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CONCEPT OF LANDSCAPE DIVERSITY MONITORING OF OPOLE PROVINCE

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Abstract: Implementing the landscape diversity monitoring is statutory requirement of Nature conservation act. Landscape monitoring is still not realized in Poland although it is obligatory. There haven't been implemented appropriate methods and procedures in realisation of landscape monitoring researches. This paper presents concept of realisation of regional landscape diversity monitoring by defining spatial scope of research and its methodology. It shows relations and scope of cooperation between Provincial Inspectorate for Environmental Protection and scientists in the realisation of that kind of monitoring.

Key words: landscape monitoring, landscape conservation, Opole Province

Introduction

The national monitoring of the environment is a system of measurements, assessments and forecasts of the state of the environment and collection, elaboration and spreading of the relevant information concerning the environment (Environment protection law act 2001). Gathered information is supposed to serve assistance in effective environmental protection, mainly by handing over of information about the environment for agencies of the civil service and the society. Tasks and duties of State Environmental Monitoring are conducted by Inspectorate for Environmental Protection.

A peculiar duty which is imposed on bodies conducting state environmental monitoring by Nature conservation act is a need to conduct the natural monitoring of the biological and landscape diversity (Nature conservation act 2004). The mentioned law is pointing out, that natural monitoring relies on observation and the assessment of the state and changes of the biological diversity and landscape, in this, types of natural habitats and landscape units being an object of the Community interest, with special attention on

types of natural habitats and landscapes with priority values, as well as on methods on the evaluation of the effectiveness of nature conservation.

The system of the State Environment Monitoring consists of three subsystems, i.e. "impacts on the environment", "state of the environment" and "assessments and forecasts". Within these subsystems the "state" is subsystem of the monitoring of the nature, which should be compatible and include other monitoring elements of the natural and landscape diversity (Programme... 2009). Within frames of this subsystem tasks are being undertaken, including the integrated monitoring of the natural environment with a purpose "delivering details about the state of representative geoecosystems of Poland (concerning geo- and biodiversity), mechanisms of their functioning, tendencies of changes under the influence of climate changes and human activities, the type and character of geoecosystems threats" (Information... 2009). Researches as part of the monitoring are being conducted on the basement of network of eight ground basic stations, within representative river and lake watersheds. An aim of this monitoring is to find out the present state of the chosen geoecosystems, typical for diversified range of landscape units of Poland. The monitoring carried out includes measurements and analyses of composition, quality and pollutants of different types of biotopes (water, air, soil) or observation of the state and qualities of plant communities. Landscape examinations are being carried out only with the support of registration of changes in cover types of the area and usage classes of grounds. Data collected in this way could be used for actions related to the landscape protection in the area of the country and setting the local and regional spatial development system (Major 2008).

Also in frames of the subsystem "pressures" a related assignment was performed with obtaining information about the change of cover/usage types of the area. It was held as part of the pan-European program Corine Land Cover (ended in 2008). The main purpose was to document the changes in cover and usage types of the earth surface, to make possible the implementation of the environmental politics, geoinformation and expansions of the system of spatial information.

Problem of regional environmental monitoring realisation regarding landscape aspects was analysed by Czochański (2009). In his opinion landscape and environmental monitoring is one of four elements of regional monitoring. Landscape and environmental monitoring includes parameters of natural environment conditions, threats of environment, landscape units, characteristics and functioning of landscapes. In Solon (2003) opinion landscape researches have integrated character and may be used in economy activities as instruments for spatial planning and management.

The assessment of landscape status as a purpose of monitoring

The regional monitoring of the landscape should include visible changes in structure and functioning of province landscape as a whole, as well as in individual types of the landscape, which represents all typical landscape units of the regional landscape diversity.

For entire area of the province the simplest method of finding the changes in management (usage) structure is assessment of differences in the ground functional structure. Such an assessment should be repeated every year with summaries in five-year periods. For depicting spatial differentiation of changes tendencies in usage types of grounds, analyses should be performed also in basic plots which in that case are districts.

This monitoring should be treated as the preliminary background for the following detailed monitoring conducted for individual types of landscape.

Separate analysis which should be made for the entire province is an assessment of changes in establishing of nature and landscape conservation areas, repeated every year.

The monitoring of individual types of the landscape being found within a region should start from the assessment of spatial diversity of landscapes and indication of representative landscape types, as well as from the assessment of the state of the landscape, i.e. its conservation status. To achieve this information, the red book of the regional landscapes should be elaborated.

Among such measures of landscape management and protection there are red books, which could be compared to this type of elaborations for wild plants and animals. The aim of preparing a red book is to acquire knowledge about distribution, status of preservation and threats to certain types of natural landscape. By preparation of a red book, the landscape is evaluated and, based on that, its protection is presented and implemented in different types of areas and spatial scales.

Preparation of a red book consists of the following stages of the investigation procedure (Badora 2006):

- setting the clear definition of the landscape to be considered and the threat categories to be used (various approaches are applied, being decisive for different procedures of distinguishing basic natural units),
- choosing the approach of area selection (natural or administrative units),
- adopting the scale of the study (which is important for e.g. basic natural unit of the evaluation),
- choosing the basic natural unit of the landscape for evaluation (e.g. whole geocomplexes, their parts, ecosystems),
- choosing criteria of evaluation and categories of threats,
- choosing the way of presenting the results.

The suggestion is, that the Red books of landscapes should consider The Landscape Status Card prepared to every types of landscapes (Badora 2008). There are 14 components to be assessed in Landscape Status Card (Fig. 1).

Regional landscape diversity monitoring

Organizational system of regional landscape monitoring is shown in figure 2. According to the law, the environmental monitoring in Poland is realized by General and Provincial Inspectorate for Environmental Protection. However landscape monitoring should be realized in cooperation with regional universities conducting landscape researches, in particular structure and functioning of landscape researches, its transformation and conservation.

Implementation and carrying of regional landscape monitoring includes four stages:

- preparatory,
- realisation of basic researches,
- landscape syntheses,
- implementation and evaluation.

Threat category: 1) Name of landscape: 2) Landscape classification: 2.1) Class: 2.2) Kind: 2.3) Species: 2.4) Variety: 2.5) Form: 3) Landcape typology notes: 4) Origin of landscape: 4.1) Natural genesis: 4.2) Anthropogenesis: 5) Status in Poland: 6) Location in region: 6.1.) Physico-geographical location: 6.2.) Administrative location: 7) Characterization of inanimate and animate nature: 7.1) Relief: 7.2) Geology of surface deposits: 7.3) Hydrogeology: 7.4) Hydrographic system: 7.5) Topoclimatic conditions: 7.6) Soils: 7.7) Plants cover: 7.8) Fauna associations: 8) Characteristic features of landscape: 9) Anthropogenic changes and threats: 10) Potential of development: 11) Trends and forecasts of landscape status change: 12) Protection state: 13) Proposed areas of the passive protection: 14) Ways of active conservation: Source of information:

Fig. 1. Landscape Status Card. Source: Badora (2008) after fine correction.





The first stage should establish the technical resources of landscape monitoring realisation and define areas and aims of analyses especially types of landscapes. Technical resources should be developed by Provincial Inspectorate for Environmental Protection. Scientists should define areas and scope of the analyses, in particular the landscapes types.

After creating the technical and scientific background of landscape monitoring it should be performed in three aspects:

- monitoring the changes of cover and usage types of grounds and landform features,
- monitoring the changes in physiognomical features of the landscape,
- monitoring the conditions of the landscape state and functioning.

On a base of researches, landscape syntheses for assessment of landscape threat status and predispositions and directions for the further changes, should be prepared. After diagnosis have been established the proposals for implementation an appropriate conservation measures should be specified. Last stage is evaluation.

After the establishing of the conservation status and threats for individual types of the landscape, the plots for monitoring should be chosen. While establishing the monitoring network, the principle of representativeness should be considered. The size of the basic field of assessment shouldn't be standardized. For some landscapes size of 1 km² is sufficient for monitoring but other landscape types must have significantly larger areas. However in every case the area must be chosen, that it doesn't constitute the part of the determined type of the landscape but the entire unit (whole entity). In case of marking out a large number of units for analysis the changes assessment in individual units can be made every 5 years.

Monitoring of landscapes in individual field, units are set up in the scale of 1:5000 – 1:10000 on topographic maps or ortophotomaps. A structure of development, as well as visual values of the space are taken to an assessment. Surface formations and cover types characterization as well as visual values are the analyzed elements. The assessment of surface formations includes changes in the surface features being an effect of natural and anthropogenic processes. The visualisation of changes is being shown on the digital terrain model. The cover changes assessment is being made for individual cover types selected for the area. The following analyze elements are being singled out:

- built-up areas: residential single-family housing, residential multifamily housing, areas of services, storage-production areas, areas of the technical infrastructure, transportation areas,
- unbuilt areas: forests, meadows and pastures, arable lands, orchards, surface waters, rushes, peat bogs, wasteland (with determining the last usage type and the current state).

The example of cartographic draft scheme with analyses of relief and landcover is shown on figure 3.

The first stage of the monitoring is describing plots with visible changes in landform features and its cover. This stage includes studies based on aerial photographs. The second stage includes the quantitative and qualitative assessment of changes and is being conducted as field examinations.

Landscape indicators are a specific group of landscape ecological characteristics allowing to obtain information from the assessment of state and changes of environment (Roo-Zielińska et. al. 2007), changes in structure and function of different landscapes (Ares et. al. 2001) or quantitative information on ecological resources and the possibility of their functioning (McAlpine and Eyre 2002).

For the evaluation of changes in the structure and functioning of the ecological landscape the chosen landscape indicators can be applied (McGarigal and Marks 1995; McGarigal 2002):

a. patch density and size metrics:

- number of patches it is use as an index of spatial heterogeneity of the entire landscape mosaic, landscape with more patches has a finer grain - the spatial heterogeneity occurs at a finer resolution;
- mean patch size it can be use as a patch fragmentation index; progressive reduction in the size of patch fragments is a key component of patch fragmentation;
- patch size coefficient of variance preferable to standard deviation for comparing variability among landscapes. Patch size coefficient of variation measures relative variability about the mean (that is, variability as a percentage of the mean), not absolute variability;
- patch size standard deviation is a measure of absolute variation. It is a function
 of the mean patch size and the difference in size among patches. Patch size
 standard deviation conveys information about patch size variability. It is
 a difficult parameter to interpret without doing so in conjunction with mean
 patch size because the absolute variation depends on mean patch size;
- patch density is a limited, fundamental aspect of landscape structure, it facilitates comparisons among landscapes of various sizes. The density of patches in the entire landscape mosaic could serve as a good heterogeneity index because a landscape with greater patch density would have more spatial heterogeneity.
- b. shape metrics:
 - shape index measures the complexity of patch shape compared to a standard shape;
 - mean shape index measures the average patch shape, or the average perimeter-to-area ratio, for a particular patch type (class) or for all patches in the landscape;
 - area weighted mean shape index of patches at the class and landscape levels by weighting patches according to their size. Specifically, larger patches are weighted more heavily than smaller patches in calculating the average patch shape for the class or landscape;
 - landscape shape index measures the perimeter-to-area ratio for the landscape as a whole, quantifies the amount of edge present in a landscape relative to what would be present in a landscape of the same size but with a simple geometric shape (circle in vector, square in raster) and no internal edge (landscapes comprised of a single circular or square patch);
 - mean patch fractal dimension bases on the fractal dimension of each patch.
 - area weighted mean patch fractal dimension computes at the class and landscape levels by weighting patches according to their size, similar to the area-weighted mean shape index;



Fig 3. Cartographic analyses for one of basic plots of landscape diversity monitoring. Odra river valley in Opole Province.

- c. edge metrics usually are best considered as representing landscape configuration, even though they are not spatially explicit at all:
 - total edge is an absolute measure of total edge length of a particular patch type (class level) or of all patch types (landscape level);
 - edge density standardizes edge to a per unit area basis that facilitates comparisons among landscapes of various sizes;
 - edge contrast index measures the degree of contrast between a patch and its

immediate neighborhood. Each segment of the patch perimeter is weighted by the degree of contrast with the adjacent patch;

- total edge contrast index this index quantifies edge contrast as a percentage of maximum possible, ignores patch distinctions; it quantifies edge contrast for the landscape as a whole, thereby focusing on the landscape condition.
- d. core area metrics:
 - total core area quantifies the core area in each patch type as a percentage of total landscape area;
 - core area density computes as number of core areas on a per unit area basis.
 - core area index at the patch level quantifies the percentage of the patch that is comprised of core area;
 - total core area index at the class and landscape levels quantifies core area for the entire class or landscape as a percentage of total class or landscape area;
- e. class area is a measure of landscape composition,
- f. total landscape area it defines extent of the landscape.

The visualization of exemplary monitoring analyse with landscape indexes for one of planning basic areas of landscape diversity monitoring located in Odra valley in Opole Province is shown on figure 4.

Review of indexes used in landscape analyses and proposals of new indexes are presented by Solon (2004).

The assessment of visual values of the landscape is carried out by one of the commonly used methods of the landscape architecture, e.g. of landscape insides.

Conclusions

The changes that have happened in the geographical space of Poland have great influence on the protection of natural environment values, as well as on the economic development. Monitoring of these changes is a statutory duty of the state which isn't being carried out for many years.

Monitoring of changes in basic types of the landscape should be based on fixed, representative basic areas, and should include the evaluation of transformations in the scale of the region and the country. To monitoring of changes using methods and techniques offered by the GIS is suggested.

Implementing of the landscape monitoring will be related to the financial capacity of technical funds and the employment of specialists. To provide effective relations between scientists and administrative bodies within the planning and management of regional landscape monitoring, the competencies coming from the law system should be concentrated in one agency, i.e. Provincial Inspectorate for Environmental Protection.

Editing landscape status cards, defining the state, threats and forecasting the changes of individual types of landscape should be a result of the monitoring. The practical effect should be implementation of principles of spatial development which will enable the optimization in using the space of separate region or the country in frames of the sustainable development.



Fig. 4. Visualisation of monitoring analyse with landscape indexes for one of basic plots of landscape diversity monitoring. Odra river valley in Opole Province.

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