

Review of biodiversity research results from Poland that directly contribute to the sustainable use of biodiversity in Europe

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1. Introduction

Diverse landscapes and climate types, various biogeographic influences and very diverse types of land use are the main sources of the high biodiversity of Poland. It is comparatively well preserved owing to long tradition of various forms of nature conservation (started in 15th century as protection of royal hunting grounds) and long-lasting extensive use of natural resources. Crop plants and animals are characterized in our country by quite high diversity of races, forms and types (some of them have very local character), which is ought to very diverse culture combined with very high share of small family farms in agricultural system [Andrzejewski & Weigle 2003].

Dominant system of land use in Poland is still traditional with wide range of management intensity. Most of the farms are small (average area is ca. 7 ha), and with small capital. This pattern of the farming is very convenient from ecological point of view, assuring conditions for preservation of very high biological diversity. Last years has brought very rapid changes of synanthropic vegetation, associated with general changes in Polish political and economic situation. Cultivation and selection of plants narrows their genetic base which in turn makes them less adaptable to changing environmental conditions. New high-tech farming is cultivating very low number of the best varieties of crops covering vast areas, causing their genetic erosion. These disadvantageous changes are accelerated also by unsustainable use (exploatation) of the natural resources, new diseases and pests as well as by various regional, state or continental policies (like CAP of EU).

Another issue to address is the problem of threats to biodiversity posed by GMO's. They may occur to be toxic, genetically unstable, allergenic. But the most serious problem from biodiversity point of view is their possibility to crossbreed with related wild species. In Poland any use of GMO's (both: in controlled and open conditions) must be agreed by Minister of Environment, however it does not assure, that the problem will not occur.

Poland has comparatively high number of research and combined didactic/research institutions carrying scientific work in the field of biology. Those are: 22 Institutes of the Polish Academy of Sciences, 11 Units of Applied Research and 101 faculties of academies and universities. Their studies in the field of biodiversity are financed by State Comitee of Scientific Research, Ministry of Agriculture, Ministry of Environment and agencies belonging to the Ministry of Environment (National Found of Nature Conservation and Water Management, State Forests and so on). During last few years some research topics has been financed by EU through the Framework Programmes.

• **What kind of biodiversity research you think contributes directly to the sustainable use of biodiversity in Europe?**

There is a very broad range of biodiversity research, which contribute directly to the sustainable use of biodiversity worldwide and part of them is applied in Europe. To these most important I would include researches aimed on:

- biological and ecological requirements of the species,
- estimation of capacity of the species and ecosystem in question – to make sure, that use stays within its limits,
- opening new economic opportunities for stakeholders to avoid overuse of biodiversity,
- development of techniques and technologies of biodiversity components management,

- crop species genetic biodiversity,
- rules of management of the areas surrounding biodiversity hotspots (protected and not protected) as economically viable production systems of high environmental value,
- protection or restoration of uncultivated ex-farmlands' biodiversity value,
- temporal and spatial movement patterns and territorial requirements of wildlife,
- climate change and the way in which species deal with it,
- developing of the new crops basing on old types of crops (they are usually more tolerant for the soil and climate and giving more stable level of production) rather than on GMO's,
- learning of interdependencies between the land use (agriculture, forestry) and natural biodiversity,
- innovative social, economic, institutional and legal frameworks aimed on developing more ecologically based management systems that take into account the multiple values of biodiversity,
- new production and consumption technologies taking into account economic development, poverty alleviation and long-term preservation of living resources and ecosystems,
- learning the influence of GMO's on biodiversity.

- **Selection criteria of publications and main topics for the review**

In this review emphasis have been set on the research covering the above mentioned topics in connectivity to objectives 2 and 4 COM216. I have tried also to cover all levels of biodiversity, all types of ecosystems and include social and economic elements aside of the biological. To keep the records of the most recent and relevant research only projects and publications not older than 10 years have been taken into account. It resulted in need to analyse close to 5000 research on the biology related topics carried during last decade by Polish research institutes. Special attention have been paid to research centres possessing high rank in the last classification of Polish biological research institutions and those carrying their research programs in the hotspots of biodiversity (e.g. Białowieża Forest, Biebrza Marshes, Bieszczady Mts., Tatra Mts. and so on).

2. Description of main findings of the selected studies

- **Identifying high value farmland (and forest) areas (Action A2.1.3)**

Poland owing to its very fine-grained structure of small farms has saved big share of the local, Central European forms of cultivated crop plants and domesticated animals. The biggest number of such forms is recently known from southern, mountainous part of the country: Beskidy and Tatra Mts as well as their foreground. Some smaller areas with cultivation of the traditional forms, breeds and cultivars are known also from eastern part of the country (Podlasie and Kotlina Sandomierska). The local forms and races have been saved there because they are favoured by rough climate, short vegetation period, unsuitable conditions for mechanical cultivation of land and geographical isolation as well as by their social distinctiveness (those areas are characterized by distinct local culture, different than in adjacent areas and the rest of the country). Twenty years ago in some of those places still were cultivated relict species of cultivated plants: *Camelina sativa*, *Raphanus sativus* var. *oleiformis*, and *Panicum miliaceum* as well as species which are no more cultivated in most of Europe: *Spergula arvensis*, *Lathyrus sativus*, *Avena strigosa* [Kulpa and Hanelt 1981]. Unfortunately the survey aimed on identifying high value farmland regions had not been

repeated during last 25 years and it is not possible to estimate how far above mentioned facts are still actual. Recently most of those local forms of cultivated plant forms are known only from specialized gene banks. Also each species of domestic animal kept in Poland (cattle, horse, sheep, pig, geese, duck and hen) had its local primitive race there. Wider information on that subject is accessible at databases of FAO DAD-IS (Domestic Animal Diversity Information System) [<http://www.fao.org/dad-is>]. Some races have been lost during last decades, most of them are kept recently in specialized centers of conservative breeding [Andrzejewski & Weigle 2003].

Aside of the specific traditional crop plants in eastern part of Poland weed associations specific for crops in which they grow are still well preserved. They are subject of some studies carried during last decade, exemplified by work of Institute of Plant Protection which clearly shows process of degradation and extinction of weed associations specific to diminishing crops or crops which currently are cultivated with high use of herbicides instead of the previous hand work (good example of such a crop is flax) [Heller 1998].

High value farmlands are found problematic from the point of view of their management and proper (wise) use. Some special works have been devoted to classification of various types of meadows with their assigning for protection, extensive use or intensive use. The idea of high value farmlands protection in the river valleys have been studied by many authors pointing out the very high biodiversity of these areas and need to stop anthropogenic transformation of such farmlands [Gacka-Grzesikiewicz 1999a, 1999b, 1999c; Gacka-Grzesikiewicz 2000; Gacka-Grzesikiewicz et al. 1999a, 1999b].

There was proposal of the very modern method of identifying of high value farmlands and classification them to different regimes of use on the basis of satellite images and other methods of so called "remote sensing". The project concept was built around the idea of spatial separation and classification of farmlands to the category of intensive production land or ecological function land up to their habitat conditions. Soil types, water management regimes, plant associations and species composition of the area, height of the vegetation and yield level have been studied on the ground and compared with satellite images [Kozłowska 2002, 2003, 2004; Kozłowska & Frąckowiak 2002; Kozłowska et al. 2003, 2004; Kosiński & Kozłowska 2003; Kozłowska & Szymczak 2004a, 2004 b].

Undoubtedly farms lying on the territory of the Natura 2000 sites should be automatically classified as high value farmlands. For this reason there were attempts to assess state of preservation of some plant associations and their habitats in those regions. At the sites with earlier studied species composition of the plant associations phytosociological studies have been repeated, plant communities have been compared and factors responsible for the changes had been assessed. In the region of Mogilany village (Southern Poland) the most advanced changes were observed in *Molinietum caeruleae* association. Observed transformations were caused by change of the meadows use technology and general change in the land use. Chemical and physical characteristics of the soils under studied vegetation were found to be changed only subtly. Distribution of vegetation change was caused mainly by infrastructure development [Bator 2004]. Modestly different results were found in Wielkopolska region (Western Poland) for the whole *Molinio-Arrhenatheretea* class of related plant communities. The changes there are caused mostly by land reclamation, decrease in ground water level, repeating droughts and excessive intensive use of some areas which should be classified as high value agricultural lands. High variability of vegetation in the framework of his class has been proved (as many as 41 syntaxonomic taxons has been determined). Most of the plant

communities belonging to this class of vegetation are specific for hydrogenic and semihydrogenic soils. Many soils were found polluted by N, K and P as they were under intensive management in past. The biggest degradation of the habitats had been observed in humidity and fertility of the soils. Decrease of the ground water level is responsible for expansion of the communities from *Arrhenatheretalia* order on the cost of communities of *Molinietalia* [Kryszak 2001]. The above results are characterizing trends in meadow species composition observed in the whole country. Intensification of land use from one side and changes of the soil characteristics are causing decline of fragile habitats which very often are of the Community interest (like *Molinietalia*). Both processes are however effect of so many drivers that bringing back the sustainable use of the biodiversity in this case seems not possible.

One of the good indicators of the high value farmlands was found diversity of spiders. Analyses were aimed on finding connection between the spiders associations and simplification of the landscape diversity. The highest numbers of species as well as the highest value of the species diversity index has been attested to the most diversified and fragmented agrocenosis. The main driving factor responsible for this very high level of biodiversity were barrens. The highest densities of the spiders per 1 m² has been found in so called ecological farms. The findings show very clearly that existence of the fragmented, fine grained farms with barrens is vital for preservation of natural resources and securing the sustainable use of the biodiversity not just for recent society but also for future generations as well. Preservation of natural values in farmlands is even more fostered if their structure would be built by fragmented ecological farms. These findings however are not in line with CAP of EU which cause (by creating of the economic frames for agriculture) slow decline in number of the small farms and increase in the average size of the Polish farms [Wolak 2001, 2002]. The ecological farming carried on the high value areas influences structure and fertility of the soils under cultivation. Organic carbon and other components positively influencing production have much higher share in the soils farmed in ecological mode than in conventional farms. Contrary: the negative, degrading elements like heavy metals had very low levels of content in the soils from ecological farms which however could be the effect of selected localizations. The other soil characteristics did not show a statistically important differences [Radoła 2004].

As forests cover close to 30% of Poland, ca. 65% of Polish biological resources are concentrated there. It was estimated [Andrzejewski & Weigle 2003] that forests are home for at least 32 000 organism species. In prehistoric times most of the country use to be covered by forest ecosystems which then had diminished under the pressure of developing agriculture and growing demand for wood. The oldest written estimations of the forest cover are from 1820 when it had in Poland share of 38%. The lowest share of the forest cover was in 1946 - 20,8%. Since 1947 the afforestation of Poland is continuously increasing. Forest trees are the only group of wild plant species which is comparatively well studied from the point of view of genetic diversity. Samples of seeds from most important populations are kept in gene banks. The best tree stands are excluded from regular forest management system and kept as seed producing stands (136 406,84 ha). It must be underlined that big share of Polish forests are of the natural character, established from native seeds or even of natural origin, floristically and faunistically very rich (281 762,02 ha). Most of them are covered by various forms of nature conservation, with forests of the highest value protected in Polish 23 national parks and many nature reserves. [**Data of the General Directorate of State Forests – State of the forest 2005**]. Forest biodiversity assessment has been done during preparatory phase of the Natura 2000 network establishing. Biological data connected to Natura 2000 network is

kept in data bases of Institute of Environmental Protection (www.ios.edu.pl) and Institute of Botany of the Polish Academy of Sciences (www.ib-pan.krakow.pl). Close to 99% of Polish state forests are managed by countrywide State Forest Company. Contrary to this almost monopolistic ownership only 0,5% of Polish forest are protected under strict regime. State Forests have own Forest Research Institute devoted to studies connected to all of the aspects of a forest and forestry. At the turn of the millennia they had funded the project aimed on development of measures allowing to assess changes of biodiversity in forest ecosystems. It means that it can be used also to identify the areas with high and stable level of biodiversity. General state of the trees, condition of seedlings, saproxylic (wood dwelling) beetles, bats and mites (Acarina) have been proposed as key groups for assessment and following monitoring of the forest habitats [Falencka-Jabłońska, unpubl.].

Part of the works aimed on high value forest identification is concentrated on establishing of refuges of the biodiversity as well as ecology and prognosis of the preservation of these refuges. Such a project has been carried in Sudety Mts., where natural values of the area are threatened by two anthropogenic caused processes: acidification and eutrophication. As a result of the work 6 refuges with the highest index of biodiversity has been established: Śnieżnik massive in Karkonosze Mts., Kaczawskie Mts., Stołowe Mts., Izerskie Mts. and foreground of the Sudety Mts. It was also proved that acidification and eutrophication in the region of Sudety Mts. are responsible for lost of microhabitats as well as plant species specific to them. Results of the work point out also that the high value areas (both: farmland as well as forest) are seriously threatened by expansion of alien invasive plant species [Fabiszewski & Brej 2000, 2001; Fabiszewski & Wojtuń 2001a, 2001b; Brej 2001; Fabiszewski & Kwiatkowski 2001, 2002].

The most recent project aimed on the high value forest identification has been launched in August 2006 by State Forests. All of the forests owned by Polish government are the subject of the accurate inventory of the species from the annex II to Habitat Directive. The project is under way and after (recent) phase of inventory, monitoring system based on the forest service is going to be established. The methodology is very efficient as it is going to use existing network of forest service workers to keep season-to-season monitoring of existing and eventual new sites of Community interest species with the aim to assure their sustainability. The inventory will give forest managers and workers a good basis for biodiversity friendly and sustainable planning in the areas managed by State Forests. The first results will be accessible at the end of 2007.

- **Influence of national plans of CAP implementation on biodiversity, including aspects of cross-compliance (Action A2.1.4)**

Polish farming system is strongly differing from both: Western and Eastern European countries by its small family farms pattern. Their recent characteristics are strongly determined by heritage of the previous generations of farmers and history of Poland. That means that one could not find the common well working attitude for Western, Eastern and Southern part of the country, as they have very different history and had develop under different social, economic and legal conditions. Its continuity and further development is strongly influenced/changed by implementation of CAP. In this context further development of family farming is found to be correlated with age and speed of exchange of the owners generations. Farms can't be treated as separate independent units as they create integrated farming system connected by many socio-economic relations [Lizińska 2000]. Development of the modern agriculture is causing an increased pressure on the environment. Reduction of

this negative influence is a very important topic in CAP implementation in Poland. It was proposed that it could be done by: 1) extensification of production (it would cause reduction of the N inflow to the system but at the same time causes reduction of production and income); 2) modernization – increase in effectiveness of use of the N inflow to the system; 3) optimization – reduction of the N inflow and increase of its effectiveness in the system. In Polish economic system only second scenario is justified as cost of the others are higher than income generated by changes and losses in traditional way of agriproduction [Machnacki 2001, 2002; Piekut et al. 2002].

Ecological assessment plays a role of the effective tool for measuring the influence of the government ecological policy on agriculture. Implementation of the government agricultural policy has been found successful only in the case of the companies lodging and processing fruits and vegetables. It was found unsuccessful towards those producing crops as it needs a lot of efforts to control all of the crops. The most influential are the mechanisms of control and enforcement of the law in the scope of conservation of environment if they are combined with subventions paid by ecological funds [Karaczun 2003].

Common Agricultural Policy implemented by European Community influenced production ability of the Polish agricultural sector long before accession of our country to EU. For this reason keeping of the previous (prior to accession) levels of agricultural production has been not possible both: in the sense of products diversity as well as in the sense of potential production (labor, land, capital). After implementation of CAP Polish agricultural sector had to enter the period of quick modernization with simultaneous limiting of the production capability. In effect there is observed decrease in number of people employed in the sector, decrease of the cultivated area as well as decrease in number of farms. But in the same time took place concentration of production and capital on the level of farm and mechanization of processes [Czarniewski 1999]. This situation has been improved after accession of Poland to EU in 2004, when Polish farmers received subsidies on similar conditions as their West European counterparts. Speed of the above mentioned process has then slow down but has not been stopped. The Polish agrarian structure has been found the limiting factor of integration of the agricultural sector with the EU. The main problem has been not the small scale structure of our farms, as there are countries in the “old” EU countries with similar structure (Greece, Portugal) but the high level of employment in Polish agriculture (23,3% of people in comparison to average 4,8% in EU). This became one of the main socioeconomic topics to solve in country [Lizińska 2000]. The main directions of the governmental policy towards the agricultural sector are: development of the employment in the sectors not associated with the agriculture, strengthening institutions playing an important role in regional and local development and reaction against increasing poverty of citizens. Strategy of further work is developing basing on instruments of National Development Plan and support of the European Union [Mączka 2004, 2005; Golik 2005a, 2005b; Zieliński 2004a, 2004b, 2004c; Prusek 2004].

Globalisation (understood here also as integration with EU) is the main factor causing and influencing process of the small farms restructurisation in Poland. It leads to changes in structuring of the society and desintegration of the peasant class. The observed restructurisation is the most modern phase of modernization, introducing new forms of diversification, both: in the scale of the societies as well as in the international scale. In Poland the problem is very specific, as during the years 1945-1989 Polish peasants had to fight against the communism and its collectivization for survival of the family farming system. After change, during first decade of the transformation in the 1990s they had to

strongly stand up against of the disintegration processes caused by disadvantageous economic system. This strong opposition of farmers against the outer destructive pressure allowed to save traditional family farming in the whole country, however recently this heritage of conservative attitude is responsible for slowing down of the modernization process. Under the influence of the CAP in Polish agrisystem develops very quick differentiation leading to polarization of farms: those adjusting to the free market and those which are being or going to be marginalized [Gilarek 1998, 2001; Gorlach 2000a, 2000b, 2001].

- **Develop indicators and monitoring schemes (Action A2.1.7)**

Polish partners are taking part in the project EuMon, which attempts to provide a European framework that standardizes, focuses and coordinates existing monitoring programs by comparing and integrating existing methods and monitoring schemes of species and habitats of community interests. The most successful methods in terms of cost effectiveness, regional robustness will be selected and tested for their European wide applicability. EuMon pays special attention that existing monitoring programs, it can incorporate these methods and will give recommendations how new and successful monitoring programs can be established. Special consideration for implementing monitoring programs is paid by studying the social effects of monitoring regimes, because the relationship between amateurs and professionals are meant to be most important for implementing a successful monitoring regime. The establishing of the NATURA 2000 network is one of the main actions on a European level to halt biodiversity loss. Therefore it is a prerequisite to evaluate its ability to maintain biodiversity. A comprehensive database on monitoring schemes and recommended methods is accessible via an Internet portal <http://eumon.ckff.si/monitoring/search.php>. It includes 117 monitoring schemes registered by Polish researchers covering almost all levels of biodiversity and most types of the organisms.

Monitoring of the landscape evolution and especially formulating the index of changes and their interpretation is very difficult, for spatial structure of the landscape is characterized as „deterministic chaos”. The authors understand under this expression that landscape variability has quasi-random character determined by many biotic and abiotic factors with crosscutting influence on each other. Each of these factors has its own spatial dimension and scale of influence. Composition of the landscape reflects mainly variability of its biotic and abiotic components. However spatial distribution and configuration of recent landscapes are controlled by anthropogenic influence. For these reasons wider comparisons and assessments of the landscape diversity and value of the diverse landscapes and diverse temporal moments should be based on careful analyses of the connections between indexes, but not on the analyses of the indexes themselves. Such an assessment can be very useful also in assessment of the sustainability of development as well as in spatial management planning on local and regional levels [Solon 2002].

One of the concepts of the forest biodiversity change assessment is built around the basic levels of the ecosystem trofic structure. The criteria of assessment were: floristic (species composition and structure, phytosociological analyses, dendrometric classification) and chemical (*Pleurozium schreberi* has been used as indicator of the toxic substances cumulated in low vegetation) and faunistic (relations between herbivorous and carnivorous insects as well as vertebrates feeding on insects). The last studied trophic level were decomposers represented by soil dwelling mites of the family Acarina. Floristic criterion including status and distribution of forest regeneration and increament of trees in the tree stands can be very

useful in assessment of the biodiversity value of the forests. Especially seedlings (their size and recruitment) are reflecting stability of forest ecosystems [Falencka-Jabłońska, unpubl.]

Additional and interesting topics:

- **Genetic diversity of crop varieties, livestock breeds and races (Action A2.1.11)**

The old varieties of crop plants are considered in Poland also as a part of the cultural heritage. Some specific places, where they are still cultivated, as for example Nadnidziański Landscape Park are used to propagate and promote this value in the society. The management recommendation for land use and agricultural technologies were prepared to conserve not only the crop plants themselves, but diversity of their specific weeds as well [Fu Dostatny 2001]. Genetic diversity is decreasing not only in traditional races of crops but also in those cultivated for comparatively short time. Cultivation of clover (*Triforium*) has changed genetic diversity of the cultivated breeds in comparison to their wild populations. The level of population diversity (structure and distribution of diversity in *Trifolium* species) is determined in 60% by biological factors in interaction with the environment. Climate plays an important role in the process of adjusting *Trifolium* populations what is expressed by much higher share of vegetative propagating breeds in temperate climate than in climates with harsher conditions [Jakubowska 2003].

In Poland still very important economic role is played by forest tree species as forestry is still generating big income. Diversity of forest trees has been found as important as diversity of agricultural crop plants. Most of the main “forest building” species are studied very accurately to find out what are the relations between their genotype and phenotype. For this reason the whole set of the so called provenience research plots, scattered across of the whole Poland has been developed at the start of 1970s. The diversity of the populations has been found very high but relations between the genotype and its answer on local habitat conditions is still not clear. Some results of the provenience experiments have been already published pointing out the most adaptable and successful provenience. These results can become very important in the future, in the process of adapting Polish forests to the changing climate [Sabor 1994; Kraj 1997; Skrzyszewska 1998; Kulej 2001; Banach 2005].

One of the most specific to Poland breeds of the cattle is “Polish red”. This race is included into national preservation programme. It was found, that in comparison to other European breeds of cattle the “Polish red” has high genetic diversity (193 alleles has been identified, $H_o=0,659$, $H_c=0,703$, average number of alleles per locus = 7,4). As much as 80% of the specimens belonging to this breed are not closely related to any of the compared European breeds. It is in contrast to long lasting trend of decline of the numbers and herds of this cattle observed in Poland during at least 40 last years. Results of the study give very high probability to save this breed as a pure separated line of the cattle [Lubieniecka et al. 2000, 2001].

A special attention should be paid for freshwater fish, as their populations are intensively used in Poland. Decreasing of freshwater fish diversity has been reported in our country since 1960s. The reason of this process was eutrofication and pollution of waters. Some authors are stressing the fact, that some pure genetic lines of cultivated fish have extinct already in 1980s [COFAD/IRS, 1993]. Last decades has brought a very frightening signals over situation of fish stocks in Baltic Sea as well [**International Council for the Exploration of the Sea 1996**]

Risk areas for soil biodiversity (actions A2.2.1/.2)

The most threatened types of the soil in Poland are the hydrogenic soils, especially peat soils. This fact is caused mostly by changes in ground water regime – effect of climate change and increased use of the water by society. Almost at each type of the soil changes in the ground water levels could be observed. General humidity of the soil is influencing further changes of vegetation and soil dynamism [Majer 2004]. For this reason peatbogs became the very popular subject of the scientific research which developed basic strategies for management of the peatbogs and set-up the monitoring schemes [Sołtys 2000]. Unfortunately most of the Polish rised peatbogs during the last 40 years have been subject of the hursh human caused pressure and in consequence their soils and vegetation undergone deep changes. For these even more important became question of stopping the observed negative trends and turning back the process of degradation of hydrogenic soils into their redevelopment [Banaś 2002]. The same processes took place also in the case of low peat bogs in the river valleys which were drained and turned into the meadows or pastures in 1960s and 1970s. Bringing them back into recent landscape is very important as they had in past comparatively big share, especially in NE Poland, where high level of ground waters, regular spring floods and extensive land use kept out succession of plant communities. Change in the land use has homogenization effect on vegetation at intensively used meadows and pastures from one side and colonization by reeds (*Phragmites australis*), and willows (*Salix* sp.) bushes from the other. The main problem to cope with during regeneration of river valleys is big amount of the biomass produced. Very often this biomass is treated as a problematic waste rather than opportunity to generate further positive effects. The disadvantages were found to be: diverse quality of the biomass determined by species composition of the managed land and by data of mowing. There were proposed two main types of this biomass utilization: a) in agriculture as fodder or bedding for animals; b) commercial as a row material for production of construction materials or as material for production of energy (heating and electricity) or production of biogas. Soils of the Roztocze region (Eastern Poland) have been found responsive on acids and less responsive on reaction with alcalies. Soils kept under full protection regime (in the limits of the Roztocze National Park) were more responsive on reaction with acids and less for alkalies than soils under the intensive agriculture. The level of Zn, Cu and Pb in the soil profile allowed to state that general level of contamination of the soils in the region is very low and that level of the contamination is decreasing with the increase of the level of nature conservation. As usually it is discussed if observed fenomenon is an effect of the protection regime or simply this is effect of much lower accessibility of the area for cars [Skwaryło-Bednarz 2001].

- **Reduction of main pollutions and its impact on biodiversity (actions A2.4)**

In Poland since 1980s in the whole country exists system of the pollution monitoring taking into consideration mainly levels of SO₂ and NO_x. At most of the points data is gathered once monthly as cumulative level of pollution. For the last twenty years general trend observed in the level of pollutants was a decrease. This decrease is partly an effect of the economic crisis of the turn of 1980s and 1990s but then, contrary to redeveloping of Polish production and market level of pollutions has been stable [Malzahn 2005]. During last decades aside of the pollutants an important question became what is the influence of the high levels of ozone on vegetation. This study has been carried in Tatra Mts., where levels of this substance has been found twice higher than average. In this conditions some plant species, namely: *Pinus cembra*, *Sorbus aucuparia*, *Alnus incana*, *Sambucus racemosa*, *Corylus avellana*, *Chaerophyllum aromaticum*, *Centaurea scabiosa*, *Gentiana asclepiadea*, *Astrantia major*,

Alchemilla sp., *Cirsium* sp., *Lapsana communis*, *Geum rivale*, *Geranium sylvaticum*, *Angelica sylvestris* as well as some others were damaged by high concentrations of ozone in atmosphere. Unfortunately, contrary to the “regular” pollutants in the case of the ozon local actions aimed on decreasing of the chemicals causing high concentrations of this substance do not give an immediate positive effects as high levels of this substance are affected by global processes [Godzik & Fleischer 2004a, 2004b; Saitanis et al. 2004; Bytnerowicz et al. 2005; Manning & Godzik 2005; Godzik 2005].

**2) From objective 4 of COM (2006) 216 [Compatibility of regional planning with biodiversity in the EU]:
Mainstreaming biodiversity aspects into different strategies and plans: Rural development plans (Action A2.1.5),**

The range of the data about environment indispensable to collect for planning and implementation of the sustainable development and spatial management planning has been defined as characteristics of: soil, landscape, flora, water, atmosphere, mineral goods and land surface relief. However to make up the rational decisions leading to diminishing of structural and spatial disproportions in level of development, aside of the environmental factors, analyzes should take into account also spatial diversity of the life standards observed in the society [Gawroński 2000].

Other important and interesting fields of the research:

Sustainable use of the biodiversity in Europe is seriously threatened by lack of **connectivity of ecosystems**, i.e. their fragmentation and barriers on migration corridors of wild animals (as the most mobile) as well as other types of organisms. Animal populations cannot develop its stabile and sustainable functionality if individuals are not allowed to move and disperse freely in the range specific for the species. This topic is intensively studied in Poland as our nature is preserved in good state (in comparison to Western Europe) and road infrastructure still poorly developed. Since start of the negotiations about accession to EU Poland has been receiving support for infrastructure development but there were no comparable amount of funds for nature (biodiversity) research and conservation. Knowledge about problems in big animals migrations and need to develop and keep migration (ecological) corridors has been summarized for Poland by Jędrzejewski et al. [2006]. Other authors [Taborska 2004; Taborska & Jabłońska 2003a, 2003b] suggest that small mammals (*Micromammalia*) are a good monitoring elements of ecological corridors functionality. The *Micromammalia* has been found extremely important, for they play role of the basic food for many predators. Lack of ecosystem connectivity has been proved also to be an important factor influencing populations of invertebrates. In the case of *Trichoptera* unstable and fragmented habitat conditions are promoting opportunistic species on the cost of specialized. The number and abundance of species is proportional to the amount of accessible food (i.e. size of the “island”) which is in line with the island theory. Biodiversity of invertebrate fauna is increasing with possibility of migrations between the isolated habitats as well as by occurring in their habitat natural disturbances. The highest species diversity has been found in the conditions in which isolation of habitats is not higher than moderate and where disturbance occur with moderate frequency [Majewski 2006]. The roads are playing role of the serious disturbance also for vegetation increasing the level of its synanthropisation. Roads very often are playing role of the invasion corridors for many alien species. Footpaths are causing only quantitative changes in vegetation cover, while changes caused by roads have already qualitative and quantitative character and their intensity increase with the increase of the road

level (from local ground road toward the fast way). Responsiveness of the forest communities on changes caused by roads is decreasing with increase of the habitat fertility and humidity [Andres 2004; Jakubowska-Gabara & Zielińska 2003].

An issue which is also weakly accented is need to conserve **biodiversity of threatened habitats and plant communities of the anthropogenic origin**. Their conservation is problematic as they need active conservation with big amounts of work and use of special technics, animals or crops to achieve their preservation. Special case in Poland are xerothermic meadows. Some even small patches of those habitats keep themselves stable and are characterized by very diverse and rich flora. The others are quickly diminishing even if kept under special type of active protection. Very often intervention aimed on habitat conservation leads to increase of the rate of species exchange and loss of the specific flora character. The most successful were those actions undertaken in early stages of the vegetation succession [Bąba 2004]. The highest species diversity was observed on the meadows strongly disturbed in past but then left intact. With the time running the diversity is however decreasing. Meadows under intensive farming had the lowest level of plant biodiversity [Korzeniak & Kalemba 2001].

Protection of plant diversity *in situ* is not possible without **pollinators**. Two groups of pollinators have a wide literature in Poland: honey bee *Apis mellifera* and species of bumble bees belonging to the *Bombus* s. str. genus. The number of honey bees depend on number of bee farms and were found to react on economic incentives. Very alarming is situation of the bumble bees and other wild bees which densities decreased in Poland 100-fold since 1950s. This is most probably an effect of excessive use of herbicides and changes in methods used in farming. The data is alarming as sustainable use of our crops will be not possible if numbers of pollinators will continue to decrease [Dylewska 1996]. Much less studies were done on other pollinating insects or relations between type of the landscape and number of insects and diversity of their species. There is a strong statistically proved correlation between number and size of the groups of the trees growing between the farmlands and the diversity and density of insects populations in the landscape [Ryszkowski 1997]. As some plants are pollinated only by insects from one species or one genus also taxons of the lower (in the sense of commercial use) economic importance are carefully studied. The small family of solitary bees Melittidae includes in Poland 11 species (out of 14 known from Europe) but as many as 50% of the species has been found to be rare or very rare and 36% threatened by extinction. It is suggested that observed characteristics are probably the true for most of solitary-bee families in Poland [Celary 2000, 2002, 2004, 2005].

Alien species invasions are recognized as a major cause of biodiversity loss and a serious environmental and socio-economic issue. Providing an appropriate protection against biological invasions requires a comprehensive, holistic and consolidated approach to be adopted across various sectors and areas of legal regulation. Trade is such an important area of legal regulation since it constitutes a meaningful pathway of non-native organisms introduction. Another area, cross-cutting with the problem of alien plant and other species invasions are the provisions aimed at safeguarding the biodiversity from potential risks posed by living modified organisms resulting from modern biotechnology (GMOs). The problem of potential invasiveness is explicitly addressed in legal acts constituting the framework for GMOs regulation. Effective responses to the invasive alien species problem require paying attention to the consistency between legal regime on non-indigenous (alien) species and regimes on trade and on GMOs. Sustainable approach to trade and development of modern biotechnology should be fostered [Talik 2006]. In Poland as well as in the whole Europe big part of the invasive species has an origin in botanical gardens (*Galinsoga parviflora*, *G. ciliata*, *Impatiens parviflora*, *Chamomilla suaveolens*, *Elodea canadensis*, *Oxalis stricta*, *Euphorbia humifusa*, *E. maculata*, *Cuscuta gronovii*, *Eragrostis multicaulis*, *Oxalis*

corniculata var. *repens*, *Veronica peregrina*, to name just a few of them). Only in eight Polish botanical gardens at the beginning of 21st century were found spontaneous populations of 190 taxa with 5 potentially invasive: *Duchesnea indica*, *Galega officinalis*, *Telekia speciosa*, *Portulaca oleracea*, *Sedum hispanicum*. The negative pressure of botanical gardens on European flora has been recently found minimized in comparison to past [Galera 2001]. One of the main factors driving biodiversity loss is climate change. We are trying to develop and implement **adaptation and mitigation strategies, however they are influencing biodiversity as well**. Highland farms in Poland are generating much less income than lowland ones for their harsh climate. Alternatively it is proposed to use farmlands lying on the height over 500 a.s.l. to produce biomass for heating. This change in “crop” type will cause changes in the flora and fauna of the big areas cultivated till now as traditional farmland. The consequences of this process for biodiversity is difficult to predict [Kąkol 2005]. Another source of the renewable energy are solid waste. It was proved both: ecologically and economically, that this material can be successfully used in bioreactors for production of biogas. It should lead to decrease in the amount of garbage thrown away on landfills as well as would allow to reduce use of the traditional coal, gas and other materials used for heating [Kozłowska et al. 1999; Ledakowicz et al. 1999; Krzystek et al. 1999; Liwarska et al. 1999]. Very big disturbances on local level are usually caused by hydroelectric dam construction. In the case of the river Pasłęka (NE Poland) damming has caused development of two separated ecosystems: above and below the dam. Biodiversity of the organisms were the highest above the dam, where water was moving slowly allowing to develop for communities of the water plants and communities of the organisms living on them [Bonar & Szymańska 2002]. Much stronger and far reaching effect on biodiversity have infrastructures needed for production of wind energy. According to common European plans in 2010 share of the energy produced in Poland from renewable sources should reach level of at least 5,06%. Construction of the wind power mills especially in the seashore is expected to harm local as well as migrating bird populations. It is a vital then to know which parts of the seashore are attractive as breeding areas for breeding birds and as resting areas for migratory species. The study aimed on monitoring of nesting and resting sites of birds as well as monitoring of the migration corridors has been set up [Meissner 2005].

3. Conclusions

Poland has long tradition of biodiversity research and monitoring. It is true especially in the case of old protected areas which for decades were considered to be a refuges for rare plants and animals. In some cases studies are carried there even for 50-60 years already and in very special places (e.g. Białowieża Forest) even for over 200 years. However it must be underlined that most of the research topics had and still have only theoretical value (knowledge about status and diversity of Polish nature). Most (close to 50%) of the biological studies carried out during last decade were concentrating on the assessment of state and evaluation of the Polish biodiversity. Less studies (ca. 10%) were dealing with threats to native biodiversity posed by invasive species and GMO's, active nature conservation and restitution of species as well as structuring of landscapes. There are not too many examples of the topics which are directly connected to sustainable use of biodiversity in Poland and Europe. The main long term programs (not mentioned in the above review) are the programs of conservation and restitution of the European bison *Bison bonasus* and conservation of the white stork *Ciconia ciconia* population. In Poland does not exist any central database about the research, for this reason information received would never cover the full range of the carried projects.

On the genetic level knowledge about biodiversity of the wild species is rather poor and concentrated on the groups which have commercial value: crop plants, breeding animals, forest trees and medicinal herbs. From the point of view of sustainable use of the biodiversity this situation is very convenient – the best recognized are those organisms which are recently in intensive use. The best genetically studied group of the wild organisms are the main forest building species of trees (in Poland: *Pinus sylvestris*, *Picea excelsa*, *Quercus robur*, *Q. petraea*, *Fagus sylvatica*, *Larix* sp. and some others – rare and protected: *Taxus baccata*, *Pinus mugho*). They have been subject of so called “provenience studies” carried since early 1970s and aimed on learning which genotypes of Polish trees in what habitat conditions are giving the best production and will allow sustainable use of the forests. They should also point out the genotypes which are best adapting to changing and unstable climatic conditions.

Our knowledge about sustainable use of biodiversity on all levels of organization is concentrating only on one – quantitative aspect. The gaps in the knowledge in the field of dynamic processes and functional aspects of the biodiversity and its sustainable use are even difficult to estimate.

Threats for sustainable use of the biodiversity on genetic level are posed by possible crossbreeding of the native species with their alien relatives and GMO's. Polish flora consists of only 68% of the native species. As many as 32% of our plant species has been classified as alien, potentially threatening native flora. This tough situation is recently aggravated by changes in traditional model of agriculture as well as by changes in composition of cultivated crop plant species and their cultivars. In effect changes in genetic diversity of crops cause changes on the level of species diversity and even on the community level (an extinction of plant communities specific for the crop in question, e.g. flax, to name just one).

Sustainable use of the wild species diversity is threatened mainly by natural factors influencing genetic diversity of small and isolated populations as well as by anthropogenic factors. The small isolated populations, no matter cultivated or wild are threatened by extinction caused by usually not optimal habitat conditions (and their going-on change), narrow gene pool, inbreeding and loss of capability to adapt. Such populations are very often subject of crossbreeding with relative species or relative breeds. But the biggest influence on sustainability of biodiversity use (or lack of it) has direct pressure of man. The reported problems with sustainability are concerning: expansion of anthropogenic plant communities and habitats, fragmentation of the natural vegetation and habitats, selective use of the native species and introduction of the alien species. Also habitat conditions are changed: ground water levels are shifting (with the trend to decrease) and chemical characteristic of waters and soils are changing as well. Described problems are concerning not only the agricultural but forest plants as well, as intensive forestry is forcing changes in genetic structure of plant communities. Use of the monocultures and change of the natural selective pressure for selection aimed on human needs causes recession of species and genetic resources of the plants with low economic importance.

Up to now sustainable use and conservation of the genetic diversity use to have a rather very low priority. Only the last years brought a basic knowledge and understanding that connectivity of populations and habitats have a meaning for saving biodiversity and its services. Contrary to this increasing level of knowledge we observe quick increase of the habitats fragmentation and as an effect – degradation of the genetic pools of wild species. To avoid cross-breeding of alien species with native ones prior to each introduction must be carried genetic study of the genes exchange between the populations. Biologists understand

the idea and problem of the ecosystem fragmentation, but are not able to pass this knowledge to politicians and develop frameworks for legal acts which would be of help to avoid biodiversity loss in the process of infrastructure development. Even in European legislation there are no rules of protection of ecological corridors. The only EU legal act dealing with this problem is a Habitat Directive which in article 10 urges on state parties that “Member States shall endeavour, where they consider it necessary, in their land-use planning and development policies and, in particular, with a view to improving the ecological coherence at the Natura 2000 network, to encourage the management of features of the landscape which are of major importance for wild fauna and flora. Such features are those which, by virtue of their linear and continuous structure (such as rivers with their banks or the traditional systems for marking field boundaries) or their function as stepping stones (such as ponds or small woods), are essential for the migration, dispersal and genetic exchange of wild species.”

Sustainable use of the biodiversity and especially preserving of old crops and breeds of animals is not possible without creating of the economic support system by the EU or each individual country. It seems that very important is also creation of the specific niche for utilization of the breed covered by conservation program. The very successful example is the cattle “Polish Red” which is reviving owing to strong economic support of its breeding by state as well as by strong involvement of NGO’s and use of this breed for active conservation of the open areas in Polish protected areas: national parks and reserves.

The main technical problem with preparation of this review was that many interesting scientific works are prepared as PhD thesis. Unfortunately most of them are inaccessible for wider public as their results in most of the cases are not published in journals. Most of them stay forever in the form of manuscripts deposited in the libraries of universities on which the thesis has been prepared and defended.

- **Main messages of the review**

On the ecosystem level biodiversity of Polish vegetation represents ca. 400 plant associations belonging to 41 vegetation classes [Matuszkiewicz 2001, Zimny 1994]. On the species level up-to-date ca. 5500 fungi species (including close 1700 species of Lichenes), 14 500 algae, close to 3300 plant species (including 2400 vascular plants) and 35 500 animal species have been recorded in Poland. There is however a very limited number of endemic species (less than 1% of vascular plant flora), and they are known almost only from the highest mountain ranges (Tatra, Karkonosze, Pieniny), and only a few from lowland [Andrzejewski & Weigle 2003].

Close to 30% of Poland is covered by forests of diverse species composition, ca. 13% by meadows and close to 5% by wetlands and peatbogs. In combination with well preserved system of rivers and lakes these ecosystems create unique and precious landscapes with very rich bioceonoses being home for vast numbers of rare plant and animal species. Great part of our biodiversity is an effect of the very wide ecological gradient stretching North-South (sea-lowlands-uplands-alpine mountains) and West-East (subatlantic to subcontinental climate). Big share of the eastern part of the country is covered by extensive patches of close-to-natural and semi natural vegetation with associated rare animals and fungi [Andrzejewski & Weigle 2003].

Typical for Poland fine-grain mosaics of ecosystems has been established by man on the originally extensive areas of homogenic forest bioms. What we observe now is new wave of

homogenization of landscapes and ecosystems and fragmentation of natural habitats by civilization. Effective ways of maintaining the abundance of life forms and their sustainable use in the most transformed and populated area of the world which is Europe needs learning the principles of landscapes ecology and appropriate development and maintaining of this aforementioned fine-grain mosaic. It is important to make sure that all species may satisfy their needs on areas occupied and managed by humans. Some parts of Eastern and Southern Poland are known to be still rich in populations of traditional crop plants and local races and breeds of animals, as well as populations of plant species associated with the traditional crops. They are still known to build there specific plant communities, typical for special types of cultivated crop plant. These kinds of weed associations are already extinct from big areas of the Western Europe. The much bigger attention should be paid to preservation of plants associated with old traditional crops. Conservation of their specific communities is complicated as it needs creation of the specific human cultivated habitats with all of their prerequisites. Unfortunately there is a very weak attention paid for identification of the high value farmlands and forests in Poland and that should be the first step towards the better conservation of the biodiversity and securing its future sustainable use.

Most of the specific for Poland breeds, races and cultivars of crop plants and domestic animals are included into special preservation programs, including conservative breeding herds and gene banks. Only the most threatened and endemic wild plant species are kept in gene banks (in liquid nitrogen). This should be seen as minimum of what should be done as without wider programs of reestablishing of wider breeding of those protected forms their future is rather uncertain.

Changes in biodiversity and distraction of the sustainable use of the biodiversity are caused by complicated cross-influence of many social, economic and political drivers. Poland is now in the period of adjusting to EU law and regulations of CAP and other common policies, which causes big number of problems and disturbances. For now it is not possible to determine how deep changes will be caused by those processes in the sustainable use of biodiversity in the future. For this, development of good monitoring systems taking into account all of the important factors is essential for future management of biodiversity and its sustainability. The minimal set of the monitored elements should include: soil, landscape, flora, water, atmosphere, mineral goods and land surface relief.

- **Broader context: How does this research contribute to a sustainable Europe?**

One of the central research themes in ecology is evaluating the extent to which biological richness is necessary to sustain the Earth system and the functioning of individual ecosystems. The relationship between biodiversity and ecosystem processes and ecosystem services is not adequately explored yet. The multiple effects of biodiversity on productivity and growth, biogeochemical cycles, animals, pests and disturbances occurring in the ecosystem are obvious but difficult to quantify. In this sense above mentioned research underlining the importance of diversity at different scales, ranging from single site to global issues is an important contribution to learning what we still have in Europe, how it is managed and it gives also suggestion how management should be continued to ensure future sustainability of the biodiversity use in Europe.

Polish legal framework on Invasive Alien Species requires further elaboration and improvements, while detailed provisions on a species administrative procedure for

authorisation of deliberate release into the environment of GMOs are established under the European Community (EC) and Polish legal acts. Some of these solutions could be helpful to create a coherent, effective legal framework to deal with alien species and also alien-species related solutions may be applicable to legal frameworks on GMOs and biosafety. Appropriate policy is essential to provide information to the public on the issues of invasive alien species and to highlight the risks they pose.

Monitoring schemes proposed by Poland and methodology of breeding and reintroduction of some wild threatened species can be applied across the whole European Community. More practical could be also using of the Polish gene resources (from gene banks and preservation breeding herds) for reintroduction of species in adjacent countries in places where they have been extinct if their habitats still exist in good shape.

Reviewed researches proved that biodiversity and its sustainable use in the landscape dominated by anthropogenic structures and crops depends on its structuring and stability in time. Implementation of the CAP brought changes which are supporting biodiversity by promoting traditional and nature oriented farming in high value farmlands but from the other side new regulations and new economic conditions are causing decrease in the number of small farms and increase in size of the farms. Big farms are highly mechanized and specialized only on one sector of production. For this reasons there is a quick polarization of farms observed in Poland on those biodiversity friendly – very often functioning at the edge of economic sustainability and those highly commercialized and very successful from economic point of view but much less caring for natural heritage of the country.

Gaps of knowledge and need for further research – in a national as well as European context

The gaps in the knowledge in the field of dynamic processes and functional aspects of the biodiversity and its sustainable use are even difficult to estimate, the most important gaps to point out are:

- knowledge about the status (distribution, numbers, trends) of populations of most threatened species and even species of the community interest;
- knowledge about genetic diversity of most of the species;
- biology of most wild species;
- methodology for conservation of some plant communities associated with extensively used meadows and fields;
- sensibility and capability of adaptation to changing climatic conditions;
- ecological range of sustainable use of most of the wild species;
- lack of almost any studies combining social, economic and ecological approaches;
- influence of adaptation and mitigation strategies on local sustainable use of biodiversity;
- relations between the biodiversity and ecosystem services as well as possible sustainable use of the biodiversity.

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