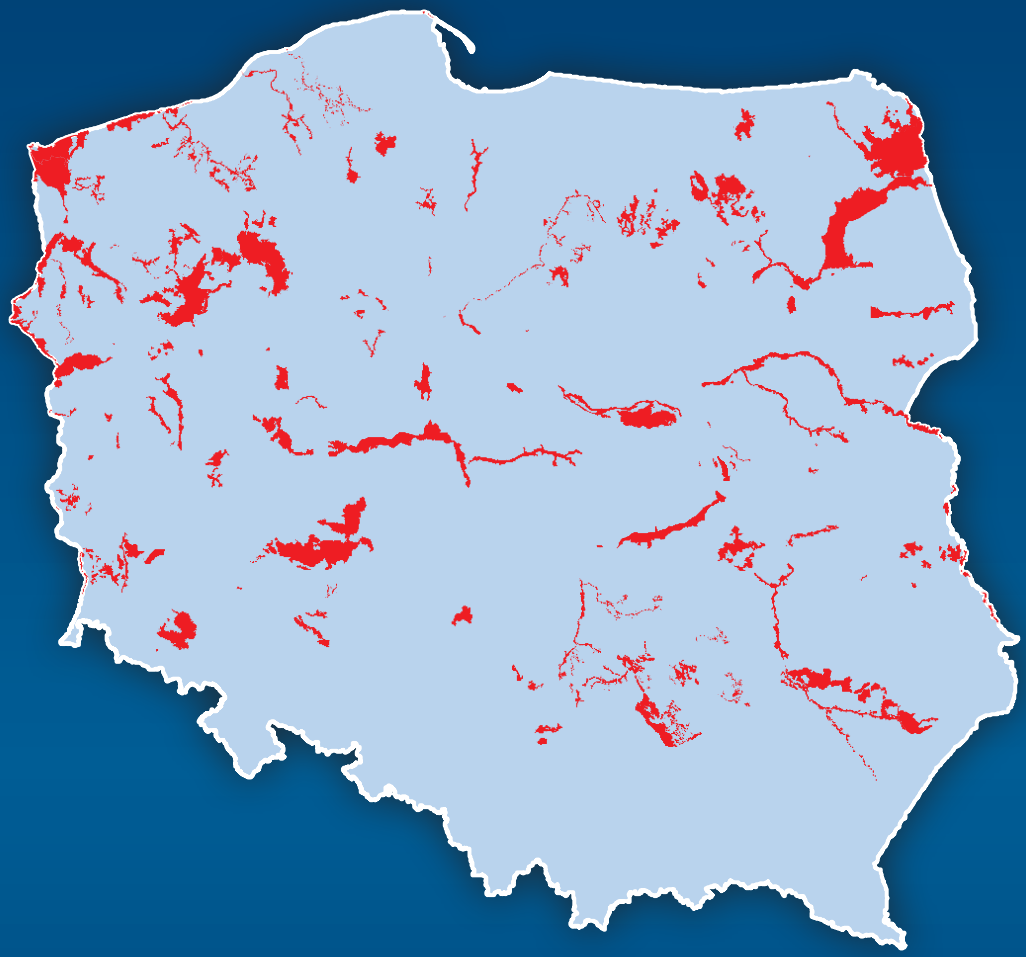
Guide
of the sandy grassland habitats protection



Michał Węgrzyn and Paulina Wietrzyk

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Michał Węgrzyn and Paulina Wietrzyk

Founded within the project „Active protection of complex of priority on-sand habitats (*6120, 2330) on the area of the Błędowska Desert by the European Community within the financial instrument LIFE+, National Fund of Environmental Protection and Water Economy by Klucze Borough

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Content

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View of the southern part of the Błędowska Desert – the area of the LIFE + project (LIFE09 NAT/PL/000259). © Michał Węgrzyn

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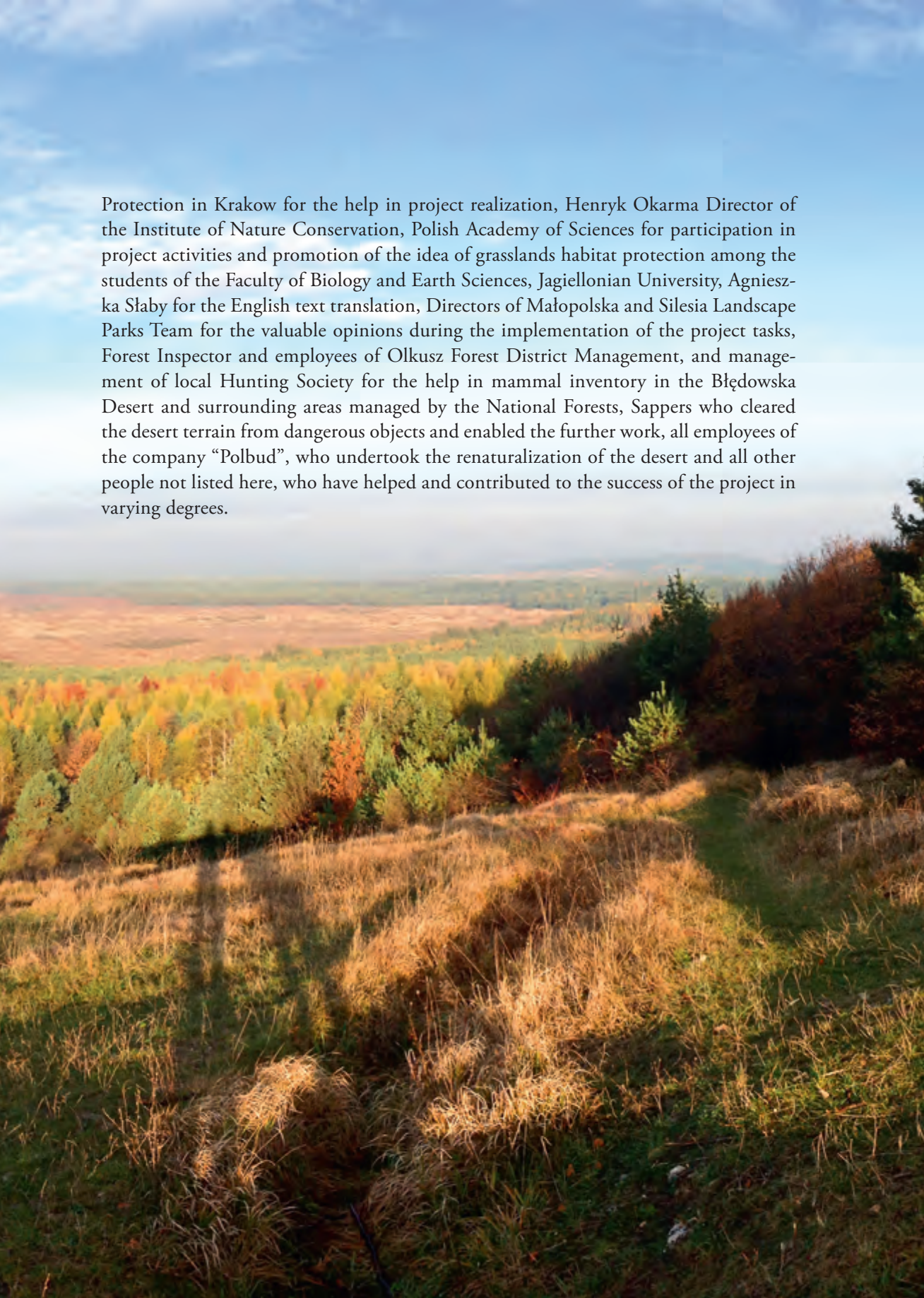

By way of introduction

On the European continent, many initiatives of biodiversity protection and development of common principles for conservation and management of valuable natural areas are undertaken. For this purpose, the European Union has developed and implemented a project known as Natura 2000. It is based on two EU Directives: the Directive 79/409 / EEC on the protection of wild birds – so-called: the Birds Directive and the Directive 92/43 / EEC on the conservation of natural habitats and of wild fauna and flora – namely: Habitats Directive.

Established Habitats Directive aims to „contribute towards ensuring bio-diversity through the conservation of natural habitats and of wild fauna and flora in the European territory of the Member States to which the Treaty applies". Actions, which are taken in accordance with directive, serve to „maintain or restore, at favourable conservation status, natural habitats and species of wild fauna and flora of Community interest".

One of the Polish pre-accession commitments was to determine the Natura 2000 areas before 1st May 2004. This task was accomplished by the entering the Natura 2000 areas as the forms of nature protection into the Nature Protection Act of 16th April 2004 and designation of them. Polish accession to the European Union, the adoption and implementation of the Habitats Directive is also associated with the obligation of taking all kinds of activities, which are intended to the preservation of existing habitats or restoration of degraded ones.

Among the 79 valuable natural habitats that occur in Poland, two are associated with sandy areas: 2330 – the inland dunes with open *Corynephorus* and *Agrostis* grasslands and 6120 (priority habitat) – the xeric sand calcareous grasslands (*Koelerion glaucae*). These habitats frequently occur together or in close proximity. Within designated Natura 2000 sites in Poland, grasslands on the dunes have been found in 90, while xeric sand calcareous grasslands in 106 sites. Interestingly, the numbers of areas where these two habitats exist in Europe are also similar and they are 462 and 453, respectively (Fig. 3 and 4). These data suggest that both habitats are fairly common. However, careful analysis of their conservation status in the European continent shows a completely different status. Indeed, the connecting feature of mentioned habitats is sandy substrate, but differently developed and preserved. In the first case, the volatile sands (quicksands), which as a result of aeoli-

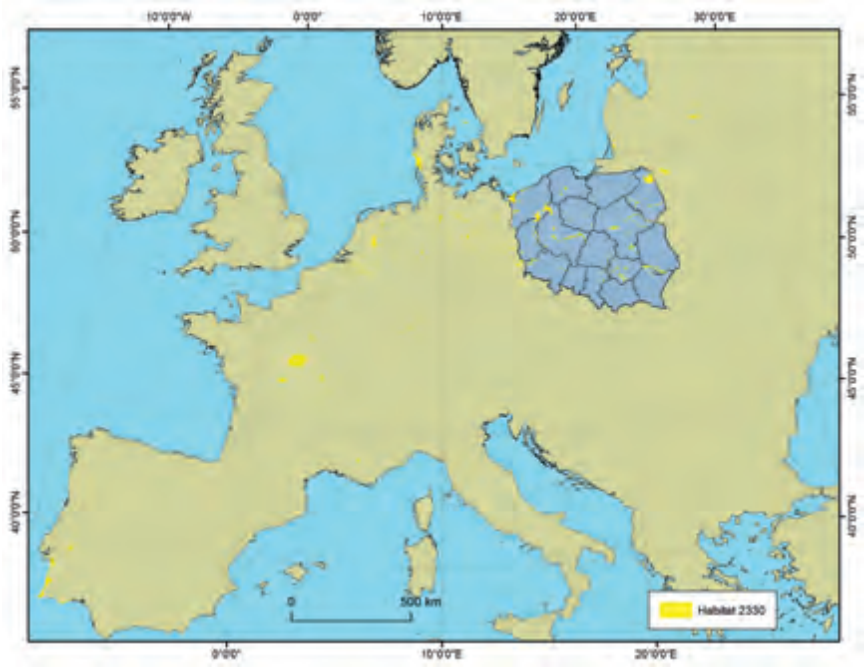

Fig. 1. Distribution of Natura 2000 sites in Europe, where a valuable Community interest habitat type the inland dunes with open *Corynephorus* and *Agrostis* grasslands (2330) occur.

Fig. 2. Distribution of Natura 2000 sites in Europe, where a valuable Community interest habitat type the xeric sand calcareous grasslands (6120) occur.

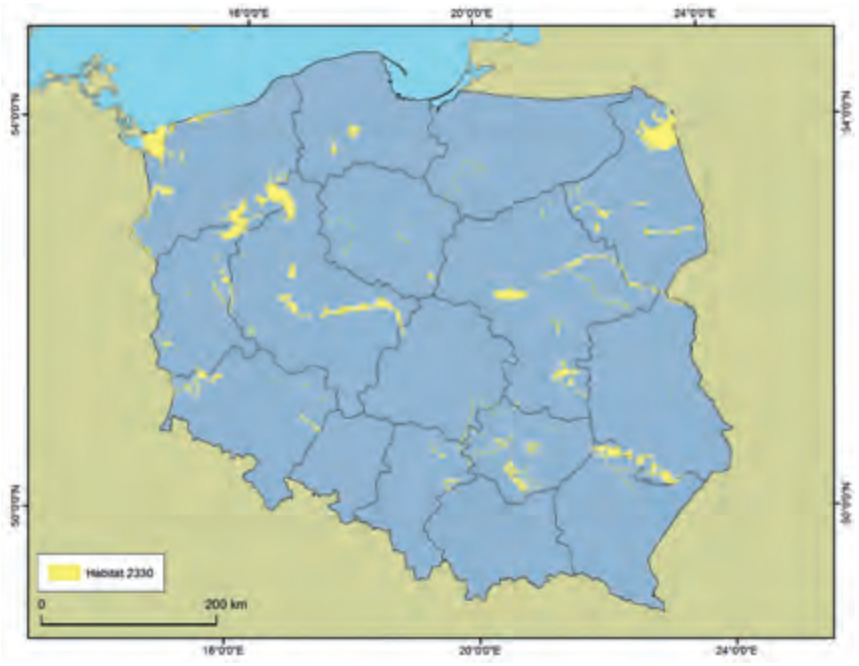

Fig. 3. Distribution of Natura 2000 sites on Polish territory, where a valuable Community interest habitat type the inland dunes with open *Corynephorus* and *Agrostis* grasslands (2330) occur.

Fig. 4. Distribution of Natura 2000 sites on Polish territory, where a valuable Community interest habitat type the xeric sand calcareous grasslands (6120) occur.

an wind activity create dunes, are the main factor that forms the substrate. On the other hand, xeric sandy grasslands cover fairly stable substrate. At this point we should ask ourselves a question: why is the conservation status of these habitats unsatisfactory, and sometimes even downright bad if the huge European lowlands and uplands abound in variously developed sandy areas? The answer to this question is possible due to the careful scientific studies of these habitats.

With the implementation of the projects related to the improvement of the conservation status of sandy grassland habitats, the causes of degradation of these habitats were identified. The most important of them is the process of ground eutrophication, or fertilization. Sandy areas in Europe are sometimes considered as deserts; however, in terms of climate they are very different from the real desert. It is hard to find places in temperate climate where rainfall is extremely low, both in the form of rain and snow. Areas located in Europe which look like a desert, were created by human, who was cutting down the primary forest during the development of civilization in the Middle Ages. For centuries, areas free of forest formations became a permanent part of the landscape in the central and eastern Europe. For various reasons, this condition lasted continuously for centuries, until the man again contributed to overgrowth these treeless areas.

LIFE+ Project

The „LIFE" is the EU financial project created for co-financing projects dedicated to environmental and climate protection, which are especially realized within areas belonging to the Natura 2000 network. Its main goal is supporting the process of environmental law harmonization, searching for and disseminating of innovative solutions of the environmental problems in the European Union. The program has been implementing by the UE members since 1992. From that time, four phases of the project were completed: „LIFE II": 1992-1995, „LIFE II": 1996-1999, „LIFE III": 2000-2006 and the „LIFE+": 2007-2013. These periods have resulted in the implementation of 4 171 projects with a total value of around 3.4 billion euros.

Since the 1990s 69 LIFE projects have been completed in Poland. Nine of them were related to non-forest habitat protection – at the same time in Europe, the number of all projects of non-forest habitats protection was 109. Three of mentioned Polish projects are focused on preventing the degradation of valuable grasslands: 2330 – the inland dunes with open *Corynephorus* and *Agrostis* grasslands, 6120 – the xeric sand calcareous grasslands (*Koelerion glaucae*), 6210 – Semi-natural dry grasslands (*Festuco-Brometalia*). These projects are:

- „The integrated conservation of non-forest natural habitat on military area in Natura 2000 site" (LIFE MILITARY HABITATS PL, LIFE12 NAT/PL/000031);
- „Protection of valuable natural non-forest habitats typical of the Orle Gniazda Landscape Park" (Protection of the area PKOG, LIFE11 NAT/PL/000432);
- „Active conservation of priority sand habitats complex (6120, 2330) in the Natura 2000 site Błędowska Desert" (LIFE09 NAT/PL/000259).

The main objectives of the projects are to achieve favourable conservation status of priority habitats listed in Annex I of the Habitats Directive, which include xerothermic grasslands and one of the two sandy grasslands natural habitats occurring in the Błędowska Desert – thermophilous grasslands (6120). Below short characteristic of two projects is presented.

„The integrated conservation of non-forest natural habitat on military area in the Natura 2000 site" (LIFE MILITARY HABITATS PL, LIFE12 NAT/PL/000031)

The project is implemented in the northern part of the Błędowska Desert, which is a military area, and is situated within Natura 2000 sites. It was launched on the 1st September 2013, and its execution is going to last until the 30th of June 2017. The initiative is funded by the European Union and The National Fund for Environmental Protection and Water Management.

The main task of the project is restoration to the proper conservation status of valuable habitats, i.e. the inland dunes with open *Corynephorus* and *Agrostis* grasslands (2330) and the xeric sand calcareous grasslands *Koelerion glaucae* (6120), occurring in the Błędowska Desert before the successional overgrowing of this area. Currently, the main vegetation forms within the project area are, being a result of self-seeding, birch and pine forests that are accompanied by shrubs of willows *Salix acutifolia* and *Salix repens* subsp. *arenaria*. The removal of trees and other forms of unwanted vegetation is one of the most important conditions for the revitalization of sandy grasslands habitats. In addition, a detailed inventory will help to create the exact characteristics of the area on conservation status of plant species, invertebrates, amphibians, reptiles, birds and mammals that occur in the overgrowing area and are not necessarily associated only with valuable sandy grasslands

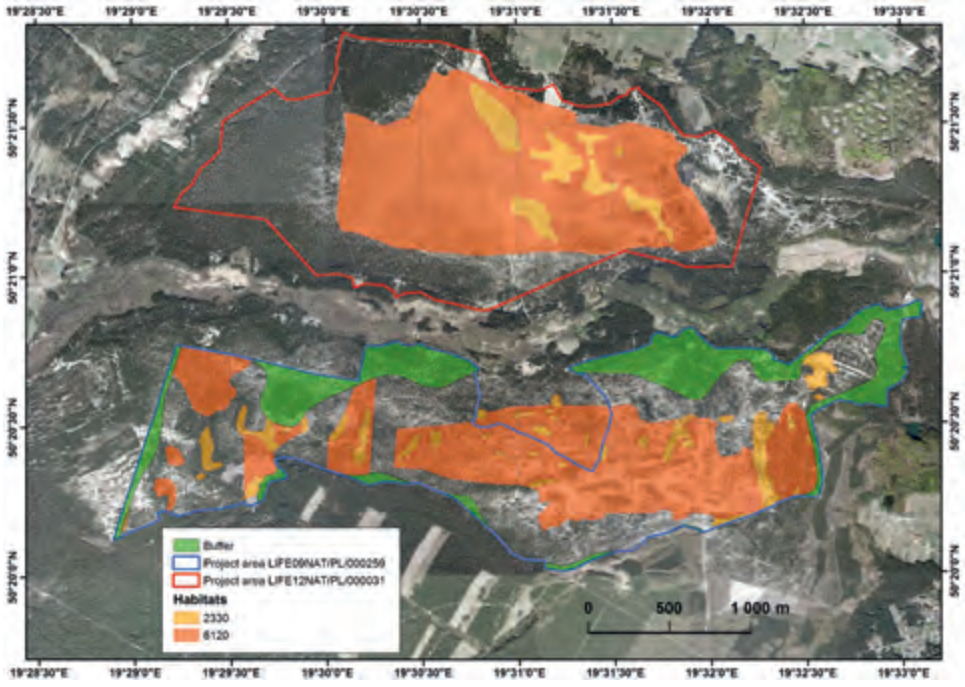

Fig. 5. The map of implemented LIFE projects in the Natura 2000 sites Błędowska Desert in order to sandy grasslands habitats protection (2330 and 6120).

Northern part of the Błędowska Desert, which is used by Polish Army as a military training ground and it is the area of LIFE + project (NAT/PL/000031). © Michał Węgrzyn

habitats. These studies allow the identification of valuable and endangered species, as well as an assessment of the possible impact of active protection measures on their local populations.

Prior to the removal of trees and shrubs, in order to ensure safety during the field work, the entire desert area must be checked in regard to presence of unexploded ordnance from the Second World War and the later time when it was a field training site for Polish Army. Until the security of the site by engineers, it is impossible to introduce heavy equipment for tree felling and wood deportation.

The additional aim of the project is to raise public and military institutions awareness through implementation of five training workshops focused on nature conservation in military zones in the Natura 2000 sites, as well as organization of an information point for these issues. At the same time, the website about described project will be prepared to reach to wider public.

LIFE+ Project „The protection of precious natural non-forest habitats specific for the area of the Orle Gniazda Landscape Park"

The project is realized in four refugia on the territory of the Orle Gniazda Landscape Park (the Krakowsko-Częstochowska Upland) i.e. the Olsztyn-Mirów refugium (240015), the Złoty Potok refugium (240020), the Kroczyce refugium (240032), and the Środkowa Jura refugium (240009).

In the framework of the LIFE project implemented within the National Landscape Park Orlich Gniazd, polish scurvy-grass *Cochlearia polonica* is actively protected. The best preserved positions of this taxa are located in the headwaters of the Centuria river. © Michał Węgrzyn

The five-year initiative was implemented in 2012 by Silesian voivodeship and more specifically by the Silesian Voivodeship Landscape Parks Complex. The principal aim of the project is to preserve and protect the most valuable habitats within the refugia: semi-natural dry grasslands *Festuco-Brometea* class (6210) and rock grasslands which include juniper (*Juniperus communis*) formations on heaths or calcareous grasslands (5130). In addition the project is intended to protect valuable species of plants *Galium cracoviense* 2189, *Cochlearia polonica* 2109 and butterflies *Colias myrmidone* 4030 and *Maculinea teleius* 1059. Progressive anthropogenic impact was considered to be one of the main threats to these habitats and species. This factor is connected with intensive human penetration in these areas, including also the unregulated rock climbing traffic. Other serious threats are progressive succession and spread of the invasive species – *Reynoutria sachalinensis* – within the refugia.

A number of active protection actions, which are designed to reduce the negative impact on habitats and species, are planned in the LIFE+ project. These include: regulation of tourist and climbing traffic by means of development of the appropriate tourism infrastructure and introduction of preventive patrols; removal of illegal dumpsters; removal of the Sakhalin knotweed (*Reynoutria sachalinensis*) and conducting activities involving removal of overgrown with shrubs and undesirable herbaceous plants areas together with introducing animal grazing in these sites; preservation or improvement of the habitat conditions of the valuable species; conducting environmental monitoring.

A different form of the project are educational and promotional actions directed especially to local communities to introduce into the matter of environment protection and to point the ways of rational farming and tourism working together.

Xerothermic and rock grasslands are valuable non-forest habitats listed in Annex I of the Habitats Directive. The successful execution of the project objectives in 2016 will not only enable preservation of the habitat sites and taxa important for the European Union, but also creating a specific system of landscape and natural chains called the ecological corridors in the area of Kraków-Częstochowa Upland, for the migration of many animal and plant species.

The preservation state of valuable sandy grasslands habitats occurring on the Polish territory was determined on the basis of the State Environmental Monitoring conducted by the the Chief Inspectorate of Environmental Protection. In most cases, the results were imperfect and at several locations even bad. In such situation, improving the habitat conditions through the active protection and enforcement of well-designed actions is the only way to stop the processes which acts destructively on these habitats.

Taking up a process of sandy grasslands rescuing is a difficult task. During the preparation of the project, several problems occur and all of them need to be taken into account. Also, during the implementation of the tasks, many times there is a need to modify the plans due to emerging further complications. One of the main difficulties is the specificity of the habitat, where once started works must be continued without interruption through all steps. Otherwise, these actions will not bring expected results. The costs of carrying out the tasks of sandy grassland habitats active protection are extremely high. Therefore, it is important to have the widest possible knowledge of the environment and nature of the selected area during creation of the project. Applying for the LIFE+ enables comprehensive grasp of all necessary and planned activities.

Sandy grasslands in Poland

According to the Habitats Directive, which is the most important legislative act of the wildlife protection in the European Union, natural habitats are terrestrial or aquatic areas, whether entirely natural or semi-natural, which are distinguished by geographical, abiotic and biotic factors. Among them, there are habitat types of Community interest, which are particularly important for the European Union. This group includes habitat which: are in danger of disappearance in their natural range; have a small area of distribution as a result of regression or natural conditions; are outstanding examples of features, which are typical of biogeographic regions where countries of the European Community lie. In Europe, five biogeographical regions are designated: Alpine, Atlantic, Continental, Macaronesian, and Mediterranean. Poland lies within the Continental region and only a small fragment in the south is included to the Alpine region. Among the habitats important to the European Community, the priority natural habitats are distinguished. They are under particular protection because their ranges are found entirely within the European Community territory. Thus, the Member States are responsible for their existence what in practice is associated with taking various protection activities.

Currently in European Union there are 218 habitats of Community interest, of which 71 are sites of priority natural habitat types. In Poland there are 79 and 15 habitats, respectively. In Table 1 all the Community interest habitats that are present on the Polish territory are listed. The priority natural habitats are bolded and indicated by an asterisk (*).

Among 79 valuable natural habitats that exist in Poland, two are associated with sandy areas: 2330 – the inland dunes with open *Corynephorus* and *Agrostis* grasslands and the priority natural habitat 6120 – the xeric sand calcareous grasslands. Grasslands on dunes have been found in 90, while grasslands on inland sands in 106 sites, within all designated Natura 2000 sites in Poland (Fig. 1 and 2, Tab. 2).

By comparing the areas where both habitats exist it is clearly seen that in most cases they occur in close proximity forming compact complexes of sandy grassland habitats. Although, both of them are clearly defined and the habitat factors, necessary for their proper functioning, are well characterized for each, the correct identification of associations, and consequently habitat types can pose many problems. Basically, the two habitats differ in terms of the substrate structure and species richness of vascular plants but communities,

Xeric sand calcareous grasslands (6120) in the area of Natura 2000 Załęczański Łuk Warty. © Maciej Kozak

or more preciously plant associations, are not fixed, as well as environmental factors which control the dynamics of the changes within them.

Sandy areas, both these currently undergoing the dunes formation process and these in which such process has never occurred, belong to the natural forms of the Polish landscape and the entire area of the European Lowlands. They deserve special attention, because only in this case the relation between the substrate and the particular plant species which forms together with other taxa plant communities is so clearly seen. The dynamics of sandy grasslands is based on the phenomenon of struggle between vegetation and unstable substrate. Especially, in the case of inland drift sand vegetation, the successional stages are observed: from the initial stages developed on completely volatile drift sandy substrate, through the intermediate stages, to totally stabilized substrate, where the phenomenon of quicksands disappears completely (Kornaś 1957; Kobendza and Kobendza 1958; Zielińska 1967).

With regard to the term „sand dunes" immediately in our minds raises the image of seaside dunes at the Baltic Sea. This association is partly related to their well-preserved current state. These landscape forms have not been changed by man over centuries so they have natural character and such remain. In the case of inland sand areas, the situation

The inland dunes with open *Corynephorus* sp. and *Agrostis* sp. grasslands (2330) in the area of Natura 2000 Przemkowskie Heathland (PLH020015) in Bory Dolnośląskie. © Michał Węgrzyn

No.	Habitat code	Type of habitat
1	1110	Sandbanks which are slightly covered by sea water all the time
2	1130	Estuaries
3	1150	Coastal lagoons
4	1160	Large shallow inlets and bays
5	1170	Reefs
6	1210	Annual vegetation of drift lines
7	1230	Vegetated sea cliffs of the Atlantic and Baltic Coasts
8	1310	Salicornia and other annuals colonizing mud and sand
9	1330	Atlantic salt meadows (*Glauco-Puccinellietalia maritimae*)
10	1340	Inland salt meadows
11	2110	Embryonic shifting dunes
12	2120	Shifting dunes along the shoreline with *Ammophila arenaria* („white dunes")
13	2130	Fixed coastal dunes with herbaceous vegetation („grey dunes")
14	2140	Decalcified fixed dunes with *Empetrum nigrum*
15	2160	Dunes with *Hippophaë rhamnoides*

Table 1. The list of Community interest habitat types occurring on the Polish territory. The priority natural habitats are indicated by an asterisk (*).

No.	Habitat code	Type of habitat
16	2170	Dunes with *Salix repens* ssp. *argentea* (*Salicion arenariae*)
17	2180	Wooded dunes of the Atlantic, Continental and Boreal region
18	2190	Humid dune slacks
19	2330	Inland dunes with open *Corynephorus* and *Agrostis grasslands*
20	3110	Oligotrophic waters containing very few minerals of sandy plains (*Littorelletalia uniflorae*)
21	3130	Oligotrophic to mesotrophic standing waters with vegetation of the *Littorelletea uniflorae* and/or of the *Isoëto-Nanojuncetea*
22	3140	Hard oligo-mesotrophic waters with benthic vegetation of *Chara* spp.
23	3150	Natural eutrophic lakes with *Magnopotamion* or *Hydrocharition* – type vegetation
24	3160	Natural dystrophic lakes and ponds
25	3220	Alpine rivers and the herbaceous vegetation along their banks
26	3230	Alpine rivers and their ligneous vegetation with *Myricaria germanica*
27	3240	Alpine rivers and their ligneous vegetation with *Salix elaeagnos*
28	3260	Water courses of plain to montane levels with the *Ranunculion fluitantis* and *Callitricho-Batrachion vegetation*
29	3270	Rivers with muddy banks with *Chenopodion rubri* p.p. and *Bidention* p.p. vegetation
30	4010	Northern Atlantic wet heaths with *Erica tetralix*
31	4030	European dry heaths
32	4060	Alpine and Boreal heaths
33	4070	Bushes with *Pinus mugo* and *Rhododendron hirsutum* (*Mugo-Rhododendretum hirsuti*)
34	4080	Sub-Arctic *Salix* spp. scrub
35	5130	*Juniperus communis* formations on heaths or calcareous grasslands
36	6110	Rupicolous calcareous or basophilic grasslands of the *Alysso-Sedion albi*
37	6120	Xeric sand calcareous grasslands
38	6150	Siliceous alpine and boreal grasslands
39	6170	Alpine and subalpine calcareous grasslands
40	6210	Semi-natural dry grasslands and scrubland facies on calcareous substrates (*Festuco-Brometalia*) (* important orchid sites)
41	6230	Species-rich *Nardus grasslands*, on silicious substrates in mountain areas (and submountain areas in Continental Europe)
42	6410	Molinia meadows on calcareous, peaty or clayey-silt-laden soils (*Molinion caeruleae*)
43	6430	Hydrophilous tall herb fringe communities of plains and of the montane to alpine levels
44	6440	Alluvial meadows of river valleys of the *Cnidion dubii*
45	6510	Lowland hay meadows (*Alopecurus pratensis, Sanguisorba officinalis*)
46	6520	Mountain hay meadows
47	7110	Active raised bogs
48	7120	Degraded raised bogs still capable of natural regeneration
49	7140	Transition mires and quaking bogs
50	7150	Depressions on peat substrates of the *Rhynchosporion*
51	7210	Calcareous fens with *Cladium mariscus* and species of the *Caricion davallianae*

Table 1. The list of Community interest habitat types occurring on the Polish territory. The priority natural habitats are indicated by an asterisk (*).

No.	Habitat code	Type of habitat
52	7220	Petrifying springs with tufa formation (*Cratoneurion*)
53	7230	Alkaline fens
54	8110	Siliceous scree of the montane to snow levels (*Androsacetalia alpinae* and *Galeopsietalia ladani*)
55	8120	Calcareous and calcshist screes of the montane to alpine levels (*Thlaspietea rotundifolii*)
56	8150	Medio-European upland siliceous screes
57	8160	Medio-European calcareous scree of hill and montane levels
58	8210	Calcareous rocky slopes with chasmophytic vegetation
59	8220	Siliceous rocky slopes with chasmophytic vegetation
60	8230	Siliceous rock with pioneer vegetation of the *Sedo-Scleranthion* or of the *Sedo albi-Veronicion dillenii*
61	8310	Caves not open to the public
62	9110	*Luzulo-Fagetum* beech forests
63	9130	*Asperulo-Fagetum* beech forests
64	9140	Medio-European subalpine beech woods with *Acer* and *Rumex arifolius*
65	9150	Medio-European limestone beech forests of the *Cephalanthero-Fagion*
66	9160	Sub-Atlantic and medio-European oak or oak-hornbeam forests of the *Carpinion betuli*
67	9170	*Galio-Carpinetum* oak-hornbeam forests
68	9180	*Tilio-Acerion* forests of slopes, screes and ravines
69	9190	Old acidophilous oak woods with *Quercus robur* on sandy plains
70	9410	Acidophilous *Picea* forests of the montane to alpine levels (*Vaccinio-Piceetea*)
71	9420	Alpine *Larix decidua* and/or *Pinus cembra* forests
72	91D0	Bog woodland
73	91E0	Alluvial forests with *Alnus glutinosa* and *Fraxinus excelsior* (Alno-Padion, Alnion incanae, Salicion albae)
74	91F0	Riparian mixed forests of *Quercus robur, Ulmus laevis and Ulmus minor, Fraxinus excelsior* or *Fraxinus angustifolia*, along the great rivers (*Ulmenion minoris*)
75	91I0	Euro-Siberian steppic woods with *Quercus* spp.
76	91P0	Holy Cross fir forest (*Abietetum polonicum*)
77	91Q0	Western Carpathian calcicolous *Pinus sylvestris* forests
78	91T0	Central European lichen Scots pine forests

Table 1. The list of Community interest habitat types occurring on the Polish territory. The priority natural habitats are indicated by an asterisk (*).

is somewhat different. In most cases, the origin of their formation is secondary. Some authors even point out that the vegetation on these habitats also have such character or even the half-synanthropic one (Medwecka-Kornaś et al. 1977).

Inland sand areas on the Polish territory are located mainly in the lowlands: in the Belt of the Great Valleys, the Silesian Lowland, the Sandomierz Basin, but also occur in the lake districts and the southern Poland uplands. They are very common in the ice-marginal and the great rivers valleys, and their formation is associated with the deposition of sandy material carried by the river or from the former activity of ice sheet and accumulation of fluvioglacial deposits.

Sandy deflation fields surrounded by small dunes in the Błędowska Desert, which were created as a result of sandy grassland active protection. © Michał Węgrzyn

It is believed that originally inland sand areas, both these forming dunes as well as those influenced by the wind, were covered with pine forests. Depending on substrata fertility and some other factors, the pine forest had a various form: from well-developed stand to rachitic, dwarf, heavily thinned and twisted pines. Natural thinning caused the formation of forest clearings with open sand areas covered with primary sandy grasslands dominated by herbaceous plants – loving light psammophytes (Medwecka-Kornaś et al. 1977). When people cut down forests to acquire wood, sandy areas have expanded their territories. Due to difficult habitat conditions in these sites, forest was not restored spontaneously. Instead of pine forests the psammophilic vegetation spread on sands. The beginnings of this process date back to the Mesolithic period, about 8000 to 4800 years BC, in the areas of the Central European Lowlands, which is a period of gradual transition from the Paleolithic to the Neolithic (Kobendza 1930; Kobendza and Kobendza 1958).

In the case of uncovering large sandy areas and under favourable climatic conditions, volatile sands were activated. The process of dunes formation has begun. It was described in detail on the example of the Kampinos Forest (Kobendza 1930; Kobendza and Kobendza 1958), or broader studies that include their distribution throughout the entire country (Galon et al. 1969).

The similarity between coastal and inland dunes is only apparent (Berger-Landefeldt and Sukopp 1965). Fluvial and fluvioglacial sands are much less volatile than the coastal

ones. Their structure, which mechanical composition is much more diverse, is responsible for that. Dust and floated parts, whose presence reduces the aeration of the forming soil, but improves ground water conditions, have bigger contribution. Nevertheless, comparing coastal and inland sands, water availability for the psammophilic vegetation is much greater on the coast. On inland sandy areas average rainfall is much higher than at the Baltic Sea. The converse situation is with temperature. During summer periods high temperatures on inland sands reach even 60°C (Kobendza and Kobendza 1958). As a result of high temperature, air is almost completely devoid of moisture. At nights, rapid heat radiation occurs, which results in lower minimum temperatures.

Such extreme climatic conditions on inland sandy areas referring to the typical climatic deserts cause that the vegetation of these areas has a prominent xerothermic character.

Except for the purely climatic factors, which are the main ones forming described inland sandy areas, the substrate fertility factor in a great extent determines the species composition of psammophytic vegetation. Differences in the content of biogenic elements in the coastal sands are very small, in contrast to significant differences that characterize inland sites. Both heavily washed decalcified and very poor sands of fluvioglacial genesis, having generally acidic pH, as well as sands with a high content of calcium, more fertile reaching nearly neutral pH.

The terms of systematic sandy associations is now well developed, except a few cases that still require more detailed phytosociological research. Currently, all inland sandy grasslands communities are included in one class: sandy grasslands *Koelerio glaucae-Corynephoretea canescentis*. According to accepted principles, the mentioned class corresponds consecutively to sandy grasslands habitats of European Community interest: inland dunes with open *Corynephorus* and *Agrostis* grasslands (2330) and xeric sand calcareous grasslands (6120).

2330 – Inland dunes with open *Corynephorus* and *Agrostis* grasslands

Class: *Koelerio glaucae-Corynephoretea canescentis* – sandy grasslands
Order: *Corynephoretalia canescentis* – open sandy grasslands
Alliance: *Corynephorion canescentis* – open grasslands rich in *Corynephorus canescens*
Association: *Spergulo vernalis-Corynephoretum* – open sandy grasslands rich in *Corynephorus canescens*

The inland dunes with open *Corynephorus* and *Agrostis* grasslands occur in inland sand dune formations, weakly fixed or shifting, with developed siliceous soils that have initial character. This poor in species community is dominated by grey hair grass *Corynephorus canescens,* sand sedge *Carex arenaria*, and annual plants *Spergula morisonii* and *Teesdalea nudicaulis*, together with rich biota of lichens (*Cladonia* sp., *Cetraria* sp., *Stereocaulon* sp.) and bryophytes among which moss *Polytrichum piliferum* dominates. More stable habitats are covered by grasslands with *Agrostis* ssp. and *Corynephorus canescens*, sometimes with other acidophilous grass species.

It should be emphasized that only those parts of loose grasslands associated with dunes created as a result of aeolian wind activity are included here. Due to recent observations

The early stages of overgrowth of initial sandy grasslands in the Błędowska Desert. © Michał Węgrzyn

Hairmoss *Polytrichum piliferum* pioneer species inhabiting the naked sand as one of the first taxa. © Michał Węgrzyn

Domination of gray hair grass *Corynephorus canescens* on dunes quicksand in the Błędowska Desert. © Michał Węgrzyn

Sandy grassland with a large proportion of terrestrial lichens on small dune in Bory Tucholskie National Park. © Michał Węgrzyn

Perennial knawel *Scleranthus perennis* – an additional species, which distinguish the habitat of inland dunes. © Małgorzata Jaźwa

and research (Mróz 2014) also areas of sand not forming dunes, but with aeolian wind activity, were included to this habitat. The phenomenon of dunes formation, and thus periodically burying grasslands growing on dunes and drift sand areas, is a factor that inhibits the sequence of plant succession. For that reason only initial, species-poor, small grasslands are formed or reborn from seeds in given area. In such places, except of a few vascular plant species, the dominance of bryophytes and cryptogams including lichens, imperfect fungi, prokaryotic (*Cyanobacteriae*) and eukaryotic algae mainly the green ones (*Cyanoohyta*), is observed.

In terms of phytosociological approach, within this habitat only one phytosociological association can be distinguished which is open *Corynephorus* and *Agrostis* grey hair grass sandy grasslands with *Corynephorus canescens – Spergulo vernalis-Corynephoretum*. This community widely takes the variability in the habitat structure that occurs within it. Therefore, within the main habitat type only one subtype is distinguished which is 2330-1 inland dunes with open *Corynephorus* and *Agrostis* grasslands. The diversity of habitat is certainly associated with variety of soil and microclimatic conditions which depend on country region.

In the typical form, these are very loose and floristic extremely poor communities with dominance of grey hair grass (*Corynephorus canescens*). This prevailing plant is the initiator of the overgrowing process on unstable, drift sands of the manifold structure in inland decalcified habitats. At high aeolian wind activity this community doesn't undergo further succession changes in the direction of increasing floristic richness and forming more

Blue bonnets *Jasione montana* – an additional species, which distinguish the habitat of inland dunes. © Małgorzata Jaźwa

Site code	Site name	6120	2330
PLB140003	Dolina Pilicy	+	-
PLB140011	Bagno Całowanie	+	+
PLB200008	Przełomowa Dolina Narwi	+	-
PLB300002	Dolina Środkowej Warty	-	+
PLB300004	Wielki Łęg Obrzański	+	-
PLB300012	Puszcza nad Gwda	+	+
PLC080001	Ujście Warty	+	-
PLC140001	Puszcza Kampinoska	+	+
PLH020003	Dolina Lachy	-	+
PLH020015	Wrzosowisko Przemkowskie	-	+
PLH020017	Grądy w Dolinie Odry	+	+
PLH020037	Góry i Pogórze Kaczawskie	+	-
PLH020041	Ostoja nad Baryczą	+	-
PLH020049	Żwirownie w Starej Olesznej	+	+
PLH020050	Dolina Dolnej Kwisy	-	+
PLH020053	Zagórzyckie Łąki	+	-
PLH020063	Wrzosowiska Świętoszowsko-Ławszowskie	+	+
PLH020072	Uroczyska Borów Dolnośląskich	+	+
PLH020076	Źródła Pijawnika	+	-
PLH020081	Lasy Grędzińskie	+	-
PLH020086	Pieńska Dolina Nysy Łużyckiej	-	+
PLH020091	Dolina Oleśnicy i Potoku Boguszyckiego	-	+
PLH020093	Skoroszowskie Łąki	-	+
PLH040007	Jezioro Gopło	+	-
PLH040012	Nieszawska Dolina Wisły	-	+
PLH040017	Sandr Wdy	+	-
PLH040018	Torfowisko Mieleńskie	+	-
PLH040026	Lisi Kat	-	+
PLH040027	Łąki Trzęślicowe w Foluszu	+	-
PLH040028	Ostoja Barcińsko-Gąsawska	-	+
PLH040029	Równina Szubińsko-Łabiszyńska	-	+
PLH040031	Błota Kłócieńskie	-	+
PLH040040	Zbocza Plutowskie	+	-
PLH040044	Leniec w Chorągiewce	+	-
PLH060013	Ostoja Poleska	+	-
PLH060031	Uroczyska Lasów Janowskich	+	+
PLH060032	Poleska Dolina Bugu	+	-
PLH060033	Dobromyśl	+	+
PLH060034	Uroczyska Puszczy Solskiej	-	+
PLH060043	Lasy Sobiborskie	+	-
PLH060045	Przełom Wisły w Małopolsce	+	-

Table 2. The list of Natura 2000 sites occurring on the Polish territory where the xeric sand calcareous grasslands 6120 (106 sites) and inland dunes with open *Corynephorus* and *Agrostis* grasslands 2330 (90 sites) are found.

Site code	Site name	6120	2330
PLH060051	Dolny Wieprz	+	-
PLH060096	Bystrzyca Jakubowicka	+	-
PLH060097	Dolina Dolnej Tanwi	+	+
PLH060108	Jata	+	-
PLH080001	Dolina Leniwej Obry	-	+
PLH080002	Rynna Jezior Obrzańskich	-	+
PLH080015	Ujście Ilanki	+	-
PLH080031	Bory Chrobotkowe koło Brzózki	+	-
PLH080032	Bory Chrobotkowe Puszczy Noteckiej	-	+
PLH080036	Jeziora Gościmskie	+	-
PLH080039	Mierkowskie Wydmy	-	+
PLH080042	Stara Dąbrowa w Korytach	-	+
PLH080051	Brożek	-	+
PLH080052	Jeziora Brodzkie	-	+
PLH080055	Przygiełkowiska koło Gozdnicy	+	-
PLH080057	Dolina Lubszy	-	+
PLH080058	Murawy Gorzowskie	+	+
PLH080060	Uroczyska Borów Zasieckich	+	+
PLH080067	Rynna Gryżyny	+	-
PLH100006	Pradolina Bzury-Neru	+	-
PLH100007	Załęczański Łuk Warty	+	-
PLH100008	Dolina Środkowej Pilicy	+	+
PLH100035	Łąki Ciebłowickie	-	+
PLH120014	Błędowska Desert	+	+
PLH140001	Ostoja Bagno Całowanie	+	+
PLH140006	Dolina Zwolenki	+	+
PLH140011	Ostoja Nadbużańska	+	+
PLH140013	Wydmy Lucynowsko-Mostowieckie	-	+
PLH140016	Dolina Dolnej Pilicy	+	-
PLH140022	Bagna Celestynowskie	-	+
PLH140025	Dolina Środkowego Świdra	+	-
PLH140028	Gołobórz	-	+
PLH140029	Kampinoska Dolina Wisły	+	-
PLH140032	Ostoja Nadliwiecka	+	+
PLH140034	Poligon Rembertów	-	+
PLH140035	Puszcza Kozienicka	-	+
PLH140047	Bory Chrobotkowe Karaska	-	+
PLH140049	Myszynieckie Bory Sasankowe	-	+
PLH140050	Łąki Ostrówieckie	-	+
PLH140052	Zachodniokurpiowskie Bory Sasankowe	-	+
PLH140055	Łąki Soleckie	+	-

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Site code	Site name	6120	2330
PLH180020	Dolina Dolnego Sanu	+	+
PLH200005	Ostoja Augustowska	+	+
PLH200007	Pojezierze Sejneńskie	+	+
PLH200008	Dolina Biebrzy	+	-
PLH200010	Ostoja w Dolinie Górnej Narwi	+	+
PLH200018	Czerwony Bór	+	+
PLH200019	Jelonka	+	-
PLH200021	Ostoja w Dolinie Górnego Nurca	+	-
PLH200022	Dolina Górnej Rospudy	+	-
PLH200023	Dolina Pisy	+	+
PLH200024	Ostoja Narwiańska	+	+
PLH220026	Sandr Brdy	-	+
PLH220033	Dolna Wisła	+	-
PLH220034	Jeziora Wdzydzkie	-	+
PLH220038	Dolina Wieprzy i Studnicy	+	-
PLH220052	Dolina Słupi	+	-
PLH220072	Kaszubskie Klify	+	-
PLH240009	Ostoja Srodkowojurajska	-	+
PLH240015	Ostoja Olsztyńsko-Mirowska	+	+
PLH240020	Ostoja Złotopotocka	-	+
PLH260003	Ostoja Nidziańska	+	+
PLH260013	Dolina Białej Nidy	+	+
PLH260014	Dolina Bobrzy	+	+
PLH260015	Dolina Czarnej	-	+
PLH260018	Dolina Górnej Pilicy	-	+
PLH260030	Ostoja Pomorzany	-	+
PLH260032	Ostoja Sobkowsko-Korytnicka	+	-
PLH260034	Ostoja Szaniecko-Solecka	+	+
PLH260036	Ostoja Żyznów	+	-
PLH260039	Wzgórza Kunowskie	-	+
PLH260040	Lasy Cisowsko-Orłowińskie	-	+
PLH260041	Wzgórza Chęcińsko-Kieleckie	+	+
PLH280001	Dolina Drwecy	-	+
PLH280012	Ostoja Lidzbarska	+	-
PLH280014	Ostoja Welska	+	-
PLH280035	Ostoja Radomno	+	-
PLH280041	Murawy na Pojezierzu Ełckim	+	-
PLH280045	Ostoja Północnomazurska	+	-
PLH280048	Ostoja Piska	+	-
PLH280052	Ostoja Napiwodzko-Ramucka	+	-
PLH300001	Biedrusko	+	+

Table 2. The list of Natura 2000 sites occurring on the Polish territory where the xeric sand calcareous grasslands 6120 (106 sites) and inland dunes with open *Corynephorus* and *Agrostis* grasslands 2330 (90 sites) are found.

Site code	Site name	6120	2330
PLH300002	Uroczyska Płyty Krotoszyńskiej	+	-
PLH300006	Jezioro Kubek	-	+
PLH300009	Ostoja Nadwarciańska	+	+
PLH300010	Ostoja Wielkopolska	+	+
PLH300012	Rogalińska Dolina Warty	+	+
PLH300016	Bagno Chlebowo	-	+
PLH300021	Poligon w Okonku	+	+
PLH300038	Dolina Cybiny	+	-
PLH300041	Ostoja Przemecka	-	+
PLH300045	Ostoja Pilska	+	+
PLH300053	Lasy Zerkowsko-Czeszewskie	+	-
PLH320004	Dolina Iny koło Recza	+	-
PLH320005	Dolina Krapieli	+	-
PLH320006	Dolina Płoni i Jezioro Miedwie	+	-
PLH320007	Dorzecze Parsęty	+	-
PLH320012	Kemy Rymańskie	+	-
PLH320013	Ostoja Goleniowska	-	+
PLH320014	Pojezierze Myśliborskie	+	-
PLH320017	Trzebiatowsko-Kołobrzeski Pas Nadmorski	-	+
PLH320018	Ujście Odry i Zalew Szczeciński	-	+
PLH320019	Wolin i Uznam	+	+
PLH320020	Wzgórza Bukowe	+	+
PLH320023	Jezioro Lubie i Dolina Drawy	+	-
PLH320025	Dolina Pilawy	-	+
PLH320037	Dolna Odra	+	+
PLH320038	Gogolice-Kosa	+	-
PLH320044	Lasy Bierzwnickie	+	-
PLH320045	Mirosławiec	+	-
PLH320046	Uroczyska Puszczy Drawskiej	+	+
PLH320048	Diabelskie Pustacie	-	+
PLH320050	Dolina Tywy	+	-
PLH320055	Wzgórza Moryńskie	+	-

Table 2. The list of Natura 2000 sites occurring on the Polish territory where the xeric sand calcareous grasslands 6120 (106 sites) and inland dunes with open *Corynephorus* and *Agrostis* grasslands 2330 (90 sites) are found.

compact sandy grasslands, because drifted sand prevents expansion of successive vascular plants. According to the characteristics of this community in terms of phytosociological approach (Matuszkiewicz 2001), majority of the association phytocenoses are secondary substitute anthropogenic communities forming as a result of degeneration or destruction of primary natural vegetation and currently occurring on fallow lands, clearcuts, forest borders and deforested areas, roadsides, sandpit areas etc. In terms of the substrate origin this association occurs on sandy places in areas of sandurs, pile cons, valley sands, inland dunes and glacial sands from ice accumulation.

Species characteristic for association *Spergulo vernalis-Corynephoretum* are spurrey *Spergula morisonii*, cress *Teesdalea nudicaulis,* speedwell *Veronica dillenii,* bent-grass *Agrostis vinealis* and various lichen species of genus *Cladina* and *Cladonia.*

*6120 – Xeric sand calcareous grasslands

Class: *Koelerio glaucae-Corynephoretea canescentis* – sandy grasslands
Order: *Corynephoretalia canescentis* – open sandy grasslands
Alliance: *Koelerion glaucae* – xeric and calcareous grasslands
Association:

- *Corynephoro-Silenetum tataricae* grassland with *Silene tatarica*
- *Sileno otitis-Festucetum* grassland with *Silene otites*
- *Festuco psammophilae-Koelerietum glaucae* thermophilic sandy grasslands of tufts grass *Festuca psammophila* and *Koeleria glauca*
- *Koelerio-Astragaletum arenarii* grassland with *Astragalus arenarius*
- *Festuco-Elymetum arenarii* association with *Leymus arenarius*
- *Cerastio-Androsacetum septentrionalis* association with *Androsace septentrionalis*
- *Kochietum arenariae* association of *Kochia laniflora*
- *Diantho arenarii-Festucetum polesicae* association with *Astragalus arenarius* and *Festuca polesica*
- *Thymo-Potentilletum puberulae* association with *Potentilla pusilla*

Xeric sand calcareous grasslands can be considered as the following succession stage of initial grassland associations that develop on drift sands including dunes corresponding to habitat type 2330.

The habitat is formed by grassy communities, often imitating xerothermic grasslands. As in case of habitat type 2330, presence of xeric sand calcareous grasslands is conditioned by climatic, soil and anthropogenic factors. While the habitat of inland dunes with open *Corynephorus* and *Agrostis* grasslands prefers areas with clearly suboceanic climate influence, the xeric sand calcareous grasslands show visible continental character. They are distributed mainly in subcontinental and continental areas of Central Europe. Outside the area of main habitat occurrence, it is found throughout the whole continent and it is associated with sandy areas rich in calcium carbonate. Such places are certainly located in the areas of river valleys and moraines. This habitat also occurs on inland dunes and dry, gravel substrate of riverside rocks.

Xeric sandy grasslands are characterized by high species richness of vascular plants, which form low, not dense and colorful grassy communities. The clumpy formation of plants having xeromorphic structure is clearly seen. Grasses and annual plants dominate. A large contribution among cryptogamic species including bryophytes and terricolous lichens is noted.

The grasslands occur on barren, loose soils forming on glacial sands and on gravels. The low level of ground water is an important feature, which clearly affects water stress in plants forming grasslands. The habitat quickly adapts the Quaternary sediments, consequently any postglacial forms such as fluvioglacial sands – sandurs, river terraces, dunes.

Xeric sand calcareous grasslands in Załęczański Łuk Warty. © Maciej Kozak

The habitat strongly prefers flat, sunny areas, with low average annual rainfall and rapid water penetration through the substrate, but it is also often found on slopes of southern exposure.

Inland xeric sand calcareous grasslands (6120) are characterized by a great diversity, from quite poor forms referring to the character of 2330 habitat type (inland dunes with open *Corynephorus* and *Agrostis* grasslands), through richer in species, thermophilous grasslands on foothill riverside rocks, to forms of sandy grasslands, floristically rich, with strong anthropogenic and xerothermic character. The anthropogenic character is associated with pastoral activity which took place in the past in the current grassland areas. In many cases this activity is not continued therefore in these places the habitat is highly threatened by slow overgrowing with shrubs and trees. The main threat, as in the case of inland dunes with sandy grasslands, is the secondary succession resulting from the semi-natural character of the community.

Corynephoro-Silenetum tataricae* grassland with *Silene tatarica

This community creates not fully thermophilic grasslands with the participation of *Silena tatarica* in Central Europe, in the valleys of the major rivers on sandy sediments, in sites above the highest water levels. In Poland it occurs in the valleys of Warta River, Middle and Lower Vistula River and over Narew and Bug rivers.

Sileno otitis-Festucetum* grassland with *Silene otites

It is thermophilic and xeric sandy grassland community, with the dominance of subcontinental vascular plant species that are characteristic for the entire alliance xeric and calcareous grasslands *Koelerion glaucae.* Species with intermediate life requirements, called mesophilic, are usually sparsely represented. This is an association with the weak typical species in terms of supra-regional; however their role locally is fulfilled by the following flowery plants *Silene otites*, *Dhianthus cartusianorum* and *Centaurea stoebe*. The association forms high grasslands, up to 60-80 centimeters, with not fully dense vegetation. At the same time equally, the species of multicolored dicotyledonous plants and grasses occur. The habitat is often developed in the vicinity of xerothermic grasslands of *Festuco-Brometea* class therefore it resembles the structure of these associations. The plant species migrate within the habitats. Depending on site conditions (soil conditions, successional stage), three sub-associations of this community are clearly distinguished: typical, xerophilous and xerothermic. The typical one is formed in more fertile areas where the better soil conditions are. In this case the grassland is dominated by xerothermic species over sandy grasslands ones. The xerophilous sub-association with prevailing *Koeleria glauca* is floristically poor and refers in the species composition to association *Festuco psammophilae-Koelerietum glaucae* (thermophilic sandy grasslands of tufts grass *Festuca psammophila* and *Koeleria glauca*). The xerothermic sub-association with *Stipa capillata* is similar to adjacent grasslands of *Stipa* species. As well as in the previous case the migration between communities occurs.

This community prefers a low permeability substrate, sandy or sandy-gravel, occurring under continental climatic conditions. It is often found on sandy moraine and kame hills, on dunes of coarse sand or in sandy valley terraces as well as in anthropogenic areas such as open gravel and sand pit mines.

Festuco psammophilae-Koelerietum glaucae* thermophilic sandy grasslands of tufts of grass *Festuca psammophila* and *Koeleria glauca

It is a strongly xerothermic variety of sandy grasslands with domination of tufty grasses *Festuca psammophila* and *Koeleria glauca*. This association is characterized by high species richness of vascular plants that have mainly continental range, otherwise known as sarmatian type of range, reaching in Poland the western and northern borders. Grasslands within the association resemble of sandy xeric grassland of *Festuco-Brometea* class, which often borders them in the field. In this case the process of described earlier migration occurs. The association is found on loose and semi-permeable sands, very dry, sometimes with a large share of gravel forms. It is the most extreme community in terms of water scarcity and high temperatures in Poland. The substrate is typically alkaline, which is due to the high content of calcium carbonate. The habitat occurs in areas of river valleys with sandy substrate and on all postglacial forms such as sandurs, moraines etc.

Koelerio-Astragaletum arenarii* grassland with *Astragalus arenarius

This association strongly refers in terms of habitat to the xerothermic grasslands. *Astragalus arenarius* is the dominant species. The community creates fairly loose sandy

grasslands growing on poor and slightly acidic or neutral substrate, with soils of initial stage. Strong insolation and high temperatures are main factors affecting this habitat. The occurrence of this community is very limited and associated with areas of eastern and south-eastern Poland.

Festuco-Elymetum arenarii* association with *Elymus arenarius

An association has a semi-natural character due to the origin of the dominant species *Elymus arenarius,* which is characteristic for coastal dunes grasslands. In the twentieth century it has been often used to stabilize the inland dunes. The habitat in Poland is found in Mazury and in the valleys of the Warta, Vistula and Bug rivers.

Cerastio-Androsacetum septentrionalis* association with *Androsace septentrionalis

This association has a very limited range in Poland. It occurs in the form of not dense sandy grasslands rich in therophytic species such as *Alyssum turkestanicum*, *Androsace septentrionalis* and *Potentilla leucopolitana*. Low quantity of perennial plants is the reason why these grasslands haven't got variegated colour.

Kochietum arenariae* association of *Kochia laniflora

Similar to the previous community, this association has a very limited range of occurrence in Poland. It is restricted to areas in the east of the country connected with loose sands. The grasslands abound in therophitic species during the small share of perennials. The characteristic, and as well dominant species, is *Kochia arenaria*. The habitat occurs in the valleys of the Bug and the Middle Vistula River.

Diantho arenarii-Festucetum polesicae* association with Astragalus *arenarius* and *Festuca polesica

This association is the sandy grassland with the dominance of two very rare vascular plants *Dianthus arenarius* and *Festuca polesica*. This community is rather poorly explored and distinguished. It is noted in the western Poland.

Thymo-Potentilletum puberulae* association with *Potentilla pusilla

This very interesting community occurs in the mountain areas, in the Western Carpathian Mountains and it is associated with foothill zone. It has the character of the xerothermic grasslands formed on fixed gravel-sand rocks along in riverbeds.

The presented characteristic of sandy grasslands is based on the division into specific associations in terms of phytosociological approach. Many times the attention was returned to the phenomenon of quite spontaneous mixing of similar neighboring phytocenoses occurring in fairly similar habitat conditions. The species migration from one formation to another is a natural process. Therefore, the correct identification of sandy grasslands during fieldworks may pose a number of problems, especially with respect to heavily changed or degraded communities. Belonging of the particular plant communities, representing different sandy grasslands phytocenoses, to the natural habitats valuable for the

Small fragment of sandy grassland with blue hair grass *Koeleria glauca* and wild thyme *Thymus serpyllum*. © Michał Węgrzyn

European Community has contractual character. The authors' experience, gained during the LIFE+ project in the Błędowska Desert, shows that a strong distinction between this two types of habitats in the area is very difficult, often strongly debatable and sometimes even impossible. We may deal with habitat whose features refer to both, the first and the second type, or even have strong species connections with another one that has features corresponding to xerothermic grasslands.

Therefore, in the case of concerns about the proper sandy grasslands classification to the association, it is worth considering to use the descriptive terminology relating to the community, not to a specific association. Even, if there is a problem to identify the species characteristic for association in the patch of grassland. This simple principle results from the statement that each plant association is also a plant community, but not every plant community is an association from the point of view of phytosociological nomenclature code (Medwecka-Kornaś et al. 1977).

Branched plantain *Plantago arenaria* © Maciej Kozak

Tasteless stonecrop *Sedum sexangulare* and grass *Festuca psammophila*. © Maciej Kozak

Fauna of inland sandy areas

Due to habitat conditions and the specific composition of plant species, sandy grasslands are characterized by rich fauna, mainly invertebrates. The typical vertebrate species for these areas are lacking. Quite often occurring reptile is the sand lizard *Lacerta agilis*. Sandy areas are mainly inhabited by beetles, flies (dipteran), wasps (hymenopteran), Heteroptera bugs, butterflies and Orthoptera insects. The most interesting taxa that are worth mentioning include antlions *Myrmeleon formicarius* and *Myrmeleon bore*, sand wasp *Bembix rostrata*, blue-winged grasshopper *Oedipoda caerulescens*, northern dune tiger beetle *Cicindela hybryda*, the Small Emperor Moth *Eudia pavonia* and a scale insect *Porphyrophora polonica*. Moreover apart of these groups and species, large contributions in entomofauna of the habitat have also ants including the ones from *Myrmicinae* subfamily. Additionally, the thermophilic sandy grasslands (6120) constitute a potential habitat for two butterfly species listed in Annex II of the Habitats Directive, i.e. the Eros blue *Polyommatus eroides* and the Danube Clouded Yellow *Colias myrmidone*. Both of these taxa are under strict species protection in Poland and are categorizing as vulnerable VU (likely to become endangered).

Among mentioned above insects, the most noteworthy are antlions. *Myrmeleon bore* are invertebrates inhabiting coastal and inland dunes. Besides these habitats, they can be also found on sandy banks of the river backwaters and even on sandy point bars in the overexposed, dry pine forests. However, in the case of pine forest, more frequently the second antlion species *Myrmeleon formicarius* can be observed. The adult antlions, resembling dragonflies, do not arouse much interest. Far more attention needs to be paid to the larvae, which are one of the most interesting predators of all insects. The larva burying itself in the sand creates distinctive, not big funnel with a diameter of a few centimeters. It lives in the bottom of the funnel, buried under a layer of sand. On the surface only the very strong mandibles are ejected. Such well-designed trap causes that the insect (usually ant), who enters his territory, has a difficulty to get out. The reason for that are not only the steep slopes of the hole, but mainly the antlion larva bombing its victim with sand grains. The giving up victim gets to the bottom of the trap, where it is caught by antlion mandibles

Northern dune tiger beetle *Cicindela hybrida*. © Dariusz Ropek

The larva of the antlion *Myrmeleon bore*. © Dariusz Ropek

Habitat of antlions on the sand surface – characteristic holes, which are traps for ants. © Dariusz Ropek

Sand wasp *Bembix rostrata*. © Dariusz Ropek

and then slowly sucked. The antlion larvae prey mostly for ants, therefore the traps are set up in a close proximity to the ant assemblages.

Another noteworthy species, which also occurs within the sandy grasslands habitat, is the northern dune tiger beetle *Cicindela hybryda*. It can be met on dunes and on sandy wetlands in the overexposed, dry pine forests. This taxon has also a unique strategy to acquire food. It is very predatory beetle hunting during the day. The adults, due to the skill of extremely fast moving, wait for their prey in a trap, and when it finds in the adequate distance, they begin to chase it. They do not have any problems to catch mostly small insect and equally quick to devour it. The victim is almost completely dissolved because of the digestive juices poured on it. The northern dune tiger beetle larvae wait for their victims in a specially dug hole – they catch the insect, drag in the hole and then eat.

Active protection of sandy grasslands habitats contributes not only to restore the vegetation characteristic for sandy, unstable substrata, but also affects the improvement of the living conditions of valuable animal species. Increasing the habitat area allows to increase the population abundance of many specific for sands invertebrates and less frequent vertebrates.

The sandy vegetation dynamics

Recently, as a result of implementation of numerous projects in Europe with the object of sandy grasslands habitats restoration, both initial ones on dunes and richer in species on more fertile substrata, we have more and better data on ecology of these communities. After the Polish accession to the European Community, the scientists attempted to define, in terms of phytosociological approach, valuable habitats occurring across the country. This classification has been quoted in the chapter about sandy grasslands. However, the attention was paid on frequent difficulties of identifying particular habitat type. The problems are caused mainly by relatively rapid succession changes that are currently taking place in the patches of sandy grasslands. The expansion of shrubs and seedlings, mostly pines, which quickly overgrow the parts of dunes and other sand areas, is the next succession stage after the stabilization of the sandy substrata. Based on numerous literature data (Rahmonov 2007), aerial photographs and historical maps, it is known that succession processes occurred much more slowly till the mid-twentieth century than it is at the moment. Attempts of afforestation of sand, which took place in those decades, repeatedly did not succeed. The breakthrough was achieved in the 1950s when the largest dunes and sandy areas in Poland such as the Kampinos Forest, the Błędowska Desert or the Bory Dolnośląskie (Lower Silesia Forest) began to be successfully afforested. The use of forecrop species, well adapted to drift sands, including long-leaved violet willow *Salix acutifolia*, simplified the task. However, for many years it was still not known why the afforestation rate so greatly accelerated. The seedlings growing in forest nurseries were introduced on sandy areas, because natural stand regeneration in the way of vegetative propagation by rhizomes or sexual reproduction from the seed, did not occurred.

Research on plant succession on sandy areas focused especially on phytosociological aspect including mainly vascular plants, and only slightly cryptogams, i.e. algae, fungi, lichens and bryophytes (Daniels et al. 1993; Masselink 1994; Paus 1997). Later studies (Sparrius et al. 2012; Sparrius et al. 2013; Hasse 2005) have a much broader range and pay attention also on the substrata and soil. Soil parameters relevant to understand the causes of the vegetation succession processes on sandy areas are pH, soil structure and also carbon and nitrogen content. Own observations in the Błędowska Desert and liter-

ature data from the same area (Rahmonov 2007) (Tab. 3) and other European countries (Sparrius et al. 2012; Hasse 2005) (Tab. 4) as well as older studies on Polish vegetation (Medwecka-Kornaś et al. 1977) show that the succession begins with open and devoid of vegetation sand. The first appearing is grey hair grass *Corynephorus canescens* – the only and the best adapted to such difficult conditions of vascular plant species. However, as indicated by Riksen at al. (2008), colonization of bare sand occurs mainly after mild winters and wet summers. In the next stage the cryptogamic (sporulated) species appear including prokaryotic algae represented by the following cyanobacteria *Chroococcus minor*, *Chroococcus minutus*, *Chroococcus varius* and eukaryotic algae, especially green algae *Chlorophyta* i.e. *Cylindrocapsa* sp., *Klebsormidium crenulatum, Stichococcus chlorelloides* and diatoms *Bacillariophyceae*: *Pinnularia borealis* (Rahmonov 2007; Rahmonov and Piątek 2007). Simultaneously with algae the sand is inhabited by fungi creating systems of chitin mycelium under the ground. The next appearing are lichens which are specific fungi that have the ability to symbiosis with algae, both prokaryotic and eukaryotic ones. In this first stage of succession only lichens with the ability of producing fruiting bodies with fungal spores enter the area, for example *Cladonia coccifera*, *Cladonia grayi*, *Cladonia phyllophora*, *Cladonia gracilis*, *Cladonia pyxidata*, *Cladonia fimbriata* and tiny structures called soralia or fragments of *Cladonia glauca* and *Cladonia macilenta* (Biermann and Daniels 1997; Bültmann and Daniels 2001). The last group of cryptogams inhabiting the sands is bryophytes with the domination of moss *Polytrichum piliferum* (Bowden 1991) and other less numerous taxa such as *Ceratodon purpureus, Racomitrium canescens*. However, they do not form the dense patches, but the places with free sand that they leave are colonized by fruticose lichens, not producing fruiting bodies with spores, e.g. *Cladonia arbuscula, Cladonia furcata* var. *furcata, Cladonia mitis, Cladonia rangiferina, Cladonia uncialis*, *Cetraria aculeata, Cetraria islandica* (Biermann and Daniels 1997; Bültmann and Daniels 2001).

With such vegetation state the following species of vascular plants begin to appear, especially grasses such as blue hair grass *Koeleria glauca*, sand sedge *Carex arenaria*, European marram grass *Ammophila arenaria*, sheep fescue *Festuca ovina,* sand fescue *Festuca psammophila*, but also perennial flowering plants develop, e.g. wild thyme *Thymus serpyllum* or goldmoss stonecropp *Sedum acre*. After all, such habitat conditions enable appearing of therophytes, namely annual plants, in spring. These are colorful flowering plants including spurreys *Spergula morisonii* and *Spergula pentandra*, cress *Teesdalea nudicaulis,* sheep's scabious *Jesione montane,* annual knawel *Scleranthus annuus* and perennial one *Scleranthus perennis*. At this stage sand is not volatile anymore and the layer of soil begins to develop on its surface creating habitat for inland dunes with open *Corynephorus* and *Agrostis* grasslands (2330), which in terms of phytosociology belongs to association *Spergulo vernalis-Corynephoretum* (open sandy grasslands with *Corynephorus canescens*). In the dynamics of sandy grasslands habitats, at this stage, the decisive moment occurs. Depending on the geographical location and environmental factors, as a result of succession, the transformation from the initial habitat to more complex sandy grasslands communities may happen or the process of habitat degradation may

Scots pine forests in the Bory Dolnośląskie. © Michał Węgrzyn

begin due to intensive, spontaneous overgrowing with shrubs and trees. Also at this stage the succession of vegetation may be inhibited, and even withdrawn.

All presented options of further changes are conditioned by environmental factors. Some of them are permanent and unchanging over time, e.g. the content of calcium carbonate compounds in the soil or sand and gravel structure, as well as climate (insolation, precipitation, wind). The intensity of impact of the other factors, such as stability, substrata pH and fertility, carbon, nutrient elements and nitrogen content in the soil, is constantly changing.

There were a number of studies devoted to the analysis and modeling of the impact of mentioned above factors on changing vegetation. According to them Hasse (2005) conducted studies in which it was demonstrated that the accumulation of organic matter in soil is a major factor activating the succession process and that it is correlated with the nitrogen content in the substrata. Sparrius et al. (2012), on the basis of the above results (Hasse 2005), carried out studies in the Netherlands on five sandy, dunes forming areas: Aekinge, Drouwen, Kootwijk, Wekerom, confirming the role of nitrogen as a prime factor that influences the dynamics of sandy grasslands habitats. The

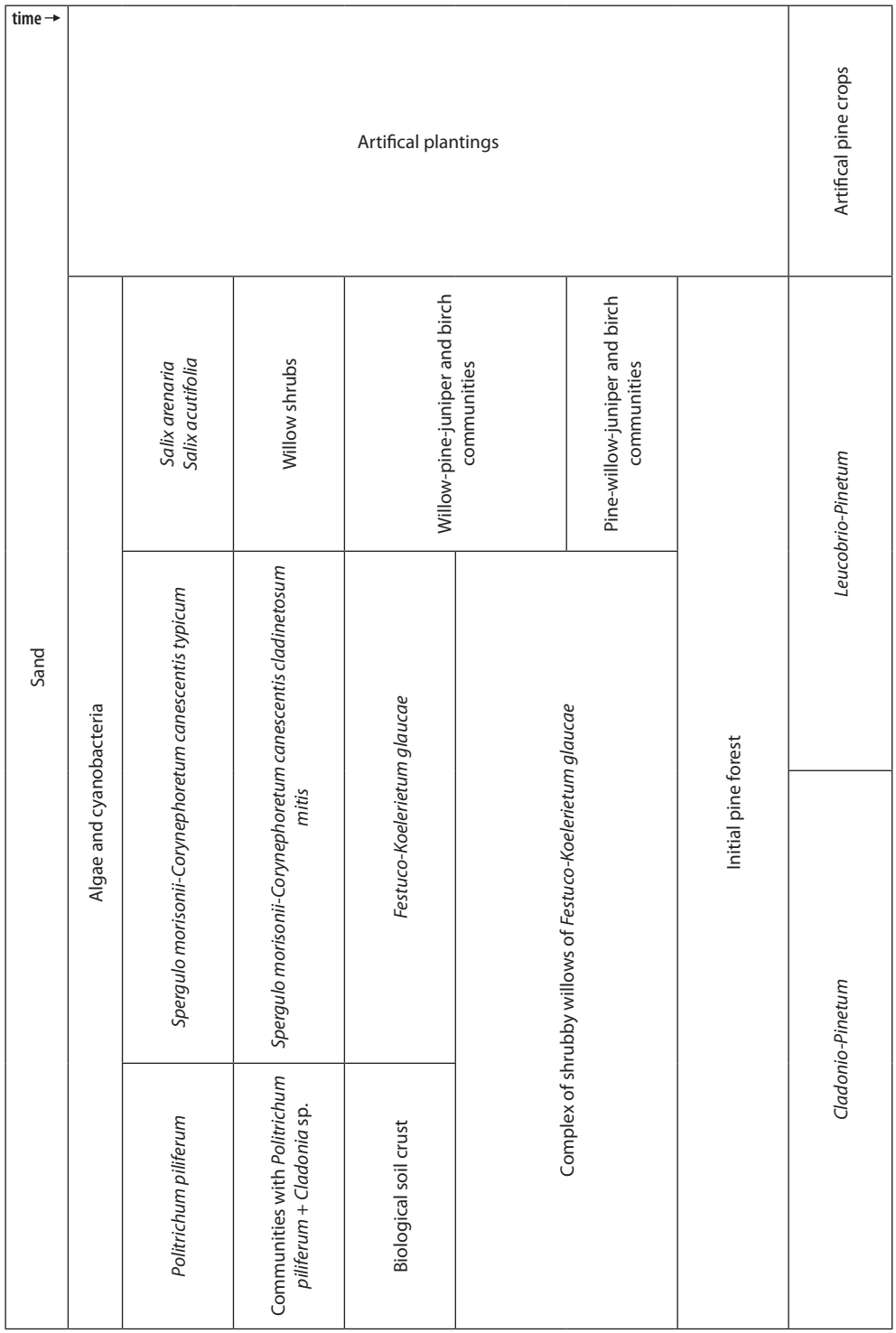


Table 3. The plant succession process in the Błędowska Desert (Rahmonov 2007 – modified).

Przemkowskie Heathland in the Bory Dolnośląskie – similar to the stage of succession described by Hasse (2005) in the Netherlands.
© Michał Węgrzyn

ion nitrogen absorbed by living organisms is the most important factor that promotes the development of algal mats on the sand surface. The sand grains are glued together by colloidal substances produced by prokaryotic and eukaryotic algae. In the result a few millimeters crust of relatively stable substrata is formed, which can be colonized by successive species of cryptogams and vascular plants. The specific properties of colloidal substances cause the collecting on the water surface, which is not able to penetrate rapidly into the deeper sand layers and to be not available for the vegetation at the surface. Colloids swell under the influence of water and have the capability to collect

time →

Sand		Pioneer vegetation				
Bare sand	*Corynephorus* (grasses)	*Polytrichum* (bryophytes)	Small lichens	*Cladonia* species	Grasslands	Dwarf shrubs (heaths)
			Campylopus (bryophytes)			

Table 4. The vegetation succession pattern in inland dunes in Netherlands (Hasse 2005). Initial stages are: bare sand, pioneer vegetation and heaths (Sparius et al. 2012).

water over a long period of time. Algae are considered by many authors to be a major soil-forming factor in areas devoid of soil crust (Rahmonov 2007).

The phenomenon of the algal crust formation intensifies in the periods of increasing air pollution of industrial gases containing nitrogen oxides. In the mid-twentieth century, in the postwar period, the strong development of industry has taken place in the country and all over Europe. The air pollution, and thus the substrata contamination due to acid rains, became bigger and bigger. Large amounts of the ion nitrogen were supplied to the soil, what initiated the eutrophication process. The more fertile habitat rather quickly became the area easier for afforestation. From 1960s to 80s most sand areas were managed to reforest on Polish territory, and what follows sandy grasslands habitats either completely disappeared, or were severely limited territorially.

The influence of nitrogen content in the soil and the development of algal mats stabilizing the sand caused the cessation of dune-formating processes on sandy areas. Dunes ceased to wander under the influence of aeolian wind activity, and over time they slowly began to overgrow. Such areas, where the dunes are covered with pine forest, are a lot in Poland and Europe. In some cases, those are dry pine varieties with patches of lichen pine forest, especially with *Cladonia* species. In another, the substrata eutrophication was so intense that the pine forests occur in the scotch variety. The examples of such areas are following: the Kampinos Forest, the Kozienicka Forest, the Bory Dolnośląskie (Lower Silesia Forest), fragments of the Tuchola Forest, the Noteć Forest and included in the project the southern part of the Błędowska Desert. Of course, there are much more similar areas, but only the largest ones, where the spaces of available sands occurred on dozens of square kilometers, were indicated. Until the 1960s the association of open sandy grasslands with C*orynephorus canescens* (*Spergulo vernalis-Corynephoretum*) growing in sandy areas where forming-dunes processes occurred, was also given out from Uznam and Wolin (Piotrowska 1966), Lubisz Land (Libbert 1932-1933), Poznań region (Filipek 1955), Eastern Pomerania (Polakowski 1963), the Białowieża Forest (Faliński 1966), the Upper Bug valley (Fijałkowski 1965; Fijałkowski 1966), the Małopolska Upland (Kornaś 1957) and the Sandomierz Basin (Fijałkowski and Górski 1968).

From the point of view of sandy grasslands habitat protection, the situation in which the dunes stabilize and overgrow with the pine forest can be considered as a phenomenon of the habitat degradation. On the other hand, it should be also pointed out that the pine forest stadium on sandy substrata is the climax one and to prevent occurring of this stage, the additional factors, mainly anthropogenic ones, have to occur. Medwecka-Kornaś et al. (1977) quoted that the cattle and sheep grazing on sandy grasslands is a limiting factor in vegetation succession and that it prevents the overgrowing of dune areas with pines. Currently, the research that document the impact of grazing on the conservation state of sandy grasslands habitats, are also conducted (Kratochwil et al. 2002). The authors show that too intense grazing on dune grasslands causes their transformation into species-poor pasture phytocenoses. Although, there is no written evidence, but in the case of the Błędowska Desert, such grazing was conducted. At-

Biological soil crusts, which stabilize the sands, are mainly formed by prokaryotic and eukaryotic algae. © Michał Węgrzyn

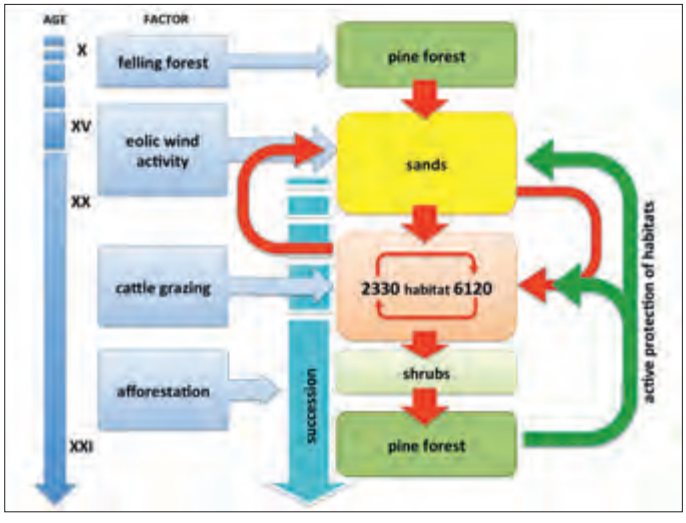


Fig. 6. Scheme of plant succession forming sandy habitat in Poland. Such factors as aeolian activity of wind and cattle and sheep pasturage on sandy grasslands effectively inhibit succession and overgrowing of habitat. The use of active protection, in the form of grubbing bushes and trees, renews degraded fragments of habitat, improving their structure and function.

Small sand storms recorded in the Błędowska Desert after cleaning the whole area are a key habitat creative factor for initial sandy grasslands on the dunes (2330). © Michał Węgrzyn

tempts of the area afforestation arose at the same time as prohibition of cattle and sheep introduction on the areas of sandy grasslands, in both the northern and southern parts of desert. Earlier, the animals were grazing on grasslands and they were driven away to watering-place in the river Biała Przemsza. Such grazing and driving away cattle and sheep herds probably inhibited the succession processes of vegetation, however if they were too intense, they could also cause species depletion on grasslands. In a very simply way it can be assumed that herding on sandy grasslands inhibited further succession and overgrowing by shrubs, as well as in some situations could lead to the depletion of grasslands and their transformation to poorer in species variants, referring to the initial stages. Cattle and sheep could, by biting and trampling, contribute to start of the erosion processes of the substrata (Fig. 6).

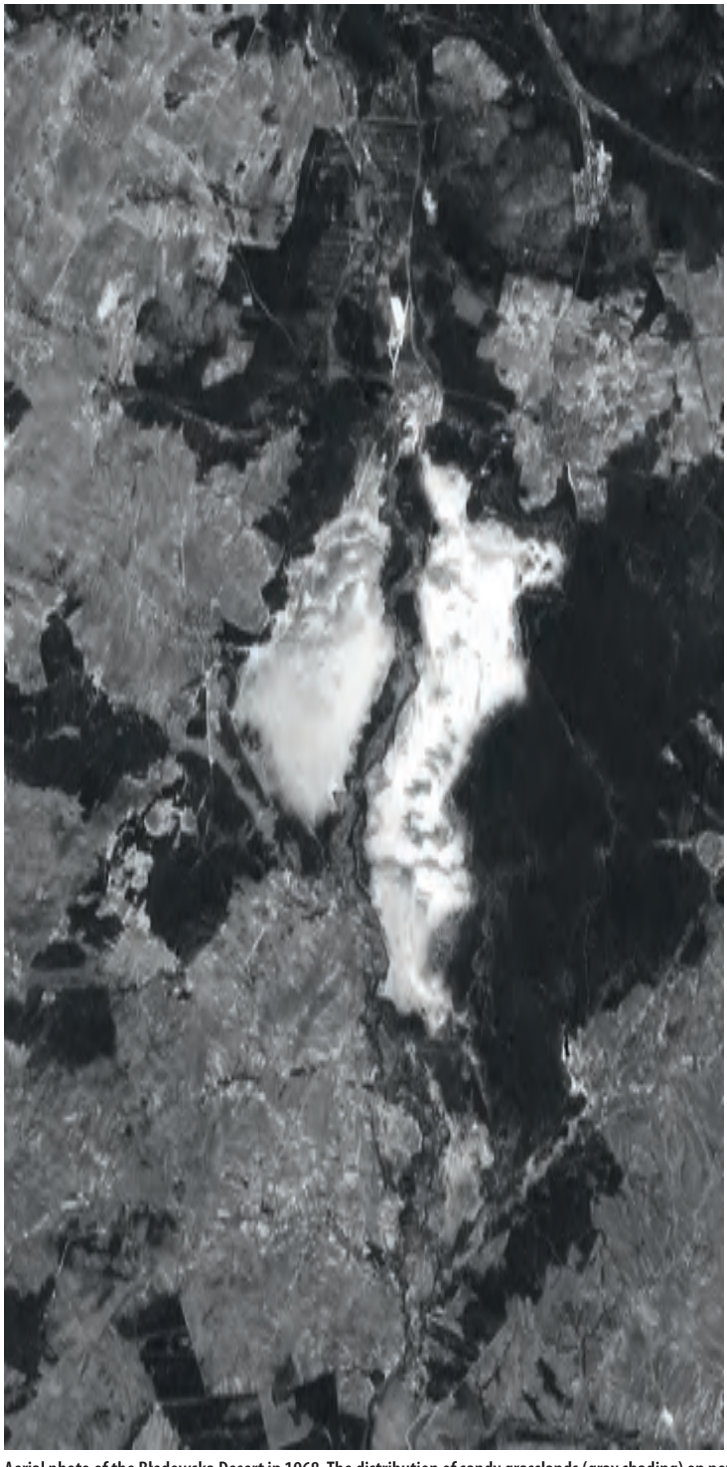
Semi-natural sandy grasslands patches were not evenly covered with vegetation specific for this type of communities. Bare, sandy areas, called blowouts (deflation fields, deflation surfaces), were sites from which the sand was carried by the wind to the places of its accumulation. Areas, where the wind was losing lift and sand particles were falling to the ground, were located along the natural field obstacles, such as monadnocks, river valleys with riparian vegetation or the tree line of forests adjacent to sandy areas. In these sites the dunes with the initial grasslands were forming. As the aeolian wind

activity and dunes formation processes were constant, the plant succession on sandy grasslands was inhibited in a natural way. Grasslands vegetation, including the grey-hair grass *Corynephorus canescens*, is well adapted to the periodically burying with sand. Thus in the following year, from the seeds or roots storing under the sand, the new individuals grew and a new grassland was created. Of course, the weather conditions and intensity of wind in particular year were variable, so the grasslands were not always completely buried by sand. However, even weak processes of dunes formation eliminated the seedlings of pine and other shrubs which were trying to germinate on the dunes. It is easily seen that as far as the dunes were overgrown by sandy grasslands, the areas of free sand without vegetation had to exist around them. Looking at aerial and satellite photographs illustrating the Błędowska Desert overgrowing, it is clearly seen where the pines appeared in a natural way. In the 1950s the grasslands in the desert were developed on the dunes, around which there were deflation fields of volatile sand. These areas were intensively afforested by man, but also in some parts, due to increasing air pollution and higher content of nitrogen in the soil, the algal mats stabilizing the sand began to develop. The gusts of wind were no longer able to transport sand grains to the existing dunes. The processes of vegetation succession caused slow dunes overgrowing with natural regenerated pines. This situation is presented in the aerial photos from the years 1973 and 1996, where the same areas at first, in 1970s, are covered with overgrowing grasslands on dunes, and then, in 1990s, the initial pine forest is observed (Rahmanow 2007).

Before the implementation of the project it was claimed, as a part of environmental monitoring conducting in the Błędowska Desert that the remains of sandy grasslands preserved exactly in sites where in the twentieth century the deflation fields had occurred, while areas of strong dunes formation were covered mainly by pine.

Up to the mid-twentieth century the initial grassland communities on the dunes were relatively stable habitats forming by grazing and the aeolian wind activity. Their structure was constantly kept at quite unchanged level. Of course, the sites where sandy grasslands habitats occurred were not all the time the same, they changed over time during dunes formation processes. Interestingly, the areas of blowouts in relation to sandy grasslands areas in the particular terrain occupied comparable sizes, despite the high dynamics rate within the whole habitat.

Described environmental issues largely are related to the initial grassland habitat occurring on the dunes and drift sands (2330). However, it should be emphasized that in some environmental conditions, within the succession stages between the initial grasslands and the pine forest, xeric sand calcareous grasslands are formed (6120). This phenomenon does not occur everywhere. In many cases, there is a faster degradation of inland dunes habitat with sandy grasslands (2330) and its total overgrowing. However, focusing only on sandy grasslands, it is clearly seen that their phytosociological diversity is high. Enclosing them within one order of open sandy grasslands *Corynephoretalia canescentis* clearly shows their origin. However, their structure, and sometimes species richness, especially of vascular plants, indicates the geobotanical specificity of particular community. In the case of the Błędowska Desert we are dealing with phytocenoses



Aerial photo of the Błędowska Desert in 1968. The distribution of sandy grasslands (gray shading) on not overgrown sand areas.

The orthophotomap of the Błędowska Desert made in 1996. The dunes areas are hardest overgrowing by sharp-leaf willow and pine.

Dune completely overgrown by with pine forest, situated along the Centuria river, west of the Błędowska Desert. © Michał Węgrzyn

Dunes in the Bory Dolnośląskie fragmentary overgrown by the heather. Ripple marks are visible on the surface of the sand, as a result of aeolian wind activity. © Michał Węgrzyn

of very species-poor sandy grasslands, in which only 3 species of grass dominated, with almost total absence of therophytic species. In the valleys of Warta River, in the area of Natura 2000 Załęczański Łuk Warty, the patches of sandy grasslands at an intermediate stage, between the inland dunes with open *Corynephorus* and *Agrostis* grasslands (2330) and xeric sand calcareous grasslands (6120), occur. On the contrary, the more to the east, the more often well-preserved habitat patches are observed. „Well" does not mean without threats and not undergoing expansion of shrubs. This is evidenced by active protection actions that aim at removing shrubs and trees seedlings from the surface of overgrowing habitats. Examples of this are the projects conducted in the Middle Bug valley.

The monitoring of sandy grasslands habitats

The environmental monitoring, including monitoring of sandy grasslands habitats, is carried out as a part of the State Environmental Monitoring (SEM) supervised by the Chief Inspectorate of Environmental Protection (CIEP). Since the year 2006 all of the tasks related to monitoring have been subcontracted by CIEP to the Institute of Nature Conservation of Polish Academy of Sciences. The reason for efforts to get the highest number of information about valuable habitats in Poland by a large team of scientists and experts is the obligation to conduct an effective nature conservation imposed on all member countries by European Union. Only with the full knowledge on the preservation state, the direction and dynamics of the ongoing changes, the dangers and environmental factors influencing these habitats, the attempts of their effective protection can be undertaken, so that the preservation state will not become worse in the future. Adequate records about necessity of conducting the wildlife monitoring are contained at the global level in the Convention on Biological Diversity (CBD), at European level in the Habitats Directive of European Union and at the national level in the Nature Conservation Act.

In the years 2006-2008, at the first stage of activities the methodology of monitoring conducting for all habitats, including sandy grasslands habitats, was elaborated by the team of specialists. However, before it is quoted, we must first define the basic concepts and laws under which the monitoring is functioning. This information is described in detail in methodological guides „Monitoring of natural habitats" issued under the Environmental Monitoring Library (Mróz 2010, 2012a, 2012b).

The environmental monitoring includes regular observations and measurements of selected components of the living nature (species, ecosystems), carried out in order to obtain the data about the changes occurring in them at a given time and also to collect and update information on the status of other important nature elements and on the direction and rate of their changes. Any information concerning the habitat preservation state in the area, both the good and the bad one, is not itself just a collection of new data, but it is also a further input to gain new experience by people responsible for controlling all the country habitats. Based on observations, measurements and environmental indicators values influencing the habitat, it is possible to assess the habitat preservation state. This

type of research gives thereby the answer what are the optimal values of the indicators with well-functioning habitat. Information about poor habitat preservation state is legally sanctioned basis to undertake actions that will inhibit the degradation process and decline of particular habitat.

The obligation of environmental monitoring is imposed by the law of 16th April 2004 of Nature Conservation as amended (Journal of Laws of 2004 No 92, item 880, as amended). In accordance with Article 112 paragraph 1 „the nature monitoring in the area of biological and landscape diversity is conducted within the framework of the State Environmental Monitoring". Its range is specified in paragraph 2 „the nature monitoring is to observe and evaluate the state and ongoing changes in biological and landscape diversity components in the selected areas, as well as to evaluate the effectiveness of applied conservation methods, including observation of natural habitats and species of plants and animals for protection of which the Natura 2000 site has been designated „and in Article 28 paragraph 10, p. 4 c „the tasks plan of protection for the Natura 2000 sites includes definition of the activities concerning the monitoring of the state of the protection objects". Whereas Article 29 paragraph 8 „the protection plan for the Natura 2000 sites includes the definition of monitoring methods of the conservation status of natural habitats, plants and animals species and their habitats, which are objects of protection". According to the Regulation of the Minister of the Environment of 30 March 2010 concerning the compilation of a draft protection plan for Natura 2000 (Journal of Laws of 2010 No 64, item 401, as amended), the monitoring of habitats and species is one of the essential elements of protection tasks and protection plans for the Natura 2000 sites. Paragraph 3.1 p.10 of this Regulation provides determining the monitoring manners of the conservation status of objects by indicating methods, frequency of research, the scope of observations and data recording methods.

In the opposite approach in accordance with the Regulation of the Minister of the Environment of 17 February 2010 concerning the compilation of a plan of protection tasks for the Natura 2000 sites (Journal of Laws of 2010 No 34, item 186, as amended) „the protection tasks plan for Natura 2000 includes a record about the necessity of determining the protection activities, including especially those concerning the monitoring of the state of the protection objects".

The obligation to conduct the environmental monitoring arises also from the European Union legislation and international conventions, particularly the Convention on Biological Diversity. According to Article 7 countries ratifying the Convention undertake to identify and monitor the components of biological diversity, essential for its conservation and sustainable use, with particular emphasis on those elements that require urgent actions and have the greatest value for sustainable use. The convention entries have been developed in the Habitats Directive, which provides the legal frameworks for the creation of European Ecological Network Natura 2000 – the main tool to maintain biological diversity in the European Union territory. Article 11 of the Habitat Directive states that „Member States will monitor the conservation status of the natural habitats and species of Community interest with particular attention paid to habitat types and priority species". However, ac-

cording to Article 17 of the Directive „every six years, Member States will draw up report on the implementation of actions taken on the basis of the Directive". This report will include, in particular, information concerning the conservation treatments and the assessment of their influence on the conservation status of natural habitat types listed in Annex I and species from Annex II of the Habitats Directive. Thus, the environmental monitoring has strong legal basis, both national and European, resulting from previous findings at the global level.

In the chapter on the characteristics of the sandy grasslands, the habitats have been described in detail in terms of phytosociological approach. Discussed associations belong to two classes, which in turn are assigned to the habitat types. And so the class *Koelerio-Corynephoretea canascentis* (xerophilic grasslands on decalcified dune sands) corresponds to inland dunes with open *Corynephorus* and *Agrostis* grasslands (2330), while the class *Koelerio glaucae-Corynephoretea canescentis* (sandy grasslands) corresponds to priority habitat – xeric sand calcareous grasslands (6120).

The first summary information on the sandy grasslands habitats have been elaborated in „Guidebooks of habitats and species conservation" (Herbich 2004). The inland dunes with open *Corynephorus* and *Agrostis* grassland habitat has been characterized in Volume I „Marine and coastal habitats, coastal and inland salt pans and dunes" (Namura-Ochalska 2004), and xeric sand calcareous grassland habitat has been included in Volume III „Grasslands, meadows, herbaceous meadows, moors, thickets" (Kujawa-Pawlaczyk 2004).

In these studies the knowledge about the sandy grasslands habitats was carefully summarized, including the classification of the vegetation communities into particular types of habitats. The threats were indicated and preliminary general rules for active protection of the habitats were proposed.

With increasing rate of works related to nature monitoring conducted since 2006, knowledge about habitats have been growing all the time. It was necessary to create new elaboration, containing this time wider information about the methodology of monitoring conducting, as well as procedures concerning the tasks of active protection. So far three volumes of „Monitoring of natural habitats" (Mróz 2010, 2012a, 2012b) were published and they were dedicated to the presentation of the monitoring methodology and the use of specific methods of natural habitats conservation.

In the first volume xeric sand calcareous grasslands (6120) (Kujawa-Pawlaczyk 2010) has been elaborated, while in the second the inland dunes with open *Corynephorus* and *Agrostis* grasslands (2330) (Kulpiński and Tyc 2012).

Based on all these mentioned studies and supporting the results of the LIFE+ project in the Błędowska Desert, below the collective methodology of natural habitats monitoring conducting within sandy grasslands were elaborated.

As it was said many times, both habitats (2330 and 6120) cover areas with similar environmental conditions. However, the analysis of these conditions in detail gives clear and fundamental difference. The inland dunes with open *Corynephorus* and *Agrostis* grasslands require the volatile sands being a result of aeolian wind activity. Thus, the vegetation of this habitat type prefers very unstable substrata of barren and acid sands. Expanding grasslands

are all the time exposed to re-burying with new layers of sand, but as it turns out, this sand does not damage the grasslands, even on the contrary – it keeps them in a stable condition. The complete opposite is xeric sand calcareous grassland (6120) that covers the sandy substrata with a stable structure. The more floristically richer and denser grasslands develop only when the quicksands are stopped. It is easy to notice that both habitats can be included in a single chain of vegetation succession in which xeric sand calcareous grassland habitat develops at the site of former inland dunes with initial grasslands.

Having in view above relationships, the indicators and parameters for both habitats were developed. What is interesting, to the assessment of both communities similar indicators are used, but with a different evaluation. A clear difference occurs only in terms of aeolian wind activity. Where, for one habitat (2330) the wind and drift sand are habitat-forming factors, for the second one (6120) the proper preservation state is provided by indeed sandy, but stable substrata. In Table 5 the comparison of indicators for both habitats is presented.

Two basic terms, that have already appeared several times, should be defined at this point. Namely, the parameter, in the nature monitoring, is called a value characterizing the particular habitat, which depends on a number of measurable factors. In the case of „the specific structure and function", this parameter is dependent on a number of factors called indicators. Both parameters and indicators, to be properly evaluated, had to be valorized (Kujawa-Pawlaczyk 2010; Kulpiński and Tyc 2012). Following these authors, in Table 6 the evaluation of parameters and indicators for inland dunes grassland habitat (2330) is presented. The same evaluation but for xeric sand calcareous grassland habitat (6120) shows Table 7.

The method of parameters evaluation – the habitat area and conservation perspectives – is the same for all natural habitats, while the third parameter – the specific structure and function – describes mainly these features which distinguish particular natural habitat and determine its unique character.

The habitat area parameter is an area which is covered by the habitat, expressed in units area (e.g. m^2, ha). When assessing this parameter, observed trend of area changes in a given time is crucial, as well as habitat structure (compact or patched habitat, patches heavily insulated from each other with other vegetation formations, excessive fragmentation etc.).

The conservation perspectives parameter is a forecast of changes occurring in tested site and its surroundings, which may affect the maintenance of a favourable conservation status of the natural habitat within the next 10-15 years. It is an expert assessment, which includes among others information about detected impacts and expected threats, investment plans, current and planned protection regime, and also the effectiveness of existing protection actions. From the point of view of the planned protection activities in the particular area this parameter is the most important one that gives baseline data for further studies. Its assessment gives a picture of how huge work, and thus financial effort, is needed to restore proper state of the habitat preservation. At the same time, at the very beginning this parameter allows to assess the effectiveness and success

Completely degraded fragment of sandy grasslands habitat in the area of the Błędowska Desert. © Michał Węgrzyn

of planned activities. The higher assessment is, the greater probability of improving the habitat state is.

The specific structure and functions parameter is used to determine the habitat type, which we are dealing with, by comparing it with typical forms. This parameter also allows the specification of all relevant environmental factors that influence the particular habitat. During selecting the indicators that characterize this parameter, it was important to capture the environmental factors, both natural and anthropogenic ones. Set of indicators is to answer how do they affect the habitat dynamics.

(2330) – inland dunes with open *Corynephorus* and *Agrostis* grasslands.		**(6120) – xeric sand calcareous grasslands**	
Structure and functions	Characteristic species	Structure and functions	Characteristic species
	Expansion of shrubs and trees		Invasive alien species
	Expansive species		Expansive native species of herbaceous plants
	Invasive alien species		Expansion of shrubs and trees
	Occurrence of aeolian proccesses		The spatial structure of grassland patches
	Percent of the area occupied by the habitat along transect		The preservation of ecotone zone
	Characteristic species of xerothermic grasslands/heaths		
	Other distortions (e.g. trampling, littering)		

Table 5. Comparison of compulsory monitoring indicators of two habitats: the inland dunes with open *Corynephorus* and *Agrostis* grasslands (2330) and the xeric sand calcareous grasslands (6120).

The overall assessment parameter is the final evaluation that includes the evaluation of the three mentioned above parameters, as well as information about the rarity of the habitat occurrence at country level, its distinctive features of development, the specific species richness, etc.

In the situation in which both habitats constitute one sequence of vegetation succession, immediately the questions appear: what in the case where in the particular area both two communities occur? How to decide which one is more important? How to properly evaluate the indicators and parameters? How to protect both habitats when they occur together and the habitat-forming factors are different? Such situation has occurred in the Błędowska Dessert, but probably in other valuable areas it is also present. The solution to this problem is partly connected with the proper approach to the monitoring methods and results interpretation. In fact, the solution of this argument matter is not at the level of monitoring, but at the stage of planning and implementation of active protection actions. The active protection methods will be discussed in a later chapter.

In the case where in the particular area only one habitat occurs, monitoring is based on the appropriate methodology. Indicators corresponding to a particular habitat (2330 or 6120) are chosen. However, when in the field there is a compilation of both habitats, the plan of properly conducted monitoring requires more preparation.

The main methodical assumption is the assessment of natural habitat status along the 200 meters – long and 10 meters – wide transect, in which three phytosociological relevés are located, and where also the assessment of the specific structure and functions of the natural habitat is made. Additionally, the conservation perspectives are determined,

Parameter/ Indicator	Description
Specific structure and functions	
Characteristic species	List of characteristic species based on the „Guidebooks of conservation of habitats and species Natura 2000" (Namura-Ochalska 2004). This list is supplemented by characteristic species from the „Guidebook to the determination of plant communities in Poland" (Matuszkiewicz 2001) – the characteristic species of association *Spergulo vernalis-Corynephoretum* and alliance *Corynephorion canescentis* were selected. There is relatively few species of vascular plants: grey hair grass *Corynephorus canescens,* spurrey *Spergula morisonii*, cress *Teesdalea nudicaulis*, speedwell *Veronica dillenii* and bent-grass *Agrostis vinealis*. There is a large contribution of lichens: *Cetraria aculeata*, *Cladonia floërkeana*, *Cladonia arbuscula* subsp. *mitis* and *Stereocaulon condensatum*. Aditionally, from the list of characteristic species of order *Corynephoretalia canescentis* (and also the class *Koelerio glaucae-Corynephoretea canescentis*), three extra species were selected that are related to the places with not dense vegetation cover: *Jasione montana*, knawel *Scleranthus perennis* and moss *Polytrichum piliferum*. This indicator allows assessing the species richness of the habitat, but does not include the abundance of occurrence of individual species – it is dependent on the total turf stocking, which is subject to significant changes. For some of the species (e.g. lichens) assessment of the percentage in the whole transect is almost impossible.

Tab. 6. Description of specific structure and functions indicators of the nature habitat and the conservation perspectives parameter for the inland dunes with open grasslands (2330) habitat (by Kulpiński and Tyc 2012).

Parameter/ Indicator	Description
Expansion of shrubs and trees	The indicator is described by total coverage of shrubs and trees along transect. Overgrowing with shrubs and trees is one of the main threats to the habitat. It is often the result of planting (especially pine), with the object of economic exploitation of the space occupied by the inland dunes.
Expansive species	This indicator is a total coverage of expansive species along transect. Their growth can lead to permanent loss of the habitat. The species included here are: *Calamagrostis epigeios* and coming form the coastal dunes, but often planted in the habitat, *Elymus arenarius*.
Invasive alien species	The indicator assess the number of invasive species found in transect. More important, however, than the list of species, is their total coverage along transect. The tendency of particular species to permanent capturing of the area and their expansivness should be also taken into account. The most common alien species are *Conyza canadensis*, *Artemisia annua* and *Quercus rubra*. The indicator also refers to alien species that are planted to stabilize the volatile drift sands, which is the initial habitat form. Such species include willow *Salix acutifolia*.
Occurrence of aeolian proccesses	The presence and extent of the processess related to the wind acticity. Their effects can assume different forms from fine wrinkles (ripple marks), through bigger hills formed at the clumps of plants (phytogenic hills) and other obstacles, to the largest sand dunes. The evaluation criterion is mainly timelines of aeolian processes, of which, to a large extent, depends the perspectives of maintaining the habitat.
Percent of the area occupied by the habitat along transect	It is the percentage of the habitat estimated along transect. Habitat usually does not fully occupied the whole transect, however, under some indicator values, the accelerated succession processes and loss of the habitat occur.
Characteristic species of xerothermic grasslands/ heaths	The number of species considered to be characteristic of later succession stages, following the initial sandy grasslands. The indicator does not take into account the often appearing in this habitat species characteristic of habitat type 6120, such as blue hair grass *Koeleria glauca*. Spacies of xerothermic grasslands, heaths, but also pine forests and meadows are included. The most commonly recorded species of this community type are *Hieracium pilosella*, *Deschampsia flexuosa, Achillea millefolium, Dianthus carthusianorum*. The increase in the number of such species shows changes in the habitat and its substantial stability, and thus disappearance of the initial character.
Other distortions (e.g. trampling, littering)	The indicator assesses direct and current human impact on the habitat. It can take a form of littering, but more important is sand extraction, trampling and running over by vehicles. The scale and intensity of these interactions are primarily subjected to the assessment. The intensive exploatation of sand is strongly negative element. Trampling and running over at a moderate intensity can favour maintaining the habitat, however, in the case of considerable increase in distortions (especially running over) the total destruction of the vegetation cover occurs.
The conservation perspectives	This parameter evaluate the opportunities of habitat protection and its maintaining in not-worsening state, with the analysis of possible to imagine factors that will really affect the habitat in the near future. The habitat status is the result of succession processes and the ones destroying vegetation. Therefore both factors should be assessed and if is it probable to achieve a dynamic balance between them.

Tab. 6. Description of specific structure and functions indicators of the nature habitat and the conservation perspectives parameter for the inland dunes with open grasslands (2330) habitat (by Kulpiński and Tyc 2012).

which are the parameter indicating the real opportunities to maintain or restore a proper natural habitat status, with the attempt of active protection. In a standard monitoring methodology overall assessment of the parameters: the specific structure and functions, the conservation perspectives and the habitat area, allows introduction to each locality and area, the total evaluation – the overall assessment of the conservation status. At this point it is worth to mention that the evaluation of all the indicators and parameters is carried out in the same, 3-point scale:

– FV – a favourable conservation status, the target value in all plans of the conservation and restoration of the natural habitats;
– U1 – unsatisfactory status, which indicates a significant deterioration of conservation status. Due to the high sensitivity of the described monitoring method, such assess-

Parameter/ Indicator	Description
Specific structure and functions	
Characteristic species	For the characteristic species are considered the species characteristic of alliance *Koelerion glaucae*, such as: *Silene tatarica*, *Silene lithuanica*, *Corynephorus canescens*, *Sedum sexangulare*, *Dianthus carthusianorum*, *Silene otites*, *Koeleria macrantha*, *Festuca psammophila*, *Astragalus arenarius*, *Ammophila arenaria*, *Festuca vaginata*, *Koeleria glauca*, *Silene borysthenica*, *Dianthus arenarius*, *Festuca polesica*, *Kochia laniflora*, *Alyssum turkestanicum*, *Alyssum montanum* subsp. *gmelini*, *Androsace septentrionalis*, *Potentilla pusilla*, *Chondrilla juncea*, *Gypsophila fastigiata*.
Invasive alien species	The optimal value of the indicator is the lack of invasive alien species. In the study sites, so far, the invasion of alien species has not been observed.
Expansive native species of herbaceous plants	The optimal value of the indicator is the lack of expansive native species of herbaceous plants. In the study sites, so far, only a few expansive species of herbaceous plants have been observed. Those are native species that often occur in a high density, eliminating other species, such as *Calamagrostis epigejos*.
Expansion of shrubs and trees	The optimal value of the indicator is lack or low coverage of shrubs and trees, less than 10% of the area, occuring sporadically. In the study sites, so far, only a few expansive shrubs and trees have been observed. Those are native species that may often occur in a high density, eliminating other species, such as pine *Pinus sylvestris*, birch *Betula pendula*, black locust *Robinia pseudacacia*, blackthorn *Prunus spinosa*, hawthorns *Crataegus* sp., rarelt other species including berberis *Berberis vulgaris*, buckthorn *Rhamnus cartharticus*, juniper *Juniperus communis* and alder buckthorn *Frangula alnus*.
The spatial structure of grassland patches	The optimal values of the indicator are the grassland patches of alliance *Koelerion glaucae*, forming a mosaic with open grassland communities rich in *Corynephorus canescens* (*Corynephorion canescentis*) or species-rich Nardus grasslands (*Nardion*) and with lowland hay meadows of alliance *Arrhenatherion elatioris*.
The preservation of ecotone zone	The optimal values of the indicator are lack of ecotone zone with forest, only a mosaic with other patches of grasslands or meadows.
The conservation perspectives	This parameter evaluate the opportunities of habitat conservation and its maintaining in not-worsening state, with the analysis of possible to imagine factors that will really affect the habitat in the near future. The current conservation status (the presence on protected area protective regime), biotic, abiotic and anthropogenic factors, economic impact and tourism are taken into account.

Tab. 7. Description of specific structure and functions indicators of the nature habitat and the conservation perspectives parameter for the xeric sand calcareous grasslands (6120) (by Kujawa-Pawlaczyk 2010).

ment is often the first sign of progressive worsening of the natural habitat state. The habitat restoration in this state should be relatively simply and after removing factors that negatively affect it, the restoration of favourable status is highly probable;

– U2 – bad status, which is an assessment indicating an extremely significant habitat transformation, strong disturbance of its structure and functions, and what goes with it – limited opportunities of its protection. In this case the habitat restoration process is relatively long and often cost-intensive, with hard to predict effects.

Analyzing the environmental indicators we can point out those that are common to both habitats, including characteristic species, expansion of shrubs and trees, invasive alien species; those that are peculiar to inland dunes with open *Corynephorus* and *Agrostis* grassland habitat (2330) only, namely expansive species, occurrence of aeolian processes, percent of the area occupied by the habitat along transect, characteristic species of xerothermic grasslands/heaths, other distortions (e.g. trampling, littering), as well as those that are relevant only to xeric sand calcareous grassland habitat (6120), namely expansive native species of herbaceous plants, the spatial structure of grassland patches, the preservation of ecotone zone. Analyzing the detailed description of particular common indicators for both habitats, big differences are seen. Table 8 shows the characteristic of elaborated indicators for the 2330 habitat type (Kulpiński and Tyc 2012), while in Table 9 the indicators for the 6120 habitat are presented (by Kujawa-Pawlaczyk 2010).

Parameter/Indicator	Assessment		
	FV	U1	U2
The habitat area	Does not change or increase	Other combinations	A clear decrease in the habitat area compared to previous studies or literature data
Characteristic species	4 and more	2-3	1 or absence of these species
Expansion of shrubs and trees	Up to 40%	40-60%	Above 60%
Expansive species	Cover up to 1%	1-10% cove	Cover above 10%
Invasive alien species	Absence	One species, with the cover up to 5% of transect	Cover above 5% or more than one species (independently of the cover)
Occurrence of aeolian proccesses	Active aeolian proccesses procesy (sand blown on tufts of grass, phytogenic hills)	Traces of former aeolian processes (e.g. former phytogenic hills, smaller dunes overgrown by shrubs)	Only well established, e.g. large dunes mostly overgrown by forest
Percent of the area occupied by the habitat along transect	Above 30%	10-30%	Up to 10%
Characteristic species of xerothermic grasslands/ heaths	1 or absence of these species	2 or 3	Above 3

Tab. 8. The evaluation of selected state parameters and the specific structure and functions indicators of the inland dunes with open grasslands (2330) (by Kulpiński and Tyc 2012).

Parameter/Indicator	Assessment		
	FV	U1	U2
Other distortions (e.g. trampling, littering)	A small numer of ruts ans tracks, lack of sand extraction, trace littering	Few roads or large numer of ruts and trucks; trace scale of sand extraction, average littering	Most shrub- and treeless area of transect without vegetation cover due to human activities or significant sand extraction; very big littering (including unauthorized landfill)
The habitat area	Does not change or increase	The slight decrease in the habitat area (up to 10%)	Decrease in the habitat area by more than 10% compared to previous studies or literature data
Overall structure and functions	All cardinal indicators were evaluated as FV, other indicators as at least U1	All cardinal indicators were evaluated as at least U1	One or more of the cardinal indicators were evaluated as U2
The conservation perspectives	Good or excellent preservation perspectives of the habitat, the significant impact of threatening factors is not expected	Average preservation perspectives of the habitat – a significant impact of threatening factors, probable deterioration of the state or decrease in the habitat area	Bad preservation perspectives of the habitat, a strong impact of threatening factors is observed, the habitat endurance can not be guarantee in the long term
Overall assessment	All parameters were evaluated as FV	One or more of the parameters were evaluated as U1, absence of U2 parameter	One or more of the parameters were evaluated as U2

Tab. 8. The evaluation of selected state parameters and the specific structure and functions indicators of the inland dunes with open grasslands (2330) (by Kulpiński and Tyc 2012).

Within all indicators for both habitats 6120 and 2330, the ones essential for assessing the structure and functions of the habitat, so-called cardinal indicators, were designated (Tab. 10).

Besides making the assessment of the habitat parameters and indicators, an integral part of the monitoring at particular site is to perform 3 phytosociological relevés. They are necessary in order to accurately description of the study area phytocenosis. The relevés must have an area of 25 m^2, two of them should be located at the opposite transect ends and one in its middle. In each relevé the list of species of plants, bryophytes and lichens is made, at the same time assigning them to the vegetation layers: A - trees, B - shrubs, C - vascular plants, D – undergrowth of mosses and lichens. For all recorded species the assessment of abundance is made, which is the percentage of the taxon in the patch of the relevé. For this purpose the standardized Braun-Blanquet scale is used: percentahe range of 1% is labeled as +, up to 5%-1, 5-25% – 2, 25-50% – 3, 50-75% – 4, 75-100% – 5. At the beginning, using such a scale poses a lot of problems, but over time the simplicity of usage and quick-

Indicator	Assessment		
	FV	U1	U2
The habitat area	Does not change or increase	Other combinations	A clear decrease in the habitat area compared to previous studies or literature data
Characteristic species	There are at least 5 vascular plant species among all mentioned characteristic species	There are at least 2 to 5 vascular plant species among all mentioned characteristic species	There is 1 vascular plant species among all mentioned characteristic species or absence of these species
Invasive alien species	Absence of these species	Invasive species are single and do not cover more than 5% of the area (up to 2 species)	Invasive species are abundant and cover more than 5% of the area (more than 2 species)
Expansive native species of herbaceous plants	Absence of these species, optionally one species occuring individually	One or two species occuring in the dispersion	More than two species forming compact patches
Expansion of shrubs and trees	None or low trees and shrubs coverage, less than 10% of the area, occuring sporadically and in the dispersion	Trees and shrubs coverage ranges from 10 to 25% of the area (shrubs do not form compact thickets) and occur in the dispersion	Trees and shrubs coverage above 25% of the area (form compact thickets) and occur in clusters
The spatial structure of grassland patches	The grassland patches of alliance *Koelerion glaucae*, form a mosaic with open grassland communities rich in *Corynephorus canescens* (*Corynephorion canescentis*) or species-rich *Nardus* grasslands (*Nardion*)	The grassland patches of alliance *Koelerion glaucae* form the majority of the mosaic with lowland hay meadows of alliance *Arrhenatherion elatioris*	The grassland patches of alliance *Koelerion glaucae* form the minority of the mosaic with lowland hay meadows of alliance *Arrhenatherion elatioris* or initial forests
The preservation of ecotone zone	The lack of ecotone zonewith forest, mainly mosaic with patches of other grasslands or meadows	Most often it is a sharp boundary grassland-forest, not adjacent to patches of temporary communities	The boundary grassland-forest or grassland-meadow is not clearly distinguished. The grassland goes smoothly into the forest, or other non-forest community type (meadow, temporary communities etc.)
Overall structure and functions	All cardinal indicators were evaluated as FV, other indicators as at least U1	All cardinal indicators were evaluated as at least U1	One or more of the cardinal indicators were evaluated as U2
The conservation perspectives	Good or excellent preservation perspectives of the habitat, the significant impact of threatening factors is not expected	Other combinations	Bad preservation perspectives of the habitat, a strong impact of threatening factors is observed, the habitat endurance can not be guarantee in the long term
Overal assessment	All parameters were evaluated as FV	One or more of the parameters were evaluated as U1, absence of U2 parameter	One or more of the parameters were evaluated as U2

Tab. 9. The valorization of selected state parameters and the specific structure and functions indicators of the xeric sand calcareous grasslands (6120) (by Kujawa-Pawlaczyk 2010).

(2330) – inland dunes with open *Corynephorus* and *Agrostis* grasslands	(6120) – xeric sand calcareous grasslands
Characteristic species	Characteristic species
Expansion of shrubs and trees	Invasive alien species
Occurrence of aeolian proccesses	Expansive native species of herbaceous plants
	Expansion of shrubs and trees
	The spatial structure of grassland patches

Table 10. The list of the cardinal indicators of sandy grasslands habitats – the inland dunes with open grasslands (2330) and the xeric sand calcareous grasslands (6120).

ness of this method is becoming more appreciated. It is worth noting that with such wide ranges it is easy to overestimate or underestimate the contribution of the species. It usually takes place in the case of early-stage researchers. As practice, the estimates are more accurate and thus more representative and repetitive at many researchers.

According to the methodology of the State Environmental Monitoring the determination os study sites should happen in the Natura 2000 sites, within a homogeneous habitat patches. Usually, within one Natura 2000 area up to several study sites are determined, wherethe monitoring is carried out. However, the presented monitoring methodology can also be used in totally different projects, and what is the moast important it can be modified as the needs of the project.

Information on the natural habitats in Poland, despite numerous projects, is permanently insufficient. Old data, mainly literature ones, are generally heavily outdated and the information copied from them often only pose problems during confrontation with reality. The tool, which the environmental monitoring is, enables opportunity of rapid analysis that we are dealing within the study area. The monitoring is often planned as a stage of the project. The aim of its realization is usually to confirm the presence, structure, threats and perspectives of the conservation status of a habitat. It is important for planned methodology that it can be modified during the project realization. The example can be sand habitats considered as successional stages. Determination of the boundaries between patches of different stages is sometimes extremely difficult, especially in the case of small, poorly noticeable differences. Due to environmental conditioning, the sandy grasslands may be very poor floristically, but the presence of characteristic species defines it as a xeric sand calcareous grassland habitat (6120). Such species-poor grasslands, by the structure, can be also considered as inland dunes with open grassland habitat (2330). The results of the LIFE+ project in the Błędowska Desert, used to the preparation of the protection activities plan for Natura 2000 the Błędowska Desert (Mróz 2014), have shown that 2330 habiat does not have to be formed on the dunes. Just the presence of loose, drift sands, on which not compact, floristically poor grasslands will form, is enough. Of course, in the case of floristically rich sandy grasslands, where the number of vascular plant species increases up to 30 species, and colorful undergrowth patches in the turn of the month May/June clearly determine the habitat borders, there will be no problem of correctly describing the plant association. The given examples highlight the necessity of checking the area before beginning to plan the monitoring and verification of its methodology.

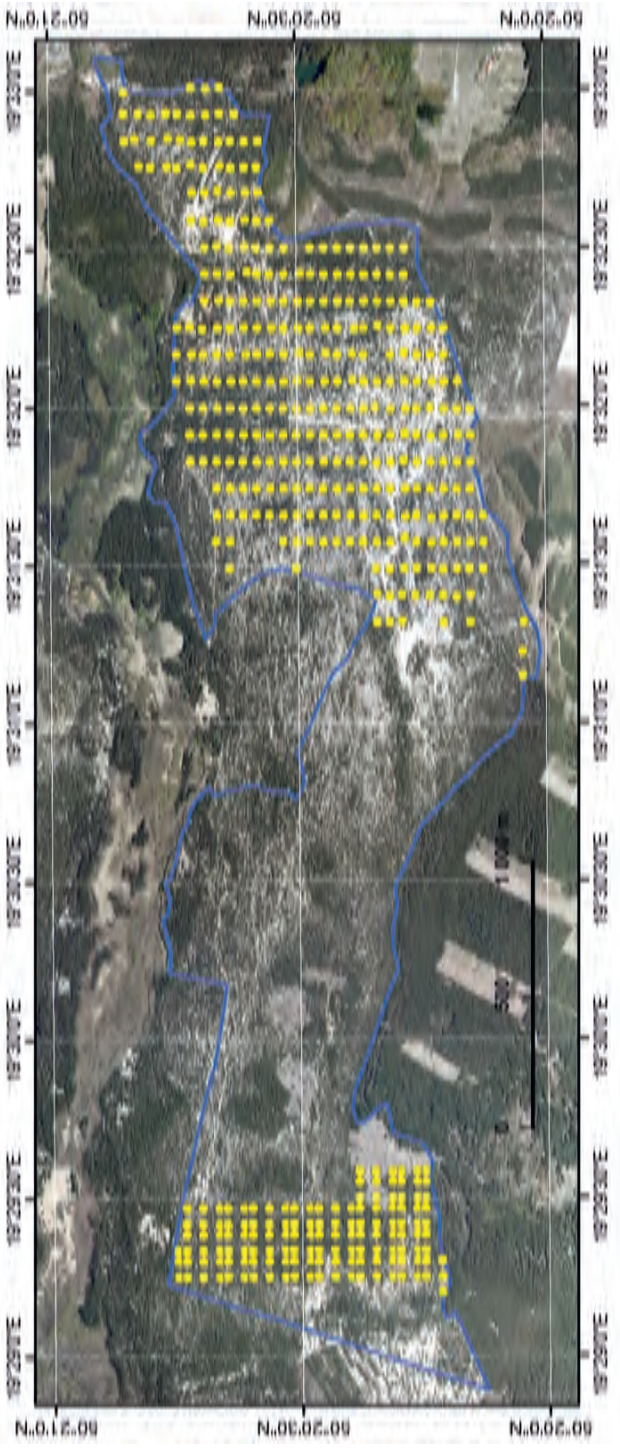


Fig. 7. Location map of research areas in the form of transects in the southern part of the Błędowska Desert (project LIFE+ Błędowska Desert).

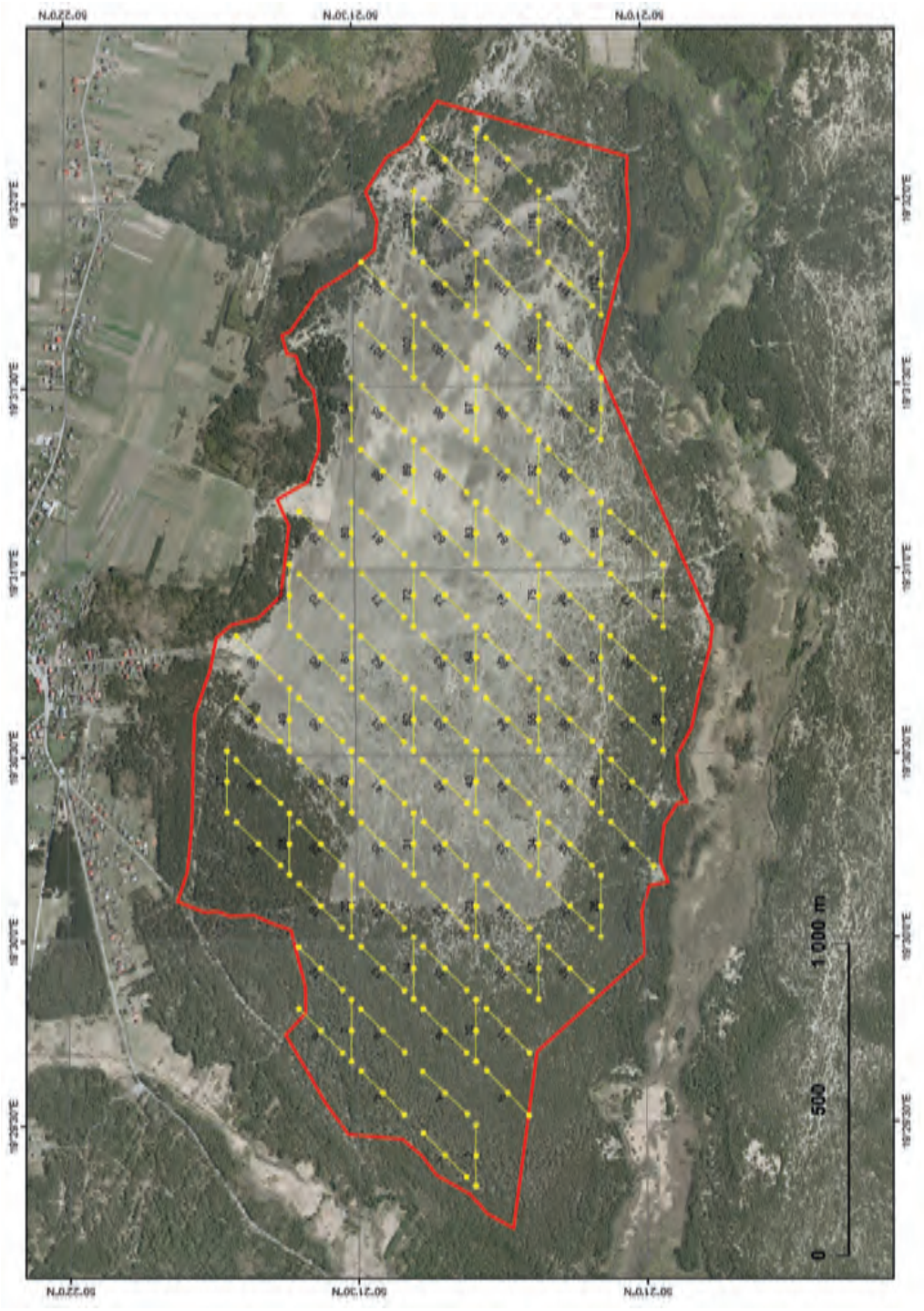


Fig. 8. Location map of research areas in the form of transects in the northern part of the Błędowska Desert (project LIFE+ Błędowska Desert).

Depending on the results of the preliminary assessment of the area, the approproate indicators should be chosen and proper evaluation should be used. Of course, when we are dealing only with the habitat of the inland dunes with open *Corynephorus* and *Agrostis* grasslands (2330), the complete monitoring of this habitat is used. In a situation where the habitat patches indicate floristically rich sandy grasslands, the indicators of the xeric sand calcareous grasslands (6120) are used. However, in the case where in a given area both habitat types coexist, the indicators should be compiled to show the variability of the structure and functions in the whole study area.

In the case of projects, which goal is to protect the sandy grasslands, the environmental monitoring should be carried out in the entire area covered by the project. Study sites must be distributed to cover the largest surface area. They also must show the habitat variability, which characterizes the area. In the case of the Błędowska Desert study sites as transects were located very densily, that resulted in obtaining a fairly detailed data on the variability of the sandy grasslands habitats in the desert (Fig. 7 and 9).

The analysis of sandy grasslands habitats threats

Results of the nature monitoring of sandy grasslands habitats (2330 and 6120) in Poland, in the framework of the State Environmental Monitoring (Kulpiński and Tyc 2012; Kujawa- Pawlaczyk 2010), do not contain a detailed analysis of the threats that have a negative impact on sandy grasslands habitats. Only the examples of the threats, which, according to authors, to a different extent affect the habitat, are mentioned. Implementation of the project in the Błędowska Desert and the analysis of available data allowed selecting the main threats that may negatively affect the conservation status of sandy grasslands habitats.

Analyzing the threats, they should be divided into those that have an impact on the conservation status of the habitats throughout the whole country, as well as those whose presence and intensity differs from a region. At the same time, the entire group of these threats, to a different degree, contributes to the habitat degradation, and in some cases, even at low intensity, is habitat-forming. All threats are discussed in detail in Table 11. They are based on the list of the interactions in accordance with Annex E of the Standard Data Form for the Natura 2000 areas.

Code	Type of influence	Description
0 A04.03	The cessation of herding, lack of grazing	The cessation of herding, because of economic reasons or prohibitions, causes disturbances in the sandy grasslands habitats dynamics. After several years a slow phenomenon of grasslands overgrowing with shrubs and tree seedlings is seen. Regular grazing eliminates the excess of organic matter in the habitat, what inhibits the eutrophication of the substrata.
0 B01	Afforestation of open, non-forest areas	Common phenomenon occurring still in the 1990s in connection with intentional afforestation of open areas, sandy grasslands and heaths. Afforestation completely destroys the sandy grasslands habitats
0 C01.01.01	Sand and gravel quarries	Many places, where currently the sandy grasslands habitats occur, are remains of the open gravel and sand pit mines activity. Re-operation in abandoned mines constitutes a threat to sandy grasslands habitats.

Table 11. Analysis of the interactions that negatively affect the conservation status of sandy grasslands habitats.

Code	Type of influence	Description
0 G04.01	Cessation of use for military purposes	As the examples of sandy grasslands habitats in several military zones show, the sustainable military activities have a positive impact on the conservation status of grasslands. Military zones are usually open areas where good conditions for grassland vegetation occur. Closing the military training fields causes overgrowing of the open areas.
0 H04	Air pollution, airborne pollutants	The increase in air pollution in the twentieth century contributed to the substrate stabilization and overgrowth of sandy areas in Europe.
0 H04.02	Nitrogen providing	Pollution from nitrogen compounds causes the development of prokaryotic and eukaryotic algae.
0 K02	Biocenotic evolution, succession	The succession is a permanent phenomenon characterizing the sandy grasslands habitats. With a well-functioning ecosystem and with a participation of proper external factors (aeolian wind activity, herding) succession in limited.
0 K02.02	The organic matter accumulation	Accumulation of organic matter is a result of the rapid overgrowth of sandy grasslands with shrubs and trees. Pine needle dropping activates the soil-forming processes.
0 K02.03	Eutrophication (natural)	Natural eutrophication is the result of the organic matter decomposition. The more organic matter in habitat is, the clearer euthrophication phenomenon is, which leads to fertilization of the substrata. The increase in the fertility causes the overgrowth of the habitat with shrubs and trees, which as a consequence increases even more the number of accumulated organic matter. This is a typical example of feedback in sandy grasslands ecosystem.
0 K02.04	Acidification (natural)	The threat od natural acidification, e.g. as a result of overgrowing with coniferous tree species, causes vanishing of thermophilic sandy grasslands plant species, which prefer neutral or slightly acidified substrata.
0 K04	Interspecific interactions among plants	The phenomenon of displacement of one plant species by another with expansive character, usually representing conifer forest habitats.

Table 11. Analysis of the interactions that negatively affect the conservation status of sandy grasslands habitats.

Sandy grasslands habitats protection program in Poland

Following numerous projects about rescuing overgrown xerothermic grasslands, an attempt of setting the actions course to elaborate a detailed program of sandy grasslands habitats protection in Poland was undertaken. It is a very difficult task due to the area extent, which occupy reported within Natura 2000 sandy grasslands habitats. As a result of conducting the State Environmental Monitoring, information on the conservation status and planned changes, which will occur within these habitats, is gained. All the time there is a lack of the summarized data on the conservation status of all inland dunes with open grassland habitats (2330) and xeric sand calcareous grasslands (6120) in the country. Such information is necessary to plan effective actions of active protection, estimate the costs that are needed to save overgrown grasslands, and in the future to maintain the grasslands in optimal stadium. After reading the chapter on dynamics and ecology of these specific semi-natural habitats, we can gain conviction that it is very difficult to achieve. On the other hand, different voices can appear: Why protect something that is not natural habitat, but in a half it is a human work?

Voices against are often the result of ignorance of the conservation value scale of these habitats. Curiously, we watch the nature films about distant countries, where incredible ecosystems, rich in plant species creating the living places for exotic animals, occur. The inland sandy areas in Europe are the natural sensation at the same scale around the world. Nowhere else outside Europe they occur in such shape, structure and relations between vegetation and animals.

Irrespectively of the rules and obligations that European Union legislation impose on the Member States on the environment and nature protection, at the global level the Convention on Biological Diversity, which is an international agreement signed on 5th of June 1992 at the Earth Summit in Rio de Janeiro, determines the principles of protection, multiplication and use of biodiversity resources. It is clearly said that the main purpose of the convention is to protect the world's biological diversity, the sustainable use of its components and honest and equitable assignment of benefits arising from exploitation of genetic resources, including appriopriate access to genetic resources and appriopriate transfer of relevant technologiest, taking into account all rights over those resources and technologies, and appriopriate funding.

Aerial view of cleaned south part of the Błędowska Desert. © Gmina Klucze

Sandy grasslands habitats, including the priority thermophilic sandy grasslands (6120), as well as many other valuable habitats being protected throughout Europe, should be covered by the protection program. Such types of programs as well as projects on the protection of similar grassland habitats are mainly implemented in the framework of the LIFE program funding, also in other Eurepean countries, since the problem of their degradation does not occur only in Poland. The common feature of these initiatives is planning and management of the habitat protection within Natura 2000 areas. In the case of projects implemented in Polish territory, the scale of habitat areas, where the active protection actions are conducted, is significant. Only in relation to the Błędowska Desert itself, actions of two projects together are carried out in the area of 770 ha. The experience gained during their implementation will be very important while planning more such projects in the future.

The crucial question, which should be put in the context of active protection is – how to protect the sandy grasslands habitat? It can be assumed that the answer to this question is one of the results achieved during the project implementation in the Błędowska Desert. The answer should be the basis to develop a program of sandy grasslands habitat protection throughout the entire country.

The stages of this study should be as follows:

1. Inventory of habitats within the Natura 2000 sites, where the sandy grasslands habitats 2330 and 6120 were demonstrated, in order to: confirm the habitats presence, correctly identify the habitat type and, as far as possible, community in terms of phytosociological approach, the overall assessment of the conservation status, including identification of particular causes that threaten the habitat. An important action at this stage is also tracing the history of the land use in a given area over the twentieth century, partly explaining the genesis of particular habitat patches. This information is necessary for proper planning of active protection actions.

2. As the first stage would be carried out by many experts, the evaluation of collected data is necessary by preparing the environmental monitoring conducted by trained people based on the methodology presented in the „Monitoring of natural habitats. Methodological guidebook" (Mróz 2010, 2012a, 2012b) and in this handbook.
3. Creating a database based on the visualization of the data in GIS technology containing the results of monitoring.
4. Selection of the main threats that cause the sandy grasslands habitats degradation in particular Natura 2000 areas in the country.
5. Preparation of the ranking list of Natura 2000 sites, depending on the level of sandy grasslands habitats degradation threat, occurring in their area. In the ranking the following elements should be taken into account: the main objective of the protection in a particular Natura 2000 area, area of sandy grasslands habitats, the conservation status, identification of threats, the protection perspectives, predicted financial outlays in relation to the real effects of active protection, undertaken so far active protection actions.
6. On the basis of conducted studies as a part of the inventory and environmental monitoring, for each Natura 2000 site, within which the occurrence of sandy grasslands habitats were confirmed, a detailed plan of active protection should be performed.
7. On the basis of the ranking list the active protection actions within Natura 2000 areas would be implemented in the correct order.

These seven steps mentioned above aim at management of sandy grasslands habitats protection in a sustainable manner, so that in the first step the actions would be taken in areas where the situation absolutely requires it.

Planning of the active protection actions should be based on careful field observations, which effect is the current data about the habitat. Historical data, including literature ones, can be used as a supplement to attempt of the habitat dynamics characterizing over the years. The ranking list of the Natura 2000 habitats can not be created based only on literature data because the sandy grasslands communities have been so dynamic in recent years that descriptions and characterizations made a few years ago may already be out of date.

In the chapter on the dynamics of sandy grasslands habitats the simplified diagram of their formation is presented, together with successional changes that occurred in the habitats. When planning the protection actions we may relate to the general scheme, trying to define the observations and assign them to the particular stages. Of course, every case of the grassland habitat occurrence in Poland may have its own unique character, but basically the whole process shoul not be too different from the general pattern.

Of all the threats that affect the sandy grasslands habitats, the main is the substrata eutrophication increase leading to the acceleration of succession process and rapid overgrowth of grasslands by shrubs, and finaly by trees, especially pine.

When planning the activities, it should be noted that the early stages of shrubs and trees succession are much easier to eliminate than well developed stands. In the first case only manual works, involving the cyclic pulling out seedlings and underground rhizomes

Manual work in order to remove organic matter from the dunes areas, where the fragments of sandy grasslands are preserved. The picture is also showing the sand carried by the wind. © Michał Węgrzyn

The identification and implementation of deflation fields, which was associated with the use of heavy equipment to remove the entire plant biomass. © Michał Węgrzyn

and also cleaning the area from dead organic matter, are enough. In the case of heavily overgrown grasslands, the use of equipment and machinery is needed to grub up the habitat area. The principle saying that the more overgrown area of habitat is, the more radical actions must be undertaken, can be accepted. This is mainly due to the intensity of transformations, which occur within the habitat under the influence of developing layer of shrubs and trees: the amount of dead organic matter increases rapidly what increases the thickness of the humus level. In addition, the soil structure completely changes: from the initial forms to the soils of forest communities. In the case of heavily overgrown grassland, we should expect not only the necessity of felling and grubbing up the habitat area, but also removing the top layer of soil. Furthermore, it should be remembered that in the case of inland dunes with open grassland habitats (2330), works should be planned so as to expose large areas of bare sand, as well as determine the area of deflation fields, which are the places from which the wind may blow the sand. In the case of very intense overgrowing processes of sandy grasslands, the strong wind activity within the habitat is the most significant factor preventing the germination of trees and shrubs seedlings.

The proportion of the blowout (deflation field) areas to areas occupied by the sand, grasslands should be minimum 1:1. In the optimal option the deflation fields should have a slightly larger area than the grasslands.

The big problem is to plan the use of heavy equipment for felling and grubbing up the bigger trees within the existing grasslands. In the case of the habitat on inland dunes, the protection of existing geomorphological forms should be also taken into account. They are usually completely overgrown and stabilized. However, removal of shrubs and trees, as well as dead organic matter from these areas, should be done carefully so as not to destroy the dunes by using the heavy equipment. After the blowouts restoration and activation of the sand carried by the wind, the existing dunes will be again covered with the sand, what will positively affect creating the grasslands on their surfaces. In order to protect the geomorphological forms only felling of the pines to the ground level and abandonment of grubbing up their pine stumps may be considered. Such actions will not cause digging up the entire dunes. Over time, the remains of the stumps will be covered by the new layers of sand.

On the one hand, the use of heavy equipment facilitates and accelerates the work but on the other hand such activities are more expensive, and moreover they may endanger the existing grasslands in the area. Therefore it is important during planning to determine areas, where only manual works are to be carried out. In practice, the deflation fields formation should only be done by machines. In contrast, cleaning the sandy grasslands from the shrubs, trees and organic matter should be carried out by hand in most cases. With regard to the inland dunes grasslands (2330) that regenerate very quickly, the use of heavy equipment does not have such a negative impact as in the case of xeric sand calcareous grasslands (6130) formed on stable substrata. Perturbation of such a substrata structure can disrupt the dynamics of the entire habitat.

In the case of xeric sandy grasslands (6120), which are not provided by aeolian wind activity, disposable cleaning the habitat from overgrowing shrubs and trees will bring only

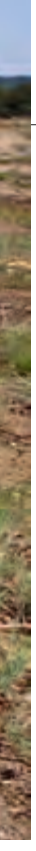
The dunes areas, where the pines were only cut. Rootwood were left in order to protect the geomorphological forms. This picture was taken before manual cleaning of habitat surface from organic matter. © Michał Węgrzyn

temporary conservation status improvement – in the long term perspective the secondary succession probably will occur. The cyclic repetition of grubbing up young trees and shrubs will doubly affect the habitat. Firstly, the removal of shrubs improves the habitat light conditions, and secondly, together with grubbed up trees and shrubs, accumulated in the habitat organic matter will be removed each time. Thus, the habitat substrata will become poorer. Over time, the intensity of overgrowing processes should gradually decrease.

The cattle and sheep grazing on sandy grasslands areas have been so far mentioned many times. In the twentieth century the sandy areas covered by grasslands were some kind of additional way to supplement the cattle and sheep diet. These areas were regarded as wasteland, and therefore leading the informal grazing was something totally normal. Animals grazing lasted many years and its continuity formed the sandy grasslands habitats, just as it happened in the case of the herothermic grasslands. Prohibition or abandonment of grazing caused overgrowing of these habitat types.

In the case of sandy grasslands, planning of the sheep grazing should be considered. However, due to low nutritional value of vegetation, grazing can not be planned only on the basis of sandy grasslands habitits. Because these habitats often neighbor with the xerothermic habitats, grazing can be planned on the basis of these two habitats.

Both sheep and cattle contribute not only to inhibiting the overgrowing process, but also, by leaving droppings with different plant seeds, to the spread of vegetation in the habitat area.



So far in this chapter has been focused on the vegetation of sandy grasslands, which as a part of the active protection should be protected. However, during planning the nature compounds that as a result of long-term habitat succession found there a place to settlement or existence should be taken into consideration. This refers to both plants and animals. Clearing the sandy grasslands can not happen at the expense of protected or valuable species of fungi, plants and animals. Therefore, it is such an essential element to conduct the inventory of nature. With regard to the reported species the nature valorization and appriopriate actions minimalize the negative effects of the planned works should be undertaken.

Active protection actions planning is extremely difficult and complex process, during which all possible data describing the history of a particular habitat formation have to be used. These data should be confronted with a detailed inventory, as well as with the results of the environmental monitoring. All nature elements that occur in the project area should be included and it should be assessed how the new habitat conditions will affect them. The planning process should be based on the experience gained by others in similar projects. The results and observations should be, if possible, quickly accessible to a public forum, so as to serve better planning of new further projects.

Why the Błędowska Desert – a case study

Introduction

The project, which results in restoration of the Błędowska Desert, the largest area of loose sand in Poland, is a big challenge. The measure of a success is: knowledge of the area history, finding the answer for a question what caused that the desert disappeared in such a short time and knowledge on the dynamics of vegetation communities, which the most important forming factor is sand.

Currently the Błędowska Desert consists of two latitudinal parts separated by the Biała Przemsza River valley. The entire area, due to the unique vegetation and a great natural value, has been covered by the protection within the Natura 2000 area the Błędowska Desert. The desert covers almost 2000 ha and includes approximately 600 ha of the nature habitat complexes: the inland dunes with open *Corynephorus* and *Agrostis* grasslands (2330), the xeric sand calcareous grasslands (6120), *Asperulo-Fagetum* beech forests (9130), bog woodlands (91D0) and alluvial forests with *Alnus glutinosa* and *Fraxinus excelsior* (*Alno-Padion*, *Alnion incanae, Salicion albae*) (91E0). However, the most significant natural value of the

A general view of the southern part of the Błędowska Desert, which dominated in 2012. © Michał Węgrzyn

Archive photo showing the Błędowska Desert in the mid-twentieth century.

whole Natura 2000 area the Błędowska Desert is complex of sandy grasslands occurring in different successional stages and overgrowing the sandy surfaces and dunes formed as a result of aeolian wind activity.

The Błędowska Desert is one of the most interesting areas in terms of nature and landscape in Poland. The phenomenon of occurrence of the vast sandy areas devoid of vegetation is unique in a temperate climate region. A number of factors, both natural and anthropogenic, contributed to the desert formation, but its time continuity over nine centuries has developed a unique desert landscape known from other latitudes on the Earth.

The Błędowska Desert lies in the eastern part of the Silesian Upland, in the vicinity of the Upper Jurrasic cuesta of the Kraków-Wieluń Upland. During the Pleistocene glaciations, and more specifically during the Odranian and Vistulian Glaciations, in this area the huge deposits of gravel and sand were accumulated. The thickness of these deposits in some places reaches 30-70 meters. The whole material was drifted by glacial rivers, which transported large amounts of fluvioglacial material accumulated during Kraków Glaciation (the South Polish Glaciation) in the Kraków-Wieluń Upland. The sandy-gravel material was carried out from that place by rivers and filles the system of pre-Quaternary deep valleys.

Since the beginning of the warm Holocene period the dense mixed forest communities began to overgrow the entire area. However, over time, about 5000 years ago, these areas were covered with a dense pine forest. In medieval times, within the current desert timber, needed to functioning of primitive steelworks, was harvested. Unrestricted felling

led to completely destruction of pine forests and formation, for the first time, the sandy desert areas.

The exposure at the same time such large surface area activated the aeolian denudation processes associated with activities of the western and south-western winds. Currently the area of volatile sands is very limited to only approx. 700 ha, which represents less than 5% of the former desert area that extended from Chechło, Błędów and Klucze, to the areas in the south of Olkusz, to the village Bukowno. In the southern areas the name „Starczynowska Desert" functioned that was located west of Olkusz, and also the name „Dziadowskie Morze" near Biskupi pine forest in the areas of Bukowno. Currently in these sites the former sand mine area occurrs, which in the most part is forested.

Territorially, the current Błędowska Desert refers to that one which boundaries were clearly determined in the aerial photos from the 1950s and 60s. Even then, it was only a small fragment of former huge desert – majority of its area was forested in the middle of the twentieth century. It can be said that only a small fragment between Błędów and Klucze has remainded, which for the longest time resisted the efforts of local and state authorities, aimed at wasteland afforestation. In the past, the Błędowska Desert was treated as one big wasteland, which had to be developed. However, the attempts undertaken till the 1950s did not totally bring any results. The success of the afforestation of the last desert fragment was achieved only due to the increasingly intensifying air pollution from the west. Probably then it was not known that the complete elimination of the desert was caused by the nitrogen compounds and on-soil algae.

One question remains – why the entire area, whose history was presented, is called desert, while the meteorogical data clearly suggest that the conditions occurring in the area from Olkusz to Błędów do not determine the formation of the desert. The Błędowska Desert does not differ form adjacent areas in terms of climatic conditions. The average annual temperature which is 7.5°C and average annual rainfall which is 650 mm exclusive the climatic desert genesis.

The name „desert" is the common name that was used by the local people in relation to sandy areas covering a large surface, where similar geomorphological phenomena that occur on real deserts, are observed.

Because in the history of this area both field trainings and hostilities took place there, in the first phase of the project the detailed inspection of the area to detect the remains of military use was carried out, such as unexploded shells and other dangerous objects buried in the sand. Planning the active protection actions in the frame of the project also required conducting a detailed inventory of nature, aimed at learning about the nature of this area and inventory of all species of plants, fungi and animals, detailing the protected and endangered species. The task of environmental monitoring performed before and after the protection actions aimed at assessing their effectiveness. The most important and most difficult task was certainly to carry out the active protection actions, which is nothing more than felling, grubbing up trees and removing organic matter from the area of the desert.

Based on the data from the state Environmental Monitoring in the Błędowska Desert the termophilic sandy grassland of tufts grass – sand fescue *Festuca psammophila* and blue

hair grass *Koeleria glauca* occurs. This association, with a distinctly contintntal character, is characterized by low, loose grasslands, with numerous tufty grasses, mostly of xeromorphic shoots structure and strongly developed root system. Inland sandy grasslands in the Błędowska Desert occur in the more stabilized ground, in the sites where the aeolian wind activity is strongly limited or completely disappeared. Plant succession is not inhibited and the inland dunes with open grasslands habitat (2330) is slowly transformed into species-richer grasslands. In the case of the Błędowska Desert the increase in number of vascular plant species is not high, but the significant increase in the coverage of the area by grasses and sparse flowering plants is seen. Thus, it should be emphasized that the sandy grasslands in the Błędowska Desert are poorer in species than other syntaxa qualified for this habitat. It is seen mainly because of therophytic (annual) species lacking. In spring the desert is not covered by a carpet of flowering vascular plants, but besides it is still one of the largest complex of this habitat in the country.

In the Błędowska Desert, due to the far-reaching habtat degradation within Natura 2000 sites, realization of active protection required huge financial outlays. In the case of grasslands in the early stages of successional overgrowing, manual removal of small trees and shrubs did not cause major problems. However, removal of the 15-meter high pines in the area between Klucze and Błędów was not easy work.

In order to gain appropriate funding an application for the LIFE+ program has been submitted. The project realized in the Błędowska Desert (the municipality of Klucze, Małopolskie voivodeship) was financed by the European Union in the frame of the Financial Instrument for the Environment LIFE+, The National Fund for Environmental Protection and Water Management and budget of Klucze municipality. Tha main objective of the project is to restore and maintain the proper conservation status of the largest Polish complex of the inland dunes with open *Corynephorus* and *Agrostis* grasslands (2330) and the xeric sand calcareous grasslands *Koelerion glaucae* (6120). The most important task of the project was restoration of the proper conditions in the Błędowska Desert to allow not only preservation of existing sandy fragments, but also the spread of the mentioned above natural habitats of Community interest. Therefore, undertaken active protection actions included the removal of trees and shrubs (mainly scots pine *Pinus sylvestris*, birch *Betula verrucosa* and willows *Salix acutifolia* and *Salix arenaria*) and undiserable herbaceous vegetation as well as litter layer occurring on sand.

The LIFE+ project in the Błędowska Desert

The entire project has been divided into stages and tasks that were implemented by various contractors. Part of the initial tasks was to elaborate a detailed methodology of the essential works related to cleaning the area of the desert. Also the sapper works were made to allow removing of trees. The main task, felling and grubbing up trees and shrubs, was implemented for the longest time as the hardest and most expensive one. Due to the fact that in the Błędowska Desert there is a network of hiking trails, a study concerning the popularization of a new form of the whole area as a tourist product had to be prepared. This action had a significant value because only by showing the desert as a tourist attraction, reaching the wider bodies with topics related to the active conservation of the natural habitats is possible.

By creating new educational-natural paths, restoration and re-setting of PTTK hiking trails, the Błędowska Desert becomes not only a valuable natural area, but also a place where in the frameworks of the school trips the educational goals can be realized among children and teenagers.

Also within the project a number of educational as well as scientific workshops were organized in order to present the main goals of the implemented project, as well as the results and problems that the concrators faced during the work. Sometimes, the field training workshops were organized as a part of the inventory of nature, when f.ex. students took part in the counting of game in the nearby Olkusz Forest District.

One of the project effects was also organization of an international conference, to which the represantives of science, institutions and organisations related to nature conservation were invited. The aim of the conference was also to present the results concerning the ending project and to encourage participants to undertake the implementation of new projects in the frameworks of the LIFE program.

The main objectives of the projects are written below, and in the following chapters their main backgrounds and implementation are widely presented.

- The preparation of the ground for the introduction of the active protection actions – detecting the occurrence of misfires and unexploded shells;
- Inventory of nature, environmental monitoring and scientific expertises;
- Nature monitoring and monitoring of the active protection actions effectiveness

Sapper patrol during the inventory of digged dangerous objects in the Błędowska Desert. © Gmina Klucze

- Active protection of sandy grassland habitats, including manual or mechanical grubbing up trees, rare and dense coppices, and also scattered thickets together with wood deportation and cleaning the site;
- The preparation and maintaining the website about the project;
- Organization of an international conference;
- Organization of a seires of workshops;
- Elaborating, editing and publication of the guidebook of protection of sandy grassland habitats;
- Creating of The Desert Information Center;
- Creating of two educational paths together with demonstrative sites.

Sapper works

Because of the history of the whole Błędowska Desert area, mainly field trainings and hostilities that were conducted on its territory, it was essential to clean the area from dangerous and explosive objects of military origin before starting any field works within the project. For this purpose standard techniques of magnetometric studies and ground-penetrating radar were used in the area of 400 ha.

In total, the task was carried out almost throughout the year. The effects of the undertaken sapper works the best indicate the necessity of their implementation. As a result 3803 pieces of dangerous and explosive objects of military origin were found and destroyed. The

Research with geosonar, which allows to detect dangerous objects at greater depth. © Gmina Klucze

various elements of military weapons, whose presence in the desert posed a serious threat to humans, were found. These were both large bullets and small ammunition. Among the remains of military use the anti-tank and anti-personnel mines were recorded. Below the list of dangerous objects found within the desert is presented: 1 piece: air bomb – over 250 kg, 8 pieces: air bomb 100-250 kg, 27 pieces: air bomb 50-100 kg, 182 pieces: air bomb up to 50 kg, 4 pieces: artillery ammunition over 120 mm, 4 pieces: artillery ammunition 76-120 mm, 22 pieces: artillery ammunition 37-75 mm, 1 piece: rifle and pistol ammunition, 2 pieces: artillery shell over 120 mm, 79 pieces: artillery shell 76-120 mm, 22 pieces: artillery shell 37-75 mm, 3 pieces: artillery shell 20-36 mm, 5 pieces: missiles, 439 pieces: mortar grenade 50 mm, 265 pieces: mortar grenade 81,82 mm, 9 pieces: mortar grenade 120 mm, 2 pieces: hand grenade, 35 pieces: rifle grenade, 90 pieces: rocket propelled grenade, 2 pieces: anti-tank mine, 4 pieces: anti-personnel mine, 42 pieces: remotely-delivered mine, 214 pieces: fuses, 83 pieces: propelling charges, 2156 pieces: other/fins, 118 pieces: shell with the content of explosives.

Abiotic elements of the Błędowska Desert

The Błędowska Desert climate

Although the origin of the Błędowska Desert is not conditioned by climatic factors, the climate deserves special attention, since it is responsible for all the geomorphological processes that occur in the discussed area. In addition, the observations of shifting dunes, car-

ried by the wind sand, the formation of rillstones, deflation pavement, ripples and other desert forms caused that local population began to define the area commonly as a desert.

On the basis of the measurement data form climate stations located close to the desert from the years 1961-1990 (later transformed into precipitation stations), provided by the Institute of Meteorology and Water Management, as well as the data presented in work of Pełka (1994) the characteristic of anemological and precipitation conditions in the desert environment was made.

The desert lies in the area of variable wind direction during the year. The time of wind blowing from only one direction without a break does not exceed four days. In both locations west (representing the average of 16,4% in Ząbkowice and 22,2% in Olewin) and south-west winds (15,5% and 13,5%, respectively) clearly dominate. In both stations also a significant contribution of winds blowing from east (13,9% and 13,8%) is shown. Together, the winds of the broad W sector: SW-W-NW are listed in Ząbkowice in 43,3% of cases, and in Olewin in 45,5% of cases. In the E sector: SE-E-NE respectively 27,6% and 27,8% of cases occur. The smallest share have S winds (4,8%) in Ząbkowice and NE ones (5,4%) in Olewin. Attention is also paid to the high frequency of wind silence occurance: from 12,7% (Olewin) to 16,0% (Ząbkowice).

In Ząbkowice the winds of western sector dominate during most months: W winds in February and from August to October (17,1-19,5%), SW winds from December to January (19,1-19,8%) and NW winds between May and July (20,1-20,3%). In March, April and November the eastern winds dominate (17,8-24,1%).

The most frequent winds are also characterized by the highest average speeds. Average long-term wind speeds recorded in Ząbkowice are: for winds of western sector – 2.9 m/s (3.1 m/s from W, 3.0 m/s from SW), of eastern sector – 2.6 m/s (3.0 m/s from E); in Olewin for winds of western sector – 3.4 m/s (3.6 m/s from W, 3.3 m/s from SW), of eastern sector – 3.0 m/s (3.4 m/s from E). The lowest average wind speeds are characteristic for SE winds (2.2 m/s), S (2.3 m/s) and N (2.4 m/s) in Ząbkowice, and also SE (2.6 m/s), S (2.7 m/s), N and NE (3.0 m/s).

Average wind speeds do not vary during the year in a wide range. In Ząbkowice the highest average speeds are recorded in the period from February to May (above 2.4 m/s) with a maximum in March (2.9 m/s) and a minimum in July (1.9 m/s).

The dominance of winds with a speed range less than 2 m/s (44,1% in Ząbkowice and 38,7% in Olewin) and 2.5 m/s (32,7% and 38,0%, respectively) in both stations is clearly seen (Pełka 1994). Morphologically effective winds of a speed exceeding 4 m/s (Borówka 1980) occur more rarely – in Ząbkowice 6,4% and in Olewin 10.54%.

In the case of morphogically active winds, even clearer dominace of western sector winds in both stations is seen, especially in Ząbkowice. In Olewin, there is a significant share of eastern sector winds.

In Ząbkowice, among strong winds, with the speed of 10-15 m/s, the western wind contribution is 34,0%, SW – 21,6%, E – 22,7%. In Olewin, also strong W winds

of this speed dominate – 39.8 %, E – 23.5%, SE and NW – 10.8 % each. The smallest shares have in Ząbkowice southern winds – 1,0% and in Olewin south-eastern – 1,2%.

The same wind directions dominate among very strong winds with the speed exceeding 15 m/s. In Ząbkowice W winds constitute 39,3%, SW – 28,6%, E – 14,3%, while in Olewin W winds have 43,8%, SW – 18,8%, E and NW – 12,5% each. In this speed range southern winds are not represented in Ząbkowice, and the same are SE winds in Olewin. Maximum wind speeds reach up to 16 m/s (Szczypek and Wach 1993b).

The majority of days with winds exceeding 10 m/s occurs in February and March (in Ząbkowice 2 days), and with wind of less than 15 m/s speed in March and August (0.4 days). Days with wind speed greater than 10 m/s are absent in June and with speed greater than 15 m/s in June and December.

The anemological conditions in the Błędowska Desert probably are not much different than those occurring in its outskirts. The extent of the desert in the latitudinal direction does not cause deviation of dominant wind directions (W and E). In contrast, opening the area to the west causes that as the most frequent and morphologically the most effective western wind can be recognized. Higher frequency of stronger winds from the western sector in relation the eastern sector and other winds confirms the exposition of leeward dune slope and the direction of collapsing sand dune laminae. Any permanent record of morfogenetic influence of sector E winds was not admitted. Microforms caused by the impact of these winds are ephemeral and quickly transformed by the opposing winds. In the desert, due to its flat surface, wind can reach higher speeds compared to the values recorded in the meteorogical stations.

Average day number with precipitation per year is similar in both stations: in Olewin it is 158,4 days, and in Ząbkowice – 160,0. In both stations also the lowest number of days with precipitation (on average less than 10 days) is recorded in September and October, with a minimum in October (in Olewin 9,7 and in Ząbkowice 9,8, respectively). The stations differ in terms of the period with the highest number of days with precipitation. In Olewin most of these days occur on average from December to February (more than 14,5), with a maximum in February (15,6 days), while in Ząbkowice the period with more than 14,5 days with precipitation is recorded in May, July, and from November to January with a maximum in May (16,0 days).

Different situation is in terms of the average monthly day number with precipitation higher than 10 mm per day. In Olewin most of these days occur from May to August (more than 2,5 days) with a maximum in July (4,3 days), while in Ząbkowice from June to August (more than 2,5 days) with a maximum in July and August (3,9 days each). The lowest number of such days (less than 1 day) is recorded in Olewin in December and February with a minimum in December (0,7 day), and in Ząbkowice in January and February (0,2 day each).

The average annual rainfall on the outskirts of the Błędowska Desert ranges from 670 mm (Błędów, Ząbkowice) to 800 mm (Chechło, Klucze). The highest monthly rainfall is characteristic for the period from May to August, when the highest intensity

rainfall occurs. At that time, the average monthly rainfall ranges from 70,4 mm (May) to 108,8 mm (July). The lowest rainfall per month, from 31,3 mm to 34,9 mm, is recorded in January and February.

During the year, an average of 106 days with dry ground occurs (without any precipitation and 1-2 days after rainfall). The distribution of rainfall during the year, compared with annual frequency and speed of the wind, presents favourably as regards the conditions for aeolian processes. The lowest rainfall coincides with the period of the dominance of W and SW winds, reaching also at the same time the highest speed (over 10 m/s). In contrast, the highest rainfall is recorded during the winds with the lowest speed. The period promoting aeolian processes, with high-frequency and high-speed of the wind affecting dry ground, is winter and early spring time. The highest frequency of the days with strong wind and minimum rainfall occurs in February. The worst conditions for aeolian processes, with low wind speed and wet ground, are during summer.

Geomorphology, the characteristic of the desert forms

Geomorphology of the area as the most visible and common part of the environment constitutes the basis for conditioning the existence of almost every valuable environmentally area. The Błędowska Desert, also considered as one of the most interesting areas in Poland in terms of nature and landscape, owes its significance mainly specific aeolian terrain relief and geomorphological processes that form it. For many years, until the ground was stabilized by vegetation, the contemporary active development of aeolian forms was unique in Europe. It gave the area desert landscape features, with shifting dunes, phenomena of sandstorms (Sosnowski 1947; Łaskawiec 2003) and mirages (Bałuka and Tritt 2001). Many of the existing there forms may be considered as valuable from the scientific, educational and landscape point of view.

The Błędowska Desert is located in the eastern part of the Silesian Upland on the border of the Kraków-Częstochowa Upland. It occupies the part of the Mitręga Basin, between Błędów, Chechło and Klucze. It is a part of so-called the Great Desert, extending further in the direction of Olkusz, Bolesław and Starczynów. It is situated within boundaries of the Orle Gniazda National Landscape Park. The Biała Przemsza River, crossing the desert from east to west, divides it into two unequal parts: the smaller one in the north and bigger in the south. The area being under the intensive conservation project is located in the central and eastern parts of the southern desert, between Klucze in the east and Kozi Róg in the west, and between the Biała Przemsza riverbed in the north and the middle part of the Biała Przemsza River in the south. It is the part of the desert with the most diversified terrain relief.

The inventory of forms within the project area was conducted in May and June 2013. Also forms located directly outside the boundary of the project, endangered by the transformations after the deforestation of adjacent areas, were taken into account. During the inventory some parts of the area have been already deforested and exposed to the wind

activity, however trying to predict the expected relief transformations as a result of the vegetation removal – in the typology of the forms only these areas that had been active before the trees felling were included to the areas of active deflation.

Geological structure

The Błędowska Desert is located within Silesian-Cracow Anticlinorium. It was prepared in Triassic and Jurassic silts (Kozioł 1952; Kiryk and Kołodziejczyk 1978). The basin is surrounded by Middle Trassic limestones and dolomites in the south, and Upper Jurrassic massive and platy limestones (Znosko 1953; Kiryk and Kołodziejczyk 1978). Middle Triasic dolomites occur additionally in some places near Klucze, limited by tectonic dislocations. On the surface they are exposed in the slopes of the Biała Przemsza Valley near Błędów. Triassic and Jurrasic deposits are inclined 5-10°NE (Przemycki 1929; Kiryk and Kołodziejczyk 1978). Both Triassic deposits in the desert ground as well as Jurrasic ones in its border (Klucze region) are cut by faults that predisposed the course of the Biała Przemsza Valley.

The basin is filled by the Quaternary deposits. Beginning from the floor those are: preglacial or Pleistocene limestone rubble with sand without the northern material, ice-dammed deposits: silts, loess clays, sandy silts and clays of the Great Interglacial, calcareous tufa, rubble and sand, clean layered quartz sand reaching the greatest thickness among all the Quaternart sediments (Kozioł 1952; Krzyżkiewicz 1952; Kotlicka 1969). Sands locally lie directly on the ground or on the residual soil.

Sands are the deposits of different age. Their accumulation occurred in several stages, from the Great Interglacial, mainly from the Odranian Glaciation, to the last glaciation inclusive approx. 200-11 thousand years ago (Lewiński 1914; Kozioł 1952; Gilewska 1972; Biernat 1984; Szczypek and Wach 1989; Lewandowski and Zieliński 1990). The genesis of the sands is complex. In their accumulation could be engaged glacial (Lewiński 1914; Kozioł 1952; Gilewska 1972; Biernat 1984) and river waters washing off moraine deposits of the Sanian 2 Glaciation from the Upper Jurrasic cuesta plateu (Krzyżkiewicz 1952), ice-dammed waters (Krzyżkiewicz 1952), precipitation and river waters (Różycki 1960), precipitation waters (Szczypek and Wach 1989; Lewandowski and Zieliński 1990; Sendobry and Szczypek 1991). The surface sand layer (1-3 meters) has the features of aeolian cover, remodeled by the wind during the last glaciation and the Holocene period (Biernat 1984; Szczypek and Wach 1995a).

Sands are lithologicaly uniform throughout the whole desert, consisting of feldspars, garnet, zircon, touchstone, quartz, glauconite, with a small content of northern material. Only in the marginal parts of the desert the contribution of limestone grains is growing (Kozioł 1952).

The sand is mainly fine- and medium-grained (Kozioł 1952; Alexandrowiczowa 1962; Biernat 1984) – in 88% composed of 0,5-0,1 mm fraction (Adamczyk 1957). The share of coarse grains increases from the west to east, according to the prevailing wind direction (Krawczyk and Trembaczowski 1986).

The sand thickness is differential. On the western and eastern ends of the study area it is 12 to 20 meters (Przemycki 1929; Kozioł 1952), and the maximum of 45 to 79 meters (Kozioł 1952; Kotlicka 1969; Kiryk and Kołodziejczyk 1978) reaches in the axis of the Przemsza ice-marginal valley (Kozioł 1952; Krzyżkiewicz 1952; Znosko 1953; Alexandrowiczowa 1962; Kiryk and Kołodziejczyk 1978; Krawczyk and Trembaczowski 1986). Deep, fossil form of the Przemsza ice-marginal valley with a width of 300 m up to 1,5 km runs longitudinally along the foot of the cuesta from Klucze towards Starczynów (Kozioł 1952). The Holocene silts, sands and peats with a 2 meters thickness fill the bottom of the Biała Przemsza Valley.

The relief

The Błędowska Desert occupies the part of pre-Quaternary (Kiryk and Kołodziejczyk 1978) denudational depression of the Mitręga Basin, prepared in Triassic and Jurassic silts (Kozioł 1952) by the Biała Przemsza River. It lies in almost completely closed basin – from the north-west, north and east limited by the elevation of structural ridges in cuestas type and by rocky monadnocks. In the south-west the Basin is closed by the Middle Triassic ridge (the Muschelkalk) extending from Sławków through Bukowno, Podlesie, Rudy, Kuźniczka and Krzykawka, built of limestones and dolomites inclining to the north-east. It consists of plateaus, horsts and hillocks with wavy or flat surface 3 to 5 kilometers wide and over 370 meters above sea level high (30 to 80 meters of relative height) (Przemycki 1929; Znosko 1953; Kiryk and Kołodziejczyk 1978). From the east and north the Basin is limited by the Jurrasic cuesta, extending through Olkusz, Pomorzany, Klucze, and Chechło to Błędów (Przesmycki 1929). It is formed by plateaus with flatten tops, built of massive and platy limestones (Znosko 1953), with maximum-height of 449 meters a.s.l. (40 to 120 meters of relative height) (Kozioł 1952; Znosko 1953; Chramiec 1959). With the rock inclination to the north-east, the hills have steep western slopes (Przemycki 1929). North of Klucze, between Czubatka and Bucza Góra, the cuesta is cutted by faults (Przemycki 1929; Kozioł 1952), which divided it into a number of parallel horsts and subsidences, determining tortuosity course of cuesta. Its elevations coincide with horsts and bays with subsidences.

In the foreground of retreated cuesta in Klucze and Rodaki (Czubatka) occur calcareous, karsted (with forms of sinkholes called karst dolines, cavities and other karst landforms) monadnock elevations called 'świadki' or 'świadek mountains' (Przemycki 1929; Chramiec 1959; Kiryk and Kołodziejczyk 1978). Cuesta and rock forms near Klucze are fragmented by latitudinal, flat-bottomed valleys filled with sand, with bottoms passing into the sands of the desert (Kiryk and Kłodziejczyk 1978).

The Błędów depression is a denudational depression prepared by Przemsza, which at the turn of Pliocene and Quaternary (Koziol 1952; Krzyżkiewicz 1952) cut out a subsequent valley within little resistant Keuper clayey sediments. During Pleistocene glaciations this form was completely filled with sand and gravel deposits of various origins and currently forms the fossil valley preserved in sub-Quaternary basin bottom. It runs through the desert from the north to south towards Starczynów and Bukowno,

along the foot of the Jurrasic cuesta, at a distance of 0,5 to 1,7 km from its slopes and in Klucze region it merges with the current valley of the Biała Przemsza River (Kozioł 1952). It is an isoclinal structure that moving together with layers inclination to the north-east has reached the width of 300 m up to 2 km, with a bottom situated more than 50 m below the current valley floor. Along its axis the Quaternary sediments reach a maximum thickness.

The current valley of the Biała Przemsza River crossing the desert from east to west is flat-bottomed form, 1-1,2 km wide and 70-150 m deep, cut in clays and shales. Within the desert the riverbed of the Biała Przemsza is characterized by the width of 4-5 m, a slight inclination (315-295 m a.s.l.) and a winding course. It cuts into the sand to the depth of 2 to 6 meters, directly undercutting the sandy shores or it is separated by floodplain. The riverbed tends to move to the north, thus mainly right bank is undercut creating in some places scarps. The left bank is occupied by lower terrace levels.

In the Biała Przemsza valley four terrace levels were distinguished (Lewiński 1914). The lowest flood level with a height of about 1 meter (Tyszkiewicz 1959) is built of silts and sands. It forms on the left bank, along the riverbed, 50-300 meters wide belt of wet, swampy, silty-peat riverside plain with wetlands and oxbow lakes. The second, higher Holocene terrace (3-4 m of height) is built of sand (Chramiec 1959).

Sandy-gravel formations build two Pleistocene terraces: vistulian (having 5 meters in height and lying outside the study area) and 7 to 10 meters high backfilling level from the Odranian Glaciation, forming the area of the desert. It rises higher in the southern bank of the Biała Przemsza than in the northern one. This area, in the south-eastern desert edge is cut to a few meters by source niche and valleys of the Biała and Białka. The source part of the Biała valley, currently periodically only drained, is characterized by a broad (300 m), swampy bottom and shores of various heights, from which the northern elevated is a dune ridge.

Sandy plain forming the area of the desert, transformed by the wind activity (Kozioł 1952), almost flat in the center, with a slope of 2-3°, in the marginal parts and at the Biała Przemsza river is raised by the dune ridges. It lowers in the west direction from 325 m a.s.l near Klucze to 302 m a.s.l near Błędów. It lowers also into the north.

The Biała Przemsza divides the desert into two parts characterized by different landform due to different location related to the surrounding hills, which modify the directions and speed of the wind. The smaller, northern part of the desert almost perfectly flat, in the center is characterized by deflation relief with rillstones and deflation troughs. Dunes formed only on the outskirts, mostly in its eastern fragment. Much larger southern part, with accumulation-deflation relief, is characterized by more varied topography. The study area is in the east and central part of the desert which is located south of the Biała Przemsza and has the most interesting terrain relief and the greatest diversity of aeolian forms.

In the landscape of the desert the most visible forms are definitely dunes. Dune forms are characterized by uneven distribution, different sizes and shapes. Most of them

were built under the influence of W and SW winds. All were ultimately formed in the period of years 1930s to 1960s, and then fixed. The largest dune concentration occurs on almost whole circumference of the former desert (of the second half of the 20th century). The area is bordered by distinct marginal dune ridge. Its origin is related to the forced sand deposition due to increased air friction of tight forest belts or an increase in soil humidity on the border of sandy level and lower Holocene terrace. The highest dune ridges (16 m) surround the study area from the south, along the source part of the Biała valley and former forest boundary and from the north along the valley of the Biała Przemsza River. Marginal ridges are complex forms of longitudinal shapes with latitudinal extent. Only at the Biała Przemsza the arc-shaped ridge imitates the course of the edge of the Pleistocene terrace. Ridges are characterized by a great length (up to 1300 m), a distinct continuity, uneven surface with different sizes of synclinic deprssions and irregular, domed or elongated hills. Their opposite slopes have similar inclinations, only locally within the southern marginal dune ridge the asymmetry of slopes is marked, the most visible on the ridge passing in the slopes of the Biała valley (slopes inclination on the desert side is 10-15°, and on the valley side is 20-40°).

In the eastern part of the desert at the foot of the Upper Jurrasic cuesta several different-sized single and complex transverse dunes, suited by its longitudinal course to the shape of the hills (Krawczyk and Trembaczowski 1986). Those are echo dunes formed as a result of the wind reflection from the topographic obstructions (Przemycki 1929). Dunes are arranged in several parallel rows. They include large-sized forms of up to 8 meters high, 1020 meters long and 160 meters wide. The largest of them have shapes of combined ridge and arched forms, ridge lines of aligned profiles, smooth slopes with a distinct asymmetry of inclination: 6-10°W and 24-32°E. The dune ridges are separated by deflation throughs and depressions.

In the middle of the desert distribution of dunes is uneven, and their shapes and sizes are various (Alexandrowiczowa 1962). The largest, but sparse complex and transverse dunes dunes occur in the western part of the area south of Kozi Róg. To the east of the desert, dunes become more numerous, smaller, different-shaped, with a predominance of longitudinal ridges forms and a large number of irregular forms. Around many isolated large dunes, on the leeside and windside the zone of drifted sands spreads.

In the central part of the area the largest dunes are complex forms and transverse ridges. Compound dunes were created of merged together tranverse and longitudinal forms or ridge and arched, characterized by different mobility. In their crest parts the secondary forms of depressions and the culmination occurs, which reach up to 11 m of height, 650 m length and up to 140 m width.

Transverse dunes longitudinally elongated are massive forms but not high (3-8 m of height) of considerable legth (up to 400 m) and widthup to 90 m. They are characterized by clearly visible slopes asymmetry (6-15°W and 20°E). They have not aligned crest lines with the secondary mounds, and smaller of them often with two culminations often resulted from combination of dome dunes.

Linear dunes with a course of SW-NE, W-E, NW-SE, occur in the whole area. Their sizes increase west from 5 to 180 m of length and from 3 to 50 of width. The yreach the height of 4 m. They have assymetrical slopes: southern on is gentle and northern is steep. The forms of not aligned crest lines and with two cumulations in the Klucze area, sperated with the depression, could arise from a combination of set in rows dome dunes.

Dunes of other types are sparce. In the center of the area and north of Czubatka several dunes with a shapes similar to barchans occur, with short 'horns' drawn to east, rarely to north-east with well-developed middle part and distinct asymmetry of slopes (10°W and 24-32°E). The forms represent initial stage of barchans development, or they were formed under the influence of unfavourable conditions characterized by often changing wind directions. Dome dunes, which length is almost the same as width, are small (3-6 m of height) and they are arranged in rows next to each other. A lot of dunes are irregular forms with shapes that are conditioned by distribution of vegetation clusters.

Sandy mounds belong to the phytogenetical forms. They form due to stopping the sand in the shade of vegetation clusters. They are very numerous, mainly in the south-eastern part of the desert: near paper mill in Klucze, south of Czubatka, near the shelter in the desert center. Larger accumulation of these forms occurs in the marginal parts of the deflation areas. They form longitudinal, transverse, linear with a course of W-E and NW-SE, arched, domed, ellipsoidal and irregular distensions with the secondary mounds. They are arranged along SW-NE, W-E, NW-SE line or they are chaotic distributed. They reach the height of less than 1 m to 3 m, the length of 1-10 m and width of 1-6 m. Their slopes W and E (leeward and windward) are symmetrical, inclined 12-16° to 22°.

The deflation forms include deppressions and deflation troughs. The deflation depressions create forms of shallow (1,5-3 m deep) depressions of oval shapes. Outside the area at the Biała Przemsza the lack of dune association of the largest of them with dunes is characteristic; however, some of them in the Czubatka area occur in the dunes foreland. Others were located in the areas of local whirlpools, associated with the field or vegetation obstacles. Some deflation depressions have forms of deflation troughs of SW-NE direction (near Czubatka). They were created due to dunes disruption or in a narrow area between forests.

Small (1-2 ha), not stabilized by vegetation fragments of the desert are called active deflation fields. They are located mainly in south-eastern and central part of the study area. They are concentrated along roads, touristic trails, and rarerly in the depressions between dunes. Most of them form almost flat areas. Only a few have a shape of shallow depressions. Some of them are varied by presence of several meters large deflation monadnocks. These are nowadays modeled by the processes of deflation, transport and aeolian accumulation. Within them the microforms of aelolian relief occur. Deflation pavement is composed of the rocky fragments, mostly 0,5-2 cm (maximum up to 10 cm) in diameter, with different petrographic composition. They include limestones, flint-

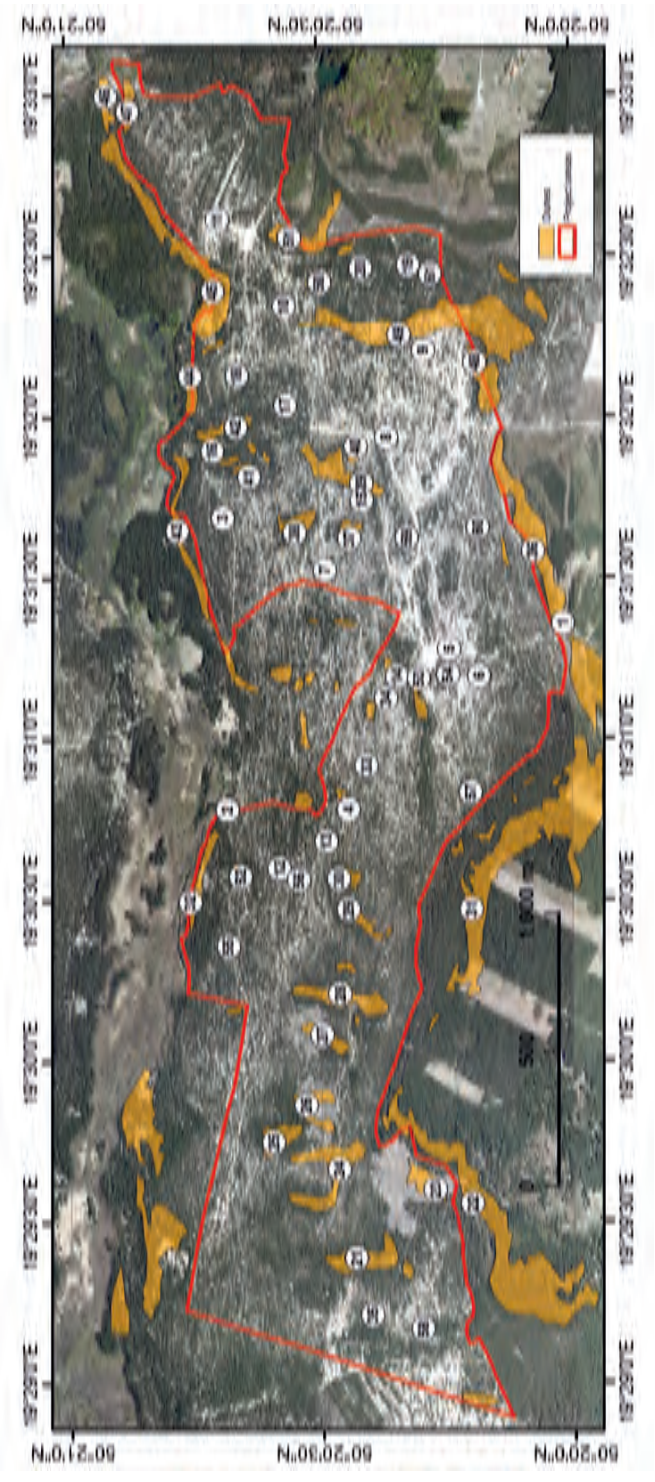


Fig. 9. Distribution of the geomorphological forms after their valorization.

No of form	Name of landform	Importance of the location on the scale of Natura 2000 area *	Explanation
1	Source part of the Biała valley	A	An example of periodically dehydrated valley, loosing the water in sands due to human activity and drop in ground water level. Great landscape values.
2	Riverbed of the Biała Przemsza	B	An example of functioning sandy-bottomed riverbed. Active processes of erosion, transport and river accumulation and development of bedriver formsin dune area. Great landscape values.
	Flood level of the Biała Przemsza	C	The course of current development of the alluvial deposits outside the riverbed and floodplain forming.
3	The area of the Biała Przemsza terrace from the perod of the Odranian Glaciation	C	Fragment of Poland largests inland area of sands of high thickness and one of the largest, until recently, modeled by the wind.
4	Deflation surface	A	The area not fixed by vegetation, actively modeled by the wind. Active processes of deflation, transport and sand deposition, and contemporary development of aeolian microforms. Great landscape values.
5	Deflation surface	A	
6	Deflation surface	A	
7	Deflation surface	A	The area not fixed by vegetation, actively modeled by the wind. Active processes of deflation, corrassion, transport and sand deposition, and contemporary development of aeolian microforms. Great landscape values.
	Dunes of barchan types	A	Forms of barchans documate the stage of increased activity of aeolian processes and indicate the conditions of their formation. The shape of forms and asymmetry of slopes permits reconstruction of the direction of the dune-forming wind.
8	Deflation surface	A	The area not fixed by vegetation, actively modeled by the wind. Active processes of deflation, corrassion, transport and sand deposition, and contemporary development of aeolian microforms. Great landscape values.
9	Deflation surface	A	
10	Deflation surface	A	
11	Deflation surface	A	
12	Deflation depression	C	It documates the stage of increased activity of aeolian processes and indicate the existence in the past larger than currently deflation surface undergoing wind activity. It allows estimating amount of blowing out sand. Significant distance from the dunes can indicate high mobility of dunes or drifting the material over long distances by the high speed wind.
13	Deflation depression	C	

Table 12. Summary of inventoried landforms.

No of form	Name of landform	Importance of the location on the scale of Natura 2000 area *	Explanation
14	Deflation depression	C	Example of deflation syncline at the foot of the dune. It documates the stage of increased activity of aeolian processes and indicate the existence in the past larger than currently surface undergoing wind activity. It allows estimating amount of blowing out sand. It is an indicator of dunes mobility or length of the dune-forming phase and directly the direction of dune-forming wind.
15	Deflation depression	C	
16	Deflation depression	C	
17	Deflation depression	B	Not-working form, fixed by vegetation. It documates the stage of increased activity of aeolian processes and indicate the existence in the past larger than currently surface undergoing wind activity. It allows estimating amount of blowing out sand. It is an indicator of dunes mobility or length of the dune-forming phase and directly the direction of dune-forming wind. Significant distance from the dunes can indicate high mobility of dunes or drifting the material over long distances by the high speed wind.
18	Deflation depression	B	
19	Deflation depression	C	Example of not-working, fixed by vegetation deflation syncline at the foot of the dune. It documates the stage of increased activity of aeolian processes and indicates the existence in the past larger than currently surface undergoing wind activity. It allows estimating amount of blowing out sand. It is an indicator of dunes mobility or length of the dune-forming phase and directly the direction of dune-forming wind.
20	Deflation depression	C	
21	Transverse dune	B	It documates the stage of increased activity of aeolian processes. Orientation and shape of form and asymmetry of slopes are the record of the dune-forming wind direction and conditions of its activity and grade of dune mobility. Great landscape values.
22	Complex longitudinal dune	B	It documates the stage of former increased activity of aeolian processes. Its location determines the course of the border of drift sands area and forest in the dune-forming period. It demonstrates the complexity of dunes forming involving vegetation. Great landscape values.
23	Transverse dune	B	It documates the stage of increased activity of aeolian processes. Orientation and shape of form and asymmetry of slopes are the record of the dune-forming wind direction and conditions of its activity and grade of dune mobility. Great landscape values.
24	Complex transverse dune	B	It documates the stage of increased activity of aeolian processes. Dune shape, indicating the complexity of its construction, determines diverse mobility or age of the included forms, longevity or multiphase of dune-forming processes and changes in the wind direction. Great landscape values.

Table 12. Summary of inventoried landforms.

No of form	Name of landform	Importance of the location on the scale of Natura 2000 area *	Explanation
25	Transverse dune	B	It documates the stage of increased activity of aeolian processes. Orientation and shape of form and asymmetry of slopes are the record of the dune-forming wind direction and conditions of its activity and grade of dune mobility. Great landscape values.
26	Complex arched dune	B	It documates the stage of increased activity of aeolian processes. Dune shape, indicating the complexity of its construction, determines diverse mobility or age of the included forms, longevity or multiphase of dune-forming processes and changes in the wind direction. Great landscape values.
27	Transverse dune	B	It documates the stage of increased activity of aeolian processes. Orientation and shape of form and asymmetry of slopes are the record of the dune-forming wind direction and conditions of its activity and grade of dune mobility. Great landscape values.
28	Transverse dune	B	
29	Transverse dune	B	
30	Transverse dune	B	
31	Complex longitudinal dune	B	It documates the recent stage of increased activity of aeolian processes. Its location determines the course of the border of drift sands area and forest in the dune-forming period. It demonstrates the complexity of dunes forming involving vegetation. Great landscape values.
32	Complex longitudinal dune	B	It documates the stage of increased activity of aeolian processes. It is an example of the form with location and shape forced by the substrata wetness.
33	Dome dune	C	It documates the stage of increased activity of aeolian processes. It is an example of initial stage of dunes development. The role of vegetation in the dune-forming processes.
34	Deflation surface	A	Not fixed by vegetation area actively modeled by the wind. Active processes of deflation, corassion, transport and deposition of sand and contemporary development of aeolian microforms. Great landscape values.
35	Deflation depression	C	It documates the stage of increased activity of aeolian processes and indicate the existence in the past larger than currently surface undergoing wind activity. It allows estimating amount of blowing out sand. Significant distance from the dunes can indicate high mobility of dunes or drifting the material over long distances by the high speed wind.

Table 12. Summary of inventoried landforms.

No of form	Name of landform	Importance of the location on the scale of Natura 2000 area *	Explanation
36	Complex longinudinal dune	B	It documates the stage of the recent increased activity of aeolian processes. Its location determines the course of the border of drift sands area and forest in the dune-forming period. It demonstrates the complexity of dunes forming involving vegetation. Great landscape values.
37	Transverse dune	C	It documates the stage of increased activity of aeolian processes. Orientation and shape of form and asymmetry of slopes are the record of the dune-forming wind direction and conditions of its activity and grade of dune mobility. Great landscape values.
38	Transverse dune	B	
39	Complex ridge-arched dune	B	It documates the stage of increased activity of aeolian processes. Dune shape, indicating the complexity of its construction, determines diverse mobility or age of the included forms, longevity or multiphase of dune-forming processes and changes in the wind direction. Great landscape values.
40	Dome dune	C	It documates the stage of increased activity of aeolian processes. It is an example of initial stage of dunes development. The role of vegetation in the course of dune-forming processes.
41	Transverse dune	C	It documates the stage of increased activity of aeolian processes. Orientation and shape of form and asymmetry of slopes are the record of the dune-forming wind direction and conditions of its activity and grade of dune mobility.
42	Transverse dune	B	
43	Longitudinal dune	B	It documates the stage of increased activity of aeolian processes. It is an example of the form with location and shape forced by the substrata wetness. Great landscape values.
44	Longitudinal dune	B	
45	Longitudinal-arched dune	B	
46	Longitudinal dune	B	It documates the stage of increased activity of aeolian processes. Orientation and shape of form are the record of the dune-forming wind direction and conditions of its activity and grade of dune mobility.
47	Longitudinal dune	B	
48	Longitudinal dune	B	It documates the stage of increased activity of aeolian processes. Its location determines the course of the border of drift sands area and forest in the dune-forming period. It demonstrates the complexity of dunes forming involving vegetation. Great landscape values.
49	Transverse dune	B	It documates the stage of increased activity of aeolian processes. Asymmetry of slopes documates the dune-forming wind direction. It is an example of the echo-dune with location and shape forced by the terrain relief. Great landscape values.

Table 12. Summary of inventoried landforms.

No of form	Name of landform	Importance of the location on the scale of Natura 2000 area *	Explanation
50	Transverse dune	C	It documates the stage of increased activity of aeolian processes. Asymmetry of slopes documates the dune-forming wind direction. It is an example of the echo-dune with location and shape forced by the terrain relief.
51	Complex arched dune	B	It documates the stage of increased activity of aeolian processes. Asymmetry of slopes documates the dune-forming wind direction. It is an example of the echo-dune with location and shape forced by the terrain relief. Great landscape values.
52	Longitudinal dune	C	It documates the stage of increased activity of aeolian processes. Orientation and shape of form are the record of the dune-forming wind direction and conditions of its activity and grade of dune mobility.
53	Longitudinal dune	B	It documates the stage of increased activity of aeolian processes. Orientation and shape of form are the record of the dune-forming wind direction and conditions of its activity and grade of dune mobility. Great landscape values.
54	Deflation monadnock	B	Actively developing, blowing off the earlier dune form documates change in the type of aeolian processes dependent on environmental conditions. It is an example of protective role of vegetation in the fight against deflation.
55	Complex of sandy mounds	C	Example of phytogenic forms. They document the role of vegetation in the aeolian forms development.
56	Complex of sandy mounds	C	
57	Complex of sandy mounds	C	
58	Deflation depression	C	It documates the stage of increased activity of aeolian processes and indicate the existence in the past larger than currently surface undergoing wind activity. It allows estimating amount of blowing out sand. Significant distance from the dunes can indicate high mobility of dunes or drifting the material over long distances by the high speed wind.
59	Complex of sandy mounds	C	Example of phytogenic forms. They document the stage of increased activity of aeolian processes. They indicate the conditions of dunes forming and the role of vegetation in the aeolian forms development.
60	Complex of sandy mounds	C	
61	Transverse dune	C	It documates the stage of increased activity of aeolian processes. Asymmetry of slopes documates the dune-forming wind direction. It is an example of the echo-dune with location and shape forced by the terrain relief.

Table 12. Summary of inventoried landforms.

stones, quartz, quartzite sandstones, touchstones, sandstones, petrified Jurrasic sponges with distinct corrasion traces: riddles, rough or smooth, with hollows. Few rocky fragments, in the central part of the area, have shapes of wind rillstones. They are small, with a diameter of not more than 3-5 cm.

Microforms of aeolian deposition are sandy ripples – aeolian ripple marks. They are formed on the surface of drift sands, mainly in south-eastern part of the area. Several centimeters high, of asymmetric cross-section, arranged transversely to the blowing wind, they record its momentary direction. They are non-persistent forms – when wind changes its direction, they change their orientation. They disappear at high wind speeds.

In the shadow of the wind, behind the obstacles of rocky fragments and rillstones or behind the clumps of grasses the sandy tongues are formed. They also change their location together with the change of the wind direction. If the change is short-lasting, the sandy ripples, which do not manage to completely reverse, enlarge their sizes and transform into a sandy clusters.

Other microforms of drift sands such as the rings around the single tall grasses can be also observed. They create as a result of moving their long leaves by the wind on sand. In the desert also fulgurites are found – up to 1 meter long natural hollow glass tubes formed by the fusion of sand during lightning strikes.

Dune entering on the slope of the valley of the Biała Przemsza river at the point no 1. © Mariusz Boniecki

Riverbed and floodplain of the Biała Przemsza at the point no 2. © Mariusz Boniecki

Deflation field no 5. © Mariusz Boniecki

Deflation field no 8. © Mariusz Boniecki

Deflation field no 9. © Mariusz Boniecki

Sandy mounds on the deflation field no 9. © Mariusz Boniecki

Deflation field no 11. © Mariusz Boniecki

The slope of complex crescentic longitudinal dunes no 36. © Mariusz Boniecki

Secondary forms of sandy mounds within the top of complex crescentic-arced dune no 39. © Mariusz Boniecki

Contemporary morphogenetic processes

The type and the intensity of morphogenetic processes depend on diversity of forms, climatic conditions and land use regime. The main processes that shape the area include fluvial and aeolian ones.

The development of most aeolian forms was inhibited by gradual succession of vegetation, artificial afforestation and plantings lasting since 1960s. Contemporary processes of deflation, corrasion and aeolian deposition occur in a small area are local, and the aeolian transport is effectively inhibited by vegetation.

In the Biała Przemsza valley the largest and the most intense transformations occur in its riverbed and floodplain. The accumulation precesses prevail over the deepening the riverbed. It is evidences by the accumulation microforms in the riverbed. Locally, also lateral erosion occurs. This process is also promoting by a delivery of material from undercuts of sandy banks and small flows associated with decreasing the ground water level and loss of sources on the Przemsza banks. In the upper part of the Biała valley, due to loss of constant outflow, the fluvial processes occur periodically.

The hydrological conditions

The orginal level of ground water of a 2-8 m depth (Koziol 1952) is currently lowered to 40-50 m (Szczypek and Wika1985) as a result of deep exploitation of zink and lead ores from the sixteenth to the eighteenth century, and also mines dehydration and conducted in the twentieth century exploitation of sand as a backfill in mines.

As a result of dehydration, the first quarternary-Jurrasic aquifer disappeared in the areas surrounding the desert, causing desiccation of ponds (Kiryk and Kołodziejczyk 1978), loss of outflow from Janda Pond, loosing water in the sands by the Biała Przemsza and streams flowing through the desert and loss of some of their parts f.ex. upper part of the Biała river) (Szczypek and Wika 1985).

Valorisation of landforms

Valorisation of landforms (Fig. 9) was conducted on the basis of their significance in the study area.The the basic criteria of categorizing the forms in classes of different importance are firstly their representativeness for the area that should identify the desert landscape – mostly sandy desert and secondly the role which due to their shape and size they have in the landscape, deciding on the touristic attractiveness of the area.

Three groups of forms were distinguished (Tab. 12):

- A – forms of high importance, representative for areas of drift sands or/and actively developing, currently not common in the areas of inland dunes.
- B – forms of medium importance, occurring in other areas of inland dunes, but due to large sizes or typical shapes and landscape values representing a large tourist attraction.
- C – forms of low importance, occurring in other areas of inland dunes, not differing in the landscape of sizes or shapes.

The first group, representing the relief of drift sands areas, may include aeolian and fluvio-denudational forms, developing nowadays, mobile or already inactive today, but with specific shapes, typical of sandy deserts. In the Błędowska Desert due to current almost complete overgrown of the area, as well as the formation of most aeolian forms involving vegetation – such examples are only few. The Błędowska Desert is one of many areas of inland dunes, that is why the aeolian and fluvio-denudational forms occurring here are not unique even on the Poland scale. Abut the uniqueness of this area decided not only the types of aeolian forms, but their activity, not found on such a scale in other areas of inland duns, as well as dominant among them, in the current climate conditions, role of the wind as morphogenetic factor.

The group of the most valuable forms includes: deflation surfaces, sand of barchan type and the source part of the Biała valley.

Deflation surfaces due to lack of the fixation by vegetation are areas that are currently modeled by the wind. Active processes of deflation, corassion, transport and aeolian deposition allow tracking the development of aeolian microforms: deflation pavement, wind rillstones, riplle marks and sandy tongues.

Dunes of barchan types occuring on the outskirts of some deflation areas are the only example in the desert of sand dunes formed without the participation of vegetation. Small, with poorly developed „horns", were fixed in the initial development stage or formed under the influence of changing wind directions. They provide a record of freely running dune-forming processes in very dry conditions.

Another form typical of grift sands areas, although in this case with anthrophogenic conditions, is the source part of the Biała valley. In is an example of periodically dehydrated valley, loosing water in sands. Surrounded and buried by the dune sands the valley illustrates the correlation betweenaeolian processes and water erosion.

Forms of medium importane are the largest group. They include: large transverse and longitudinal dunes, and arched ones, both single and complex, deflation monadnocks, deflation depressions and Biała Przemsza riverbed.

Among the aeolian forms of this group in the landscape the most important role has dunes of large sizes and regular shapes,although those are usually ridge forms, so not the most typical to inland dunes. Fixed since 1960s, they are now stabilizedand inactive. Their scientific importance lies in the fact that their location, orientation and shapes are a record of conditions and aeolian processes from the period before the final fixation of forms. The presence of forms documate the existence of dune-forming phase in this area.Their orientation and shape, as well as asymmetry of slopes allow to reconstruct the dune-forming wind direction and conditions of its activity, as well as the grade of mobility of particular dune types. The shapes of complex dunes indicate the complexity of their construction, diverse mobility or different age of the including forms, longevity or multiphase of dune-forming processes and changes of the wind direction. Interesting are examples of dunes at the foot of the Upper Jurrasic cuesta with location and shape forced bz terrain relief. While the marginal ridge dunes by its location determine the course of the former border between the drift sand area and forest.

Deflation monadnocks are blowing off dunes, indicating the change of aeolian process type due to the change of processes conditions. They are also an example of protective vegetation role in the fight against deflation.

Large deflation depressions, currently fixed, like sand dunes, indicate the stage of increased activity of aeolian processes occurring in a much larger area than currently. Their sizes allow to estimate the amount of blowing out sand. The distance of the deflation depressions from dunes is an indicator of dunes mobility or length of the dune-forming phase, and directly of the direction of dune-forming wind.

Great landscape values have Biała Przemsza riverbed, cut in sandy formations with river ripple marks on the bottom of the river and with actively developing undercuts of shores erosion. In the vicinity of dune ridges there is a possibility of tracking the correlation between aeolian and riverbed processes, with examples of pushing the riverbed by dunes.

The group of low importance forms includes the ones which are not distinguished in the landscape. Among them small and/or abnormally developed deflation depressions, dunes and sandy mounds, as well as flat parts of terrace areas of Biała Przemsza occur.

Scientific importance of dunes and deflation areas is the same as in the case of large forms (of medium importance). In contrast, dome and irregular dunes are the examples of initial stage of the dunes development or their fragmentation and disruption.

Sandy mounds, as phytogenetical forms, document the conditions of creating forms and the role of vegetation in the aeolian forms development.

The largest importance of backfilling level from the period of the Odranian Glaciation is that it is a fragment of the largest in Poland inland area of sands of high thickness and one of the largest, until recently, modeled by the wind. In contrast, the flood level allows tracking the course of the current development of the alluvial deposits outside the riverbed and floodplain forming.

Threats of forms due to area deforestation

The direct threats to forms related to trees and shrubs felling, that was conducted within the frameworks of active conservation, is the use of heavy equipment, which can significantly transform the area surface, built of little resistant sandy formations. Mainly dunes, which are threatened by cut, fragmentation, and in the case of small forms even overcoming, are especially subjected to its influence.

The threats to currently existing forms after area deforestation may include a change of conditions of the terrain relief modeling and, consequently, starting the new or intensification, or inhibition of morphogenetic currently active processes, what translates into transformations, the destruction of existing foems or creating the new ones.

The main threat to the majority of established currently forms, both covered by deforestation as well as located on the outskirts of the deforestataion area, will be exposure of loose sandy formations and exposing them to the morphogenetic processes activity, especially aeolian ones. Activation of the wind activity will occur, because its speeds are sufficient to move the substrata material.

Form type	Threat	Expected form changes	Expected transformations	Recommendations of conservation
The Biała valley	Activation of aeolian processes in the adjacent area and the possibility of increase in sand supply.	Transformation involving a size and shape change of the form.	The possibility of local slopes overbuilding and elevation of the valley bottom, possible narrowing and increase in the tortuosity of the riverbed.	It is advisable to preserve the protection forest belt, covering not only dune ridge adjacent to the valley but also its foreground.
Riverbed of the Biała Przemsza	Activation of aeolian processes in the adjacent area and the possibility of increase in sand supply.	Transformation involving a size, shape and location change of the form.	Possible increase in the river loading and development of the riverbed accumulation forms, a shortness and local narrowing of the riverbed, the course change in the plan with an increase in the tortuosity, pushing the current and development of the undercuts in erosion slopes.	It is advisable to fix by vegetation the slopes of the terrace, from the period of the Odranian Glaciacion, along the riverbed.
The flood level of the Biała Przemsza	Activation of aeolian processes in the adjacent area and the possibility of increase in sand supply.	Transformation involving a size change of the form.	Possible local increase in height and width of the flood level.	It is advisable to preserve the protection forest belt along the current bottom of the valey.
Backfill surface of the Odranian Glaciation	Activation of aeolian processes and creating aeolian forms on the backfill surface, blowing the sand outside the desert area.	Transformation involving a land form change.	Creation of deflation forms and aeolian deposition, increase in the denivelation area together with its very slow lowering.	During trees grubbing up it is acceptable to use heavy equipment.
Deflation areas	None	Transformation involving a size and locally also a landform change.	Increase of the area, more intensive development of the wind rillstone forms, sandy tongues and ripple marks, the possibility of overlapping and creating the dune forms.	During trees grubbing up it is acceptable to use heavy equipment.
Deflation depression	None	No change or transforma-tion involving a size and shape change of the form.	Possible increase of the area, depth, orientation change of the forms.	During trees grubbing up it is acceptable to use heavy equipment.

Table 13. Summary of the risks for landforms after the removal of trees and shrubs and proposal actions to minimize the negative impact of the active conservation.

Form type	Threat	Expected form changes	Expected transformations	Recommendations of conservation
The complex of sandy mounds	Activation of aeolian processes and forms within them, and in the adjacent area.	Destruction or transformation involving a size, shape and type change of the form.	In the central part of the desert transformation of the forms into deflation monadnocks and their blowing off, with the possibility of destruction. Outside the study area, near the forest border, an increase of forms sizes together with a shape change and the possibility to transform into shifting dunes.	The preservation of hills in the current form possible with the presence of vegetation within them. During trees grubbing up it is acceptable to use heavy equipment.
Deflation monadnocks	Activation of aeolian processes within the forms.	Destruction or transformation involving a shape and type change of the form.	Forms blowing off with the possibility of their destruction or their transformation into dune forms.	Mainaining the forms in the current state requires the preservation of vegetation clumps in their top areas. During trees grubbing up it is unacceptable to use heavy equipment.
Transverse and longitudinal dunes, dome dunes, barchans in the central desert part	Activation of aeolian processes within the forms and in the adjacent areas, activation of dunes and their transformation under the influence currently prevailing wind direction different from the direction of the dune-forming wind.	Transformation involving a size, shape, location and type change of the dune forms.	Dunes transformation into the shifting forms, changing their locations and sizes. Orientation changes or shape and type changes of the forms. The possibility to combine with adjacent dunes into complex forms.	For free development of the forms the complete absence of vegetation within dunes as well as in their victinity is required. During trees grubbing up it is unacceptable to use heavy equipment.
Complex dunes in the central desert part	Activation of aeolian processes within the dunes and in the adjacent areas, and also activation of dunes.	Transformation of the forms involving their size, shape and location change.	Dunes transformation into the shifting forms, with various mobility within them. The possibility of fragmentation or combination with adjacent dunes. A size, shape and location change of the forms.	During trees grubbing up it is unacceptable to use heavy equipment.

Table 13. Summary of the risks for landforms after the removal of trees and shrubs and proposal actions to minimize the negative impact of the active conservation.

Form type	Threat	Expected form changes	Expected transformations	Recommendations of conservation
Transverse dunes at the foot of the Upper Jurrasic cuesta	Activation of aeolian processes within the dunes and in the adjacent areas.	Transformation involving a size change of the forms.	Increasing the form sizes.	During trees grubbing up it is unacceptable to use heavy equipment.
Dunes of marginal ridge in forested areas outside the study area	None.	No changes.	Preservation of the forms in unchanged state.	
Dunes of marginal ridge along the forest border and in the afforested area	Activation of aeolian processes in the adjacent areas, increase in sand supply.	Transformation involving a size change of the forms.	Increasing the form sizes.	During trees grubbing up it is unacceptable to use heavy equipment.

Table 13. Summary of the risks for landforms after the removal of trees and shrubs and proposal actions to minimize the negative impact of the active protection.

The deforestation will also indirectly affect the change of conditions of morphogenetic wind activity. Latitudinal extension of the deforeststion area will fix existing currently predominance of W and E winds. However, near the sharp folds in the course of the forest border at Biała Przemsza local changes of the air flow direction will be possible.

After felling the trees, the surface roughness reduces, so the increase in the wind speed will occur close to the earth's surface. This means an increase in the deflation and aeolian transport intensity in the central part of the area, while on its outskirts, along the new border of drift sands and forest, the decrease in wind speed will mark. An increase of wind influence area will also have an impact on the increase of the effectiveness of aeolian processes. Due to deforeststaion the change of rainfall conditions, and hence substrata humidity, will occur. Felling of trees will reduce the air humidity and frequency of rainfalls. The period of snow cover melting will accelerate, due to the period with dry substrata, favouring the aeolian processes. This could mean an increase in the development of aeolian forms of E wind, reaching the highest frequency in the spring. The air and ground humidity changes will be partially compensated by an increase in the supply of moisture from dew, forming at night as a result of intense heat radiation from the heated sandy desert area.

On the exposed surface of loose sands the activation of aeolian processes will occur, and the increase of currently existing deflation area and the increase of the wind speed will affect their intensification. This will result in an increase in the length of aeolian transport with a possibility of carrying out the sand outside the desert area, directly by the wind and through rivers. The wind will retrieve the role of the most important morphogenetic factor in terrain relief transformation, and the greates threat to forms preservation in their present state, will be activation of aeolian processes within and in adjacent areas, or the increase of processes insensity in currently deforested areas.

Prediction of forms changes after area deforestation

After area deforestation, most landforms occurring in the study area will transform due to the change of conditions or morphogentic processes. The size and type of transformations will depend on the origin and locations of forms.

Due to the degree of expected transformations the forms can be divided into several groups (Tab. 13):

– Not threatened by transformation.
– Threatened by transformation: size change, shape change, size and shape change, or size, shape and locality change.
– Threatened by destruction or size, shape and location change.

Only these forms, which will remain fixed and will locate at least 200-250 meters away from deforested area, will not undergo changes. At this distance, counting form the edge into the forest, the transport of aeolian material can occur, in the amount that affects the landform changes. This forms group includes part of the dune ridges located both outside the border of the study area in the south, as well as the marginal ridges together with dunes, deflation depressions and the part of the terrace plain of the Odranian Glaciation in the north and east of the study area, where it is expected to leave the protective forest belts.

Other forms will be exposed to different kinds of transformations. The smallest changes will involve only the size change (increase) of the forms. This forms group includes marginal dune ridges located directly along southern and northern forest border with deforested area, where due to increased friction, the loosing speed wind will deposite transported sand. In a similar situation will be the dunes at the foot of the Upper Jurrasic cuesta, located in the zone of the wind speed decrease in front of the field obstacle. Similar changes associated with activation of the sand supply will undergo also the complexes of sandy mounds and the terrace area from the period of the Odranian Glaciacion, just outside the southern border of the deforested area.

The backfill area of the Odranian Glaciation period is threatened by a shape changes. After deforestation it will transform into an active deflation field. The result of the aeolian processes activation will be for sure the development of new forms of destructive and accumulative wind activity (deflation pavement, rillstones, sandy covers, dunes), as it is observed in sand pit in Bukowno (Szczypek 1988; Szczypek 1994; Szczypek and Wach 1991; Szczypek and Wach 1993a; Szczypek and Wach 1995a; Szczypek and Wach 1995b). The sand will move mainly east – north-east, in accordane with the prevailing SW-W wind directions. Its deposition will occur mainly along the desert and forest border. Along the forest edge, the new marginal dune ridges will be formed. The denivelation of currently almost flat surface will increase, together with its very slow progressive lowering, occurring as a result of blowing the sand out and carrying it outside the desert area – from the center in the direction of the surrounding forests and the Przemsza valley.

Its sizes and shapes will change the surfaces and depressions of deflation. The deflation surfaces will enlarge their areas by the adjacent deforested areas what will condition the increase in the intensity of currently acting aeolian processes and the possibility of aeolian

deposition, locally connected with dunes overlapping. So the shape of surface will change. Also currently not working deflation depressions, due to activation of aeolian processes, may enlarge their area and depth, and locally, near the sharp folds of the forest border, also an orientation change of forms may occur.

The impact of activated in the deforested area aeolian processes will include also the adjacent source part of the Biała valley. Increase in the sand supply drifting directly by the wind, as well as sliding from the slopes surrounding the dunes to the valley, in the absence of permanent dehydration, will lead to the slopes overbuilding and elevation of the valley bottom with the possibility of narrowing and increase in the tortuosity of the riverbed.

Dunes located in the center of deforested area will be threatened by a size, shape and location changes. It will be influenced by activation of aeolian processes in both the adjacent areas, as well as withindunes which will transform into shifting forms.The dunes mobility is associated with the possibility of a location, shape and size change. The direction of these changes is difficult to predict. Their prediction can not be based on the results of comparsions of dunes distribution and shape, analyzed since 1958 (Alexandrowiczowa 1962), and in the following years: 1973, 1981 (Szczypek and Wika 1984), 1987 (Szczypek et al. 2001), up to current state, showing small differences, because in this period the gradual fixation of dunes proceeded.

It can be assumed that the large forms, as in the past, will not be distinguished by the high mobility. Probably, the large form increases its size, at basically not changed shape, and it only complicates the structure of its crest part. Smaller forms, more mobile, can combine in the complex forms or undergo disrupting. An orientation change of the forms will be also possible, under the influence of locally prevailing wind direction, different than the dune-forming wind. Complex dunes, especially those which include forms of different types (longitudinal, transverse, arched) probably will be characterized by various mobility, what can lead to the fragmenatation or complexity of the forms shape and orientation changes of the incompatible elements with the current wind direction.

Large changes may affect the Biała Przemsza riverbed in the part directly adjacent to the deforested area and/or separated from it only by a narrow flood level. Increase in the sand supply, drifting to the riverbed directly by the wind, as well as sliding from the slopes of dunes and from the undercuts in sandy erosion shores, may cause an icrease in the river loading, development of the riverbed accumulation forms, a shortness and local narrowing of the riverbed, change in its course with an increase in the tortuosity, pushing the current and development of the undercuts in erosion slopes.

Only complexes of sandy mounds and deflation monadnocks are threatened by total destructuion or transformation into another type of forms. Not protected by vegetation, they can be blown off or they can transform into the dune forms. On blowing off and total destruction threatened will be mainly forms located in the central part of the desert, where deflation is a dominant process. In areas located nearer the forest border, the forms will be rather overbuilding, they can change their shapes, combine together and even transform into dunes.

Comparing the degree of threat and the scale of predicted landform changes with their value, it should be noted that activation of aeolian processes will not constitute a threat to relief of the deforested area.

Total destruction may affect only the least valuable forms of sandy mounds and deflation monadnocks. Besides, there is a great probability that at least some of them will transform into more typical to drift sands areas forms of dunes. The most valuable of the currently existing forms – deflation surfaces will find more favourable conditions for their development. Also dunes finally formed during the second half of the twentieth century, with the participation of vegetation, will develop freely, like in the deserts. That is why any changes, which the forms are threatened by as a result of deforestation, can be regarded as positive ones, moving towards the restoration of the desert landscape in the area. So its scientific, educational and touristic attractiveness will also increase, as unique landscape on the European scale.

Activation of aeolian processes should not also constitute threats to adjacent areas. The area of active conservation is surrounded from all side by forest. With an average intensity of aeolian transport the sand from the desert will be blowing outside on short distances (200-250 m) from the edge of the forest, depending on the height of trees and their species composition. Low and pine stands the least inhibit the wind.

During the wind with very high speed, small part of the most fine-grained material can be transferred above the trees crowns over a greater distance. Amount of blowing out of the desert sand are minimal, what is evidenced by the nearby piles of Pilecka adit which for over 300 years of its existence has not been covered with sand, despite the fact that they adhere the Błędowska Desert (Przemycki 1929). It should also not be expected so intense drifting the sand out of the desert, which occurred during sandstorms in the 1920s and 1930s (Sosnowski 1947). This phenomenon occurred in much larger than currently area of drift sand and with less number of the surrounding forests. The sand was then transferred above the forest over a distance up to 1 km to the Klucze-Papiernia raod (Szczypek and Wach 1991). In the past, however, Klucze were never threatened by burying with the desert sand (Szczypek at al. 2001). It seems that also currently the desert revitalization will not pose a threat to neighbouring developed areas.

Protection recommendations

The main aim of undertaken protection actions is to restore specific landscape with characteristic forms for drift sands areas, to justify its name. The conservation plan should provide the most favourable conditions for the development of aeolian processes and forms in the active conservation area and also it should protect the surrounding areas against the negative effects of their activation. To this end, the scale of felling, kind of used mechanical equipment and proper management of deforested areas should be considered.

In the active protection area it would be advisable to preserve the protective forest belts of several hundred meters width along the riverbed and nowadays forming the flood level

of Biała Przemsza and in the foreground of the dune ridge neighbouring with the Biała valley, in order to protect them against increased deposition of sand. From east, the width of the forest complex seems to be sufficient to prevent the transferring the sand to Klucze area.

In the area of restored desert the exposure of 50% of dunes area is sufficient to activation of these forms. But in such way that their development leads to transformation into forms with shapes similar to the desert ones (f.ex. barchans), the complete removal of vegetation, both on dunes and intheir surroiindings, is necessary.

To maintain the sandy mounds clompexes and deflation monadnocks in their current state, the preservation of vegetation clumps within their area is required. These froms, however, belong to the commonly occurring and not requiring special protection. If the preservation of forest fragments is considered due to the preservation of some plant species, they should have a form of loose plantations, tree groups, which stabilize the sand in the small area, withoutlarge dunes and depressions between dunes. Among currently occurring tree and shrub species, two willows (long-leaved violet willow and creeping willow) stabilize the sand the best (Szczypek and Wika 1985).

During trees grubbing up it is unacceptable to use heavy equipment ondunes, so as not to cause the fragmentation or even destruction of these forms. When cutting the trees it is very important to remove the stumps, especially on the upwind slopes of dunes, to protect them against the creation of local deflation centres, deforming the shape of form. To activate the sand it is also necessary to remove the litter, which covers the sand with a thick layer in a substantial area.

After deforestation, a main threat to aeolian processes and the development of aeolian forms will be overgrowing of the open sandy areas. Natural vegetation succession is favoured by the large sand pollution caused by industrial dusts which fertilize the soil (Łaskawiec 2003). So the successive protection against desert overgrowing, causing masking of forms, will be necessary.

Another threat is a tourism pressure manifested by creating deflation depressions within dunes, initiating their fragmentation. The proper establishment of the tourist tracks, avoiding dunes, will be significant but also technical protection of tourist paths, entry ban on unpaved roads, reducing tourism and lack of interference in the area outside the tracks.

Biotic elements of the Błędowska Desert

One of the first stages of the project was to conduct an inventory of wildlife. It consisted of the detailed description of the preservation status of species of plants, amphibians, reptiles, birds, mammals and insects, which presented on the Błędowska Desert. Implementation of this research before starting the active protection, served not only the assessment of population of individual species of plants and animals, but also allowed planning and ensuring the eventual protection of any taxa, which are unrelated to sandy grasslands habitat, during the work. Analysis of the obtained results, confirmed the need for active protection, which intended to increase the surface of open sandy areas. This type of habitat is used by the valuable species of plants and animals, whose was retreating from the desert areas because of progressive succession.

Flora

Area of the Błędowska Desert, due to the prevailing habitat conditions, is characterized by specific species composition. In the study area were found plant species, which are protected by law and endangered, but also the expansive taxa, foreign to the domestic flora.

During the project, the Polish law related to the list of protected plants, fungi and animals was changed. At the time of inventory termination, the Regulation of the Minister of the Environment of 5 January 2012 on the species protection of plants (Journal of Laws of 2012 No. 0, item 81) was in force. According to this regulation, several plant species under strict and partial protection were recorded in the Błędowska Desert. Species under strict protection were: stemless carline thistle *Carlina acaulis*, dark-red helleborine *Epipactis artrorubens*, broad-leaved helleborine *Epipactis helleborine*, umbellate wintergreen *Chimaphila umbellata*, creeping lady's-tresses *Goodyera repens* and stiff clubmoss *Lycopodium annotinum*. Species under partial protection were: guelder-rose *Viburnum opulus*, lily of the valley *Convallaria majalis*, alder buckthorn *Frangula alnusi*. Particularly noteworthy are listed, valuable species of orchids, which are not associated with sandy grasslands habitat. In order to protect their populations from destruction, the fragments of trees areas, within the creeping lady's-tresses *Goodyera repens* has performed, have been preserved and in the case of dark-red helleborine *Epipactis artrorubens,* 300 individuals were transferred to the area not covered by the work.

In the light of the new polish law, most species listed as being subject to strict protection lost their status. Since the 1st October 2014, the new Regulation of the Minister of the Environment on the species protection of plants has been come into force. According to it, such species as: stemless carline thistle *Carlina acaulis*, dark-red helleborine *Epipactis artrorubens*, broad-leaved helleborine *Epipactis helleborine* and stiff clubmoss *Lycopodium annotinum* began to be partially protected. Guelder-rose *Viburnum opulus*, lily of the valley *Convallaria majalis* and alder buckthorn *Frangula alnusi* are no longer protected by law.

Plants protected by law were not the only valuable species in the study area. Five other taxa were considered as valuable. These were: round-leaved wintergreen *Pyrola rotundifolia*, green-flowered wintergreen *Pyrola chlorantha*, one-flowered wintergreen *Moneses uniflora*, serrated wintergreen *Orthilia secunda* and yellow bird's-nest *Monotropa hypopitys*. All of them are listed in the *Red List of vascular plants of Upper Silesia* (Parusel et al. 1996). According to the new regulation, partially protected species are three of mentioned taxa: round-leaved wintergreen *Pyrola rotundifolia*, green-flowered wintergreen *Pyrola chlorantha*, one-flowered wintergreen *Moneses uniflora*.

Despite law changes, actions took to minimize the negative effects of active protection to these valuable taxa were important, because, beyond the aspect of the species protection, the natural value has been taken into consideration. The evidenced of this is the inclusion of species on the *Red List of vascular plants of Upper Silesia* (Parusel et al. 1996). In addition, the creeping lady's-tresses *Goodyera repens* is a species included on the *Red List of vascular plants in Poland* (Zarzycki and Szeląg 2006).

During the flora inventory, six species foreign to the domestic flora were noted. These were: wild black cherry *Padus serotina*, northern red oak *Quercus rubra*, large-leaved lupine

Umbellate wintergreen *Chimaphila umbellata*. © Małgorzata Jaźwa

Lupinus polyphyllos, black locust *Robinia pseudacacia*, Banksian pine *Pinus banksiana* and long-leaved violet willow *Salix acutifolia*.

These plants are invasive taxa, threatening the native vegetation of the country. Besides mentioned species, one taxon is native to the country flora, but its artificial introduction to the Błędowska Desert was observed – the sea lyme grass *Leymus arenarius*. This species was considered to be dangerous, because of the possibility of spreading in the Błędowska Desert after the completion of active protection. Therefore, this plant and other alien taxa have been removed from the project area.

Protected species of plants

Strictly protected vascular plant species (according to the Regulation of the Minister of the Environment of 5 January 2012 on the species protection of plants (Journal of Laws of 2012 No. 0, item 81).

Stemless carline thistle *Carlina acaulis*

Distribution and abundance

It is a perennial plant of the *Asteraceae* family widespread throughout the whole southern Poland. In other regions of the country, except for maritime belt, central and north-east

Dark-red helleborine *Epipactis artrorubens*. © Kamil Kulpiński

Poland, the locations of this species are dispersed. In the project area the locations of stemless carline thistle were concentrated in its eastern part, near the Biała Przemsza River valley. The specimens usually occurred on the outskirts of pine tree groups and by forest roads. Populations ranged from one to a dozen specimens per location, only few of them were flowering ones. The total abundance of the populations in the inventory area was estimated at slightly more than 20 specimens.

Typical habitats and ecological requirements

In terms of habitat the species is mainly associated with sandy xeric calcareous grassland communities of *Festuco-Brometea* class and species-poor *Nardus* grasslands of *Nardetalia* order. It also often occurs in light forests or their peripheries. It is a photophilous plant, but it may bear the temporary shading. It grows in moderately poor habitats (mesotrophic) or rich in nutrients (eutrophic). It requires dry to moderately rich in water soils, and in terms of acidity, it prefers moderately acidic, through neutral to basic soils (pH> 5). The species is found on the sands and also on clay substrata, on soils of mineral-humus character, as well as rich in organic matter. It tolerates an increased content of heavy metals in soil.

Protection and conservation status

According to the new Regulation of the Minister of the Environment of 9 October 2014 on the species protection of plants (Journal of Laws of 2014 No 0, item 1409) the species is currently partially protected. The taxon has also a conservation category of R (rare) by the *Red List of vascular plants of Upper Silesia*.

Threats resulting from planned active protection actions and protective recommendations

Active conservation actions, involving the tree felling, contributed to the improvement of light conditions of majority of the species populations. However, the works associated with the conservation actions, conducting with the use of heavy equipment, could contribute to mechanical damages of some leaf rosettes of this species. In addition, efforts to restore 2330 habitat (inland dunes with open *Corynephorus* and *Agrostis* grasslands), where one of the essential factor are shifting, drift sands, will cause a destruction of the species population over time. Stemless carline thistle is a species preferring stable substrata and it is not adapted to overblowing by sand.

Dark-red helleborine *Epipactis artrorubens*

Distribution and abundance

It is an herbaceous perennial plant of the family *Orchidaceae*. It occurs in the dispersed localities throughout the whole country. The Błędowska Desert lies in the area of the highest concentration of locations of this species in Poland, which occurs in the belt of uplands. Dark-red helleborine had scattered locations in the entire southern part of the

Stemless carline thistle *Carlina acaulis*. © Kamil Kulpiński

Błędowska Desert covered by the project. In the less forested desert parts it grew usually in the pine tree groups, rarely specimens occurring on open sand were found. Moreover, it grew in pine forests and on a former forest burnt sites. An interesting phenomenon was frequent occurrence of *Epipactis artrorubens* in the vicinity of crumbling remains of concrete poles and fortifications. Locally, in some places the orchid populations reached even 100-150 specimens. However, single specimens, mostly small-sized, were found most frequently. Relatively few specimens were blooming and bearing fruit. Flowering individuals occurred mainly in the vicinity of mentioned above concrete fragments or on a former forest burnt sites. This resulted from the orchid soil preferences (see below). Both concreate, as well as post-fire ash, cause substrata alkalization (alkalinity increase), which fosters the proper plant growth and flowers and fruit formation. Places after fires are also additionally fertile which also has a positive effect on the population – on the forest burnt sites in the south-western part of the project area specimens in the best condition and with the largest inflorescences were found. In total, approximately 2500 specimens of this species occurred in the inventory area.

Typical habitats and ecological requirements

The species occurs, among others, in thermophile birch forests of the *Cephalanthero-Fagion*, where the fleece is often rich in orchids. In addition, it is also found in different types of thickets and in habitats transformed by a man. In occurs usually in partial shade, but

Dark-red helleborine *Epipactis artrorubens*, which grows on open areas between the group of scot pine. © Kamil Kulpiński

also tolerates open and sunny areas. It grows on sandy or clayey substrata, moderately poor to quite rich (eutrophic). It requires mineral-humus soils, dry to moderately wet (fresh). The preferences regarding to soil pH are very important. It favors locations with neutral of basic soil (pH ≥ 7).

Protection and conservation status

According to the new Regulation of the Minister of the Environment of 9 October 2014 on the species protection of plants (Journal of Laws of 2014 No 0, item 1409) the species is currently partially protected. The taxon has also a conservation category of V (vulnerable) by the *Red List of vascular plants of Upper Silesia*.

Broad-leaved helleborine *Epipactis helleborine*. © Małgorzata Jaźwa

Threats resulting from planned active protection actions and protective recommendations

Specimens, especially the largest ones and these in the best condition, growing in the area where the tree and shrub felling was conducted, had been transferred to similar, possibly closest locations.

Broad-leaved helleborine *Epipactis helleborine*

Distribution and abundance

It is a perennial plant of the family *Orchidaceae*, relatively common in Poland. In the Błędowska Desert, in the project area, the species occurred singly in the pine tree groups

or in pine forest near the Biała Przemsza River valley. It was often found together with dark-red helleborine *Epipactis artrorubens*. All locations of broad-leaved helleborine were located in north-eastern part of the area, and its total abundance was about 20 specimens.

Typical habitats and ecological requirements

It is a species typical of deciduous forests and bushes of *Querco-Fagetea* class. It prefers partially shaded locations or overexposed sites – it repeatedly grows in the forest edges. It requires mineral-humus soils with slightly acidic to basic pH (pH > 5). It grows on the substrata made of the sandy clays, moderately poor up to rich in nutrients (eutrophic) with an average humidity (fresh).

Protection and conservation status

According to the new Regulation of the Minister of the Environment of 9 October 2014 on the species protection of plants (Journal of Laws of 2014 No 0, item 1409) the species is currently partially protected. The taxon has also a conservation category of R (rare) by the *Red List of vascular plants of Upper Silesia*.

Threats resulting from planned active protection actions and protective recommendations

Due to the small number of specimens growing in the project area the protection actions were not undertaken since the destruction of the species habitat had no significant impact on the local populations.

Umbellate wintergreen *Chimaphila umbellata*

Distribution and abundance

It is a perennial plant of the *Ericaceae* family, widespread across Poland on lowlands, and rare in the mountains. Recently the species locations have been in decline. In the Błędowska Desert, in the project area, the taxon was associated with larger clusters of pines and pine forests. Flowering and bearing fruit specimens were found quite often. In the pine forests of the Błędowska Desert probably one of the most numerous populations of umbellate wintergreen in the region occurred. Its size was estimated at about 4500 specimens. Sometimes it was growing in numerous (50-100 individuals) groups, but more often a dozen or so specimens in locations were observed.

Typical habitats and ecological requirements

The species associated with dry and fresh pine forests of *Dicrano-Pinion* alliance. As a plant of pine forests fleece it prefers partial shade. It grows on acidic, mineral-humus soils (pH ± 4). It occurs on dry sands, in nutrient-poor habitats (oligotrophic).

Protection and conservation status

According to the new Regulation of the Minister of the Environment of 9 October 2014 on the species protection of plants (Journal of Laws of 2014 No 0, item 1409) the species

Umbellate wintergreen *Chimaphila umbellata*, dying after deforestation. © Kamil Kulpiński

is currently strictly protected. The taxon has also a conservation category of V (vulnerable) by the *Red List of vascular plants of Upper Silesia*.

Threats resulting from planned active protection actions and protective recommendations

Umbellate wintergreen is a pine forests species. Active protection actions resulting from the project and involving the trees and shrubs felling caused the destruction of its habitat. One of the main factors, which have changed after tree logging, is amount of light reaching plants. Umbellate wintergreen prefers partial shade and in the full light it begins to die. This phenomenon can be observed in the area, already cut out by the Silesian Voivodeship Landscape Parks Management, which is located northwest of Czubatka. The specimens devoid of tree cover yellow and wither there. Additional threat is also the character of 2330 habitat type (inland dunes with open *Corynephorus* and *Agrostis* grasslands) which is characterized by free, drift, mostly unstable sands. The species prefers stabilized substrata, covered by litter of coniferous trees and it is not adapted to burying with sand. Due to undertaken conservation actions the locations of this species were limited to areas of surrounding coniferous forests.

Creeping lady's-tresses *Goodyera repens*

Distribution and abundance

It is a perennial plant of the family *Orchidaceae*, and mountain species (Zając 1996). It occurs mainly in the mountains, in Pomerania and in north-eastern Poland. Moreover, it has scattered locations in Wielkopolska region and in the southern Poland uplands.

Inflorescence of creeping lady's-tresses *Goodyera repens*. © Kamil Kulpiński

The number of its localities has been in decline recently. In the Błędowska Desert only one location of this species was found, in the pine forest in the western part of the project area. One flowering stem and 24 leaf rosettes were observed there. The nearest locations of creeping lady's-tresses are located in the vicinity of Bolesław (Fagasiewicz 1986; Nowak et al. 2011) and in Dąbrowa Górnicza (Błońska 2012). However, it should be noted that in the region it is an extremely rare plant (Bernacki 1998) – in the Silesian Upland only two locations of this species have been known so far (Błońska 2012; Nowak et al. 2005, 2011). In the Silesian Voivodeship, directly adjacent to the inventory area, the species had a category of extinct until recently.

Rosette leaves of creeping lady's-tresses *Goodyera repens*. © Kamil Kulpiński

Typical habitats and ecological requirements

The species is typical of *Vaccinio-Piceetea* coniferous forests, on lowlands mostly associated with pine forests. On Polish lowland the habitat conditions and plant communities that are preferred by this orchid are different than in the mountains. In this work the environmental requirements proper for lowland areas, which include the Błędowska Desert region, were presented. Creeping lady's-tresses grows on soils formed on sands or clays, acidic (pH < 5) and nutrient-poor (oligotrophic). In terms of soil humidity it prefers dry or slightly damp soils. It is associated with coniferous forests fleece and it grows only in places where small amount of light is received – in shade or partial shade.

Protection and conservation status

According to the new Regulation of the Minister of the Environment of 9 October 2014 on the species protection of plants (Journal of Laws of 2014 No 0, item 1409) the species is currently strictly protected. The taxon has also a conservation category of E (threatened with extinction, critically endangered) by the *Red List of vascular plants in Poland* and a conservation category of E (threatened with extinction) by the *Red List of vascular plants of Upper Silesia*.

Threats resulting from planned active protection actions and protective recommendations

The species was found only in one location, in decades-old pine forest. In order to protect the population from destruction during conducting active protection actions, the frag-

ment of pine forest, where the specimens were growing, was left and the protective zone for this species was determined.

Stiff clubmoss *Lycopodium annotinum*

Distribution and abundance

It is a perennial plant of *Lycopodiaceae* family. The species is widespread across Poland; however, the number of its locations has been decreasing. In the Błędowska Desert, in the project area, just eleven places of its occurrence were observed. It usually forms small patches, much less than 1 m^2. Only in two locations the occurrence of strobili was noted.

Typical habitats and ecological requirements

It is a species of *Vaccinio-Piceetea* coniferous forests. It grows in moderately shaded and well-hydrated places (fresh, damp and wet soils). It occupies nutrients-poor habitats, on very acidic or acidic soils (pH < 6). It occurs on sands and sandy clays, on mineral soils rich in humus and organic matter.

Protection and conservation status

According to the new Regulation of the Minister of the Environment of 9 October 2014 on the species protection of plants (Journal of Laws of 2014 No 0, item 1409) the species is currently partially protected. The taxon has also a conservation category of V (vulnerable) by the *Red List of vascular plants of Upper Silesia*.

Threats resulting from planned active protection actions and protective recommendations

Stiff clubmoss is a sensitive species to changes in both soil humidity and light conditions. Felling of trees caused a decrease in humidity and significantly changed the amount of light reaching the plant, which resulted in the destruction of the part of existing population. However, the locations of occurring nearby precious orchid *Goodyera repens* were preserved.

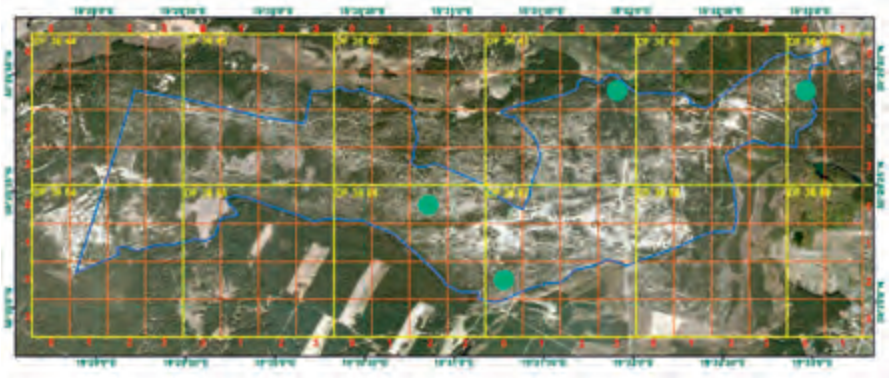


Fig. 10. Distribution (ATPOL squares) of the stemless carline thistle *Carlina acaulis* in the Błędowska Desert.

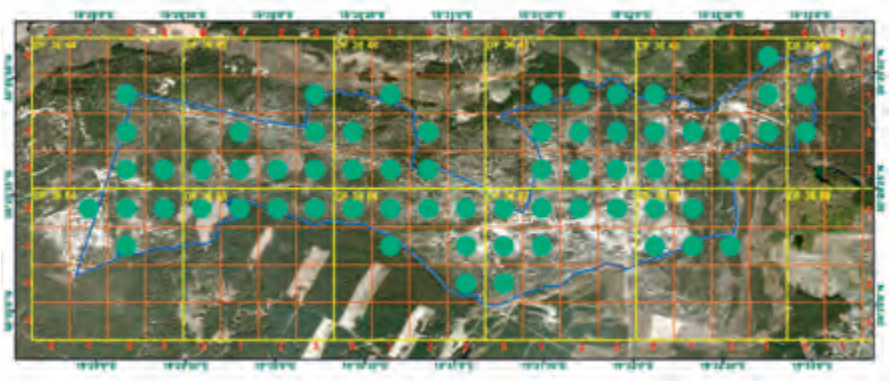


Fig. 11. Distribution (ATPOL squares) of dark-red helleborine *Epipactis atrorubens* in the Błędowska Desert.

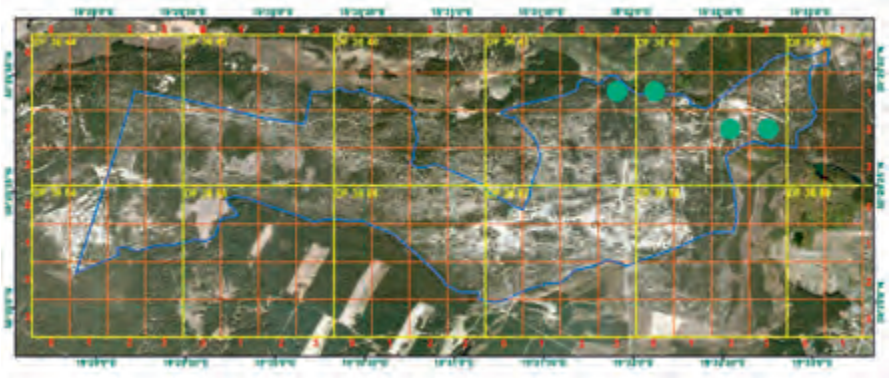


Fig. 12. Distribution (ATPOL squares) of broad-leaved helleborine *Epipactis helleborine* in the Błędowska Desert.

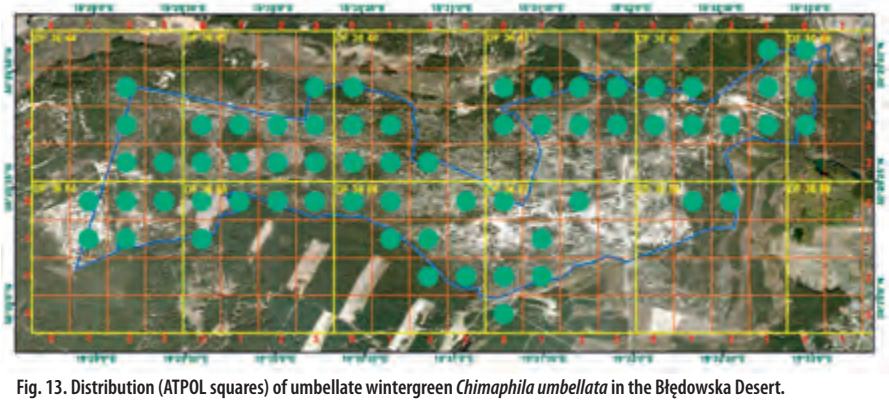


Fig. 13. Distribution (ATPOL squares) of umbellate wintergreen *Chimaphila umbellata* in the Błędowska Desert.

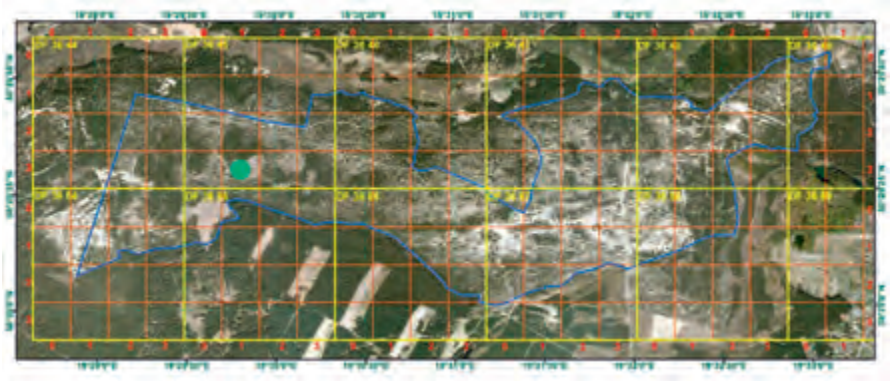


Fig. 14. Distribution (ATPOL squares) of creeping lady's-tresses *Goodyera repens* in the Błędowska Desert.

Partially protected vascular plant species (according to the Regulation of the Minister of the Environment of 5 January 2012 on the species protection of plants (Journal of Laws of 2012 No. 0, item 81).

Guelder-rose *Viburnum opulus*

Distribution and abundance

It is a common shrub in the family *Caprifoliaceae*. In the part of the Błędowska Desert covered by the project the species occurred mainly in the vicinity of the Biała Przemsza River valley. Populations usually consisted of one or several specimens. Most of them were characterized by small growth, and all were characterized by lack of inflorescences and fruits. In total, slightly more than 20 specimens were recorded.

Typical habitats and ecological requirements

The shrub is associated with various deciduous forest types, thickets and mixed forests. It prefers partially shaded locations, semi-shade. It grows on damp and fresh mineral-humus soils, rich or moderately rich in nutrients. It has a broad tolerance of substrata pH– from acidic to basic, but most often it occurs on neutral soils ($6 \leq pH < 7$).

Protection and conservation status

According to the new Regulation of the Minister of the Environment of 9 October 2014 on the species protection of plants (Journal of Laws of 2014 No 0, item 1409) the taxon was excluded from the partial species protection.

Threats resulting from planned active protection actions and protective recommendations

The species is common both in the whole country, as well as in the region. Specimens occurring in the Błędowska Desert, in the project area, were characterized by small growth and poor condition. Therefore, their destruction has not caused much harm to the population of this species in this region.

Guelder-rose *Viburnum opulus* and rowan *Sorbus aucuparia*. © Kamil Kulpiński

Lily of the valley *Convallaria majalis*

Distribution and abundance

It is a perennial plant of the family *Convallariaceae*, common in the whole lowland Poland, less frequent in the mountains. In the Błędowska Desert area slightly less than thirty specimens at only two locations, in forest habitats, occurred. Both locations were located in north-eastern part of the project area, right near its border.

Typical habitats and ecological requirements

It is a species of poor oak forests (*Quercetea robori-petraeae*), thermophile forests and thickets of *Quercetalia pubescenti-petraeae*, mixed forests (*Pino-Quercetum*) and thermophile beech forests (*Cephalanthero-Fagion*). It requires partial shade and grows in sunny light thickets and forests and on their outskirts. It prefers dry to moderately rich in water soils. It occurs in moderately nutrient-poor habitats (mesotrophic), on mineral-humus, acid to moderate basic (pH ≥ 3) soils.

Protection and conservation status

According to the new Regulation of the Minister of the Environment of 9 October 2014 on the species protection of plants (Journal of Laws of 2014 No 0, item 1409) the taxon was excluded from the partial species protection.

The most common form of alder buckthorn *Frangula alnus* in the Błędowska Desert. © Kamil Kulpiński

Threats resulting from planned active protection actions and protective recommendations

Trees felling constituted a serious threat to the existing specimens, however, it did not have a significant impact on the local population.

Alder buckthorn *Frangula alnus*

Distribution and abundance

It is a tall deciduous shrub in the family *Rhamnaceae*, common throughout the whole Poland. In the Błędowska Desert the species occurred in the pine tree groups and in pine forests. In comparison to the shrubs of the same species, which grow in a short distance from the project area – by the Biała Przemsza and Centurianka rivers, alder buckthorn in the southern part of the desert was characterized by much less rapid growth. Only few specimens exceed the height of 1,5 m. In addition, very few specimens were blooming and fruiting while often found were groups of seedlings and young specimens, most of which suffered the gradual withering. In total, in the inventory area approximately 1500 specimens of this species occurred, but only a few percent of them reached a larger size. The largest population were located in the northern part of the area, near the Biała Przemsza River valley.

Typical habitats and ecological requirements

The species occurs mainly in the communities of wetland forests with a domination of alder of the *Alnetea glutinosae* class, poor oak forests (*Quercetea robori-petraeae*) and in coniferous and mixed forests of *Vaccinio-Piceetea* class. The plant has a broad ecological

Alder buckthorn *Frangula alnus* and the seedling of northern red oak *Quercus rubra*. © Małgorzata Jaźwa

tolerance. It may grow in various light conditions – from moderate shade to full sunlight. It occurs on soils with various pH – from acidic to basic (pH > 4), different mineral compounds and humus content and various abundance in nutrients. It prefers habitats at least moderately wet – from fresh to wet, and tolerates also permanently flooded sites.

Protection and conservation status

According to the new Regulation of the Minister of the Environment of 9 October 2014 on the species protection of plants (Journal of Laws of 2014 No 0, item 1409) the taxon was excluded from the partial species protection.

Threats resulting from planned active protection actions and protective recommendations

Alder buckthorn is sensitive to the water content in the soil. Felling of trees and shrubs, resulting from the planned active protection actions, caused a decrease in soil humidity, and as a consequence the gradual withering of this species. Due to the commonness of the taxon, the destruction of the specimens during project works has not caused much harm to the population of this species at the region level.

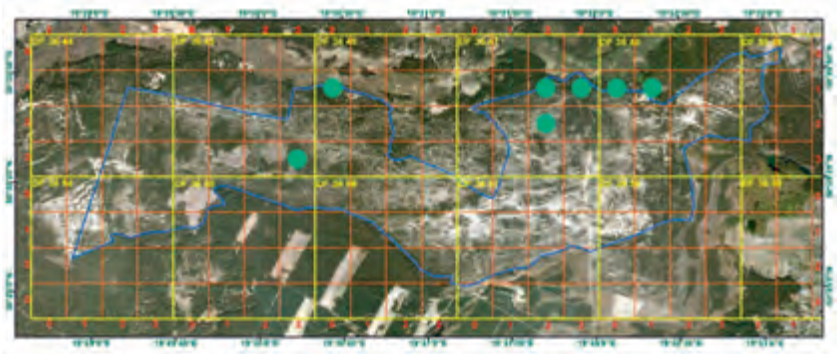


Fig. 15. Distribution (ATPOL squares) of guelder-rose *Viburnum opulus* in the Błędowska Desert.

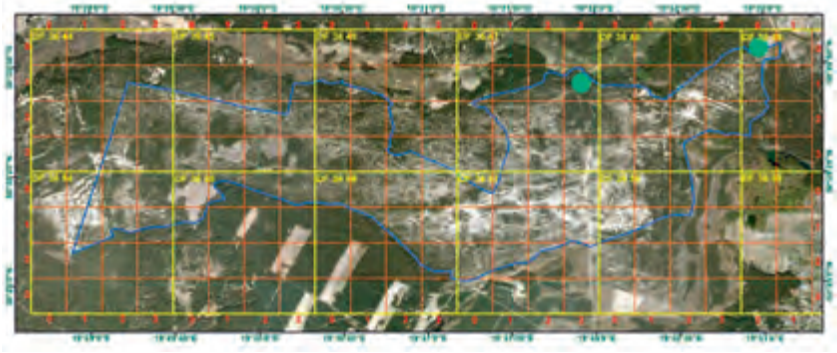


Fig. 16. Distribution (ATPOL squares) of lily of the valley *Convallaria majalis* in the Błędowska Desert.

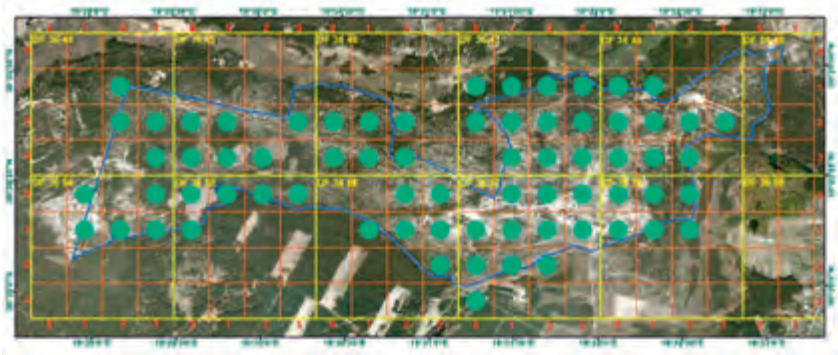


Fig. 17. Distribution (ATPOL squares) of alder buckthorn *Frangula alnus* in the Błędowska Desert.

Valuable plant species not protected by law

Round-leaved wintergreen *Pyrola rotundifolia*

Distribution and abundance

It is a perennial plant of the *Pyrolaceae* family. It is dispersed throughout the whole country; however, it is more common in the southern and eastern Poland. Recently, there has been a decline in the number of locations of this species. It was found only in the north-eastern part of the inventory area. The largest location included several hundred specimens, while the abundance of this species throughout the entire project area was estimated at about one thousand specimens.

Typical habitats and ecological requirements

The species is associated with coniferous forests of *Vaccinio-Piceetea* class. It is a shade-loving plant, but it also tolerates partial shade. It grows on mineral-humus soils, with average water content (fresh soils) and a moderate abundance in nutrients. In terms of substrata pH, it prefers acidic soils (pH < 6).

Protection and conservation status

According to the new Regulation of the Minister of the Environment of 9 October 2014 on the species protection of plants (Journal of Laws of 2014 No 0, item 1409) the species is currently partially protected. The taxon has also a conservation category of R (rare) by the *Red List of vascular plants of Upper Silesia*.

Threats resulting from planned active protection actions and protective recommendations

Both trees felling, as well as the drift sands activation, do not foster the occurrence of round-leaved wintergreen, which is a plant preferring shady or partially shady places and fresh soils. The destruction of specimens has not caused much harm to the population of this species at the region and also country level due to its scattered locations throughout the whole Poland.

Green-flowered wintergreen *Pyrola chlorantha*

Distribution and abundance

It is a perennial plant of the *Pyrolaceae* family. It has dispersed locations throughout the whole country, whose number has been in decline in recent years. In the Błędowska Desert, in the project area, the species occurred in the pine tree groups and in pine forests. The populations had even approx. 400 specimens; however, more often they consisted of groups of several individuals. They were well-conditioned – often blooming and bearing fruit. The number of the species in the whole project area was estimated at about two thousand specimens.

Typical habitats and ecological requirements

The species of dry and fresh pine forests of *Dicrano-Pinion*. It requires partial shade to proper growth. It occupies nutrient-poor habitats, formed on sands and sandy clays.

Round-leaved wintergreen *Pyrola rotundifolia*. © Małgorzata Jaźwa

Green-flowered wintergreen *Pyrola chlorantha*. © Małgorzata Jaźwa

It prefers very acidic (pH 4-5), mineral-humus soils and with average water content (fresh soils).

Protection and conservation status

According to the new Regulation of the Minister of the Environment of 9 October 2014 on the species protection of plants (Journal of Laws of 2014 No 0, item 1409) the species is currently partially protected. The taxon has also a conservation category of R (rare) by the *Red List of vascular plants of Upper Silesia*.

Threats resulting from planned active protection actions and protective recommendations

As in the case of round-leaved wintergreen trees felling and the activation of drift sands do not foster the occurrence of green-flowered wintergreen, which is a plant preferring

One-flowered wintergreen *Moneses uniflora*. © Małgorzata Jaźwa

shady or partially shady places and fresh soils. The destruction of specimens has not caused much harm to the population of this species at the region and also country level due to its scattered locations throughout the whole Poland.

One-flowered wintergreen *Moneses uniflora*

Distribution and abundance

It is a perennial plant of the *Pyrolaceae* family. Its locations are scattered throughout the whole country, but in central Poland it is rare. As in the case of green-flowered wintergreen *Pyrola chlorantha* the number of locations of this species has been in decline in recent years. In the Błędowska Desert, in the project area, the species occurred in the pine tree groups and in coniferous forests. It often grew massively (patches of more than 400 specimens were found), blooming and bearing fruit. The abundance of the species in the whole project area was estimated at about 1500 specimens.

Typical habitats and ecological requirements

The species typical of dry and fresh pine forests of *Dicrano-Pinion*, and in the mountains also of *Vaccinio-Piceion* spruce forests. It requires moderate shade to proper growth. It occupies nutrient-poor habitats, formed on sands and sandy clays. It prefers acidic (pH 4-5), mineral-humus soils with average water content (fresh soils).

Protection and conservation status

According to the new Regulation of the Minister of the Environment of 9 October 2014 on the species protection of plants (Journal of Laws of 2014 No 0, item 1409) the species is currently partially protected. The taxon has also a conservation category of R (rare) by the *Red List of vascular plants of Upper Silesia*.

Threats resulting from planned active protection actions and protective recommendations

The destruction of individuals habitat in the project area has not significantly influenced the population of this species at the region and also country level due to its scattered locations throughout the whole Poland.

Serrated wintergreen *Orthilia secunda*

Distribution and abundance

It is a perennial plant of the *Pyrolaceae* family, common throughout the whole country. In the Błędowska Desert, in the project area, the species occurred in the pine tree groups and in coniferous forests. The populations ranged from a few to several dozen individuals, some of which were blooming and fruiting. The total abundance of the species in the whole inventory area was estimated at more than four thousand specimens.

Typical habitats and ecological requirements

The species associated with coniferous forests of class *Vaccinio-Piceetea*, but it also occurs in poor oak forests of *Quercetea robori-petraeae*. It requires moderate shade to prop-

Sidebells wintergreen *Orthilia secunda*. © Małgorzata Jaźwa

er growth. It occupies habitats moderately rich in nutrients, on moderately acidic soils (pH 5-6). It is found on sands and sandy clays, on mineral-humus substrata with average water content (fresh soils).

Protection and conservation status

The taxon is not protected by law in Poland but it has a conservation category of R (rare) by the *Red List of vascular plants of Upper Silesia*.

Threats resulting from planned active protection actions and protective recommendations

The destruction of individuals habitat in the project area has not significantly influenced the population of this species at the region and also country level due to the frequent occurrence of the species in Poland.

Dutchman's pipe *Monotropa hypopitys* and the leaves of sidebells wintergreen *Orthilia secunda*. © Kamil Kulpiński

Yellow bird's-nest *Monotropa hypopitys*

Distribution and abundance

It is a perennial plant of the *Monotropaceae* family, common throughout the whole country. In the Błędowska Desert, in the project area, the species was found only in one location – in its north-eastern part, near the valley of the Biała Przemsza. Number of 25 individuals was recorded there.

Typical habitats and ecological requirements

The species associated mainly with pine forests of *Dicrano-Pinion*, but it also occurs in other types of coniferous forests and in deciduous woodlands. It does not contain chlorophyll, so it does not conduct photosynthesis. Organic compounds are derived from fungi that form a mycorrhiza (live in symbiosis) with nearby tree species, mainly pines. Such a life style determines the ecological requirements of this plant. As not conducting photosynthesis plant it does not need light – it is a shade-loving species. Moreover it grows predominantly on nutrient-poor substrata, because it derives nutrients from fungus, not from the substrata. It prefers fresh and acidic (pH <6) soils, formed on sands and clays.

Protection and conservation status

The taxon is not protected by law in Poland but it has a conservation category of R (rare) by the *Red List of vascular plants of Upper Silesia*.

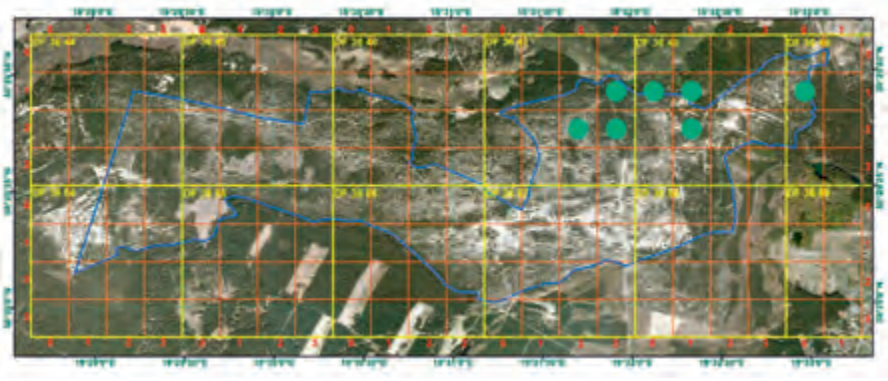


Fig. 18. Distribution (ATPOL squares) of round-leaved wintergreen *Pyrola rotundifolia* in the Błędowska Desert.

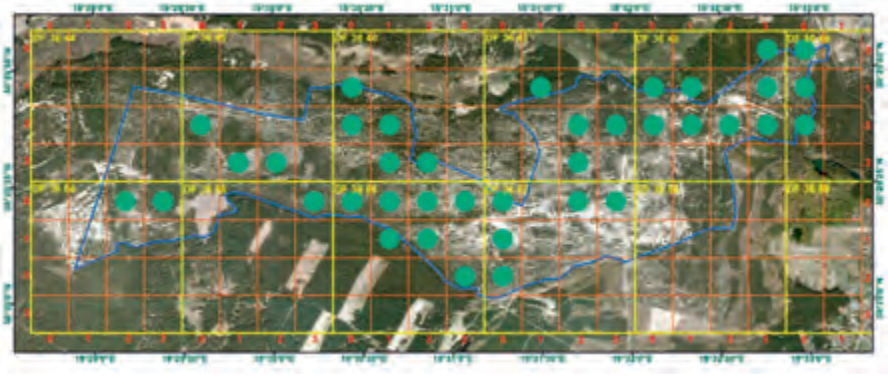


Fig. 19. Distribution (ATPOL squares) of green-flowered wintergreen *Pyrola chlorantha* in the Błędowska Desert.

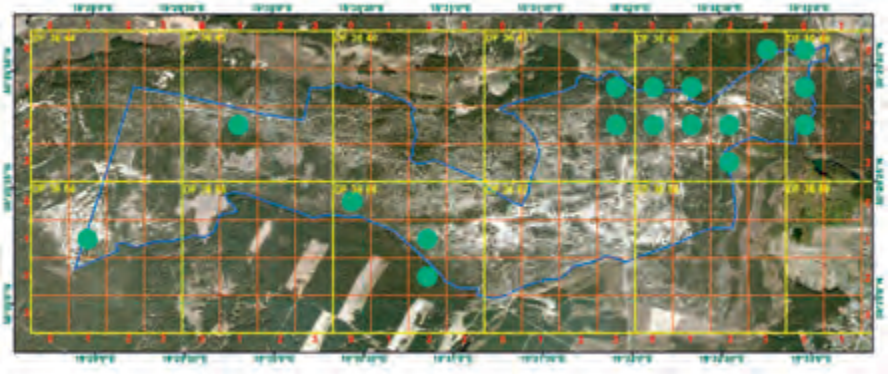


Fig. 20. Distribution (ATPOL squares) of one-flowered wintergreen *Moneses uniflora* in the Błędowska Desert.

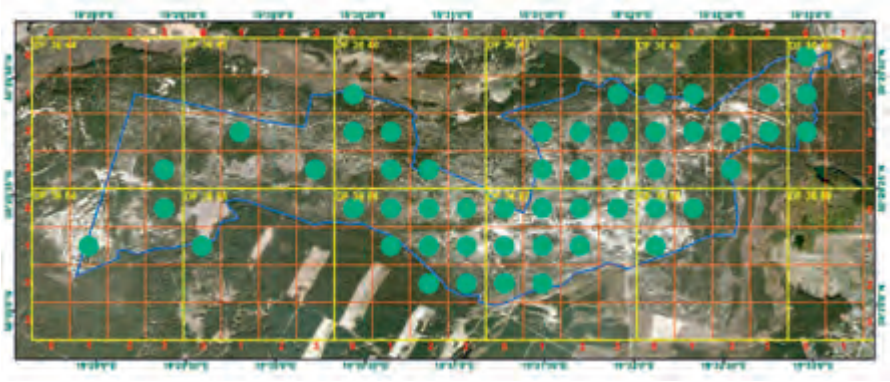


Fig. 21. Distribution (ATPOL squares) of serrated wintergreen *Orthilia secunda* in the Błędowska Desert.

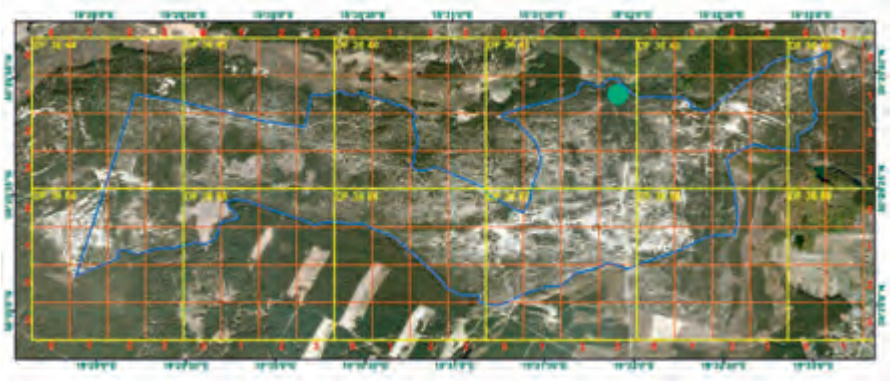


Fig. 22. Distribution (ATPOL squares) of yellow bird's-nest *Monotropa hypopitys* in the Błędowska Desert.

Threats resulting from planned active protection actions and protective recommendations

Yellow bird's-nest is a plant that derives the nutrients through the mycorrhizal fungi from pine trees. Felling of neighboring with the plant trees, resulting from the planned active conservation actions, was equivalent to the destruction of its population. Due to the frequent occurrence of the taxon in the whole Poland, damage of specimens in the project area has not significantly influenced its population in the country.

Invasive and alien plant species

Within the desert area the presence of six alien plant species for Poland were recorded, including four (wild black cherry, northern red oak, large-leaved lupine, black locust) that belong to the category of invasive plants. During the categorization of these species the definition of an alien species was as follows: it is a species, sub-species or lower taxon

Black cherry *Padus serotina*. © Kamil Kulpiński

introduced to the area outside its native distributional range, while an invasive species is called the non-indigenous species domesticated in the originally foreign area, producing vigorous offspring, often in huge amount, spread on significant distance from the parental plant.

Wild black cherry *Padus serotina*
Distribution and abundance

It is a woody plant of the family *Rosaceae*, a neophyte, native to North America. It belongs to invasive species. It occurs throughout the whole country and the number of its location has recently increased. It is found in both natural and semi-natural ecosystems as well as in these completely transformed by human. In the southern part of the Błędowska Desert, in the project area, it occurred in the pine tree groups or in pine forests. The most common were seedlings and very young specimens, while single individuals higher than 1,5 m, blooming and bearing fruit, were rare. Wild black cherry was formerly planted in forests and also in gardens as an ornamental plant. It spreads by birds that feed on its fruit (ornithochory). In the Błędowska Desert the source of its dispersal are most likely fruiting specimens growing in open areas at the foot of Czubatka and specimens at the Biała Przemsza River. A total of a bit over 200 specimens were recorded. Due to difficult habitat conditions that prevail in the Błędowska Desert area, the species do not pose a threat to natural sandy vegetation. With a total exposure of sand surfaces, the germination of wild black cherry seeds is strongly limited.

One of the bigges northern red oak *Quercus rubra* found in the Błędowska Desert. © Kamil Kulpiński

Typical habitats and ecological requirements

The species grows in various light conditions – from partial shade to moderate light. In Poland it is currently found in different communities of deciduous forests, in pine forests and on set aside meadows and fields. It occurs on moderately acidic and basic soils (pH 5-7) of mineral-humus character, on sandy or sandy-clay substrata. It prefers moderately nutrient-poor habitats, where the soil is characterized by an average water content (fresh soil).

Northern red oak *Quercus rubra*

Distribution and abundance

It is a woody plant of the family *Fagaceae*, a neophyte, native to North America. It inhabits mostly natural ecosystems. It is an invasive plant, which is still planting in forest ecosystems. So far it has been a species planted in forests – it is seen, for example, in the vicinity of the project area, on the road running near the ponds from the center of Klucze to the Błędowska Desert (nearby the educational path). Small, planted in rows, young red oaks are grown there. In the project area, in the southern part of the Błędowska Desert, the species occurred in dispersion in most parts of the area. It grew mainly in shady places – in the pine tree groups and in pine forests. It was frequent, but mostly in the form of seedlings. Specimens growing up to 50 cm were very rare. It demonstrated low viability of seedlings in desert habitat conditions – most of them were not able to survive first winter or it was dying under the influence of low humidity.

Typical habitats and ecological requirements
The species occurs in Poland mainly in poor oak forests, pine and mixed forests (it was introduced also to other forest types). It requires moderate light and prefers poor and moderately poor in nutrients habitats formed on sandy clays and sands with an average water content (fresh soil). It occurs on mineral-humus soils, from acidic to moderately acidic ones (pH 4-6).

Large-leaved lupine *Lupinus polyphyllus*
Distribution and abundance
It is an invasive perennial plant of the *Fabaceae* family, a neophyte, native to North America. In Poland, except of the Carphatians, it is widespread. It occurs in both natural and semi-natural ecosystems as well as in these completely changed by a man. In recent years, the number of the species locations has increased. In the Błędowska Desert, in the project area, the plant occurred only in its eastern part, in the pine forest and in loose tree clusters adjacent to the valley of Biała Przemsza. The population was not very large and it contained about 50 individuals.

Typical habitats and ecological requirements
It usually grows in mixed forests and dry and fresh pine forests. Especially often the species is found in clearings and at the forest roads and edges – it requires full or moderate light to proper growth. It occurs on dry and fresh soils, moderately poor or rich in nutrients. It prefers mineral-humus soils, acidic to basic ones (pH 5-7).

Black locust *Robinia pseudacacia*
Distribution and abundance
It is a woody plant of the *Fabaceae* family, neophyte. It is native to North America and it is an invasive species. It occurs in both natural and semi-natural ecosystems as well as in completely transformed by human. The taxon is widespread throughout the whole country, less frequent only in north-eastern Poland. In the project area it occurred only in its extreme eastern and western parts. In the western part 15 specimens were recorded, including quite large trees, which were vegetatively reproducing and fruiting. They grew at the edge of pine forest. In the eastern part 17 specimens were located in pine forest.

Typical habitats and ecological requirements
The species usually grows on the edges of forests, in thermophilic thickets, on dry, sunny slopes and in wastelands. More frequently it has also overgrown the xerothermic grasslands. It is a photophilous plant. The soil requirements of this species are small. Like many other plants of the *Fabaceae* family it has symbiotic nitrogen-fixing bacteria that fix free nitrogen from the air, what contributes to the change in the chemical substrata composition.

Large-leaved lupine *Lupinus polyphyllus*. © Małgorzata Jaźwa

Black locust *Robinia pseudoacacia*. © Kamil Kulpiński

Needles and pine cones of *Pinus banksiana*. © Kamil Kulpiński

Banksian pine *Pinus banksiana*

Distribution and abundance

It is a woody plant of the family *Pinaceae*, native to North America, a neophyte. In Poland its status is still not fully known in terms of invasiveness. Currently, it is assumed that it is locally domesticated plant. Formerly Banksian pine was planted on wastelands. Moreover, it is also an ornamental plant cultivated in gardens. In the southern part of the Błędowska Desert, covered by the project, only three adult specimens of this species were recorded. Most likely Banksian pine did not reproduce in the desert; however it was almost completely impossible to distinguish its seedlings and young specimens from seedlings and young specimens of Scots pine *Pinus sylvestris*.

Typical habitats and ecological requirements

It is a light-loving species that was introduced in Poland, mainly in pine forest habitats. It prefers nutrient-poor, sandy soils.

Long-leaved violet willow *Salix acutifolia*

Distribution and abundance

It is a shrub of the *Salicaceae* family, a neophyte, native to eastern Europe and western Asia. In Poland, its distribution is mainly related to the occurrence of dunes and large sandy areas, where it was introduced. The species does not have invasive plant status; it is identified as domesticated species. Although long-leaved violet willow is not invasive species, it is the major threat to sandy grasslands of all alien plant species recorded in the Błędowska Desert. This

Sharp-leaf willow *Salix acutifolia*. © Kamil Kulpiński

is due to its facility of inhabiting the drift sands. Cut branches buried in the sand easily germinate within one season, binding the sand. Also due to these properties violet willow was introduced and planted in the Błędowska Desert. It has notably adapted to the open sandy areas. By binding the sand, it simultaneously produces a huge amount of dead matter, which activates the soil-forming processes, and thus it facilitates the germination of other trees and shrubs, including mainly pine. Within the project area the plant was evenly and commonly spread. For some time, it has begun to gradually die. Viability was generally shown only by single shoots, whereas there were a lot of dead willows. The largest number of dead individuals was recorded in pine forests and dense pine tree clusters. The disappearance of this light-loving species has been partially caused by expanding of Scots pine *Pinus sylvestris*.

Typical habitats and ecological requirements

The species was introduced on dunes and in the sandy grassland habitats. It is a strongly photophilous plant – from overheating it is protected by a white waxy bloom on the shoots. It grows on humus-poor soils, where pH is acidic or moderately acidic (pH 4-6). It occurs on dry sands, in nutrient-poor (oligotrophic) habitats.

Sea lyme grass *Leymus arenarius*

Distribution and abundance

It is a psammophylic plant of the grass family (*Poaceae*). It is not an alien species to country flora. Its native locations are limited to the Baltic coasts. Other locations are the anthropogenic ones, arising due to plantings. In these sites it is a locally alien species, which is not an element of sandy grasslands. The grass was planted on dunes to fix the sands.

Lyme grass *Leymus arenarius*. © Kamil Kulpiński

In the Błędowaska area the largest patches of this species were recorded in the northern part of the area, in Chechło (outside the project area) and in north-eastern part of the project area, in the vicinity of Biała Przemsza River valley. Moreover, in the eastern part of the project area single shoots of this plant were found – mainly in clumps of creeping willow *Salix repens* subsp. *arenaria*, but also on sandy grasslands and in loose tree groups. Few shoots were also recorded in similar sites in the south-western part of the area. A total of slightly less than 500 shoots of this species was found.

Typical habitats and ecological requirements

The species occurs naturally on sandy coastal dunes of *Ammophiletea* class. Locations in other habitats in Poland have anthropogenic character. It is a sand- and light-loving plant. It prefers humus-poor and mineral-humus, dry and fresh soils. It requires moderately acidic to basic substrata (pH 5-7). The taxon is found in poor and moderately poor in nutrients habitats (mesorophic).

Fig. 23. Distribution of invasive plant species: northern red oak, wild black cherry, black locust and large-leaved lupine in the Błędowska Desert.

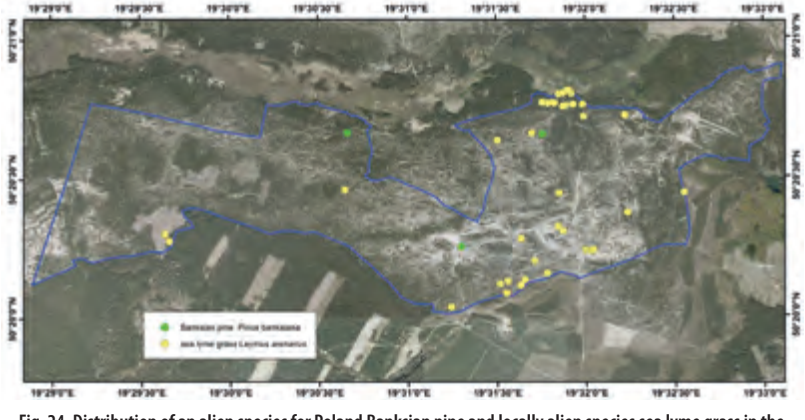


Fig. 24. Distribution of an alien species for Poland Banksian pine and locally alien species sea lyme grass in the Błędowska Desert.

Invertebrates

Conducting the entomologic inventory, particular attention was given to protected taxa included in the IUCN Red List, as well as the National Red List. Apart from field observations, the trapping of terrestrial insects was carried out, using an insect net, a butterfly net and pitfall trap. All individuals were caught, identified in field and released.

Results showed a relatively low species diversity of insects in the Błędowska Desert. Despite this, much of the individuals represented very valuable taxa inhabiting mainly in the open grasslands habitats. In the area of inventory, the following species, among others, have been found: striped-winged grasshopper *Stenobothrus lineatus*, european garden spider *Araneus diadematus*, black-tailed skimmer *Orthetrum cancellatum*, Réal's wood white *Leptidea reali*, green-veined white *Pieris napi*, common brimstone *Gonepteryx rhamni*, scarce copper *Lycaena virgureae*, large blue *Maculinea arion*, silver-washed fritillary *Argynnis paphia*, pearly heath *Coenonympha arcania*, ringlet *Aphantopus hyperantus*, small heath *Coenonympha pamphilis*, grayling *Hipparchia semele*, rock grayling *Hipparchia alcyone*, burnet moth *Zygaena ephialtes*, slender blue-winged grasshopper *Sphingonotus caerulans*, blue-winged grasshopper *Oedipoda caerulescens*, vagrant darter *Sympetrum vulgatum*, wasp spider *Argiope bruennichi*, common green lacewing *Chrysoperla carnea*, red-banded sand wasp *Ammophila sabulosa*, antlion (*Myrmeleon formicarius* and *Myrmeleon bore*), sand wasp *Bembix rostrata* and northern dune tiger beetle *Cicindela hybryda*. It is worth noting, that the last four listed species are valuable taxa inhabiting open sandy habitats. Apart from them, on the non-forest areas a lot of ant colony of *Myrmicinae* subfamily was recorded and also an ant belonging to the species *Formica cinerea* – this taxon occurs on sandy areas, which are dry and open.

Active conservation activities increased the surface of non-forest sandy habitats, which are used by valuable taxa as places of existence and feeding. On the other hand, in order to minimize the negative impact of the project on the forest species populations (e.g. colonies of ants *Formica rufa*), it was decided to keep approx. 100 hectares of pine forest.

Slender blue-winged grasshopper *Sphingonotus caerulans*

Distribution and abundance

The species was observed throughout the entire study area within the desert, in places where the dunes and exposed sandy point bars occur. It is quite numerous and widespread in the country and on the continent. The population size is limited by the habitat conditions – it requires dry and sandy areas.

Elements of the species biology

The species is a representative of the grasshopper family (*Acrididae*). This pioneer species inhabits dry, sandy and poor in vegetation areas. It occurs also on completely bare, sandy surfaces. Imago is recorded in the period from August to September. The body length of an adult individual is from 16 to 31 mm. The colour of its body is similar to blue-winged grasshopper *Oedipoda caerulescens*, however it has much longer wings and more slender body.

Protection and IUCN conservation status
The species is not protected by law.

Threats resulting from planned active protection actions and protective recommendations
Slender blue-winged grasshopper disappears together with overgrowing of sandy areas. Active protection of sandy grasslands increased the number of available habitats used by this species.

Striped-winged grasshopper *Stenobothrus lineatus*
Distribution and abundance
The species occurs almost throughout the whole Europe. In Poland it is common and recorded quite frequently throughout the entire project area.

Elements of the species biology
The species belongs to the grasshopper family (*Acrididae*). It is dry-liking species inhabiting heaths, dry grasslands and the edges of pine forests. Imago is found from July to October. The body length of an adult individual is from 15 to 26 mm. The colour of its body is yellow, green or brown.

Protection and IUCN conservation status
The species is not protected by law.

Threats resulting from planned active protection actions and protective recommendations
Active protection of sandy grasslands increased the number of available habitats used by this species.

Antlion *Myrmeleon formicarius*
Distribution and abundance
The species was repeatedly found in the project area. In Poland it is widespread.

Elements of the species biology
The taxon belongs to the antlion family (*Myrmeleontidae*). The adult individuals, resembling dragonflies, do not arouse much interest, while the larvae are certainly one of the most interesting predators among all insects. They occur on sandy surfaces, especially in the area of pine forests. The larva buries itself in the sand forming distinctive, not big funnel with a diameter of a few centimeters. In the bottom of the funnel there is a larva buried in the sand, which ejects on the surface only the very strong mandibles. Such well-designed pit causes that the insect (usually ant), who enters this trap, has a difficulty to get out. In addition, the antlion larva using the mandibles throws grains of sand bombarding its victim with them. The insect, which gets to the bottom of the trap, is caught

Stenobothrus lineatus. © Dariusz Ropek

The larva of *Myrmeleon formicarius*. © Dariusz Ropek

by antlion mandibles and then slowly sucked. The antlion larvae prey mostly for ants, therefore the traps are set up in a close proximity to the ant assemblages.

Protection and IUCN conservation status
The species is not protected by law.

Threats resulting from planned active protection actions and protective recommendations
In Poland the species is relatively abundant. Active protection of sandy grasslands increased the number of available habitats used by this species, located especially at the edges of the pine forests.

Antlion *Myrmeleon bore*
Distribution and abundance
The species was observed throughout the entire study area, in places where dunes are not covered by the humus layer. The population of this species is relatively large within the desert.

Elements of the species biology
The taxon belongs to the antlion family (*Myrmeleontidae*). It occurs on coastal and inland dunes. Suitable habitats are also sandy banks of the river backwaters and sandy point bars in the overexposed, dry pine forests. The antlion food is primarily ants and other insects moving over the surface of the sand. A larva of *Myrmeleon bore* has exactly the same way of hunting for victims as a larva of *Myrmeleon formicarius*.

Protection and IUCN conservation status
The species is not protected by law.

Threats resulting from planned active protection actions and protective recommendations
A major threat is currently overgrowing of sandy areas and thus decreasing the area of dunes and sandy point bars. Active protection of sandy grasslands had a positive impact on the species population due to increase of the number of habitats used by this species.

Large blue *Maculinea arion*
Distribution and abundance
Several individuals of this species were observed in the desert area, which has already undergone the actions of removing trees and shrubs. Probably, it occurs also in other places, where its host plant wild thyme *Thymus serpyllum*, lemon thyme *Thymus pulegioides and oregano Origanum vulgare.*

The trap, which was prepared by antlion *Myrmeleon bore*. © Dariusz Ropek.

Trace of a moving antlion larva *Myrmeleon bore*. © Dariusz Ropek

Elements of the species biology
The species is a representative of the gossamer-winged butterfly family (*Lycaenidae*). This butterfly prefers dry, midforest meadows, clearings, pastures and xerothermic grasslands. The development of this taxon is associated with the presence of ants of the genus *Sabuleta Myrmica sabuleti* Nyl. Young caterpillars first feed on flowers, and then their development continues in anthills. Imagoes eat the nectar of flowers with petals colour ranges from red to blue-purple. Imagoes are recorded from June to August. Large blue butterflies have a wingspan of up to 35 – 40 mm.

Protection and IUCN conservation status
In Poland it is legally protected. It is included in the Polish Red Book of Animals. The species has a category of threatened with extinction in Poland: EN (Endangered).

Threats resulting from planned active protection actions and protective recommendations
A major threat for this species is the disappearance of habitats together with the locations of food plant. Active protection of sandy grasslands within the desert area tends to the protection, or even increasing the number of sites of the wild and lemon thymes.

Grayling *Hipparchia semele*
Distribution and abundance
In Poland it is a common species occurring throughout the whole country. In the project area it was recorded several times.

Elements of the species biology
The species belongs to the brush-footed butterfly family (*Nymphalidae*). This butterfly inhabits dry pine forests, heaths and xerothermic grasslands. It prefers sandy areas and dunes. It lays eggs singly on withered blades of grasses low above the ground. Caterpillars are active at night, during the day they look for a shelter on the ground. Pupation takes place in a cocoon just above the earth surface. Imago preferably sits on the ground and tree trunks with folded wings. They feed on flowers nectar and juices of injured trees. Imago is observed from June to August. Grayling has a wingspan of up to 45 – 55 mm. Primary host plants of this species include grasses, fescues, tufted hairgrass, reed rass and sea lyme grass.

Protection and IUCN conservation status
The species is not protected by law.

Threats resulting from planned active protection actions and protective recommendations
Active protection of sandy grasslands had a positive impact on the population of the taxon due to the increase of areas used by this species.

Large blue *Maculinea arion*. © Dariusz Ropek

Rock grayling *Hipparchia hermione*

Distribution and abundance

The species is less and less frequently observed in Poland. It is seen in the entire country except Małopolska region. In the project area only single observations of this taxon were noted.

Elements of the species biology

The species belongs to the brush-footed butterfly family (*Nymphalidae*). This butterfly inhabits dry pine forests, heaths and xerothermic grasslands. It prefers sandy areas and dunes. Caterpillars are active at night. Primary host plants of this species include grasses, bromes and bunch grasses of *Brachypodium*. Imago is observed from July to August.

Protection and IUCN conservation status

In Poland the species is protected by law. It is also included in the Polish Red Book of Animals. According to the Red List of threatened animals in Poland it has a category of threatened with extinction: EN (Endangered).

Threats resulting from planned active protection actions and protective recommendations

Active protection of sandy grassland habitats had a positive impact on the population of the taxon due to the increase of areas used by this species.

Digger wasp *Sphex maxillosus*

Distribution and abundance

In Poland it is very rare species, although recently it has shown expansion and there is a chance that its abundance and range will noticeably increase. Within the desert area only one location of this species was observed, however the occurrence of higher number of this butterflies is likely.

Elements of the species biology

Digger wasp is a representative of the wasp family (*Sphecidae*). It is a thermophilic species (xerophilous) inhabiting sandy areas near forests covered with sparse vegetation. It reaches a size of 15 to 22 mm, and the ability to fly has from July to September. Imago feed on nectar. Larvae for the development need food rich in proteins. Female deliver to their nests captured, paralyzed grasshoppers and crickets – 2 or 3 insects per nest – where there are 3 to 4 nesting chambers.

Protection and IUCN conservation status

The species is not protected by law.

Threats resulting from planned active protection actions and protective recommendations

Active protection of sandy grassland habitats had a positive impact on the population of the taxon due to the increase of areas used by this species.

Sand wasp *Bembix rostrata*

Distribution and abundance

In Poland only one location of the species was observed within the study area, but there are probably many more.

Elements of the species biology

Sand wasp belongs to the sphecoid wasp family (*Sphecoidea*). Imago feed on plants, while the larvae eat the protein-rich food. Adult individuals catch large flies (dipteran) and feed the offspring with them – even up to 50 insects per one larva. During the season they raise only about 6 larvae. The species inhabits sandy areas sparsely covered with vegetation. Individual reaches a size of 15 to 24 mm.

Protection and IUCN conservation status

The species is included in the Red List of threatened animals in Poland and it has a category of threatened with extinction: EN (Vulnerable).

Threats resulting from planned active protection actions and protective recommendations

Active protection of sandy grassland habitats had a positive impact on the population of the taxon due to the increase of non-forest areas used by this species.

Rock grayling *Hipparchia alcyone*. © Dariusz Ropek

Sphex maxillosus. © Dariusz Ropek

Ant *Formica cinerea*

Distribution and abundance

The species occurs throughout the whole area of Poland and almost in all other areas of Europe. Within the desert the large number of the species colonies was found.

Elements of the species biology

The ant belongs to the *Formicinae* subfamily. The workers reach a size of 4-7 mm, while the queens are up to 8-11 mm. Individuals are characterized by coloration in shades of black (black, brown-black, gray-black). The colonies are formed in dry, exposed, sandy areas. Ants work together when they move larger insects to their nest.

Protection and IUCN conservation status

The species is not protected by law in Poland.

Threats resulting from planned active protection actions and protective recommendations

Active protection of sandy grassland habitats had a positive impact on the population of the species due to the increase of sandy areas of the non-forest habitats used by this taxon.

Red wood ant *Formica rufa*

Distribution and abundance

In Poland it is a common forest insect. In the study are the anthills were not observed. In Poland the nests of these ants are protected. However, at the desert entrance there is one anthill (outside the area under inventory).

Elements of the species biology

The ant belongs to the *Formicinae* subfamily. Individuals reach up to 9 mm. They feed on honeydew, larvae and small insects. Workers are wingless; the membranous wings are present only at fertile females. On the abdomen they have tiny hair, and their legs are strong and long.

Protection and IUCN conservation status

In Poland the species is partially protected.

Threats resulting from planned active protection actions and protective recommendations

Active protection of sandy grassland habitats, by removing the trees and shrubs, caused the decrease in the population of the species within the desert area, but it did not affect significantly the preservation status in the region and the whole country.

Formica cinerea. © Dariusz Ropek

Anthill of ants of the genus *Formica*. © Dariusz Ropek

Northern dune tiger beetle *Cicindela hybryda*

Distribution and abundance

In Poland the species can be found throughout the whole country. It was recorded throughout the entire project area, in places where dunes were not covered by the humus layer.

Elements of the species biology

It belongs to the ground beetle family (*Carabidae*). The species occurs in sandy areas. Suitable habitats for this beetle are dunes and sandy point bars in the overexposed, dry pine forests. Beetle activity may be observed in warm, sunny days. It is a very predatory insect. It waits in the shelter for its victims, and when the time is right, it starts to chase them very fast. Larvae wait for their potential prey hidden in a shelter. Once captured, they draw them inside the shelter and devour them there. The body length of this beetle ranges from 11 to 16 mm.

Protection and IUCN conservation status

The species is not protected by law in Poland.

Threats resulting from planned active protection actions and protective recommendations

A major threat to the species is currently overgrowing the sandy desert areas and the decrease in the area of dunes and sandy point bars. Active protection of sandy grassland habitats had a positive impact on the population of the taxon due to the increase of the non-forested areas used by this species.

Birds

During survey of the Błędowska Desert area 45 species of birds were found. Ornithological observations consisted of 12 field controls, which were carried out as linear transects, from 5:00 to 15:00 o'clock. Each observed and heard bird was recorded.

A large majority of recorded taxa were adult birds. For some species, including song trush *Turdus philomelos* and chaffinch *Fringilla coelebs*, nesting was confirmed. Non-breeding species in the study area were eg.: great egret *Ardea alba*, black woodpecker *Dryocopus martius*, raven *Corvus corax*, barn swallow *Hirundo rustica*, common house martin *Delichon urbicum*, swift *Apus apus* and buzzard *Buteo buteo*.

The dominant group among observed species was birds associated with forest habitats. These included e.g. redstart *Phoenicurus phoenicurus*, blackbird *Turdus merula*, wood pigeon *Columba palumbus*, european crested tit *Lophophanes cristatus*, great tit *Parus major*, coal tit *Parus ater*, chaffinch *Fringilla coelebs*, jay *Garrulus glandarius*, great spotted woodpecker *Dendrocopos major*, willow warbler *Phylloscopus trochilus*, song trush *Turdus philomelos*, spotted nutcracker *Nucifraga caryocatactes*.

In the group of forest birds less frequently were observed: hawfinch *Coccothraustes coccothraustes*, wood nuthatch *Sitta europaea*, cuckoo *Cuculus canorus*, nightjar *Caprimulgus europaeus*, goldcrest *Regulus regulus*, robin *Erithacus rubecula*, wood warbler *Phylloscopus sibilatrix*.

Northern dune tiger beetle *Cicindela hybrida*. © Dariusz Ropek

The shelter of northern dune tiger beetle *Cicindela hybrida*. © Dariusz Ropek

Species found on individual positions included: black woodpecker *Dryocopus martius*, jackdaw *Corvus monedula*, European turtle dove *Streptopelia turtur*.

The least numerous were species associated with open areas. These were mainly: woodlark *Lullula arborea*, tawny pipit *Anthus campestris*, wheatear *Oenanthe oenanthe* and hoopoe *Upupa epops*. These birds were the most valuable taxa recorded in the study area. The main reason for their low number was probably the lack of suitable habitat. As a result of progressive succession, the area of open spaces, which are feeding and nesting place for mentioned individuals, had drastically decreased. Active protection has contributed to increase the non-forest habitats, thereby provided the opportunity to rebuild the population of listed species.

During the study, the species listed in Annex I of the Birds Directive were reported. These taxa were: great egret *Ardea alba*, nightjar *Caprimulgus europaeus*, black woodpecker *Dryocopus martius*, woodlark *Lullula arborea*, tawny pipit *Anthus campestris*. Furthermore, the species listed in Annex II / 1 of the Birds Directive (pheasant *Phasianus colchicus* and wood pigeon *Columba palumbus*) and Annex II / 2 of the Birds Directive (collared dove *Streptopelia decaocto*, turtle doves *Streptopelia turtur*, blackbird *Turdus merula*, song trush *Turdus philomelos*, jay *Garrulus glandarius*, jackdaw *Corvus monedula*, starling *Sturnus vulgaris*) were observed.

The Błędowska Desert was dominated by common and widely distributed species, both in the region and Poland. Some of them used the open areas as feeding sites, but the vast majority was associated with forest habitats. Conducted tree harvesting was leveraged primarily for birds associated with non-forest areas. At the same time, due to the commonness of the other recorded taxa and access to forest habitats outside the project area, there was no risk of a negative impact on regional populations of these species.

Common pheasant *Phasianus colchicus*

Distribution and abundance

In Poland the species inhabits mainly lowland areas. It is a breeding and resident bird, sparse, locally moderately abundant. During field observations three individuals of this species were found within the project area.

Elements of the species biology

Pheasant is a representative of the pheasant family (*Phasianidae*). It is a chicken-sized bird whose body length is from 53 to 90 cm. The species is characterized by a clear sexual dimorphism. Colored male is distinguished by the green sparkling head, rusty plumage of the body, a long tail and a white neck ring. Appearance of a female is much less spectacular (light brown plumage all over and a shorter tail) that provides the easier ability to mask in the field, especially in the breeding season. Female lays 10 to 12 olivegreen eggs, which are incubated about 23-28 days. Individuals prefer agricultural areas with clumps of bushes, shrubby river valleys and edges of forests with dense undergrowth located preferably near the water reservoirs.

Protection and IUCN conservation status

Pheasant is a game species (roosters hunting period lasts from 1st October to the end of February, while hunting for hens is permitted from 1st October to 31st January only

Common pheasant *Phasianus colchicus*. © Dawid Oruba

in the areas of game breeding centers, where a pheasant aviary breeding is carried out. The species was introduced in Poland in the sixteenth century, and currently its population is still supported by the birds releasing into the wild for hunting. The taxon has a conservation category of LC (least concern) by the IUCN.

Threats resulting from planned active protection actions and protective recommendations

The species is not threatened with extinction on a scale of Małopolska region, as well as the whole Poland area. The implementation of active protection of sandy grassland habitats, which leads to the formation of open areas, does not negatively affect the population of this species.

Northern wheatear *Oenanthe oenanthe*

Distribution and abundance

It is a migratory, sparse, and even locally very sparse breeding bird occurring throughout the whole country. During the research conducted within the project area two individuals of this species were observed, feeding in the part of the desert devoid of trees.

Elements of the species biology

Wheatear belongs to the Old World flycatcher family (*Muscicapidae*). It is a sparrow-sized bird (a body length is up to 15-16 cm, weight approx. 20-30 g). The breeding plumage of a male has grey upperparts, a black face mask, black wings and a tail. The bottom of its

Northern wheatear *Oenanthe oenanthe*. © Dawid Oruba

body is light orange from the throat to the chest, but lower, towards legs becomes white (therefore the polish name of the species which draws attention to a white rump and white bottom of the tail). The plumage of male outside the breeding season and female is less contrast. Female lays up to 5-6 pale green eggs, which incubation period is about 13 to 14 days. The species prefers dry, open, sunny areas with stones, abandoned gravel pit mines, areas near railway embankments, and also freshly plowed areas of felling in dry stands.

Protection and IUCN conservation status
According to the Polish law the species is strictly protected. The taxon has a conservation category of LC (least concern) by the IUCN.

Threats resulting from planned active protection actions and protective recommendations
The species is not threatened with extinction on a scale of Małopolska region, as well as the whole Poland. The implementation of the project tasks has contributed to the increase of the open habitat areas used by wheatear.

Great egret *Ardea alba*
Distribution and abundance
In Poland it is an extremely sparse breeding and migratory bird. During the research conducted in the project area only one individual flying over the desert was observed.

Elements of the species biology
Great egret is a large bird of the heron family (*Ardeidae*). Its size is similar to the grey heron (body length 85-100 cm), but with all-white plumage. In the breeding plumage the great

Great egret *Ardea alba*. © Dawid Oruba

egret is distinguished by black beak, yellow legs and elongated delicate ornamental feathers on the shoulders. The non-breeding plumage is characterized by yellow beak and dark yellow-green legs. In Poland the white heron nests in dense willow thickets, in marshy floodplains of the river valley, near the water reservoirs and fish ponds. Female lays from 2 to 5 pale blue eggs in the nest, which incubation period lasts about 25-26 days.

Protection and IUCN conservation status

According to the Polish law the species is strictly protected. The taxon is listed in Annex I of the Birds Directive and has a conservation category of LC (least concern) by the IUCN.

Threats resulting from planned active protection actions and protective recommendations

The implementation of active protection of sandy grassland habitats, which leads to the formation of the open areas, does not negatively affect the population of this species.

Willow tit *Poecile montanus*

Distribution and abundance

In Poland it is a breeding and wintering species, moderately abundant or sparse. In the project area six individuals were observed.

Elements of the species biology

Willow tit belongs to the tit family (*Paridae*). It is a petite tit with a body length of 11-12 cm, similar to marsh tit. The plumage of the upper body part is grey-brown, and the bottom is light. On the wings there is a light patch, which does not occur at marsh tit.

European crested tit *Lophophanes cristatus*. © Dawid Oruba

On a head there is a clear black cap reaching the neck and under the throat there is a black bib (both elements are larger and longer than those ones at marsh tit). This species has no sexual dimorphism. Female lays from 6 to 9 white, rusty-spotted eggs which incubation lasts about 13-15 days. The taxon inhabits marshy and moist mixed forests and sometimes also mid-field and riverside forests and parks.

Protection and IUCN conservation status
According to the Polish law the species is strictly protected. The taxon has a conservation category of LC (least concern) by the IUCN.

Threats resulting from planned active protection actions and protective recommendations
The species is not threatened with extinction on a scale of Małopolska region and the whole Poland. Active protection of sandy grassland habitats has not contributed to the deterioration of the species population size in the country, due to the availability of the habitats used by this taxon outside the project area.

European crested tit *Lophophanes cristatus*
Distribution and abundance
In our country it is a breeding and wintering species, moderately abundant. In the project area several individuals were observed.

Elements of the species biology
European crested tit belongs to the tit family (*Paridae*). It is a small bird with a body length of 11-12 cm. Its main feature is erectile, black-and-white crest on a head. The

Hoopoe *Upupa epops*. © Dawid Oruba

plumage of the upper body part is grey-brown, and the bottom is light. Both sexes are equally feathered. Female lay from 5 to 6 white, reddish-spotted eggs which incubation lasts about 15-18 days. The taxon inhabits all types of coniferous forests and, more rarely, mixed forests.

Protection and IUCN conservation status

According to the Polish law the species is strictly protected. The taxon has a conservation category of LC (least concern) by the IUCN.

Threats resulting from planned active protection actions and protective recommendations

The species is not threatened with extinction on a scale of Małopolska region and the whole Poland. Active protection of sandy grassland habitats has not contributed to the deterioration of the species population size in the country, due to the availability of the habitats used by this taxon outside the project area.

Hoopoe *Upupa epops*

Distribution and abundance

In Poland it is a breeding and migratory bird, sparse or locally even very sparse. During field observations two feeding individuals of this species were observed in the part of the desert devoid of trees.

Elements of the species biology

Hoopoe belongs to the *Upupidae* family. Particular attention is paid to an orange plumage of the individuals with black-and-white stripes on the back and wings, a black tail with

a white band and impressive, distinctive „crown" of feathers on a head, which is spread in the moments of concern. A long, thin bill, which is black, is a perfect tool to search for food in the ground. Female lays from 5 to 7 olive or grey eggs which are incubated for about 18-20 days. The hoopoe nests are usually characterized by unpleasant odor. The reason for this is an effective anti-predator weapon of a female and the nestlings. In the face of danger their uropygial glands produce a foul-smelling secretion towards the enemy to deter predators. The species prefers peripheries of forests near meadows, pastures, fields, and also agricultural areas with avenues or clusters of old trees.

Protection and IUCN conservation status
According to the Polish law the species is strictly protected. The taxon has a conservation category of LC (least concern) by the IUCN.

Threats resulting from planned active protection actions and protective recommendations
Active protection actions of sandy grassland areas have contributed to the increase of the open habitat areas used by this species as a place of feeding.

Black woodpecker *Dryocopus martius*
Distribution and abundance
In the country area it is sparse, and locally moderately abundant breeding and resident bird. In the project area it was observed only once.

Elements of the species biology
The species belongs to the woodpecker family (*Picidae*). It is the largest bird of all European and Polish woodpeckers (a body length is up to 45-50 mm). Both sexes are characterized by a black plumage; however, a male has a clear red cap on a head, while female has only a small red spot on the back of a head. The species nests in tree hollow which is made in a tree trunk. Female lays from 4 to 6 white eggs, which are incubated for about 12-14 days. The bird inhabits the vast stands of different age and species composition, mostly old pine and mixed forests, as well as large and old woodlands and parks.

Protection and IUCN conservation status
According to the Polish law the species is strictly protected. The taxon is listed in Annex I of the Birds Directive and has a conservation category of LC (least concern) by the IUCN.

Threats resulting from planned active protection actions and protective recommendations
Active protection of sandy grassland habitats has not contributed to the deterioration of the species population size due to lack of nesting in the grubbing up area and due to the availability of the habitats used by this taxon outside the project area.

Black woodpecker *Dryocopus martius*. © Dawid Oruba

Great spotted woodpecker *Dendrocopos major*

Distribution and abundance

In the country area it is a moderately abundant breeding migratory bird. Although, it is the most abundant of all other Polish woodpeckers. In the project area several individuals were listed.

Elements of the species biology

The species belongs to the woodpecker family (*Picidae*). It is a medium-sized bird whose body length is 22-26 cm. The plumage is dominated by black and white colour, except for the red bottom of a tail and male red cap on a head, which is replaced in female by a red spot on the back of a head. Female lays 5-6 white eggs in a tree hollow, made in a tree every year from the beginning, which are incubated for about 12-13 days. The taxon inhabits deciduous, mixed and coniferous forests of different age, and as well as riverside and midfield woodlands, parks, gardens, orchards and urbanized areas.

Protection and IUCN conservation status

According to the Polish law the species is strictly protected. The taxon has a conservation category of LC (least concern) by the IUCN.

Threats resulting from planned active protection actions and protective recommendations

The species is not threatened with extinction on a scale of Małopolska region and the whole Poland. Active protection of sandy grassland habitats has not contributed to the

Great spotted woodpecker *Dendrocopos major*. © Dawid Oruba

deterioration of the species population size due to conducting felling of trees outside the breeding season and due to the availability of the habitats used by this taxon outside the project area.

European greenfinch *Carduelis chloris*

Distribution and abundance

It is a partially resident, breeding, moderately abundant or locally abundant bird in Poland. In the project area several individuals were noted.

Elements of the species biology

The species is a representative of the finch family (*Fringillidae*). It is a chunky bird, similar in size and shape to a house sparrow (body length of 14-16 cm), with rather thick and strong conical beak. An olivegreen plumage of males is brightened by yellow patches on the wings and tail. The female plumage is browner. In the nest usually 5 to 6 grey eggs can be found with characteristic, but not numerous, red spots. Incubation lasts about 13-14 days. The species inhabits the peripheries of dense forests, woodland edges, roadside trees, gardens, parks, cemeteries and city center trees.

European greenfinch *Carduelis chloris*. © Dawid Oruba

Protection and IUCN conservation status

According to the Polish law the species is strictly protected. The taxon has a conservation category of LC (least concern) by the IUCN.

Threats resulting from planned active protection actions and protective recommendations

The species is not threatened with extinction on a scale of Małopolska region and the whole Poland. Active protection of sandy grassland habitats has not contributed to the deterioration of the species population size due to the availability of the habitats used by this taxon outside the project area.

Hawfinch *Coccothraustes coccothraustes*

Distribution and abundance

It is a sparse or moderately abundant breeding species. Depending on the availability of food it is a resident or partially migratory bird. In the project area several individuals were identified.

Elements of the species biology

The species is a representative of the finch family (*Fringillidae*). Although its body length is 16-18 cm it is quite massive bird, which can be easily identified after particularly conspicuous, large and strong bill (its bill is a reason for its Polish name). The colour of feathers is dominated by beige and brown. Black colour is around bill, near eyes and along wings. Male, as opposed to female, is characterized by more intense and glossy plumage. Eggs in the number of 4-5 have different colour, they are spotted or dashed. The incubation

Common wood pigeon *Columba palumbus*. © Dawid Oruba

period lasts about 11-13 days. Hawfinch prefers mixed forests, especially with majority of hornbeam and beech, large orchards and gardens, and in urban areas larger urban parks.

Protection and IUCN conservation status
According to the Polish law the species is strictly protected. The taxon has a conservation category of LC (least concern) by the IUCN.

Threats resulting from planned active protection actions and protective recommendations
The species is not threatened with extinction on a scale of Małopolska region and the whole Poland. Active protection of sandy grasslands has not contributed to the deterioration of the species population size in the country due to the availability of the habitats used by this taxon outside the project area.

Common wood pigeon *Columba palumbus*
Distribution and abundance
In Poland it is a moderately abundant breeding bird. In the project area several individuals were observed feeding in the part of the Błędowska Desert devoid of trees. Also a migratory individuals flying over the desert were noticed.

Elements of the species biology
The species belongs to the dove and pigeon family (*Columbidae*). It is larger than a rock pigeon (a body length is about 4–42 cm). In Europe it is the largest representative in its family. It is distinguished by a grey-blue plumage, a white spot on both sides of the neck

and white upperpart of wings. The plumage of female is less intense and glossy. Female lays only 2 white eggs, which are incubated for about 16-17 days. The species used to be only forest taxon, but currently besides woodlands and forests edges, it inhabits also clusters of trees, roadside avenues and urban parks.

Protection and IUCN conservation status
It is a game species (hunting season lasts from 15th August to 30th November). The taxon has a conservation category of LC (least concern) by the IUCN.

Threats resulting from planned active protection actions and protective recommendations
The species is not threatened with extinction on a scale of Małopolska region and the whole Poland. Active protection of sandy grassland habitats has not contributed to the deterioration of the species population size due to the availability of the habitats used by this taxon outside the project area.

Barn swallow *Hirundo rustica*
Distribution and abundance
In Poland it is an abundant breeding migratory bird. In the project area the individuals feeding on the desert area devoid of trees and shrubs were noted.

Elements of the species biology
The species belongs to the swallow and martin family (*Hirundinidae*). It is a slim and small bird (body length is up to 17-23 cm) with a blue-black, glossy plumage of the upper body part, white or creamy underparts and a rufous throat, chin and forehead. A characteristic feature is long and forked tail. Sexual dimorphism is invisible. A pair usually returns to the clay nest (built also of fragments of plants), which they used in the previous years. They fix it if it is damaged or in case of total nest destruction they join together to build a new one. Barn swallows usually nest inside human settlements where the can fly in. Female lays 4-6 whitish and rusty spotted eggs which are incubated for about 14-16 days. The species is almost exclusively associated with human settlements, especially villages or alone standing farms. In case of lack of this type of habitats it nests also in rocks.

Protection and IUCN conservation status
According to the Polish law the species is strictly protected. The taxon has a conservation category of LC (least concern) by the IUCN.

Threats resulting from planned active protection actions and protective recommendations
Active protection of sandy grassland habitats has contributed to the increase of the open habitat areas used by this species as a place of feeding.

Common house martin *Delichon urbicum*

Distribution and abundance

In Poland it is an abundant migratory species. In the project area the individuals feeding in the desert area devoid of trees and shrubs were observed.

Elements of the species biology

The species belongs to the swallow and martin family (*Hirundinidae*). It is a slender bird, smaller than barn swallow (body length is up to 13-17 cm) with a blue-black plumage of the upper body part and pure white underparts. There is a visible white spot on the upper side of the rump. In contrast to barn swallow, a tail of house martin is shorter, less and not as deeply forked. Sexual dimorphism is invisible. House martins often nest in colonies. A pair usually returns to the nest (made entirely of clay), which they used in the previous years. They fix it if it is damaged or in case of total nest destruction they join together to build a new one. Individuals usually nest outdoors, close to the attics, roofs, window frames (hence comes its Polish name) etc. Female lays 4-6 white eggs which are incubated for about 14-15 days. The species is significantly associated with human settlements. It occurs even in highly urbanized areas, making nests in blocks of flats in the cities or under the bridges. Similar to barn swallow in case of lack of this type of habitats it eventually uses rocks for nesting.

Protection and IUCN conservation status

According to the Polish law the species is strictly protected. The taxon has a conservation category of LC (least concern) by the IUCN.

Threats resulting from planned active protection actions and protective recommendations

Active protection of sandy grasslands has contributed to the increase of the open habitat areas used by this species as a place of feeding.

Common swift *Apus apus*

Distribution and abundance

In Poland it is a breeding migratory species, moderately abundant and locally even abundant (especially in cities). In the project area the individuals feeding on in the place of observations were recorded.

Elements of the species biology

The species belongs to the swift family (*Apodidae*). It is considered to be the best aviator among national avifauna. At first glance it is similar to swallow, but it is however, unrelated to that species. It is larger than it (body length is about 16-19 cm) and has a completely different coloration. Plumage is entirely blackish-brown and it is brightened only in the vicinity of the throat. The wings are narrow and long, and the tail is short forked. The common swift legs are not large enough to be used for efficient walking, therefore

Common swift *Apus apus*. © Dawid Oruba

the species has a great difficulty in starting the flight if it is directly on the ground. The main difficulty in searching for food is rainy weather – in case of rain individuals can migrate long distances in order to satisfy hunger. During the period of malnutrition the hungry young swifts can pass in a torpid state to save energy. Female lays 2-3 white eggs, which are incubated for about 18-21 days. The birds often nest in colonies. The taxon prefers urban areas with tall residential and industrial buildings, well exposed to the sun fissured rock walls, sometimes old forests, mainly pine ones. It uses also special nesting boxes.

Protection and IUCN conservation status

According to the Polish law the species is strictly protected. The taxon has a conservation category of LC (least concern) by the IUCN.

Threats resulting from planned active protection actions and protective recommendations

Active protection of sandy grassland habitats has contributed to the increase of the open habitat areas used by this species as a place of feeding.

Eurasian blackcap *Sylvia atricapilla*

Distribution and abundance

In Poland it is an abundant breeding migratory species. In the project area the presence of two individuals was reported.

Eurasian blackcap *Sylvia atricapilla*. © Dawid Oruba

Elements of the species biology

The species is a representative of the Old World warbler family (*Sylviidae*). It is sparrow-sized bird with a body length of 14-15 cm. Both male and female are characterized by a grey plumage and paler bottom of the body, but male is distinguished by a black cap on top of a head, which is replaced by rusty one in females. In the nest 5 bright brown, spotted eggs are laid, which are incubated for about 13-14 days. The species inhabits all forests types, parks, cemeteries, gardens, urban and field woodlands.

Protection and IUCN conservation status

According to the Polish law the species is strictly protected. The taxon has a conservation category of LC (least concern) by the IUCN.

Threats resulting from planned active protection actions and protective recommendations

The species is not threatened with extinction on a scale of Małopolska region and the whole Poland. Active protection of sandy grassland habitats has not contributed to the deterioration of the species population size in the country due to the availability of the habitats used by this taxon outside the project area.

European jackdaw *Corvus monedula*

Distribution and abundance

In Poland it is a moderately abundant breeding bird, whose number significantly increases during the winter season when the individuals fly to the country from eastern and northern areas. In the project area individuals flying over the area of observations were noticed.

Common blackbird *Turdus merula*. © Dawid Oruba

Elements of the species biology

The species is a representative of the crow family (*Corvidae*). In size it is similar to pigeon with a body length of 31-35 cm. The plumage is graphite-black, except for a grey head and neck. It has a characteristic visible black cap on a head and also characteristic blue iris eyes. Sexual dimorphism does not occur. Female lays 5-6 greenish mottled eggs which are incubated for about 17-19 days. The taxon nests singly or in colonies. It inhabits buildings and structures such as towers or chimneys, and also hollow trees in the parks.

Protection and IUCN conservation status

According to the Polish law the species is strictly protected. The taxon has a conservation category of LC (least concern) by the IUCN.

Threats resulting from planned active protection actions and protective recommendations

The species is not threatened with extinction on a scale of Małopolska region and the whole Poland. Active protection of sandy grassland habitats has not contributed to the deterioration of the species population size in the country due to the availability of the habitats used by this taxon outside the project area.

Common blackbird *Turdus merula*

Distribution and abundance

In the country it is a moderately numerous, and locally abundant bird which is partially a migratory species. In the project area a few individuals were observed.

Eurasian nuthatch *Sitta europaea*. © Dawid Oruba

Elements of the species biology

The species belongs to the trush family (*Turdidae*). Its body is 24-27 cm long. Male is distinguished by a glossy black plumage and a yellow bill, while female is brown with a dark bill. Female lays 5-6 greenish, rusty spotted eggs which are incubated for about 12-14 days. The species inhabits all types of forests, young forests, mid-field woodlands, small groups of shrubs, withies, urban areas, gardens, parks and also roadside trees and shrubs.

Protection and IUCN conservation status

According to the Polish law the species is strictly protected. The taxon has a conservation category of LC (least concern) by the IUCN.

Threats resulting from planned active protection actions and protective recommendations

The species is not threatened with extinction on a scale of Małopolska region and the whole Poland. Active protection of sandy grassland habitats has not contributed to the deterioration of the species population size in the country due to the availability of the habitats used by this taxon outside the project area.

Wood nuthatch *Sitta europaea*

Distribution and abundance

It is a moderately abundant breeding and resident bird in Poland. In the project area two individuals were observed.

Elements of the species biology

It is a representative of nuthatch family (*Sittidae*). It is a sparrow-sized bird (a body length is up to 13-15 cm) but it has more compact, chunky body and different plumage colour.

The upper body part is grey and the bottom is beige. It has a blackish cap and a long black eye stripe which runs from the base of a dark bill above its eyes, finishing near the neck. It is the only bird of native avifauna, which can climb along the tree trunks and branches upside down. The sexes look almost similar. In the nest female usually lays from 5 to 8 white eggs with few rusty spots which are incubated for 22-24 days. The taxon inhabits different types of deciduous and mixed forests, extensive pine forests, sometimes but rather sparsely also parks, gardens and old cemeteries. It is more frequently observed in urban areas, mainly in larger groups of trees.

Protection and IUCN conservation status
According to the Polish law the species is strictly protected. The taxon has a conservation category of LC (least concern) by the IUCN.

Threats resulting from planned active protection actions and protective recommendations
The species is not threatened with extinction on a scale of Małopolska region and the whole Poland. Active protection of sandy grassland habitats has not contributed to the deterioration of the species population size in the country due to the availability of the habitats used by this taxon outside the project area.

Common raven *Corvus corax*
Distribution and abundance
In Poland it is a sparse breeding, resident or nomadic species. In the project area a large population of this species was observed.

Elements of the species biology
It belongs to the crow family (*Corvidae*). It is one of the largest birds of all corvids whose body length is about 60-67 cm. The species is significantly larger than the rook, and in contrast to the rook it has a massive, thick black bill. The common raven plumage is black and glossy. Sexual dimorphism does not occur. Female lays 4-6 greenish-blue eggs which are additionally clearly brown spotted. The incubation period lasts about 20-23 days. The species inhabits extensive forest complexes, less frequently small high-growing stands near the river valleys, meadows and fields, as well as rocky areas and crags.

Protection and IUCN conservation status
According to the Polish law the species is partially protected. The taxon has a conservation category of LC (least concern) by the IUCN.

Threats resulting from planned active protection actions and protective recommendations
Active protection actions of sandy grassland areas have contributed to the increase of the open habitat areas used by this species as a place of feeding.

Common cuckoo *Cuculus canorus*
Distribution and abundance
In Poland it is moderately numerous breeding and migratory bird. In the project area two individuals were observed.

Elements of the species biology
The species is a representative of the cockoo family (*Cuculidae*). Its size is similar to kestrel with a body length of 32-38 cm. Plumage of upper body part is grey, while the bottom of the body is covered by stripes. A tail is long and, like wings, it is edged with black colour. Plumage of females is different – two varieties of colours are distinguished: the first morph is similar to male and the second one has rufous shade. As it is well known female lays eggs in the nests of other bird species which then raise her offspring. Those are usually passerine bird nests such as wagtails, warblers, pipits, red-backed shrikes etc. After hatching the young cuckoos push the remaining eggs and chicks out of the nest, so they gain much more food from „host parents". The species usually inhabits the peripheries of pine forests and all types of other forests, parks, orchards, gardens, meadows and fields with numerous clusters of trees and shrubs, as well as floodplains of major rivers, coastal rushes and reeds, if only there are trees and shrubs nearby. It is occasionally observed also in urban clusters of trees.

Protection and IUCN conservation status
According to the Polish law the species is strictly protected. The taxon has a conservation category of LC (least concern) by the IUCN.

Threats resulting from planned active protection actions and protective recommendations
The species is not threatened with extinction on a scale of Małopolska region and the whole Poland. Active protection of sandy grassland habitats has not contributed to the deterioration of the species population size in the country due to the availability of the habitats used by this taxon outside the project area.

European nightjar *Caprimulgus europaeus*
Distribution and abundance
Throughout the country area it is a sparse or very sparse breeding and migratory species. The taxon was listed twice in the project area.

Elements of the species biology
It is a medium-sized crepuscular or nocturnal bird of the nightjar family (*Caprimulgidae*). It has a body length of 25-28 cm, long wings and tail, and a large head. Its body plumage is significantly masking: feathers are in different shades of brown, grey and beige so they are difficult to see in the daytime on the ground. There are white patches in the bottom side of wings and the final part of a tail. Individuals do not build nests and 2 ol-

ive-grey blotched eggs are laid directly on the ground or forest litter. The incubation period is about 17-18 days. After hatching young nightjars hide in the undergrowth and are fed by the adults. The species inhabits pine forests in the vicinity of extensive felling areas, fallow lands, fields or pastures.

Protection and IUCN conservation status

According to the Polish law the species is strictly protected. The taxon is listed in Annex I of the Birds Directive and has a conservation category of LC (least concern) by the IUCN.

Threats resulting from planned active protection actions and protective recommendations

Active protection of sandy grassland habitats has not contributed to the deterioration of the species population size in the country due to lack of nesting in the grubbing up area and due to the availability of the habitats used by this taxon outside the project area.

Woodlark *Lullula arborea*

Distribution and abundance

In Poland it is a breeding and migratory species, sparse and locally moderately numerous. During field observations individuals feeding on the desert area deforested by the Silesian Voivodeship Landscape Parks Complex were recorded.

Elements of the species biology

It is the last surviving species representative of the lark genus *Lullula*, belonging to the lark family (*Alaudidae*). It is the smallest lark of all national species of avifauna with a body length of 14-16 cm. It is characterized by a relatively short tail and broad wings. Its plumage is masking: upper body part is brown-grey with brown spots, while the bottom is beige and clearly dashed. The attention is also paid to the wide, pale eyebrows. Sexual dimorphism does not occur and both sexes are equally feathered. Female lays 4-5 white eggs covered with grey and brown spots which are incubated for about 13-15 days. The species is one of the rare forest birds singing at night. It inhabits the edges of forests, forest clearings and dry, well exposed to the sun young forests, as well as pine forests and sandy, sparsely forested with pine wastelands.

Protection and IUCN conservation status

According to the Polish law the species is strictly protected. The taxon is listed in Annex I of the Birds Directive and has a conservation category of LC (least concern) by the IUCN.

Threats resulting from planned active protection actions and protective recommendations

Active protection actions of sandy grassland areas have contributed to the increase of the open habitat areas used by this species as a place of nesting and feeding.

Eurasian blue tit *Cyanistes caeruleus*. © Dawid Oruba

Eurasian blue tit *Cyanistes caeruleus*

Distribution and abundance

In the country it is a numerous breeding and wintering species. In the project area a few individuals were observed.

Elements of the species biology

The species belongs to the tit family (*Paridae*). It is a small, 11-12 cm long, very agile passerine bird. A characteristic feature of the species is a large share of blue plumage: wings and a tail are blue and on the top of a head there is a visible azure blue cap. It has a dark blue line passing through the eye and encircling the white cheeks to the chin. The upper body parts are olive and the bottom side is mostly sulphur-yellowish. Both sexes look almost identical, but plumage of female is less intense, especially on a head and wings. In the nest 10-12 white, reddish spotted eggs are laid which incubation period is about 12-14 days. The species inhabits deciduous and mixed forests, cemeteries, orchards, avenues, gardens and parks, as well as the cities.

Protection and IUCN conservation status

According to the Polish law the species is strictly protected. The taxon has a conservation category of LC (least concern) by the IUCN.

Threats resulting from planned active protection actions and protective recommendations

The species is not threatened with extinction on a scale of Małopolska region and the whole Poland. Active protection of sandy grassland habitats has not contributed to the de-

terioration of the species population size due to the availability of the habitats used by this taxon outside the project area.

Goldcrest *Regulus regulus*
Distribution and abundance
In Poland it is a numerous breeding and resident species. It is seen throughout the whole country; in the mountains its population reaches the upper forest limit. Due to frequent occurring high in the tree branches, the species is often overlooked during bird watching. In the project area a few individuals were observed.

Elements of the species biology
The species belongs to the kinglet family (*Regulidae*). It is the smallest bird of all national avifauna. It is characterized by chunky body, a large head, a very short tail and a small, thin bill. Goldcrest plumage is olive-green with two white wing bars and white edge of flight feathers. Male has a clearly visible, bordered black, orange spot on the top of a head. In females the spot is yellow. In the nest usually 8-10 creamy, red mottled eggs are laid which are incubated for about 14-17 days. The species is frequently found in spruce, fir and mixed forests. It rarely inhabits pine forests.

Protection and IUCN conservation status
According to the Polish law the species is strictly protected. The taxon has a conservation category of LC (least concern) by the IUCN.

Threats resulting from planned active protection actions and protective recommendations
The species is not threatened with extinction on a scale of Małopolska region and the whole Poland. The implementation of the active protection tasks has not contributed to the deterioration of the species population size in the country due to the availability of the habitats used by this taxon outside the project area.

Common buzzard *Buteo buteo*
Distribution and abundance
In Poland it is a moderately numerous, resident or partially migratory breeding bird. During field observations a large population of this species was recorded. The desert are is used by this birds as a hunting place.

Elements of the species biology
The species is a representative of the *Accipitridae* family. Buzzard is certainly the most common bird of prey in the country. It measure between 50 and 57 cm in length. The plumage of brown and beige is extremely variable. There is no clear sexual dimorphism. Female lays 2-4 white, rusty spotted, eggs which are incubated for about 33-35 days. The

Common buzzard *Buteo buteo*. © Dawid Oruba

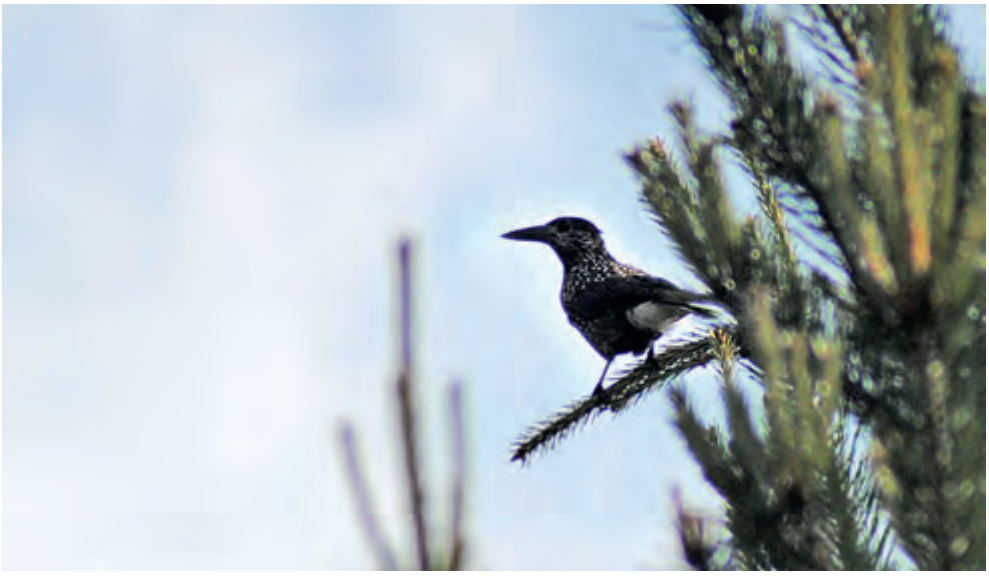
species inhabits all types of stands adjacent to the open areas. Recently it is also seen more often also in not large mid-field tree clusters.

Protection and IUCN conservation status
According to the Polish law the species is strictly protected. The taxon has a conservation category of LC (least concern) by the IUCN.

Threats resulting from planned active protection actions and protective recommendations
Active protection actions of sandy grassland areas have contributed to the increase of the open habitat areas used by this species as a place of feeding. On the other hand, forest habitats where the species nests are available in the vicinity of the project area.

Spotted nutcracker *Nucifraga caryocatactes*
Distribution and abundance
It is a sparse, locally moderately abundant, bird breeding and wintering in Poland. During field observations five individuals were recorded in the project area.

Elements of the species biology
The species belongs to the crow family (*Corvidae*). It is a medium-sized bird with a body length of 28-33 cm. In size it is similar to the Eurasian jay but it is slightly larger. It has longer tail, thicker bill and a characteristic chocolate brown plumage with distinct white spots and streaks. The wings and upper tail are black and it has clearly visible brown cap on a head.



Eurasian nutcracker *Nucifraga caryocatactes*. © Dawid Oruba

In the nest 2-4 pale, blue-green eggs covered with darker spots are laid. The incubation period is about 17-19 days. The species inhabits lower and upper mountain zone forests, mostly spruce ones with quite dense undergrowth, sometimes coniferous forests with a share of beech in foothill and hilly areas.

Protection and IUCN conservation status
According to the Polish law the species is strictly protected. The taxon has a conservation category of LC (least concern) by the IUCN.

Threats resulting from planned active protection actions and protective recommendations
The species is not threatened with extinction on a scale of Małopolska region and the whole Poland. Active protection of sandy grassland habitats has not contributed to the deterioration of the species population size due to the availability of the habitats used by this taxon outside the project area.

Common treecreeper *Certhia familiaris*
Distribution and abundance
In the country it is a moderately numerous breeding and resident bird. In the project area only a single observation of this species was recorded.

Elements of the species biology
The species is a representative of the treecreeper family (*Certhiidae*). It is a small bird (12-13 cm long) with a slim body and long tail and bill. It is similar to the short-toed

Eurasian treecreeper *Certhia familiaris*. © Dawid Oruba

treecreeper in appearance and cloloration. Male and female are characterized by similar plumage – the upper body part is brown covered with white spots, while the bottom is whitish. Female lays 5-6 white with purple-red blotches. The incubation period lasts for about 13-15 days. The taxon inhabits all types of old stands and mid-field clusters of trees. It prefers trees with rough and cracked bark, especially oaks, pines, maples and firs.

Protection and IUCN conservation status
According to the Polish law the species is strictly protected. The taxon has a conservation category of LC (least concern) by the IUCN.

Threats resulting from planned active protection actions and protective recommendations
The species is not threatened with extinction on a scale of Małopolska region and the whole Poland. Active protection of sandy grassland habitats has not contributed to the deterioration of the species population size due to the availability of the habitats used by this taxon outside the project area.

Willow warbler *Phylloscopus trochilus*
Distribution and abundance
In Poland it is a numerous breeding and migratory bird. In the project area 10 individuals were observed.

Elements of the species biology
It is a representative of the *Phylloscopidae* family. It is a tiny bird (11-12cm long) with an olive-grey plumage of upper body part, a pale yellow-white bottom and a clear white

eyebrow on a head. From the common chiffchaff it is primarily distinguished by completely different song, clearer eyebrow and paler plumage, but the trained eye is able to see also the different arrangement of the primary flight feathers. Female lays 6-7 white, red spotted eggs which are incubated for about 13 days. The species inhabits loose deciduous and mixed forests with dense undergrowth and fleece and shrubs near the forests edges, water reservoirs and watercourses. It avoids compact and old stands, and also urban tree clusters.

Protection and IUCN conservation status
According to the Polish law the species is strictly protected. The taxon has a conservation category of LC (least concern) by the IUCN.

Threats resulting from planned active protection actions and protective recommendations
The species is not threatened with extinction on a scale of Małopolska region and the whole Poland. Active protection of sandy grassland habitats has not contributed to the deterioration of the species population size due to the availability of the habitats used by this taxon outside the project area.

Common chiffchaff *Phylloscopus collybita*
Distribution and abundance
In the country it is a numerous, locally even very abundant, breeding migratory bird. In the project area the presence of 6 individuals was recorded.

Elements of the species biology
The species is a representative of the *Phylloscopidae* family. It is similar to willow warbler in appearance and size but its plumage is darker and an eyebrow less visible. There is no visible sexual dimorphism in this species. Female lays 4-7 cream-coloured eggs with spots which incubation lasts about 13-15 days. The species inhabits pine forests and all types of woodlands, mid-field and riverside tree clusters, meadows, parks, gardens and urban green areas.

Protection and IUCN conservation status
According to the Polish law the species is strictly protected. The taxon has a conservation category of LC (least concern) by the IUCN.

Threats resulting from planned active protection actions and protective recommendations
The species is not threatened with extinction on a scale of Małopolska region and the whole Poland. Active protection of sandy grassland habitats has not contributed to the deterioration of the species population size due to the availability of the habitats used by this taxon outside the project area.

Common redstart *Phoenicurus phoenicurus*

Distribution and abundance

In Poland it is a sparse breeding and migratory species. In the project area the presence of several individuals was reported.

Elements of the species biology

The species is a representative of the Old World flycatcher family (*Muscicapidae*). It is similar to the black redstart in size (a body length of 14-15 cm), but with a different plumage. Chest, abdomen and tail underside of a male are rusty, wings are brown and the upper body parts are blue-grey. Male has also characteristic black head, throat and a white forehead. Female is less intensely coloured and it is grey-beige. In the nest 6-7 bluish eggs are laid and incubated for about 13-14 days. The taxon inhabits parks, gardens and orchards, also forest clearings, as well as the edges of woodlands and pine forests with well developed undergrowth.

Protection and IUCN conservation status

According to the Polish law the species is strictly protected. The taxon has a conservation category of LC (least concern) by the IUCN.

Threats resulting from planned active protection actions and protective recommendations

The species is not threatened with extinction on a scale of Małopolska region and the whole Poland. Active protection of sandy grassland habitats has not contributed to the deterioration of the species population size due to the availability of the habitats used by this taxon outside the project area.

White wagtail *Motacilla alba*

Distribution and abundance

In the country it is a moderately numerous, breeding and migratory bird. In the project area the presence of 2 individuals was recorded.

Elements of the species biology

The species belongs to the *Motacillidae* family. It is a common bird with black, white and grey plumage and a characteristic long, constantly wagging tail. A body length is about 18-20 cm. Female plumage is less contrast. It usually lays 5-6 creamy eggs heavily spotted grey and brown. The species inhabits different types of open areas, often along roads, railway tractions, riverbanks, but also areas near large forest complexes and in higher mountain parts.

Protection and IUCN conservation status

According to the Polish law the species is strictly protected. The taxon has a conservation category of LC (least concern) by the IUCN.

White wagtail *Motacilla alba*. © Dawid Oruba

Threats resulting from planned active protection actions and protective recommendations

The species is not threatened with extinction on a scale of Małopolska region and the whole Poland. Active protection of sandy grassland habitats has not contributed to the deterioration of the species population size due to the availability of the habitats used by this taxon outside the project area.

European robin *Erithacus rubecula*

Distribution and abundance

In the country it is a numerous breeding and migratory Bird, sporadically also wintering. In the project area only one individual was observed.

Elements of the species biology

The species is a representative of the Old World flycatcher family (*Muscicapidae*). It is smaller than the sparrow with a body length of 13-14 cm. It is characterized mainly by a rusty chest, throat and part of a head which is separated from the brown upper body part by a greyish belt. The bottom of a body is whitish. Both males and females bear similar plumage. Female lays 6-7 white rusty spotted eggs which are incubated for about 13-14 days. The bird inhabits all types of stands with lush fleece and undergrowth, as well as parks, gardens, rarely cemeteries.

Protection and IUCN conservation status

According to the Polish law the species is strictly protected. The taxon has a conservation category of LC (least concern) by the IUCN.

European robin *Erithacus rubecula*. © Dawid Oruba

Threats resulting from planned active protection actions and protective recommendations

The species is not threatened with extinction on a scale of Małopolska region and the whole Poland. Active protection of sandy grassland habitats has not contributed to the deterioration of the species population size due to the availability of the habitats used by this taxon outside the project area.

Eurasian collared dove *Streptopelia decaocto*

Distribution and abundance

In Poland the species has been noted since 1970s. Currently it is a common breeding and wintering taxon throughout the whole country area. During the research conducted in the project area only one flying individual was observed.

Elements of the species biology

The species belongs to the dove and pigeon family (*Columbidae*). It is a medium-sized dove, smaller than the wood pigeon, with a body length of 29-35 cm. It has a fairly iniform beige-grey plumage with characteristic black half-collar edged with white on its nape from which it gets its name. Sexual dimorphism practically does not occur. Female lays 2 white eggs which are incubated for about 15-18 days. Young reach volatility in less than 3 weeks. The bird usually inhabits cities, villages and other urban areas. In chooses sites in the vicinity of single houses and forest edges near human settlements. It is strongly associated with tree clusters, however in the centers of big cities it occurs in places devoid of trees, because it nests in breakes of walls and window sills.

Eurasian collared dove *Streptopelia decaocto*. © Dawid Oruba

Protection and IUCN conservation status
According to the Polish law the species is strictly protected. The taxon has a conservation category of LC (least concern) by the IUCN.

Threats resulting from planned active protection actions and protective recommendations
The species is not threatened with extinction on a scale of Małopolska region and the whole Poland. Active protection of sandy grassland habitats has not contributed to the deterioration of the species population size in the country due to a single record of this species in the study area and the availability of the habitats used by this taxon outside the project area.

Great tit *Parus major*
Distribution and abundance
This is the taxon that is the most easily fund all over the country. In the project area several individuals were observed. It is a breeding and resident bird in Poland.

Elements of the species biology
It belongs to the tit family (*Paridae*). It is the largest of all our native tits with a distinctive appearance. It has an olive upper nape and back, yellow belly with a dark broad stripe in the middle, a black cap, white cheeks and dark legs. It reaches 13-15 cm of a body length. Nests are made in the tree hollows and nesting boxes. Female lays 8-12 eggs which incubation lasts for about 13-14 days. Young gain volatility in about 15-20 days. The

Great tit *Parus major*. © Dawid Oruba

species is almost omnivorous bird – it does not despise insects and spiders, but it also feeds on fruit and seeds. It inhabits pine forests and all types of woodlands, mid-field and riverside tree clusters, but it also frequently occurs in the vicinity of humans inhabiting avenues, orchards and parks.

Protection and IUCN conservation status
According to the Polish law the species is strictly protected. The taxon has a conservation category of LC (least concern) by the IUCN.

Threats resulting from planned active protection actions and protective recommendations
The species is not threatened with extinction on a scale of Małopolska region and the whole Poland. Active protection of sandy grassland habitats has not contributed to the deterioration of the species population size in the country due to a single record of this species in the study area and the availability of the habitats used by this taxon outside the project area.

Coal tit *Periparus ater*
Distribution and abundance
In the country it is a sparse, locally moderately abundant, breeding and wintering species. In the project area several individuals were observed.

Elements of the species biology
It belongs to the tit family (*Paridae*). It is medium-sized, 10-11 cm long, bird which, as all tits, has a large head and a chunky body. The plumage of throat and head is black with

Coal tit *Periparus ater*. © Dawid Oruba

white chicks and a clear, vertical, white stripe on the back of a head. The upper body part is grayish, the underparts are whitish, and the wings have two visible white stripes. In the nest 7 to 10 white, reddish-spotted, eggs are laid. The incubation period is about 14-15 days. The tit inhabits coniferous forests and mixed forests with a domination of spruce, fir and pine, rarely gardens and parks or deciduous forests.

Protection and IUCN conservation status

According to the Polish law the species is strictly protected. The taxon has a conservation category of LC (least concern) by the IUCN.

Threats resulting from planned active protection actions and protective recommendations

The species is not threatened with extinction on a scale of Małopolska region and the whole Poland. Active protection of sandy grassland habitats has not contributed to the deterioration of the species population size in the country due to a single record of this species in the study area and the availability of the habitats used by this taxon outside the project area.

Song trush *Turdus philomelos*

Distribution and abundance

In the whole Poland it is a numerous breeding and migratory bird. In the project area the presence of several individuals was recorded, including pairs leading-out young.

Elements of the species biology

Song trush is a representative of the trush family (*Turdidea*). It is 22-24 cm long. Male and female have the same plumage. The upper body part is plain brown, while the underparts

Song thrush *Turdus philomelos*. © Dawid Oruba

are creamy and neatly brown-spotted. Female lays 5 bright glossy blue eggs which are lightly spotted with black or purple. It incubates the eggs alone for about 12-13 days. The species inhabits all types of stands, young forests, mid-forest trees clusters, withies. In the urban areas it is present much less often than the blackbird; occasionally it inhabits larger old parks or cemeteries. The Polish name emphasizes the vocal ability of the bird that are nice for human ears.

Protection and IUCN conservation status

According to the Polish law the species is strictly protected. The taxon has a conservation category of LC (least concern) by the IUCN.

Threats resulting from planned active protection actions and protective recommendations

The species is not threatened with extinction on a scale of Małopolska region and the whole Poland. The implementation of active protection of sandy grassland habitats, which leads to the formation of open areas, does not negatively affect the population of this species. The felling of trees was conducted outside the breeding season for protective purposes.

Eurasian jay *Garrulus glandarius*

Distribution and abundance

In Poland it is a moderately numerous breeding species which inhabits quite regularly the breeding sites within its acreage, but often it is migratory or nomadic bird. Migration is determined by, among others, the availability of food supply (mainly acorns). The taxon

Eurasian jay *Garrulus glandarius*. © Dawid Oruba

is recorded throughout the whole country, but it avoids the high mountains. In the area covered by active conservation actions several individuals were observed.

Elements of the species biology

The species belongs to the crow family (*Corvidae*). In size it is similar to the jackdaw (a body length is 32-36 cm), but it has a characteristic beige-brown plumage which is decorated by blue feathers on black wings. Jay creates its nest at the stump of a tree – it is made of thin sticks and moss. Female lays 5-7 eggs from which, after 16-17 days, the nestlings hatch out. They gain ability to fly after 19-21 days. The species inhabits all types of forests, especially mixed stands, dense mid-field tree clusters, as well as parks and urban green areas. It is worth to say, as a matter of curiosity, that jay together with the wood nuthatch are considered to be the rangers of forest – worried it alerts with loudly „screeching".

Protection and IUCN conservation status

According to the Polish law the species is strictly protected. The taxon has a conservation category of LC (least concern) by the IUCN.

Threats resulting from planned active protection actions and protective recommendations

The species is not threatened with extinction on a scale of Małopolska region and the whole Poland. Active protection of sandy grassland habitats has not contributed to the deterioration of the species population size in the country due to the availability of the habitats used by this taxon outside the project area.

Eurasian wren *Troglodytes troglodytes*

Distribution and abundance

In the country it is a moderately numerous migratory species. In the project area it was observed only once, probably due to its secretive lifestyle.

Elements of the species biology

The species belongs to the wren family (*Troglodytidae*). It is one of the smallest Polish birds (a body length is 9-10 cm). The plumage is beige-brown, barred with darker brown and grey. However, the main feature to distinguish the species is a characteristic, upturned short tail. Both sexes are colored the same. Female lays 6-7 white eggs, covered with red spots, and the incubation period lasts for about 14-16 days. The bird inhabits all types of forests, especially wet ones, near rivers and streams, rarely mid-field trees and parks.

Protection and IUCN conservation status

According to the Polish law the species is strictly protected. The taxon has a conservation category of LC (least concern) by the IUCN.

Threats resulting from planned active protection actions and protective recommendations

The species is not threatened with extinction on a scale of Małopolska region and the whole Poland. Active protection of sandy grassland habitats has not contributed to the deterioration of the species population size in the country due to the availability of the habitats used by this taxon outside the project area.

Common starling *Sturnus vulgaris*

Distribution and abundance

In Poland it is a very numerous breeding species, sparse wintering, and migratory bird. In the project area about thirty individuals were observed.

Elements of the species biology

It belongs to the starling family (*Sturnidae*). It is a small to medium-sized passerine bird with a slender body of 21-23 cm long. The plumage is dominated by the black colour with pale „arrows" on the feathers, while the bill is yellow. Starlings often vocalize – they have a great ability to imitate the voices of other birds creating often quite complicated birdsongs. They nest in tree hollows, nesting boxes and building crevices. Female usually lays 3 to 6 pale blue eggs which are incubated for about 2 weeks period. Subsequently, the nestlings stay in the nest for the next 21 days. In spring starlings often feed on an animal feed, and in later months on fruit and other vegetation. They often create flocks. Migratory birds leave Poland in late October and early November, and come back in March. The taxon inhabits mostly meadows, pastures, fields in the vicinity of all types of forests and mid-field tree clusters. In addition, it lives in the roadside trees, parks and urban areas.

Eurasian wren *Troglodytes troglodytes*. © Dawid Oruba

Common starling *Sturnus vulgaris*. © Dawid Oruba

Tawny pipit *Anthus campestris*. © Dawid Oruba

Protection and IUCN conservation status

According to the Polish law the species is strictly protected. The taxon has a conservation category of LC (least concern) by the IUCN.

Threats resulting from planned active protection actions and protective recommendations

The species is not threatened with extinction on a scale of Małopolska region and the whole Poland. Active protection of sandy grassland habitats has not contributed to the deterioration of the species population size in the country due to the availability of the habitats used by this taxon outside the project area.

Tawny pipit *Anthus campestris*

Distribution and abundance

In Poland it is a sparse, breeding and migratory bird, in some areas even disappearing. In the project area the presence of two individuals was recorded.

Elements of the species biology

The species is a representative of the *Motacillidae* family. It is a quite large pipit (a body length of 16-17 cm) with a buff-grey plumage of the upper body part and a pale bottom. Wings are composed of Black feathers with pale margins. The distinguishing feature in adults is lack of visible hatching on the chest, as well as a clear, pale eyebrow. Both sexes are similarly colored. Female lays 4-5 white, brown spotted, eggs which are incubated for about 12-13 days. The species prefers sandy, dry and sunny open areas with rare and low vegetation.

Wood warbler *Phylloscopus sibilatrix*. © Dawid Oruba

Protection and IUCN conservation status

According to the Polish law the species is strictly protected. It is threatened by loss of the habitats due to management of fallow lands, barrens, intensification of agriculture and lack of proper food protection. The taxon is listed in Annex I of the Birds Directive and has a conservation category of LC (least concern) by the IUCN.

Threats resulting from planned active protection actions and protective recommendations

Active protection actions of sandy grassland areas have contributed to the increase of the open habitat areas used by this species as a place of feeding and nesting.

Wood warbler *Phylloscopus sibilatrix*

Distribution and abundance

In Poland it is a numerous breeding and migratory bird. In the project area the presence of five individuals was recorded.

Elements of the species biology

The species is a representative of the *Phylloscopidae* family. It is a small-sized bird with a body length of about 12 cm. It is green above and whitish below with a lemon-yellow throat and breast. It has also a yellow eyebrow on a head that catches attention. Sexual dimorphism does not occur. Female lays 5-6 white, brown-spotted, eggs which are incubated for about 13 days. The species inhabits deciduous, coniferous and mixed forests, parks, cemeteries and gardens, sparsely it also occurs also in mid-field tree clusters.

Yellowhammer *Emberiza citrinella*. © Dawid Oruba

Protection and IUCN conservation status

According to the Polish law the species is strictly protected. The taxon has a conservation category of LC (least concern) by the IUCN.

Threats resulting from planned active protection actions and protective recommendations

The species is not threatened with extinction on a scale of Małopolska region and the whole Poland. Active protection of sandy grassland habitats has not contributed to the deterioration of the species population size in the country due to the availability of the habitats used by this taxon outside the project area.

Yellowhammer *Emberiza citrinella*

Distribution and abundance

In Poland it is numerous, and locally even very abundant, breeding bird, usually resident. It occurs throughout the whole country being, together with the lark, the most common bird species in the open areas. In the project area five individuals were observed.

Elements of the species biology

The species is a represenative of the bunting family (*Emberizidae*). It is a small-sized bird with a body length of 16-18 cm. It has a characteristic yellow plumage with dark spots in the bottom of a body and rusty-brown ones on the upper body part. Plumage of females is less contrast than males. The bird often nests on the ground under the clumps of grass and vegetation. Female lays 4-5 eggs which incubation lasts less than 2 weeks, and the young leave the nest after the next 12-14 days. Yellowhammer feeds mainly on seeds and also small invertebrates. The species inhabits the edges of woodlands and pine forests,

young coniferous and deciduous forests, fields and meadows with small trees and shrubs clusters, as well as river valleys. It can be frequently found also in the vicinity of human.

Protection and IUCN conservation status
According to the Polish law the species is strictly protected. The taxon has a conservation category of LC (least concern) by the IUCN.

Threats resulting from planned active protection actions and protective recommendations
The species is not threatened with extinction on a scale of Małopolska region and the whole Poland. Active protection of sandy grassland habitats has not contributed to the deterioration of the species population size in the country due to the availability of the habitats used by this taxon outside the project area.

European turtle dove *Streptopelia turtur*
Distribution and abundance
In the whole country it is a breeding and migratory species, moderately abundant and locally even sparse. In the project area four individuals were observed.

Elements of the species biology
The species belongs to the dove and pigeon family (*Columbidae*). Adult bird reaches a body length of 27-32 cm. Underparts plumage is grey-pink-beige, while the upper body part is rusty-black patterned. It has a visible black-and-white collar on the side of its neck which is much wider than at the Eurasian collared dove. The Polish name is given after its voice that reminds a little the voice of the collar dove. The nest is made too high of a thin layer of small twigs. Female usually lays 2 eggs, which are incubated for about 2 weeks. After the next 2 weeks the nestlings are able to fly. The species inhabits deciduous and mixed forests, tree clusters and young forests with rich undergrowth near meadows, as well as ole parks adjacent to open areas.

Protection and IUCN conservation status
According to the Polish law the species is strictly protected. The taxon has a conservation category of LC (least concern) by the IUCN. The main reasons for the disappearance of turtle doves are hunting for them during the flights, and the destruction of alder forests in the breeding sites, as well as more intensive agriculture, cutting out hedges, combining lands which take them their natural habitats.

Threats resulting from planned active protection actions and protective recommendations
The species is not threatened with extinction on a scale of Małopolska region and the whole Poland. Active protection of sandy grassland habitats has not contributed to the deterioration of the species population size in the country due to the availability of the habitats used by this taxon outside the project area.

Eurasian golden oriole *Oriolus oriolus*

Distribution and abundance

In Poland the species occurs throughout the whole lowlands and it avoids the high mountain locations. It is a moderately abundant breeding in the country migratory bird. In the project area several individuals were observed.

Elements of the species biology

The species belongs to the Old World oriole family (*Oriolidae*). It is a medium-sized passerine with a body length of 23-25 cm. It is easy to recognize by the characteristic contrast yellow-black plumage. Despite the coloration it is difficult to see, but it is easy to hear because of the beautiful melodious singing. The species builds nests in the tree forks using grasses. Female usually lays 4-5 pinkish eggs, which incubation lasts for about 15-18 days. After hatching nestlings are volatile in about 17 days. The taxon inhabits all types of deciduous and mixed forests, stands between 35 to 50 years old, mid-field tree clusters, parks, orchards, and also larger tree avenues. Oriole arrives to Poland in May and flies away from August to September.

Protection and IUCN conservation status

According to the Polish law the species is strictly protected. The taxon has a conservation category of LC (least concern) by the IUCN.

Threats resulting from planned active protection actions and protective recommendations

The species is not threatened with extinction on a scale of Małopolska region and the whole Poland. Active protection of sandy grassland habitats has not contributed to the deterioration of the species population size in the country due to the availability of the habitats used by this taxon outside the project area.

Common chaffinch *Fringilla coelebs*

Distribution and abundance

The bird, according to many estimates, is considered to be the most abundant breeding species in Poland. It migrates for winter, only sparsely wintering in the country. In the desert area several individuals were recorded.

Elements of the species biology

It belongs to the true finch family (*Fringillidae*). Individual reaches a body length of 14-16 cm. Male has more contrast plumage than female. The back of the body is rusty, chest and the bottom are a bit brighter, the tail is black and so are the wings, but on wings the attention is drawn to two white stripes. It has a visible blue-grey cap on a head and rusty chicks. The bird makes nest of moss and lichens in the forks of branches and near the trunk. Female usually lays 4-5 blueish eggs which incubation lasts up to 13 days. After hatching nestlings leave the nest in about 2 weeks. The species inhabits pine forests and all

Common chaffinch *Fringilla coelebs*. © Dawid Oruba

other types of forests, especially places with less tree density, rarely large forest complexes, woodlands and roadside trees. It visits also parks, orchards and gardens.

Protection and IUCN conservation status

According to the Polish law the species is strictly protected. The taxon has a conservation category of LC (least concern) by the IUCN.

Threats resulting from planned active protection actions and protective recommendations

The species is not threatened with extinction on a scale of Małopolska region and the whole Poland. Active protection of sandy grassland habitats has not contributed to the deterioration of the species population size in the country due to the availability of the habitats used by this taxon outside the project area.

Historical data currently not confirmed

During conducted detailed nature inventory several interesting and rare bird species were not recorded in the study area, which had been observed in the 1960s in the Błędowska Desert (Rydzewski 1967). The most interesting include the stone curlew and black grouse, described below.

Stone curlew *Burhinus oedicnemus*

Distribution and abundance

Until recently it was considered to be extremely sparse breeding bird, currently presumably non-breeding one. Occasionally, it was found during migration. A pair of this species

nested in the Błędowska Desert. The traces of adult and young curlews were repeatedly seen, especially in the second half of the summer. The singing of the bird was also heard. In recent years it has disappeared probably due to the desert overgrowing and disturbance by humans. The last time the species was heard was in 1987. It cannot be excluded that it was only migrating bird.

Elements of the species biology

It is a representative of stone-curlew family (*Burhinidae*). It is a fairly large bird, similar in size to a pigeon (a body length of 40-45 cm, weight of approx. 475 g). It is characterized by large yellow eyes and long yellow legs. The species does not show a distinct sexual dimorphism – male is only slightly larger than female. Nesting takes place in the ground cavities. Female lays 2 eggs which are incubated for about 24-27 days. It prefers dry, sandy fallow lands overgrown with sparse herbaceous vegetation with single dwarf pines, junipers and birches.

Protection and IUCN conservation status

According to the Polish law the species is strictly protected. The taxon has a conservation category of LC (least concern) by the IUCN. The main threats to this bird are afforestation and management of fallow lands, regulation of rivers, environment pollution and disturbance these extremely timid birds by humans. In the Polish Red Book of Animals the taxon has a category of CR (critically endangered).

Threats resulting from planned active protection actions and protective recommendations

The exposure of a large area of the desert is equivalent to restoring habitats that are preferred by the species. These activities may contribute to the repopulation of the Błędowska Desert by the individuals of this species.

Black grouse *Tetrao tetrix*

Distribution and abundance

In Poland it is a very sparse breeding bird. In the Błędowska Deser area it was sparsely recorded at the turn of years 1931-1962; during the last war it was almost completely exterminated. After the war the population state has improved and in the recent years the bird was observed on the outskirts of the Błędowska Desert, near Chechło and Błędów villages. During the inventory its presence was not confirmed.

Elements of the species biology

It is a representative of the pheasant family (*Phasianidae*). It is a chicken-sized bird whose male body length is from 53 to 68 cm, while female is 40-51 cm long. Sexual dimorphism is strongly visible: the cock with a black, dark blue-glossy plumage is distinguished by a lyre-shaped tail and red eyebrows swelling during the mating season. Female plum-

age is definitely masking: it has buff-rusty-grey feathers. Female lays 7-10 yellowish-rusty spotted eggs in the hole dug in the ground, lined sparsely with vegetation. The incubation period is about 24-26 days. The species chooses wet stands bordering with meadows and wetlands, and forests in the vicinity of the moors. It prefers primary areas not used by man. In forests with compact and old stands it occurs only in the ecotone zones.

Protection and IUCN conservation status

According to the Polish law the species is strictly protected. It requires an active protection. Around black goruse mating places from 1st February to 31st May the protective zone within a radius of 500 m is in force. According to the Birds Directive the bird is considered to be highly endangered with extinction due to the habitat changes in forests, where the afforestation of mid-forest areas and drainage of moors are carried out. These birds are also sensitive to disturbance, competition from pheasants and attacks of the predatory mammals. In the Polish Red Book of Animals the taxon has a category of EN (very high risk, highly endangered).

Amphibians and Reptiles

Dry and sandy conditions, which characterized the Błędowska Desert, were not conducive to the occurrence of amphibians. The only exception was the European common spadefoot *Pelobates fuscus*, which was recorded in the north-eastern part of the study area. Due to the lack of flowing or standing water, there was no breeding habitat of this group of animals within the project area. However, amphibians and the position of their breeding habitats were observed in areas located close to the places where the active protection were taken. These were the wetlands in the valley of the Biała Przemsza, which is overgrown by natural alluvial forest and two ponds (Staw Zielony and Staw Czerwony), which were created in the result of an old mine workings. Finally, in those locations, the presence of several species of amphibians and reptiles was reported: sand lizard *Lacerta agilis*, slow worm *Anguis fragilis*, grass snake *Natrix natrix*, common toad *Bufo bufo*, common frog *Rana temporaria* and green frogs (marsh frog *Pelophylax ridibundus*, pool frog *Pelophylax lessonae*, edible frog *Pelophylax esculentus*).

Spring and autumn migration of amphibians took place between wetlands and limestone hills covered by deciduous forest, which are located south of the pounds.

The only reptile species observed in the desert was sand lizard *Lacerta agilis*. There was no smooth snake *Coronella austriaca,* despite the existing reports of his presence.

All recorded species of amphibians and reptiles were strictly protected. On 1 October 2014, the new Regulation of the Minister of the Environment on the species protection of animals was forced. According to it, the status of some taxa has changed. Currently, the strictly protected species is the European common spadefoot *Pelobates fuscus*. Taxa partially protected are sand lizard *Lacerta agilis*, slow worm *Anguis fragilis*, grass snake *Natrix natrix*, common toad *Bufo bufo*, common frog *Rana temporaria* and three green frogs.

Common spadefoot *Pelobates fuscus*. © Dawid Oruba

European common spadefoot *Pelobates fuscus*

Distribution and abundance

European common spadefoot is the only representative of the European spadefoot toads family (*Pelobatidae*). It is a lowland taxon occurring in areas reaching up to 300 m a.s.l. In the lowland the localities of spadefoot are quite evenly spread, but due to secretive lifestyle and nocturnal, it may seem that they are not abundant species. The presence of this amphibian was recorded in the north-eastern part of the project area. The occurrence of spadefoot in the Błędowska Desert area is associated with the presence of dry sandy substrata. It avoids wet habitats.

Elements of the species biology

European common spadefoot is often called in polish „huczek ziemny". Males reach a size of 40-50 mm, while females up to 45-60 mm. The body is chunky with characteristic stripe between big eyes. This nocturnal species is very terrestrial and only during the mating season it chooses water reservoirs, usually located in an open area. The mating season is associated with the occurrence of rainfall and may occur several times in the period from April to July. The female lays eggs in the form of short string of spawn, which lies loosely on the bottom of the water reservoir. Their tadpoles are the largest of all of other species of our native amphibians. Their length reaches even up to 170 mm. In the autumn period adult individuals using their calluses of the hind foot dig deep burrows in the soil, where they hibernate.

Protection and IUCN conservation status

According to the Regulation of the Minister of the Environment of 6 October 2014 on the species protection of animals (Journal of Laws of 2014 No 0, item 1348) the spe-

Ropucha szara *Bufo bufo*. © Dawid Oruba

cies is strictly protected. The taxon has a conservation status of LC (least concern) by the IUCN.

Threats resulting from planned active protection actions and protective recommendations

Common spadefoot individuals were noted in the area of the former paper factory in the places where old setting tanks are located. Records were occasional. The larval forms were not recorded. Active protection actions that were undertaken did not directly negatively affect the population of the species.

Common toad *Bufo bufo*

Distribution and abundance

Common toad is a representative of the true toads family (*Bufonidae)*. In Poland the species occurs through the whole country with the expection of the high mountain parts. The common toad in the eastern part of the Błędowska Desert has a very numerous population. It is associated with the presence of two ponds (Staw Zielony and Staw Czerwony) as well as many slow-flowing water courses. These watercourses form meandering curves, where the common toad spawn and huge amount of tadpoles of this species were recorded. In these places the brown frogs had also their reproduction processes. The species was not recorded directly in the project area.

Elements of the species biology

Females reach the length up to 13 cm, while males do not exceed 10 cm. The individual moves by walking not jumping like other amphibians. Usually large ponds and larger water reser-

voirs, overgrown by vegetation, are chosen as breeding places. Mainly on the turn of March and April collective migrations to the breeding places take place. The female lays eggs in the form of two thin strings, spreading them among the plant stems and various underwater objects. Juveniles after metamorphosis leave water reservoirs in July and spend winter on land.

Toads are tied to their water reservoir and they come back to it in the next breeding season. Also young individuals, after reaching a maturity, choose for mating the water reservoir in which they were hatched. After leaving the tank adult toads spread around even at a distance of several kilometers away. They are active mainly at night.

Protection and IUCN conservation status

According to the Regulation of the Minister of the Environment of 6 October 2014 on the species protection of animals (Journal of Laws of 2014 No 0, item 1348) the species is partially protected. The taxon has a conservation status of LC (least concern) by the IUCN.

Threats resulting from planned active protection actions and protective recommendations

The species was not recorded within the project area. Active protection actions did not negatively affect the population of the species.

Green toad *Bufo viridis*

Distribution and abundance

Green toad is a representative of the true toads family (*Bufonidae)*. The species occurs almost throughout the whole area of Poland with exception of the high mountain parts. The long strings of spawn were found in a pond Staw Zielony. Both adult as well as larval forms at different stages of development were recorded. The green toad population is quite numerous but not as big as the population of common toad.

Elements of the species biology

The body size of males varies between 48 and 90 mm, and females from 59 to 103 mm. The green toad has characteristic green spots on the dorsal part of the body. Between them, particularly on the body sides there are small red dots. Individuals appear in the spring and start mating in the end of April. Practically, only during mating the species uses the water reservoirs and the remaining time they spend on land. The spawn in the form of two equally long strings is laid ae night. One female lays 5 to 12 thousands of eggs. The dark tadpoles are similar to other toad tadpoles, but they are even twice as big (reach a length of up to 45 mm). The green toad is characterized by large migration capabilities – they can travel a distance of up to several kilometers.

Protection and IUCN conservation status

According to the Regulation of the Minister of the Environment of 6 October 2014 on the species protection of animals (Journal of Laws of 2014 No 0, item 1348) the spe-

European green toad *Bufo viridis*. © Dawid Oruba

cies is strictly protected. The taxon has a conservation status of LC (least concern) by the IUCN.

Threats resulting from planned active protection actions and protective recommendations

The species was not recorded within the project area. Active protection actions that were undertaken did not negatively affect the local population of the species.

European common frog *Rana temporaria*

Distribution and abundance

European common frog is a representative of the true frogs family (*Ranidae*). In Poland, it belongs to the most common amphibians. The common frog individuals were recorded in the area of the valley of the Biała Przemsza, both in the riverbed as well as throughout the whole area of the local riparian forests. The second region of the species occurrence was the area near ponds Staw Zielony and Staw Czerwony, where their larval stages were observed. The population of this frog is very numerous in the outskirts of the Błędowska Desert. Certainly, the centers of distribution are cumulated around water reservoirs and water courses. The species were not observed in the project area.

Elements of the species biology

Females rarely exceed 10 cm of body length while males do not reach 10 cm. As one of the first species of amphibians it appears in the water reservoir and as a first starts mating. Pairing occurs in the same place as hibernation. Eggs are laid in the form of cloud, usually

Common frog *Rana temporaria*. © Dawid Oruba

in large numbers in a shallow and sunny place. First juveniles leave water in June and begin active life on land. After leaving the tanks adult common frogs lead crepuscular and nocturnal life. They reside in forests, on farmlands, in gardens and meadows. They spend winter in water, mainly in slow-flowing small streams or drainage ditches.

Protection and IUCN conservation status

According to the Regulation of the Minister of the Environment of 6 October 2014 on the species protection of animals (Journal of Laws of 2014 No 0, item 1348) the species is partially protected. The taxon has a conservation status of LC (least concern) by the IUCN.

Threats resulting from planned active protection actions and protective recommendations

The species not recorded in the project area. Undertaken active protection actions did not negatively affect the local population of the species.

Green frogs (marsh frog *Pelophylax ridibundus*, pool frog *Pelophylax lessonae*, edible frog *Pelophylax esculentus*)

Distribution and abundance

Green frogs are the representatives of the true frogs family (*Ranidae*). In Poland they occur throughout the whole country, being one of the most common amphibians. The biggest threat is for them pollution and degradation of the water reservoirs (Głowaciński and

Young common frog *Rana temporaria*. © Dariusz Ropek

Rafiński 2003). Few specimens of green frogs were found visually and by listening in the area of ponds Staw Zielony and Staw Czerwony.

Elements of the species biology

Two domestic species marsh frog *Pelophylax ridibundus* and pool frog *Pelophylax lessonae* together with their natural hybrid edible frog *Pelophylax esculentus* (Berger 1968, 1987) constitute the group of amphibians with similar ecology, morphology and biology (Graff and Polls-Pelaz 1989). In Poland they usually form the mixed populations made from one of parental species and hybrid individuals (Rybacki and Berger 1994). These frogs lead semi-aquatic (amphibious) life, usually strongly connected with aquatic environment. They jump and fly well. The migrations concern not only juvenile individuals, but also adult forms, colonizing new places. They hibernate in water and near the tanks on land (Juszczyk 1987). Large morphological similarity of green frogs, as well as inhabiting the same habitats and similar mating time, pose problems with their correct determination. Therefore, to avoid mistakes, in conducted studies they were merged in on aggregated group *Pelophylax esculentus complex*.

Protection and IUCN conservation status

According to the Regulation of the Minister of the Environment of 6 October 2014 on the species protection of animals (Journal of Laws of 2014 No 0, item 1348) the species is partially protected. The taxon has a conservation status of LC (least concern) by the IUCN.

Edible frog *Pelophylax esculentus*. © Dawid Oruba

Threats resulting from planned active protection actions and protective recommendations

The species not recorded in the project area. Undertaken active protection actions did not negatively affect the local population of the species.

Sand lizard *Lacerta agilis*

Distribution and abundance

Sand lizard is a representative of the true lizards family (*Lacertidae*). In Poland it belongs to the most common reptiles in our country and it is not an endangered species now (Głowaciński and Rafiński 2003). Sand lizards were recorded sporadically in the desert area, in strongly sunny places where they were sunbathing. Active during the day, it basks on the rocks.

Elements of the species biology

It is a little reptile with a length of 20cm. It is a heliothermic species inhabiting all warmer and drier habitats: pine forests, deciduous and mixed forests with numerous meadows, moors, roadside slopes, railway embankments, grasslands (Głowaciński and Rafiński 2003). Active during the day, it basks on the rocks. It hibernates in ground holes or crevices (Juszczyk 1987). The mating season is from the end of March and lasts till June. Males, during mating, fight duels with each other. In the end of June females lay 5 to 14 eggs in previously dug hole. After 8 weeks the juveniles hatch from the eggs. In the end of September adult individuals hibernate.

Slow worm *Anguis fragilis*. © Dawid Oruba

Protection and IUCN conservation status

According to the Regulation of the Minister of the Environment of 6 October 2014 on the species protection of animals (Journal of Laws of 2014 No 0, item 1348) the species is partially protected. The taxon has a conservation status of LC (least concern) by the IUCN.

Threats resulting from planned active protection actions and protective recommendations

Undertaken active protection actions will increase the area of habitats used by this species.

Slow worm *Anguis fragilis*

Distribution and abundance

Slow worm is a representative of *Anguidae* family. It is a fairly common reptile in Poland, although its secretive lifestyle may suggest few in number populations. During conducted studies the species was recorded outside the project area, in the eastern part of the Błędowska Desert, in deciduous and coniferous forests and in the valley of the Biała Przemsza River.

Elements of the species biology

It is a limbless lizard living in the forests and thickets. It buries itself in the litter or in mosses and leaves. It avoids places with strong sunlight. It leads quite hidden lifestyle. It wakes

from hibernation in the late March and early April. The mating season begins in May and during this time it is easy to monitor the occurrence of this species in the field. Slow worm is ovoviviparous. It begins to hibernate in October and hibernates in groups in forest habitats.

Protection and IUCN conservation status

According to the Regulation of the Minister of the Environment of 6 October 2014 on the species protection of animals (Journal of Laws of 2014 No 0, item 1348) the species is partially protected. The taxon does not have any conservation status by the IUCN.

Threats resulting from planned active protection actions and protective recommendations

Species not recorded in the project area. Undertaken active protection actions did not negatively affect the local population of the species.

Grass snake *Natrix natrix*

Distribution and abundance

Grass snake is a representative of *Colubridae* family. It is considered as the most common snake in our country. A major threat to the population is currently the loss of habitats and gradual decrease of the number of amphibians, as well as anthropopression (Głowaciński and Rafiński 2003). During the field studies it was recorded near the area of two ponds Staw Czarny and Staw Zielony, where it was hunting the amphibian larval stages and adult individuals of green frogs.

Elements of the species biology

The snake reaches the length of up to 140 cm. It inhabits wet and moist meadows, the areas near standing waters, such as ponds and the banks of rivers and streams. This active during the day species swims well and dives. It hibernates in the compost, under the rocks and in the rock crevices near waters (Juszczyk 1987). The mating season is in April and May. In July and August female lays up to 30 eggs in the humus on land. Individuals typically spend winter in groups in burrows, windfallen trees etc.

Protection and IUCN conservation status

According to the Regulation of the Minister of the Environment of 6 October 2014 on the species protection of animals (Journal of Laws of 2014 No 0, item 1348) the species is partially protected. The taxon has a conservation status of LC (least concern) by the IUCN.

Threats resulting from planned active protection actions and protective recommendations

Species not recorded in the project area. Undertaken active protection actions did not negatively affect the local population of the species.

Grass snake *Natrix natrix*. © Dawid Oruba

Mammals

Survey was carried out from June 2012 to August 2013 both on the Desert and nearby forests – the Błędowskie Forests, Olkusz Forest District. The used methods were: mammal tracking on transects and estimating using sampling plots. During studies tree sampling plots (one in the desert and two in the Błędowskie Forests) and four tracking transects (one in the desert and tree on the forest roads, located nearby hunting areas) were set. All tracks and signs of animals (tracks, droppings, dens, feeding traces) were reported.

Results of the estimating using sampling plots were: 8 roe deers *Capreolus capreolus*, 3 foxes *Vulpes vulpes*, 2 hares *Lepus europaeus* (Tab.14). There was no sign of elk *Alces alces*, red deer *Cervus elaphus* or wild boar. Additionaly, 18 tracks of roe deers, and 14 wild boar *Sus scrofa* tracks were spotted (Tab.15).

Obtained results were used to calculate a wildlife density indicator – number of animals per 1000 ha (10sq km) (Tab. 16). Tracks indicator per 1km was also calculated (Tab. 17). Additional analyses gave the possibility to estimate the number of roe deer in test area – 85,45 individuals /1000 ha. According to the lack of observations of wild boars and lack of elk, fox, and hare tracks, it was impossible to estimate density of these individuals.

Tracking on transects resulted in spotting 273 roe deer tracks, 73 wild boar tracks, 161 fox tracks and 131 hare tracks (Tab.18 and Tab.19). Distribution of tracks during following days of survey is gathered in Table 19. Elk tracks were not found on transects, but were present on some nearby roads.

The number of animals on the Błędowska Desert was lower than in the nearby Błędowskie Forests. Mainly roe deer, foxes and wild boars were noticed in the project area. According to the winter tracking, it was observed, that roe deers prefer ecotone between

Number of sampling plot	Roe	Boar	Fox	Hare	Area [ha]
M-1	3	0	1	0	28,06
M-2	2	0	1	2	55,17
M-3	3	0	1	0	59,50
Sum	**8**	**0**	**3**	**2**	**142,73**

Tab. 14. Observed mammals (2nd February 2013).

Number of transect	Roe	Boar	Lenght [km]
T-1	1	0	0,99
T-2	5	0	1,53
T-3	2	0	1,58
Sum	**8**	**0**	**4,10**

Tab.15. Number of tracks of mammals, which leaving the sampling plots (2nd February 2013).

Number of sampling plot	Roe	Boar	Fox	Hare
M-1	106,91	0,00	35,64	0,00
M-2	36,25	0,00	18,13	36,25
M-3	50,42	0,00	16,81	0,00
N/1000ha	**56,05**	**0,00**	**21,02**	**14,01**
Average	64,53	0,00	23,52	12,08
SD	37,38	0,00	10,51	20,93
SE	21,58	0,00	6,07	12,08

Tab.16. Density of mammals (N) per 1000 ha.
SD – standard deviation
SE – standard error

Number of transect	Track indicator	
	Roe	Boar
T-1	1,01	0,00
T-2	3,27	0,00
T-3	1,27	0,00
Sum	**1,95**	**0,00**
Average	1,85	0,00
SD	1,24	0,00
SE	0,72	0,00

Tab. 17. The tracks indicator (track/1 km).
SD – standard deviation
SE – standard error

open spaces and pine forest, and alluvial forest on the Przemsza riverbank. Wild boars searching for food were moving between desert and the Błędowskie Forest area. Huge number of foxes tracks probably was connected with beginning of their mating season and their higher activity.

To sum up, two protected species were noticed – european beaver and red squirel, and seven non-protected: roe deer *Capreolus capreolus*, wild boar *Sus scrofa*, badger *Meles meles*, fox *Vulpes vulpes*, hare *Lepus europaeus*, stone marten *Martes foina*, pine marten *Martes martes* and elk *Alces alces* (protected by moratorium).

Roe				
Transect	**Sum of tracks***	**Average**	**Lenght [km]**	**X**
T-1	72	14,4	4,21	3,42
T-2	144	28,8	4,12	6,99
T-3	17	3,4	5,57	0,61
T-4	40	8,0	2,93	2,73
Sum	**273**	**54,6**	**16,83**	**3,24**

Boar				
Transect	**Sum of tracks***	**Average**	**Lenght [km]**	**X**
T-1	29	5,8	4,21	1,38
T-2	28	5,6	4,12	1,36
T-3	16	3,2	5,57	0,57
T-4	0	0,0	2,93	0,00
Sum	**73**	**14,6**	**16,83**	**0,87**

Tab.18. Results of tracking on transects (8 – 12th February 2013).
*** – sum of tracks from five following days**
X – track indicator per 1 km * day-

Day	Roe	Boar	Fox	Hare
1	57	10	44	29
2	60	15	29	20
3	57	29	19	10
4	40	8	30	33
5	59	11	39	39
Sum of tracks	**273**	**73**	**161**	**131**

Tab.19. Sum of tracks from five following days (8 – 12th February 2013).

European beaver *Castor fiber*

Distribution and abundance

In the Błędowska Desert area beavers do not occur. Their presence has been found several times in the Biała Przemsza Valley on the basis of traces. In Poland they are currently quite numerous species, living along most watercourses. The abundance is estimated at tens of thousands of individuals.

Elements of the species biology

Beavers are adapted for semi-aquatic life. They are highly territorial. The size of territories depends on their abundance of food and mostly ranges from 1 to 4 km length of the watercourse (Czech 2001). Their habitat consists mainly of watercourses and water reservoirs together with adjacent coastal areas, particularly rich in herbaceous vegetation and trees. The beaver's food consists mainly of herbs, grasses, aquatic plants and leaves, rhizomes and roots. Whereas the dominant components of the winter diet are bark, stems of trees and shrubs. They often feed on willows, aspens, oaks, birches and alders, and during the late summer also on spruces, pines and larches (Żurowski 1989). They live up to 30 years. Annual population growth in our climatic conditions, after taking into account the losses, ranges from several to over a dozen percent, depending on the country region, density

Traces of the beaver near the Biała Przemsza river. © Mateusz Kolecki

and age structure of the population, water conditions of the environment, availability of food and the number of possible colonization places. The beaver has a significant impact on aquatic ecosystems and wetlands. Its influence on the environment reaches much further than its requirements, concerning the living space and the nutritional needs, define it. The changes, which individuals make in the environment, depend on the density and population dynamics as well as the time of residence of beavers in the particular area. In the area of beavers ponds the level of ground water increases and stabilizes, the erosion reduces and the deposition of mineral and organic particles increases. Natural processes of wetlands creating are initiated, what have a positive effect on the biodiversity of these environments (Czech 2004).

Protection and IUCN conservation status

According to the Regulation of the Minister of the Environment of 6 October 2014 on the species protection of animals (Journal of Laws of 2014 No 0, item 1348) the species undergoes partially protection. The taxon is also mentioned in the list of animal species of EU Community interest (Annex II and IV of the Habitats Directive) and has a conservation status of LC (least concern) by the IUCN.

Threats resulting from planned active protection actions and protective recommendations

The threats resulting from planned active protection actions are not expected. The whole beaver habitat is well insulated by the buffer of pine forest that was left, as well as shrubs of the riverside riparian forest of alder and ash.

Male elk *Alces alces*. © Dawid Oruba

Eurasian Elk *Alces alces*

Distribution and abundance

Information on elk distribution and abundance was obtained from Olkusz Forest District. Within the Błędowska Desert area and in the Biała Przemsza Valley occurs the elk population which during the last 5 years initially has increased its number, and currently it remains at constant level. In the 2006/2007 hunting season 5 individuals were inventoried, while in the 2011/2012 season 8 individuals were found. There is no good methodology for estimating the elk population, so it is difficult to determine its abundance in Poland – it is estimated that it ranges from a few to several thousands of individuals, while the highest density is in the east and north-east of the country.

Elements of the species biology

Elks are the largest representatives of the deer family in Poland. Adult males, bulls, may reach the weight of even 400 kg, while females (called cows) are smaller – they weigh up to approx. 300 kg. The wither height of the body reaches up to approx. 230 cm. The life expectancy is up to 25 years. Elks do not form large herds, usually solitary individuals and females with one-year-old offspring are found. Only during winter time males sometimes form „stag" herds. Elks belong to the animals characterized by seasonal changes in habitat requirements (Gębczyńska 2004). From spring to autumn they live on wetlands, where rich in quality food, consisting mainly of aquatic plants, is available in large quantities. In winter the elk refuges constitute forests in young age classes of stand (up to 20 years old) located on mineral soils (Frąckowiak 2004). These refuges provide both protective cover that protects against bad weather conditions, as well as provide food

in the form of so-called 'shoot food'. During winter the elk diet is dominated by pine and other important species such as willow, aspen, alder buckthorn, oak, blueberry and juniper. The highest nutritional values for elk have alder buckthorn, willow, oak and blueberry, while the lowest – pine and juniper (Mickiewicz 2004).

Protection and IUCN conservation status

In Poland elk is a species included in the list of game animals and it is covered by yearlong protection period (moratorium). This means that its abundance is determined by the Forest Districts in consultation with the local hunting clubs, but it should not be haunted. The taxon has a conservation category of LC (least concern) by the IUCN.

Threats resulting from planned active protection actions and protective recommendations

The Błędowska Desert area of the planned felling was covered by dry pine forest, at the age of about 20 years, with tiny addition of other trees and shrubs species. During winter time it could be a poor food supply for elks; however it did not provide optimal protective cover. To the south and south-west of the Błędowska Desert, the Błędowskie Forests are located, which are optimal refuges for elks in winter time. During spring and summer elks live in the valley of Przemsza, thus the trees felling in the desert did not affect the population of this species. Planned active protection actions within the Błędowska Desert caused the partial loss of winter food supply; however, left valuable parts of forest near the Biała Przemsza Valley and small patches of trees in the desert area still enable the migration of elks in winter in the direction of the Błędowskie Forests.

European roe deer *Capreolus capreolus*

Distribution and abundance

It is a territorial species, common in our country, associated with farmland and woodland habitats. It occurs throughout Poland with fairly uniform distribution. During field observations roe deer were found only on the outskirts of the Błędowska Desert, adjacent to the Biała Przemsza Valley and the Błędowskie Forests. Such spatial distribution of the species is confirmed by the data obtained from Olkusz Forest District. It is related to poor both food supply and protective cover in the habitats located within the Błędowska Desert area. On the basis of the conducted animals inventory in the hunting district no 22 the number of roe deer varied between 60 and 66 individuals. The target of the Forest District is to reach the number of 79 roe deer in 2017 in the area of the whole hunting district.

Elements of the species biology

The roe deer is the smallest national representative of the deer family. It reaches up to 20 kg of body weight and 90 cm of the wither body height. If the hunting management is properly conducted, roe deer prefers particular forest habitats. In the case of excessive roe deer number in particular forest complex, the lack of opportunity to inhabit the optimal territory forces the part of the population to occupy the rural areas (it is called

Roes *Capreolus capreolus*. © Paulina Wietrzyk

the field ecotype of roe deer). The size of the territory depends on the gender, season, the habitat type and forest mosaic, and the population size (Pielowski 1988). The roe deer habitat preferences may be explained on the basis of the feeding strategy and energy balance of this species. The older age classes of the coniferous tree sands are preferred providing protective cover, as well as young trees with rich vegetation of the forest undergrowth. During winter the coniferous stands provide ethological and thermal comfort (Tomanek 1963). The undergrowth abundance, having in winter much higher nutritional values than only shoot food, is the highest in the scotch pine and mixed pine-oak forests. The blueberries and blackberries which herbaceous (not woody), evergreen stems contain a lot of protein (Szulakowska 1974) are abundant there. Due to the harsh environmental conditions (poor food supply) during winter roe deer avoid the pine forests, dry and fresh forests (Mikoś 2007).

Protection and IUCN conservation status

In Poland roe deer is a game species. Its abundance and the amount of animals allocated to hunting, based on the Hunting Law, are determined by the Forest Districts in consultation with the local hunting clubs. The taxon has a conservation category of LC (least concern) by the IUCN.

Threats resulting from planned active protection actions and protective recommendations

Trees and shrubs felling in the area covered by the project did not affect in any way the abundance and spatial distribution of the roe deer individuals. It is due to the fact that the pine forest habitat that had been developed in the Błędowska Desert area was avoided by this species because it did not constitute the attractive food supply and protective cover

Roe tracks near the Biała Przemsza river. © Mateusz Kolecki

base. The buffer left on the border between the Błędowska Desert and the State Forests covers with the belt of ecotone where higher density of the tracks of these animals was found.

Wild boar *Sus scrofa*

Distribution and abundance

The wild boar is a species occurring numerously in the country, and its abundance is still increasing. The presence of wild boars throughout the whole area of the Błędowska Desert was recorded. During the field observations the traces of wild boar rooting in litter were found several times. It was related to searching for food (roots and rhizomes of plants, insect larvae and other soil invertebrates) by the individuals of this species. According to the data received from Olkusz Forest District in the area of hunting district no 22, which includes the project area, the number of wild boars varied between 18 and 23 individuals during the last five years. The target number of boars planned to achieve by 2017 according to the Longtime Hunting Breeding Plans is 22 individuals. In 2006 the number was estimated at approx. 170 000 individuals in Poland.

Elements of the species biology

The wild boar is the only representative of the Suidae family in Europe. The animal is chunky reaching up to 200 cm of body length and up to 320 kg (males) and 140 kg (females) of body weight. They can live up to 27 years. They are herd animals living in family groups. In the wild, during winter these animals stay mainly in forest complexes, preferring fertile and wet habitats (Kolecki 2002). In the growing season wild boars inhabit mainly farmlands and small forest complexes (Fruziński 1993). The wild boar

Boar tracks near the Biała Przemsza river. © Mateusz Kolecki

Wild boar rooting. © Mateusz Kolecki

is omnivorous species. In the seed years of oak and beech, their seeds may constitute even 85% of consumed food. In the years of low production of above-mentioned seeds and in the poor forest habitats (which constitute nearly 100% of the Błędowska Desert area) wild boars search for food on fields and suburban dumps. Individuals very easily adapt to the changing habitat conditions caused by human activities. Current overcrowding of the population results in very large damages in agriculture and in invading the wild

boars in highly urbanized areas (Baś and Okarma 2008). The taxon is found both in forests, urban parks and garden plots, as well as on the street of the cities and towns. It is also a cause of traffic accidents.

Protection and IUCN conservation status

In Poland the wild boar is a game species. The management of the wild boar population, based on the Hunting Law, is determined by the Forest Districts in consultation with the local hunting clubs. The taxon has a conservation category of LC (least concern) by the IUCN.

Threats resulting from planned active protection actions and protective recommendations

The wild boars easily adapt to changing habitat conditions, and in search of food they can overcome long distances (several to several tens of kilometers per day). Fertile and wet habitats in the Biała Przemsza Valley are very convenient refuges for this species. Due to poor character of the habitats within the project area, rarely used by the wild boars, active protection actions in the Błędowska Desert did not significantly affect the size of the population in the region.

Fox *Vulpes vulpes*

Distribution and abundance

During the fields observations the presence of foxes throughout the whole area of the Błędowska Desert covered by the project was recorded. The abundance of this species was not determined in the study area; however in Poland foxes are common throughout the whole country. Their number is estimated at approx. 200 000 individuals.

Elements of the species biology

Fox is the most common predator in the country. It belongs to the Canidae family. Foxes have elongated body with fluffy tail, which is even longer than half of their body length. They are characterized by a relatively light body construction and they weigh an average from 2,2 up to 10kg with a body length of about one meter. Like all canines they have well-developed senses, especially the sense of hearing. Some foxes are territorial, while others are migratory. It happens that in one territory a few individuals from the family occur. In some regions the social behaviors are observed similar to those of wolves (e.g. parental care, the hierarchy in the herd etc.). Fox can live up to 14 years. Its habitats are forests, fields and meadows, but the favourite ones are small mid-field forests. In large complexes the fox occur more on the outskirts or in the mid-forest enclaves. These mammals often dig the burrows used as a shelter or a breeding place. As a synanthropic species they often inhabit in the vicinity of human and human settlements. Unfortunately, they are susceptible to diseases and parasites. They are common and important vectors in spreading rabies and scabies.

Fox tracks. © Mateusz Kolecki

Protection and IUCN conservation status

In Poland fox is a game species. The management of the fox population, based on the Hunting Law, is determined by the Forest Districts in consultation with the local hunting clubs. The taxon is listed as Least Concern (LC) by the IUCN.

Threats resulting from planned active protection actions and protective recommendations

The planned felling of trees in the Błędowska Desert may cause the decrease of the fox abundance in this area due to the loss of the habitat and potential victims. The drop of the fox number will not negatively affect the population of this species, and perhaps it will contribute to the increase of the abundance of other species of small animals and birds.

Badger *Meles meles*

Distribution and abundance

Based on the tracks on snow the presence of badgers was noticed in the hunting district no 145 at Olkusz Forest District. Directly in the Błędowska Desert the tracks, traces and individuals themselves were not observed. The taxon occurs almost throughout the whole Europe inhabiting fertile forests and the areas with of the meadows and forests mosaic. In Poland it can be found throughout the whole country and the population is estimated at approx. 70-120 thousands of individuals.

Elements of the species biology

Badger is a representative of the Mustelidae family. The individual reaches a body length of up to approx. 90 cm, height of approx. 30 cm and weight of 7 kg. Badgers live

European badger *Meles meles*. © Dawid Oruba

in family groups. They dig the extensive systems of chambers (called setts) up to a depth of 4 m, which are connected by underground passages. Their total length is often more than several or several dozen of meters. In the autumn the badger plugs the exits of the setts with dry leaves and branches, and then falls into hibernation. The taxon is an opportunistic omnivore, easily adapting to the food supply near occupied habitat. Earthworms are the most important source of its food. Other important compounds of its diet include also large insects, small and young mammals and, when it has an opportunity, birds, carrion, cereals and fruits.

Protection and IUCN conservation status

In Poland badger is a game species. The management of the badger population, based on the Hunting Law, is determined by the Forest Districts in consultation with the local hunting clubs. The taxon is listed as Least Concern (LC) by the IUCN.

Threats resulting from planned active protection actions and protective recommendations

Conducting the felling of trees and shrubs in the project area will not affect the regional badger population.

Stone marten *Martes foina* and pine marten *Martes martes*

Distribution and abundance

The stone marten always stays close to the human settlements. Pine marten inhabits well-wooded areas where it makes dens in abandoned tree hollows or rock bends. During selecting the habitat it chooses rather the old mixed forests. Pine marten more often and

Marten tracks. © Mateusz Kolecki

more likely climbs the trees treating them as a shelter than the stone marten. In Poland the population of the pine marten has almost uniform distribution throughout the whole country and it shows stabilized, although not high level. However, there are no uniform estimates of abundance – probably in the Polish territory there are several thousands of individuals. During field observations the presence of martens in the whole desert area covered by the project was recorded. The abundance of both marten species in the study area was unable to determine.

Elements of the species biology

Both stone and pine marten are medium-sized representatives of the of the Mustelidae family. The body length of individuals reaches about half a meter, and the weight is maximum 1,5 to 1,8 kg. Martens live up to 15 years. Their diet includes mainly rodents, whose abundance has the greatest influence on the population state of martens. Typically, one year after an outbreak of rodents, the number of offspring taking out by adult martens dramatically increases. Both taxa also eat eggs, birds, amphibians, insects and fish. They prey on both trees and on the ground. Martens are ecologically valuable species, keeping together with other predators the stability in the rodent populations. They move effectively on the ground – mainly by small jumps – and they greatly cope with climbing the trees. Beyond the parenting period they are solitary animals.

Protection and IUCN conservation status

In Poland both pine and stone marten is a game species. The abundance of marten, based on the Hunting Law, is determined by the Forest District. Both species belong to Least Concern category (LC) by the IUCN.

Brown hare *Lepus europaeus*. © Michał Węgrzyn

The influence of planned active protection actions

Implementation of the project will cause withdraw of individuals of both species from the project area, however it will not have negative influence on the entire population of marten inhabiting in the surrounding forests.

Hare *Lepus europaeus*

Distribution and abundance

Hare occurs throughout the whole country. Its abundance and distribution is varied, but most individuals may be found in central Poland. The taxon avoids wet and moist areas. Hare was originally a steppe species, so the most suitable areas are lowlands, especially in a diversified agricultural landscape. Species also inhabits forests, coastal dunes, reclaimed terrains and even urban areas. The size of population in the country is estimated at about 0,5 million of individuals. During field observations only single tracks and droppings of hares were observed in the belt of ecotone on the outskirts of the project area.

Elements of the species biology

Hare body length reaches 75 cm and their weight varies between 3 to 6 kg. Hares are territorial animals and live alone except during the mating season. The number of hare in a given year depends largely on the weather that prevailed during hare births (the offspring delivery). Constant factor reducing their number are foxes, whose population due to preventing rabies and insufficient hunting has clearly increased its size. Hare enemies should also include larger predatory birds and the stray dogs. What is interesting in the context of the desert – hares rarely drink water – usually water from the dew on the plants, which they feed, is enough for them.

Protection and IUCN conservation status

In Poland har is a game species. Its abundance and the amount of animals allocated to hunting, based on the Hunting Law, are determined by the Forest Districts in consultation with the local hunting clubs. The taxon has a conservation category of LC (least concern) by the IUCN.

Threats resulting from planned active protection actions and protective recommendations

The belt of ecotone where the presence of individuals was stated covers with the buffer left on the border between the Błędowska Desert and the State Forests. Therefore trees and shrubs felling within the rest of the project area that was conducted, did not affect the population of the species.

Red squirrel *Sciurus vulgaris*

Distribution and abundance

In the study area the presence of red squirrel was recorded only in the complex of the Błędowskie Forests. In the Błędowska Desert, directly within the project borders, the individuals of this species were not observed. It is due to the lack of the old trees rich in tree hollows which may constitute its shelter. There are also no studies showing the population of squirrel in Poland – there are only estimates, which indicate the number of approximately tens of thousands of individuals throughout the country. In recent years the abundance of squirrel has systematically decreased.

Elements of the species biology

The red squirrel reaches a typical head-and-body length of 20 to 24 cm (a tail is additional 17-20 cm). Its weight is approx. 300 g. Individuals live up to 5 years. They lead solitary lifestyle or mate. They are omnivorous, but they they eat mostly seeds, young shoots of trees, fruit, bird eggs and chicks. Squirrels make nests (dreys) on the trees out of twigs or use tree hollows and bird nesting boxes as a shelter. Their habitats are mainly forests, parks and orchards.

Protection and IUCN conservation status

According to the Regulation of the Minister of the Environment of 6 October 2014 on the species protection of animals (Journal of Laws of 2014 No 0, item 1348) the species undergoes partially protection. The taxon has a conservation status of LC (least concern) by the IUCN.

Threats resulting from planned active protection actions and protective recommendations

Due to the lack of the squirrel exactly in the project area, the state of its local population did not deteriorate.

Environmental monitoring in the Błędowska Desert

The most important goal of the environmental monitoring and the monitoring of the effectiveness of active conservation carried out within the project „Active conservation of priority sand habitats complex (6120, 2330) in the Natura 2000 site Błędowska Desert (LIFE09 NAT/PL/000259)", was the overall assessment of the initial state of natural habitats in the project area, as well as assessment of changes that occurred after the implementation of active conservation (mainly the felling and grubbing stumps of Scots pine *Pinus sylvestris*). Monitoring had also to answer the question, how to plan activities around the area to optimally achieve stable complex of sandy grasslands habitats.

Realized monitoring allowed to gather rich documentary material, which was developed in specially prepared forms (Tab. 20). On the one hand, the collected data were used for practical purposes related to the implementation of the project; on the other hand, they can be used for further research on species diversity, phytosociological and spatial distribution of xeric sand calcareous grasslands and inland dunes grassland. In addition, they can be used to improve planning of the natural grassland habitats monitoring in other Natura 2000 areas in the future.

The present study contains an analysis of the results from all 150 transects (450 phytosociological relevés), localized in project area in the Błędowska Desert.

The results show not only the habitat condition before taking the actions of active conservation, but also has been compiled with data about the habitats after the cutting down and grubbing and renewal the successional stages of grassland habitats. The results of the study are presented and compared with each other in Table 21. Pie charts illustrate the evaluation of the analyzed parameters and indicators.

Project area is dominated by patches of xeric sand calcareous grasslands (6120), but their species composition is very poor. Because the sand dunes in the twentieth century have been completely stabilized, sandy grasslands was also reported on the slopes of geomorphological forms. In the few places, where the bare patches of sand were persisted, the fragments of initial inland dunes grassland (2330) occurred. Implementation of the project increased potential areas for both types of habitats. Phenomenon of quicksand has been restored – the most important factor for existence of the poor and initial inland dune grasslands (2330). Meanwhile, in a sheltered position the xeric sand calcareous grasslands (6120) will develop.

Hilly and sandy area of the Błędowska Desert was almost completely devoid of shrubs and trees till the mid-twentieth century. Intensive habitat changes, manifested by a significant increase of succession, occurred in the postwar period, together with the rapid development of the Silesian mining and metallurgy. Due to the increase of air pollution caused by nitrogen compounds, on the so far existing sandy grasslands, the shrubby vegetation and pine trees began to develop. Very similar phenomena for the same types of habitats were described in the Netherlands and in the United Kingdom (Sparrius et al. 2012).

Monitoring of conservation status of natural habitat – the Błędowska Desert, Transect number: …					
Date of observation			Author		
Phytosociological relevé 1					
Geographic coordinates: Height: Relevé surface area ……...m^2, Slope …..… degrees, Exposure -…….. Layer stocking: a: ...…, b: …...c: ...…. d: ...… Layer height: a: ….., b: …...c: …... d: …..					
Species (latin name), layer	Amount				
Phytosociological relevé 2					
Geographic coordinates: Height: Relevé surface area ……...m^2, Slope …..… degrees, Exposure -…….. Layer stocking: a: ...…, b: …...c: ...…. d: ...… Layer height: a: ….., b: …...c: …... d: …..					
Species (latin name), layer	Amount				
Phytosociological relevé 3					
Geographic coordinates: Height: Relevé area ……...m^2, Slope …..… degrees, Exposure -…….. Layer stocking: a: ...…, b: …...c: ...…. d: ...… Layer height: a: ….., b: …...c: …... d: …..					
Species (latin name), layer	Amount				

Parameters and indicators	Value of the indicator	Indicator assessment
Characteristic species		
Expansion of shrubs and trees		
Expansive species		
Invasive alien species		
Occurrence of aeolian processes		
Percent of the area occupied by the habitat along the transect		
Characteristic species of xerothermic grassland / heaths		
Other distortion (e.g. trampling, littering)		
Conservation perspectives		
Overall assessment	Different status	FV / U1 / U2

Human activity				
Code	**Name of activity**	**Intensity**	**Influence**	**Description**

Table 20. Form of field observations used during the work on the monitoring of natural habitats in the Błędowska Desert.

	Parameters and indicators									
	Conservation perspectives	Characteristic species	Expansion of shrubs and trees	Expansive species	Invasive alien species	Occurrence of aeolian processes	Percent of the area occupied by the habitat along the transect	Characteristic species of xerothermic grassland / heaths	Other distortion	Overall assessment
	Monitoring before active conservation									
FV	0	96	35	145	21	19	27	66	52	0
U1	58	52	35	5	76	57	57	31	83	52
U2	92	2	80	0	53	74	66	53	15	98
	Monitoring after active conservation									
FV	54	72	44	134	131	46	49	133	81	45
U1	51	57	70	14	8	58	52	9	46	69
U2	45	21	36	2	11	46	49	8	23	36

Table 21. Summary results of natural habitats monitoring carried out before and after active conservation.

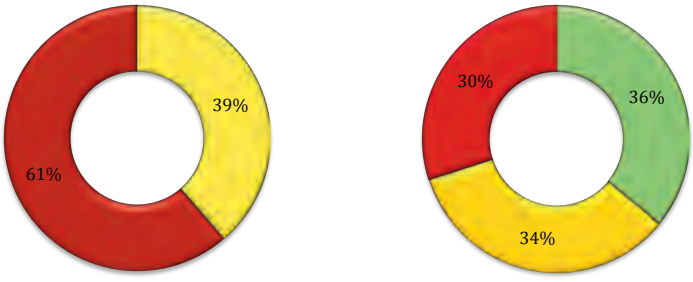


Fig. 25. Conservation perspectives: before active protection – the left graph, after active protection – the right graph.

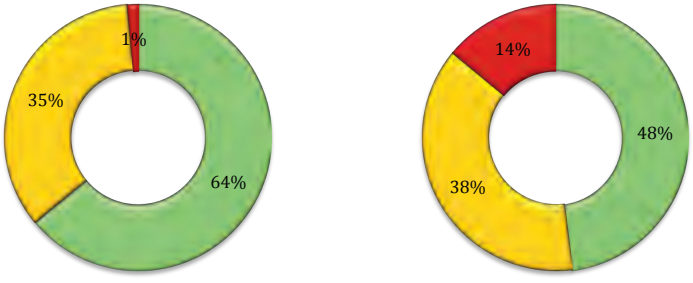


Fig. 26. Characteristic species: before active protection – the left graph, after active protection – the right graph.

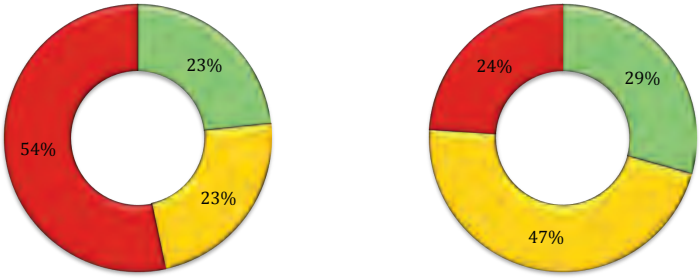


Fig. 27. Expansion of shrubs and trees: before active protection – the left graph, after active protection – the right graph.

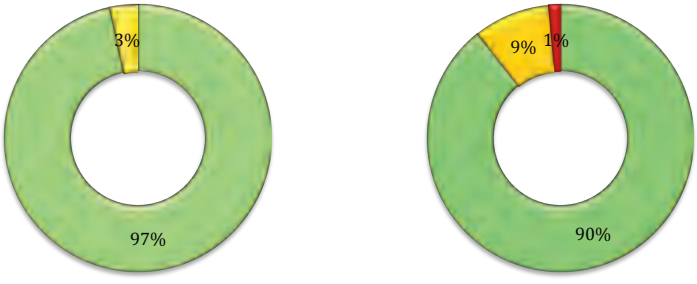


Fig. 28. Expansive species: before active protection – the left graph, after active protection – the right graph.

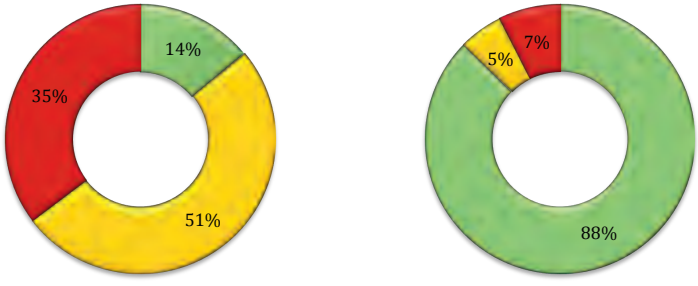


Fig. 29. Invasive alien species: before active protection – the left graph, after active protection – the right graph.

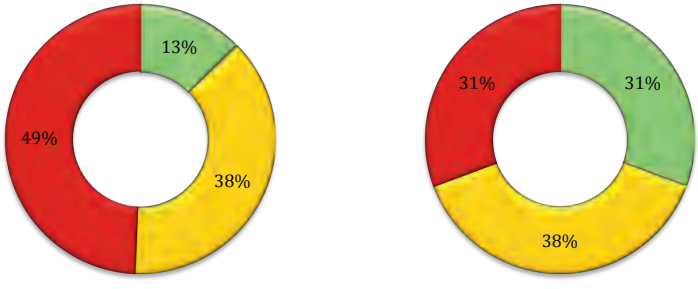


Fig. 30. Occurrence of aeolian processes: before active protection – the left graph, after active protection – the right graph.

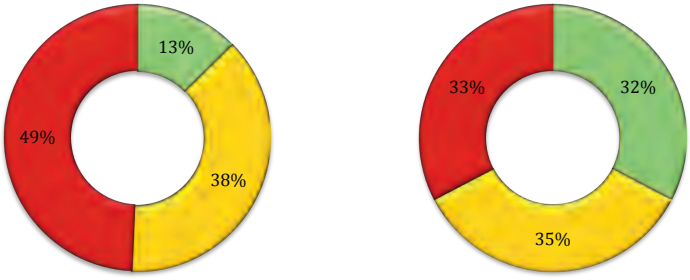


Fig. 31. Percent of the area occupied by the habitat along the transect: before active protection – the left graph, after active protection – the right graph.

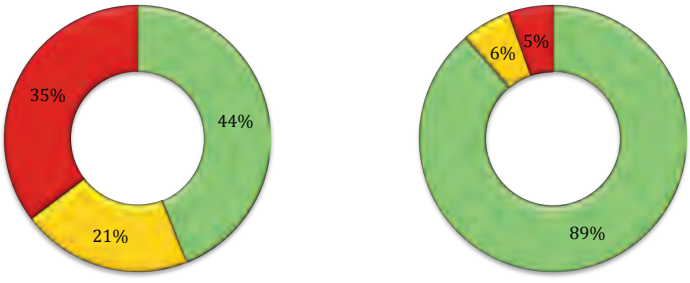


Fig. 32. Characteristic species of xerothermic grassland / heaths: before active protection – the left graph, after active protection – the right graph.

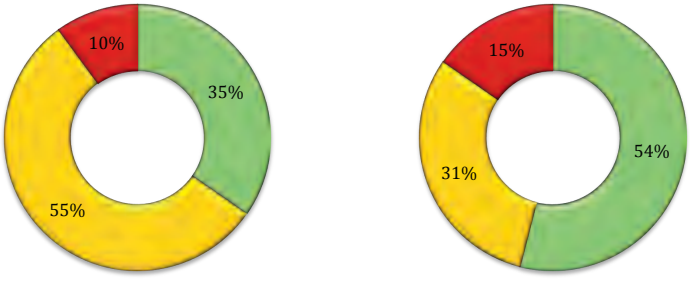


Fig. 33. Other distortion: before active protection – the left graph, after active protection – the right graph.

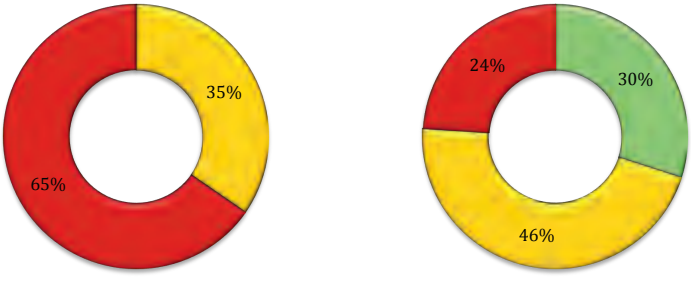


Fig. 34. Overall assessment: before active protection – the left graph, after active protection – the right graph.

The aeolian activity of wind is the necessary factor for the proper functioning of the sandy grasslands communities, which form on the dunes. Analysis of aerial photographs from the mid-twentieth century, showed the presence of sandy grasslands in the upper parts of the dunes. The rest of the areas were so-called deflation surfaces – blowouts, from which the sand blown by the wind was transported to the dunes. Described two types of geomorphological ground were overgrown by vegetation perfectly adapted to the prevailing conditions. Strong winds and large amounts of supplied sand eliminated undesirable plant species not related to the sandy grasslands. The increase in air pollution resulting in enrichment of the substrate by nitrogen compounds enabled the expansion of soil biological crust on the sand surface, thereby stabilized the top layer of it. Over time, most of the quicksand of the desert has been stopped. Thus, all processes responsible for creation of dunes disappeared and the dunes became a places colonized by shrub vegetation and pine seedlings.

Monitoring carried out before the realization of active conservation, clearly demonstrated the high degree of successional processes spreading in the study area. Dunes area was characterized by advanced process of ground podzolisation, and worse, development of the pine forest on their surface. However, due to the low fertility of the ground, stand structure did not match its age – scot pine took the form of a dwarf pine, mostly of height to 15 m, with twisted trunks and roots concentrated in the surface layer of the soil. Under the canopy of trees evolved a large layer of litter and dead matter. On the whole monitored area, there were only severely limited fragments of sandy grasslands.

Monitoring realized after finishing the active conservation showed a great improvement in the conservation status of habitats. Results of particular monitoring indicators and parameters show the changes that were recorded as a result of the implementation of actice conservation actions. Some assessments have undergone far-reaching changes in the direction of improvement, while others have slightly improved. Percentage of bad evaluation (U2) was decreased and the unsatisfactory (U1) and good (FV) evaluations were increased for most of the parameters and indicators. In the case of southern part of the Błędowska Desert the conservation perspectives before the project realization were very bad (Fig.10). More than half of the area was completely degraded. Other fragments also were passing into slow degradation state. Fragments with little coverage by pine occupied already a relatively small area and they were located within the former deflation fields. Currently, more than half of the area shows good conservation perspectives due to complete removal of trees and shrubs from the sandy grasslands. Bad assessment concerning approximately 14 % of the area in the coming years will be improved. The processes of spreading of sandy grassland will occur in this area. In many areas the processes of overowing by shrubs and pine seedlings will renew. Presumably, this phenomenon will be inhibited by activated sands. It is important to follow the ongoing changes very carefully in order to undertake early the corrective works. The changes, that took place within the indicator (characteristic

species) (Fig. 25) show a decrease in the area together with occuring there diagnostic taxa. No entry of new taxa characteristic of sandy grasslands communities was also observed. It is a temporary effect, resulting from the short time which has elapsed since the completion of the work related to the cleaning of the desert surface. It should be remembered that the monitoring areas were divided into areas of grasslands and deflation fields. In the places of deflation fields currently the bare sand occurs. Areas designated as sandy grasslands, due to improving habitat conditions, will successively restore, constantly increasing its acreage wogether with the characteristic species. In the case of total coverage of the designated as grasslands areas by sandy vegetation, the indicator will improve.

Indicator of shrubs and trees expansion (Fig. 26) has completely improved. Currently, 90% of the area is rated the highest. It demonstrated well conducted works of complete trees and shrubs removal. Before the beginning of these activities more than half of the area was totally overgrown, and almost 30% were undergoing slow overgrowing processes. In some places the regeneration of aspen and small young specimens of long-leaved violet willow was recorded. The presence of litter, pinecones, branches or wood together with the occurrence of soil podzolisation process, promote germination of seedlings and development of small shrubs. The presence of pine regeneration is particularly good indicator of the places, where the ground is still too fertile. Therefore, a decision about corrective work was made immediately. Percent of the area occupied by the habitat in 91% reached a good assessment (Fig. 30). The habitat hac new restored surface, where it can develop. Other indicators have changed only slightly (Fig. 27, 28, 29, 30, 31, 32). However, over time, further slow improvement resulting from still stabilizing habitat conditions is forecasted. The time which has elapsed since since the completion of the work related to the cleaning of the desert surface is too short. In fact, the effects will be seen within 5 to 10 years.

Active protection of sandy grasslands habitats in the Błędowska Desert

It was the most important and probably the most difficult task in the project. The whole desert was divided into surface stages (Fig. 35). Both, engineers and project contractor, conducted their work according to a specific order. According to the findings resulting from the inventory and monitoring, the final area of 300 hectares has been designated in order to be cleared of trees and shrubs. Due to the fact, that the project included 400 hectares of desert, 100 hectares of land, mostly on the outskirts of project area, was left without felling and grubbing, as a buffer separating the future desert of the adjacent lands. Desert cleaning works was divided into several technical phases. In the first place all trees and shrubs on designated surfaces were cut. Due to the periods of nesting birds protection, trees felling was limited to the winter months. Quite important recommendation was leaving in the desert a few circle areas of trees with a diameter of 30 m, within which were located the large groups of protected species

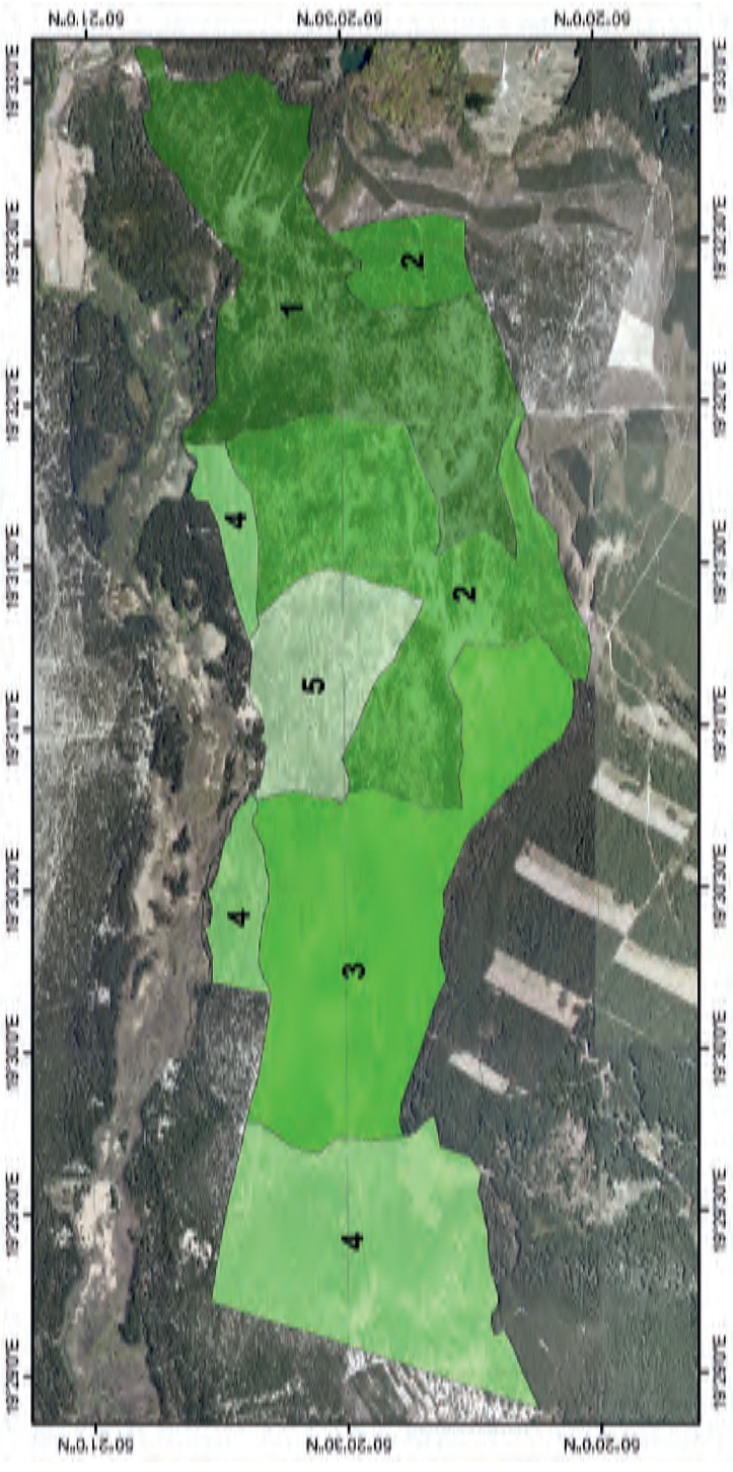


Fig. 35. Stages of the project realization in the Błędowska Desert.

Chipping of cutted scot pines in desert. © Michał Węgrzyn

of orchids. During the winter felling was not possible to find dark-red helleborine individuals in the field. Leaving trees allowed waiting until the summer months, when the orchids are in bloom phase and moved them to the replacement locations. Next winter the circle tree areas were cut. In the next phase, fallen trees, mainly pine trees and a small number of birches were chipping with using portable equipment. Wood chips were transported out of the desert and stored for further transport as a solid fuel for heating plants. Part of the chips was processed in so-called pellets, also the form of solid fuel, which is adapted to burn in special furnaces.

Due to the huge amount of wood, the disposal of it took the most time. Regardless of the work, in places where the wood has been removed, in accordance with a plan, began to define areas for the deflation fields and location of the grasslands. It was a very important step, because the contractor must have clear instructions which work need to carry out in certain location, so as not to damage the existing patches of grasslands. In areas where grasslands were situated, only handwork was possible. For fixed dunes desisted root grubbing, in order to protect the geomorphological forms. In places, where the deflationary field was supposed to be created, heavy equipment was used to grubbing the root of pine, birch and willow. Also in these areas, mechanical equipment was used to remove the organic matter and expose the bare sand. Finally, the whole area of the desert was cleared in varying degrees of intensity. Areas of sandy grasslands have been cleaned manually of organic matter, which defaulting on their area, while in other locations created vast deflation fields consisted of bare sand (Fig. 5).

Tourism on the Błędowska Desert

Despite the values, the Błędowska Desert is a place poorly prepared for tourists with lack of infrastructure and places of tourist utility. Forms of activity and number of to-

urists in that region are determined by the neighborhood of the Polish Jurassic Highland. Vast open sandy spaces and dunes retain only in memories of inhabitants and enthusiasts. For great part of society desert was just an isolated wasteland. According to natural and social conditions, place became attractive for extreme tourism lovers (motocross, quad and off-road).

According to surrounding landscape desert is easily accessible to reach for trekking and cycling tourists. Higher number of tourists in Jura region starts in May (depending on the weather), and lasts till first cold days (October/November). Jura region is slightly colder than surrounding places – air temperature is lower about 2-3 degrees; due to that fact, snow cover the ground much longer and is more abundant. Moreover, hilly region favours the development of cross-country skiing. In general, good conditions for winter activities last from November/December till March/April. Spring (period between May and June) and autumn (time between September and October) seasons, are the best moments for short weekend and holiday trips. Colorful forest in autumn is especially attractive for visitors. During summer season number of tourists is highest – especially in summer holidays.

On the Błędowska Desert the biggest in Poland and Europe sandy regions and inland dunes exist. Its landscape and environment are different to surrounding regions. Indirectly, during the project realization the following values were restored:

Natural values:

a) Unique flora and fauna:
   - sandy grasslands,
   - the opportunity to see species of fauna and signs of their existence,

b) Non-living objects:
   - quicksand,
   - dunes and dune forms,
   - physiognomy of area,

c) Climate phenomenon:
   - sand storms,
   - mirage,
   - beautiful sunsets and sunrises,

d) Landscape values:
   - panoramically views from viewing points,

e) Values in neighborhood:
   - The Orle Gniazda Track,
   - Polish Jurassic Highland,
   - Historical places in Olkusz.

During project realization, propositions of tourist infrastructure improvement and access to the Błędowska Desert were prepared.

Proposed activities were prepared with taking into account two documents: „The development strategy of the municipality of Klucze 2004-2013" („Strategii rozwoju

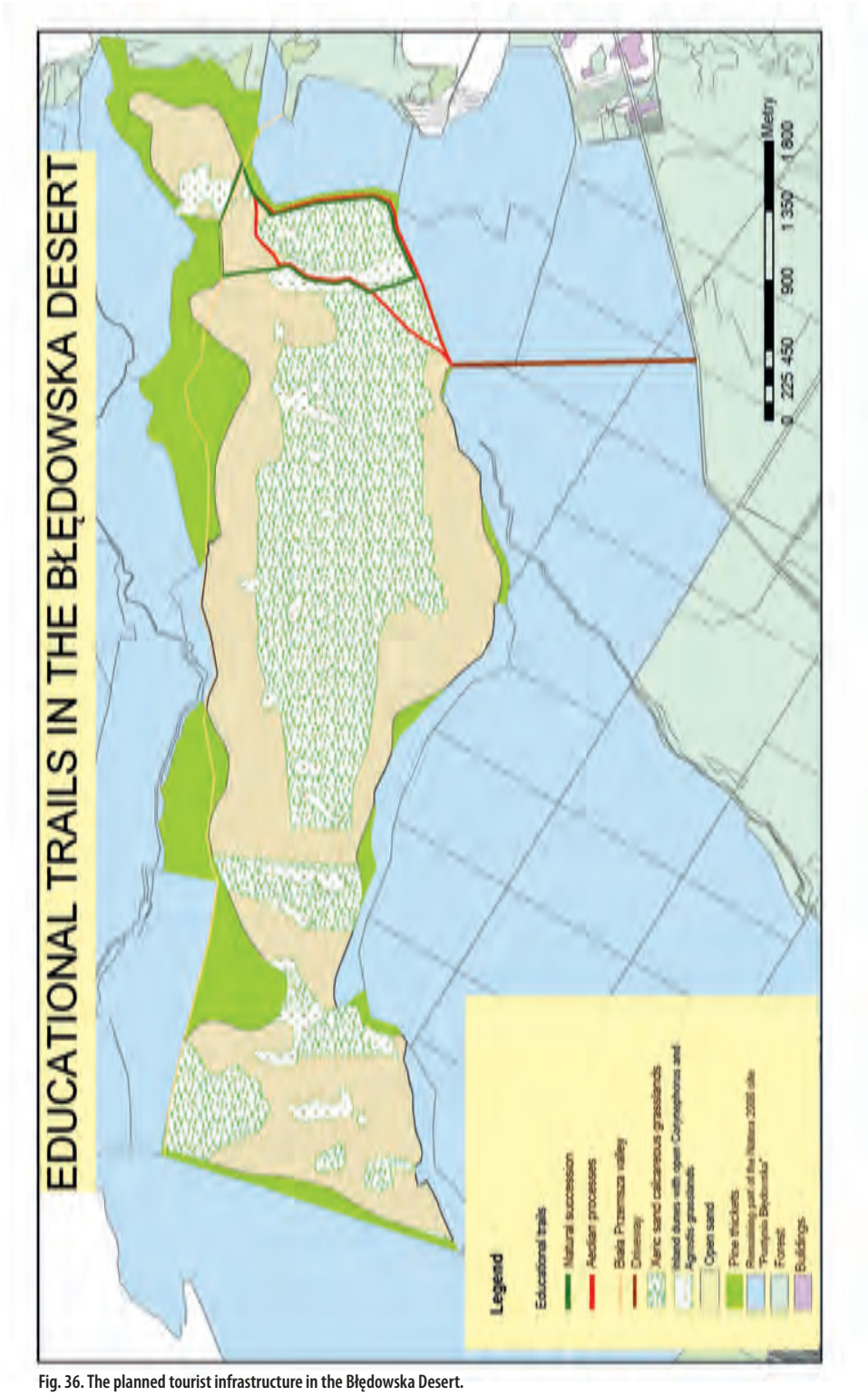


Fig. 36. The planned tourist infrastructure in the Błędowska Desert.

Gminy Klucze 2004-2013") and „The Orle Gniazda Track. The concept of the development of the tourism product. Marketing communication strategy 2012-2017" („Szlak Orlich Gniazd. Koncepcja rozwoju produktu turystycznego. Strategia komunikacji marketingowej 2012-2017").

Especially the „Szlak Orlich Gniazd" includes detail instructions about realization of activities intended to develop the local tourism. Proposed activities for Błędowska Desert have supplementary character, and they take into account the natural values, the nature conservation requirements and also the natural and legal conditions.

Developing of infrastructure has great influence on the competitiveness of the region and its impact on the assessment of commune. Due to that, actions to improve quality of infrastructure and quick and easy movement to other neighborhood areas should be taken, because of the great diversity and wealth of tourist offer of the Polish Jura region. Therefore, supporting of initiatives aimed at creation and improvement of the existing infrastructure, supplementing and efficient use and also development of existing tourism values must be continued. Easy access and possibility to quick and safe travel in region are really important indicators, when it comes to decide about place and way of spending free time.

Improvement of road infrastructure and access to mass transport will contribute to increase in number of tourists visiting the place. To reach that target it's important to take or continue following actions:

– improvement of road quality, tourist tracks, educational paths, especially leading to attractive places,
– improvement of quality of direct access roads to attractive places,
– improvement of quality of trekking and cycling tracks,
– improvement of road signs and marks, especially in places the most often visited by tourists,
– enlargement of number of car parks places in localities, which are located close to attractive places, in neighborhood of sport places and close to places, where tourist track crosses public road,
– preventing the excessive tourism pressure.

The main idea of proposed plan is to rebuild old and build new tourism infrastructure, and also create new educational paths.

Proposed scheme of new educational paths: „Aeolic processes", „Plant succession", „Nature 2000" (Fig. 36), includes creating few partly overlying loops. That solution gives bigger possibilities to lead educational activities and recreation.

Proposed new educational paths („Aeolic processes" – red marks, „Plant succession" – green marks, „Nature 2000" – blue marks) will be dedicated to only one topic and will be prepared to make trips with local guide or on your own with using activity scenario.

In places where track will be crossing dune, wooden footbridge will be created to provide the chance for wind to transport sand easily further on. Thanks to this, also protection for plants on dunes will be provided.

At the neighborhood of stop points, panel boards will be prepared. On the top of the dunes, a fenced wooden platform will be built. Track leading through open spaces will be protected by poles or rootwoods.

At the junction of educational paths, in the immediate neighborhood of wooden footbridge over dune, there is a need to prepare the benches, which won't interrupt landscape.

It's important not to place them in the first line of sight, but in some lower places or in front of phytogenetic hill, which is overgrown by creeping willow *Salix repens* subsp. *arenaria*.

In places, where educational tracks will cross or connect („Wildlife educational path", „Valley of the Biała Przemsza river" and PTTK Desert walking path), at the edge of forest, there is a need to prepare gathering place for tourists and people taking part in educational activities. The area for that purpose should be fenced and inside there should be a shelter for 20-30 people, which will give the chance to rest or take shelter during bad weather conditions. In that place, the boards about Natura 2000 Błędowska Desert and the LIFE+ project should be also arranged. According to fact that, the place will be easy to reach by tourists, the trash bins are necessary in whole area.

In relation to PTTK Desert Track Błędów – Błędowska Desert– Jałowce Mountain (Czubatka) – Klucze – Jaroszowiec – Zalesie – Kobylica – Golczowice – Stoki Kwaśniowskie – Ryczów, it is suggested to move it a little to the north, to the edge of forests (a buffer zones) and then connect it with educational path „Valley of the Biała Przemsza river".

Course of the PTTK Trans Jurrasic Horse Trail need to be corrected – moved to the edge of forest and further in NEE direction to the crossing of the Biała Przemsza River.

The Błędowska Desert will be a great tourist attraction only if all aspects will be well planned and done with respect to sustainable development of tourism. There is a necessity to create many diverse cycling tracks that will be safe for people who are walking and cycling.

Network of cycling paths should give a chance to reach all observation places, also for people, who won't ride through the desert. Those places should be equipped with bicycle racks. This solution allowed having greater chance to rest without stress about stealing the bike during for e.g. taking photos.

More and more common way of spending free time is the horse riding. Numerous events are organized, e.g. searching for fern flowers on the 22nd of June. Also other types of horse tourism are developing: horse riding trips, carriage rides, sledge rides, hippotherapy etc. Because of that, horse tracks should be present in the Błędowska Desert landscape.

Organized the motor vehicle tourism in the form of trips to the interesting areas has a great educational value. It gives opportunity for people with health problems to reach places, which seemed to be out of range for them. It's also quite attractive for children and youth. Car „safari" trips with well-prepared transport, may allow making

available desert areas with obeying the tourist capacity norms. Not only can the car tracks be regulated, but also number of cars and frequency of rides. Additionally, the number of people taking part in trips can be limited. Creating the safari tour routes on a great deflation fields in the SW part of desert will also take part in habitats protection. Plant succession in the blowouts localized close to the forest stand (closer than 300m) will be higher in case of existence the natural barrier (forest) for the wind. It will result in lower lift force and weaker wind erosion. Deflation fields are absolutely key places for keeping mosaic of habitats on the desert and the structure of desert landscape. Track will be used in summer time for organized trips with special concession and limit of drives.

The Błędowska Desert is an interesting place for extreme sport activities.

Each of further mentioned sport activities need conditions, which exist on the Błędowska Desert or in close neighborhood.

Paragliding used to be popular in the region in the past. Hill of Czubatka used to be a starting place for paragliders. It stopped due to changing conditions – overgrowing by trees of the open area of the desert. After project realization, area will regain conditions for paragliders.

The Błędowska Desert area is recommended as interesting and unique for survival trips. Organizers of survival camps prepared offer for tourist from Poland and foreign country. It is also possible to organize short term camps on the desert.

One of the most controversial sport that takes place on the desert is off-road. Driving by terrain vehicle (cars, cross-motorcycles etc.) nowadays takes place in informal way and is illegal (not obeying law about driving in forests and other protected areas). Moreover acquired experiences during restrictions of motorsport in the desert area are unsatisfactory. There is a great lobby of drivers who want to illegally use the desert area. Besides the existence of many rules and codecs about this form of recreation, there is a great danger of lack of respect for the principles of nature conservation and destruction of the most valuable fragments of grasslands and dunes. Compromise and a good solution, would be using the post-mining heaps and creating the appropriate condition for off-road driving. Potentially, it is possible to provide a limited area occupied by the deflationary field and organizing mass events, also automotive.

In the case of progressive plant succession, which will result in the inhibition of aeolian processes, particularly the wind erosion in the deflation fields, withdrawal of succession and start of quicksand can be achieved by intense traffic on a specific area. Depending on the needs of nature protection (the need to remove the vegetation cover), areas designated for this form of recreation should be operated alternately under the strict supervision.

In the Błędowska Desert area and in its surroundings, there are attractive areas with a slight inclination – it allows mapping the tracks for the cross-country skiing, differing in difficulty and length, and overcome in the time from 1 to 8 hours. They would lead through the natural areas attractive at view. Tracks should start at the car

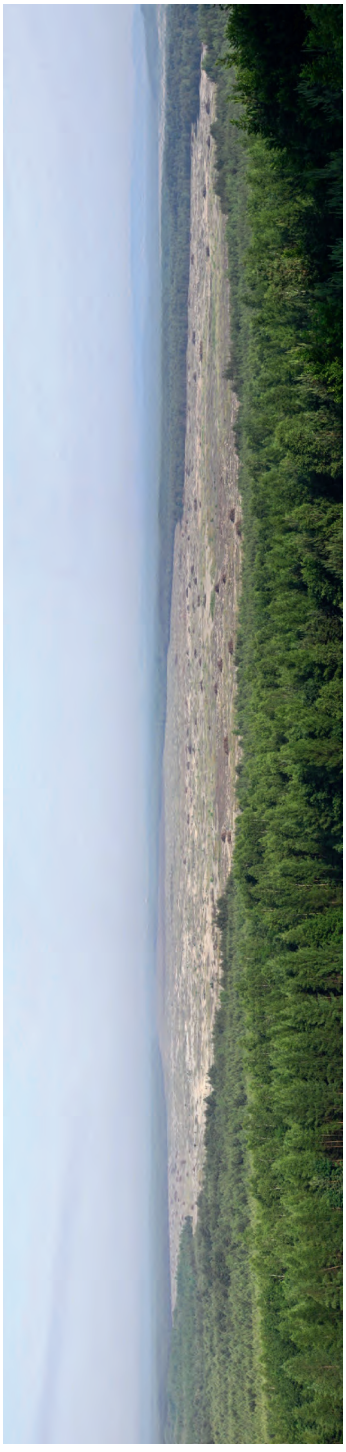
parks or recreational centers. Near the starting points should also be locate the gastronomical places, equipment rentals, and boards with clearly marked tracks. The attractiveness of the tracks is determined mainly by forest cover, different shape and its preparation.

Summary and recommendations for those who want to protect sandy grasslands in Poland and Europe

Protection of sandy grasslands habitat in Polish and other European countries is currently carried out under a wide range of projects, mainly the LIFE program, because it is the only EU financial instrument exclusively devoted to the co-financing of projects in the field of environment and climate protection.

Implementation of the sandy grasslands protection project in the Błędowska Desert contributed to the achievement of the project aims, including the most important one – saving the desert before the complete overgrow, and thus protect valuable sandy grasslands habitats from degradation. The Natura 2000 areas in the Błędowska Desert were established primarily due to the biggest complex of sandy grasslands in Poland and Europe. Taking the effort of saving these habitats was associated with large financial outlays, because of their poor state of conservation. However, the successful realization of the project is a proof, that there are opportunities to take an active protection of natural habitats even on such a scale. The condition for success is a well-planned project with real objectives to achieve. In order to facilitate the task of creating new projects, the effects presented, as well as the experience gained by contractors during realization of specific tasks can be used. At the time of the work planning, many factors, which can greatly hinder the implementation of tasks, can not be predicted. The big problem is the management of activities that are causally and temporally dependent on each other. However, cooperation of all contractors and project managers should result in rapid repair decisions. It must be remembered, that in projects related to the protection of natural elements, the methods, which can not be modified in a flexible manner during the project, should not be used. Nature is not schematic, although scientists are trying to push it into the framework of structured classification. During planning and implementation of projects, all known methods of active conservation should be used, which were elaborated in this and other similar projects, as well as scientific knowledge, practical experience and knowledge of local communities. It is also important to keep common sense when key decisions, that need to be consulted in a wide group of professionals, are making.

View of the souther part of the overgrown Błędowska Desert from Czubatka. © Michał Węgrzyn



The same view of the Błędowska Desert, which was cleared from trees and shrubs. © Michał Węgrzyn

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How difficult it is to write in the beginning of the twenty-first century about the habitat of disappearing sandy grasslands that creates in inland sand areas. Reading previous elaborations and being in the field on few remains of the former sand areas, heavily overgrown by pine forest, it is hard to imagine such large areas that were once devoid of forest vegetation. Pine forest became for sandy dunes the same what photographic fixer is for photographic print. Slowly, but very effectively, the shape of substrate was fixed forever. The descriptions that sand areas and dunes are common in the landscape of Poland and play a large role in its formation disappeared from school geography textbooks. Unfortunately, at that time, from an economic point of view, bare sand was treated as serious problem. Fight with dunes and their insistent afforestation were very often one of the propaganda themes on the civilization development of the country in the twentieth century.

Through the implementation of the LIFE+ Pustynia Błędowska Project the authors using numerous examples once again are trying to bring us sandy habitats, their history, transformations, current conservation state and dynamics. Also on the pages of this guidebook the history of the completely overgrown the Błędowska Desert transformation is described. Slowly, due to the efforts of many people and financial opportunities of the European Commission and the National Fund for Environmental Protection it has restored. Slowly, it is gaining such form which the oldest inhabitants of Klucze, Chechło or Błędów remember from the childhood.

The natural habitats of Community interest, including sand grasslands, are an evidence of the coexistence of man and nature on the European continent over the years. Thus making any attempts contributing to ensure the biodiversity by their protection are the priority actions.

Anyone can get involved in these activities, and this guidebook certainly will help in this.

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