# Communities of Small Mammals as Indicators of Biodiversity Changes in Reclaimed Areas after Coal Mining

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**Abstract**

One way to assess restoration success is to examine the biodiversity in the "newly created" areas. We chose small mammals as biodiversity indicators because of their good reproductive capacity and invasive ability. The aim of the study was to compare different types of restoration from the small mammal biodiversity perspective. We captured small mammals five times during the 2003/2004 season at spoil heap localities with various types of restoration: agricultural, forest and wetland, using standard methods of capturing with snap traps in lines and quadrates. In total, 393 individuals of 7 small mammal genera were captured (128 ind. of *Apodemus*, 38 ind. of *Clethrionomys*, 147 ind. of *Microtus*, 21 ind. of *Sorex*, 1 ind. of *Arvicola*, 1 of. *Mus*, 1 ind. of *Micromys*, and 56 ind. not yet determined). Using a standard number of trap-nights, a similar number of individuals were captured at all localities. The results are still being processed, but we can already see that the wetland localities were the richest in small mammal diversity (6 genera), the forestry restored areas were second (4 genera), and the agriculturally restored areas were the poorest (2 genera).

Our results support the opinion that wetlands are very important, not only for the water regime and water quality of the reclaimed area, but also for its biodiversity. So, wetlands should be considered an indispensable part of restoration.

**Key words**: restoration, spoil heap, biodiversity, bioindicators, small mammals

## Introduction

Opencast mining significantly affects all components and functions of the landscape. Because of ecosystem destruction, the diversity of the landscape decreases, which reduces biodiversity and ecological stability. The restoration of a devastated landscape should be realized in accordance with the natural principles of ecosystems functioning. The aim of such restoration is to bring the original function to the landscape, which should be reflected by the number and variety of plant and animal species inhabiting the area.

Species diversity can be considered a phenomenon that reflects the quality and functionality of a landscape. The more diverse and natural the landscape is, the higher the biodiversity. Because of their good reproductive capacity and invasive ability, small mammals are a suitable model group to use to assess environmental quality.

A positive correlation between the species diversity of small mammal communities and the stage of development of their environment has been described already by Bejček (1983). He studied the natural changes in small mammal populations that developed in an area of a spoil heap that developed without human intervention. Specific species of small mammals inhabited specific stages of spoil heap development. In addition, specific plant species indicated concrete stage of succession. There was only one species (*Apodemus sylvaticus*) recorded (with increasing abundance) on the spoil heap during the first five years of its development. Nevertheless, all the important species captured on the spoil heap were between 5 and 13 years old. The higher dominance of some species was typical for the late stages of spoil heap development (Bejček, 1983). Similar trends had been described also by Wetzel (1958) on spoil heaps after coal mining in Illinois (USA).

Somewhat different problem was studied by Pecharová and Hanák (1997). They focused on the influence of the restoration type on the species diversity and abundance of small mammals in the area of the Podkrušnohorská spoil heap. Again, *Apodemus sylvaticus* was an invasive species, migrating rapidly onto the freshly created parts spoil heap with minimal vegetation cover. The number of species was relatively low on the agriculturally restored areas (4 species), higher on the forestry restored areas (6 species), and the highest diversity was found on the areas of artificial created wetlands (9 species; Pecharová and Hanák, 1997). Nevertheless, it was just a pilot study and the results should be interpreted as preliminary because of the small number of trappings and insufficient processing of the

material. The aim of this study was to continue the study of small mammal biodiversity on diversely restored places in the area of the Podkrušnohorská spoil heap.

**Methods**

The standard method of capturing with snap traps in lines and quadrates was used (Wilson et al., 1996; Dykyjová, 1989). There were always 50 traps laid in 5 m distances in a line, so that the total length of the line was 250 m. With respect to the structure of studied area, we used smaller quadrates than standard 1 ha quadrates, namely 11 x 11 traps at 5 m distances, so there were always 121 traps per quadrate on an area of 25 are (2500 $m^2$).

Line trappings lasted three nights, quadrate trappings six nights. Three line trappings (spring: April 16$^{th}$ till 20$^{th}$; summer: June 21$^{st}$ till 24$^{th}$, and autumn: October 6$^{th}$ till 9$^{th}$) and two quadrate trappings (spring: May 24$^{th}$ till 30$^{th}$ and autumn: November 2$^{nd}$ till 8$^{th}$) took place during the 2003/2004 season.

We used standard snap traps, which were always checked in the morning. A wick impregnated by flour roasted on sunflower oil was used as bait. We used snap traps instead of live traps because we took samples from the animals' stomachs for food preference analysis.

The study took place at the spoil heap localities with various types of restoration: agricultural, forest, and wetland. Fully grown original forest land near the opencast mine was used as a control. One line trapping was also made on the Lítovská spoil heap, which is almost without vegetation, because of its toxic substrate.

**Localities**

*1) Agricultural restoration*

1. Regularly mowed meadow in the catchment of Panský stream; both line and quadrate trapping.

*2) Forest restoration*

1. Young forest plantation in the catchment of Panský stream; line trapping across the growth.
2. Higher growth on the border of Panský stream catchment; both line and quadrate trapping.

*3) Wetland restoration*

1. Milena pond in the Panský stream catchment; line trapping around the pond, in the coastal vegetation.
2. Anita wetland in an area of an educational path; line trapping in the wetland vegetation around the wetland.
3. Artificial wetland at the base of the spoil heap; both line and quadrate trapping.

*4) Original forest*

1. Mixed forest with dominance of pine on the edge of Jiří opencast mine; line trapping.

*5) Toxic spoil heap, Lítov*

1. Almost bare spoil heap with toxic substrate near the vilage Chlum sv. Máří.

Captured animals were divided into genera in the field and will be speciated this year. The animals will be also measured (standard body measures according to Wilson et al., 1996), the reproductive status of individuals will be determined, and the samples of stomachs contents will be taken in order to define food preferences (therefore, invertebrates, representing food, was also trapped in the main localities).

**Results and Discussion**

In total, 393 individuals of 7 small mammal genera were captured (128 ind. of *Apodemus*, 38 ind. of *Clethrionomys*, 147 ind. of *Microtus*, 21 ind. of *Sorex*, 1 ind. of *Arvicola*, 1 of. *Mus*, 1 ind. of *Micromys*, 56 ind. were not yet determined). The results are still preliminary, but we can already see that:

1) The small mammal diversity was the highest at the wetland localities (6 genera: *Apodemus*, *Clethrionomys*, *Microtus*, *Sorex*, *Arvicola*, *Micromys*), second best on forestry restored areas (4 genera: *Apodemus*, *Clethrionomys*, *Microtus*, *Sorex*), and lowest on agriculturally restored areas (2 genera: *Microtus* and *Mus*). The details are described in Graf 1 and Table 1.

2) Using the standard number of trap-nights during quadrate trappings, a similar number of individuals were captured at all localities (72 individuals on wetland restoration, 70 ind. on agricultural restoration, and 62 ind. on forest restoration). But the structure of the small mammal populations varied radically between the areas (Graf 2).

One individual of *Microtus arvalis* was even recorded on the toxic spoil heap at Lítov.

***Table 1*** *The numbers of captured individuals from various genera for each individual restoration type.*

| | Agricultural restoration | Forest restoration | Wetland restoration | Original forest | Toxic spoil heap Lítov | Altogether |
|---|---|---|---|---|---|---|
| *Apodemus* | | 62 | 47 | 19 | | 128 |
| *Microtus* | 72 | 27 | 47 | | 1 | 147 |
| *Clethrionomys* | | 2 | 15 | 21 | | 38 |
| *Arvicolis* | | | 1 | | | 1 |
| *Micromys* | | | 1 | | | 1 |
| *Mus* | 1 | | | | | 1 |
| *Sorex* | | 2 | 18 | 3 | | 21 |
| Not determined | | | 12 | | | 56 |
| Altogether | 73 | 93 | 141 | 41 | 1 | 393 |

The results confirm the assumption that the highest diversity of small mammal develop in wetland localities, as found already by Pecharová and Hanák (1997). This is not surprising because a lot of small mammal species are closely connected to a wetland habitat (e. g. *Microtus agrestris*, *Arvicola terestris*, *Neomys fodiend*, and *anomalus*). Moreover, most of the other species, living in other (for example forest) biotopes, prefer moister microhabitats (e. g. all of our *Sorex* species, the majority of our *Apodemus* species, *Pitimys subterraneus*; Anděra and Horáček, 1982; Cobert and Ovenden, 1982; Mitchell-Jones et al., 1999). It also explains the fact, that while (with only minor exceptions) only *Microtus* was captured in the meadow, the diversity of species was significantly higher in the narrow growth of rushes around the nearby pond Milena (4 genera).

This observations support the hypothesis that wetlands are a very important part of mined land restorations. Besides the high number of small mammal species, those areas offer habitat for a number of amphibians and reptiles (Přikryl and Pecharová, 1997) and have a cardinal importance for other functions of the landscape. Wetlands increase water retention capacity, which supports the water cycle. Also, the quality of water flowing through wetlands is higher than the quality of water flowing directly from a spoil heap into the surrounding landscape. Moreover, the aesthetic value of wetlands in a newly created landscape of spoil heaps is also considerable (Pecharová, 2004).

Forest restoration shows the second highest diversity of small mammals. But, according to our results, the age and type of planted growth is very important for small mammal biodiversity. Too young, monocultural, and non-connected forest growths are very rarely inhabited by small mammals, most probably because of high predation risk and high temperature oscillations during the day (Pecharová et al, 2004). Species composition of planted growths also differs from original forests, which have a higher abundance of typical forest species (e. g. *Clethrionomys glareolus*) than restored areas. All the studied forestry restored areas were relatively dry, which could also affect the presence of hygrophilous species, such are e. g. species of *Sorex* genus. A lot of *Microtus arvalis* individuals (a typical species for meadows) were captured in those localities, maybe because of the low density of planted trees, which allowed the presence of a dense grass undergrowth.

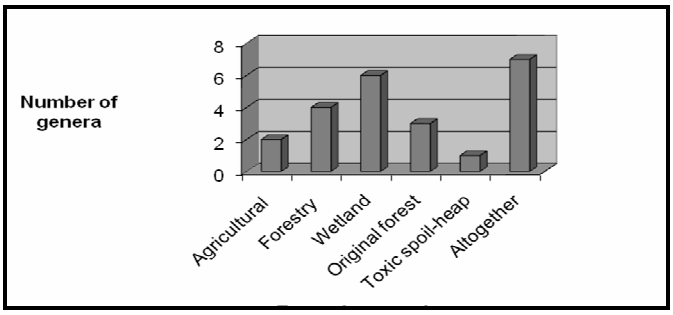
The least biodiverse area with respect to small mammal species was the agricultural restoration area, where only two genera were recorded, and the house mouse (*Mus musculus*) was captured only in one unique case. Most of the small mammals were voles (*Microtus*), which is completely in accordance with their biotope preferences. An interesting event was the trapping of a black, melanic *Microtus arvalis* individual.

Surprisingly, one *Microtus arvalis* individual was captured on the toxic spoil heap at Lítov, which is almost without vegetative cover. One may question whether it was a migrating individual, or if voles are really living in this harsh environment.

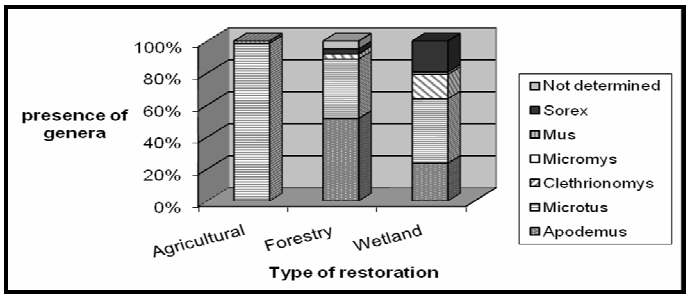
**Conclusion**

The Podkrušnohorská spoil heap area is relatively rich in small mammal species. A total of 393 individuals of 7 small mammals genera were captured (128 ind. of *Apodemus*, 38 ind. of *Clethrionomys*, 147 ind. of *Microtus*, 21 ind. of *Sorex*, 1 ind. of *Arvicola*, 1 of. *Mus*, 1 ind. of *Micromys*, 56 ind. were yet not determined).

***Graf 1*** *The number of captured genera at the individual types of restoration.*




***Graf 2*** *The proportional representation of genera in the small mammal community at the differently restored localities.*




The small mammal diversity was the highest in wetland localities (6 genera: *Apodemus*, *Clethrionomys*, *Microtus*, *Sorex*, *Arvicola*, *Micromys*), then in forestry restored areas (4 genera: *Apodemus*, *Clethrionomys*, *Microtus*, *Sorex*) and the lowest in agriculturally restored areas (2 genera: *Microtus* and *Mus*). Using the standard number of trap-nights during quadrate trappings, the similar number of individuals at all localities was captured, but the structure of small mammal populations varied radically between the areas.

These observations support the hypothesis that wetlands are a very important part of mined land restorations because they support animal diversity in the area.

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