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Support of the development of xerothermophilous biocoenosis Festuco-Brometea in the rehabilitation area of excavation (quarry) in Górażdże Cement S. A.

Wspomaganie rozwoju biocenozy murawy kserotermicznej Festuco-Brometea w ramach rekultywacji obszaru poeksploatacyjnego Górażdże Cement S. A. Heidelberg Cement Group

STRESZCZENIE

Celem projektu prowadzonego przez wybranych studentów Uniewersytetu Opolskiego w ramach międzynarodowego konkursu Quarry Life Award organizowanego przez grupę Heilderberg Cement jest restytucja murawy kserotermicznej na wybranych fragmentach spągowej części wyrobiska w kopalini Górażdże.

Realizacja projektu prowadzona była w okresie marzec – wrzesień 2012. Obejmowała ona trzy główne etapy, jakimi były: wybór stanowisk eksperymentalnych na obszarze poeksploatacyjnym Kopalni Górażdże, zbiór materiału roślinnego (i elementarne odłowy entomologiczne) oraz wysiew materiału na wcześniej wybranych poletkach badawczych.

W okresie marzec – maj 2012 przygotowywane były stanowiska eksperymentalne na obszarze kopalni Górażdże. Prace polegały na wyznaczeniu odpowiednich obszarów (pod względem takich parametrów jak m. in.: rodzaj gleby, nasłonecznienie, wystawa, poziom wód gruntowych) i ich odpowiednim oznaczeniu. Finalnie wybrano trzy obszary, z których jeden stanowił będzie w przyszłości obszar do badań kontrolnych. Każdy z obszarów podzielony został na mniejsze poletka doświadczalne, na które w odpowiedni sposób wysiany zostanie materiał roślinny.

W okresie maj – wrzesień przeprowadzono prace polegające na wyborze stanowisk (muraw kserotermicznych, ciepłolubnych), z których pobierany był materiał roślinny. Na podstawie zdjęć fitosocjologicznych wybrano trzy główne murawy źródłowe, które najbardziej odpowiadały składem gatunkowym murawom kserotermicznym (klasy Festuco – Brometea). W wyżej przytoczonym okresie prowadzono zbiór nasion oraz całych roślin (w postaci suchej masy roślinnej), które zostały dokładnie wysuszone, zliczone i przygotowane do wysiewu.

W końcowym okresie września przeprowadzono wysiew wcześniej przygotowanego materiału roślinnego. Diaspory oraz sucha masa wszystkich gatunków roślin została podzielone na odpowiednie partie i rozsiane na określonych poletkach badawczych.

ABSTRACT

The main goal of the Project led by volunteer students of Opole University in the international competition Quarry Life Award, organized by Heilderberg Cement group is restitution of xerothermophilous swards within the selected areas of the quarry bottom in Górażdże.

The realization of the project was carried out in the period of March - September 2012. It consisted of three main stages, which are: the choice of experimental plots in the out of use Górażdże Mine, a collection of plant material (and basic entomological catches), and plant sowing on the chosen research plots.

Between March and May, the project plots were delimited and prepared for conducting the experiment. The works focused on determining the appropriate areas (in terms of habitat type, light conditions, inclinations, exposition groundwater level etc.). Then the specified subdivision of the research area was marked regarding the different types of planned management activities. Three basic subplots were selected: first as a "null" area to compare the differences between managed and unmanaged plots. On the second plot we saw the seeds of the diagnostic species for xerothermophilous swards, however we implement the weeding here. And finally the third plot will be manages in the same manner as second but without weeding.

From May to September three patches of *Festuco-Brometea* swards were chosen. From this source phytocoenoses, which were assessed as well developed, the plant material (seeds mainly) were collected. All the collected material, the seeds and the dried plants, have been carefully counted and prepared for sowing.
At the end of September previously prepared plant material have been spread on the experimental plots. Seeds and the dry mass of all plant species were divided into the appropriate parts and disseminated on specific research plots.

INTRODUCTION

Xerothermophilous swards belong to specific plant communities, whose existence in the area depends on several important factors. These are mainly: constant insolation, alkaline soil and low groundwater level. This type of grasslands are often developed on extensive slopes, natural and artificial escarpments, heaps, hills as well as excavations. They are known to be extremely rich of flora and fauna including several endangered and threatened species of plants and invertebrates.

For this reason, conservation of xerothermophilous grasslands in Poland is very important in protecting the biodiversity. Conserving grasslands should have active character . In the absence of any human activieties they pass over into the brushwood communities, and then into the forests. Active protection in this case should be based on specific agronomic treatments: regular mowing or grazing by sheep.

OBEJCTIVES

The main aim of the project is the restitution of xerothermophilous grasslands on the selected fragments of the quarry bottom of Górażdże mine. The project is focused especially on the recovery of xerothermophilous flora of considerable conservation value and related entomofauna and other selected groups of invertebrates. The main works of the project have been divided into three stages: selection of experimental plots in out of use parts of Górażdże Mine, a collection of plant material (and basic entomological surveys), and sowing material on the previously selected research plots.

Additionally, the project was also concentrated on the phytosociological analysis of the total area of grasslands or fragments thereof. Reestablishment of a xerothermophilous grasslands and inter-situ conservation of related species of flora and fauna are very important from the point of view of the protection of biodiversity. One of the objectives was also to test the methods of ecosystem restoration of the so-called sensitive group, sensitive in a post-industrial areas that may have huge importance in the future to maintain the grasslands share in the polish landscape.

METHODS

Selection of experimental areas

The aim of the first phase of the project was to choose the right piece of after-care area in the Górażdże mine. After a detailed analysis of the area and the planned management (in cooperation with the mine's management Górażdże) three areas have been selected as appropriate for the project. They characterize of good light conditions, alkaline soils, low groundwater and meet the requirements of a specific exposition suitable for thermophilous flora. Each of the research area has been marked appropriately using the letters of the alphabet: A, B, and C [Fig. 1 - 3].

Fig. 1. Research area A (phot. P. Kandziora)

Fig.2. Research area B (phot. A. Knurowska)

Fig.3. Reserach area C (phot. A. Knurowska)

The position A is located in the western part of the excavation, and the positions B and C are in the east part [Fig 4].

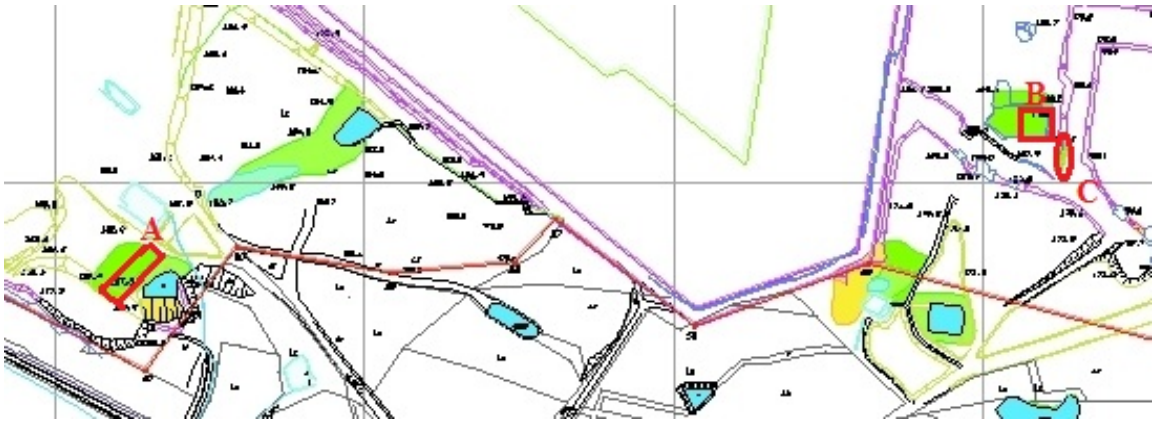

Fig. 4. Location of research areas in the after-care Górażdże Cement (red colour). A - research position A, B - test area B, C - test area C (oryg). Purple color on the map makred nature reserve area "Kamień Śląski".

Area A is the first research plot. Composed of two main parts: a slightly inclined slope (about 30^0) and long flattering. This fragment was covered with a layer of sand mixed with alkaline humus (the upper humus) coming from the the overburden covering the mineral deposit. The whole area was leveled and compacted. Dimensions of area: about 100 × 25 m (2500 m^2).

Area B was designed and in the future will be for monitoring purposes only and will constitute a control for the entire area of the excavation. There will not be sown biological material, neither provides nor run agrotechnical measures. Dimensions: approximately 70 × 70 m (400 m^2).
Area C is the third area. This area is part of the slope covered with partially fragmented rock material. It was also covered with a layer of humus overburden (in the same way as area A). Approximately dimensions: 30 × 10 m (300 m^2).
Disproportionate sizes research area result from the reclamation of post-mining plans and mine development plans Górażdże Cement. To the project were made available only these research areas subject to their size and the surface on where value we haven`t the overall impact.
Preparation of the research areas for seeding biological material, except a suitable substrate cover also included the appropriate divide them into smaller research fragments (plot). They have been created by crossed all of the areas A [Fig. 5] and C [Fig. 6] grid transects.
By transect mean an part of the area designed for the purposes of research and they are clearly marked in the consistent way. Transects were create by used wooden stakes (then driven into to the ground), caution tape (white-red) and yellow fluorescent spray.
Each of the designated transects experimental areas was marked with a symbol:
- 0 - control surface. Not used to seed the biological material. This passage is to determine the rate of natural succession and identify the species composition of the plants that grow from spontaneous seeding.
- 1 - area, which has been sown and scattered over plant material. Plots will not be subject to the later process of weeding. Examined will be plant species and the time of joining and regression in the area of research.
- 2 - area, which has been sown and scattered over plant material. Later weeding treatments are carried out in such a way that the left will only species with grasslands xerothermic (or areas thermophilous) are natural habitats. All non-grassland species will be removed (in particular ruderal species and seedlings of shrubs and trees).
- SB - buffer zone. Means a designated piece of a width of approximately 8 meters and the length of the test area designated on each of its sides. This zone has been designated by virtue of the plan for the rehabilitation of areas mine Górażdże forested areas adjacent that could result in future too strong shading the area and prevent the development of grasslands.
Additionally, each area designated numbers 1 and 2 was divided into two parts marked with the appropriate letters A and B:
- A (1A, 2A) - means that on the fragment of surface were sown the diasporas plants collected from the previously selected grasslands (source).
- B (1B, 2B) - means that on this fragment are spread all plants or plant fragments in the form of plant dry mass collected (by cutting mechanical) with pre-selected grasslands (source).

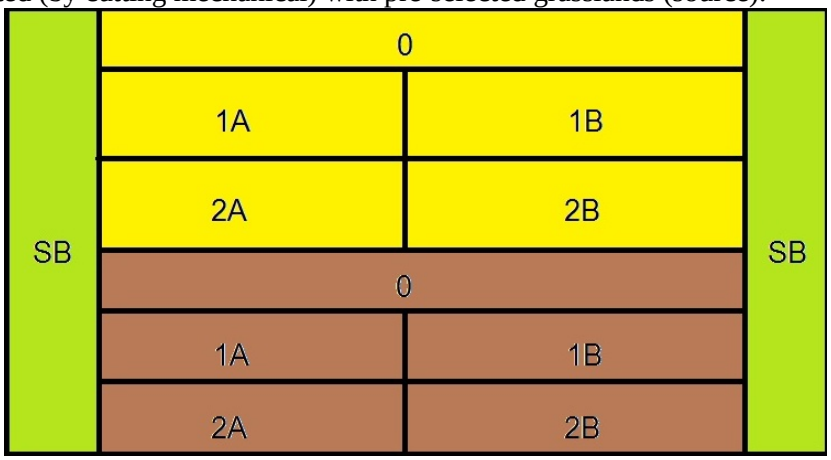

Fig. 5. The diagram showing the arrangement of transects on research plots A (A1, A2). Yellow - fragment A1 (slope), brown - a piece of A2 (flattening). SB - buffer zone, 0 - control surface, 1A - sowing / no weeding, 2A - sowing / weeding, 1B - spread / no weeding, 2B - scatter / weeding (orgy.)

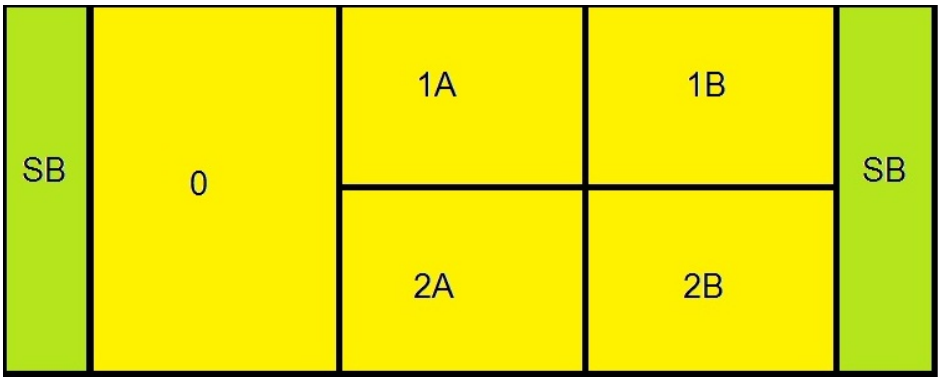

Fig. 6. Diagram showing arrangement transects the research plot C. The yellow color marked area of the slope. SB (green) - buffer zone, 0 - control surface, 1A - sowing / no weeding, 2A - sowing / weeding, 1B - spread / no weeding, 2B - scatter / weeding (oryg.)

The choice of source grasslands and collection of plant material.

In the second stage grasslands which are the source of biological material have been selected on the basis of their nature phytosociological character. Selected were the grassland or their fragments, where the best species composition (the highest degree) corresponding to grass class *Festuco-Brometea* have been detected. After the final analysis selected the following areas: xerothermic grasslands in a disused quarry - Gogolin (N: 50 ° 29 '51.89 ", E 18 ° 2' 42.69") (Figure 7), xerothermic the nature reserve Ligota Dolna (N 50 ° 28 '54.58 ", E 18 ° 7' 28.04") (Figure 8), the inactive fragment grasslands explosive composition – Kamień Śląski (N: 50 ° 33 '46.58 ", E 18 ° 3' 25.80 ") (Fig. 9).

Fig. 7. Xerothermophilous grasslad with dominant *Bromus erectus* Huds. in Gogolin (phot. A. Knurowska)

Fig. 8. Fragment of xerothermophilous grassland in Nature Reserve Ligota Dolna (phot. A. Knurowska)

Fig. 9. Fragment of xerothermophilous grasslands in Kamień Śląski (phot. A. Knurowska)

In all of these areas conducted preliminary floristic analysis. Were also taken phytosociological releves to allow the later detailed analysis of the classification of community. Another element was to conduct entomological inventory, mainly in terms of species composition of beetles (Coleoptera), bugs (Hemiptera).
At each of the source grasslands designated monitoring position (control) for the whole community. These positions are divided into two plots 10 × 10 m (Fig. 10). One of them was the area of catching insects, while the second was for collection of plant material (control for the entire community).

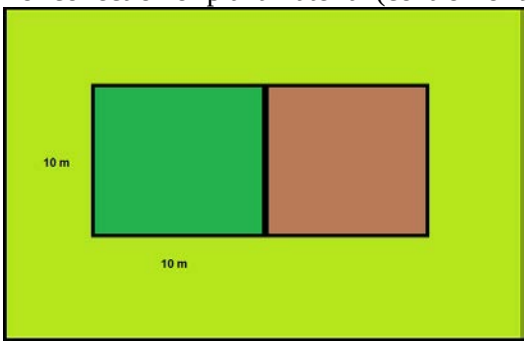

Fig. 10. Schematic control plots of source grasslands. Marking: light green color - grass area, dark green - the collection area diasporas, brown - entomological catches area (orig.)

The plant material (seeds, whole plants) were collected from the entire area of the grasslands in the period March - September 2012. This material was extracted by mechanical mowing (hand scythes) and a hand collection of whole fragments of plants and seeds. All the materials have been properly segregated, dried, counted and translated into marked containers (Fig. 11, 12,13)

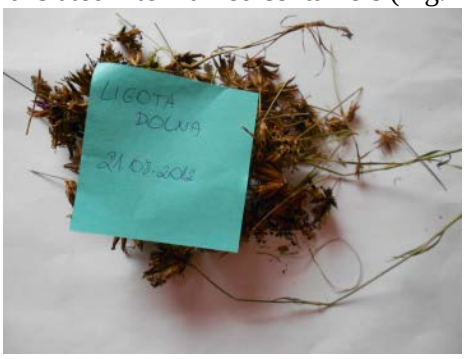

Fig. 11. Seeds and whole heads *Dianthus cartusianorum* before segregation and counting (phot. P. Kandziora)

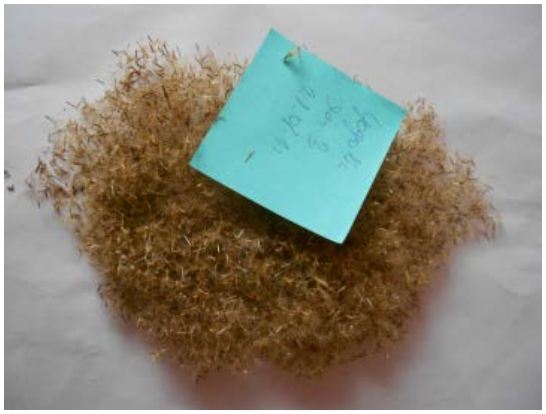

Fig. 12. *Leonthodon hisipidus* seeds after counting and oreparation for sowing (fot. A. Knurowska)

Fig. 13. Ears of *Bromus erectus* during drying (fot. P. Kandziora)

Plant dry mass (hay) designed for spreading on the selected test plots was collected in the reserve Ligota Dolna (Fig.14). Hay were collected by hand (using a rake, fork) and put into bags (a similar capacity) (Fig. 16).

Fig. 14. Mowed xerothermophilous Grasslad in Nature Reserve Ligota Dolna (phot. A. Knurowska)

Fig. 15. Bagd with hay prepared for transport to the research plots in the mine Górażdże (phot. A. Knurowska)

The whole diasporas and dry mass of plant was in the middle of September 2012 sown and spread out on previously prepared plots in accordance with these diagrams and descriptions of activities (Fig. 16 - 18).

Fig. 16. Bags of hay ready to spreading in the test area A in the mine Górażdże (phot. A. Knurowska)

Fig. 17. Raking the spilled material in the research area C (phot. A. Knurowska)

Fig. 18. Raking the spilled material in the research area A (phot. P. Kandziora)

The seeds were divided into appropriate parts, so that one portion of the seeds was seeded on a previously prepared test plot (Fig. 19). In order to minimize seed losses (due to spreading by wind or animals) they were spread by hand and immediately raking under the soil. Collected plant dry mass was divided so that each one made previously scattered plot was approximately equal number. The spreading of hay has been evenly spread on the surface of the plot, and covered with soil, in order to reduce the losses caused by the blowing wind.

Fig. 19. Division seeds into lots of for sowing the test area A (phot. P. Kandziora)

RESULTS

	Species	**Research place**	**Collecting date**	**Number of seeds**
1.	*Carex flacca* L.	Gogolin	10.07.2012	ca. 26 000
2.	*Coronilla varia*	Gogolin	08.08.2012	ca. 2 500
3.	*Salvia pratensis*	Gogolin	03.07.2012	ca. 2 000
4.	*Leontodon hispidus*	Gogolin	08.08.2012/21.08.2012	ca. 1 500/9 000
5.	*Thymus pulegioides*	Kamień Śląski Gogolin	21.08.2012 21.08.2012	ca. 4 000 ca. 300
6.	*Sanguisorba minor*	Gogolin	03.07.2012	ca. 10 000
7.	*Potentilla heptaphylla*	Gogolin	04.06.2012	ca. 400
8.	*Centaurea stoebe*	Gogolin	08.08.2012/21.08.2012	ca. 600/450 whole heads
9.	*Carlina acaulis*	Gogolin	21.05.2012	ca. 300
10.	*Potentilla neumanniana*	Gogolin	04.06.2012	ca. 2 000
11.	*Galium album*	Gogolin	08.08.2012	ca. 12 000
12.	*Thesium linophyllon*	Gogolin	10.07.2012/21.08.2012	ca. 2 700/750
13.	*Bromus erectus*	Gogolin	03-04.07.2012	ca. 200 000
14.	*Brachypodium pinnatum*	Ligota Dolna	21.08.2012	ca. 50 000
15.	*Scabiosa ochroleuca*	Gogolin	21.08.2012	ca. 8 000
16.	*Dianthus cartusianorum*	Ligota Dolna Kamień Śląski	21.08.2012 21.05.2012/21.08.2012	ca.600 ca. 0/ 3 000
17.	*Primula officinalis*	Kamień Śląski	21.05.2012	ca. 120
18.	*Plantago lanceolata*	Gogolin	21.08.2012	ca. 10 000

19.	*Anthylis vulneralia*	Gogolin	03.07.2012/21.08.2012	ca. 22 000/1 800
20.	*Inula salicina*	Gogolin	21.08.2012	ca. 20 000
21.	*Trifolium arvense*	Ligota Dolna	21.08.2012	ca. 5 000
22.	*Clinopodium vulgare*	Ligota Dolna	21.08.2012	ca. 7 500
23.	*Trifolium montanum*	Kamień Śląski	21.08.2012	ca. 4 000
24.	*Trifolium rubens*	Kamień Śląski	21.08.2012	ca. 5 000
25.	*Achillea pannonica*	Ligota Dolna	21.08.2012	ca. 700
26.	*Vincetoxicum hirundinaria*	Ligota Dolna	21.08.2012	ca. 2 500
27.	*Agrostis capillaris*	Ligota Dolna	21.08.2012	ca. 8 800
	TOTAL	-	-	ca. 423 120

Total of collected seeds from 27 plants was about 423 120. Whole diasporas was then mixed and divided into six equal parts, and prepared for plating in 6 suitable test plots. In one plot was fitting about 70 520 seeds.

In the nature reserve Lower Ligota collected 24 bags of dry plants. Each of the bags weighed approximately 10 kg (total collected about 240 kg of hay). Bags were then divided into parts of 4 pieces for the spreading on 6 prepared test plots. For each plot was around 40 kg of dry matter plant.

DISCUSSION

The undeniable side effect of the huge technological leap in modern times is the degeneration of the environment leading to the loss of biodiversity. Biological wealth is very important in the development of science, as well as an important part of the economy, especially tourism. Therefore, measures should be adopted to protect the many unique biocenosis. In fact in favor of such measures is the lack of accurate knowledge about what can be long-distance effects of the reduction in biodiversity.

It is obvious that the modern economy is based primarily on the exploitation of the environment. You cannot clearly and indisputably give up such activities to preserve biodiversity. Such efforts must also allow for further exploitation of the environment in the future, and preserving biodiversity. One such method is also reclamation of abandoned mining areas. It is not always possible to reconstruction the original structure of the site because of irreversible damage to the environment. That is not make the area cannot be any protective action. Exploitation of environment allows to create a specific environment,

biologically diverseand thereby having a higher value from the nature conservation. point of view.

Our project was directed at the restoration of land voids , because we believe that it represents an important element in the protection of biodiversity. The reason for choosing this theme of the project was that the areas of the mine voids Górażdże is a specific area that gives you the opportunity to develop xerothermic grasslands. Xerothermic grasslands plant communities is of great importance for the conservation of biodiversity. They are characterized by a high abundance of flora and fauna - and some species are limited only to the presence of this community. Given this, and the rarity of these grasslands our project is of great importance in maintaining biodiversity.

Another important aspect of our project is the fact that this type of reclamation of abandoned mining areas in Poland are rare. Our project is paving the way in this direction, which is important for future research groups - will allow them to avoid our mistakes and effectively carry out the restoration, which is certainly be an important element of future conservation.

CONCLUSION

Diversity of xerothermic grasslands because of its unique flora and fauna composition definitely stands out from the neighboring ecosystems. Vanishing nature of these habitats in natural environments is the most important reason to be actived protected.

Xerothermophilous grasslands are usually semi-natural habitats arranged in Poland lobar and require specific conditions biocenotic. The aim of our project is the active protection xerothermic grasslands biocenoses. The project is already at the stage its creation and was founded as a long-term process and long-distance, provided a minimum of 20 years of his conduct, whether by the project participants or the next research groups. Creating a biocenosis xerothermic grasslands is slow, long-lasting, requiring specific environmental conditions and external actions, among others. such as appropriate management and conservation efforts. The first phase is only the beginning for further projects.

The necessity of leading the project for the next year is very important from the nature conservation point of view. Launched and completed in the period March - September 2012 was the most important, but not the last point of the forming of the biocenosis. Nature of the research forces in the coming years, many activities related to the research area described in the project.

Examples actions to be taken in the coming years are detailed annual monitoring of flora and fauna, weeding (at the level of seedlings) ruderal species, invasive, trees and shrubs and not all species associated with dry grasslands, sowing diasporas which grew on plots and new species plants, annual process of cutting grasslands during early autumn.

Apart from these basic operations should be conducted annually natural statistical analysis that will allow objectively look at the complicated processes: forming of the grasslands, natural succession, the rate of ascent and the disappearance of plant species. Such studies will help to bring new knowledge, which will allow for better handling of these and other processes in the future.

Undoubtful fact is the need to continue the project, involving scientists and specialists from the special fields and students who, through such initiatives gain the necessary knowledge useful in the future life. Abandonment carrying out these tasks in the coming years will lead to the destruction of the effects of earlier actions, which bring the futility of the whole project. Such studies are extremely important, especially with the fact that this project is also a pioneering project in Poland, and one of the few in Europe.