Final Project Report (to be submitted by 30th September 2016)

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1. Contestant profile

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2. Project overview

Title:	GROUND-DWELLING INVERTABRATES AS BIOINDICATORS IN QUARRIES
Contest:	The Quarry Life Award 2016
Quarry name:	Shakh-Tau quarry, Russia
Prize category: (select all appropriate)	☐ Education and Raising Awareness ∗ Habitat and Species Research ☐ Biodiversity Management ☐ Student Project ☐ Beyond Quarry Borders

Abstract

Invertebrates which are living on the surface of the soil can serve as indicators of biodiversity in quarries due to their sensitiveness to habitat changes.

Our faunistic survey of ground-dwelling invertebrates took place in the Shakh-Tau quarry, Russia, from May 24th till August, 30th 2016. There are 5 people in our team, all from the Bashkir State University. The invertebrates were captured by pitfall traps in four habitats: centre of the quarry (1), slope (2), forest edge (3) and riverside (4). The materials from 3000 trap-days were analyzed.

More than 120 species from 13 orders and 51 families with a total number of nearly 10 000 specimens were captured in the Shakh-Tau quarry. The most specimen were captured at the riverside (habitat 4) (2288 specimens (with ants 5646)) and the least specimen were collected in the centre of the quarry (774). Both the invertebrates diversity and abundance decrease towards the center of the quarry (dynamic density decreases from 2,42 to 1,65 specimen per trap day). Both the invertebrates diversity and abundance decrease from June to August, 30th (from 3,30 to 0,94).

We think, that good indicators for quarries can be the following animal groups: for the centre of a quarry – Harvestmen; for grassy land – True bags; for stable soil conditions on the outskirts of a quarry – Ants; for all habitats except central part – Carabid beetles. Not suitable: Myriapoda, Isopoda, Diptera, Lepidoptera.

In terms of the QLA contest we obtained the unique data on invertebrate diversity in the Shakh-Tau quarry from the territory, although the quarry is not open for visitors. Our results contribute to the knowledge of regional fauna: we have found six species, that were previously unknown in the Republic of Bashkortostan. On the basis of obtained data one manuscript is submitted for publication, several other papers are in progress and will be published soon.

Although the biodiversity in the centre of the quarry is very low, in the adjacent territory it is practically as diverse as in the intact landscapes. We have elaborated several recommendations for the company, that can improve situation with biodiversity in quarries and public awareness on this topic in the future. Even the low cost quarry management can produce high gain biodiversity.

The local and regional societies now have information about animal diversity in the quarries, sometimes surprisingly high. This information can change the local people attitude towards quarries and company.

Final report

Our team, from left to right: Eliza Khaydarshina, Natalia Miranda Chikurova, Viner Khabibullin, Alexander Gladkikh, Marat Farukshin.

Background

Invertebrate animals numerically make up a major part of biodiversity and make a fundamental contribution to ecological processes and ecosystem functioning (Kim, 1993). Since invertebrates utilize even the smallest of microhabitats, they are likely to provide a very useful tool for observing changes in the environment (Kremen et al., 1993). However, changes in the structure of invertebrate communities caused by environmental changes are largely unknown due to problems with sampling and identification (Hilty, Merenlender, 2000). Soils are biodiversity hotspots. Ground-dwelling invertebrates are widely regarded as powerful monitoring tools in environmental management because of their great abundance, diversity and functional importance, their sensitivity to perturbation, and the ease with which they can be sampled. In contrast, most vertebrates are either too mobile, generalized or uncommon to be effective indicator taxa (Rohr et al., 2007).

Objectives

The main goals of our project are: inventory of the ground invertebrates; investigation of their biodiversity changes in the gradient of habitat disturbance; research of the seasonal dynamics of biodiversity; identification of the rare and endangered species; assessment of the possibility of using certain species (groups) of ground invertebrates as bio-indicators of natural and disturbed ecosystems.

Material and Methods

The sampling took place from May, 24th till August, 30th, 2016. The study was carried out in the Shakh-Tau quarry, the Republic of Bashkortostan, Russia (fig.1).
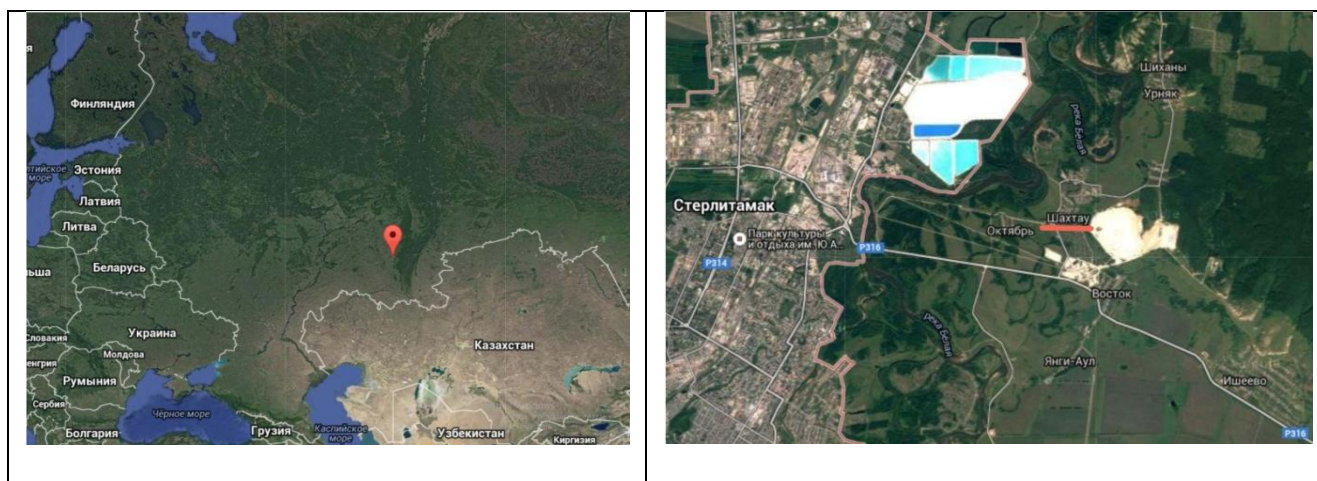

Fig. 1. General view of the Shakh-Tau quarry.

Fig. 2. Location of the Shakh-Tau quarry.

The operating quarries create a variety of habitats with different level of disturbance. It makes conditions for continuous creation/restoration and spontaneous succession and habitats.

We have chosen four habitats (fig. 3 and 4), representing basic gradient of transformation: from the centre of quarry (habitat 1; 5 traps) through the slope (habitat 2; 10 traps) and forest edge (habitat 3; 5 traps) to the riverside (habitat 4; 10 traps). We checked traps every two weeks. The materials from 3000 trap-days were analyzed. We calculated the active density of invertebrates per 1 trap day.

Fig 3. Habitats that we have studied.

1 - Centre of the quarry

2 – Slope of the quarry

3 - Forest edge

4 - flood plain of the river

Fig 4. Habitats.

One of the principal methods of measuring invertebrate community parameters is pitfall trapping. The advantages of using these traps include the following: they are simple and have no moving parts; they are cheap; collect large numbers of animals; safe for the operator; capturing species which are difficult to obtain by other methods; operate round-the-clock. Each trap (fig 5) consisted of two stacked 500 mL clear plastic cups buried with the rim level to the soil surface. The outer cup remained in place to prevent reburial when servicing the trap. The inner cup contains 100 mL of 4% formalin preservative. Organisms unable to detect the presence of the trap fall in and are captured. Pitfall traps estimate activity density – the interaction of absolute density and species movement.

Fig. 5. The settled pitfall trap.

We have visited the Shakh-Tau quarry, which is situated about 150km from Ufa-city, 8 times. Each trip took the whole working day – from 8:30 am to 5:00 pm. In our first working trip we have set 30 pitfall traps. Since May, 24th till August, 30th, we expect about 3000 trap-days. Some traps were destroyed by excavators. Intervals between checking traps were 14 days. So we can trace the difference in species composition and relative abundance over the period of 100 days.

Results

All the collected specimen were sorted out. The laboratory work is very time- and labour consuming: 5 team members plus 44 volunteers (biology students) had participated; with the total 622 working hours. Invertebrates' taxonomic identification has been made by team leader and lasts for more than 72 hours (4 hours per day for 18 days). However, the process of identification is not yet complete. The list of already identified species is included in Appendix.

The percentage of recorded species by habitats has been calculated (fig. 6-9).
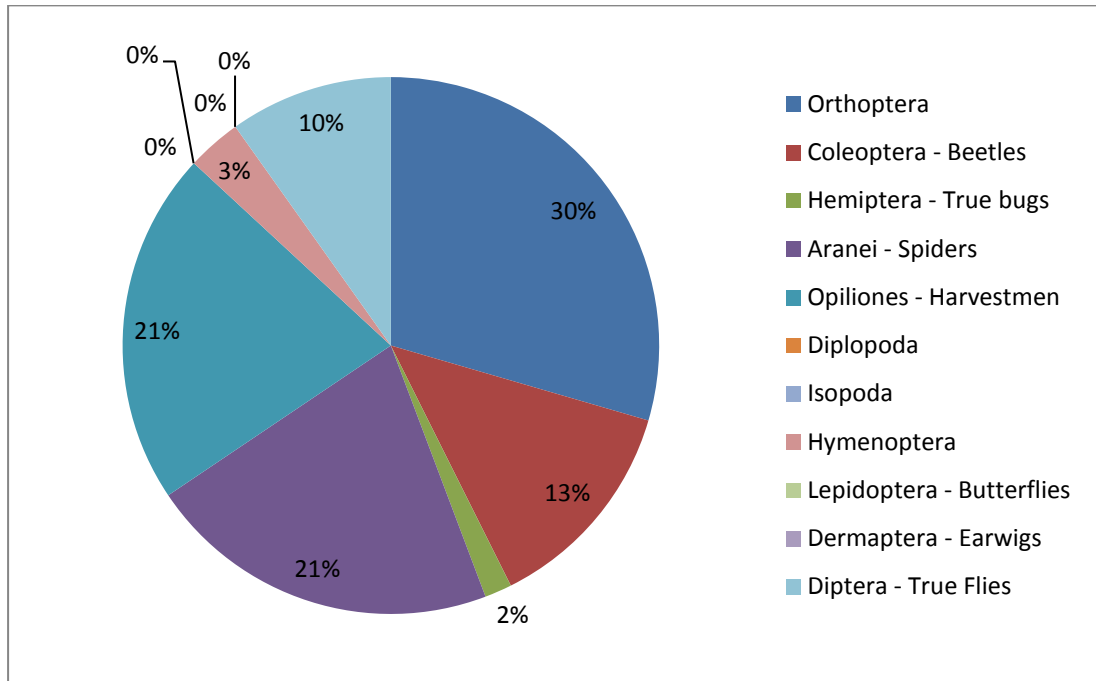

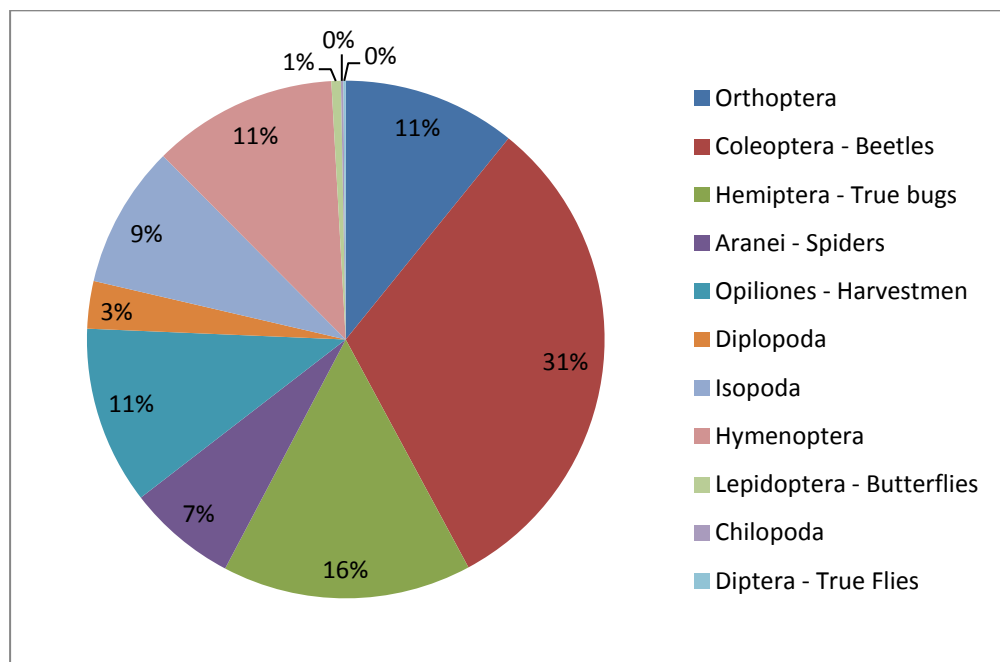Fig. 6. Percentage of recorded species in the centre of the quarry.

Fig. 7. Percentage of recorded species in the slope of the quarry.
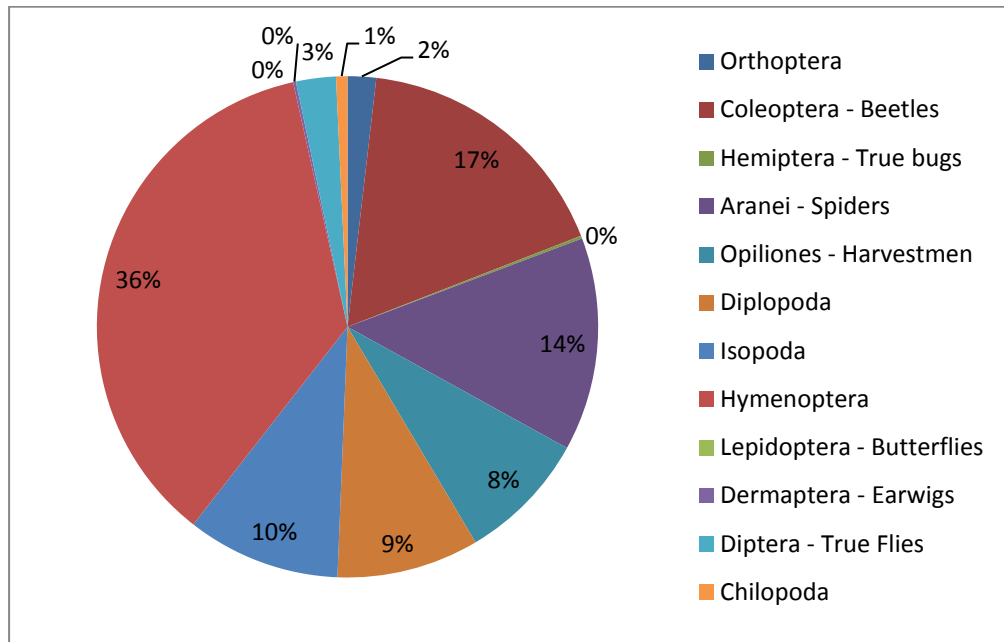
Fig. 8. Percentage of recorded species in the forest edge.
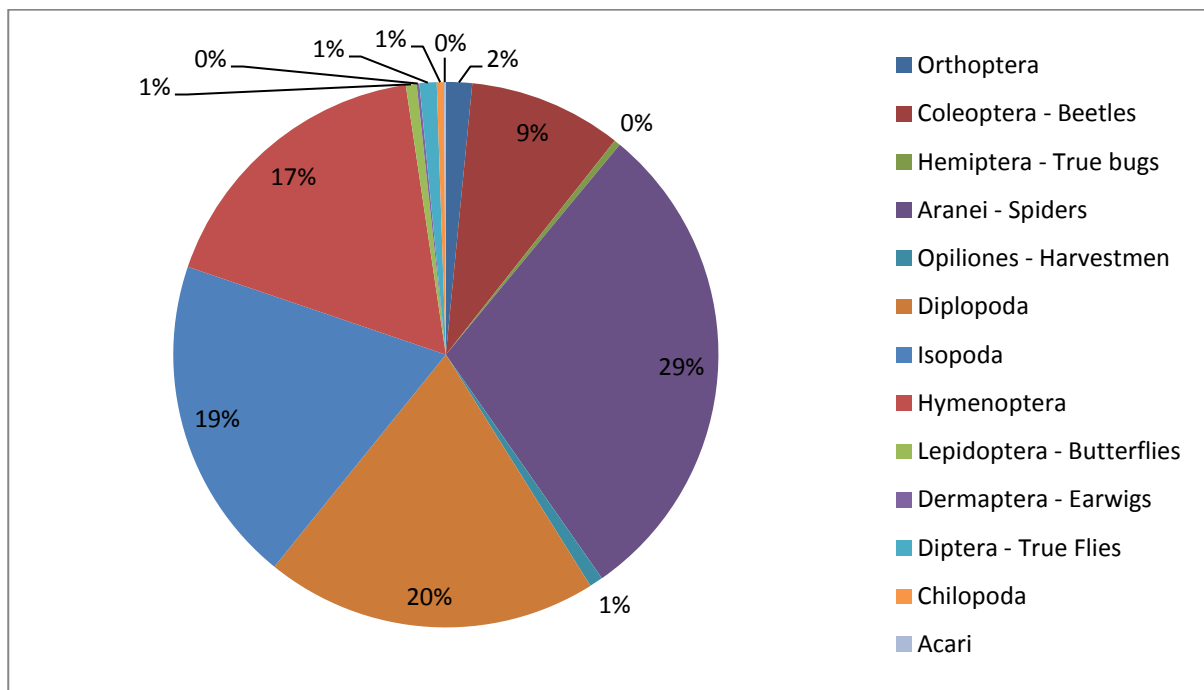

Fig. 9. Percentage of recorded species in the riverside.

More than 120 species from 13 orders and 51 families with a total number of 9794 specimens were captured in the Shakh-Tau quarry. The most specimen were captured at the riverside (habitat 4) (2288 specimens (with ants 5646)) and the least specimen were collected in the centre of the quarry (774).

No protected species from the regional or federal Red book were detected. Some species are relatively rare and deserve careful treatment.

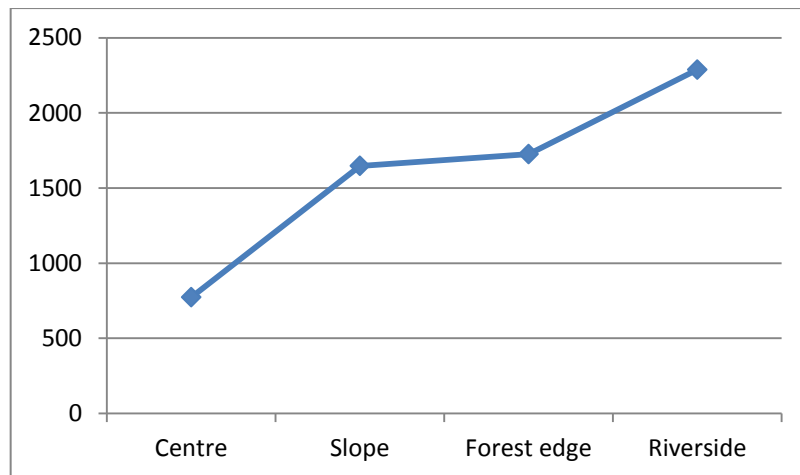The abundance of invertebrates as well as dynamics can be seen on figures 10-11.

Fig. 10. Change in invertebrate abundance towards the center of the quarry.
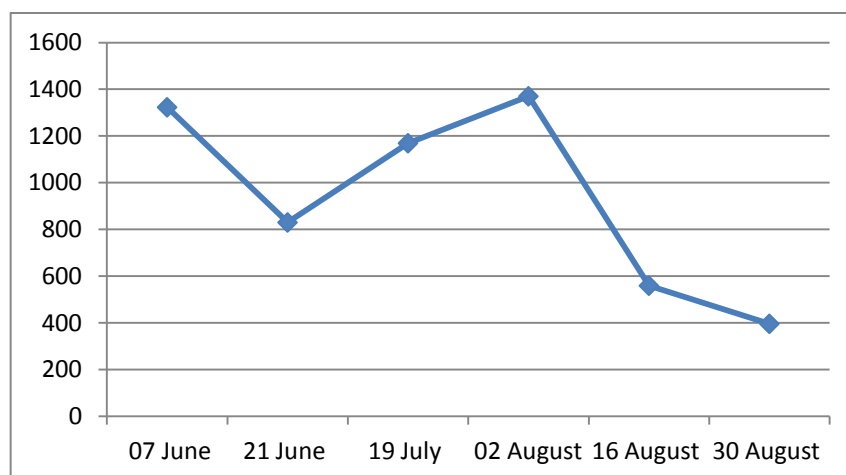

Fig. 11. Dynamics of invertebrates abundance from June to the 30th August.

Discussion

Dominant groups in the centre of the quarry: harvestmen, spiders, crickets; dominant groups on the slope of the quarry: beetles and true bags; dominant groups in the forest edge: ants and beetles; dominant groups on the riverside: spiders, myriapods, ants, woodlice.

Both the invertebrates diversity and abundance decrease towards the center of the quarry (dynamic density decreases from 2,42 to 1,65 specimen per trap*day). Both the invertebrates diversity and abundance decrease from June to August, 30th (from 3,30 to 0, 94).

Selecting indicator species for monitoring ecosystem health is not an easy task (Carignan, Villard, 2002). We think, that good indicators for quarries can be the following animal groups: for the centre of a quarry – Harvestmen; for grassy land – True bags; for stable soil conditions on the outskirts of a quarry – Ants; for all habitats except central part – Carabid beetles. Not suitable: Myriapoda, Isopoda, Diptera, Lepidoptera.

We have found interesting ecological data about ladybeetles winter hibernation mortality near the ant nests. We obtained the unique data on invertebrate diversity in the Shakh-Tau quarry from the territory, otherwise forbidden to visit. Our results contribute to the knowledge of regional fauna. Thus, we have found six species, that were previously unknown in the Republic of Bashkortostan (according to the Catalogue of animals of the Republic of Bashkortostan, 2015). Among the interesting findings: the desert cricket *Eumodicogryllus bordigalensis,* myriapod *Lamyctes emarginatus,* froghopper *Cercopia sp.* On the basis of obtained data one manuscript is submitted for publication, several other papers are in progress and will be published soon.

The local and regional societies now have information about animal diversity in the quarries, sometimes surprisingly high. This information can change the local people attitude towards quarries and company and make more positive.

The results of our project can be served as a basis for future study of biodiversity and searching for indicator groups. We propose to create the colorful "Atlas of biodiversity in quarries" (for every geographical regions), where along with species list will be photographs of keystone and flagship species. This could benefit both the scientific community, general public, local authorities and the HeidelbergCement ecological policy (2010). The ideal timing and estimated costs of implementation for Russian quarries – 2 years and about 10000 euro plus typographical expenses.

Conclusion

More than 120 species from 13 orders and 51 families with a total number of 9794 specimens were captured in the Shakh-Tau quarry from May 24th till August 30th, 2016. The most specimen were captured at the riverside (habitat 4) (2288 specimens (with ants 5646)) and the least specimen were collected in the centre of the quarry (774). Our results contribute to the knowledge of regional fauna: we have found six species, that were previously unknown in the Republic of Bashkortostan.

Both the invertebrates diversity and abundance decrease towards the center of the quarry. Both the invertebrates diversity and abundance decrease from May to the end of August.

Quarrying operations need not be a limiting factor on the development of biodiversity: even within the most active parts of quarries there is a range of opportunities for wildlife. Despite the fact that the center of the quarry creates extreme conditions, it shelters a variety of species that are not common in another place.

Although the biodiversity in the centre of the quarry is very low, in the adjacent territory it is practically as diverse as in the intact landscapes. We have elaborated several recommendations the company, that can

improve situation with biodiversity in quarries and public awareness on this topic in the future. Even the low cost quarry management can produce high gain biodiversity (Lucas et al., 2014).

Recommendations

Sampling and analyzing the entire invertebrate assemblages is very difficult; time and labour consuming process, requiring involvement of many professional taxonomists from various institutes and universities. Development of ecological indicators requires significant research investments.

For management and monitoring purposes the most feasible way is to monitor invertebrates at family or morphospecies levels. We also recommend to focus on several indicator groups, representing different taxa and apply presence/absence and frequency data.

In active quarries, operating schedules should be adjusted temporally and spatially to maintain entire successional series within the quarries and on their perimeters.

We propose to create the colorful "Atlas of biodiversity in quarries" (for every geographical regions), where along with species list will be photographs of keystone and flagship species.

Literature

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Project tags (select all appropriate):

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

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

Flora:
- ☐Conifers and cycads
- ☐Ferns
- ∗Flowering plants
- ☐Fungi
- ☐Mosses and liverworts

Fauna:
- ☐Amphibians
- ☐Birds
- ☐Dragonflies & Butterflies
- ☐Fish
- ☐Mammals
- ☐Reptiles
- ∗Spiders
- ∗Other insects
- ∗Other species

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

Stakeholders:
- ∗Authorities
- ∗Local community
- ☐NGOs
- ∗Schools
- ∗Universities