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ECOSYSTEM SERVICES IN POSTGLACIAL LANDSCAPE – BASIC ASSUMPTIONS AND RESEARCH METHODOLOGY

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ŚWIADCZENIA EKOSYSTEMOWE W KRAJOBRAZIE MŁODOGLACJALNYM. PODSTAWOWE ZAŁOŻENIA I METODA BADAŃ

STRESZCZENIE: W artykule przedstawiono założenia teoretyczne i metodologię badań projektu finansowanego przez Narodowe Centrum Nauki (2012/07/B/ST10/04344) zatytułowanego "Świadczenia ekosystemowe w krajobrazie młodoglacjalnym – ocena zasobów, zagrożeń i wykorzystania". Celem projektu jest zastosowanie koncepcji usług ekosystemowych do oceny wartości potencjałowej środowiska przyrodniczego i kulturowego w dostarczaniu ES w trzech gminach (Nowinka, Giby, Suwałki), położonych na obszarze młodoglacjalnym.

SŁOWA KLUCZOWE: potencjał ekosystemów, identyfikacja i ocena usług ekosystemowych, preferencje społeczne, typy ekosystemów, tematyczne mapy usług ekosystemowych

Introduction

The use of natural resources and potential of environment has long been of interest to both scientists and practitioners, primarily related to the spatial management and planning. The concept of ecosystem services, treated as a synthetic approach in the evaluation of environmental potential and resources is in line with such research direction and dates back to the mid-sixties of the twentieth century¹. However, the development of research referring to the concept of ecosystem services advanced considerably in the last decade of last century. At the time, the fundamental works for further research and development of ES concept were published². Such rapid increase in interest of ecosystem services caused a growing number of publications, which exceeded the 1000 papers per year at the end of the first decade this century, on a global scale.

Nevertheless, the hypotheses presented by most authors were poorly documented and justified as they concentrated only on selected groups of ecosystem services, viewed in various spatial or temporal scales and frequently, in a rather general manner. It resulted in a large number of case stud-

¹ R.T. King, *Wildlife and man*, "Conservationist" 1966 no. 20(6), p. 8–11; D.R. Helliwell, *Valuation of wildlife resources*, "Regional Studies" 1969 no. 3, p. 41–49; R. Hueting, *Functions of nature: should nature be quantified?*, in: R. Hueting (ed.), *What is nature worth to us? A collection of articles 1967–1970*, (in Dutch) 1970; E.P. Odum, H.T. Odum, *Natural areas as necessary components of man's total environment*, Transactions of the 37th North American Wildlife and Natural Resources Conference, March 12–15, Washington D.C., 1972 no. 37, p. 178–189.

² G. Bingham et al., *Issues in ecosystem valuation: improving information for decision making*, "Ecological Economics" 1995 no. 14, p. 73–90; R. Costanza et al., *The value of the world's ecosystem services and natural capital*, "Nature" 1997 no. 387, p. 253–260; G.C. Daily (ed.), *Nature's services: societal dependence on natural ecosystems*, Washington D.C. 1997, p. 334; G.C. Daily, P.A. Matson, *Ecosystem services: From theory to implementation*, "Proceedings of the National Academy of Sciences of the United States of America. PNAS" 2008 no. 105(28), p. 9455–9456; R.S. de Groot, *Functions of nature: evaluation of nature in environmental planning, management and decision making*, Amsterdam 1992, 315 pp.; R. Haines-Young, M. Potschin, *Methodology for defining and assessing ecosystem services*, Nottingham 2009, 94 pp.; K.E. Limburg, C. Folke, *The ecology of ecosystem services: introduction to the special issue*, "Ecological Economics" 1999 no. 29, p. 179–182; MEA, *Ecosystems and Human Well-being: Current State and Trends*, vol. 1, Findings of the Condition and Trends, Working Group of the Millennium Ecosystem Assessment, Washington, Covelo, London 2005, p. 917; D. Pimentel et al., *Economic and Environmental Benefits of Biodiversity*, "BioScience" 1997 no. 47(11), p. 747–757; K.J. Wallace, *Classification of ecosystem services: Problems and solutions*, "Biological Conservation" 2007 no. 139, p. 235–246; M.A. Wilson, S.R. Carpenter, *Economic valuation of freshwater ecosystem services in the United States: 1971–1997*, "Ecological Applications" 1999 no. 9, p. 772–783.

ies. The biggest problem concerned ES terminology and methodology, which contributes to deprecation of the flagship concept³. In recent years, attempts have been made to organize both the terminology and methodology of ES research⁴, what has enabled to understand easily the meaning of the ES concept and to optimize research methods.

Nonetheless, to date, there has been rather a small number of scientific papers which verified in a comprehensive manner the methodological assumptions of the ES concept as a conglomerate of material and non-material benefits derived by human from natural environment and cultural heritage. Such scientific approach to ES concept has been adopted and implemented in the project “Ecosystem services in young glacial landscape – assessment of resources, threats and use” supported by National Science Centre (2012/07/B/ST10/04344), carried out in Institute of Geography and Spatial Organization, Polish Academy of Sciences since 2012. This article presents the project objectives, assumptions and research methodology.

Theoretical background of the project

In the project, we adopted the potential approach to ES, assuming that it is not always possible to determine the actual ES flows. The ecosystem services were considered in an interrelated triangle involving:

- local community and its preferences;
- individual ecosystems viewed as the service suppliers;
- the whole landscape with land use types and their functions.

In this context, the main scientific objectives of the project were as follows:

- to identify, quantify, order and rank ecosystem services;

³ M. Degórski, J. Solon, *Ecosystem services as a factor strengthening regional development trajectory*, “Economics and Environment” 2014 no. 4(51), p. 48–57.

⁴ EEA Annual report 2013 and Environmental statement 2014. *Air quality in Europe – 2013 report EEA*, European Environment Agency, Copenhagen, Denmark, Report No 9/2013. 112 pp.; J. Maes et al., *Mapping and Assessment of Ecosystems and their Services. An Analytical Framework for Ecosystem Assessments Under Action 5 of the EU Biodiversity Strategy to 2020. Mapping and Assessment of Ecosystems and their Services. An Analytical Framework for Ecosystem Assessments Under Action 5 of the EU Biodiversity Strategy to 2020*. Publications Office of the European Union, Luxembourg 2013, available from: www.ec.europa.eu [12-09–2014]; *The Economics of Ecosystems and Biodiversity Ecological and Economic Foundations*, Pushpam Kumar (ed.), Earthscan, London, Washington 2010; TEEB, *The economics of ecosystems and biodiversity for local and regional policy makers*, www.teebweb.org [12-09–2014]; The UK National Ecosystem Assessment (UK NEA), *Understanding nature’s value to society. Synthesis of the Key Findings*, 2011, 87 pp.; *White Cover Publication* 2013, United Nations Statistic Division, www.unstats.un.org [12-09–2014].

- to compile a list of ecosystem services supplied by various ecosystem types and assign to them direct and indirect measures;
- to compile a complete list of reliable and scientifically validated direct and indirect indicators for evaluating ES potential supply and/or demand;
- to document the actual relationship between ecosystem and landscape structure and the service supply;
- to develop a model assessing relations between services provided by ecosystems or landscapes and their flow to society.

These objectives have been used in development of the following three research hypotheses:

- measures of ecosystem/landscape structure and function can serve as indirect measures of the ES supply;
- the supply and value of an ecosystem service depend not only on ecosystem features, but also on its spatial location;
- the supply and demand for particular ecosystem service depend on preferences of local communities (user groups) and may be shaped by the spatial management.

The most important specific research goals were:

- assessment of relations between social preferences and actual use of ecosystem services;
- identification of indirect indicators (surrogate measures) for evaluating ecosystem service stocks;
- selection of an optimum set of ecosystem services provided by studied ecosystem types and a corresponding set of direct and indirect indicators;
- service valuation (using the indicators) and ranking (by importance, by advantage) for individual ecosystems;
- ecosystem valuation and ranking with regard to individual categories of services provided. Six thematic blocks (described in the chapter *Research Methodology*) were distinguished which defined a detailed research plan.

Study area

The study area is located in north-eastern Poland, in the north part of Podlaskie voivodeship. It was influenced by Vistulian glaciation and its morphological characteristics and structure are associated with moraine uplands, outwash plains and with postglacial lakes, what determines the present structure of land-use. The areas covered with light lithological material are dominated by forests, while areas covered by clay are dominated by farmland. The average population density is several times lower (approx. 16

inhabitants/km²) than the average for Poland (approx. 124 inhabitants/km²), (table 1).

Table 1. Some characteristics of studied communes

Commune	Area [km ²]	Inhabitants	Density [pers./km ²]
Nowinka	203,8	2800	13,7
Suwałki	264,8	7000	26,4
Giby	323,6	3000	9,3
Total	792,2	12800	\bar{x} 16,5

Three communes: Giby, Nowinka and Suwałki have been selected for the identification, valuation and assessment of ecosystem services (figure 1). The selection of three test communes was non-random and relied on two basic criteria: (1) the degree of anthropogenic transformation (assessed on the basis of the proportion of forest in overall land cover, population density and presence or absence of industry) and (2) landscape diversity.

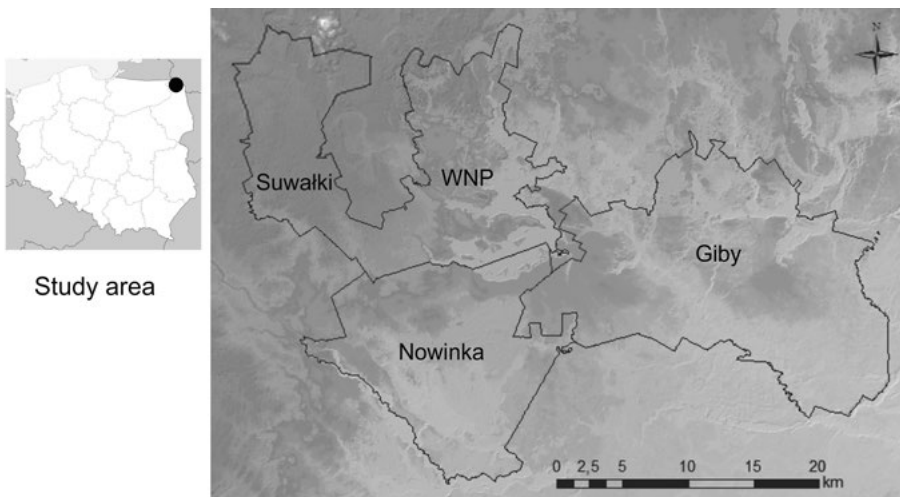


Figure 1. Study area

The Giby commune, dominated by forests (approx. 75 %), is characterized by a large number of lakes, and almost lack of industry. The large coverage of Natura 2000 sites (over 80%) confirms the high nature value in the commune. The Nowinka commune is also characterized by the predominance of forests (approx. 60%) that are part of the Wigry National Park and the Augustów Forest. Farmland comprise approx. 27% of the commune. A signif-

icant area is occupied by waters here. The commune is dominated by protected natural ecosystems, which occupy 84% of the area. Natura 2000 sites cover 78%. The biggest advantage of the commune is the beautiful landscape, tourism and rich peat deposits. The Suwałki commune has an agro-forest landscape. Farmland constitute approx. 55%, while forests – 29%. Agriculture, successfully developed on the plains, play a dominant role in the economy of the commune. Farmland is managed mostly (approx. 84%) by individual farmers. The characteristic feature of agriculture in the Suwałki commune is the diversity of production, and the dominance of dairy cattle and pigs. In contrast to two other communes, in Suwałki many small industry companies are located (carpentry, car mechanics, building industry, production of building materials, water supply and sewage systems, quarrying). The Suwałki Special Economic Zone, offering favourable conditions for investors, is partly situated within the commune.

Research methodology

The methodology and research procedure were closely related to the thematic blocks and stages presented on figure 2.

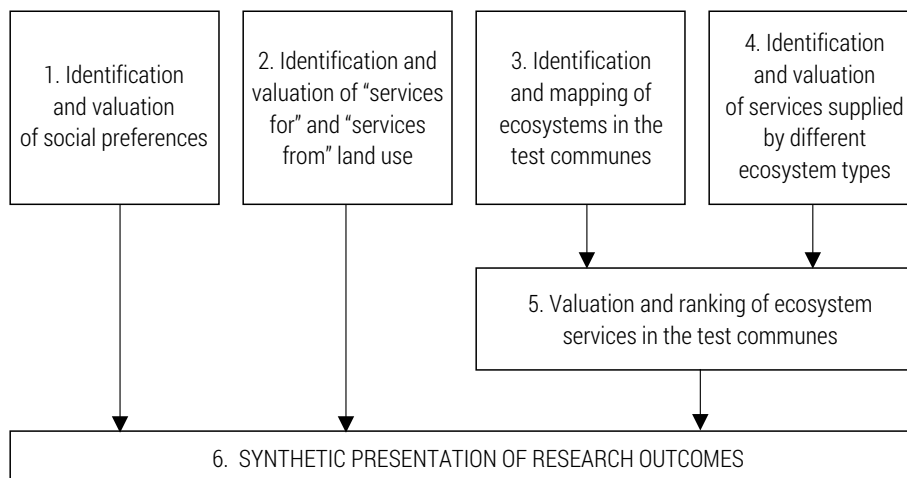


Figure 2. Thematic blocks and relations between them – basis for project activities

The tasks of Block 1 (identification and valuation of social preferences) were performed using the following basic research methods:

- a detailed analysis of written information and maps;
- development and formulation of questions included in a questionnaire for selected groups of ecosystem service users.

To conduct an overall assessment of ecosystem services in the study area it was also necessary to take into account the opinion of direct ecosystem service users. As recent studies show, participatory evaluation of the surrounding environment is becoming increasingly popular and is perceived as a solution to improve social engagement and to achieve greater public acceptance of spatial strategies and plans. Therefore, we decided to carry out a questionnaire survey among residents and tourists that consisted of four parts. The first and second part were constructed to gather information on the awareness and actual use of ecosystem services (for results see Affek and Kowalska⁵). The first one comprised only open-ended, non-suggestive questions, whereas the latter was a list of 45 provisioning and cultural services with scale 1–5 to mark usage intensity over the 3 years preceding the survey. In the third part, respondents were asked to assign services to ecosystem types and rank them in order of importance. Seven ecosystem types and 11 categories of goods and services were included. Our intention was to show the potential/capacity of each ecosystem type to deliver particular services in the view of direct landscape users (for results see Kowalska et al⁶). The last part comprised a set of socio-demographic questions regarding age, sex, education, source of income, place of residence etc. The collected data were used to verify sample representativeness and to perform between-group comparisons. The scientific term ecosystem services was not used in the survey. We replaced it by a more colloquial and intelligible phrase *goods of nature* (pol. *dobrodziejstwa przyrody*). The anonymous questionnaire was distributed with the *door-to-door* method during two summer seasons among residents and tourists staying in selected localities in the study area. In total, 251 questionnaires were collected back.

The tasks of Block 2 (identification and valuation of “services for” and “services from” land use) were accomplished via:

- a very detailed analysis of the literature data, including Studies of Determinants and Directions of Land-Use (Spatial Organization) Planning (SUiKZP);
- consultations with experts to identify as many ecosystem services that can be provided in each commune as possible (depending on its specific characteristics, especially those related to land-use structure);
- a statistical analysis of relationships to identify causal and/or correlative relationships between the indicator value and an absolute value of a given service.

⁵ A. Affek, A. Kowalska, *Benefits of nature. A pilot study on the perception of ecosystem services*, “Ekonomia i Środowisko” 2014 no. 4(51), p. 154–160.

⁶ A. Kowalska et al., *Potential of cultural ecosystem services in postglacial landscape from the beneficiaries’ perspective*, “Ekonomia i Środowisko” (in press).

The tasks of Block 3 (identification and mapping of ecosystems). Research results on spatial heterogeneity of ecosystem services were presented on the map of ecosystems in a local scale. The map constituted a synthetic presentation of land-cover differentiation, in a way that each ecosystem type has assigned the size or range of environmental resources that deliver definite ecosystem services (especially provisioning). We based on Common International Classification of Ecosystem Services (CICES)⁷. The map was constructed on the basis of the available cartographic materials (e.g. Database of Topographic Objects 1:10 000, Agricultural Map of Soils 1:25 000, Orthophotomaps 1:5000, Digital Forest Map) and fieldwork data. Local scale affected the legend of map, that was not based on too general MAES division⁸ containing a basic ecosystem types but more detailed units. In a final version, the legend contains 44 ecosystem types of which 25 are different categories (age and habitat) of forests, three categories of grassland, three types of cropland, four categories of wetlands, six classes of lakes, one category of rivers and urban areas⁹.

Block 4 (identification and valuation of services supplied by different ecosystem types) – The analyses involved the maximum number of ecosystem services and most of them, if possible, were measured directly in the field using a service-specific method (e.g. a measurement of biomass, physical and chemical characteristics of soils, phytosociological relevés to describe plant communities of ecosystems). The remaining data were collected reviewing the literature or using expert knowledge. The tasks of Block 5 (valuation and ranking of ES in individual commune) were based on desk studies of the collected data and will subsequently be used to develop a synthesis of the results (Block 6).

Summing-up

Development of a detailed methodology and work plan allowed to elaborate most of the results planned in the described project. As it was mentioned in *Introduction* authors assessed potential of ecosystem services, their indicators and measures. On the scheme presenting the steps to achieve the results we included 9 selected ES (figure 3).

⁷ R. Heines-Young, M. Potschin, *Common International Classification of Ecosystem Services (CICES): Consultation on version 4*, August-December 2012, EEA Framework Contract No EEA/IEA/09/003 2013.

⁸ European Commission, *Mapping and Assessment of Ecosystems and their Services. Technical Report – 2013-067*, 2013.

⁹ B. Kruczkowska et al., *Map of ecosystems – concept and realization*, "Geographia Polonica" (in preparation).

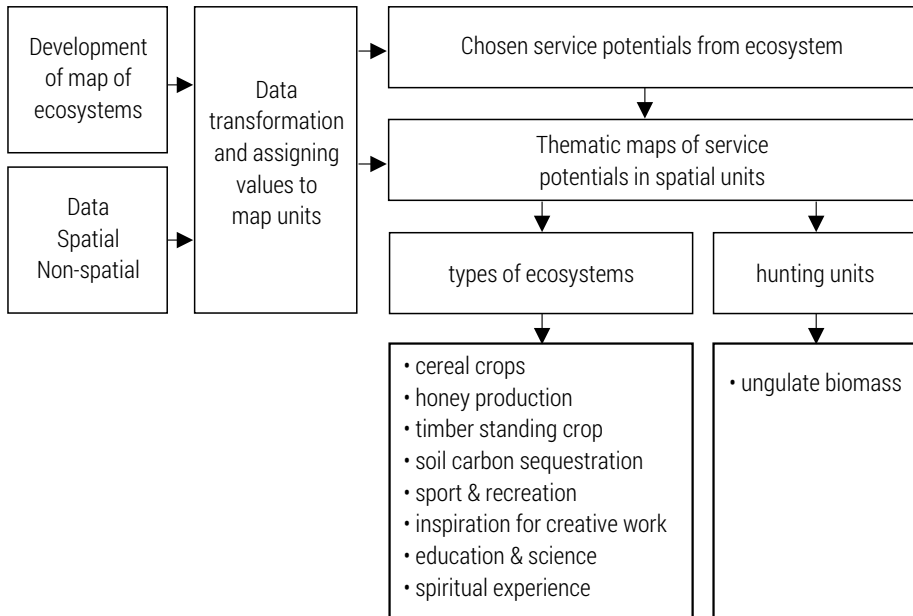


Figure 3. General scheme of ES potential evaluation

We analyzed 4 provisioning ecosystem services (cereal crops, honey production, ungulate biomass and timber standing crop), one regulating ES (carbon sequestration in the soil) and four cultural services (sport and recreation, inspiration for creative work, education and science, as well as spiritual experience). Spatial differentiation of ES potentials was presented on the thematic maps. In two volumes of “Economics and Environment” we present two papers describing these ecosystem services¹⁰.

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¹⁰ E. Roo-Zielińska et al., *Potential of provisioning and regulating ecosystem services in postglacial landscape*, “Ekonomia i Środowisko” 2016 no. 4(59); A. Kowalska et al., *Potential of cultural ecosystem services in post-glacial landscape from the beneficiaries’ perspective*, “Ekonomia i Środowisko” 2016 (in press).

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