (29.80)			2	$< 10^{-6}$
	2012	0 (0.00)	150 (90.91)	15 (9.09)				
Shore slope	2008	1372 (95.54)	64 (4.46)				1	$< 10^{-6}$
	2012	154 (93.33)	11 (6.67)					
Insolation	2008	6 (0.42)	307 (21.38)	1123 (78.20)			2	$< 10^{-6}$
	2012	0 (0.00)	39 (23.64)	126 (73.36)				
Surrounding environment	2008				573 (39.90)	863 (60.10)	1	$< 10^{-6}$
	2012				71 (43.03)	94 (56.96)		
Status of reclamation	2008	187 (13.02)	1249(86.98)				1	$< 10^{-6}$
	2012	38 (23.03)	127 (76.97)					

Tabla 10: Log-linear frequency analysis of number of clutches of Rana dalmatina according to year (2008 – highest level of abundance, 2012 – poorest level of abundance) and the particular level of the given variable (numbers from one to five). Only the interactions between particular variables and the reclamation status are presented as the results of the analyses. The percentages in parentheses represent pond ratios within a particular reclamation status and the level of the given variable. For an explanation of the levels of variables (see Table 3).

For number of clutches and percentage in each year (2008 and 2012) and each the particular levels of the given variable were obtained next results; level two which represented medium depth was predominant for the variable maximum depth (Table 10).

Also, second level was predominant in the case of vegetation cover in which represented partially covered. While for variable shore slope, gentle slopes were most frequents. Then, in ponds with full insolation the number of clutches was the highest (Table 10).

Finally, in surrounding environment both levels (forest steppes and forest) were almost equals but this last had a little more of clutches. In the case of status reclamation, the presence of clutches was predominant in reclaimed ponds (Table 10).

4. DISCUSION

CONECTIVITY OF WATER HABITATS

Ponds per hectare of spoil bank, and higher number of ponds inside of 300 m on spontaneous succession spoil banks (Fig. 12) is due to heterogeneous surface of unreclaimed post-mining sites (BEJČEK, 1982). For European amphibians, ponds are crucial not only as reproduction habitats. Groups of suitable and accessible ponds also maintain amphibian metapopulations (PETRANKA et al., 2007) and support the colonization of new sites (HARTEL and ÖLLERER, 2009), including spoil banks (VOJAR, 2006). Thus the considerably higher pond connectivity on spontaneous succession parts of spoil banks should lead to more stable amphibian meta-populations and should enhance spoil bank colonization by amphibians better than on reclaimed sites.

POND FEATURES

Shallow ponds with gentle shore slopes, also with partial insolation of pond and partial vegetation cover were found in pond under influence of successional sites. As oppose, the ponds on technically reclaimed sections of spoil banks were larger and deeper, with steeper shore slopes; full insolation and partial vegetation cover (Table 5).

Is known that central European amphibians prefer middle-sized (about 500 m2), stable water ponds with depth allowing development of partial vegetation cover (FICETOLA and DE BERNARDI, 2004). In front of this, very large and deep ponds are unsuitable for amphibians due to intensive fish management and could even represent barriers for them (JOLY et al., 2001; HARTEL et al., 2007). Very small and shallow ponds, on the other hand, are often threatened by desiccation (KOPECKÝ et al., 2010), and due to restricted size and suboptimal conditions they often host small populations (HARTEL et al., 2007). For some species, however, small temporary ponds represent crucial habitats and, as pond clusters, could maintain their large metapopulations (KOPECKÝ et al., 2010).Tiny water bodies are also relevant as amphibian refuges (VAN BUSKIRK, 2003), as they increase landscape permeability and support colonization of new areas (HARTEL and ÖLLERER, 2009). Then for size pond and depth, we can declare that under our results spontaneous succession spoil banks are more suitable, i.e. small and middle sized, water bodies supporting the existence of most amphibian species living in spoil bank surroundings.

Vegetation cover keeps closely related to shore slope and pond depth, also this cover protects amphibian eggs, larvae and adults against predators (JOLY et al., 2001).Water bodies on both successional and technically reclaimed spoil banks were predominantly partially vegetated (Fig. 15 and Table 5). In the case of large and deep ponds that prevailed on reclaimed sites, however, partial vegetation represented merely a narrow ring of vegetation around the pond. Along with intensive fish predation, this does not offer suitable conditions for amphibians (JOLY et al., 2001; HARTEL et al., 2007). Fully vegetated ponds are in high proportion in spontaneous succesion sites because there small ponds with gentle slopes and lower depths, the trouble can be risk of drying of pond by vegetation invasion (KOPECKÝ et al., 2010).

Forest steppes and forests considerably prevailed as the terrestrial habitats around ponds on successional spoil banks, whereas the ratios of landscape types in pond surroundings on reclaimed sites were more balanced (Fig. 16 and Table 5). In the case of the Kopistská and Teplická spoil banks, this was due to forest reclamation in the past (Table 1) while in others successional sites forest steppes prevailed Most Central European amphibians prefer forest steppe or forest habitats during their terrestrial period (HARTEL and ÖLLERER, 2009).

In spontaneous succesion spoil banks where ponds are small surrounded by forests or forest steppes there are generally less insolated than larger ponds on reclaimed spoil banks (Fig)

SIGNIFICANT OF ENVIRONMENTAL FACTOR WITH DIFFERENT LEVELS OF ABUNDANCE AND HABITAT PREFERENCE OF RANA DALMATINA

Pond area is more significant pond feature in year 2008, when there were high levels of abundance, because the specie had more dispersion which allowed that Rana dalmatina could colonise (49, 12%) more ponds and achieve more success in ponds with area medium- size(FICETOLA and DE BERNARDI, 2004). Otherwise, when the abundance is poorest as in the year 2012, pond area was significant, but less than in 2008 because also less ponds were colonise (29, 82%) (Table 8).

Maximum depth came to show that with the poorest levels was double significant than in highest levels of abundance. This is because when there is low levels of abundance Rana dalmatina can choose ponds with medium depth (0, 5 -1, 5 m) which is the best for them (FICETOLA and DE BERNARDI, 2004) and where fish presence is not usual (JOLY et al., 2001). While there is high levels of abundance is more dificult find these ponds without intraspecific competence. As in the case of maximum depth, when abundance is poor the individual have more possibilities to choose ponds with partial vegetation cover. Because full covered can be lend to drying (KOPECKÝ et al., 2010) while when there isn´t vegetation is very easy that fishes are there (HARTEL et al., 2007). In oppose, with highest abundance levels Rana dalmatina haven´t the same ease for it (Table 8, 9 and 10).

In the case of slope, this in both years was significant. Although a bit more when levels of abundance of clutches are high, thus we can understand that when Rana dalmatina colonises more ponds in these case is when she tend occupy she try occupy them with gentle slopes that keep strong relation with large area ponds, as we could see before. For variable surrounding environment, the significance when there is low levels of abundance is high than when these levels are high. However, in the case of this variable for both years is considered significant. As before, we declare that when the individual have more posibilities of choose these variables got more importance. The last two levels that these are more important (forest steppes and forest) are the unique levels which are represented in this ponds with presence of clutches in Radovesická and Růžodolská spoil banks.

When we work with status of reclamation, we can see that when there is a poor level of abundance this variable is significant while in the other case it isn't. But when you see table 9 and 10 you can observed that in reclaimed ponds there is more clutches, this can contradict important studies. Therefore, we can see the table 2 where Radovesická and Růžodolská spoil banks counts with more ponds in reclaimed sites, even though many reclaimed ponds fulfills with the best environmental conditions: middle-sized, stable water ponds, medium depth and partial vegetation cover (FICETOLA and DE BERNARDI, 2004).

Last, variables of insolation and connectivity inside of 300 metres aren´t significant in any of both years; i.e. almost all ponds with presence of clutches are under total insolation (Table 8, 9 and 10).

5. CONCLUSIONS

First, our results showed that ponds on spontaneous succession have more suitable characteristics for amphibians (Rana dalmatina) than does technical reclamation. However, the most important feature is her high number of ponds that allow union of clusters of ponds to favor creation metapopulation structures. Then, when increase suitable ponds; also abundance of Rana dalmatina will do it (ZANINI, 2006).

The most important problem is the historical trend in Czech Republic in favor to technical reclamation inherited of communism methods which looked for economic profit as main aim. Thus is necessary that researchers, scientists, national institutions and the private companies join forces to change this historical trend.

As we said previously, spontaneous succesion spoil banks represent a wonderfull potential for nature conservation (TROPEK et al., 2010); besides mines and spoil banks cover about 500 km2 in Czech Republic which is half of national parks area (MINISTRY OF THE ENVIRONMENT OF THE CZECH REPUBLIC). Thus, we must try to change trend toward the reduction thecnical reclamation which supposes high costs. While habitats with great value can be get naturally on spontaneous succession PMA, without the need of substantial investment (PRACH and HOBBS, 2008). In addition to the trouble of costs, technical reclamation could lead to negative effect about habitat and species diversity (HODAČOVÁ and PRACH, 2003; ŘEHOUNEK et al., 2010). Also patently, European policy about energy resources tends toward the reduction emission of contaminant gases and also is known that lignite mining entail high levels of CO_2 emissions. This, added to drastic descent of subsidies planned for next years for mining in all the European Union, must do us see that large areas which are mines and spoil banks will have be managed for ecological restoration. In our hands is the use of method innovative, cheaply and effective represented by spontaneous succession when be possible or, on the contrary, we can continue with the tradicional and expensive technical reclamation.

Also, is very important remember that all past mines and spoil banks can´t be manage by spontaneous succesion directly. Can be cases in that are necessary the inclusion of some technics of reclamation: forest reclamation, improve soil conditions, introduction of leguminous plants, etc. In addition, investments must being used, besides for ecological restoration inmediately after the end of mining; for habitat management and its monitoring in a future. Between measures could be promoted are: elimination of excesive vegetation or control the characteristics of the pond water: pH and conductivity (VOJAR, 2007).

One hand, our results showed that almost all environmental variables are more important for presence of clutches when their abundance is poor. Other hand, many studies have showed that trend of abundance of amphibians is decrease because these are affected by environment changes and in uses of land (VOJAR, 2006). Thus, in view the future situation is highly recommended take measures to favor areas and ponds with suitable features for them and as we could see before the best characteristics are: middle-sized area, stable water ponds, medium depth, shallow slope and partial vegetation cover. Finnally, we know that these features are more frequent on spontaneous succesion ponds.

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