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THE STRUCTURE OF POLISH RESEARCH ON THE MAPPING AND ASSESSMENT OF ECOSYSTEMS AND THEIR SERVICES

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ABSTRACT: Ecosystem services (ES) concept has been popular among researchers in the last several years. In this paper, we assessed the development and trends in Polish ES research in the period 2010-2016 using the content analysis of 84 scientific papers – the outcome of ECOSERV Symposia. We analysed such attributes as the type, dimension and scale of the study, ecosystems and ES investigated, the system used to name or classify ES, data used, as well as the considered policy and business questions. In addition, we compared the Polish studies with the European research in the database developed in the ESMERALDA project. The conducted study provides insight into the major achievements as well as challenges that the Polish ES research community will have to face. The findings may serve a discussion on how future directions of the research can be shaped in order to mainstream ES into environmental management.

KEY WORDS: ecosystem services; literature review; content analysis; Poland

Introduction

Twenty years ago, the ground-breaking publications of Costanza et al. (1997) and Daily (1997) kicked off an explosion of research, policy, and applications of the ecosystem services (ES) concept. A group of Polish scholars undertook research on the mapping and assessment of ecosystems and their services quite early (e.g. Ryszkowski, 1995; Żylicz, 2000; Mizgajski, 2004; Zalewski, 2004). The uptake of the ES approach by the community of Polish researches have accelerated since 2010, which was reflected in the organisation of conferences concerning this subject, launching of diverse research projects, as well as in the growth of the number of publications (Stępniewska et al., 2018).

In this paper, we conducted a literature review to examine the development and trends in ES research in Poland. The analysis covered scientific papers being the outcome of Symposia ECOSERV – "Ecosystem services in transdisciplinary approach". ECOSERV Symposia have been taking place every two years in Poznan since 2010, playing an important role in the dissemination of the ES approach in Poland as well as for levering the research quality (Mizgajski et al., 2014; Solon et al., 2017). These meetings allow to present new research on ES, including, among others, case studies, methods, tools, models and implementation. About 100 participants – scientists, as well as representatives of environmental protection authorities and non-governmental organisations – take part in the meetings each time.

Research methods

To understand the nature of the Polish ES research, we used the content analysis method, which is popular for the analysis of trends in ES-related documents (e.g. Piwowarczyk et al., 2013; Kabisch, 2015; Mączka et al., 2016; Jiang, 2017). We analysed 84 scientific papers – outcomes of Symposia ECOSERV 2010, 2012, 2014 and 2016; papers published by authors affiliated in Poland were taken into consideration, with the omission of single papers written by foreign participants (ECOSERV Symposia gained international format in 2018). The investigated conference papers were published in the issues no. 37, 42, 51, 59 and 60 of the "Ekonomia i Środowisko" ("Economics and Environment") Journal.

The content analysis was conducted with the use of criteria developed in the multilateral project ESMERALDA – Enhancing ecoSysteM sERvices mApping for poLicy and Decision mAking within the Horizon 2020 Programme

(Burkhard et al., 2018). The scope of the criteria is a result of a long consultation process within the ESMERALDA consortium. Hence, we analysed such attributes as the type, dimension and scale of the study, ecosystems and ES investigated, the system used to name or classify ES, data used, as well as the considered policy and business questions (figure 1). It should be noted that the analysis did not cover all the important ES aspects, e.g. ecosystem conditions, ES accounting, monitoring aspects and supply-demand issues. However, the use of the adopted criteria made it possible to compare the structure of the Polish research with the collection of European studies on the mapping and assessment of ecosystems and their services, recorded in the database developed in the ESMERALDA project (Santos-Martin et al., 2018); the database from April 2018 that we used contained 855 entries from 28 countries.

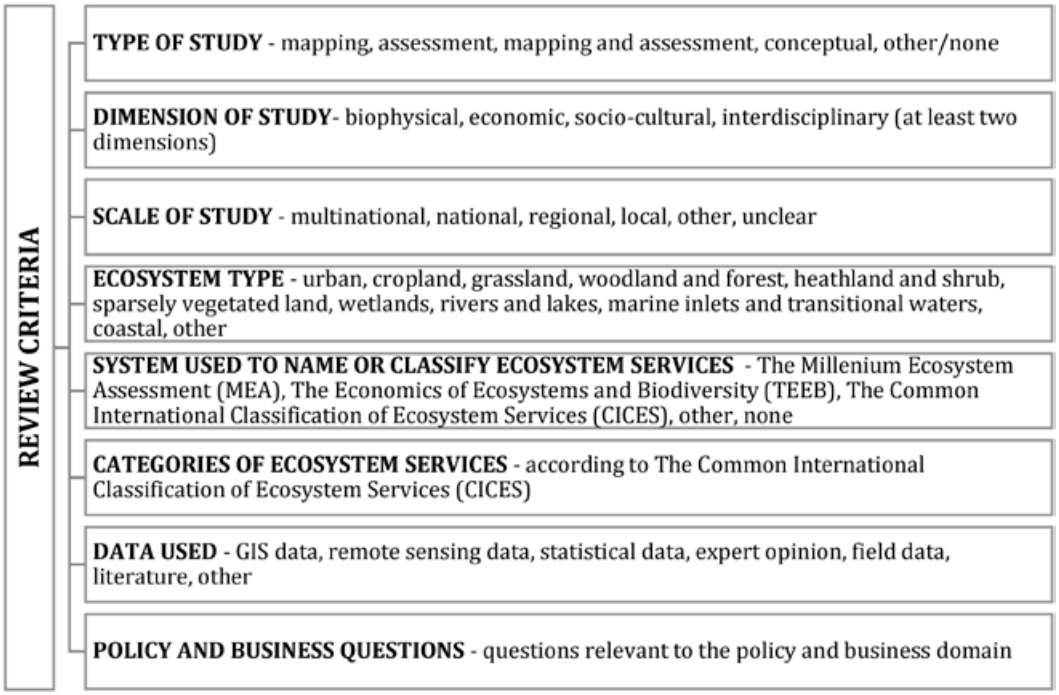

Figure 1. An overview of the criteria used in analysing the research on ecosystem services

Source: author's own work based on Santos-Martin et al., 2018.

We are aware of the fact that the source material insufficiently shows the existing collection of studies on the topic of ES. The ECOSERV proceedings constitute ¼ of ES-related documents indexed by Google Scholar and published by the authors affiliated in Poland in the years 2010-2016 (Stęp-

niewska et al., 2018). Whereas, the ESMERALDA database contains studies arbitrary selected by ESMERALDA project partners, according to their recognition of the state of ES research in individual countries. Therefore, the results should be interpreted with some caution. Nonetheless, in the authors' opinion, the conducted research provides a valuable insight into the major achievements as well as current challenges that the ES research community will have to face. The findings may serve a discussion on how future directions of the research can be shaped in order to mainstream ES into policy and decision-making.

Results of the research

Type of study

The distributions of papers due to the type of study in ESMERALDA and ECOSERV samples were varied (figure 2A). Very characteristic for ECOSERV sample were: a high share of assessment studies (45%), the absence of papers related to mapping only and the presence of theoretical and general works, which we considered as conceptual studies. However, the share of the latter was decreasing in time from 44% in 2010 to 19% in 2016 in favour of case studies related to the mapping and assessment of ecosystems and their services.

Whereas, in the case of the ESMERALDA database, mapping and assessment studies were the most common (56% of total entries). They were followed by studies related to assessments only (33%). The shares of mapping works only as well as other types of studies were quite low.

Dimension of study

Regarding this criterion, the structures of the given samples were quite similar. Most papers had an interdisciplinary character; the second most numerous group included studies on biophysical dimension. The papers focused only on economic or socio-cultural aspects were identified less frequently (figure 2B).

Taking the ECOSERV proceedings into consideration, a significant increase in the share of biophysical studies can be observed in the years 2010-2016 (from 10 to 36%). We noticed also the decrease of the share of economic works (by 10 percentage points). With reference to interdisciplinary studies, the share of three-dimensional studies was decreasing in favour of biophysical-economic and biophysical-socio-cultural ones. This should be

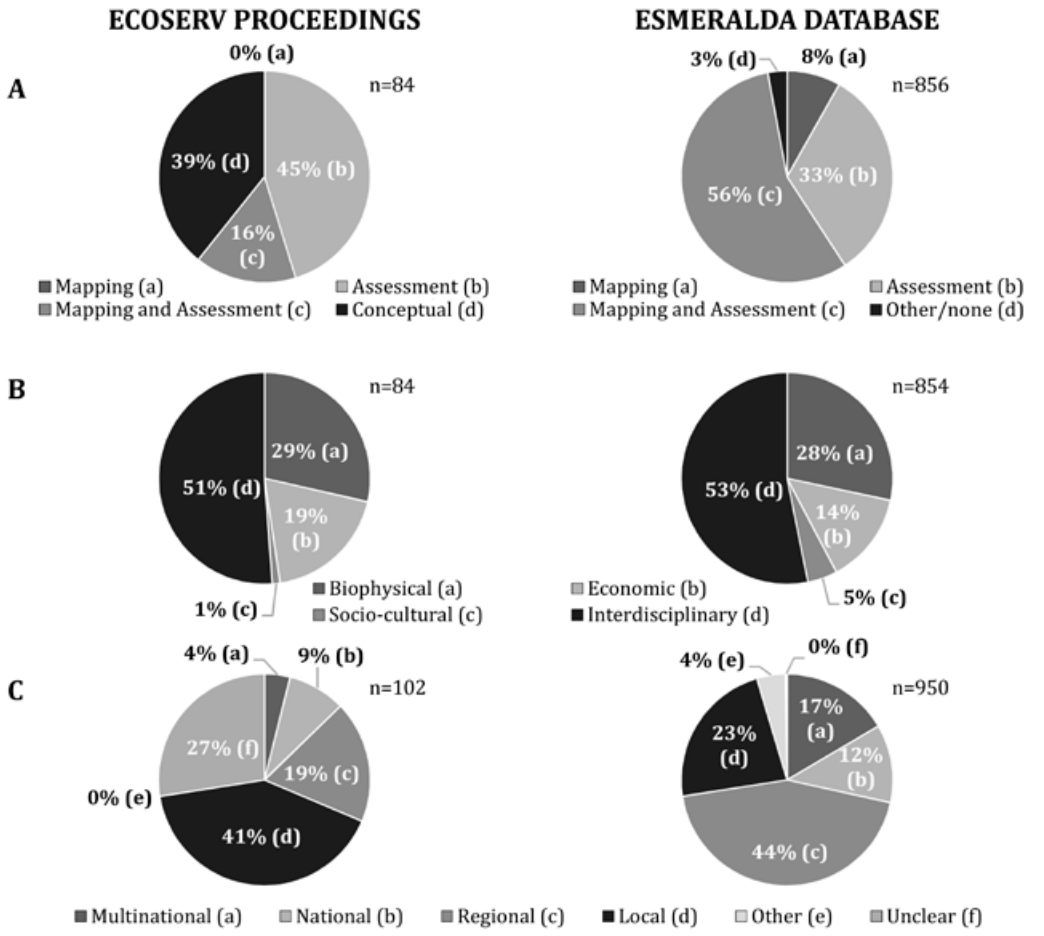

Figure 2. The analysed studies by type of study (A), dimension (B) and scale (C)
Source: author's own work.

combined with a decreasing number of conceptual studies, which had mostly a three-dimensional character.

Scale of study

Another criterion implemented in our analysis was the scale of study. Regarding this, the distributions of works in both samples were varied (figure 2C). Compared to the ESMERALDA database, in the ECOSERV sample we identified a much higher share of local scale studies (by 18 percentage points); we also noticed lower shares of the regional and multinational stud-

ies (by 25 and 11 percentage points). Characteristic for ECOSERV papers was also a relatively high share of studies carried out at an unclear level of scale (27%). However, it must be emphasised that most of them had a conceptual character.

Ecosystem type considered

We review the studies taking into account the main ecosystem types, which are considered by them. In the case of the ECOSERV sample, the "other" ecosystem types were mainly represented in papers (40% of studies). We included in this group the research in which ecosystem types were not pointed out directly by authors. In this kind of studies, ES was considered mostly in relation to the nature protection areas or geographic regions without reference to the particular ecosystem types (e.g. ES provided by a given national park).

The urban ecosystems (26% of studies), rivers and lakes (25%), woodlands and forests (23%), grasslands (20%), and croplands (19%) were taken into account in the other ECOSERV papers. Remaining ecosystem types were investigated by authors very rarely (sparsely vegetated land, heathland and shrub, coastal ecosystems, wetlands) or not present in analysed set of studies at all (marine inlets and transitional waters). These ecosystem types have a low share in the total structure of ecosystems in Poland (Mizgajski, Stępniewska, 2012), which can be the reason for a smaller interest of Polish researchers. Nevertheless, a lack of or a small number of studies on the above-mentioned ecosystem types can be considered as gaps in the research on ES in Poland.

In the ESMERALDA sample, all considered ecosystem types were present in at least fifty studies. Urban ecosystems, woodland and forests, croplands and grasslands were studied most frequently. The research on coastal ecosystems and water bodies – rivers and lakes, marine inlets and transitional waters – were among the least popular.

System used to name or classify ecosystem services

Regarding this criterion, both samples were quite similar in terms of using the Millennium Ecosystem Assessment classification (MEA) and Common International Classification of Ecosystem Services (CICES) (figure 3A). The biggest difference referred to the use of the Economics of Ecosystems and Biodiversity (TEEB) classification; it was used in 10% of studies regis-

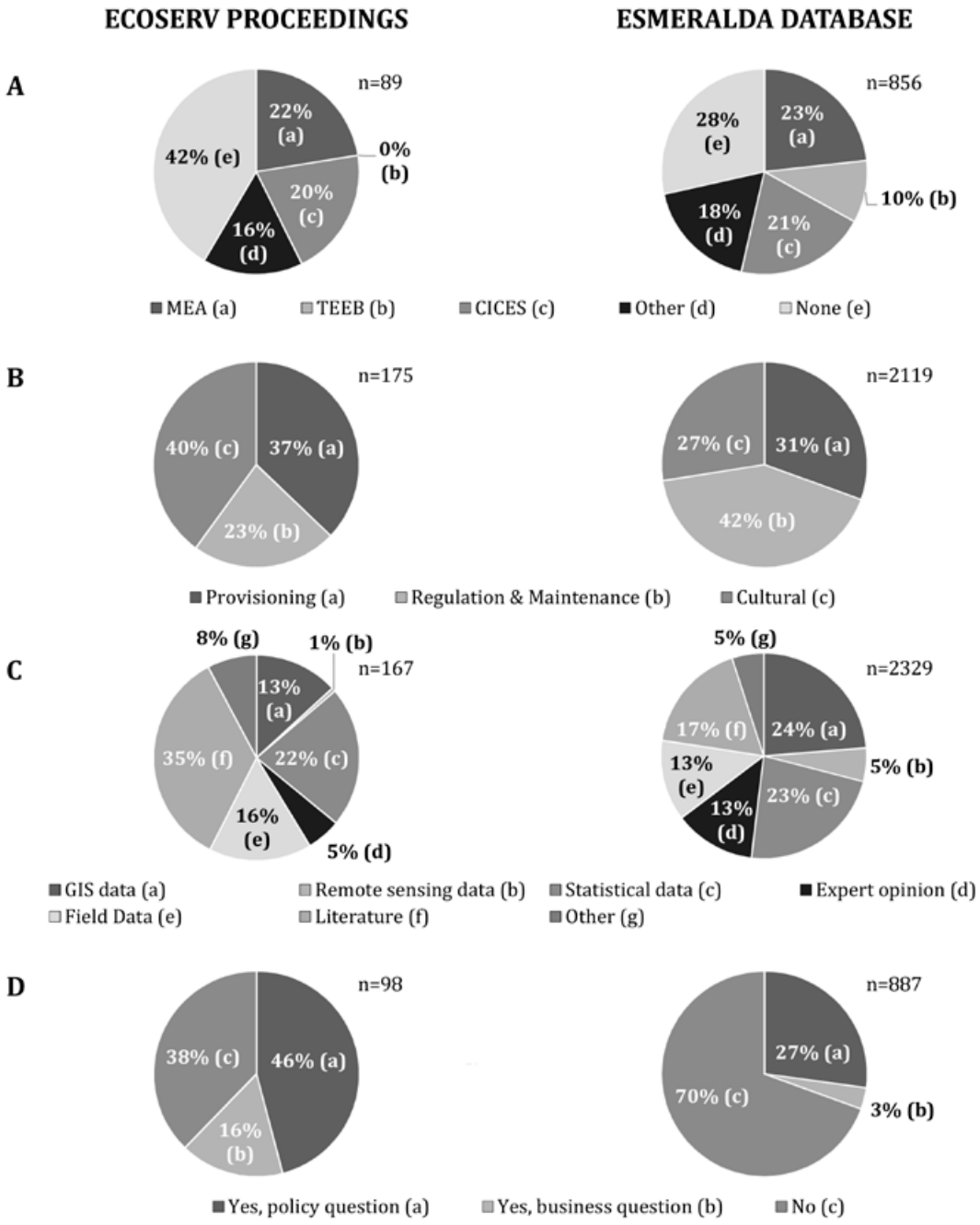

Figure 3. The analysed studies by system used to name or classify services (A), services investigated (B), data used (C) and considered policy and business questions (D)

Source: author's own work.

tered in the ESMERALDA database, but not even in one paper from the ECOSERV sample. In addition, a lot of Polish researchers were not using a concrete system to name and classify ES. In the case of these studies, the authors often used their own terms to define benefits from ecosystems or used very general terms, e.g. leisure and recreational opportunities.

It is important to note the changes in the popularity of particular systems in the subsequent years. In 2010, Polish researchers did not apply any classification (48% of ECOSERV papers) or applied MEA (26%) or other systems (26%). Whereas, the works from 2016 often referred to the CICES classification (36% of papers); the share of the papers, in which no system for naming or classifying ES was used has decreased (by 7 percentage points).

Ecosystem services categories

In this case, we categorised the benefits from ecosystems considered by the authors according to Common International Classification of Ecosystem Services (CICES). Although CICES version 5.1 was published in January 2018, we used version 4.3 from January 2013, which allowed us to compare the Polish studies with the European research from the ESMERALDA database. CICES has a hierarchical structure with five levels of generality (section – division – group– class – class type). We considered the level of section (i.e. provisioning, cultural, and regulation & maintenance ES) and class (forty eight). Because in the ECOSERV sample only 20% of works used the CICES classification, for remaining papers, we re-named the ecosystem benefits considered by authors according to CICES terminology (to ES section or ES classes, depending on the level of detail of an article).

It can be observed that in ECOSERV sample, the cultural (40%) and provisioning (37%) ES were investigated more often than regulation & maintenance ones (23%). This is in opposition to the ESMERALDA sample, where the regulation & maintenance ES were most frequently analysed (42%) (figure 3B).

In the case of provisioning ES, distribution between ES classes was relatively similar in both ECOSERV and ESMERALDA samples. The services related to crops and fibers were studied most frequently, followed by reared and wild animals with their outputs. In both samples, animal-based energy and resources, as well as plants, algae and animals from in-situ aquaculture were not examined often.

Taking regulation & maintenance ES into account, the ECOSERV papers were focused mainly on global climate regulation, hydrological cycle and water flow, and flood protection. The number of studies related to other

regulation & maintenance ES was very limited. In addition, we have not found any work related to bio-remediation, filtration by micro-organisms, storm protection, pest control, disease control, weathering processes, and the chemical condition of salt waters. In turn, studies registered in the ESMERALDA database usually investigated services related to filtration by ecosystems, global climate regulation, mass stabilisation and control of erosion, maintaining nursery populations, as well as hydrological cycle and water flow. Every other regulation & maintenance service was included in at least several dozen studies.

Regarding cultural ES, the ECOSERV papers were centered around the physical use of land-/seascapes and experiential use of plants, animals, and land-/seascapes (commonly called recreational services). The number of works related to other cultural ES was low. Entertainment and symbolic services were not included in any study in this sample. In contrast, papers from the ESMERALDA database covered all classes of cultural ES. However, attention was paid mainly to the physical use of land-/seascapes, aesthetic services, existence services, experiential use of plants, animals and land-/seascapes, heritage and educational services.

Data used

The distributions of data types used were different in both samples. In ECOSERV papers, the most important sources of data were literature (35%), statistics (22%), field data (16%), and GIS data (13%). For comparison, in the ESMERALDA sample, the most frequently used were GIS data (24%), statistics (23%), literature (17%), field data (13%) and expert opinions (13%). We also noticed the difference in the use of remote sensing data, which were more common in studies registered in the ESMERALDA database (figure 3C).

The changes in the sources of data used by Polish researchers in the years 2010-2016 should be highlighted. The first ECOSERV papers (from 2010) were based mostly on the literature and statistical data. In the next few years, the share of these sources of data was gradually decreasing in favour of field data, GIS datasets, and high-resolution remote sensing data. This process is characteristic not only of Polish research – the dynamic uptake of advanced technologies like GIS, as well as more accurate data acquisition methods and tools, stimulate the worldwide development of innovative research, including the ES field (Palomo et al., 2017). Technological changes allow for work on increasingly large datasets (Vihervaara et al., 2018). On the other hand, interpreting the values and comparing the results obtained on the basis of data from various sources requires particular attention to avoid errors (Lupa,

Mizgajski, 2014). The errors may also be result of using only secondary information (Maes, 2016), which still prevail as a source of data in ECOSERV papers; also, the review of Seppelt et al. (2011) covering 153 ES studies from around the world showed that less than 40% of the papers had derived their results on primary data from observations or measurements. This highlights the need for more efforts to collect the primary data of ES (Maes et al., 2012; Stępniewska et al., 2017).

Policy and business questions

The inclusion of policy and business (P&B) questions in the study was another criterion used in our analysis. The specific P&B questions being researched guide the scope and methodological approach for particular ES analysis (Kruse, Petz, 2017). The sets of P&B questions were presented by e.g. Stępniewska (2016), Albert et al. (2017), Maes et al. (2018). The examples of P&B questions can also be found in case studies collected on a thematic webpage developed in the ESMERALDA project (http://www.maes-explorer.eu/page/1). Based on the list of questions from the above materials, we investigated whether the analyzed papers contain a reflection on the practical use of ES research in policy and business.

We found that P&B questions were included more often in ECOSERV studies (56%) than in the ESMERALDA ones (28%) (figure 3D). However, these results should be interpreted with due caution. From the beginning, one of the goals of ECOSERV Symposia is to strengthen the application potential of the ES concept, hence many conference papers consider the issues of result operationalisation. We did not, however, analyze the quality of these P&B links, which differs same as their thematic scope. The latter ranged from studies indicating the significant role of ES for society and entrepreneurs to general discussions on how to include ES valuation in the national accounting. It should be noticed the identification of P&B questions in papers was causing difficulties for many ESMERALDA partners; therefore, the data collected in the ESMERALDA database may be somehow incoherent.

Conclusions

The study provide an overview of the research on the mapping and assessment of ecosystem and their services (MAES) in Poland. The results show the gradual development of competences of Polish researchers within the scope of the ES analysis. It is confirmed in the growing number of publi-

cations, including papers that refer, apart from theoretical deliberations, to case studies related to MAES. We also noticed the increase in use of primary sources of data, as well as presenting research results based on classifications and terminology recognized internationally, and referring the findings to environmental management issues. Our work helps to identify the gaps, which are still an obstacle in mainstreaming ES into policy and practice. They include the concentration of research on a relatively small number of ecosystems and ES, the application of an interdisciplinary approach mainly in theoretical and general studies, and only local perspective in many works. One can say that to overcome the gaps mentioned above, increased cooperation between scientists representing different disciplines is necessary. This would facilitate the mapping and assessment of key ES for all main ecosystem types, as well as the identification of significant ES synergies, trade-offs and bundles, and cross-cutting analysis of the ecological, cultural and economic values of ES.

The contribution of the authors

Piotr Lupa – 50%.

Małgorzata Stępniewska – 50%.

Literature

Albert C. et al. (2017), *Map interpretation/end-user issues*, in: B. Burkhard, J. Maes (eds), *Mapping Ecosystem Services*, Sofia, p. 290-293

Burkhard B. et al. (2018), *Mapping and assessing ecosystem services in the EU – Lessons learned from the ESMERALDA approach of integration,* "One Ecosystem" No. 3: e29153

Costanza R. et al. (1997), *The value of the world's ecosystem services and natural capital*, "Nature" No. 387, p. 253-260

Daily G.C. (1997), *Nature's Services: Societal Dependence on Natural Ecosystems*, Washington

Haines-Young R., Potschin M. (2013), *Common International Classification of Ecosystem Services (CICES) V4.3*., www.cices.eu [29-11-2018]

http://www.maes-explorer.eu/page/1 [29-11-2018]

Jiang W. (2017), *Ecosystem services research in China: A critical review*, "Ecosystem Services" No. 26, p. 10-16

Kabish N. (2015), *Ecosystem service implementation and governance challenges in urban green space planning – The case of Berlin, Germany*, "Land Use Policy" No. 42, p. 557-567

Kruse M., Petz K. (2017), *Mapping provisioning services*, in: B. Burkhard, J. Maes (eds), *Mapping Ecosystem Services*, Sofia, p. 189-198

Lupa P., Mizgajski A. (2014), *The influence of the data analysis scale on the estimated size of ecosystem services*, "Ekonomia i Środowisko" No. 4(51), p. 125-136

Maes J. et al. (2018), *Which questions drive the mapping and assessment of ecosystems and their services under Action 5 of the EU Biodiversity Strategy?* "One Ecosystem" No. 3: e25309

Maes J. (2016), *Mapping and assessment of ecosystems and their services (MAES): highlights and uncertainties of a science-policy interface on biodiversity and ecosystem services*, "Ekonomia i Środowisko" No. 4(59), p. 52-64

Maes J. et al. (2012), *Mapping ecosystem services for policy support and decision making in the European Union*, "Ecosystem Services" No. 1(1), p. 31-39

Mączka K. et al. (2016), *Application of the ecosystem services concept in environmental policy – a systematic empirical analysis of national level policy documents in Poland*, "Ecological economics" No. 128, p. 169-176

Mizgajski A. et al. (2014), *Development of the ecosystem services approach in Poland*, "Ekonomia i Środowisko" No. 4(51), p. 10-19

Mizgajski A. (2004), *Problemy percepcji idei zrównoważonego rozwoju w naukach przyrodniczych,* in: A. Graczyk (ed.), *Zrównoważony rozwój w teorii ekonomii i w praktyce*, Prace Naukowe Akademii Ekonomicznej we Wrocławiu, p. 171-180

Mizgajski A., Stępniewska M. (2012), *Ecosystem services assessment for Poland – challenges and possible solutions*, "Ekonomia i Środowisko" No. 2(42), p. 54-73

Palomo I. et al. (2017), *Tools for mapping ecosystem services*, in: B. Burkhard, J. Maes (eds), *Mapping Ecosystem Services*, Sofia, p. 72-76

Piwowarczyk J. et al. (2013), *Marine ecosystem services in urban areas: Do the strategic documents of Polish coastal municipalities reflect their importance?* "Landscape and Urban Planning" No. 109, p. 85-93

Ryszkowski L. (1995), *Managing ecosystem services in agricultural landscapes*, "Natural Resources" No. 31, p. 27-36

Santos-Martin F. et al. (2018), *Creating an operational database for Ecosystems Services Mapping and Assessment Methods*, "One Ecosystem" No. 3: e26719

Seppelt R. et al. (2011), *A quantitative review of ecosystem service studies: Approaches, shortcomings the road ahead*, "Journal of Applied Ecology" No. 48, p. 630-636

Solon J. et al. (2017), Świadczenia ekosystemowe w krajobrazie młodoglacjalnym. *Ocena potencjału i wykorzystania*, Warszawa

Stępniewska M. et al. (2018), *Drivers of the ecosystem services approach in Poland and perception by practitioners,* "Ecosystem Services" No. 33, p. 59-67

Stępniewska et al. (2017), *Possibilities of using the concept of ecosystem services at the regional level in experts' opinions*, "Ekonomia i Środowisko" No. 1(60), p. 81-91

Stępniewska M. (2016), *Ecosystem Service Mapping and Assessment as a Support for Policy and Decision Making,* "CLEAN – Soil, Air, Water" No. 44(10), p. 1414-1422

Vihervaara et. al. (2018), *Biophysical mapping and assessment methods for ecosystem services*, Deliverable D3.3 EU Horizon 2020 ESMERALDA Project, Grant agreement No. 642007, http://ESMERALDA-project.eu/getatt.php?filename= ESMERALDA%20D3.3_14966.pdf [29-11-2018]

Zalewski M. (2004), *Ecohydrology as a system approach for sustainable water biodiversity and ecosystem services*, "Ecohydrology & Hydrobiology" No. 4, p. 229-235

Żylicz T. (2000), *Costing Nature in a Transition Economy. Case Studies in Poland*, Chelthenham