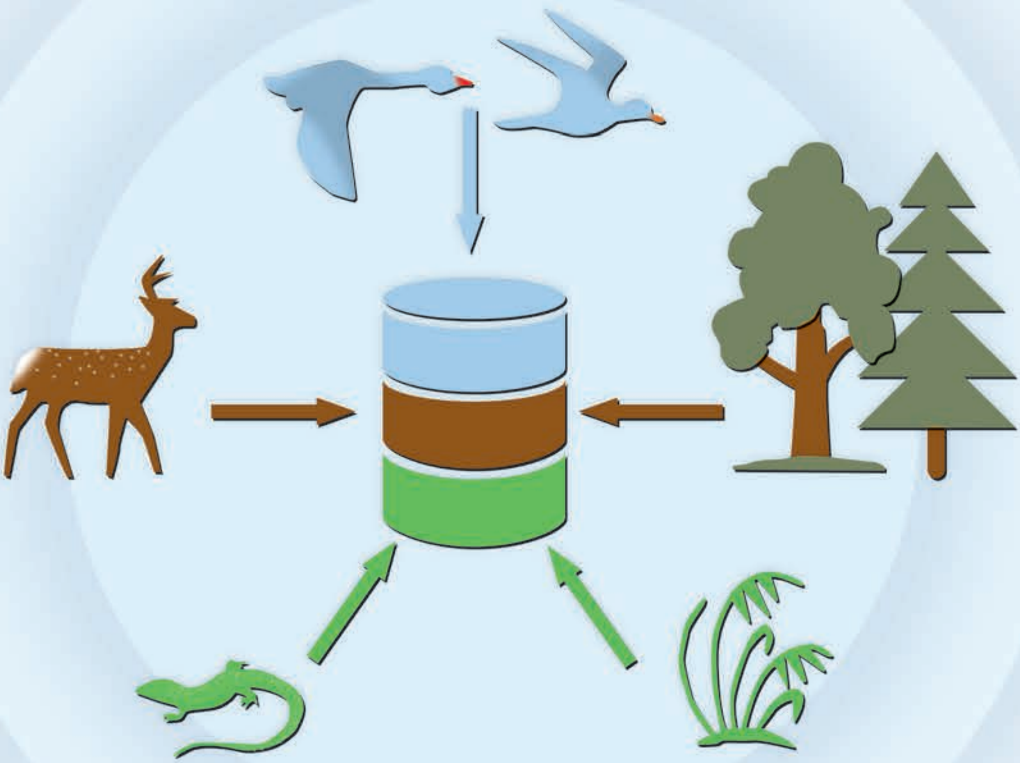
Scientific, Technological and Legal Background of Creating

Integrated Biotic Databases

Edited by Maciej Nowak



Wydawnictwo Naukowe UAM

Scientific, Technological and Legal Background of Creating Integrated Biotic Databases

Honorary Patronage Generalna Dyrekcja Ochrony Środowiska

Special thanks to Esri Polska and Zespół Parków Krajobrazowych Województwa Wielkopolskiego for participation in the organization of the Second Forum BioGIS

ADAM MICKIEWICZ UNIVERSITY IN POZNAŃ
SERIA BIOLOGIA NR 80

Scientific, Technological and Legal Background of Creating Integrated Biotic Databases

Edited by
Maciej Nowak

WYDAWNICTWO NAUKOWE

POZNAŃ 2015

ABSTRACT. Nowak Maciej (ed.), *Scientific, Technological and Legal Background of Creating Integrated Biotic Databases*. Poznań 2015. Adam Mickiewicz University Press. Seria Biologia nr 80. Pp. 126, Tabs. 8, Figs. 33. ISBN 978-83-232-2859-2. ISSN 0554-811X. Text in English.

This monograph consists of ten original chapters which explore topics that are very important today, i.e. the design of GIS databases, the management of these databases and factors that determine the availability of spatial data. Increasingly, these issues, which are associated with abiotic databases, affect numerous emerging resources of data about animate nature.
The monograph also contains information on legal matters concerning access to spatial information or issues related to the INSPIRE directive, which provides a basis for creating national laws concerning the infrastructure of spatial information. Much attention was also paid to examples of using research studies that generate great resources of spatial data, which are used to establish databases and make them available, for example, on web portals. This monograph presents several examples of how databases are created and how they function, including the Polish Biodiversity Information Network (*PL: Krajowa Sieć Informacji o Bioróżnorodności*) and Open-Access Bio- and Geodiversity Database for Silesia Province (*PL: Ogólnodostępna Baza Danych Bio- i Georóżnorodności Województwa Śląskiego*).

Maciej Nowak, Adam Mickiewicz University in Poznan, Laboratory of Biological Spatial Information, ul. Umultowska 89, 61-614 Poznań, Poland

Recenzenci
prof. Marianne Cohen (Université Paris-Sorbonne)
prof. Elżbieta Bielecka (Wojskowa Akademia Techniczna)
dr Jolanta Kijowska (Państwowa Wyższa Szkoła Zawodowa w Gorzowie Wlkp.)

Publikacja sfinansowana przez
Rektora Uniwersytetu im. Adama Mickiewicza w Poznaniu
oraz Wydział Biologii UAM

Wydano na podstawie maszynopisu gwarantowanego

Redaktor techniczny: Elżbieta Rygielska
Łamanie tekstu: Danuta Kowalska
Projekt okładki: Helena Oszmiańska-Napierała
Rysunek na okładce: Dorota Obiegała i Michał Antkowiak

ISBN 978-83-232-2859-2
ISSN 0554-811X

WYDAWNICTWO NAUKOWE UNIWERSYTETU IM. ADAMA MICKIEWICZA W POZNANIU
UL. FREDRY 10, 61-701 POZNAŃ
www.press.amu.edu.pl
Sekretariat: tel. 61 829 46 46, faks 61 829 46 47, e-mail: wydnauk@amu.edu.pl
Dział sprzedaży: tel. 61 829 46 40, e-mail: press@amu.edu.pl

Wydanie I. Ark. wyd. 9,00. Ark. druk. 7,875

EXPOL, WŁOCŁAWEK, UL. BRZESKA 4

CONTENTS

INTRODUCTION

Increasing awareness of the dangers caused by the intensive exploitation of the Earth is a reason for implementation of a large number of research projects. Their aim is to protect the natural resources, minimalize the negative impact of the human activity, and meet the standards of sustainable development. To achieve these aims, it is necessary to obtain comprehensive knowledge about the state of the globe. Many projects focus on observation ofselected phenomena. These phenomena include glacial processes, floods, forest fires, pests' gradation, pollution of surface water, migration of alien species, and many others. These tasks are performed by scientists, public institutions, departments of environmental protection and ecological organizations at the global, national and local level. It is estimated that 2.5 trillion of data bytes are created each day. Interestingly, 90% of the data available today have been created in the last two years (www.itfocus.pl).

While dividing the spatial data resources into abiotic and biotic parts, it is worth mentioning that the former functions in an orderly manner, i.e. the data is stored in the national repositories. It is also available to the public and easy to find. One of the reasons for that is the fact that these resources are often referred to as the reference data (topography, land cover, geology, soils, aerial imaging, LiDAR, etc.). Therefore, state institutions (e.g. Polish Head Office of Geodesy and Cartography) are interested in collecting this type of data. Unfortunately, it is hard to find national spatial data resources on, for example, native flora and fauna or alien species. This does not mean, however, that there is little data of this type. There are are many research projects that provide vast resources of data, primarily about the location of species and their habitats. In addition, biotic information is provided through the environmental impact assessment reports and protection tasks of the National Parks as well as in the scope of the project Natura 2000. However, there is no system approach to the collection of spatial data in the field of biodiversity at the regional and national levels. Lack of a coherent spatial data resource is also a problem. Many groups of organisms are not covered by any uniform standards of field inventory and building databases. There are no publicly available state records of data on animated nature.

On the other hand, progressive computerization in the field of environment; including biodiversity research, legislation for gathering, storage and sharing of spatial data (INSPIRE Directive) as well as standardization of methodology concerning field inventory and databases; allows us to think optimistically about the future of biotic data resources. Articles presented in this monograph can definitely prove this. They describe the scientific, technological and legal conditions of assistance in building and using integrated databases of animated nature. These articles are the result of the conference "II Forum BioGIS – System Informacji Przestrzennej w badaniach różnorodności biologicznej" (2nd BioGIS Forum – Geographical Information System in the study of biodiversity), held on 25 – 26 September 2013 at the Faculty of Biology of the Adam Mickiewicz University in Poznań. The main objectives of the conference included the popularization of the topic, exchange of experience, and discussion between the suppliers, disposers and recipients of spatial data on animated nature. One of the most important aims of this meeting was to illustrate the cooperation between scientific and educational institutions, as well as institutions managing the environment (in terms of data exchange and joint projects). During the meeting, the participants discussed currently existing legal and technological conditions for the acquisition, processing, transfer and integration of data (construction of local, inter-institutional, open databases).

Maciej Nowak

GEOSPATIAL INFORMATION SYSTEMS – COPYRIGHT AMBIGUITIES ARISING FROM THE IMPLEMENTATION OF THE INSPIRE DIRECTIVE

Marlena Jankowska

Department of Private Law and Private International Law, Faculty of Law and Administration,
University of Silesia, Katowice, Poland

ABSTRACT: Fulfilling the obligation of creating NSDIs (National Spatial Data Infrastructures) imposed by the INSPIRE Directive did not spark as much attention in the theory of law as it should. The practice of using NSDIs has nevertheless shown that there are quite many legal issues worth of note, especially concerning the intellectual property rights. What happens in that subject to lay at the heart of the conundrum we have to face in the doctrine of copyright law is the relation of the principles of accessing the public information towards the principles of copyright protection. At the same time, the technological challenge stimulates the doubts about the copyright protection even more, as it is not certain whether NSDIs are at all copyrightable. As there are many standpoints in that matter it has to be answered whether the UE Decisions and Regulations (mentioned in this paper) as well as the technical framework of creating the digital data and databases (e.g. the ISO standards) do not reclaim the personal stamp from the creation. It has to be also noted that the standpoint on maps is a liberal one and might be incapsulated into the tenet that any idea might be copyrightable if only it is individualized and creative, as well as has been established in any form. For this reason, after going into details of creating a digital map one might be able to claim that his creation shall be the subject of the copyright protection. This paper goes into further details in that subject.

KEYWORDS: INSPIRE, Geoinformation and copyright law

1. Introduction

The process of creating digital spatial information systems began as early as in 80-ties of XX century. Probably, at that time, it would be hard to predict that the process of gathering spatial information will be so far-going and deep-reaching that it will entail quite a few detrimental consequences of a legal, let alone ethical, nature. That would be even hard to speculate that quite a few years later an average citizen would find it hard to live his day-to-day existence without reaching for spatial information on a daily basis. Indeed, one should note that the scope of geodata used by an average user grows every year along with his rising consciousness of the importance of this sort of data. Surveys conducted in Poland in 2004, 2006 and in 2009

(Adamczyk 2007; Gajos 2009) one after another paint a fine picture of what kind of needs intricates the use of geodata and encounters the change of attitude of users to geoinformation over these years. No matter what the needs are (or yet are to become), it is plain to see that they evaluate rapidly and significantly enough to catch a glimpse of how they trigger the geoinformation society phenomena. The aforementioned term, of "geoinformation society", has been coined by J. Gaździcki, who by this notion denotes a citizenry which largely uses the geoinformation accessed by generally available services of geoinformation infrastructure (Jankowska & Pawełczyk 2014). As a practice of accessing geodata by the society grows, it is important to note that geoinformation is being used in business and public sector not the less (Kozubek, Ney & Werner, 2011).

Proliferation of the search and use of geodata make GI industry insiders and commentators pay more attention to the legal aspects of geoinformation. The research in this area reveals its importance especially nowadays, as technology trends change its context and make a new ground for legal questions to come. For this reason this paper takes a deeper insight into geoinformation from a copyright angle and takes a chance on determining what kind of legal aspects we are to face in the coming future.

2. Geoinformation and copyright law

With no exaggeration we dare say that quite a lot of ink has been spent on geoinformation so far, but the legal literature in this subject is rare and of general nature. Central to understanding this practice is the recognition of the fact that most of the shortcomings or pitfalls emerging in the course of creating geo-databases are of purely technical, organisational and financial matter. However, the overwhelming need to use geoinformation and the continuous rise of the Internet as a medium for consumption coupled with a significant shift towards questioning about the legal frames of creating and owning the infrastructure, has increased the interest of legal grounds, dangers and risks of using it. One of the major acts referring to spatial information so far is the Directive 2007/2/EC of the European Parliament and of the Council of 14 March 2007 establishing an Infrastructure for Spatial Information in the European Community (INSPIRE), which entered into force on the 15 May 2007.[1] The Directive addresses 34 spatial data themes essential for environmental applications, whereas the key components are specified

[1] OJ L 108/1, 25.04.2007, p. 1-14.

through common technical implementing rules (IR) which are adopted as Commission Decisions or Regulations and refer to such specific areas as Metadata, Data Specifications, Network Services, Data and Service Sharing and Monitoring and Reporting). These Decisions and Regulations are summarized as follows:

- Commission Regulation (EC) No 1205/2008 of 3 December 2008 implementing Directive 2007/2/EC of the European Parliament and of the Council as regards metadata,[2]
- Commission Decision of 5 June 2009 implementing Directive 2007/2/EC of the European Parliament and of the Council as regards monitoring and reporting,[3]
- Commission Regulation (EC) No 976/2009 of 19 October 2009 implementing Directive 2007/2/EC of the European Parliament and of the Council as regards the Network Services,[4]
- Corrigendum to Commission Regulation (EC) No 1205/2008 of 3 December 2008 implementing Directive 2007/2/EC of the European Parliament and of the Council as regards metadata (OJ L 326, 4.12.2008),[5]
- Commission Regulation (EU) No 268/2010 of 29 March 2010 implementing Directive 2007/2/EC of the European Parliament and of the Council as regards the access to spatial data sets and services of the Member States by Community institutions and bodies under harmonised conditions,[6]
- Commission Regulation (EU) No 1088/2010 of 23 November 2010 amending Regulation (EC) No 976/2009 as regards download services and transformation services,[7]
- Commission Regulation (EU) No 1089/2010 of 23 November 2010 implementing Directive 2007/2/EC of the European Parliament and of the Council as regards interoperability of spatial data sets and services,[8]
- Commission Regulation (EU) No 102/2011 of 4 February 2011 amending Regulation (EU) No 1089/2010 implementing Directive 2007/2/EC of the European Parliament and of the Council as regards interoperability of spatial data sets and services,[9]

---

[2] OJ L 326, 4.12.2008, p. 12–30.
[3] OJ L 148, 11.06.2009, p. 18-26.
[4] OJ L 274, 20.10.2009, p. 9–18.
[5] OJ L 328, 15.12.2009, p. 83–83.
[6] OJ L 83, 30.3.2010, p. 8–9.
[7] OJ L 323, 8.12.2010, p. 1-10.
[8] OJ L 323, 8.12.2010, p. 11-102.
[9] OJ L 31, 5.02.2011, p. 13–34.

- Commission Regulation (EU) No 1253/2013 of 21 October 2013 amending Regulation (EU) No 1089/2010 implementing directive 2007/2/EC as regards interoperability of spatial data sets and services;[10]

The INSPIRE Directive has doubtlessly supported the EU countries' trend to make day by day more spatial data sets, services and applications available as well as has served as a good trigger for many institutions to start opening their datasets and sharing them with other institutions (Cetl, Tóth, Abramić & Smits 2013). It is generally known that "INSPIRE responds the need for quality geo-referenced information to help understand the complexity of, and interactions between, human activities and environmental pressures and impacts. It addresses the current general situation with respect to spatial information in Europe, where there is an urgent need to fill in gaps in data availability and to eliminate the duplication of information, as well as to compensate for the fragmentation of existing datasets and sources. Given the importance of data to a large number of policy and information themes across various levels of public authority, these obstacles make it difficult to identify, access and use the data that are available, to the detriment of environmental integration" (Cetl, Tóth, Abramić & Smits 2013). Therefore this is worth of note that EU countries have taken their efforts towards the implementation of the Directive, and as a matter of fact have done that in a multiple number of ways. Some of the EU countries have implemented the Directive by issuing national laws on infrastructure for spatial information, whereas other integrated the INSPIRE Directive provisions in the geodetic and cadastre law. Therefore one may observe that the implementation takes place mainly in a twofold way: by a full transposition of the provision of the Directive by issuing a new legal act or by only attuning some of the provisions to the existing law. If we take a closer look at Poland as an example it has to pointed out that our country chose the first way of implementation by issuing Act of 4 March 2010 concerning the infrastructures for spatial information (hereinafter referred to as: u.i.i.p.).[11] However it shall be noticed that Poland did not abide from attuning the already existing legal acts regulating issues related to gathering and accessing (spatial) data, e.g.: Act of 17 May 1989 – geodetic and cartographic law (hereinafter referred to as: p.g.k.).[12] More than that, the implementation is relying on the application and interpretation of the Act of 6 September 2001 concerning the

[10] OJ L 331, 10.12.2013, p. 1-267.
[11] Journal of Laws [Dz.U.] No 76 Item 489.
[12] Consolidated text, Journal of Laws [Dz.U.] of 2010 No 193 Item 1287 as amended.

access to public information[13] and the Act of 3 October 2008 concerning the disclosure of environmental information, and its protection, the participation of society in environmental protection and on the evaluation of the impact on the environment.[14] The implementation did not reach as far as to amend the Act of 4 February 1994 on copyright and neighbouring rights (hereinafter referred to as: pr.aut.)[15] or the Act of 27 July 2001 concerning the protection of databases.[16] At the same time the practice of accessing the geoinformation invoked a debate whether the NSDI (National Spatial Data Infrastructure) is as a matter of fact a work of authorship or not. The relation of u.i.i.p. towards pr.aut. in that subject happens to lay at the heart of the conundrum we have to face in the doctrine of copyright law, as this issue is not literally settled out on the legislative level. The basic point of departure that we take is Article 2 of u.i.i.p., pursuant to which the u.i.i.p. does not interfere with other rights derived from the legal norms related to the protection of intellectual property rights and to the disclosure of environmental information, and its protection, the participation of society in environmental protection and on the evaluation of the impact on the environment. This wording is open to many interpretations which don't support any of the thesis whether or not u.i.i.p. overrules the pr.aut. At the same time it seems slightly impossible for both of the regimes of legal norms to coexist without drawing a fine line between indicating the right scope of application of them.

First question that we have to face in that matter is the one whether the NSDI may consist of or constitute itself an official document or an official material which according to Article 4 of pr.aut. is does not fall under the copyright protection. As the interpretation of the notions of an "official document" and of an "official material" is general and unsure similarly uncertain remain the results of the legal analyze. The legal interpretation proves to be challenging which reflects in a large number of contrary decisions which have been issued in respectively similar cases. The below mentioned verdicts give a general overview of standpoints taken in the Polish jurisprudence:

1) "the Computerized Map of Hydrographic Division of Poland (MPHP) is a hydrographic database and is a visualization and a cartographic representation of these data. As a database, MPHP is a set (collection) of data arranged in an established way, structured according to the assumed data

---

[13] Journal of Laws [Dz.U.] No 112 Item 1198 as amended.

[14] Journal of Laws [Dz.U.] of 2008 No. 199 Item 1227, Journal of Laws [Dz.U.] of 2013 Item 1235.

[15] Journal of Laws [Dz.U.] 2006 No. 90 Item 631 with further amendments.

[16] Journal of Laws [Dz. U.] No 128 Item 1402 as amended.

model. For a set of specifically ordered hydrographic data concerning the territory of Poland, including the river basins of the rivers Vistula and Oder outside the border, being at the same time a visualisation and cartographic representation of these data, constitutes a public information and is subject to sharing compliant to the rules described in the public information act", WSA verdict of 2 December 2005, file ref. No. II SAB/Wa 154/05, lex No. 189839;

2) "public information is every message delivered by or referring to broadly understood public authorities, or delivered or referred to other subjects discharging functions in the scope of carrying out the tasks of public authority and managing communal assets or the property of the State Treasury. In the light of the access to public information act, an information protected by the Copyright and Neighbouring Rights Act of 4 February 1994 is not considered to be a public information (Journal of Laws [Dz.U.] 2006 No. 90 Item 631 with further amendments). The Computerized Map of Hydrographic Division of Poland as a copyrighted item is not public information in the view of the Act of 6 September 2001 concerning the access to public information" WSA verdict of 17 July 2007, file ref. No. II SAB/Wa 58/07, lex No. 368237;

3) "not only the documents directly edited and created by the public administration bodies are considered to be public information, but also of such character are documents used by the body to perform legal tasks, even if the copyright belongs to another entity. For it is of rudimentary significance that these documents are used to perform public tasks by specified bodies, and were created at their request. The point is not a disposal of copyright, it is rather the matter of access to a document created by request of the public body in order to perform public tasks. It shall be pointed out that this stance has been well-grounded in the interpretation of the administrative courts for a number of years (inter alia verdict of 9 February, file ref. No. I OSK 517/06; of 7 December 2010, file ref. No. I OSK 1774/10; of 18 September 2008, File No. I OSK 315/08). In this case, it should not raise any doubts that the maps connected with the works of "Directions of spatial development" and "Conditions for spatial development" constitute public information. They were created for the need of a specified public task, by the request of a public administration body. Therefore, sharing the data does not transfer copyright, but rather provides a realization of access to public information pursuant to abovementioned Act of 6 September 2001 concerning the access to public information ", WSA verdict of 15 July 2011 file ref. No. I OSK 667/11;

4) in the view of the Court, the body wrongly assumed that public information requested by the plaintiff is subject to copyright protection in the

scope that disables (excludes) its sharing as per the access to public information act [...] However, Art. 4 of the mentioned act, the legislator provided for copyright disclaimers, deciding that the following do not constitute a copyrighted item: 1) normative acts or their drafts; 2) official documents, materials, signs, and symbols; 3) published patents or protective specifications 4) simple press information. The maps "Directions of spatial development" and "Conditions for spatial development" in the form of colour print are enclosed to the conditions and directions of the spatial management study, being an integral part of the official document. If it is so, in the view of the discussed regulations they are not copyrighted items [...] Therefore, also papers, maps, expert opinions enclosed to the documents and created at the request of an administrative body are not protected by copyright in the scope that it is impossible to make them available by the way of the access to public information", WSA in Kraków verdict of 22 November 2010. file ref. No. II SAB/Kr 114/10;

5) "in the view of the Court, the body wrongly assumed that public information requested by the plaintiff is subject to copyright protection in the scope that disables (excludes) its sharing as per the Act of 6 September 2001 concerning the access to public information [...] Also, the Court does not share the opinion of the Mayor of Rabka Zdrój concerning the scope of exclusion from the regulation of the access to public information act with the reference to the Art. 4 of the Copyright and Neighbouring Rights Act. The Access to Public Information Act refers to other acts in the matters not regulated by it, but also it contains a very broad objective scope – in principle, every piece of information concerning public matters is public information. The regulation of Art. 6 u.d.i.p. contains an example catalogue of such information, directly indicating that public information is subject to sharing, especially information concerning the plans of the regulatory and executive authorities actions, and normative acts design (Art. 6 sec 1 item 1 letter a and b u.d.i.p.). If a public administration body, in the course of fulfilling public tasks, orders the creation of any documents used to or applied in the scope of the performed public task, it is public information. In the course of designing the draft of the act concerning the research on conditions and directions of the spatial planning of a given district, the body (bodies) of a given district needed maps in various versions (e.g. vector, digital, analogue). It means that the maps were or could have been helpful in accomplishing a given public task by the self-government body (passing the research act). To admit that the maps are public information, it is of no significance whether they were prepared by the body itself (auxiliary administrative body), or requested to be prepared by third parties. The issue of the design

studio claiming copyright to some versions of the map does not influence recognizing such maps to be a public information item", NSA verdict of 12 December 2012. file ref. No. I OSK 2149/12.

As the jurisprudence indicates, this might be not justified to exclude NSDI from the copyright protection on the basis of Article 4 point 2 of pr.aut. Therefore we will not avoid answering the fundamental question whether the NSDI is or might be a work of authorship. Bearing in mind that according to Article 1 Section 1 of pr.aut. the object of copyright shall be any manifestation of creative activity of individual nature, established in any form, irrespective of its value, purpose or form of expression, this question might be answered only after examining the legal premises. Therefore a work may be copyrighted when it meets the following requirements:

1) it's creative,
2) it's of individual nature,
3) stems from a human,
4) is established in a form.

Not to mention the digital maps, which make the legal analysis far more complex, the copyrightability of maps was left behind with silence for a long time, becoming in and out the matter of a legal issue whenever a dispute brought the parties to the court. When it comes to Polish legislation the category of maps was recognized and introduced for the first time in the legal Act on copyright and neighboring rights in the Article 1 Section 2 point 1 under the name "cartographic works" respectively to the Head Office of Geodesy and Cartography (pol. Główny Urząd Geodezji i Kartografii) efforts (Jankowski 2002; Pawlak 2002). Though, it shall be remembered that the Article 1 Section 2 of the pr.aut. directed at explicitation of the categories of work which were granted the protection, does not provide any presumption on this point. In other words, the copyrightability of a work shall be proved on a case by case basis. The technological challenge stimulates the doubts about the copyright protection even more. As there are different standpoints in that matter it has to be answered whether the UE Decisions and Regulations (mentioned on the top of this paper) as well as the technical framework of creating the digital data and databases (e.g. the ISO standards) do not reclaim the personal stamp from the creation. According to Ch. Waelde the datasets are not creative at all and therefore they may be granted only the database protection (Waelde & McGinley M. 2007). On the other hand, G. Cho notices that every change to the vector or raster data may become the creative act eligible for the copyright protection (Cho, 2005). Though copyrightability issues might not be answered easily I assume that a deeper insight into the act of creation of the database will provide us with essential information to estimate accordingly (Felchner & Jankowska 2013). As a matter of fact the Court of Appeals in Lublin issued a judgment of 5 February 2013 (sign. I ACa 681/12, lex no 1298951), in which it granted the protection to the map. It noticed, that in the doctrine of law it is often stated that the protection cannot be denied only on the ground that the nature of the map is to truly reconstruct the existing reality. The individual nature of the map lies witin decisions on the content of the map, incorporating or omitting the elements of the reality into the map, the way of introduction on the elements into the map, lettering affecting the readability of the map or the plan, plastic composition of the whole (Barta & Markiewicz, 2011). In that case the courts examined the disputed map and upheld the reasoning of the claimant asserting that it is impossible to the third party to create the other map without having the glimpse on his. The Court of Appeals indicated that the standpoint of the Supreme Court on maps is a liberal one and might be incapsulated into the tenet that any idea might be copyrightable if only it is individualized and creative, as well as has been established in any form. For this reason, after going into details of creating a digital map one shall be able to claim that his creation shall be the subject of the copyright protection. Even if the creation of infrastructure for spatial information falls under the EU requirements set in the abovementioned Regulations and Decision, the regulations refer only to the interoperability of the data and the other features, which seem not to deny the copyright protection. At the same time programs dedicated for creating digital maps supply a wide range of options allowing the creator to make relevant choices and put his stamp if personality.

The copyrightablility of the digital maps has not been proved to be excluded. More than that, this matter has been addressed in the repealed order of the Ministry of the Regional Development and Construction of 15 May 2001 regarding the designation of the kinds of maps, photogrammetric materials and remote sensing materials, constituting the national geodetic and cartographic resource, which use, distribution and reproduction aiming at its use and distribution need the permission, and on the procedure of the granting the permissions, issued as a fulfillment of the obligation imposed in the Article 19 Section 1 point 5 of p.g.k.[17] According to the § 1 of the aforementioned act the permission was obligtory in case of the following kind of materials:

1) topographic maps,
2) administrative maps,

[17] Journal of Laws of 2001 no. 56, Item 588.

3) thematic maps,

4) site maps,

5) photogrammetric and remote sensing aerial photos,

6) satellite photos,

7) derivative materials, elaborated on the basis of the materials enumerated in the points 5 and 6.

It shall be mentioned that according to § 23 Section 2 of the Order the permission should have entailed the warning that the materials fall under the protection of the Act on copyright and the neighbouring rights. This was another argument in favour of the copyright protection for the digital maps. Having in mind that the act has been repealed as a whole the question of copyrightability of these documents is left open and needs further full-fledged elaboration.

3. Conclusions

The implementation of the INSPIRE Directive makes ground for copyright issues. The uncertainty abounds in the midst of discrepant jurisprudence, standpoints taken in the doctrine of law and in the deficiency of legal regulations addressing the issue of creating NSDIs. In this regard, this paper aims to show the state of mind in the Polish doctrine of copyright concerning the issue of creating, protecting and accessing geoinformation databases.

Bibliography

ADAMCZYK J. 2007, Geoportale infrastruktur danych przestrzennych w opiniach użytkowników, Roczniki Geomatyki, No. 5, p. 7-17

BARTA J. & MARKIEWICZ R. (eds.) 2011, Komentarz do art. 1 ustawy o prawie autorskim i prawach pokrewnych, lex/el. note 46

CETL V., TÓTH K., ABRAMIĆ A., SMITS P. 2013, Report on the status of INSPIRE in the Balkan countries, Luxembourg: Publications Office of the European Union, doi: 10.2788/49715 (pdf)

CHO G. 2005, Geographic Information Science. Mastering the Legal Issues, John Wiley & Sons Ltd, Chichester.

GAJOS M. 2010, Badanie potrzeb i zachowań informacyjnych użytkowników geoinformacji, Roczniki Geomatyki, No. 5, p. 63ff

FELCHNER K. & JANKOWSKA M. 2013, Ustawa o infrastrukturze informacji przestrzennej. Komentarz lex/el.

JANKOWSKI W. 2002, Kartografia w prawie autorskim, Biuletyn Stowarzyszenia Kartografów Polskich, No. 7, p. 36-37

KOZUBEK E., NEY B., WERNER P. 2011, *Rozwój społeczeństwa informacyjnego w Polsce w latach 2005-2010*, Roczniki Geomatyki, No. 6, p. 103

PAWLAK W. 2002, Etyka w interpretacji i stosowaniu ustawy „Prawo autorskie i prawa pokrewne", Biuletyn Stowarzyszenia Kartografów Polskich, No. 7, p. 35-36

WAELDE CH. & MCGINLEY M. 2007, *Designing a licensing strategy for sharing and re-use of geospatial data in the academic sector*, http://edina.ac.uk/projects/grade/gradeDigitalRightsIssues.pdf

LEGISLATIVE ASPECTS OF THE IMPLEMENTATION OF THE INSPIRE DIRECTIVE IN POLAND: THE CASE OF BIODIVERSITY SPATIAL DATA AND SERVICES

Dariusz Dukaczewski

Institute of Geodesy and Cartography
dariusz.dukaczewski@igik.edu.pl

ABSTRACT. Increasing need for the data on the state of the environment gives rise to quick access to up-to-date, credible, qualitatively comparable, interoperable spatial information. Many attempts at integrating spatial data into the databases have demonstrated the incoherence of data managed by different institutions and have proven the need for expensive and time-consuming data conversion and harmonization. The practice has proven, that these tasks can be successfully carried out in the Spatial Data Infrastructures (SDI), where all spatial data are produced employing the same base map layer. The strict assignment of thematic data layers to responsible partners can made it possible to avoid the production of multiple, similar (but incoherent) base map layers. This can result in time and money economies, as well as in spatial data harmonization. After success of local, regional and national SDIs the European Commission has ordered to build the Infrastructure for Spatial Information in the European Community (INSPIRE), based on national SDIs. The Directive 2007/2/EC has laid down general rules aimed at the establishment of the Infrastructure for Spatial Information in the European Community and has obligated the EU Member States to make available the metadata and spatial data sets related to one or more of the themes listed in Annex I, II or III, according to the EU implementing rules, national laws and technical specifications. Five of themes listed in the Annexes concerns the biodiversity. The general legislative aspects of the implementation of the INSPIRE directive in Poland have been described by many authors (i.e. Gaździcki 2008, 2009, 2011, Bielecka 2011, Dukaczewski 2011). The goal of this paper was to signalize the requirements arising from the law and technical specifications which must be fulfilled during the process of harmonization of spatial data sets and services concerning the biodiversity. The author has analysed the legislative aspects of the implementation of the INSPIRE directive in Poland. The lecture of EU legal documents related to the INSPIRE (Directive, Commission Regulations, Commission Decisions), as well as Polish laws and orders allowed to identify its part, which is essential for building the elements of infrastructure concerning the biodiversity. The analysis of the Technical Guidelines allowed to identify the tasks related to this process and to precise its time schedule.

KEYWORDS: INSPIRE, Poland, Biodiversity, law

Increasing demand for shrinking natural resources, in conjunction with needs related to environmental protection and research on biodiversity, gives rise to a need for quick access to up-to-date, credible, qualitatively comparable, interoperable spatial data, as well as the ability for its efficient query, browsing, processing and spatial analyses. All this has led to a considerable surge in demand for spatial data standardization and harmonization, the production of metadata, as well as the development of interoperable spatial data services. Even the first attempts at integrating spatial data into the databases of the first GISes – Sweden's CFD (Centralnämuden för fastignetsdata) (Rystedt 1977) and GISA in 1962 (Eklund 1977), as well as Canada's CNGIS in 1964 (Tomlinson 1977), demonstrated the incoherence of data coming from different sources and have proven the need for expensive and time-consuming data conversion and harmonization. These tasks were completely and successfully carried out in the first urban data infrastructures: Toulouse's SIGeT (1972), Aix-en-Provence's SIGAP (1980), Orléans' SIGOR (1982) and Reykjavik's LUKR (1988), where all spatial data were produced employing the same base map layer. The strict assignment of thematic data layers to responsible partners made it possible to avoid the production of multiple similar (but incoherent) base map layers and resulted in time and money economies, as well as in spatial data harmonization. Similar solutions were applied in the case of regional data infrastructures (for the first time in the case of Venice's SIUTE in 1986). In 1986 the first national SDI (spatial data infrastructure) was inaugurated in Australia. The first national SDI in Europe was set up in 1990 in Portugal. By 2013, national SDI were built in 107 countries of the World (and 26 countries of Europe).

The need to provide metadata on EU national databases on the environment and to make the spatial data sets interoperable, as well as to make available the services of discovery, view, download and transformation of spatial datasets, and (last but not least) to ensure the sharing of spatial data and services between the public authorities were the reasons why work on the ESDI (European Spatial Data Infrastructure) initiative, later known as INSPIRE (Infrastructure for Spatial Information in the European Community), was begun in the late 1990s.

1. EU legal basis of INSPIRE

24 April 2007 saw the publication of Directive 2007/2/EC of the European Parliament and of the Council of 14 March 2007 establishing the Infrastructure for Spatial Information in the European Community – INSPIRE. This regulation, which came into effect on 15 May 2007, was binding for EU Member States, obligating them to 'bring into force the laws, regulations and

administrative provisions necessary to comply with this directive by 15 May 2009' (article 24). In Poland, this directive was transposed into the Polish law system by the Law on Spatial Information Infrastructure of 4 March 2010. According to Article 1, Section 2 of the directive, 'INSPIRE shall build upon infrastructures for spatial information established and operated by the member states'. This infrastructure shall cover spatial data sets in electronic format, which are related to an area where a member state has and/or exercised jurisdictional rights and are held by or behalf of a public authority or a third party to whom the network has been made available, and which are related to one or more of the themes listed in Annex I, II or III of the Directive (Article 4). According to Article 5, Member States shall ensure that metadata are created for the spatial data sets and services corresponding to the themes listed in the Annexes. These countries are also obligated to carry out the process of harmonization of data sets and services (Chapter III, Article 7), as well as to establish and to operate a network of the following services for spatial data sets (Chapter IV, Article 11):

- discovery services (to search for spatial data sets and services on the basis of the content of the corresponding metadata and to display the content of the metadata);
- view services (as a minimum to display, navigate, zoom in/out, pan or overlay viewable spatial data and to display the legend);
- download services (enabling copies of spatial data sets, or parts of such sets, to be downloaded and, where practicable, accessed directly);
- transformation services (enabling spatial data sets to be transformed with a view to achieving interoperability);
- services allowing spatial data to be invoked.

According to Article 14, Section 1, Member States shall ensure that these services are available to the public free of charge. It is, however, possible to limit public access to spatial data and services, where such access would adversely affect: the confidentiality of proceedings of public authorities (where such confidentiality is provided for by law), international relations, public security or national defense, the course of justice or the confidentiality of commercial or industrial information (Article 13, Section 1). According to Article 17, 'each member state shall adopt measures for the sharing of spatial data and services between its public authorities'. In accordance with Article 18, 'Member States shall ensure the appropriate structures and mechanisms for coordinating, across the different levels of government, the contributions of all those with an interest in their infrastructures for spatial information'.

The EU implementing rules go into effect in the EU Member States' law systems directly (without transposition). Thus the common legislative basis of INSPIRE in all EU Member States includes 9 elements:

- Commission Regulation (EC) No 1205/2008 of 3 December 2008 implementing Directive 2007/2/EC of the European Parliament and of the Council as regards metadata, with the corrigendum of 15 December 2009 (defining the metadata elements and value domains);
- Commission Decision of 5 June 2009 implementing Directive 2007/2/EC of the European Parliament and of the Council as regards monitoring and reporting (describing the common provisions for monitoring and reporting, as well as setting the indicators concerning: metadata, spatial data sets, network services, quality assurance, functioning and coordination of the infrastructure, its use, data sharing arrangements);
- Commission Regulation (EC) No 976/2009 of 19 October 2009 implementing Directive 2007/2/EC of the European Parliament and of the Council as regards the Network Services (specifying the conditions concerning quality of service, and parameters of discovery and view services);
- Commission Regulation (EU) No 268/2010 of 29 March 2010 implementing Directive 2007/2/EC of the European Parliament and of the Council as regards the access to spatial data sets and services of the Member States by Community institutions and bodies under harmonised conditions (defining, among other factors, the maximal response time to provide spatial data sets and services);
- Commission Regulation No 1088/2010 of 23 November 2010 amending Regulation (EC) No 976/2009 as regards download services and transformation services (specifying the conditions concerning quality of service, and parameters of download and transformation services);
- Commission Regulation (EU) No 1089/2010 of 23 November 2010 implementing Directive 2007/2/EC of the European Parliament and of the Council as regards interoperability of spatial data sets and services (including a list of common data types, enumerations, code lists, generic network model, attributes, as well as requirements for spatial data themes listed in Annex I to the Directive);
- Commission Regulation amending Regulation 1089/2010 as regards interoperability of spatial data sets and services (amending the list of common data types, enumerations, code lists, code values, generic network model, attributes, and requirements for spatial data themes listed in Annex I to the Directive);
- Commission Regulation (EU) No 1253/2013 of 21 October 2013 amending Regulation (EU) No 1089/2010 implementing Directive 2007/2/

EC as regards interoperability of spatial data sets and services (amending the list of common data types, enumerations, code lists, code values, generic network model, attributes, and requirements for spatial data themes listed in Annex I to the Directive, as well as including the new lists to the data themes listed in Annex II and III).

These implementation laws are available at http://inspire.jrc.ec.europa.eu/index.cfm/pageid/3.

2. Implementation of INSPIRE directive in Poland

According to the Polish Law on Spatial Information Infrastructure of 4 March 2010, the governmental body responsible for the transposition of INSPIRE and the formation and development of Spatial Information Infrastructure in Poland was the Ministry of the Interior and Administration – since 18 November 2011 the Ministry of Administration and Digitization (Article 18, Section 1), which entrusted these tasks to the Surveyor General of Poland. As an NSDI coordinator, the Surveyor General of Poland is responsible for building and maintaining the national geoportal (geoportal.gov.pl), being the central access point to the spatial data services. The Surveyor General is also responsible for the registering of spatial data and spatial services, NSDI planning, monitoring and reporting. The Surveyor General of Poland is a National Contact Point for INSPIRE with the European Commission. The advisory organ of the Surveyor General is the Spatial Data Infrastructure Council, whose responsibilities include the planning of development of NSDI. According to the Law on Spatial Information Infrastructure, 34 INSPIRE thematic groups were assigned to 12 leading bodies (table 1).

Table 1. INSPIRE spatial data themes and Polish leading bodies

Leading body	No.	Spatial data themes
Minister in charge of the infrastructure: Minister of Infrastructure and Development	3.4	Land use
Minister in charge of the Maritime Economy: Minister of Infrastructure and Development	1.8 3.15 3.16	Hydrography Oceanographic geographical features Sea regions
Minister of Culture and National Heritage	1.9	Protected sites (historical monuments)

Leading body	No.	Spatial data themes
Minister of Agriculture and Rural Development	3.9	Agricultural and aquaculture facilities
Minister of Environment	**1.9** 3.12 3.13 3.14 **3.19**	**Protected sites** Natural risk zones Atmospheric conditions Meteorological geographical features **Species distribution**
Surveyor General of Poland	1.1 1.2 2.3 3.11	Coordinate reference systems Geographical grid systems Orthoimagery Area management / restriction / regulation zones and reporting units (with Minister of Environment)
Surveyor General of Poland co-leading with: • President of the Central Statistical Office, Minister of Administration and Digitization, Minister of Culture and National Heritage • President of the Central Statistical Office • President of the Central Statistical Office • President of the Central Statistical Office, Director of The State Forests National Forest Holding • Minister of Infrastructure and Development • Minister of National Defence • **Chief Inspector of Environmental Protection,** President of Agency for Restructuring and Modernisation of Agriculture • Minister of Infrastructure and Development • Minister of Agriculture and Rural Development, President of Agency for Restructuring and Modernisation of Agriculture, **Chief Inspector of Environmental Protection** • Minister of Environment, Minister of Health, Minister of Administration and Digitization Minister of Economy • Minister of Environment • Minister of Environment	1.3 1.4 1.5 1.6 1.7 2.1 2.2 3.2 3.3 3.6 3.8 3.11	Geographical names Administrative units Adresses Cadastral parcels Transport networks Elevation Land cover Buildings Soil Utility and governmental services Production and industrial facilities Area management / restriction / regulation zones and reporting units

Leading body	No.	Spatial data themes
Minister of Health	3.5	Human health and safety
Chief National Geologist	2.4 3.20	Geology Energy resources
Chief Inspector of Environmental Protection	**3.7**	**Environmental monitoring facilities**
Chief Nature Conservator	**3.17** **3.18**	**Bio-geographical regions** **Habitats and biotopes**
President of the Central Statistical Office	3.1 3.10	Statistical units Population distribution – demography
President of National Water Management Authority	1.8	[Inland] Hydrography

All leading bodies are responsible for the identification of spatial data and spatial services, as well as its notification; the production, updating, validation and publication of metadata (Article 5, Section 1); spatial data harmonization (Article 7), its updating and publication in close cooperation with the Surveyor General of Poland; setting up and maintaining spatial data services (Article 9) and the organization of training for public administration (Article 6).

Implementation of INSPIRE in Poland has given rise to a need to amend 6 laws: the Law on Geodesy and Cartography of 17 May 1989, the Law on Geology and Mining of 4 February 1994, the Law on Public Statistics of 29 June 1995, the Law on Environmental Protection of 27 April 2001, the Law on Protection of Nature of 16 April 2004, the Law on Recycling of Motorized Vehicles of 20 January 2005. In the case of the latter five laws, an obligation was introduced for the registration of the geographical coordinates of objects mentioned in the laws.

By the end of 2013 it was also necessary to publish 24 Polish implementation orders. Three of them: the Order of the Minister of the Interior and Administration of 13 September 2010 on Spatial Data Infrastructure Council; the Order of the Minister of the Interior and Administration of 20 October 2010 on register of spatial data and spatial data services included into the NSDI and a Government order of 12 April 2012 on the National Framework of Interoperability, minimal requirements for public register and numerical data exchange, and minimal requirements for data transmission systems are of great importance for implementation of INSPIRE directive in Poland. Next three orders were bounded up with the Law on Geology and Mining. Two implementation regulations: the Order of the Minister of the Environment, the Minister of Transport, Construction and the Maritime Economy, the Minister of Administration and Digitization and the Minister of the Interior on the development of flood hazard maps and flood risk maps; the Order of the Minister of the Environment of 11 September 2012 on the Central Register of Protected Areas were directly connected with the subject of biodiversity. The rest of orders were bounded up with the Law on Geodesy and Cartography. The full list of these orders and its description was done by Dukaczewski (2011).

3. Implementation tasks related to the biodiversity

According to Law on Spatial Information Infrastructure, the Minister of the Environment is directly responsible for the coordination of tasks related to two INSPIRE thematic groups concerning biodiversity: 1.9 'Protected sites' and 3.19 'Species distribution'. As the superior of the Chief Inspector of Environmental Protection, the Minister of the Environment is also indirectly responsible for group 3.7 'Environmental monitoring facilities' and as the superior of the Chief Nature Conservator – for groups 3.17 'Bio-geographical regions' and 3.18 'Habitats and biotopes'. Thereby the Minister of the Environment, the Chief Inspector of Environmental Protection and the Chief Nature Conservator are responsible for all tasks mentioned in articles 5, 6, 7 and 9 of the Law on Spatial Information Infrastructure of 4 March 2010. The most labour-intensive task is the harmonization of spatial data and spatial data services. This should be carried out according the 7 Commission regulations and one Commission decision mentioned above, as well as 5 INSPIRE Data specifications:

- D2.8.III.17 Data Specification on Bio-geographical Regions – Technical Guidelines, v. 3.0;
- D2.8.III.18 Data Specification on Habitats and Biotopes – Technical Guidelines, v. 3.0;
- D2.8.III.19 Data Specification on Species Distributions – Technical Guidelines, v. 3.0;
- D2.8.III.7 Data Specification on Environmental Monitoring Facilities – Technical Guidelines, v. 3.0;
- D2.8.I.9 Data Specification on Protected Sites – Technical Guidelines, v. 3.1.0.

All INSPIRE data specifications are made according to the methodology described in ISO 19 131 norm 'Geographic Information – Data Product Specification UML' and INSPIRE DS-D2.6 'Methodology for the development of data specification' document. The data model is described in a natural language (in English) and in UML. The objects and data are described according with INSPIRE DS.-D2.5 'Generic Conceptual Model' document. All data specifications include information on the thematic scope of data (defined by types of objects, their attributes and relations), identification information, data content and structure including basic notions (on stereotypes, placeholder and candidate types, voidable characteristics, enumerations, code lists and coverages) and application schemas, spatial and temporal reference systems, data quality, rules concerning metadata, delivery, as well as data portrayal. They include also abstract test suites and informative use cases and examples from different countries.

Some of elements of these specifications are common, like coordinate and temporal reference systems, identifiers for coordinate reference systems, metadata, data quality requirements, encoding, identifiers, portrayal. In the case of the coordinate reference system the datum of the European Terrestrial Reference System 1989 (ETRS89) in areas within its geographical scope (i.e. Poland) should be employed. In areas that are outside the geographical scope of ETRS89 the datum of ITRS (or other geodetic coordinate reference system compliant with ITRS) can be used. For the vertical component on land the European Vertical Reference System (EVRS) shall be employed. In the case of three-dimensional coordinate reference systems it is possible to employ the three-dimensional Cartesian coordinates or three-dimensional geodetic coordinates, using the parameters of the GRS80 ellipsoid. In the case of two-dimensional coordinate reference systems it is possible to use the two-dimensional geodetic coordinates and the parameters of the GRS80 ellipsoid. It is also possible to employ plane coordinates using the Lambert Azimuthal Equal Area projection (for majority of standard visualisations and spatial analyses) or the Lambert Conformal Conic (especially for visualizations of extensive areas at 1: 500 000 or smaller scale) or Transverse Mercator projection (for visualizations of extensive areas at scale bigger than 1: 500 000). The Universal Time Coordinated – UTM (or local time including the time zone as a offset from UTM) shall be employed as a temporal reference system, while Gregorian calendar shall be used as a reference system for date values. The visualization of data sets should be in accordance with D003 152/02 specification. The description of the elements and measure of data quality are based on Annex D of ISO/DIS 19 157 'Geographic information – Data quality' standard. It should be emphasized, that the metadata describing spatial data set series related to all themes concerning the biodiversity shall comprise the metadata elements required by the by Regulation

1205/2008/EC and specified in Table 2 and Table 3. The common encoding system is GML and common character set is UTF-8.

The key spatial object of the application schema 'Bio-geographical Regions' is the feature type 'Bio-geographicalRegion'. The structure of this application schema is simple – 'Bio-geographicalRegion' is the only single spatial object type and represents any type of bio-geographical. Each spatial object comprise information on geometry, an identifier and classification properties. The classification system is specified by 3 attributes: information on the classification scheme, the classification value and voidable attribute 'regionClassificationLevel'. Values for first two attributes can be selected from a code list, while the values for the third attribute document the level of the classification (international, national, regional, local). It should be stressed that currently this application schema includes 4 distinct European classification schemes, but through the mechanism of code lists this model can be extended to include other classifications, for example: Natura2000 and Emerald Bio-Geographical regions, Environmental Stratification of Europe, Natural Vegetation of Europe, Marine Strategy Framework Directive regions. However links between the 'Bio-geographicalRegion' application schema and 'SpeciesDistribution' package have been identified, it should be stressed that currently no explicit associations are necessary from 'Bio-geographicalRegion' application schema to this theme.

The Data Specification on Habitats and Biotopes includes the specification of rules concerning the identification of habitats and biotopes themselves, as well as specification of rules concerning of their distribution. In the first case it is necessary to define the geometry of the object, type of habitat, habitat species type, local name (and language), habitat type and habitat vegetation type. It is possible also to specify the habitat species, habitat vegetation, local species name and area of the habitat. In the case of the specification of habitat and biotope distribution, it is obligatory to define the identifier of the habitat, its name and short name geometry, type of the habitat and source of information. It is also possible to specify the data on lifespan, total area and local names. Currently links between the 'HabitatsAndBiotopes' application schema and 'SpeciesDistribution' package have been identified.

The key spatial object of the application schema 'SpeciesDistribution' in Data Specification on Species Distributions is the spatial object type 'SpeciesDistributionDataSet', which represents collection of instances of the species distribution units defined by spatial object type 'SpeciesDistributionUnit'. A 'SpeciesDistributionDataSet' must have an identifier and can have domain extent, life span and name as a voidable attributes. The 'SpeciesDistributionUnit' shall be employed to present species distribution data aggregated over the units with geometry (i.e. areas, grid cells) and over periods of time. The 'SpeciesDistributionUnit' must have an identifier, information about the geometry and information on the species name and can have information about the life cycle of the data object as a voidable attribute. The data type 'DistributionInfoType' includes the information about the occurrence category. It can provide also the voidable data on population size, the residency status and information on the sensitiveness of these population. It is also possible to specify the data on lifespan, total area and local names. However links between the 'SpeciesDistribution' application schema and 'HabitatsAndBiotopes', 'ProtectedSites, as well as 'Bio-geographicalRegion' packages have been identified, it is to emphasize, that no explicit associations are necessary from 'SpeciesDistribution' application schema to these themes.

The Data Specification on Environmental Monitoring Facilities comprises rules concerning encoding data on monitoring networks, its devices, scientific projects, as well as direct links to the data. The application schema contains 4 spatial object types: Environmental Monitoring Programme, Environmental Monitoring Activity, Environmental Monitoring Network and Environmental Monitoring Facility. The key spatial object type of the application schema 'EnvironmentalMonitoringFacility' is the 'AbstractMonitoringObject'. This object type must have an identifier, name and information about the geometry. This object can be fixed, mobile or attached to other one. As such a facilities can be described at various levels of detail, the model provides a hierarchical link between them. The 'EnvironmentalMonitoringNetwork' is a spatial object type in the model, which consists of a number of environmental facilities. It can provide the voidable data on the organisation level. The 'EnvironmentalMonitoringProgramme' is a policy relevant description defining the target of a collection of observation in the field. The 'EnvironmentalMonitoringActivity' express the need to describe environmental campaigns which are carried out with specific equipment for a specific period of time. The feature type 'EnvironmentalMonitoringActivity' must have an identifier and can include the voidable data about the operational time, activity conditions, responsible party and link to the data.

The Data Specification on Protected Sites includes rules concerning objects and areas of habitat, bird and water directives, as well as areas protected under the World Heritage Convention, Ramsar Convention, Barcelona Convention, Helsinki Convention, OSPAR Convention, and (last but not least) all protected areas set up on the basis of the national laws of EU member states. The key class of three application schemas employed in this data specification (the Simple application schema, the Full application schema, the Natura2000 application schema) is the 'ProtectedSite'. This class contains Protected Sites of all types, possibly including multiple versions (differentiated using the object identifier). The Simple application schema is a subset of the Full application schema and contains a limited set of fundamental attributes only on current Protected Sites (geometry, identifier, name, designation type, legal foundation time, document reference). The Full application schema includes all attributes of current and historical Protected Sites. It is to mention, that majority of them is voidable (activities and impact, spatial resolution, site description, quality and importance, vulnerability, ownership, documentation, legal expiry date, official list, site length, founding source, site management plan, Natura2000 respondent, protected entity, present habitat, time period, life cycle). The Natura2000 application schema includes all attributes of current and historical Protected Sites, as well as a number of constraints, particularly specifying mandatory attributes required for updating and maintaining of Natura2000 site data by Member States. The links between the 'ProtectedSites, application schema and 'HabitatsAndBiotopes', 'SpeciesDistribution', 'Bio-geographicalRegion' have been identified.

All these specifications are available at http://inspire.jrc.ec.europa.eu/index.cfm/pageid/2.

According to the INSPIRE time schedule the metadata on spatial data mentioned in Annex III to the Directive (and included in the national spatial data registers) should be available by 3 December 2013. The new and significantly modified spatial data mentioned in Annex I and III should be available by January 2015. All other spatial data corresponding to the thematic groups of Annex I should be available by June 2016. All other spatial data mentioned in Annex II and III should be available in a final form by 30 May 2019.

Conclusions

The implementation of the INSPIRE directive has contributed to the considerable stimulation of legislative work on NSDI in many European countries. The setup of INSPIRE infrastructure and development of NSDI have provoked very intensive work on the production and adaptation of metadata. The EU implementing rules have laid down a general technical arrangements for the interoperability and harmonization of spatial data sets and services, while the data specifications have defined the detailed rules, which must be accomplished to achieve the interoperability of spatial data sets. The application schemas published in data specifications can allow Member States to satisfy the requirements concerning the preparation of data sets, while the encoding system (GML) will assure the common format of its publication. Analysis of the data specifications concerning thematic groups related to biodiversity has shown that the thematic scope of data and metadata which should be taken into consideration in the case of INSPIRE infrastructure is not very extended. However, it should be emphasized that the scope of tasks related to the adaptation of spatial data sets and metadata to published requirements is very wide and time-consuming. The adaptation of metadata and data, as well as spatial data and spatial services harmonization will allow to achieve the interoperability of data sets and services which, should lead to significant improvement of access to the data and its sharing by many institutions in EU countries.

Bibliography

BIELECKA E. 2011. In: S. Białousz and E. Bielecka (ed.) INSPIRE i Krajowa Infrastruktura Informacji Przestrzennej. Podstawy teoretyczne i aspekty praktyczne. Skrypt dla uczestników Szkolenia Eksperckiego, pp. 87–106. GUGiK, Warszawa.

Commission Regulation (EC) No 1205/2008 of 3 December 2008 implementing Directive 2007/2/EC of the European Parliament and of the Council as regards metadata. Official Journal of the European Union, L.326:12-29. 4.12.2008.

Corrigenda. Corrigendum to Commission Regulation (EC) No 1205/2008 of 3 December 2008 implementing Directive 2007/2/EC of the European Parliament and of the Council as regards metadata. Official Journal of the European Union, L.328:83. 15.12.2009.

Commission Decision of 5 June 2009 implementing Directive 2007/2/EC of the European Parliament and of the Council as regards monitoring and reporting. Official Journal of the European Union, L.148:18-26. 11.06.2009.

Commission Regulation (EC) No 976/2009 of 19 October 2009 implementing Directive 2007/2/EC of the European Parliament and of the Council as regards the Network Services Official Journal of the European Union, L.274: 9-18. 19.10.2009.

Commission Regulation (EU) No 268/2010 of 29 March 2010 implementing Directive 2007/2/EC of the European Parliament and of the Council as regards the access to spatial data sets and services of the Member States by Community institutions and bodies under harmonised conditions. Official Journal of the European Union, L.83:8-9. 30.03.2010.

Commission Regulation No 1088/2010 of 23 November 2010 amending Regulation (EC) No 976/2009 as regards download services and transformation service. Official Journal of the European Union, L.323:1-8. 8.12.2010.

Commission Regulation (EU) No 1089/2010 of 23 November 2010 implementing Directive 2007/2/EC of the European Parliament and of the Council as regards interoperability of spatial data sets and services Official Journal of the European Union, L.323:11-102. 08.12.2010.

Commission Regulation (EU) No 102/2011 of 4 February 2011 amending Regulation 1089/2010 as regards interoperability of spatial data sets and services. Official Journal of the European Union, L.31:13-34. 05.02.2011.

Commission Regulation (EU) No 1253/2013 of 21 October 2013 amending Regulation (EU) No 1089/2010 implementing Directive 2007/2/EC as regards interoperability of spatial data sets and services. Official Journal of the European Union, L.331:1-267. 8.12.2013.

D2.8.III.17 Data Specification on Bio-geographical Regions – Technical Guidelines, v. 3.0. European Commission Joint Research Centre. 10.12.2013.

D2.8.III.18 Data Specification on Habitats and Biotopes – Technical Guidelines, v. 3.0. European Commission Joint Research Centre. 10.12.2013.

D2.8.III.19 Data Specification on Species Distributions – Technical Guidelines, v. 3.0. European Commission Joint Research Centre. 10.12.2013.

D2.8.III.7 Data Specification on Environmental Monitoring – Technical Guidelines, v. 3.0. European Commission Joint Research Centre. 10.12.2013.

D2.8.I.9 Data Specification on Protected Sites – Technical Guidelines, v. 3.1.0. European Commission Joint Research Centre. 03.05.2010.

Directive 2007/2/EC of the European Parliament and of the Council of 14 March 2007 establishing an Infrastructure for Spatial Information in the European Community – INSPIRE. Official Journal of the European Union, L.108. 14 pp.

Dukaczewski D. 2011. Przepisy wykonawcze do ustawy o Infrastrukturze Informacji Przestrzennej. In: S. Białousz and E. Bielecka (ed.) INSPIRE i Krajowa Infrastruktura Informacji Przestrzennej. Podstawy teoretyczne i aspekty praktyczne. Skrypt dla uczestników Szkolenia Eksperckiego, pp. 458–477. GUGiK, Warszawa.

EKLUND O. 1977. GISA: a Geographic Based Information System. Cartographica Monograph. 20: 94-98.

GAŹDZICKI J. 2008. Implementacja dyrektywy INSPIRE w Polsce: stan aktualny, problemy i wyzwania. Roczniki geomatyki. VI 3: 21 – 30.

GAŹDZICKI J. 2009. Druga faza programu prac INSPIRE: stan w Europie i wyzwania dla Polski. Roczniki geomatyki. VII 6(36). 61 – 72.

GAŹDZICKI J. 2011, Prawo Unii Europejskiej kształtujące INSPIRE. Roczniki geomatyki. IX 6(50): 21 – 30.

ISO 19 131: 2007 Geographic Information – Data Product Specification UML.

ISO/DIS 19 157 Geographic information – Data quality.

Rozporządzenie Ministra Spraw Wewnętrznych i Administracji z dnia 13 września 2010 r. w sprawie Rady Infrastruktury Informacji Przestrzennej. Dziennik Ustaw 2010, Nr 183, poz. 1233: 13912.

Rozporządzenie Ministra Spraw Wewnętrznych i Administracji z dnia 20 października 2010 r. w sprawie ewidencji zbiorów i usług danych przestrzennych objętych infrastrukturą informacji. Dziennik Ustaw 2010, Nr 201, poz.1333: 14526-14530.

Rozporządzenie Ministra Środowiska z dnia 11 września 2012 r. w sprawie centralnego rejestru form ochrony przyrody. Dziennik Ustaw 2012, Nr 0, poz. 1080: 1-8.

Rozporządzenie Ministra Środowiska, Ministra Transportu, Budownictwa i Gospodarki Morskiej, Ministra Administracji i Cyfryzacji oraz Ministra Spraw Wewnętrznych w sprawie opracowania map zagrożenia powodziowego oraz map ryzyka powodziowego. Dziennik Ustaw 2013, poz. 104: 1 – 11.

Rozporządzenie Rady Ministrów z dnia 12 kwietnia 2012 r. w sprawie Krajowych Ram Interoperacyjności, minimalnych wymagań dla rejestrów publicznych i wymiany in-

formacji w postaci elektronicznej oraz minimalnych wymagań dla systemów teleinformatycznych. Dziennik Ustaw 2012, Nr 0, poz. 526: 1-18.
RYSTEDT B. 1977. The Swedish Land Data Band – A Multipurpose Information System. Cartographica Monograph. 20: 19-48.
Le SIGeT. 1994. Mairie de Toulouse. 69 pp.
Le Système d'Information Géographique de Toulouse. D.T.M.G., Mairie de Toulouse. 15 pp.
TOMLINSON R.F., CALKINS M.W., MARBLE D.F. 1977. Computer Handling of Geographical Data. An Examination of Selected Geographic Information Systems. UNESCO, Paris.
Ustawa z dnia 4 marca 2010 o infrastrukturze informacji przestrzennej. Dziennik Ustaw 2010, nr 76, poz. 489: 6462-6477.

RESULTS OF STUDIES OF NATURE RESOURCES AS A SOURCE OF SPATIAL DATA FOR A REGIONAL INFORMATION SYSTEM UNDER THE AUSPICES OF THE BIOGEO-SILESIA ORSIP GROUP

Barbara Tokarska-Guzik[1*], Ryszard Chybiorz[2], Jerzy B. Parusel[3], Jacek Frąckowiak[4]

[1]Faculty of Biology and Environmental Protection, University of Silesia, Katowice, Poland

[2]Faculty of Earth Sciences, University of Silesia, Sosnowiec, Poland

[3]Centre of Nature Heritage of Upper Silesia, Katowice, Poland

[4]Pro-Info Jacek Frąckowiak, Murowana Goślina, Poland
[*]e-mail: barbara.tokarska-guzik@us.edu.pl

ABSTRACT: The Silesia Voivodeship is currently establishing an Open-access Regional Spatial Information System (ORSIP) whose purpose is to set up a regional open-access digital platform integrating referential and thematic spatial data resources. An Open-access Spatial Database will be an integral part of ORSIP, or more specifically, of the 'Nature' subsystem, which is being set up under the "Open-access Bio- and Geodiversity Database of the Silesia Voivodeship – an integral part of the Open-access Regional Spatial Information System, BIOGEO-SILESIA ORSIP" project, dedicated to animate and inanimate components of nature. This database will cover information cross-referenced to 18 sets of data on biodiversity, and 1 set of data on geosites in the Silesia Voivodeship. Data from scientific research are the basic source of information.
Decision-making is essential to address conceptual, organisational and legal problems encountered during the various stages of project implementation. In essential terms, the key elements of BIOGEO-SILESIA project were as follows: accumulating a representative team of experts working with a specific type of data; identification of 'external' sources of data to supplement the existing resources; compilation of concepts and descriptions of the structure of specific thematic sets of data, and, with respect to each and every one of them, it was essential to: identify constrains/risks related to the incorporation (sharing) of personally-owned data to the database; validation of quality and validity of external data; assignment to the existing geometric data sets and consolidation of nomenclature, terminology, systematics and classification of descriptive data.

KEYWORDS: biological diversity, geological diversity, GIS, nature resources database, Silesia Voivodeship, Poland

Background

Human beings have been observing the nature from the beginning of time; historical scripts and other artefacts provide ample evidence of such observations dating back to the ancient times (Tykarski 2007). Today's observations of nature are based on modern methods of data collection, storage, handling, processing, sharing and dissemination. They are intended to explore the components of nature, how they interrelate and change in time, how they are influenced by human, and what are the mechanisms of life on Earth (Zając 1978; Tykarski 2007; Kącki & Śliwiński 2011; Chybiorz & Tokarska-Guzik 2012; Trueman 2013). In the 21st century, studies of natural resources became a vital tool in evaluating the impact of human on the ecosystem, and the results of environmental studies are the indicators and the measures of environmental impact of human activities and their compliance with the sustainable growth principles. Studies of natural resources are undeniably fundamental for the survival of human and the preservation of nature in a state which is changed as little as possible. Accessible through open-access databases and geoportals, the results of such research can become an effective tool used in the management of natural resources, encouraging active involvement of the society (Geneletti 2004; Walczak 2011; TNCMAPS).

Today, the assessment of human impact on natural habitats and the planning of environmental protection (of species, natural habitats) cannot do without integrating the knowledge we have on the natural resources existing in a specific region and the spatial dimension of existing data (McPherson *et al*. 2008; Kaminski *et al*. 2013; Murrow *et al*. 2013).

Also, new analyses can be now performed, both explorative and practical in nature, by combining latest developments in photogrammetry and teledetection and the expertise shared in the form of descriptive data, by merging information from different sources and by combining facts (Dewey *et al*. 1991; Franklin *et al*. 2000; Thuiller *et al*. 2005; Sluiter & Pebesma 2010; Dorigo *et al*. 2012).

The existing stakeholders: public administration bodies, businesses, researchers and private individuals increasingly use spatial databases or geoportals to find and access spatial information (Białousz 2013). The spatial data themes are, as a rule, made conditional on the needs of potential uses, and also depend on the existing technical, organisational and intellectual background of the database creator, owner or administrator.

The Silesia Voivodeship is currently establishing an Open-access Regional Spatial Information System (abbreviated ORSIP) whose purpose is to set up a regional open-access digital platform integrating referential and thematic spatial data resources. The new platform will make room for cooperation in collecting and sharing spatial data both internally, within public administration bodies of the Silesia Voivodeship, and externally, by sharing data with independent institutions or citizens (http://mapy.orsip.pl/imap/).

This Open-access Spatial Database (abbreviated OBD) will be an integral part of ORSIP, or more specifically, of the 'Nature' subsystem, which is

being set up under the "Open-access Bio- and Geodiversity Database of the Silesia Voivodeship – an integral part of the Open-access Regional Spatial Information System, BIOGEO-SILESIA ORSIP" project, dedicated to biotic and abiotic components of the regional natural resources (http://biogeo.us.edu.pl/).

The database, created by researchers from two independent faculties of the University of Silesia (the Faculty of Biology and Environmental Protection and the Faculty of Earth Sciences) in collaboration with the Silesia Voivodeship (The Centre for the Natural Heritage of Upper Silesia, and the Silesian Centre for Information Society) covers information cross-referred to 18 sets of biodiversity data and 1 set of data on geosites in the Silesia Voivodeship. Data from scientific research are the basic source of information. Biodiversity data sets go beyond the GIS environmental protection data standard (Chybiorz & Tokarska-Guzik 2012; Tokarska-Guzik *et al*. 2013a & b) as the narrow scope of knowledge it represents (Sadowski 2011) is too limited to satisfy the needs of many institutions involved in conducting environmental studies (Burdziel *et al*. 2013; Zbierska 2013).

Decision-making is essential to address conceptual, organisational and legal problems encountered during the various stages of project implementation. Therefore this paper seeks to identify conceptual (and technical) problems which are likely to be encountered along the way.

Materials and methods

The starting point for identifying conceptual problems of the BIOGEO-SILESIA ORSIP project was the analysis of the results of the "Diagnosis of the state of resources of the natural environment of the Silesian Voivodeship" for the purpose of the "Strategy of the conservation of nature of the Silesian Voivodeship to 2030", which revealed that a comprehensive database dedicated to biodiversity and geodiversity has been missing and pointed out to the major needs and problems in environmental management at the regional scale (Fig. 1).

The conceptual assumptions made to identify problems, or critical points, during specific stages of the project implementation have been examined with reference to (i) conceptual, (ii) organisational, and (iii) legal aspects.

Detailed tasks have been focused on:

- establishing clear definitions and general assumptions to provide a basis for determining major goals of the database, defining the scope of data sets, and designing the data model;
- setting up indicators for environmental monitoring at regional level.

The tasks have been implemented stage-wise, by means of analyses of the effects of adaptations/verifications of existing definitions, nomenclature, pre-defined criteria (originating from different sources), existing solutions, experience and the results of studied carried out by the project participants.

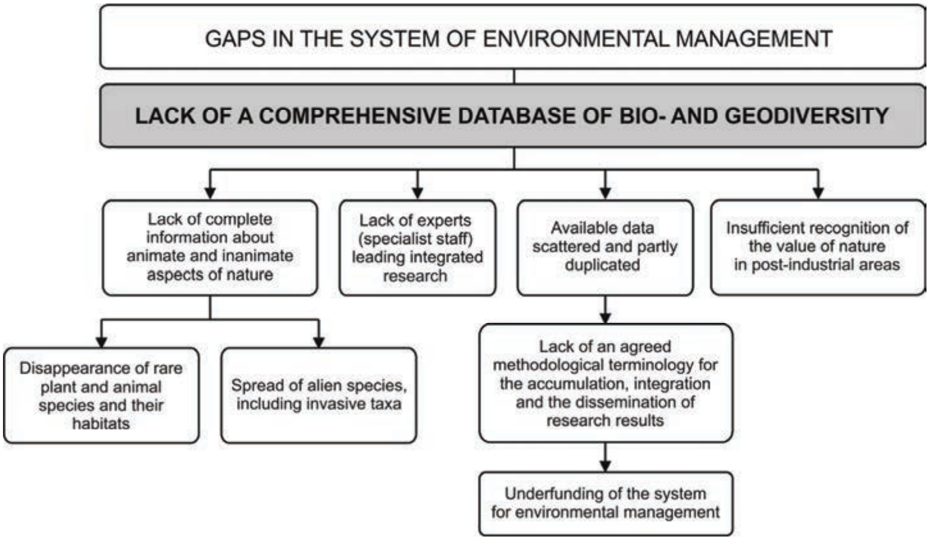


Fig.1. Management of the natural environment in the Silesian Administrative Region by "Diagnosis of the state of resources of the natural environment of the Silesian Voivodeship", in: Strategy of the conservation of nature of the Silesian Voivodeship to 2030.

Source: the Centre of Nature Heritage of Upper Silesia and selected case studies; http://www.cdpgs.katowice.pl/attachments/257_strategia-ochrony-przyrody.pdf

Results

Purpose, general assumptions and database model

The purpose of the Open-access Spatial Database set up under the BIO-GEO-SILESIA ORSIP project is to systematically collect, process, feed, update and disseminate descriptive and spatial data on biotic and abiotic resources: their abundance, distribution, resources, preservation, (active and passive) protection, risks, use and development as necessary for the proper environmental management at regional scale, reflecting the principles of sustainable and balanced development (Fig. 2).

Environmental management will rely on continuous diagnosis of the condition of the environment using a set of environmental monitoring indicators and regular forecasts of changes in the environment, followed by short- and long-term action plans and programmes intended to safeguard sustainable development.

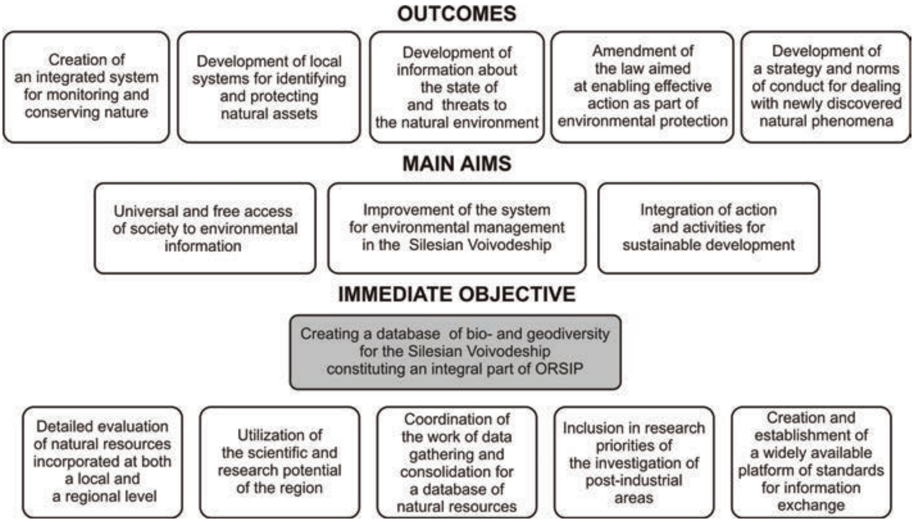


Fig. 2. Aims of the BIOGEO-SILESIA ORSIP project

Explanation: ORSIP – Open-access Regional Spatial Information System

The database should also cover other information on biotic and abiotic components of the natural resources which is important for scientific, didactic and educational purposes.

The database structure should be such to facilitate its adaptation to the prospective needs of the user of the database system dedicated to the environment. The data set should provide for interoperability and compatibility with selected international (global), European, EU (EEA or leading databases in the Member States) and national databases.

The data set should be a source of reliable information arranged in the following general pattern: what (species, natural habitat/communities, area, object, etc.), where (locality, place), when (when was the information collected), how many (population size, area, etc.), how (preservation status, risks, etc.) whose (owner, administrator, supervisor, etc.), intentions (protection, utilization, recultivation, revitalization, restitution, introduction plans, etc.), who (source of information, contributor).

As a minimum, a data set should include the following information (or such information should be accessible via other referenced database systems) (Table 1):

A/ Species, natural habitats, plant communities: 1/full name (of species / natural habitats / plant communities) in Polish and Latin, incl. synonyms, 2/location of information/observation, 3/site geometric data, 4/ observation data/year of publication, 4/ observation source/author, 5/ observation place (site), 6/ detailed observation data / information about: animal, population, natural habitat, plant community, 7/ area occupied, 8/ evaluation of the population/natural habitat/plant community condition on site, 9/ evaluation of the risk the population/natural habitat/plant community is exposed to on site, 10/ environmental protection status, 11/ environmental protection perspectives, 12/ management of species population/natural habitat/plant community (supervisor of the area/existing plans and programmes for environmental protection, utilization, recultivation, revitalisation, restitution, introduction).

Table 1. The data set range accessible via BIOGEO-SILESIA database systems for species, plant communities and natural habitats (generalized).

Type of information	**Objects**			
	Flora (mosses & vascular plants)	**Fauna** (selected invertebrates & all vertebrates)	**Plant communities** (vegetation)	**Natural habitats**
Taxonomy & nomenclature Syntaxonomy & classication	x	x	x	x
Ecological indicators	x	-	-	-
Biology of species	x	x	-	-
Origin & range	x	x	x	x
Invasiveness	x	x	x	-
Conservation status	x	x	x	x
Threat status	x	x	x	x
Qualitative characters of plant community	-	-	x	-
Type of habitat	-	-	x	-
Qualitative characters of habitat	-	-	-	x
Additional information	x	x	x	x
Sources of information/Links	x	x	x	x
	Observations			
Locality (geographic coordinates and additional information)	x	x	x	x

Type of information	Objects			
	Flora (mosses & vascular plants)	**Fauna** (selected invertebrates & all vertebrates)	**Plant communities** (vegetation)	**Natural habitats**
Data	x	x	x	x
Source of information	x	x	x	x
Features of the habitats (including post-industrial)	x	x	x	x
Population data	x	x	-	-
Phytosociological relevé	x	-	x	-
Herbarium documentation	x	-	-	-
Scientific/museum collection	-	x	-	-
State of the protection of the species on the observed site	x	x	x	x
Current impacts and threats	x	x	x	x
Potential impacts and threats	x	x	x	x
Management and the active protection	x	x	x	x
Additional information	x	x	x	x

B/ Areas, objects: 1/full name/location of the area/object, 2/ geometric data of the area/object, 3/ observation data/year of publication, 4/ observation source/author, 5/ area occupied, 6/ land use structure, 7/ land ownership structure, 8/ intended use of land (= conclusions of the study of conditions and directions of spatial development), 9/ risks, 10/ protection status, 11/ protection perspectives, 12/ area management (supervisor, existing plans and programmes for protection, use, recultivation, revitalisation, restitution, introduction).

C/ Information common for all thematic datasets (separate databases / dictionary tables / integrating): 1/ sources of information (references), 2/ multimedia information (graphics, images, sound), 3/ spatial information/cartography (validity, reliability, exactness of data localisation), 4/ glossary of terms used in the database, 5/ user manuals, 6/ links to specific themes (to international, European, and EU databases; databases of Member States or leading institutions, national databases) and general links.

D/ Data set in all specific databases dedicated to particular subject area (thematic databases) should also include an introduction, i.e. a concise summary of the database contents. Dictionary tables should be coherent and based on the current laws and regulations, standards, generally recognised models and methods.

Data model should rely on realistic assumptions; account must be taken of the actual legal, organisational, technological, financial and time-related constrains in its implementation.

According to what has been assumed, the Open-access Spatial Database dedicated to natural resources, based on pre-defined criteria, would make it possible to accomplish the project objectives, or more specifically, it would provide the general public with open and free access to environmental information, contribute to the improvement of environmental management system in the Silesia Voivodeship, and consolidate concerted actions for sustainable development (Fig. 2).

Environmental monitoring system in the Silesia Voivodeship

An environmental monitoring system should take into account the guidelines of the cause-and-effect framework of DPSIR indicators, which help identify the driving forces generating pressures on the environment and resulting in a specific state of the environment, as well as the environmental impact and social responses to changes in the environment. DPSIR indicators have been used by the European Environmental Agency, the Executive Secretariat of the Convention on Biological Diversity, the Organisation for Economic Co-operation and Development, and the UN Commission on Sustainable Development. The model should reflect the principles and conceptual guidelines arising out of the implementation of the INSPIRE (Infrastructure for Spatial Information in the European Community) Directive in EU Member States, and the resulting implementations into national legislation.

According to the project, as many as 20 environmental monitoring systems were assumed to be established in the Silesia Voivodeship. More specifically, these are environmental monitoring subsystems. A set of (several or more) numerical indicators has been proposed for each of the subsystem, with a total of 45 indicators. The following environmental monitoring subsystems have been designed: 1/ examination status of biotic resources, 2/ examination status of abiotic resources, 3/ abundance of biotic resources, 4/ abundance of abiotic resources, 5/ protection status of biotic resources, 6/ protection status of abiotic resources, 7/ preservation status of biotic resources, 8/ risk status of biotic resources, 9/ extinction and loss status of biotic resources, 10/ synanthropisation of biotic resources, 11/ invasion of alien species, 12/ adaptation of biotic resources to changes in the environment, 13/ functioning of biota resources, 14/ modelling of potential habitats of rare, endangered and protected species, 15/ modelling of potentially rare, endangered and protected natural habitats, 16/ modelling of habitats potentially exposed to changes in the environment, 17/ use of databases in the management of natural resources, 18/ implementation of plans and programmes for the protection of natural resources, 19/ implementation of programmes for the monitoring of natural resources, 20/ environmental awareness of local residents.

These indicators will be computed from simple mathematical formulas in Microsoft Excel, and on the basis of simple spatial analyses using GIS software. The major share of results will be compiled into a report from a thematic database or with the use of functionalities available in the ORSIP IT environment. Indicators will be computed by an expert in charge of the database, or may be also calculated directly by the use (if the indicator in question uses data from a database only).

The indicators will be computed for various time frames: annual, multiyear or random. The frequency depends on the degree to which the thematic database is complete and populated with data referring to the specific subject area.

The indicators will be computed mainly by relying on data compiled into thematic databases; reference data disclosed specifically for project implementation or submitted from other public bodies will be also in use. A part of data needed to calculate the indicators will be drawn from publications or experts' knowledge.

Reports will be compiled from the database, diagrams, cartograms, thematic maps for areas diversified in administrative terms (voivodeship, district, commune) and in geographic terms (in any regionalization units of natural resources) using functionalities operating in ORSIP's IT environment. The diversification of spatial visualisation of the results of indicator calculations will increase progressively as the databases will be populated with data and in the end, visualisation of virtually any area of the Silesia Voivodeship will be possible. A 'voivodeship' scale will be conceptually correct during the initial stage of the database construction.

With the progressive development of the 'Nature' subsystem in ORSIP, new environmental monitoring indicators in the Silesia Voivodeship will be added to incorporate data collected in other ORSIP subsystems and spatial data services.

Identified conceptual problems

In essential terms, the key problems of BIOGEO-SILESIA project were as follows: accumulating a representative team of experts working with a specific type of data; identification of 'external' sources of data to supplement the existing data resources; compilation of concepts and descriptions of the structure of specific thematic sets of data involving fundamental constrains (Fig. 3). A major problem occurred during the development and adaptation of environmental monitoring system to the existing monitoring systems operating as part of the State Environmental Monitoring and the public statistics system of the Central Statistical Office GUS referring to environmental protection. This problem can be mainly attributed to the level of detail of data collected, both in terms of spatial data and with respect to the levels of the ecosystem.

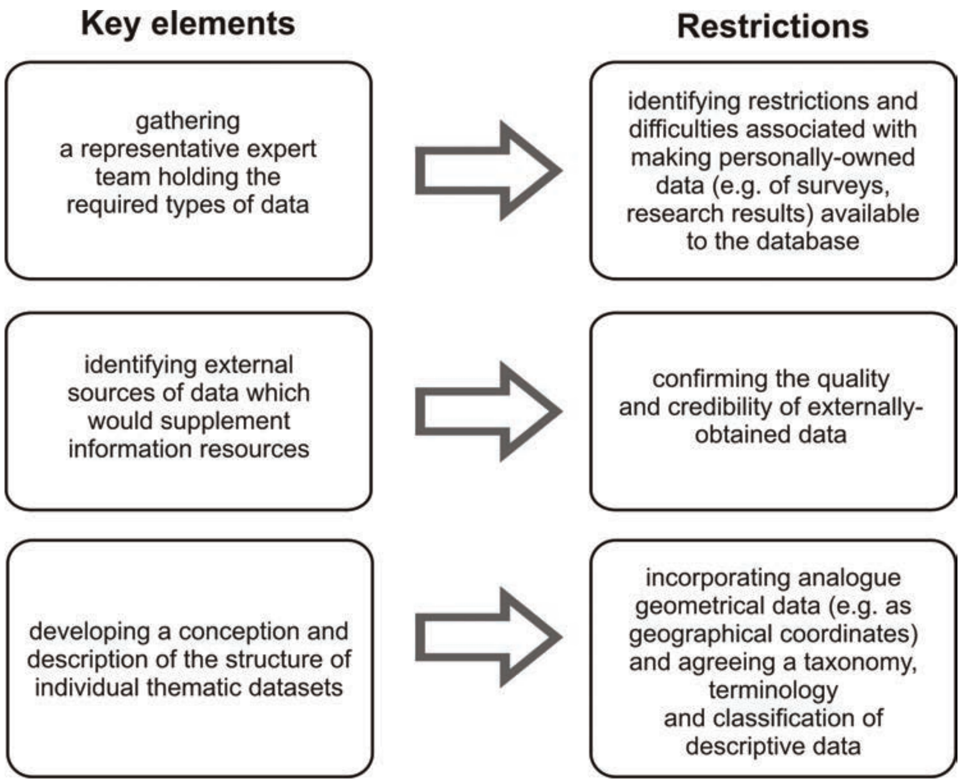


Fig. 3. Challenges identified by the BIOGEO-SILESIA ORSIP project

Discussion

There is no rule of law in Poland which makes it compulsory to create environmental databases. However, it is compulsory to provide specific information and documents featuring environmental data, such as registers (i.e. register of forms of nature protection, protection zones, direct risks of environmental damage and damages to the environment), notifications (notification of environmental damage), plans of protection and activities related to environmental protection (collecting the records of the components of nature, or thematic maps, which have been digitalised from 2005 and compiled with the use of GIS), or environmental impact reports (unfortunately investors are free to choose any methods they like in compiling such reports). Meta-data and source data (reports, expert opinions, information) are as follows:

– publically disclosed lists of data on documents featuring environmental information and environmental protection information, including information listed in Article 21 (2, 3) of the Act on Access to Information on the Environment and Its Protection,

– database dedicated to environmental impact assessments referring to investments and the strategic environmental impact assessments kept by the General Directorate for Environmental Protection (GDOŚ) (http://bip.gdos.gov.pl/index.php?option=com_content&view=article&id=1647).

However, these types of information are not specifically descriptive or spatial databases referring to the environment. For this reason, and with the acknowledgement of the need to establish an Open-access Regional Spatial Information System at the regional level, the decision was taken to set up a subsystem dedicated to the environment.

First attempts to create environmental databases in Poland date back to Poland's accession to the EU and the transposition of EU legislation into the national legal system. The Environmental Protection Law Act of 2004 made it compulsory to monitor the environment in terms of biological and landscape diversity, covering specifically species and natural habitats enumerated in the Birds and Habitats Directives. Under the Habitats Directive, it is compulsory to establish protection plans and plans of activities related to environmental protection for Natura 2000 sites (Sadowski 2011; Michalak & Sadowski 2012), which have been implemented based on GIS standards from 2011 onwards (Łochyński & Guzik 2009, 2013).

Still, Directive 2007/2/EC of the European Parliament and of the Council of 17 March 2007 establishing an Infrastructure for Spatial Information in the European Community (INSPIRE) (OJ: L 108/2 PL, 25.4.2007) is the key legal act laying down the obligation and standards for keeping databases related to the environment in the EU. Spatial data themes are listed in Annex I to III, and the implementing rules have been drafted into *Technical Guidelines*, *Draft Technical Guidelines*, *Guidelines*, *Draft Guidelines*. The directive was implemented into Polish legislation in the Spatial Information Infrastructure Law Act of 4 March 2010 (Dz. U. No. 76, item 489). The Act established three spatial data themes and bodies responsible for their setup. The implementing rules of the INSPIRE Directive set forth technical, technological and conceptual standards for spatial data. It must none the less be stated that the conceptual level of detail reflects the scale of EU Member States and the EU in general, and that the INSPIRE guidelines are of limited use in creating databases at the regional level.

The development of environmental databases has not been made compulsory for environmental protection authorities in Poland (although regional governments have been under the duty to document the condition of the environment since 1991) and, in consequence, no such databases exist at the national level. There are two reasons why this state of affairs is by no means favourable for the establishment of a regional database: a regional database should preferably draw from a national database for reasons of restricted financial means and the project implementation deadline, however, since no such national database exists, the major share of data has been created from scratch at the regional level, which may involve a certain degree of misinterpretation error arising from the adoption of a regional perspective.

Also, the growing acceptance of graphical user-friendly operating systems and the existing software (including databases) have opened door for the decision-makers who have been ready to use them in spatial planning and environmental management. Scientists responded with the design and implementation of experiments, data collection and analyses, and the development of models based on state-of-the-art tools offering new and better diagnostic and forecasting options referring to environmental processes (Ascough *et al.* 2008). This was accompanied by substudies and syntheses describing limitations in environmental management and decision-making attributed to gaps in knowledge, as well as constraints inherent to management systems and processes limitations (expertise, practical qualifications, competence, etc.) Therefore, in order to provide for the proper use of the results of environmental research by the decision-makers, data should be disseminated in the most convenient and transparent way, with the indication of adopted criteria and indicators and explanation of terminology (Geneletti 2004). The reliability of data fed into databases which later shape the effects of phenomena modelling and decision-making is another important aspect.

Environmental management, understood as decision-making, is extremely difficult and complicated due to the complexity and interdependence of the analysed environmental systems, and the competing interests of all stakeholders who use the environmental assets.

The assumptions of this project are intended to guarantee that the open-access regional database created will meet the existing standards, and that in the future, a coherent environmental monitoring, protection and management system will come into existence in the Silesia Voivodeship.

It must be emphasised that the results of environmental studies contained in the database will be reusable in the modelling of environmental processes and phenomena which are important from the explorative and practical point of view.

Conceptual problems identified during specific stages of the BIOGEO-SILESIA ORSIP implementation have been analysed in relation to the knowledge at hand, existing organizational solutions, and the current legal framework. The solutions adopted will be verified during the construction stage and during the final data feeding to the system. However, conceptual and technical correctness of the system and the actual effects of mitigating critical points (risks) identified during specific stages of project implementation can only be conclusively evaluated after the project has been finally completed.

Acknowledgements. *This project has been implemented as part of the 2007-2013 Regional Operational Programme of the Silesia Voivodeship, Priority Axis V: Environment, Action 5.4. 'Environmental Management' and classified as a project dedicated to the 'Creation and Development of Open-access Regional Information Systems and Databases on the Status of the Environment'.*

Authors wish to express their gratitude to all persons engaged in the project – scientists from the University of Silesia in Katowice, from the Faculty of Biology and Environmental Protection and the Faculty of Earth Sciences, and the Office of the Marshall of the Silesia Voivodeship: the Centre for the Natural Heritage of Upper Silesia, and the Silesian Centre for Information Society.

References

ASCOUGH J.C., MAIER H.R., RAVALICO J.K. & STRUDLEY M.W. 2008. Future research challenges for incorporation of uncertainty in environmental and ecological decision-making. Ecol. Model. 219: 383–399.

BIAŁOUSZ A. (ed.). 2013. Informacja przestrzenna dla samorządów terytorialnych. 452 pp. Oficyna Wydawnicza Politechniki Warszawskiej, Warszawa. [In Polish].

BURDZIEL J., ORLIKOWSKI R., KOCHANOWSKI J., LUBIŃSKA K. & TUROWSKA A. 2013. Selected problems of spatial database standardization for environmental protection on the example of "Bory Tucholskie" national park (Wybrane problemy standaryzacji baz danych GIS w ochronie przyrody na przykładzie Parku Narodowego „Bory Tucholskie"). In: M. Kunz, A. Nienartowicz (ed.). Geographical information systems in the management of protected areas – from theory to practice (Systemy informacji geograficznej w zarządzaniu obszarami chronionymi – od teorii do praktyki), pp. 26-39. Uniwersytet Mikołaja Kopernika w Toruniu. [In Polish, English summary].

CHYBIORZ R. & TOKARSKA-GUZIK B. 2012. BIOGEO-SILESIA – regionalny system informacji i baz danych o środowisku województwa śląskiego nowym wyzwaniem dla śląskich badaczy przyrody. Problemy środowiska i jego ochrony 20: pp. 167–171. Centrum Studiów nad Człowiekiem i Środowiskiem Uniwersytetu Śląskiego w Katowicach. [In Polish].

DEWEY S.A., PRICE K.P. & RAMSEY D. 1991. Satellite remote sensing to predict potential distribution of dyers woad (*Isatis tinctoria*). Weed Technol. 5: 479–484.

DORIGO W., LUCIEER A., PODOBNIKAR T. & ČARNI A. 2012. Mapping invasive *Fallopia japonica* by combined spectral, spatial, and temporal analysis of digital orthophotos. Int. J. Appl. Earth Obs. Geoinf 19: 185–195.

GENELETTI D. 2004. A GIS-based decision support system to identify nature conservation priorities in an alpine valley. Land Use Policy 21: 149–160.

FRANKLIN S.E., HALL R.J., MOSKAL L.M., MAUDIE A.J. & LAVIGNE M.B. 2000. Incorporating texture into classification of forest species composition from airborne multispectral images. Int. J. Remote Sens. 21: 61–79.

KAMINSKI D. J., CHRISTOPHER E. COMER C. E., GARNER N. P., HUNG I-K. & CALKINS G. E. 2013. Using GIS-based, regional extent habitat suitability modeling to identify conservation priority areas: A case study of the Louisiana black bear in east Texas. J. Wildl. Manage. 77(8): 1639–1649.

KĄCKI Z. & ŚLIWIŃSKI M. 2012. The Polish Vegetation Database: structure, resources and development. Acta Soc. Bot. Pol. 81 (2): 75–79.

ŁOCHYŃSKI M. & GUZIK M. 2009. Standard danych GIS w ochronie przyrody wersja 3.03.1. Poznań-Zakopane-Kraków, Poland. [In Polish]. http://www.gdos.gov.pl/ProjectCategories/viewProject/8/2/1/71/Materialy_do_pobrania

ŁOCHYŃSKI M. & GUZIK M. 2013. GIS data standard in nature preservation – common language of nature preservation services in garnering and exchanging geographic information (Standard danych GIS w ochronie przyrody – wspólny język ochrony przyrody w gromadzeniu i wymianie informacji geograficznej). In: M. Kunz, A. Nienartowicz (ed.). Geographical information systems in the management of protected areas – from theory to practice (Systemy informacji geograficznej w zarządzaniu obszarami chronionymi – od teorii do praktyki), pp. 116–125. Uniwersytet Mikołaja Kopernika w Toruniu. [In Polish, English summary].

McPherson M., Schill S., Raber G., John K., Zenny N., Thurlow K. & Sutton A.H. 2008. GIS-based Modeling of Environmental Risk Surfaces (ERS) for Conservation Planning in Jamaica. J. Conserv. Plan. 4: 60-89. http://maps.usm.edu/pat/files/jcp.pdf

Michalak R. & Sadowski J. 2012. Platforma Informacyjno-Komunikacyjna jako narzędzie wspomagające tworzenie planów zadań ochronnych dla obszarów Natura 2000 wersja 2012.1. GDOŚ. [In Polish]. http://www.gdos.gov.pl/ProjectCategories/viewProject/8/2/1/71/Materialy_do_pobrania

Murrow J. L., Thatcher C.A., van Manen F.T. & Clark J. D. 2013. A Data-Based Conservation Planning Tool for Florida Panthers. Environ. Model. Assess. 18:159–170, DOI 10.1007/s10666-012-9336-0

Sluiter R. & Pebesma E.J. 2010. Comparing techniques for vegetation classification using multi- and hyperspectral images and ancillary environmental data. Int. J. Remote Sens. 31: 6143–6161. DOI 10.1080/01431160903401379

Sadowski J. 2011. Adaptacja Standardu danych GIS w ochronie przyrody na potrzeby gromadzenia danych przestrzennych dla projektu POIS.05.03.00-00-186/09 pn. „Opracowanie planów zadań ochronnych dla obszarów Natura 2000 na obszarze Polski" w roku 2011. Wersja 2011.3. [In Polish]. http://www.gdos.gov.pl/ProjectCategories/viewProject/8/2/1/71/Materialy_do_pobrania

Smith P.G.R. & Theberge J.B. 1987. Evaluating natural areas using multiple criteria: theory and practice. Environ. Manage. 11 (4): 447–460.

TNCMAPS – Conservation Maps and GIS Data, 2011-2013. The Nature Conservancy http://maps.tnc.org/gis_data.html

Tokarska-Guzik B., Babczyńska-Sendek B., Pasierbiński A., Rostański A., Fojcik B., Nowak T., Bula R., Parusel J.B., Romańczyk M., Bzdęga K., Woźniak G., Jędrzejczyk-Korycińska M., Urbisz Al., Węgrzynek B., Orczewska A., Błońska B. & Sierka E. 2013a. Botanical databases: possible practical uses and the inspiration for further research (Botaniczne bazy danych: inspiracja dla dalszych badań i możliwości wykorzystania w praktyce). In: A. Biedunkiewicz & M. Dynowska (ed.) Interdyscyplinarne i aplikacyjne znaczenie nauk botanicznych. Streszczenia wystąpień ustnych i plakatów, 56 Zjazd Polskiego Towarzystwa Botanicznego, pp. 170–171. Wyd. Mantis, Olsztyn. [In Polish, In English].

Tokarska-Guzik B., Parusel J.B. & Chybiorz R. 2013b. Botanical databases in the Silesian spatial information system (Botaniczne bazy danych w śląskim systemie informacji przestrzennej). In: A. Biedunkiewicz & M. Dynowska (ed.) Interdyscyplinarne i aplikacyjne znaczenie nauk botanicznych. Streszczenia wystąpień ustnych i plakatów, 56 Zjazd Polskiego Towarzystwa Botanicznego, pp. 462–463. Wyd. Mantis, Olsztyn. [In Polish, In English].

Thuiller W., Richardson D.M., Pyšek P., Midgley G.F., Hughe G.O. & Rouget M. 2005. Niche-based modelling as a tool for predicting the risk of alien plant invasions at a global scale. Glob. Chang. Biol. 11: 2234–2250.

Trueman I.C. 2013. Exploring the flora records. In: I.C. Trueman, M. Poulton & P. Reade Flora of Birmingham and the Black Country, pp. 133-176. Pisces Publications, UK

Tykarski P. 2007. Bazy danych i poziom organizmalny bioróżnorodności. Wszechświat 108 (7-9): 190–196. [In Polish].

Walczak M. 2011. The database „Protected areas in Poland" – the possibilities of using the information contained (Baza danych „Obszary chronione w Polsce" – możliwości wykorzystania zawartych w niej informacji). Ochrona Środowiska i Zasobów Naturalnych 47: 163–172. [In Polish, English summary].

WALSH S.J., MCCLEARY A.L., MENA C.F., SHAO Y., TUTTLE J.P., GONZÁLEZ A. & ATKINSON R. 2008. QuickBird and Hyperion data analysis of an invasive plant species in the Galapagos Islands of Ecuador: implications for control and land use management. Remote Sens. Environ. 112: 1927–1941.

Ustawa z dnia 4 marca 2010 r. o infrastrukturze informacji przestrzennej. Dz.U. Nr 76 poz. 489. [In Polish].

ZAJĄC A. 1978. Atlas of distribution of vascular plants in Poland (ATPOL). Taxon 27 (5-6): 481–484. http://dx.doi. org/10.2307/1219899

ZBIERSKA A. 2013. Protected areas in the local spatial information systems for planning (Obszary chronione w lokalnych systemach informacji przestrzennej na potrzeby planowania przestrzennego). In: M. Kunz, A. Nienartowicz (eds.), Geographical information systems in the management of protected areas – from theory to practice (Systemy informacji geograficznej w zarządzaniu obszarami chronionymi – od teorii do praktyki), pp. 237–250. Uniwersytet Mikołaja Kopernika w Toruniu. [In Polish, English summary].

POLISH BIODIVERSITY INFORMATION NETWORK (KSIB), ITS RESOURCES AND WEB APPLICATIONS

Piotr Tykarski

Department of Ecology, Faculty of Biology, Biological and Chemical Research Centre, University of Warsaw, Warsaw, Poland, e-mail: ptyk@biol.uw.edu.pl

ABSTRACT: The Polish Biodiversity Information Network (PolBIN, KSIB) was founded in 2003. Its basic goal is to open the access to data on species distribution in Poland and worldwide. It has a status of scientific network, composed by scientific institutions, mainly universities and institutes of Polish Academy of Science. The data are based on specimen collections or verified observations.

Resources of KSIB comprise databases of the participants, their working copies on a central server and the database system of „Biodiversity Map", the main scientific project. A considerable part of the data is made available worldwide through the Global Biodiversity Information Facility (GBIF). A data record is meant as a triplet „taxon – place – date". There is ca. 1.6 million records published via GBIF and 800,000 records accumulated recently.

Biodiversity Map is a long-term programme that has accomplished its first phase with a text browser and a GIS application as a supplementary view on data. The system offers a wide range of filters depending on a selected data perspective: taxon, publication, unit, author, record or map. The detail level of accessed information depends on the user authorization. This is especially important in case of sensitive data on protected species or unpublished records.

A tool for on-line input of data is on the schedule of further development of Biodiversity Map, which is essential to mobilize new data. One of the main challenges is the quality control of new data, requiring cooperation of a number of specialists. KSIB is capable to meet this requirement having assembled the taxonomic part of the Biodiversity Map database on 12,000 insect species (beetles, butterflies, true bugs).

KEYWORDS: biodiversity, biodiversity informatics, GBIF, PolBIN, KSIB, GIS, biological databases

Introduction

Currently, information technology gives possibilities that were beyond imagination of naturalists before the Internet era. Until 1980's the main medium of accumulating biological data was paper. Hand-written notes were the most obvious every-day way of documenting observations and describing specimens, while paper publications were the most secure and respected form for presenting and disseminating knowledge. Paper photos and photocopies were the easiest way of dealing with images. Paper maps were the main source of geographic information for determination of study areas. The documentation of biological research comprised also special analogue media for photography, film and sound recordings, which usually demanded costly equipment, processing and storage.

Digital revolution completely changed the traditional routines of processing scientific information, providing a novel form for storage of almost all its types: text, images, videos or sounds. Gradually more and more existing data has been converted to the digital form, while new types of equipment enabled users to directly record data digitally. Along with development of the Internet, new communication methods emerged and new publishing mechanisms became common and obvious for everybody, causing traditional paper publications to lose their primary core function in the scientific information flow.

The new techniques created the whole universe of information sources that became available through the Internet after being digitized or were created as such and connected without additional conversion steps. These sources differ in size and depth of information, type of data, availability, completeness, complexity, reliability and other aspects. As soon as Internet expanded and became really worldwide, the need for efficient information exchange and communicating existing data sources became more and more important. Biodiversity-related sciences were early in the group of fields utilizing advantages of Internet technologies.

GBIF

In 1999, OECD Megascience Forum decided to create the global mechanism for sharing biodiversity data. Thanks to political decisions, Global Biodiversity Information Facility[1] (GBIF) came to existence: the interoperable system for information on world biodiversity. This is both an international organization and a long-term technical facility aimed at providing access to data. It works as a distributed information structure, aggregating biodiversity data, with a special focus on organismal level of biological diversity and species distribution data. GBIF brings together many countries and international organisations.

Formally, this is an international scientific co-operative project based on a multilateral agreement (Memorandum of Understanding[2]) between countries and international organisations, dedicated to provide access to primary biodiversity data in order to make the world's scientific biodiversity information freely and universally available. The structure was built upon achievements of a number of scientific communities constructing information exchange protocols and biodiversity information standards for sharing information on biological specimens, initially focused on natural history

[1] http://www.gbif.org

[2] http://www.gbif.org/resources/2605

collections. Gradually, the standards were refined and expanded to comprise practically all types of information content at the organismal level (Endresen and Knüpffer 2012, Wieczorek et al. 2012). The data standards and web services helped to create a GBIF Data Portal[3] that enables users to search data using complex queries, and moreover, to download all data records they find.

Although the information shared by GBIF members is freely available, the links to its creators and owners are preserved and clear. The intellectual property rights are one of the main concerns of the network, expressed in both Data Sharing[4] and Data Use Agreements[5] that must be respected by data publishers and end users. One of the core concepts structuring the GBIF information is unique identifiers (Page 2006) that make every record in the network unique and easily trackable. Currently, GBIF serves above 440 million occurrence records on almost 1.5 million species, published by 600 data publishers through ca. 15 thousand datasets. The network consists of 52 countries and 38 international organizations (fig. 1).

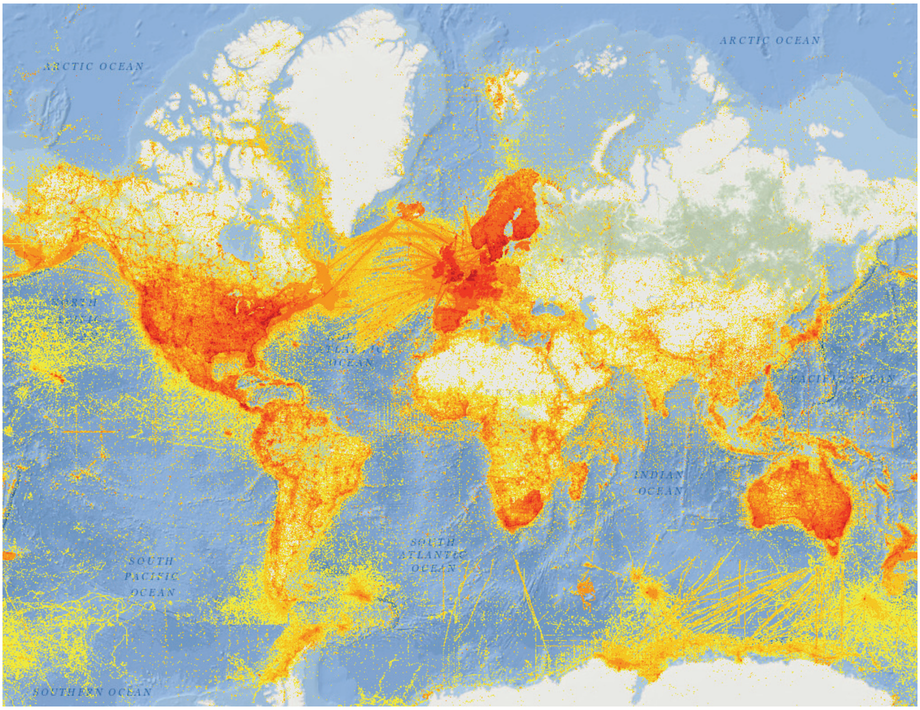


Fig. 1. Distribution of all data records published in the GBIF network.

[3] http://www.gbif.org/occurrence
[4] http://www.gbif.org/disclaimer/datause
[5] http://www.gbif.org/disclaimer/datasharing

PolBIN – KSIB

Poland has been actively participating in the global network since its foundation in 2001. In order to promote GBIF concepts and join the international biodiversity information sharing community, the Polish Biodiversity Information Network[6] (PolBIN, Krajowa Sieć Informacji o Bioróżnorodności, KSIB) was founded. Since 2004, the network grew from a few to 22 member institutions and 11 cooperating partners, bringing together the majority of the most important centres for biodiversity research in the country. All of them share the idea of cooperation for opening access to biodiversity data and implement GBIF standards, contributing to the global information system more than 1.6 million records, containing information on biodiversity of Poland and many regions all over the world (fig. 2). The Polish contribution to GBIF comprises 92 databases published by 25 network members[7]. Each of the contributing institutions is recognized and presented by the GBIF Data Portal as a separate entity authorizing data it provides[8].

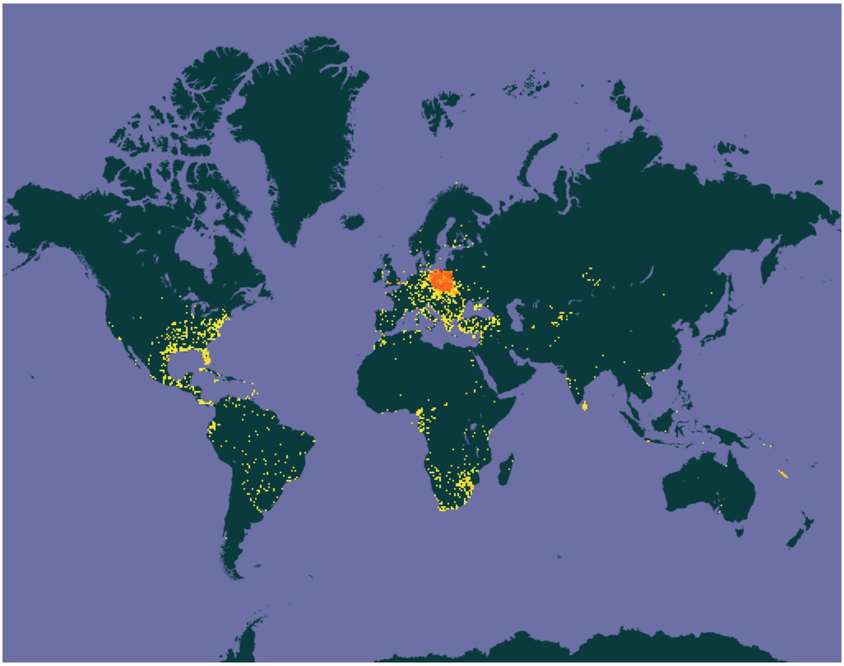


Fig. 2. Distribution of data records published in the GBIF network by data publishers from PolBIN.

[6] http://www.ksib.pl
[7] http://www.ksib.pl/index.php?id=db&l=pl
[8] http://www.gbif.org/country/PL/publishers

Along with cooperation with GBIF, KSIB develops its own solutions and mechanisms in order to facilitate exchange of biodiversity information in Poland. Understanding the typical problems and routines commonly used by local scientists is necessary for maintaining existing activities and expanding of the network in the future. As the largest Polish organization that collects biodiversity data, the Network has capacity and potential to create research programmes, not only to document existing knowledge but also to actively create the new one through research projects and specialists on different organism groups from member institutions.

Data structure, quality and standards

Structuring data on biodiversity of organismal level is a complex issue. Properly organized information has to cover taxonomy, occurrence and metadata of an event, usually referred to as a record. Typically, two types of records are used: observation and specimen, the latter being attributed to a physical voucher specimen. A record type (or "record basis") is one of the elements of record metadata. The other refer to authors, owners, provider institutions, collection methods, names of collections containing the specimen (for specimen records) etc. A fundamental attribute of a record is its identifier that has to be unique at a level of a containing dataset. The combination of a record id and a dataset or collection name creates a unique identifier of a record that enables to precisely point to every single piece of occurrence data in the network.

Taxonomic accuracy is a matter of great importance for PolBIN as a network created by scientific institutions. A vast majority of records are classified to a species level. In order to provide a solid and flexible basis to deal with a dynamic realm of taxonomic names, each record has a number of attributes covering the atomized taxonomic name (differently for animals and plants, according to relevant codes of nomenclature). Filling more fields than just genus and specific epithet minimizes risk of potential future synonymy issues after changes in classification of a taxon.

A geographical part of an occurrence record is probably the most technically difficult to tackle with, due to a wide scope of datasets in the network and different derivation of particular cases. Most of legacy data were described with a free text, giving a rough or more detailed description of a place of the origin of a record. New records often contain geographical coordinates acquired directly by their authors in the field or after the gathering event. However, in spite of technical progress and ease of use of GPS devices nowadays, preserving the precise georeference in records is still not an obvious practice. Some researchers pay too little attention to this part of record description, being satisfied with lower accuracy of coordinates, using only grid coordinates (like UTM, ATPOL) or even keeping the traditional, free-text format of the description. In order to maximize usability, record definition includes a set of fields that can be optionally filled, depending on the original content. Such information can be further augmented or specified with more accurate georeference terms, including latitude, longitude, datum and altitude.

Acquiring occurrence data from old specimen collections, old notes and bibliography, combined with a normal amount of errors during digitization, creates a challenge that the network hast to overcome to work properly. Cleaning data is a very time consuming process that has to be conducted carefully, not only because of a threat of introducing errors through e.g. bad georeference. It is equally important to preserve the original information accompanying a record, especially in case of collection specimens, because these data can be reinterpreted further, if necessary and possible. Fortunately, data cleaning issues are typical for occurrence data in every country and GBIF created special work groups and programmes to solve them. Thanks to these efforts a number of tools and procedures are available for everybody interested (Chapman 2005).

KSIB resources

A. Datasets published in GBIF

Due to technical and security reasons, PolBIN chose a centralized model of network organization. All network members keep working copies of their databases on a central server of the network coordinator (University of Warsaw), which makes it possible to optimize GBIF indexing procedures and to increase efficiency of local applications and services. Each database is connected to GBIF as a separate instance of a provider application. Because of a complex character of biodiversity information and specific requirements depending on a particular application, there are several data schemes and standards in use in KSIB.

For communication with GBIF, datasets are presented using TAPIR protocol[9] and ABCD schema[10] (Access to Biological Collections Data), defining the way of mapping the structure of data onto the common exchange mechanism used by the GBIF system. As GBIF introduced new efficient communica-

[9] http://wiki.tdwg.org/twiki/bin/view/TAPIR/WebHome
[10] http://wiki.tdwg.org/ABCD

tion tool – Integrated Portal Toolkit[11] (IPT), all existing databases of KSIB will be switched to the new provider software, and remapped to another information schema – Darwin Core[12] (DwC). Currently, the databases published for GBIF are powered by PostgreSQL software and are organized uniformly according to the specification based on ABCD Schema[13].

B. Biodiversity Map

Another set of databases, also using PostgreSQL environment, has been created in a loose connection with GBIF activities. In order to integrate Polish biodiversity data, a project called "Biodiversity Map" was launched. Planned as a long-term programme, Biodiversity Map has been initially thematically confined to three major insect groups that should be treated as a model providing environment for tests and building applications that would facilitate access to data (Tykarski 2011). The groups are beetles (Coleoptera), butterflies and moths (Lepidoptera) and true bugs (Hemiptera), covering ca. 12,000 species in the country, which makes a considerable part of a Polish fauna. Gradually, next invertebrate groups could also be covered and the system could be extended to the rest of the biota. The choice of the model groups was not casual. The insect taxonomy itself is a complex and multi-level hierarchical system, their life history is often complicated, and tradition of entomological research in Poland is long, providing rich and diverse sources of information that could be used to build upon.

The Biodiversity Map[14] information system could be technically divided into two components: the database itself and the online application. The database consists of a set of tables linked with relations and dependencies, among which five main data categories could be distinguished: taxa, occurrence (further referred to as records), publications, units and authors. An additional part covers GIS layers using the PostGIS extension. All the five data categories are reflected at the Biodiversity Map web portal as "data perspectives". When browsing a perspective, a user sees the selected category as a primary one, and the rest of the categories as its related objects (fig. 3). E.g. for a taxon it is possible to see a list of related publications or collections with specimens. Each perspective offers a set of filters that helps to find its elements using different criteria.

---

[11] http://www.gbif.org/ipt
[12] http://rs.tdwg.org/dwc/index.htm
[13] http://www.ksib.pl/materials/standards/standardy_jakosci_danych.pdf
[14] http://www.biomap.pl

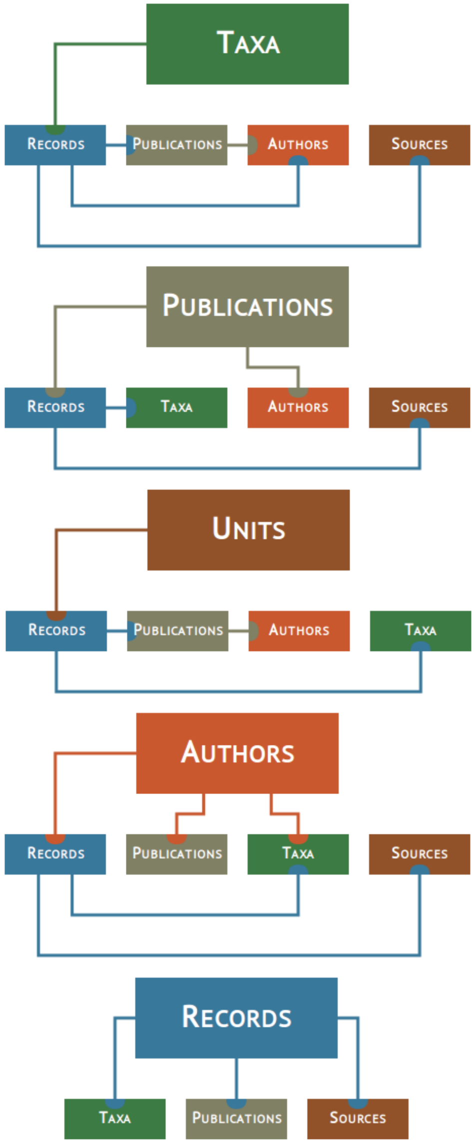


Fig. 3. Data categories and their relations to a main perspective in the text browser to the Biodiversity Map. Each scheme represents relations of categories in each of the five available perspectives: Taxa, Publications, Units, Authors, Records. Note the key role of Records category in linking other data categories.

The taxonomical part covers lists of taxa and their synonyms of the covered insect groups, organized hierarchically, which in total makes more than 58,000 names for the three model groups. The "Taxa" perspective is the most complex and information rich of all because of many levels of a hierarchy of the taxa, a need for flexibility in browsing through taxon trees and lists, and corresponding multi-level generalizations of objects in the connected categories (fig. 4).

Fig. 4. An example view from the "Taxa" perspective in the text browser to the Biodiversity Map.

Relational tables creating a bibliographical part describe almost 16,000 articles and books, accessible from the perspective "Publications", some of them presented together with pdf files (only where there are no IPR issues). There are easy to follow links to taxa and collections available from this perspective. A user can see a list of publications filtered according to search criteria, or open a publication "file" showing detailed information on a particular paper with lists of related objects.

Similarly, the "Units" category pertains to physical specimen collections, KSIB datasets presented in GBIF (if relevant) and recordsets sent to Biodiversity Map system by its contributors. It is possible to view unit lists as well as details on a single unit.

Elements of the "Authors" perspective correspond to names of persons and link to virtually all the rest of perspectives, through relations that could be attributed as their roles: publication author, taxon description author, gathering agent, specimen identifier, collection owner etc.

When looking at the structure of data, the core perspective is "Records", as it is a link between the rest of the data categories, e.g. publications and taxa. Records describe the fact of occurrence of a taxon at a place and time, and the rest of the categories – publications, units, authors – correspond to elements of metadata connected with records. Because of the above mentioned complexity of locality descriptors, it is impossible to present a readable list of records in full detail. Instead, lists of records use a simplified set of fields describing place and time of occurrence, while details are accessible for a single record. On the other hand, there is no need to show lists of objects connected with a record, as this is the lowest level of database granularity and all objects related to a single record are actually its attributes. Lists of related objects are useful as an addition to lists of records as a way of summarizing their content (fig. 5). At the moment, the total count of records exceeded 800,000.

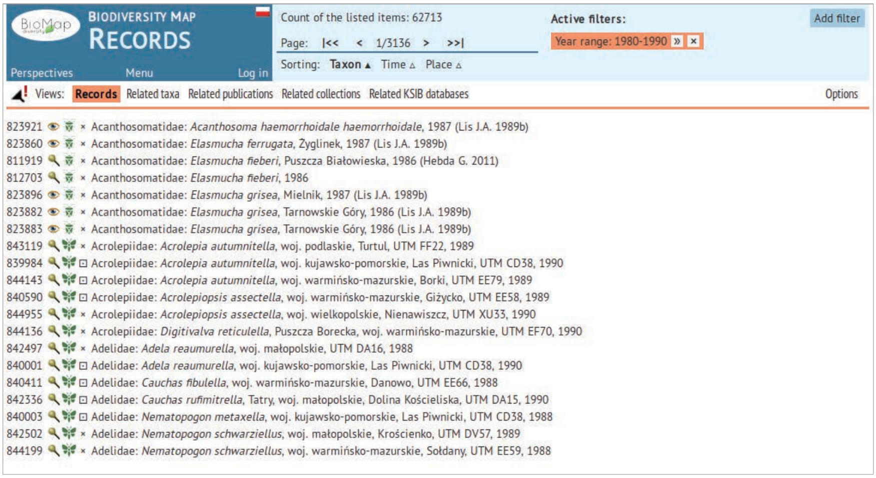


Fig. 5. A record list displayed in the "Records" perspective in the text browser to the Biodiversity Map.

As in most cases the best way to present spatial data is using maps instead of text, the Biodiversity Map includes a GIS service to visualize occurrence data. It uses PostGIS and MapServer to generate static maps accessible from the "Taxa" perspective. A separate interface, created with OpenLayers, offers an interactive map with following properties and functionalities:

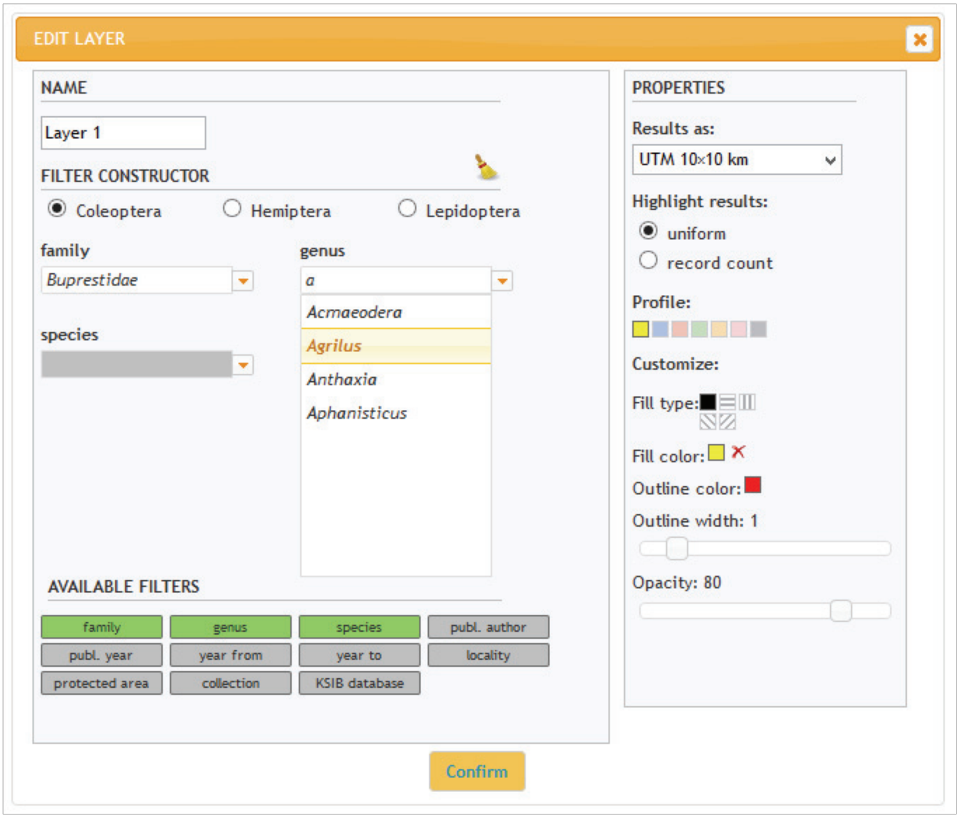


Fig. 6. A dialog box displayed in the interactive map interface to the Biodiversity Map to set search criteria and attributes of the result layer.

- a choice from a number of GIS vector layers: administrative boundaries, regionalizations – physicogeographical by Kondracki, traditional faunistic from Catalogus Faunae Poloniae, geobotanical, grids – UTM and ATPOL (10 x 10 km); layers can be displayed directly as outlines or used as result layers for generalization of record queries,
- rasters as background layers; Open Street Map and Google Maps as general backgrounds, digital terrain model covering the whole Polish territory; more rasters and external WMS services planned to be used in future,

- a click on the map retrieves records and related objects connected with the clicked area; the result visible as a table or list of related objects,
- a tool to create layers using criteria set with the filter constructor (fig. 6); results, based on records matching the criteria, visible as polygons or points (depending on authorization of a user); layer attributes are customizable when defining the search or afterwards,
- a set of tools to zoom, find geographical objects, switch between views displayed in the user's session
- two-direction communication with the text application; map to text: display details of selected records of a created layer in the "Records" perspective of the text application; text to map: display a set of records from "Records" perspective as a layer on the interactive map.

Data use and development plans

Data in the Biodiversity Map system may have many uses, depending on user needs. The perspective "Taxa" would be probably the most popular and a default starting point for most of users, as a taxon is usually the main object of interest. As pictures are included as one of relations in the database, as well as descriptions of taxa biology, the "Taxa" perspective offers a sort of fact sheets on species, that may be helpful e.g. in identification of specimens. It is possible to quickly collect a bibliographical list for a taxon of every rank or to identify collections where specimens of a species of interest are deposited. The range of uses will depend on user needs and the system developers should realize them.

The main lack of the system at the moment is an online tool for introducing new data. It is planned to be included, as it is an essential part that would greatly enhance usability of Biodiversity Map. Once launched, it will enable users to add new occurrence records, photographs, publications, etc. and to edit and verify existing ones. To make it functional and efficient, a number of technical and organizational issues must be fixed. One of the most important is the quality control, demanding activity of a group of specialists responsible for validation of new data.

The basic requirement – the control of user access and privileges has been already met. The system offers different tools, functions and a level of detail depending on a user. This way some sensitive data may be secured, e.g. details on occurrence of protected species or private records of a user that would be publicly accessible after publication.

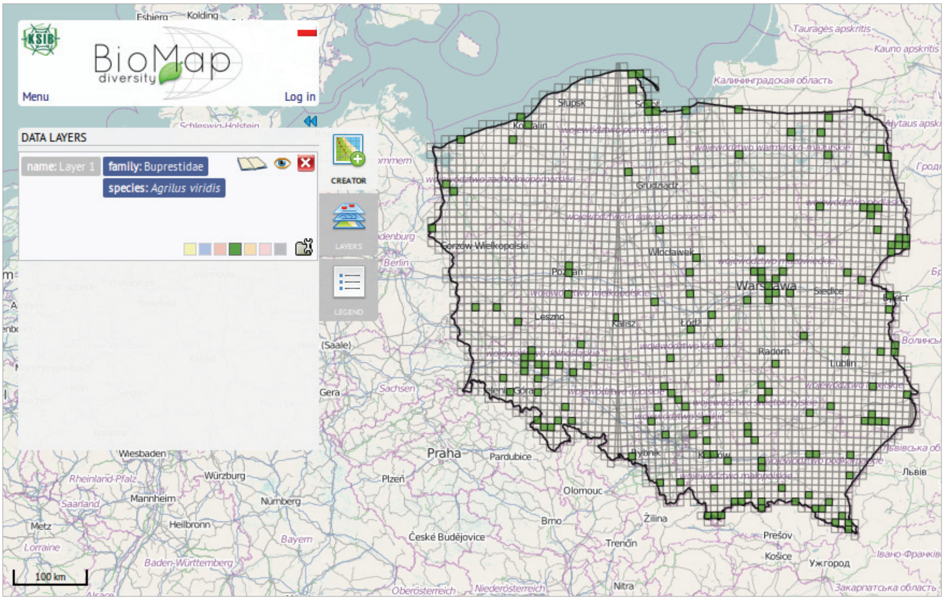


Fig. 7a. An example of a map generated by the interactive map interface to the Biodiversity Map for a taxon. The result layer based on the UTM grid.

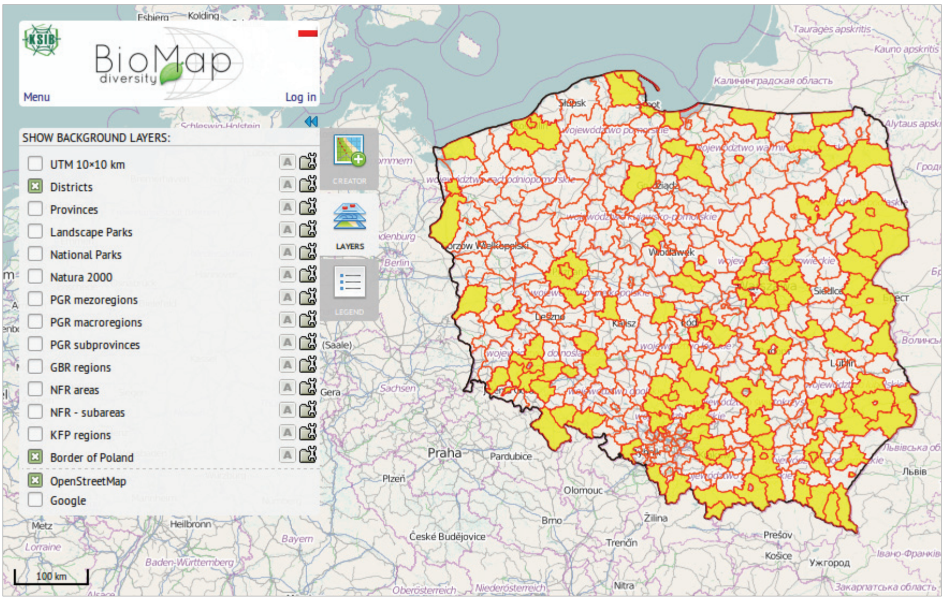


Fig. 7b. An example of a map generated by the interactive map interface to the Biodiversity Map for a taxon. The result layer based on districts.

The future usefulness and functioning of the tools created by the Polish Biodiversity Information Network will depend on the reception of the Biodiversity Map and direction of usage of open-access records offered by GBIF for science. As activities of the KSIB network are scientifically oriented and realized mostly by scientists, continuation of this approach needs at least organizational support from the scientific policy of the country. Information from biodiversity databases offers a wide range of potential uses, both in pure science, like taxonomy or biogeography, and applications, e.g. invasive species analyses, nature conservation, education. There is also an important social function of such initiatives: integration of the scientific community. The hitherto achieved results have proved its importance. The Biodiversity Map would have never been accomplished without cooperation of a wide group of its contributors and the interinstitutional agreement between the members of PolBIN.

Bibliography

CHAPMAN A. D. 2005. Principles and Methods of Data Cleaning – Primary Species and Species-Occurrence Data, version 1.0. Report for the Global Biodiversity Information Facility, Copenhagen. Available online at http://www.gbif.org/orc/?doc_id=1262.

ENDRESEN D.T.F. & KNÜPFFER H. 2012. The Darwin Core extension for genebanks opens up new opportunities for sharing germplasm data sets. Biodiversity Informatics, 8, 12-29. URI: https://journals.ku.edu/index.php/jbi/article/view/4095.

PAGE R.D.M. Taxonomic names, metadata, and the semantic web. Biodiversity Informatics, 3:1-15. URI: https://journals.ku.edu/index.php/jbi/article/view/25.

TYKARSKI P. 2011. Insects on the Biodiversity Map of Poland – objectives and scope of the project. Polish Journal of Entomology. 80(2): 153-154. DOI: 10.2478/v10200-011-0011-6

WIECZOREK J., BLOOM D., GURALNICK R., BLUM S. & DÖRING M. 2012. Darwin Core: An Evolving Community-Developed Biodiversity Data Standard. PLoS ONE 7(1): e29715. DOI: 10.1371/journal.pone.0029715

ATLAS OF AMPHIBIAN DISTRIBUTION IN POZNAN – A TOOL FOR EFECTIVE CONSERVATION

Jan M. Kaczmarek[1], Mikołaj Kaczmarski[1], Katarzyna Pędziwiatr[2*]

[1] Institute of Zoology, Faculty of Animal Breeding and Biology, University of Life Sciences, Poznan, Poland

[2] Institute for Agricultural and Forest Environment, Polish Academy of Sciences, Poznan, Poland
*e-mail: kas.pedziwiatr@gmail.com

ABSTRACT: The project "Atlas of amphibian distribution in Poznan – a tool for effective conservation" was performed in 2013 by the local branch of Klub Przyrodnikow (The Naturalists' Club – NGO). The project was funded by the Poznan municipality. The aim of the project was to create a database of the distribution of amphibians in the city.
Within the project, all existing published and unpublished data on amphibian distribution in Poznan were investigated, as well as fieldwork was conducted in the known and potential amphibian habitats. The outcome of the project is: 1) a database on water reservoirs in the city of Poznan including amphibian species present, 2) a GIS layer showing locations of breeding reservoirs and locations of mass road mortality of amphibians. The database was delivered to the municipal environmental and spatial planning offices, it was also prepared to be included in the Spatial Information System of the city.

KEYWORDS: urban, anthropopressure, urbanization, GIS, NGO, frog, toad, newt

Introduction

All native amphibian species are under strict legal protection in Poland. For some species, the legal protection is also required in the European Union by the Council Directive 92/43/EEC on the Conservation of natural habitats and of wild fauna and flora. There are 18 species of amphibians native to Poland, from which 13 species live in the lowlands of western Poland, where the city of Poznań is located. There has been a major decrease in amphibian populations in Western Europe in the 2nd half of 20th century (Beebee et al. 2009; Denoël 2012). In Poland, most amphibians are still fairly numerous and widespread, though long-term data on population trends are insufficient and probably most populations are decreasing (Bonk & Pabijan 2010). The current intensive development of urban areas and infrastructure will probably cause amphibian population crisis in Poland analogous to that in Western Europe. The lack of accessible data on local distribution of amphibian species may be one of the factors restricting effective conservation, especially in densely populated, urban areas. In the United Kingdom, local species distribution data are collected by the net of Local Environmental Records Centres, providing local databases for administration, local stakeholders, scientific community etc. (ALERC 2014). An example of such an approach in urban areas is the Amphibians & Reptiles Atlas of London, provided by the NGO Greenspace Information for Greater London (GiGL 2014). In Poland, although valuable data on amphibian distribution exist for several urban areas (Mazgajska & Mazgajski 2003), such information often remain in the form of MSc thesis or a conference abstract. As a consequence, even existing data are generally inacessible for the public and they are usually ommited in planning of any activities performed by the NGOs or the local administration responsible for conservation. The only exception known by the authors is the city of Opole (SW Poland), where some limited open-access amphibian distribution data are available in the municipal spatial database (http://hiram.um.opole.pl/imap/).

The project aiming to create a database of amphibian breeding locations within the city of Poznań was designed to help solving several scientific and conservation issues: 1) provide a detailed distribution reference map, essential for future population monitoring and investigating impact of urbanization on amphibian communities, 2) provide a tool for sustainable urban planning, 3) provide data enabling prediction of potential conflicts between nature conservation and urban development. We believe that such a wider-scale approach is essential for successful conservation of amphibian communities, both in urban and natural areas.

Materials and methods

The project was conducted in spring and summer 2013 by the local branch of the Klub Przyrodników (The Naturalists' Club), a registered environmental NGO. After the list of confirmed and potential amphibian breeding sites had been created, mainly by map analysis, the database was gradually populated with data. We collected all existing published data on batrachofauna in the area of the city. Although archival information was also a part of the database, for later investigations we used only data that were published after 2010. Previously unpublished data, provided by the NGO's, local nature enthusiasts and universities, were also included. Of those, possibly the most valuable were the previously unpublished results of road mortality mitigation projects. However, the most of the data were data collected in field in season 2013, both before and during the realization of the project.

The field investigation included both non-invasive methods (visual and acoustic location of individuals in the ponds and in immediate vicinity) and invasive methods (collection of adults and larvae by nets and floating traps).

Gathered data are presented both as a database and vector layers. All databases were created according to the Polish standards of GIS data in environmental conservation (Łochyński & Guzik 2009).

Two separate databases were created. The main database contains data on investigated and potential breeding locations of amphibians in urban area. All locations (mainly permanent water reservoirs, but also e.g. locations of temporary or ephemeral water bodies) were described with geographic coordinates, name, area, type of services provided for the urban system (e.g. in case of roadside ditches), potential conflicts (e. g. amphibian conservation versus real estate development) and other remarks. For each investigated location database contains data on amphibian species present, but because of the relatively short time in which field data were collected (one season only), we were not able to estimate population size in each location. To manage variable validity and reliability of data, for each species within locality we used the following codes: 0 – species absent, 3 – species present according to pre-2010 published data (to be verified in the future), 5 – species present according to post-2010 published data/reliable unpublished information/data gathered within the project, 9 – species present according to probably unreliable unpublished information (to be verified in the future). While in the version of the database published so far the data from different sources are pooled, the future goal is to populate the database only with current field data.

Data on locations of mass amphibian road mortality were delivered separately. The database contained: geographical coordinates, data source, species subject to mortality, type of mortality (confirmed mass mortality vs. verification needed), proposed mitigation activities, remarks. Based on data gathered for the project, a series of maps were created. Topics included: 1) distribution of breeding localities for particular species; 2) potential migration/dispersal ranges (based on Kurek *et al.* 2011); 3) proposed ecological buffers designed for conservation of amphibians and water resources (approach based on Semlitsch & Bodie 2003); 4) road fragments associated with mass amphibian mortality (based on accesible road layers); 5) species richness in particular breeding locations

For the potential migration/dispersal ranges, we did not investigate whether they provide information on actual distribution of amphibians in terrestrial ecosystems. The visualisations only aimed to confront the conservation administration with the dimensions of areas where potential conflicts agains amphibian conservation and human activity may occur. Similarly, the idea of ecological buffers by Semlitsch & Bodie (2003) is not a tool originally designed for densely populated, urbanized areas. However, it enabled us to support the idea and visualize the importance of treating numerous, geographically close breeding ponds as single conservation units (see Fig. 1).

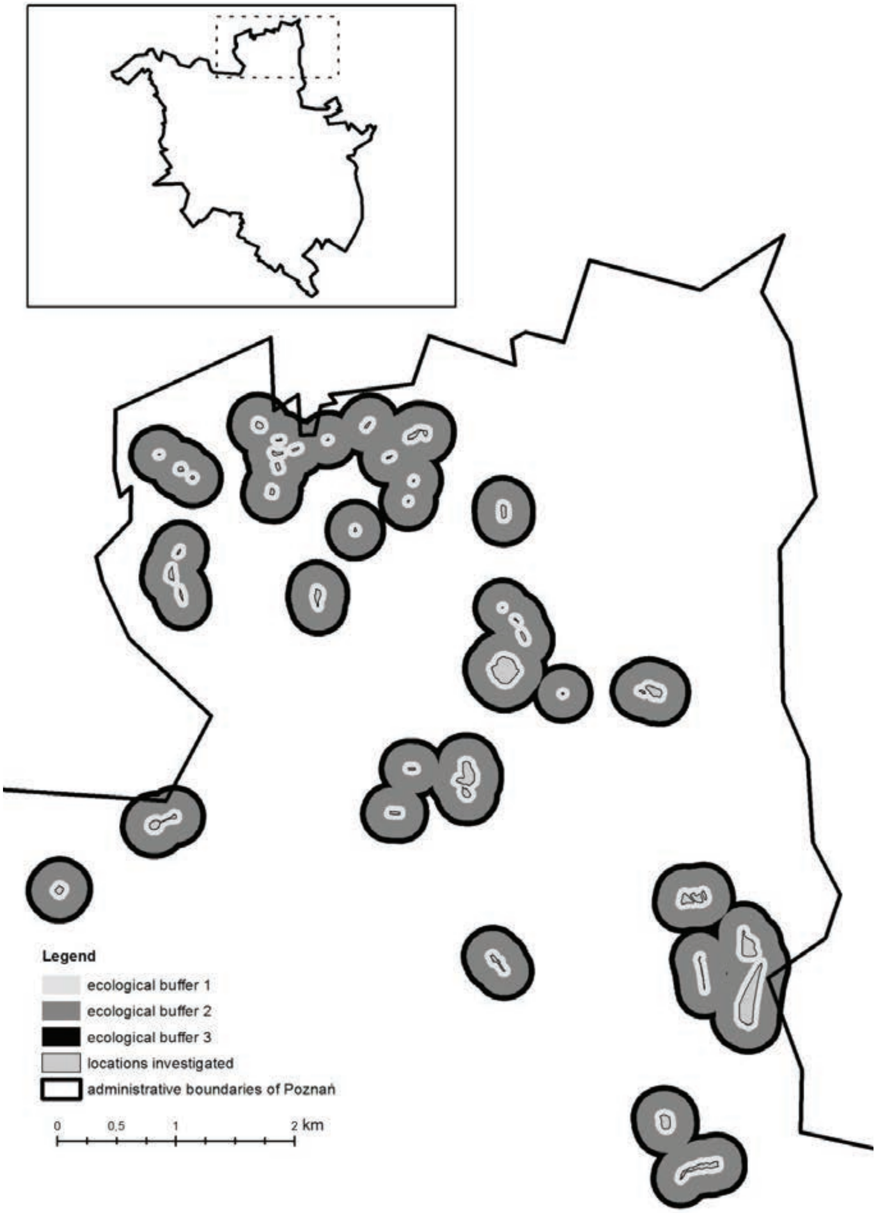


Fig. 1. Suggested ecological buffers around amphibian breeding ponds in northern part of the city. Note that numerous small reservoirs, essential for species like Fire-bellied toad *Bombina bombina*, should be treated as a single conservation unit. Conservation regime is the strictest in the Buffer 1; Buffer 2 comprises the core terrestrial habitat with limited human activity, and in Buffer 3 more activity is acceptable. For details, see Semlitsch & Bodie (2003).

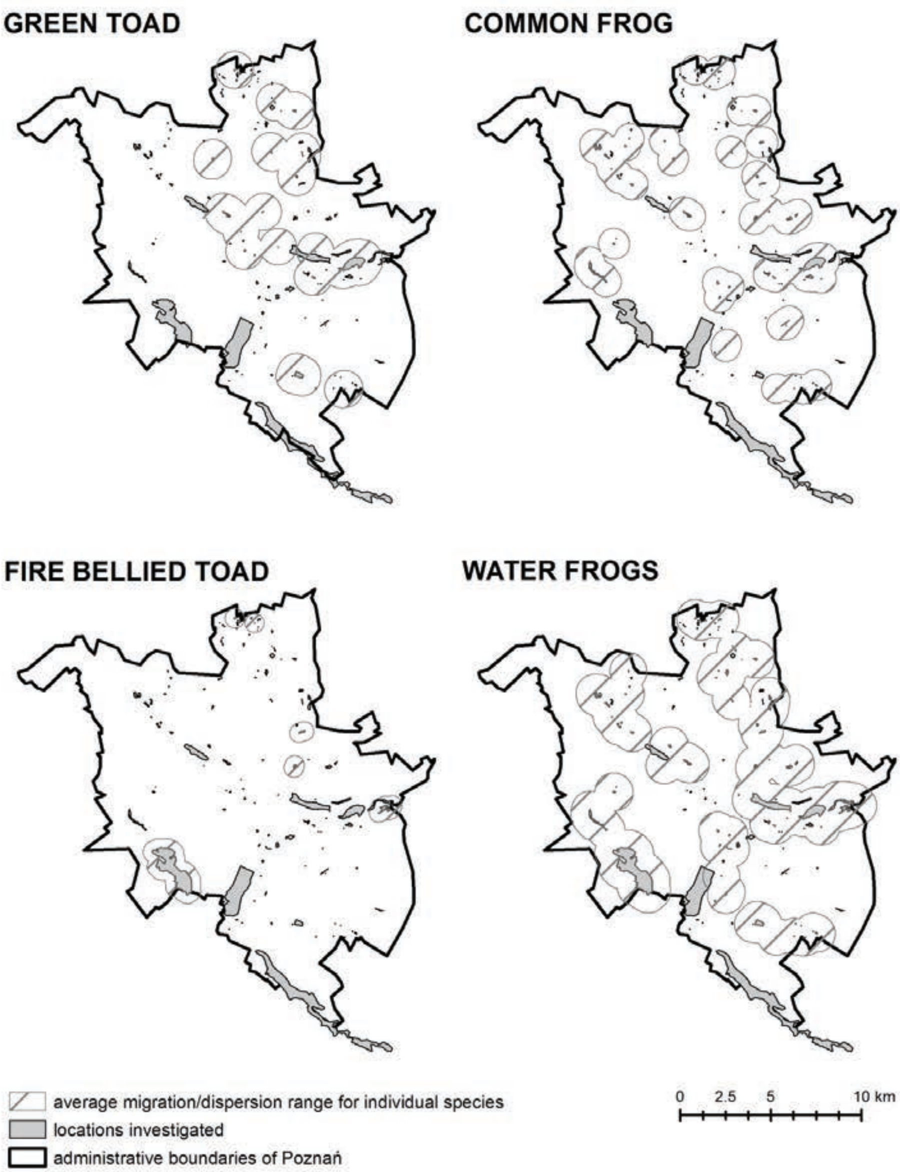


Fig. 2. Distribution of sample species in urban area of Poznań. Clockwise from upper left: green toad *Bufotes viridis,* common frog *Rana temporaria,* water frogs *Pelophylax sp.*, fire-bellied toad *Bombina bombina.* Buffers around confirmed breeding sites indicate average migration/dispersion range for each species based on Kurek *et al.* (2011).

Results

The amphibian distribution database contains 201 geographically explicit entries. For 150 entries, the database contains data on amphibian presence/absence (archival or present), 51 entries are potential amphibian breeding localities that need further investigation. Information on species abundance is presented in Table 1. Comparison of data gathered within the project with archival data from Pawłowski (1993) was discussed elsewhere (Kaczmarek *et al.* 2014). Sample distribution maps and map fragments are presented in this paper (Fig. 2). The mortality database contains 19 locations of confirmed (14) and potential (5) amphibian road mortality. 11 from 14 confirmed mortality sites are located within ecological buffers based on Semlitsch & Bodie (2003).

Table 1. Number of breeding localities per species in Poznań. BO – *Bombina bombina*; PF – *Pelobates fuscus*; BB – *Bufo bufo*; BV – *Bufotes viridis*; EC – *Epidalea calamita*; HA – *Hyla arborea*; PEC – *Pelophylax sp.*; RA – *Rana arvalis*; RT – *Rana temporaria*; TC – *Triturus cristatus*; LV – *Lissotriton vulgaris*

	BO	*PF*	*BB*	*BV*	*EC*	*HA*	*PEC*	*RA*	*RT*	*TC*	*LV*
pre-2010 records only	6	5	7	4	0	0	10	8	10	4	5
post-2010 records	9	29	51	26	0	0	81	26	65	6	32
uncertain records	0	0	1	0	2	3	0	0	0	2	1

Discussion

Only two amphibian species present in the region are probably absent in urban areas of Poznań (tree frog *Hyla arborea* and natterjack toad *Epidalea calamita*) – existing data are doubtful and further investigation is needed. The remaining species differ in their distribution schemes according to habitat preferences – the most common amphibians in Poznań, the water frogs *Pelophylax sp.* are more or less uniformly distributed within the city's water reservoirs, as for those species terrestrial habitat is less important than for some other anurans. The green toad *Bufotes viridis* is the only other species thriving in the strict city centre, although its distribution range has been much reduced recently (Kaczmarek *et al.* 2014). Distribution of other common species, like the common frog *Rana temporaria*, is limited by the presence of terrestrial habitats, so their distribution is linked to natural and semi-natural green areas throughout the urban zone (the scheme is similar for the moor frog *Rana arvalis* and the common toad *Bufo bufo* – not shown in the results). Species more vulnerable to anthropopression, like the fire-bellied toad *Bombina bombina* or the great crested newt *Triturus cristatus* (not shown in the results) thrive only in peripheral areas of the city. Completing the database in the future will enable further, more detailed analyses of interactions between species distribution and urban structure.

Until relatively recently, amphibians were not considered as a group prone to extinction in Poland, so distribution data were gathered mostly for scientific, not conservation reasons (e.g. Juszczyk 1987). Amphibian fauna of urban areas is easily accessible, so although a city is not an optimal habitat for amphibians, it is mostly the cities for which long-term population data exist – e.g. Krakow in Budzik *et al.* (2013). Only relatively complete databases enable monitoring trends in distribution – if such are missing, then usually data are limited to few locations only (as in Ogielska & Kierzkowski (2010) for Wroclaw).

Development of spatial databases is crucial in shifting to more effective approach to conservation, not only amphibians but also other taxa. So far, the dominant approach in amphibian conservation in Poland has been to protect local, possibly endangered populations (e.g. by creating municipal reserves – *użytek ekologiczny*). With no reference to spatial distribution on local and regional scale, such efforts may remain ineffective. Spatial distribution databases are also the key tool for long-term monitoring – in Poland, the publications on this subject remain scarce (but see Bonk & Pabijan 2010). Local amphibian distribution databases may thus provide an important resource for future research on reactions of amphibian communities to human pressure.

By creating the database, we aimed to facilitate the transfer of knowledge from scientists and environmentalists to local and governmental administration. Subsequently, amphibian distribution maps created for the project became a part of the open-access Spatial Information System of the city of Poznań (http://www.city.poznan.pl/mapa_geopoz/). By enabling the general public the access to the data, we hope to help to avoid conflicts e.g. between real estate development and the need for protection of amphibian habitats and urban greenery.

Acknowledgements. We are grateful to P. Konieczna, M. Antkowiak, A. Jakubowska and the volunteers from the Herpetological Section of the Students' Scientific Association at Adam Mickiewicz University (KNP UAM) and the Naturalists' Club (Klub Przyrodników) for their help in the field and provision of valuable data. Amphibian handling was performed according to the Regional Directorate for Environmental Protection (RDOŚ) permission no. WPN-II.6401.207.2013.AG. The project was funded by the Environmental Department of the City of Poznań (agreement no. OS-IV.526.11.2013 on July 6th 2013).

Literature

ALERC 2014. Association for Local Environmental Records Centres. Website: http://www.alerc.org.uk/ [Access: 04-11-2014].

BEEBEE T., WILKINSON J. & BUCKLEY J. 2009. Amphibian declines are not uniquely high amongst the vertebrates: trend determination and the British perspective. Diversity, 1: 67-88.

BONK M. & PABIJAN M. 2010. Changes in a regional batrachofauna in south-central Poland over a 25 year period. North-West J. Zool, 6(2): 225-244.

BUDZIK K., BUDZIK M. & ŻUWAŁA K. 2013. Amphibian situation in urban environment – history of the common toad Bufo bufo in Kraków (Poland). Ecol Questions 18: 73-77 DOI: 10.2478/ecoq-2013-0009.

DENOËL M. 2012. Newt decline in Western Europe: highlights from relative distribution changes within guilds. Biodivers Conserv 21: 2887-2898. DOI 10.1007/s10531-012-0343-x.

GiGL 2014. Greenspace Information for Greater London. Website:http://www.gigl.org.uk/atlas/amphibians-reptiles-atlas/ [Access: 4-11-2014].

JUSZCZYK W. 1987. Płazy i gady krajowe. Cz. II – Płazy. PWN, Warszawa.

KACZMAREK J. M., KACZMARSKI M. & PĘDZIWIATR K. 2014. Changes in the batrachofauna in the city of Poznań over 20 years. In: INDYKIEWICZ P. & BÖHNER J.(eds.). Urban Fauna. Animal, Man, and the City – Interactions and Relationships, pp.169-177. University of Technology and Life Science in Bydgoszcz.

KUREK R., RYBACKI M. & SOŁTYSIAK M., 2011. Poradnik ochrony płazów. Ochrona dziko żyjących zwierząt w projektowaniu inwestycji drogowych. Problemy i dobre praktyki. Stowarzyszenie Pracownia na rzecz wszystkich Istot, Bystra. [in Polish]

ŁOCHYŃSKI M. & GUZIK M. 2009. Standardy danych GIS w ochronie przyrody. Version 3.03.01 pp. 57-58. Poznań-Zakopane-Kraków. [in Polish]

OGIELSKA M. & KIERZKOWSKI P. 2010. Long term data on the amphibians of Wrocław. Fragm Faunist 53(2): 195-212.

PAWŁOWSKI A. 1993. Amphibians of Poznań. MSc Thesis, Department of General Zoology, Adam Mickiewicz University, Poznań, Poland. [in Polish]

SEMLITSCH R. & BODIE R. J. 2003. Biological Criteria for Buffer Zones around Wetlands and Riparian Habitats for Amphibians and Reptiles. Conserv Biol 17(5): 1219-1228.

THE SOZOLOGICAL DATABASE AS A BASIS FOR NATURAL STUDIES OF THE BIODIVERSITY ON THE MORASKO AREA

Katarzyna Pędziwiatr[1]*, Paulina Konieczna[1], Kamila Stachura[2], Michał Antkowiak[3], Mariusz Meissner[4]

[1] Institute for Agricultural and Forest Environment, Polish Academy of Sciences, Poznan, Poland

[2] Department of Integrated Geography, Faculty of Geographical and Geological Sciences, Adam Mickiewicz University, Poznan, Poland

[3] Department of Plant Ecology and Environmental Protection, Faculty of Biology, Adam Mickiewicz University, Poznan, Poland

[4] BioGIS Section of Student Scientific Society of Naturalists, Faculty of Biology, Adam Mickiewicz University, Poznan, Poland

*e-mail: kas.pedziwiatr@gmail.com

ABSTRACT: The sozological map presents the state of the natural environment, reasons and results of the changes it undergoes, which are consequences of positive as well as negative human impact. An intensive urban development has made the official data in the scale of 1: 50 000 (for the studied area from 2004) no longer up to date. There is also an urgent need to create sozological studies with the use of Geographical Information Systems, suitable for the natural environment researches. The integrated sozological database which has been prepared as a part of the "Interactive Biodiversity Atlas of Morasko – New Approach in Management of the Natural Environment" project covers that knowledge gap. Furthermore, the database is a valuable source of knowledge about the terrain, provides precise and suitable data for natural research in the local scale, which is related to new informative layers. In the light of the above-mentioned arguments, the study is putting forward an integrated sozological database as a basis for further natural research of the biodiversity in the area of Morasko.

KEYWORDS: sozology, GIS tools, database, Morasko, biodiversity, Poznań

Introduction

The sozological map is a thematic map, presenting the state of the natural environment, reasons and results of both its positive and negative changes in the natural environment, diverse influence of processes of mainly human origin, and forms of its preservation. One of the main objects of sozology is the dynamics of changes in nature as a result of anthropogenic transformation, which usually disturbs the natural balance in the ecosystem or geoecosystem (Wytyczne Techniczne 2005).

The concept of a sozological map was created at the turn of the 60s and 70s of XX century (Kozacki & Macias 2004). Sozological maps have existed in the current form since the 90s, during that time there have been numerous changes and modifications (Kunz & Kot 2007). The first guidelines were written in 1990 (Wytyczne Techniczne K-3.6 Mapa Sozologiczna w skali 1:50 000). The guidelines were amended in 1997, the thematic range of the map was also modified by implementing the principles of creating new numerical database and map forms. Since that time, the sozological map fulfills the basic function of GIS, while the numerical version provides its users with numerous opportunities. The latest amended guidelines, adapted to the new legislation connected with Poland's accession to the EU, were published in 2005 as GIS-4 Mapa Sozologiczna Polski w skali 1:50 000 (Wytyczne techniczne).

Nowadays, GIS tools have become commonly used devices for capturing, storing, managing, retrieving, analyzing, and displaying georeferenced spatial information to the coordinates of a particular projection system. The creation of vector maps is one of many possible GIS tools applications. Paper maps are being replaced with digital versions because of their greater capacity for information and the ability to edit them. GIS tools also take advantage of broadly defined environmental protection (Urbański 2012).

The scale of the study is a matter of importance. Hence, Ławniczak (2013) emphasizes the importance of the usefulness of sozological maps in the scale of 1: 10 000 particularly in urban areas and areas with intensive human activities. This scale corresponds with the available topographic materials, thus facilitating the creation and comparison of specific thematic layers. The author also stresses the need to establish guidelines for the contents of the map, together with its counterpart graphics and database infrastructure, stressing the need for modification of these elements in the event of legislative changes in environmental law. Furthermore, Fagiewicz (2007) highlighted the fact that sozological map in the scale of 1:50 000, suitable for the poviat level, is not detailed enough for the local scale. According to the author, adaptation of the currently existing databases of the regional level to the local scale could support numerous issues concerning an integrated and uniform system of spatial information concerning the natural environment.

Actually, the need to carry out sozological studies on a larger scale was already noticed in 1999 for Górznieńsko-Lidzbarski Landscape Park (in the scale 1:25 000). Many maps of naturally valuable areas. such as landscape parks, were prepared in the 1990s by the Institute of Geography of Nicolaus Copernicus University (Kunz & Kot 2007).

Achtenberg et al. (2013) in order to conduct natural research, took an attempt to study sozological map in the scale of 1:10 000. In the study attention was particularly focused on great detail of the obtained data, as well as their categorization and visualization. Moreover, additional new informative layers were added, which were omitted in the maps published in the scale of 1:50 000 (because of reasons such as generalization or illegibility). The accomplished spatial compounds analysis of maps (allowing for the scale) did not indicate quantitative, but qualitative differences.

The presented integrated sozological database has been prepared as a part of the project "Interactive Biodiversity Atlas of Morasko – New Approach in Management of the Natural Environment", conducted by Student Scientific Society of Naturalists (KNP) members from Faculty of Biology of the Adam Mickiewicz University in Poznań. The BioGIS section of KNP manages the entire project. In case of this project, interdisciplinarity means an inventory of various types of organisms (e.g. plants, insects, reptiles, zooplankton, small mammals). The research area covers 14,2 km^2. The final result will be an online GIS map of the biodiversity. The atlas will be a useful tool for establishing naturally valuable areas, endangered by anthropogenic factors. Furthermore, BioGIS section cooperates with the project partners United Nations Decade for Biodiversity 2011-2020.

Morasko is characterized by valuable landscape in the context of history and culture of its inhabitants, as well as the natural environment for naturalists. Unfortunately, intensive urban development (particularly housing) has led to some irrecoverable damages. However, there are still some spots of nature in the neighborhood and the area of Poznań which have not completely been transformed by urban activity. The most precious one is 'Meteoryt Morasko' wildlife reserve (Janyszek & Szczepanik-Janyszek 2002).

In the light of the above, the aim of the presented study is to put forward an integrated sozological database as a basis for further natural research of the biodiversity in the area of Morasko.

Materials and methodology

The project was divided into three steps: preliminary work, a fieldwork, and chamberwork.

First, the content of a sozological map in the scale of 1:50 000 (Kownacka et al. 2005) was analysed in the context of its usefulness for natural studies in the scale of 1:10 000, taking into account the Wytyczne Techniczne GIS – 4. Also, entire available literature concerning the Morasko area was studied. Secondly, additional informative layers were selected . During the process of metadata preparation the database structure with particular layer attributes and its geometry was established. Furthermore, the abbreviations of names as well as descriptive data were standardised. Next, an orthophotomap of the research area was digitalized, taking into account the land cover. Finally, research areas for particular mapping team were established.

During the fieldwork, GPS receiver – Dacota 10 by GARMIN company for the mapping purposes was used. The data obtained in the process of digitalization from orthophotomap were verified in the parallel photographic documentation. The fieldwork started in October 2012 and finished in May 2013.

After collecting the data, the chamberwork has started using software ArcGIS Desktop 10.1. by ESRI company. Thematic layers were prepared in .shp format, adjusted to the proposed categories. Every particular layer had a unique symbol, where a shape, a size, a given colour (CMYK), as well as an outline thickness and etc. were taken into account. The gathered data were visualized synthetically and divided into separate categories.

New category division was proposed as following: 1) Forms of the natural environment protection; 2) Potentially negatively influenced elements on the natural environment; 3) Elements counteracting against degradation or mitigating human impact on the natural environment; 4) Elements supporting biodiversity; 5) Other environmental elements. Additionally, new informative layers were inserted, not taken into account by the map published in the scale of 1:50 000.

Results

The effect of the presented study was a map and a database of sozological elements in the scale suitable for local research (1:10 000). The considered compounds cover location of environmentally essential elements, such as nest boxes, fallen trees, etc. The practical implication of a study of that particular area is better comprehension of the observed processes through a detailed analysis of the data with some environment elements which were excluded in the previous studies. It can benefit future environmental research. The study contains updated elements of the sozological map with additional biotic, abiotic and anthropogenic compounds, classified into the following categories:

1. Forms of the natural environment protection – elements protected by law in accordance with Ustawa o ochronie Przyrody (Dz.U. 2004 nr 92 poz. 880) and Prawo Ochrony Środowiska (Dz.U. 2001 nr 62 poz. 627). It is essential to take into account the biodiversity conservation through legal restrictions limiting the human impact.

2. Elements potentially negative for the natural environment – various intensity of human impact. The category concerns the results of human activity, which can affect diverse intensity of the natural environment. That group of compounds consists of mainly man-made products; permanently occupied space of natural environment such as roads, buildings or parking places. Every element of the group can have both direct and indirect effect on nature, as well as a short or long-term influence. The category also includes constituents affecting the environment indirectly, but not necessarily leading to its degradation, for instance tourist paths or viewing points.

3. Elements counteracting against degradation or mitigating human impact on natural environment – actions aimed to maintain a good condition of the natural environment. The category includes human activities aimed at mitigating human impact on the natural environment. These constituents limit negative human influence, through industrial water treatments, containers for waste and etc.

4. Elements supporting biodiversity – habitats or areas important from the ecological point of view because of the increasing probability of diverse flora and fauna occurrence. The group of compounds comprises objects essential for biological research, such as anthills or fallen trees as well as land cover types and water surface.

5. Other environmental elements – elements not having crucial importance in the natural research. These include the following compounds: gauges, forester's lodge and border of the research area.

As has been mentioned, the discrepancy between the sozological map in the scale of 1:10 000 and the official one 1:50 000 (Kownacka et al. 2005) in the context of a number of informative layers (not considering their geometry) should be also take into account. The created sozological database was additionally enriched with diverse unique information. The group concerning forms of natural environment protection was expanded on Natura 2000 site. In the group of potentially negatively influenced elements on natural environment, the following elements were added: hydrants, dustbins, tourist paths, public toilets, illegal parking. The group of elements counteracting against degradation or mitigating human impact on natural environment was enlarged with corrugated grain silos, household sewage treatment plants, containers, recycling containers. The group of elements supporting biodiversity was expanded with anthills, nest boxes, small ponds, fallen trees, single trees, strips buffer, small group of trees, the feeding grounds of beavers, wells, old sewer manholes, recreational facilities and culverts. Boulders were inserted into others environmental elements.

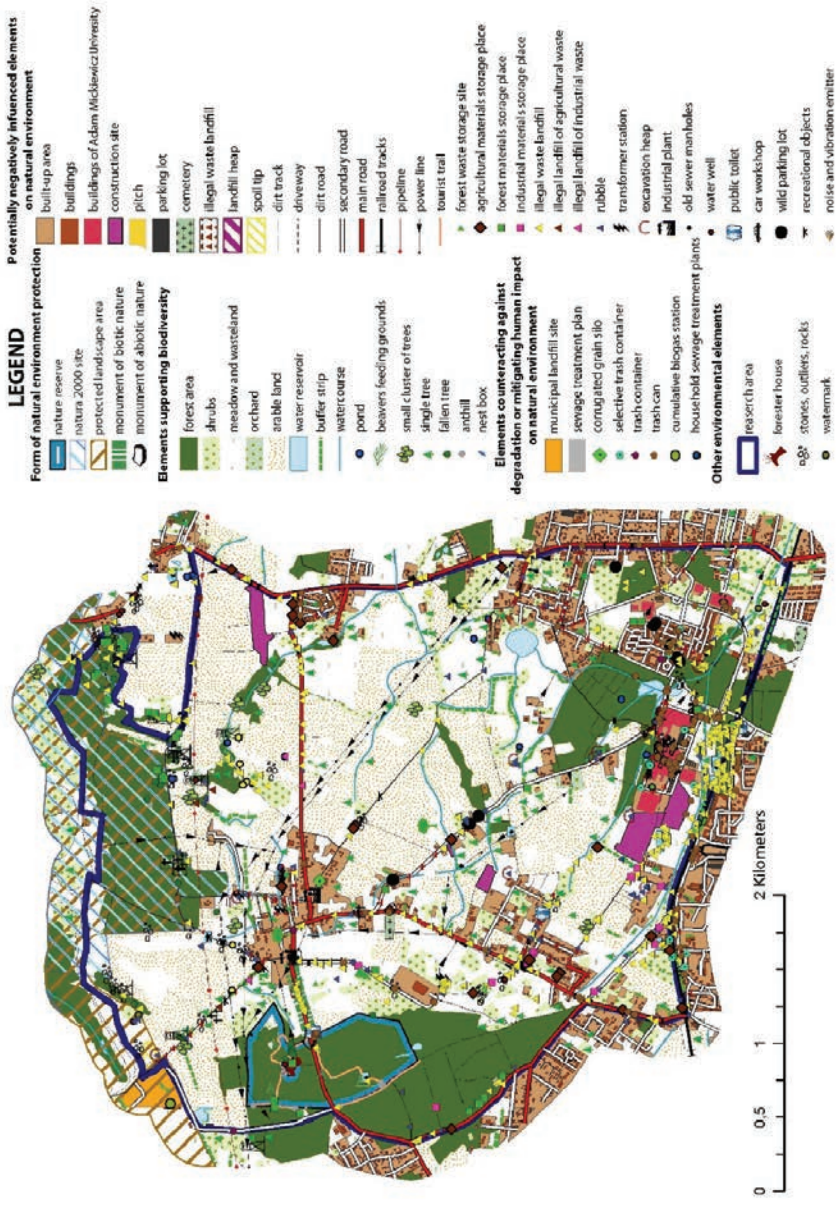


Fig. 1. Proposed sozological map of Morasko area (source: own elaboration)

The natural research is also focused on large-scale studies, but it mostly concerns the landscape scale on the level of the local population. Therefore, the most characteristic spatial elements (objects and relation) allow the completion of the analysis and comprehension of the investigated transformation area. Moreover, the defined standards in the gaining and processing the spatial data, for example about fallen trees, can be useful for further naturalistic field work of employees and students. It is vital information for entomologists about a potential site of occurring saprobiontic organisms or the bank of seed plants. Thus, the investigation of changes in time of the number of fallen trees could be an excellent basis for the estimation scale of environment transformations.

Aggregated and elaborated spatial data were exploited in order to create a sozological database, necessary for an analysis of the intensity of the natural environment anthropogenic transformation. During the database construction, the scale of mapping was taken into account (landscape level). The drilldown of spatial data range and the scale of mapping lead to complete discernment of the terrain, and in the consequence to better protection against the negative effects of human impact. Frequently, the use of the published sozological map information in natural studies on intensively anthropogenic transformed urban areas runs the risk of unreliable spatial analyses. In the future, the detailed data resources can be applied to spatial planning or ecophysiographic studies, which require the scale of 1: 10 000 and smaller (Kozacki & Macias 2004).

The gathered data, as well as the proposal for the visualization, are shown in Figure 1. The legend presents the amount of inventoried layers included in the studied categories.

Discussion

The sozological map of the Morasko area can be considered as a valuable source of knowledge about the terrain. It gives a basis for implementing an effective action preserving the natural environment of the region. The gathered data and the defined standards of capturing and processing spatial data can be useful for further natural field work for students and professionals. Furthermore, in the near future there are plans for launching a widely accessible Internet application presenting the collected data. An environmental valorization of the area in the parallel with the establishment of particularly valuable sites, threats identification of natural habitats concerning negative human impact, as well as determination of mitigation or compensation actions, are possible thanks to numerous attributes analyses of the developing sozological database. For example, a preliminary analysis of the collected material suggests that one of the alarming, currently observed phenomena is a great deal of illegal municipal landfill sites. Over 400 places were classified as potentially dangerous for natural habitats as the result of illegal garbage dumps. As a result, the necessity of monitoring the changes of the researched area was perceived through the constant updating of the newly-created database.

The natural research is also focused on large-scale studies, but the works mostly concern the landscape scale, on the level of the local population. Therefore, the most characteristic spatial elements (objects and relation) allow the completion of the analysis and comprehension of the investigated transformation area. Moreover, the results of a more detailed study are new informative layers, which give more precise and broad view of the terrain.

The category "elements supporting biodiversity" can be considered as the most valuable input of the study. As it was mentioned above, these are habitats or areas important from the ecological point of view as hotspots of biodiversity. The buffer strips can be mentioned as an example. It is valuable information for naturalists about the potential site of occurring f.i. rodents or birds. Thus, the investigation of changes in time of buffer strips network could be an excellent basis for estimating the scale of the intensity of the environment transformations.

Acknowledgements. We are grateful to dr Maciej Nowak for his contribution to the research. We would like to thank dr Lidia Poniży and dr Jolanta Kijowska for their critical reading of the manuscript. Paulina Zagórska, Danuta Dera-Jakobczyk and dr Grażyna Liczbińska are acknowledged for improving the English version of the manuscript. This work was supported by the Dean of the AMU Faculty of Biology as a result of the best student research project award for the project in the second edition of Student Research Grant.

Bibliography

ACHTENBERG K., ANTKOWIAK M., CYGAN A., KONIECZNA P., NOWAK M., PĘDZIWIATR K. & STACHURA K. 2013. Mapa sozologiczna w lokalnych badaniach przekształceń środowiska przyrodniczego. [In:] Czaja J. (ed.) Geomatyka i inżynieria 01:27-50. Jarosław.

FAGIEWICZ K. 2007. Numeryczna mapa sozologiczna jako narzędzie stanu środowiska przyrodniczego. AWEL. Poznań. pp. 1-168.

JANYSZEK S. & SZCZEPANIK-JANYSZEK M. 2002. Okolice góry Moraskiej In: Wśród zwierząt i roślin, Kronika miasta Poznania. Wydawnictwo Miejskie. Poznań. pp. 219-241.

KOWNACKA G., KIJOWSKA J., KIJOWSKI A. & ŻYNDA S., 2005, Mapa sozologiczna w skali 1:50 000, arkusz nr N-33-130-D POZNAŃ Wielkopolskie Przedsiębiorstwo Geodezyjno-Kartograficzne GEOMAT

KOZACKI L. & MACIAS A. 2004. Opracowania ekofizjograficzne a mapy sozologiczne In: M. Kistowski (ed.). Studia ekologiczno-krajobrazowe w programowaniu rozwoju zrównoważonego. Przegląd polskich doświadczeń u progu integracji z Unią Europejską, Problemy Ekologii Krajobrazu, vol. XIII, Gdańsk, Bogucki Wyd. Naukowe, pp. 79–87.

KUNZ M. & KOT R., 2007. Doświadczenia Instytutu Geografii UMK w zakresie sporządzania numerycznych mapsozologicznych, [In:] M. Kunz (red.), Systemy informacji geograficznej w praktyce (studium zastosowań), Wyd.UMK, Toruń, pp. 139-147.

ŁAWNICZAK. R. & KUBIAK J. Implementation of the 1 : 10 000 Scale for Visualisation of Environmental Changes, The Cartographic Journal Vol. 50 No. 1 pp. 82–90 February 2013 The British Cartographic Society 2013 DOI: 10.1179/1743277412Y.0000000009

URBAŃSKI J. 2012. GIS w badaniach przyrodniczych. Wydawnictwo UG. Gdańsk, pp. 6-248.

Ustawa z dnia 16 kwietnia 2004 o ochronie przyrody (Dz.U. 2004 Nr 92 poz. 880 z późn. zm.) (Nature Protection law)

Ustawa z dnia 27 kwietnia 2001 Prawo ochrony środowiska (Dz.U. 2001 Nr 62 poz. 627 z późn. zm), (Environmental Protection law)

Wytyczne Techniczne GIS-4, 2005. Mapa sozologiczna Polski, skala 1:50 000, GUGiK, Warszawa

Wytyczne Techniczne K-3.6. System Informacji o Terenie. Mapa Sozologiczna Polski, skala 1: 50 000 w formie analogowej i numerycznej, GUGiK, 1997

THE USE OF GIS DATABASE IN THE DOCUMENTATION OF WILLOWS OF THEIR COLLECTION AT THE POZNAŃ UNIVERSITY OF LIFE SCIENCES (POLAND)

Paweł Rutkowski[1], Monika Konatowska[2], Piotr Goliński[3], Mirosław Mleczek[3], Kinga Szentner[3], Bogusława Waliszewska[3]

[1] Uniwersytet Przyrodniczy w Poznaniu, Wydział Leśny, Katedra Siedliskoznawstwa i Ekologii Lasu, Poznań
e-mail: redebede@wp.pl

[2] Zespół Parków Krajobrazowych Województwa Wielkopolskiego. Poznań, Poland

[3] Uniwersytet Przyrodniczy w Poznaniu, Wydział Technologii Drewna. Poznań, Poland

ABSTRACT: The usefulness of the ArcGIS computer program was demonstrated at an example of the studies conducted on more than 16000 willow shrubs (150 taxa of the collection of the Poznań University of Life Sciences, planted randomly, in 36 replicates in 6 locations in the country, with diverse site conditions).

KEYWORDS: willows from the Collection of Poznań University of Life Sciences; ArcGIS

Introduction

Almost all large industrial companies, and ecological and research organizations use GIS software. Shell has been using ArcGIS for more than 20 years. (Marchenko 2013). Valdez and others (2013) used the ArcMap to the visualization of the voters' preference during Mexican Presidental Elections in 2012. GIS technics could be very useful to disaster and emergency management (Kearns, Islam 2013). Gámez et al. presented application od ArcGIS tools for Flood Risk Assessment (2013). Van Rensburg (2013) put an attention on the ArcGIS Mobile as a tool to the assessment of any kinds of damages.

In the long-term ecological studies, or during long-lasting venture very important issue is to collect and archive data in readable and understandable manner, clean to potential customer even after several years. Also in larger research team works on the same object, the way of collecting, sharing and supervising of the experimental data is of prime concern. During recent project (N R12 0065 10) above-mentioned issues were carefully introduced into studies conducted on 150 willows taxa of the collection of the Poznań University of Life Sciences. The results indicates that the ArcGIS computer program enables both data archivisation and ongoing control of the willows subjected to examination. The aim of this study was to demonstrate the usefulness of the program.

Material and methods

The beginning of the collection dates back to the 60s of the twentieth century with varieties collected before 1966 by professor Leon Mroczkiewicz, former head of the Department of Silviculture at High School of Agriculture in Poznan, followed by varieties and species collected by Jan Białobok, the former head of the Department of Cultivation of Basket Willows (National Institute of Soil Science and Plant Cultivation). The above collection was transferred in 1966 to the Murowana Goślina Forest Experimental Station, of the Agriculture University of Poznan, (now Poznań University of Life Sciences). During years 2000 - 2001 it was transferred by professor Bohdan Drogoszewski (head of the Department of Silviculture) to the Dobrygość Forest Range (Siemianice Forest Experimental Station, of the Poznań University of Life Sciences). In 2011, under the National Developmental Project (# N R12 0065 10) financed by the National Centre for Research and Development all the above varieties of willows were

planted randomly, in 36 replicates in 6 locations in the country, with diverse site conditions (Siemianice near Kępno - 3 experimental areas; Grodziec Mały near Głogów - 1 experimental area; Zielonka near Murowana Goślina - 1 experimental area and Bałdy near Olsztyn - 1 experimental area). Totally 16200 cuttings were planted in different parts of Poland.

Biomass increase as well as phytoremediation abilities (accumulation of trace metals) and willow wood usefulness in production chipboard was compared and data was introduced into the system by ArcGIS program according to the schema presented in the results of this paper.

Results

The method of archiving data using the ArcGIS program was as follows:

1. ArcGIS program allows to create maps consisting of any number of thematic layers.

2. The coordinates of the corners of each plot were determined by Garmin device.

3. The first map layer, with the borders of experimental areas, was plotted accordingly to the coordinates of each plot.

4. On the base of the layout of planting individual willows taxa the next layer was generated by the ArcGIS program where each shrub, planted as cutting, was marked as a point

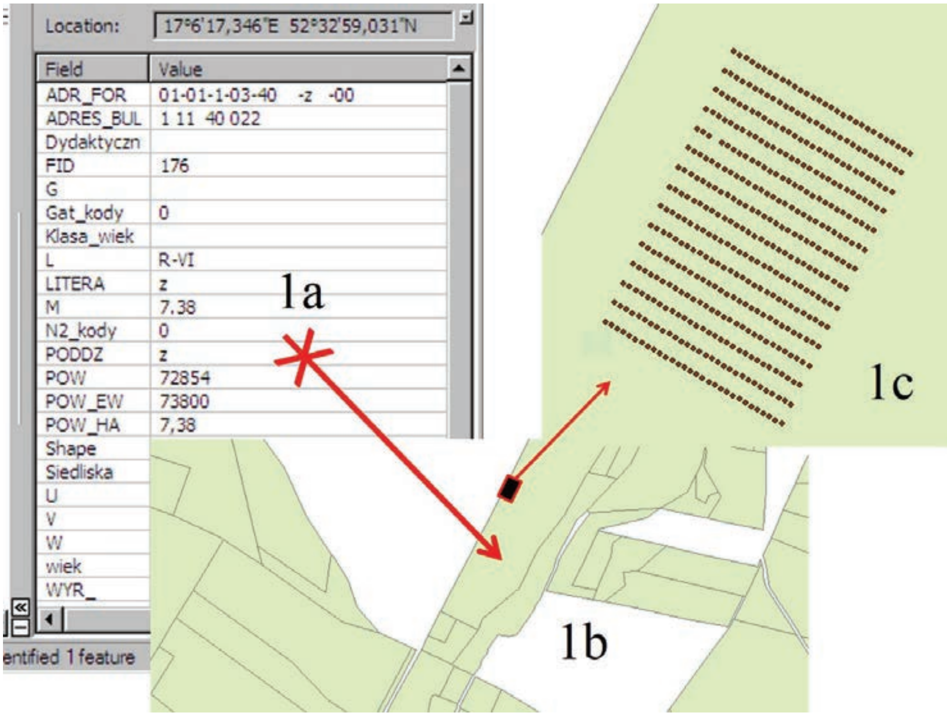


Fig. 1. Location of willows collection at experimental plot of Zielonka Experimental Forest District. Part 1a of the figure shows a part of the ArcGIS data form where i.e. category of the area is described (position "L" in the "Field" column and the position "R-VI" in the "Value" column mean: arable land of the worst category of usefulness in agriculture); in the header there are coordinates of the center of the contour]. Part 1b of the figure shows the fragment of the map with the boundaries of the arable land, where the experimental plot was established and other sections of Zielonka EFD ; the location of the experimental plot is marked as black rectangle. Part 1c shows an enlarged fragment of the experimental plot and the location of planted willows (15 rows; 10 taxa in a row; the three plants of each taxon in a row; total 450 shrubs).

5. In ArcGIS, each point or shape applied on the map could by described in the form of data compiled in tabular form, so-called attribute table. Data entered in the table depend of its creators and for example figures 1 and 2 show excerpts from two thematic layers for the study area located in the Zielonka Experimental Forest District. Fig. 1 base layer creates a map with the different categories of land using at Zielonka EFD. The land on which is

located the experimental area was the field of the VI class (the class with the worst agricultural properties in Polish classification) (Fig. 1a, row of the table is described by the letter "L"). The geographical center of the area is marked by the coordinates given in the table header (Fig. 1a, item "Location"). The boundaries of the field is shown in Fig. 1b. The figure also marks the location of the experimental plot with planted willows (black rectangle). Fig. 1c presents the enlargement of the plot, with the points representing the individual plants. Fig. 2 shows a sample data set for one of the bushes (2a). The attribute table (Fig. 2b) includes data concerning the timing of planting (position "Planting", gender (sex), the copper content in the leaves and shoots (Cu_leaf, Cu_twig) and others

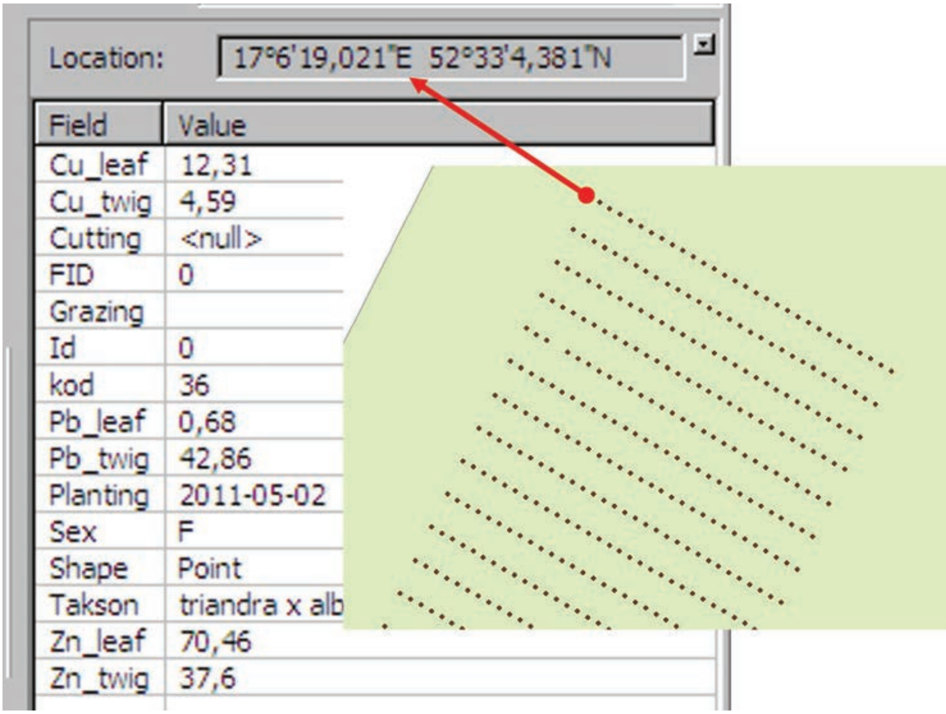


Fig. 2. Characteristics of selected shrub on the experimental plot of Zielonka Experimental Forest District. Coordinates of the shrub are given in the header of form; in the column "Field" copper content in leaves ("Cu_leaf ') and shoots (" Cu_twig "), sex (here: F = female), date of planting (Planting), name of taxon („Takson" – here: *Salix triandra* × *alba*) and others are given.

6. So compiled data are easy to sort according to the selected features (Fig. 3a), and the determining of the location on the map of a shrub characterized by selected feature is easy (3b).

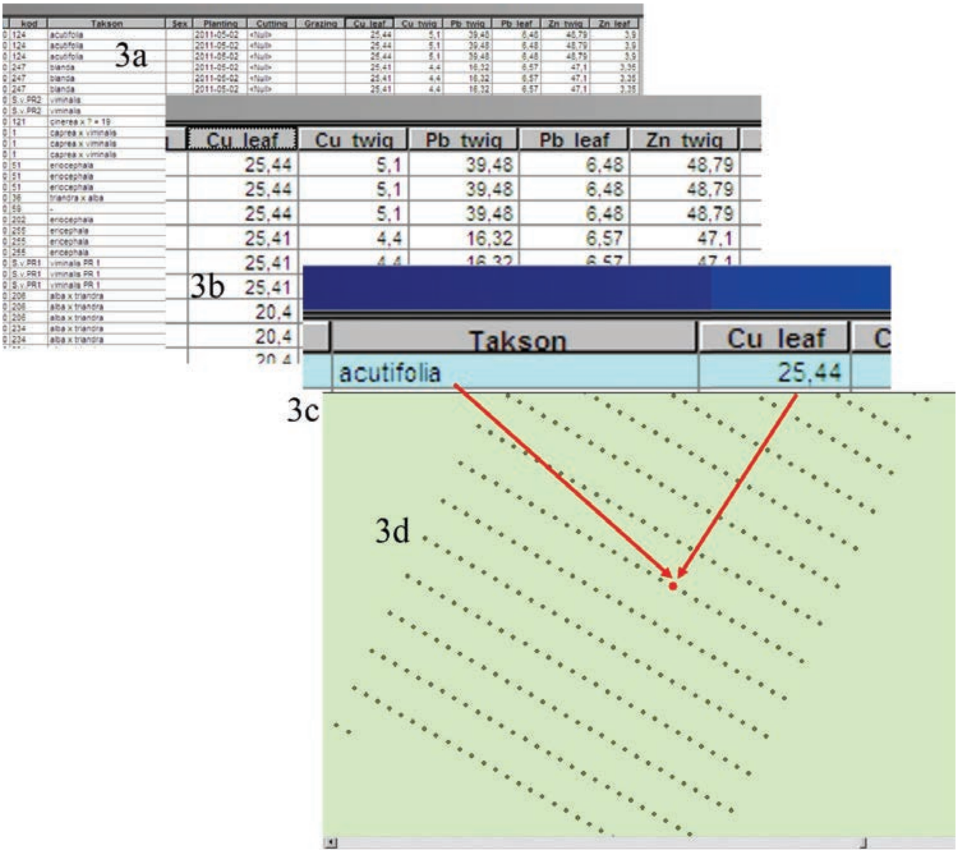


Fig. 3. Searching of information: 3a – attribute table; 3b - magnified attribute table with the values sorted according to decreasing copper content in the leaves; 3c - selected shrub with high copper content in the leaves and its systematic name (*Salix acutifolia*); 3d – highlighted in the table bush lights up on the map in red, showing its location

Conclusions

1. Graphic (maps) and tabular (data) form of gathered information, even with their large numbers, make it easy to locate a shrub of the determined variety, as well as specify the location bushes on selected features.

2. Construction of the database in ArcGIS program facilitates the introduction of new information concerning the specified shrubs, what allows data to be continuously updated.

3. To some extent, the same ArcGIS program generates opportunities that can bring new value in the interpretation of gathered data, for example by adding new thematic layers created by other users, such as geological, climatic and/or other data.

4. The gathered database is easy to follow for another users, now and in the future.

Acknowledgements. Experimental blocks (36) where willows were planted in 2011 as well as studies during 2011-2013 were financed by the National Centre for Research and Development under the framework of the National Developmental Project (N R12 0065 10).

References

GÁMEZ B., CAVAZOS T., MENDOZA L. 2013. Application od ArcGIS tools for Flood Risk Assessment (2013). https://s3.amazonaws.com/webapps.esri.com/esri-proceedings/proc13/papers/536_105.pdf

KEARNS CH., ISLAM T., 2013. 9-1-1- and GIS. Analyzing 9-1-1- Call Data from an Emergency Management Prespective. https://s3.amazonaws.com/webapps.esri.com/esri-proceedings/proc13/papers/322_111.pdf

MARCHENKO N. 2013. Geographical Informational Systems for sustainable arctic technology. Proceedings of the 22nd international conference on port and ocean engineering under arctic conditions. June 9-13, 2013. ESPOO, Finland. http://www.unis.no/35_STAFF/staff_webpages/technology/nataly_marchenko/Marchenko_POAC13.pdf

VALDEZ Y., ZAVALA O., ZAVALA J., TAI E., AVILA M., BARREDA J., STANTIAGO D. 2013. Analysis of the 2012 Mexican Presidential Elections. https://s3.amazonaws.com/webapps.esri.com/esri-proceedings/proc13/papers/1135_254.pdf

VAN RENSBURG S.J. 2013. ArcGIS Mobile Implemented to Improve Damage Assessment Field Data Capture. https://s3.amazonaws.com/webapps.esri.com/esri-proceedings/proc13/papers/120_204.pdf

USE OF FOREST INVENTORY DATA FOR THE ASSESSMENT OF FOREST BIOLOGICAL VALUE – POLAND AS AN EXAMPLE

Krystyna Stachura-Skierczyńska

Laboratory of Biological Spatial Information, Faculty of Biology, Adam Mickiewicz University, Poznan, Poland

ABSTRACT: This paper present the results of mapping of Biologically Important Forests (BIFs) in Poland. BIFs, considered as forests retaining natural characteristics, are key areas for the protection of specialist forest-dependent species. BIF Mapping project has involved several Eastern-European countries, encompassing a wide range of forest habitat types. Main sources of data were national forest inventory databases, providing consistent information at various spatial scales, from stand level to larger management units. The total area of forests fulfilling at least one BIF criterion in Poland was estimated a 967 700 ha (11% of its total forest area). The BIF mapping methodology and database has been applied in several project aimed at the predictive mapping of the distribution of specialized woodpecker species. It was found that woodpecker preferred forest characterized by some BIF criteria, mostly the advanced age and uneven stand structure. BIF approach provides efficient, ready-to-use tools for the conservation of forest-dependent species and their habitats, as well as for the improvement of existing network of protected areas.

KEYWORDS: forest conservation, forest inventory database, predictive mapping.

Introduction

Conservation of forest biological diversity is one of the main goals of sustainable forest management. In practice, it requires maintaining and preserving representative functional networks of all forest habitat types at various spatial scales and configurations (Hanski 2013) under different conservation regimes, with a substantial share of strictly protected areas (no forestry practices).

For the purpose of efficient conservation strategy, forestry authorities need to know the type, location, and spatial extent of potentially valuable sites. In practice, many biologically important areas remain unprotected not only due to political or economic reasons, but also because of the lack of information (Hanski & Walsh 2004). Moreover, even those that actually have some legal protection status might not be adequately conserved because of a lack of true non-intervention regime or ecologically-oriented management practices (Stachura-Skierczyńska & Walsh 2010).

The concept of Biologically Important Forests (BIFs) was invented by Birdlife European Forest Task Force in order to develop an uniform set of scientific, objective criteria that depict types of forests with particular value for biodiversity. BIF is defined as a forest retaining or having started to develop natural characteristics. It is considered a key area for the protection of specialist forest-dependent species that require a certain quantity and quality of suitable habitat to survive. These include species with large area requirements (i.e. large carnivores) as well as locally occurring specialist species, such as epiphytic plants or lichens (Kurlavicius et al. 2004, Uliczka & Angelstam 2000). In particular, the BIF approach focuses on birds as one of the best studied taxonomic groups, often functioning as indicator and/or flagship species (Angelstam et al. 2003, Angelstam & Donz-Breuss 2004). Fore the purpose of conservation planning, the term 'BIF' can function as a basket for other existing designations that refer to forests with important ecological functions, such as High Conservation Value Forests (Forest Stewardship Council 2012), IUCN protected areas, NATURA 2000 sites etc. (Kostovska et al. 2008).

The idea of BIF mapping was firstly implemented in 2001-2003 in Lithuania, Latvia and Estonia (Kurlavicius et al. 2004), then in 2005-2007 in Poland and Belarus (Yermokhin et al. 2007) and in 2007-2009 in Bulgaria and Romania (Ratarova 2009), thus encompassing a wide range of forest habitat types from subboreal coniferous communities to mountain beech forests, including rare, endemic and threatened habitats as well as more common ones, yet still preserving some natural features.

The BIF database and maps are based on forest inventory databases supplemented by additional information. By their nature, national forest inventories cover wide areas and provide information at different spatial scales, from stand level to larger management units (compartments, forest districts). Although designed primarily for economic and management purposes, many of them include elements directly or indirectly pertaining to forest biodiversity. i.e. description of stand structure, species composition, presence of rare species etc. Thus, the possibility of using existing forest inventories to assess forest biodiversity has been discussed since 1990s (Rondeux 1999, Winter et al. 2008, Chirici et al. 2010). Since then, many authors have made attempts to link the forest stand characteristics with the ecological requirements of specialized species that often depend on forest naturalness and/or function as biodiversity indicators (i.e. Uliczka & Angelstam 2000, Pakkala et al. 2002, Angelstam et al. 2003, Roberge et al. 2008). However, the BIF mapping project was the first approach that used the information extracted directly from existing national forest inventories along a wide coverage of detailed numeric maps and combined it into consistent, ready-to-use Geographic Information Systems (GIS) database, suitable for analyses at various spatial scales.

Material and methods

This paper describes the use of national forest inventory database in the Polish part of BIF project, encompassing the whole area of Poland.

Typology of BIF forests

For the purpose of this project, we applied the simplified classification based on combined typologies from the forest inventory database and Forest Types for Biodiversity Assessment
(Bradshaw & Möller 2004):

1. Relatively dry lowland coniferous and mixed forests
2. Wet lowland coniferous and mixed forests
3. Lowland beech forests
4. Lowland oak forests and mixed broadleaved forests
5. Alder forests and similar swamp forests on potential sites of alder or alder-ash or wet mixed broadleaved forests
6. Flood-plain forests
7. Upland oak forests and mixed broadleaved forests
8. Upland and montane beech forests
9. Upland and lower montane coniferous forests
10. Upland and montane riverine forests
11. Upper montane spruce forests

BIF mapping criteria

Criteria for the identification of BIFs referred to several features considered typical to forests with high degree of naturalness, including:

– little or no human impact,
– limited access,
– high age of stands,
– uneven age structure and/or rich species composition
– presence of rare/endangered species and habitats
– specific site conditions (water regime, topography, slope steepness).

As the above criteria represent rather general categories, there were applied nationally on the basis of the existing data and adjusted to address specific conditions of Polish forest. For some criteria the information was extracted directly from forest inventory database; for the remaining ones the information was obtained from complementary data sources (Table 1).

Table 1. BIF criteria applied in Poland and main data sources. STRM – Shuttle Radar Topography Mission, CLC – CORINE Land Cover, SDF – Standard Data Form (Standardowy Formularz Danych).

No.	General criterion	Adjusted criterion for Poland	Data sources
1	Little or no signs of human influence	Forests in nature reserves strictly protected areas in National Parks	Forest inventory, National Parks' databases
2	Average age of stand more than X years	Age thresholds: pine - 140; spruce - 100; fir -120; oak, ash, maple, elm, lime - 120; hornbeam, alder - 80; birch, aspen - 60; willow - 40;	Forest inventory
3	Forests on steep slopes	Over 17° (lowlands) and 30° (mountains, ravines)	SRTM
4	Uneven age/canopy structure; presence of very old trees of previous generations	4a. At least 30 years of difference between tree species and average stand age at least 80 years 4b. At least 5 species in the dominant canopy layer and at least 50 years old (excluding understory) 4c. Trees at least 20 years older than in criterion 2 are present	Forest inventory
5	Forests after natural disturbances	Stands disturbed by fire, storms, flooded etc., naturally regenerating	Forest inventory, field checks
6	Endangered vegetation types present	Endangered forest habitat types from Annex I of the Habitat Directive,	Forest inventory, NATURA 2000 SDFs
7	Endangered species present	Capercaillie leks, raptor nests, nest-sites of rare woodpeckers, breeding areas of large carnivores, often combined with other BIF criteria	Data collected by NGOs and scientific institutions
8	Rare broadleaved trees present in the can-layer	Elm, cherry, wild apple, wild pear, lime (at least 10% of lime share per stand	
9	Small water courses; surface springs, flooded areas	Flood-plain or montane riverine forests, stands along small watercourses and surface springs	Forest inventory, topographic maps, field checks
10	Limited access areas	Forested islands on lakes and	Forest numeric CLC, topographic maps

In order to combine the information obtained from several data sources with different accuracy, the BIF database was organized at three basic levels (Fig. 1):

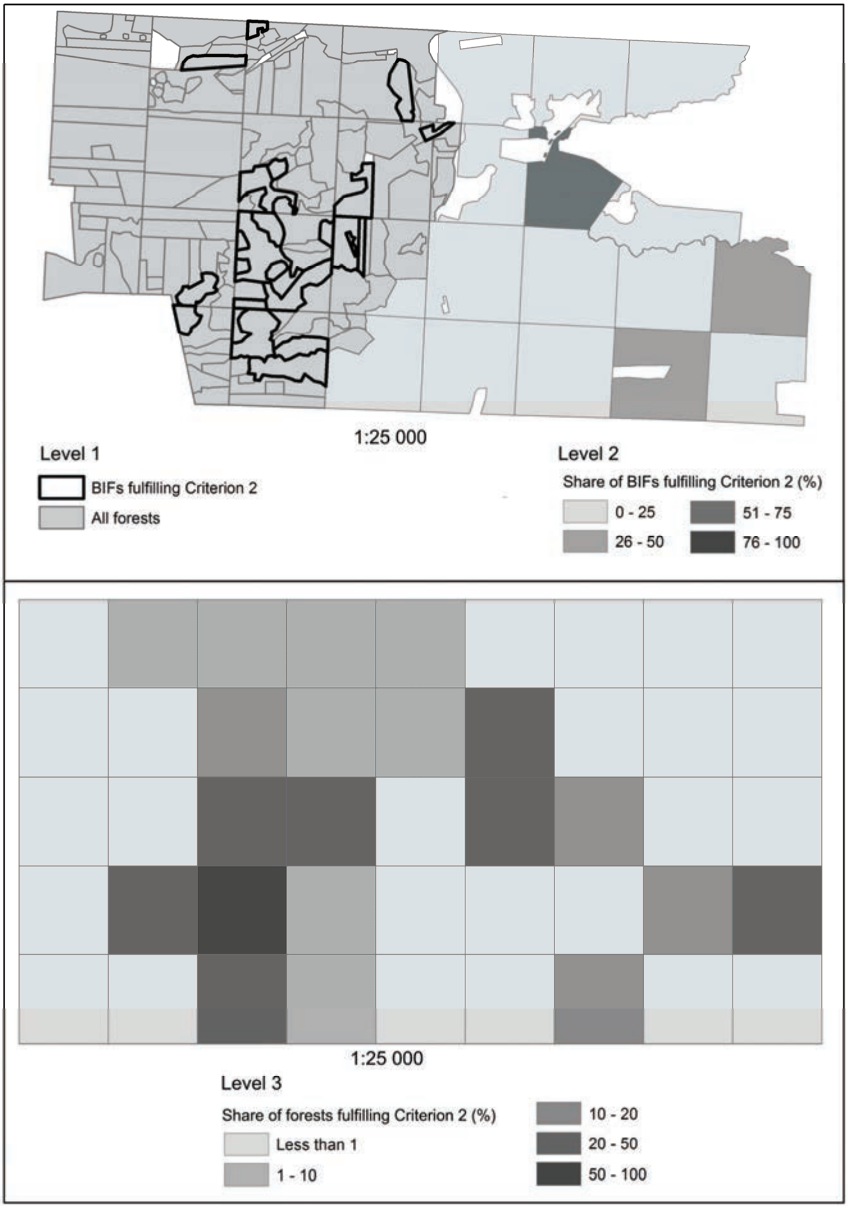


Fig. 1. Structure of BIF database: Level 1 – forest stand level, Level 2 – forest compartment level, Level 3 – generalized 25 grid

– forest stand level
– forest compartment level
– generalized 25 ha grid, combining both levels (publicly available for display and use).

During the realization of the project, the stand-level data was available for 60% of the area maintained by State Forests Holding (approximately 47% of all Polish forests). For the remaining area of state-owned forests the inventory data was aggregated to the compartment level. The majority of National Parks did not have numeric forest maps compatible with the forest inventory database at this time and the alternative sources of data (topographic maps, databases, aerial photos) could only provide information referring to some BIF criteria, but not the entire set. Moreover, no data was available for privately owned forest (approximately 19% of total forest area).

Results

The total area of forests fulfilling at least one BIF criterion in Poland was estimated at 967 700 ha, which comprised c.a. 11% of its total forest area. The most common BIF forest types were lowland oak forests and mixed broadleaved forests (38% of all BIFs), which means that these forests types are likely to develop structural characteristics typical for BIFs. Lowland coniferous and mixed forests also made a significant contribution (20% of BIFs), which results, however, from the relatively high contribution (approximately 50%) of coniferous and mixed forest sites to the total forest area in Poland. Upland and montane beech forests were next, contributing to further 13% of all BIFs.

BIFs in Poland most frequently met the criterion *Uneven age/canopy structure; presence of very old trees of previous generations*. In total, nearly 59% of BIFs were forest stands with uneven structure. Many BIFs also fulfilled criteria *Average age of stands more than X years* (32%) and *Forests on steep slopes* (29%).

The spatial distribution of BIFs across Poland depends on prevailing natural condition soils, land history of use and locally preferred forest management measures. The biggest concentrations of forests fulfilling any BIF criteria were found in the North-East of Poland and in the mountainous southern part (Fig. 2). The North-West also had locally high concentrations of BIFs, most of them corresponding with the post-glacial moraine landscapes. The central part of the country had few BIFs, mainly due to its long history of human settlement and high deforestation. It could be noticed, however, that major BIF concentrations in this region were located in its eastern part, suggesting the presence of west-eastern gradient in forest naturalness.

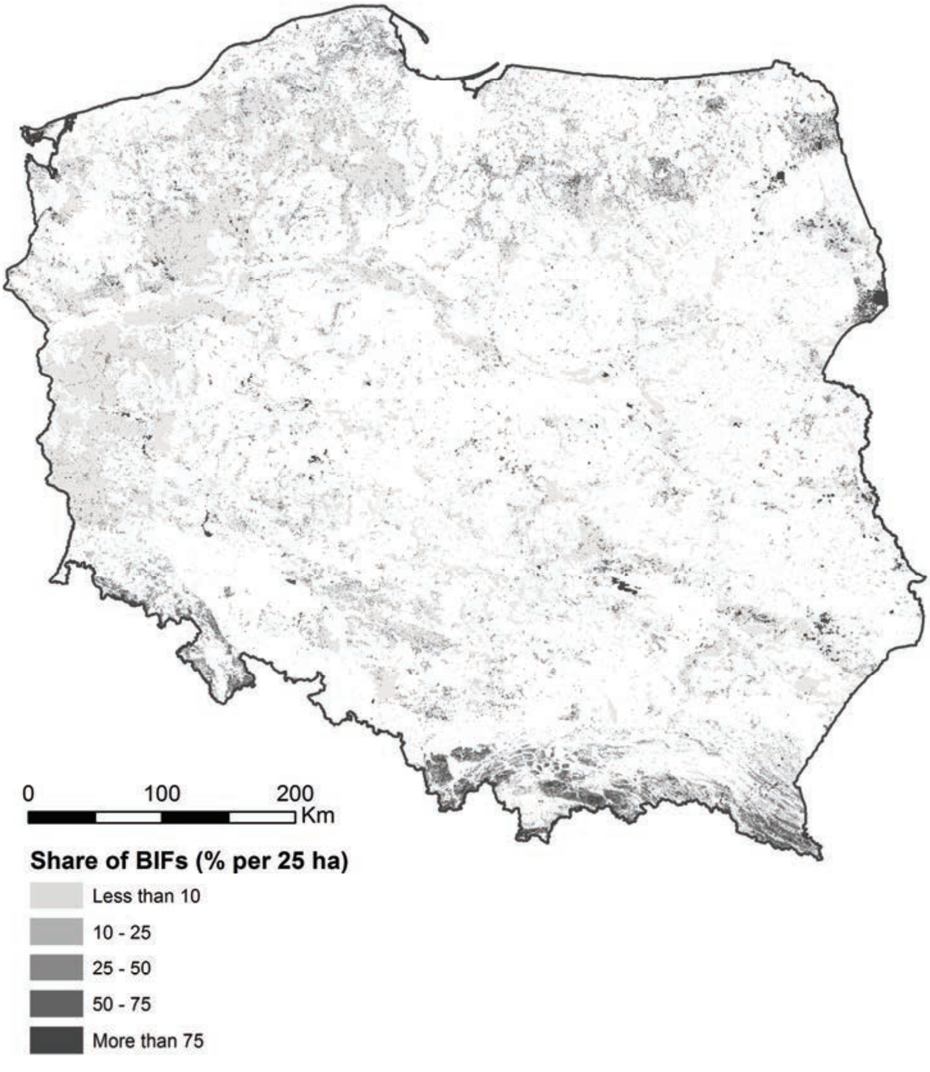


Fig. 2. Distribution of forests meeting at least one BIF criterion across Poland

When evaluating this project, it should be noticed that the main aim of the project was to analyze the distribution of BIF at landscape level. Regions with higher concentrations of BIFs are more likely to maintain forest biological diversity. The probability of preserving high conservation values (or a potential to increase them in the near future) is much greater in extensive forests with large aggregations of BIFs than in 'average' wooded landscapes.

Discussion

Problems and limitations of the BIF mapping approach

Many BIF criteria are constructed in the way that allows for the automatic search of databases. This method is fast and effective, but it requires the use of strict search criteria, which means that some potentially valuable sites might be omitted (i.e. stands with well developed structure and features of old forest but still below the age threshold specified in the search criteria) However, this is not important when results are analyzed on the landscape scale. On the other hand, some stands classified as BIFs (e.g. on account of their advanced age) might have a low conservation value because of, for example, even age structure or poor diversity.

Also, potential errors might be caused by the misclassification of forest types (including also rare and endangered habitat types) on the basis of forest inventory database. For the purpose of this project, we applied the methodological approach by Pawlaczyk et al. (2003) aimed at the identification of NATURA 2000 habitats on the basis of forest site type and stand composition. However, the inventory database has not been designed for this purpose and for many types of forest communities the above information is not sufficient to define their associations.

Possible applications of BIF approach

Despite its limitations, BIF methodology and data can be efficiently used for various conservation purposes, i.e. in mapping potential habitats of rare, forest-dependent species. In Poland, it has been applied in several project aimed at the predictive mapping of the distribution of specialized woodpecker species: three-toed woodpecker *Picoides tridactylus*, white-backed woodpecker *Dendrocopos leucotos* and middle spotted woodpecker *Dendrocopos medius* in selected regions of north-eastern, southern and central-western Poland. Results showed that woodpecker preferred forest characterized by some BIF criteria, mostly the advanced age and uneven stand structure (Stachura-Skierczyńska et al. 2009, Skierczyński et al. 2013, Walczak et al. 2013, Stachura-Skierczyńska & Kosiński 2014). The predictive maps of potential woodpeckers' distribution were also used for management planning in NATURA 2000 sites (Stachura-Skierczyńska & Kosiński 2011) and in the monitoring of indicator bird species (Skierczyński et al. 2013).

Conclusion

Both the loss of naturally diverse, old-growth forest stands and the scarcity of decaying wood in managed forests are the most significant reasons for specialist forest-dependent species becoming endangered and disappearing (Angelstam & Mikusiński 1994, Pakkala et al. 2002). Theoretical and empirical research results suggest that such species begin to go extinct once the area of natural forests drops below 10–20 percent of the forested area (i.e. (Andren 1994, Carlson 2000). Therefore in order to prevent their populations from further decline, at least 10 percent of forest cover in the region should be maintained in natural state (or as close to natural as possible), with further 10 percent under special, ecologically-oriented management regime. Despite this, most European countries have 1-2 percent (or even less) of their forests under strict protection regime, corresponding to IUCN Protected Areas categories I-II (Hanski & Walsh 2004). Moreover, the majority of strictly protected forests are located in poorly productive areas (mountain areas or northern latitudes), which means that the representative coverage of all types for forest habitats and biological diversity is not secured.

BIF mapping project provides rational premises for the improvement of current insufficient conservation system (Kostovska et al. 2008). Known areas of high BIF concentrations should be considered a basic framework for the restored functioning landscapes, linking together the refuges of old-growth biodiversity with other sustainably managed forests.

Acknowledgements. The BIF Mapping project was founded by The Aage V. Jensens Fonde, which is gratefully acknowledged. In Poland, the project was coordinated by The Polish Society For The Protection of Birds. Forest inventory data and numeric maps were provided by The State Forest Holding (PGL Lasy Państwowe).

References

ANDREN H. 1994. Effects of habitat fragmentation on birds and mammals in landscapes with different proportions of suitable habitat: a review. Oikos 71: 355–366.

ANGELSTAM P. & DONZ-BREUSS M. 2004. Measuring forest biodiversity at the stand scale – an evaluation of indicators in European forest history gradients. Ecological Bulletin 51: 305–332.

ANGELSTAM P. K., BÜTLER R., LAZDINIS M., MIKUSIŃSKI G. & ROBERGE J.-M. 2003. Habitat thresholds for focal species at multiple scales and forest biodiversity conservation - Dead wood as an example. Annales Zoologici Fennici 40: 473–482.

ANGELSTAM P. & MIKUSINSKI G. 1994. Woodpecker assemblages in natural and managed boreal and hemiboreal forest – a review. Annales Zoologici Fennici 31: 157–172.

BRADSHAW R. H. W. & MÖLLER P. F. 2004. European forest types for biodiversity assessment - a qualitative approach. EFI Proceedings 51: 121–133.

CARLSON A. 2000. The effect of habitat loss on a deciduous forest specialist species: The White-backed Woodpecker (Dendrocopos leucotos). Forest Ecology and Management 131: 215–221. DOI:10.1016/S0378-1127(99)00215-7.

CHIRICI G., WINTER S. & MCROBERTS R. E. 2010. National forest inventories: contributions to forest biodiversity assessments. Springer Ed., Dordrecht. 206 pp.

FOREST STEWARDSHIP COUNCIL. 2012. FSC-STD-01-001 V5-0 EN: FSC Principles and Criteria for forest stewardship. FSC International.

HANSKI I. 2013. Extinction debt at different spatial scales. Animal Conservation 16: 12–13. DOI: 10.1111/acv.12024

HANSKI I. & WALSH M. 2004. How much, how to? Practical tools for forest conservation. Birdlife International, Helsinki. 48 pp.

KOSTOVSKA D., STACHURA-SKIERCZYŃSKA K., YERMOKHIN M. & BOBIEC A. 2008. Mapping Biologically Important Forests - towards the restoration of a trans-European forest megacorridor. *Towards a sustainable future for European ecosystems – Providing restoration guidelines for Natura 2000 habitats and species*. Ghent, Belgium, 8-12/09/2008.

KURLAVICIUS P., KUUBA R., LUKINS M., MOZGERIS G., TOLVANEN P., ANGELSTAM P., KARJALAINEN H. & WALSH M. 2004. Identifying high conservation value forests in the Baltic States from forest databases. Ecol Bull 51:351–366. Ecological Bulletin 51: 351–366. DOI:10.2307/20113321

PAKKALA T., HANSKI I. & TOMPPO E. 2002. Spatial ecology of the three-toed woodpecker in managed forest landscapes. Silva Fennica 36: 279–288.

PAWLACZYK P., HERBICH J., HOLEKSA J., SZWAGRZYK J. & ŚWIERKOSZ K. 2003. Rozpoznawanie siedlisk przyrodniczych na podstawie danych opisu taksacyjnego lasu. Pp. 1–64.

RATAROVA V. (ed.) 2009. Bulgarian-Romanian Forest Mapping Project, final report. Pp. 1–69. Birdlife European Forest Task Force.

ROBERGE J. M., ANGELSTAM P. & VILLARD M. 2008. Specialised woodpeckers and naturalness in hemiboreal forests – Deriving quantitative targets for conservation planning. Biological Conservation 141: 997–1012. DOI:10.1016/j.biocon.2008.01.010

RONDEUX J. 1999. Forest inventories and biodiversity. FAO.

SKIERCZYŃSKI M., STACHURA-SKIERCZYŃSKA K., KAJTOCH Ł., CIACH M. & STRZELIŃSKI P. 2013. Forest inventory data in conservation planning: Predicting rare woodpeckers habitat quality on regional scale. Acta Biologica Cracoviensia Series Botanica 55 (suppl. 1) 55 (suppl. 1): 32.

STACHURA-SKIERCZYŃSKA K. & KOSIŃSKI Z. 2011. Predyktywne mapowanie jako narzędzie wspomagające planowanie zadań ochronnych w obszarach NATURA 2000 na przykładzie OSOP Dąbrowy Krotoszyńskie. Studia i Materiały CEPL w Rogowie 27: 177–185.

STACHURA-SKIERCZYŃSKA K. & KOSIŃSKI Z. 2014. Evaluating habitat suitability for the middle spotted woodpecker using a predictive modelling approach. Annales Zoologici Fennici 51: in press.

STACHURA-SKIERCZYŃSKA K., TUMIEL T. & SKIERCZYŃSKI M. 2009. Habitat prediction model for three-toed woodpecker and its implications for the conservation of biologically valuable forests. Forest Ecology and Management 258: 697–703. DOI:10.1016/j.foreco.2009.05.007

STACHURA-SKIERCZYŃSKA K. & WALSH M. 2010. Against The Grain: Improving the management of NATURA2000 sites and other forests in the EU. Birdlife European Forest Task Force. 38 pp.

ULICZKA H. & ANGELSTAM P. 2000. Assessing conservation values of forest stands based on specialised lichens and birds. Biological Conservation 95: 343–351.

WALCZAK Ł., KOSIŃSKI Z. & STACHURA-SKIERCZYŃSKA K. 2013. Factors Affecting the Occurrence of Middle Spotted Woodpeckers Revealed by Forest Inventory Data. Baltic Forestry 19: 81–88.

WINTER S., CHIRICI G., MCROBERTS R. E. & HAUK E. 2008. Possibilities for harmonizing national forest inventory data for use in forest biodiversity assessments. Forestry 81: 33–44. DOI: 10.1093/forestry/cpm042

YERMOKHIN M., STACHURA-SKIERCZYŃSKA K., BOBIEC A., PUCHACZEUSKI A. & WALSH M. 2007. Belarusian-Polish Forest Mapping: Final Report. Pp. 1–69. Birdlife European Forest Task Force.

METAPOPULATIONS OF THE ROMAN SNAIL (*HELIX POMATIA* L.) ANALYSED WITH THE GPS SYSTEM

Jerzy Błoszyk[1], Tomasz Kalinowski[1], Krystyna Szybiak[1], Maciej Nowak[2], Agnieszka Napierała[1]

[1] Department of General Zoology, Faculty of Biology, Adam Mickiewicz University, Poznan, Poland

[2] Laboratory of Biological Spatial Information, Faculty of Biology, Adam Mickiewicz University, Poznan, Poland

ABSTRACT: Despite the fact that much has been said so far about habitat preferences of the Roman snail (*Helix pomatia* L.), little has been done to examine metapopulations of the species. For this reason the current study presents results of an extensive and long-term research into metapopulations of the species in an area covering 14km² in the northern part of Poznań. In the period 2009-2013 the researchers discerned 149 local populations, in which they tagged over 15 000 specimens of the snail. Moreover, during the observation period the location of each specimen was monitored with GPS devices and visualized with computer software. Frequent observation sessions, which took place at least several times a week, conducted in a few selected study sites provided data that allowed to establish the dynamics of biological activity of the species, abundance of the local populations, and migration routes of the examined specimens.

KEYWORDS: Helix pomatia, metapopulation, GPS, distribution

Introduction

Łomnicki (1971) was probably one of the first researchers who noticed that the Roman snail (*Helix pomatia* L.) can be a good model species for ecological studies, especially those focusing on community structure of this species. However, little has been done so far to describe community structure of the species and the studies that attempt to give such descriptions are usually based on data gained from unsystematic research carried out in a very small area. The idea of using the Roman snail in research on metapopulations came up a few years ago, and since 2009 such research has been regularly conducted by the staff and students of the Department of General Zoology in Faculty of Biology at Adam Mickiewicz University in Poznań. The large size and slow locomotion of the species make possible monitoring the dynamics of biological activity of individual specimens, which is impossible in the case of other invertebrates. For these reasons the Roman snail meets the formal criteria for a species that can be used in analysis of metapopulations. Moreover, the choice of the study site for this study was also not accidental. The area under scrutiny is located in the northern part of Poznań, near Morasko Campus of Adam Mickiewicz University, which obviously made the regular everyday observations possible. What is more important, this study presents the first malacological research based on data obtained from GPS devices, which were used to track individual specimens, and the data were processed by means of the latest software for special visualization with the GIS system. The results of the analysis presented in the study are based on careful yearly observations in the period 2009-2013 conducted in three study plots located in the area of Morasko Campus (usually as part of B.Sc., M.Sc., and D.Sc. research projects).

The term "metapopulation" is used here in the sense of a group of local populations inhabiting similar areas connected by migration routes of the specimens. This term was used for the first time by Levins (1969). Metapopulations can be sustained only when extinction of local populations is compensated by emergence of new populations, mainly through colonisation of new areas. It is thought that existence of a metapopulation is to a large extent determined by the following factors: (i) the habitat should consist of inconsistent sectors, (ii) even most numerous local populations can always become endangered and extinct, (iii) local habitats are isolated only to the extent which allows recolonisation, and (iv) the dynamics of local populations cannot be entirely synchronized (see Pullin 2004).

Materials and methods

As has been already said, the study site is located in the northern part of Poznań, or more precisely, between Morasko Campus and a housing estate called Różany Potok. The ground plot on which the observations of metapopulations were conducted covers an area of 537 acres (Fig. 5) with an artificially grown pine tree stand at the age of about 40-50 years, which has dense deciduous undergrowth. In the southern and eastern part the area is adjacent to dirt roads (each of them 6m wide), whereas in the western part the area is close to a water stream and a lake created by means of a dam. In the northern part the examined area borders on private gardens of the housing estate.

The observations were conducted during the period 2009-2013 (between April and October) and embrace the whole period of biological activity of the species in the examined area. The observations of the metapopulation of the Roman snail were lasted 20 weeks. The total number of the observation sessions is 37. The snails were observed between 9:00 a.m. and 11:00 p.m. (most of the observation took place between 9:00 a.m. and 11:00 a.m. – 18 observation sessions), once or several times a week in the period 29 March – 10 August 2010. The shells of the snails found in the examined area were tagged with a permanent pen.

Moreover, each of the collected snails was weighed and in each case also the diameter of the shell was measured. The diameter of the shell was also used to establish whether a given specimen was big enough (the value of the diameter had to be higher than 30mm). This means that such specimens could be harvested without breaking the law (Regulation of The Minister of the Environment issued on 12 October 2011 – species protection regulations).

The exact location of each specimen was established with GPS Garmin 62st devices (measurement error of 3 to 6 m., depending on the weather and land cover). The results of the data analysis revealed the distribution of the specimens in the analysed population (Fig. 1 and 2). What is more important, the analysis of the multiple occurrences of a given specimen provided information about the migration routes of the specimen (Fig. 3). The size of the area inhabited by the local population was established on the basis of the furthest places of occurrence of the found specimens.

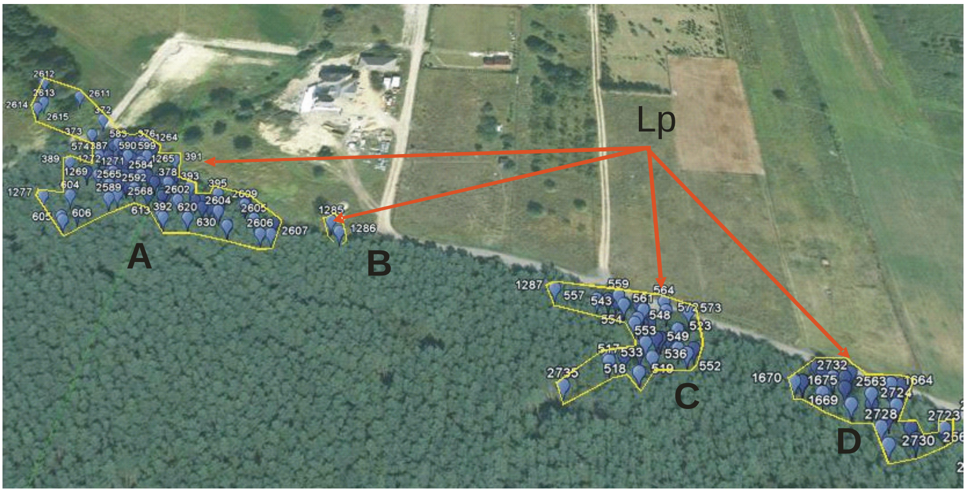


Fig. 1. Local populations on the basis of the furthest places of occurrence of specimens in a given population: Lp – local populations, A-D – identified local populations

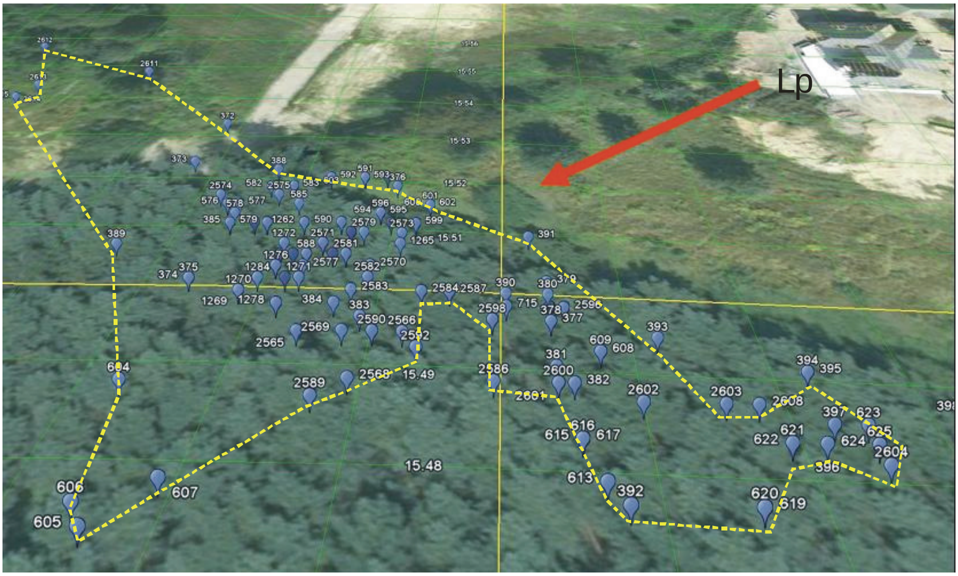


Fig. 2. Range of distribution of specimens in a local population on the basis of the furthest place of occurrence of specimens: Lp – local population

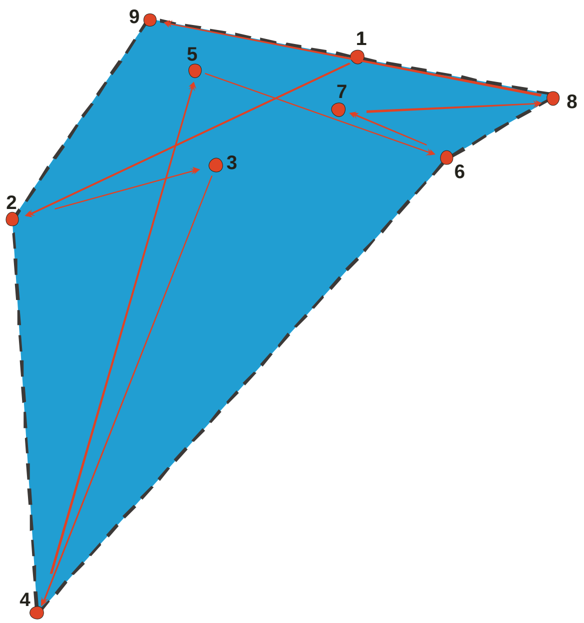


Fig. 3. Occurrence range of one specimen in the penetrated area: 1-9 consecutive observations

Results

Distribution of the Roman snail in northern part of Poznań

During the observations conducted in the period 2010-2012 in the are under scrutiny 104 local populations of the Roman snail were localized with their range of occurrence (see Fig. 4). The study site covers an area of 9 km^2 and the found populations were different as to the size of the inhabited area and type of habitat. The smallest population inhabited an area of 56m^2 and the largest 43338m^2. The snails were most numerous in different types of thicket (i.e. 43,27% of all examined plots), including forests (14,42%) and gardens (7,69%).

Fig. 4. Distribution of local populations of the Roman snail in northern part of Poznań (the arrow indicates the Umultowska case study)

In 2010 the snails were active since March 29 and the observations ended on the 10th of August. During this period the snails were observed in 55 plots, which contained 3510 specimens, including 2374 adult specimens (68%) and 1136 juvenile (32%), whose shells were not fully developed. Besides these, there were also 323 empty shells (which means mortality at the level of 13,6%). There were also 2072 specimens with shell size appropriate for harvesting (i.e. shell diameter >30mm), out of which 1860 were adult and 212 were juvenile. The average weight of an adult specimen was 18,67g, whereas the height of the shell was 39,06mm.

In 2011 the observations were conducted in 82 locations. In 35 of them the snails occurred also in the previous year. The total number of snails found in these locations was 4415, including 2560 adult (57,98%) and 1855 juvenile (42,02%). In this group there were 1231 specimens whose shell size was appropriate for harvesting them, including 1080 adult and only 151 juvenile specimens.

Metapopulation in the examined area

Table I shows the results of the observations of 76 most active specimens in the examined area. These most active specimens were observed on soil surface for 13 or 15 days. However, most of the found snails (>73%) were active for 3 or 5 days. Table II shows the activity of all observed snails in the examined area. The data presented below clearly show that 88% of the found specimens occurred at least 1 or 2 times.

Table I. Size of migration area and distance covered by 76 most active snails in examined area

Number of specimens	Observation period	Number of observations with present snails in the study site	Size of migration area [min. - max. m^2]	Covered distance [min. - max. m]
1	17.04. - 16.07.2010	15	582,7	183,83
1	17.04. - 14.05.2010	14	224,7	110,54
1	17.04. - 10.08.2010	13	204,7	123,12
3	18.04. - 10.08.2010	10	227,8 - 849,4	72,56 - 157,5
2	30.03. - 19.07.2010	9	304,5 - 560,7	116,27 - 122,58

Number of specimens	Observation period	Number of observations with present snails in the study site	Size of migration area [min. - max. m²]	Covered distance [min. - max. m]
4	17.04. - 19.07.2010	8	134,4 - 253,0	54,63 - 74,28
2	17.04. - 19.07.2010	7	110,2 - 341,2	80,70 - 93,32
6	18.04. - 16.07.2010	6	16,8 - 346,5	27,86 - 76,36
13	30.03. - 12.05.2010	5	50,4 - 504,0	23,96 - 116,85
15	17.04. - 10.08.2010	4	2,1 - 1228,0	19,13 - 174,38
28	30.03. - 10.08.2010	3	1,1 - 239,4	12,48 - 126,7
Average			**154,1 m²**	**62,74 m**
±SD			**203,7**	**37,7**

Table II. The number of repeated observations of individual specimens during the whole study period

Number of observations	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**13**	**14**	**15**	**Total**
Number of specimens	524	48	28	15	13	6	2	4	2	3	1	1	1	648
% of observed specimens	80,86	7,41	4,32	2,31	2,01	0,93	0,31	0,62	0,31	0,46	0,15	0,15	0,15	100

The found specimens formed 5 local populations, which inhabited areas of different size (Fig. 5). Moreover, the abundance of these populations was also different in each case.

The highest number of snails was observed in the south-eastern part of the examined area. This part of the area is also quite frequently visited by local citizens. The local population no. 5 turned out to be the largest whereas population no. 1 was the smallest. Finally, during the observation period only two specimens from population no. 5 moved to population no. 4, which proves that in the examined area the species occurs only in metapopulations.

Fig. 5. Distribution of 5 local populations in the examined area; the arrow shows the migration direction of specimens from population no. 5 to local population no. 4.

Discussion

Species protection is one of the most important environment protection programmes in Poland. The major principles of the programme are stipulated in Act no. 46 of the resolution issued on the 16th of April 2004. The resolution issued by the Minister of Environment Protection on the 12th of October 2011 dealing with species protection contains a list of species partially protected by the law, which can be harvested as well as the ways in which this can be done. The Roman snail also belongs to this group of animals. Specimens of this species whose shell diameter is higher than 30mm can be harvested for 30 days between the 20th of April and 31st of May. Every year Regional Nature Conservators issue special resolutions with limits for harvesting the Roman snail in particular regions of Poland. The regulation is also a legal obligation, which allows to monitor the natural resources of the species.

The first attempt at establishing the natural resources of the Roman snail in Poland was the research conducted by Stępczak (1976). However, the major drawback of his research is that it is based on information from questionnaires and not empirical data. Unfortunately, from the technical point of view establishing the abundance of invertebrates in large areas is still extremely hard or even impossible. The Roman snail is an exception in this respect due to its body size and very slow locomotion, which makes the species easy to observe.

The frequent occurrence of the species has been noticed by many researchers (e.g. Berger 1961, Urbański 1963, Łomnicki 1971, Pollard E. 1975, Stępczak 1976, Dyduch-Falniowska 2001, Andreev 2006, Błoszyk et al. 2010, 2012). Moreover, many unpublished works (i.e. B.Sc., M.Sc., D.Sc. theses, and expert reports) also contain a lot of valuable information about the Roman snail. However, there is no system of unified central database of this information. The only available database with such information is being still compiled for the General Directorate for Environmental Protection (GDEP), within a research project conducted by the Institute of Nature Conservation (Polish Academy of Sciences in Cracow). This database is incomplete and obviously does not solve the whole problem.

In this situation there is a clear need for standardization of data collection methods and visualization of obtained results. Although Stępczak (1976) suggested that researchers should use the UTM grid (of the size 25km x 25km) a long time ago, the results of his studies quite often are not precise, especially when they are compared with data obtained in the field (see e.g. Kołodziejczyk, Skawina 2009, Błoszyk et al. 2010, 2012). This in turn suggests that any evaluation of the natural resources of the Roman snail in particular regions of Poland is possible only by systematic data collection consisting in establishing precise distribution, abundance, and community structure of the species in local populations. Thus, it seems obvious that the limits for harvesting the Roman snail can be set out only on the basis of statistical data. Such data will allow to control local populations of the species both in each region and in the whole country, especially in places where the species is harvested in high quantities.

The system of data collection about the species in question proposed in this study is applicable for establishing and visualization of distribution range of local populations in large areas as well as evaluating abundance of the species. The statistical data collected in this way will be extremely helpful in developing new programmes intended to protect the species, which is the largest terrestrial snail in Poland. The database with such information will be a very useful tool for constant monitoring the natural resources of the Roman snail in the whole country.

Acknowledgements. The authors of the article would like to express their gratitude towards Maria Głowacka, Marta Rybak, Michalina Grześkowiak, Paulina Kupczak, Agnieszka Filoda, Agnieszka Mikołajczak, Krzysztof Bolaczek, and Jakub Błoszyk for their help in the field research.

References

ANDREEV N. 2006. Assessment of the status of wild population of land snail (escargot) *Helix pomatia* L. In Moldova: the effect of exploitation. Biodiversity Conserv. 15: 2957-2970.

BERGER L. 1961. Mięczaki pogranicza Wielkopolski, Śląska i Jury Krakowsko-Wieluńskiej. PTN. Prace Komisji Biologicznej. PWN.123pp

BŁOSZYK J., MACHNIKOWSKI M., NAPIERAŁA A., GOŁDYN B., RYBSKA E., STĘPCZAK K., SZYBIAK K., KONWERSKI SZ., LESZCZYŃSKA-DEJA K., DYLEWSKA M., KALINOWSKI T., JANKOWIAK A. 2010. Assessment of abundance and distribution of the Roman Snail (*Helix pomatia* Linnaeus, 1758) in Kujawsko-Pomorskie voivodeship. Folia Malacol. 18: 137-145

BŁOSZYK J., RYBSKA E., KALINOWSKI T., JANKOWIAK A., NAPIERAŁA A. 2012 Assessment of abundance and distribution of the Roman snail (*Helix pomatia* L.) in Poland. II. Podlaskie voivodeship. Folia Malacol. 20: 305-309

DYDUCH-FALNIOWSKA A., MAKOMASKA-JUCHIEWICZ M., PERZANOWSKA-SUCHARSKA J., TWOREK S., ZAJĄC K. 2001. Roman snail (*Helix pomatia* L.) - conservation and management in the Małopolska region (southern Poland). Ekologia (Bratislava) 20: 265-283

KOŁODZIEJCZYK A., SKAWINA A. 2009. The Roman Snail (*Helix pomatia* Linnaeus, 1758) in Northern Mazovia. Folia Malacol, 17: 68.

KONWERSKI S., LESZCZYŃSKA-DEJA K., DYLEWSKA M., KALINOWSKI T., JANKOWIAK A. 2010. Assessment of abundance and distribution of Roman snail (*Helix pomatia* Linnaeus, 1758) in Kujawsko-Pomorskie voivodeship. Folia Malacol. 18: 113-121.

LEVINS R. 1969. Some demographic and genetic consequences of environmental heterogeneity for biological control, Bulletin of the Entomological Society of America 15: 237–240

ŁOMNICKI A. 1971. Struktura i regulacja wielkości populacji ślimaka winniczka (*Helix pomatia* L.) a niektóre zagadnienia jego ochrony. Ochr.Przyr. 36: 189-255.

POLLARD E. 1975. Aspects of the ecology of *Helix pomatia* L. J. Anim. Ecol. 44: 300-329.

PULLIN S.A. et. all 2004 Do conservation managers use scientific evidence to support their decision-making? Biological Conservation,119: 245-252

Rozporządzenie Ministra Środowiska z dnia 12 października 2011 r. w sprawie ochrony gatunkowej zwierząt. Dz. U. z 2011 r. Nr 237, poz. 1419

STĘPCZAK K. 1976. Występowanie, zasoby, uzyskiwanie i ochrona ślimaka winniczka (*Helix pomatia* L.) w Polsce. Wydawnictwo UAM, Zoologia, 3: 67 pp.

URBAŃSKI J. 1963. Ślimak winniczek *Helix pomatia* L., jego systematyka, biologia, znaczenie gospodarcze i ochrona. Drukarnia Uniwersytetu Jagiellońskiego. 40pp

MAPS OF PROBABLE OCCURRENCE OF BURIED SOILS

Adrian Zarychta[1], Roksana Zarychta[2]

Faculty of Earth Sciences, , University of Silesia, Sosnowiec, Poland
[1] adrian.zarychta@o2.pl, [2] roxana_z@vp.pl

ABSTRACT: Location of buried soils (palaeosols, fossil soils) is difficult to define clearly, since it involves the need to conduct time-consuming pedological field studies. Dense vegetation may be one of signs of presence of palaeosols. However, its occurrence does not not always indicate layers of fossil soil horizons in a given place. Hence, a research question has appeared: how to estimate probable occurrence of residual fossil soil horizons in a particular place basing on a small amount of qualitative data.
The purpose of this publication was to generate a map of probable distribution of fossil levels within two research plots of different size which were located in the Błędowska Desert. The obtained figures illustrate probable distribution of locations of palaeosols patches within the two research plots. If applied during the subsequent exploratory field trips, they will definitely increase the chance of finding fossil soils.

KEYWORDS: the Błędowska Desert, fossil soil, ordinary kriging, probability.

Introduction

Palaeosol, so called fossil or buried soil is "*a complete profile of soil formations (or in case of outcrops and removal of upper genetic horizons – only their lower ones) formed in the past in the environment usually different from the current one and then covered with younger sediments (e.g. diluviums, aeolian or anthropogenic formations) and thus partially preserved*" (Prusinkiewicz 2004). Dense vegetation may be one of indicators of occurrence of fossil soil horizons in a given area, although their identification based on photo-interpretation materials (e.g. air photography) requires verification in the field. Field works include identification and evaluation of viability of the flora and in many cases also making deep soil profiles of genetic horizons. However, it should be remembered that the field work does no always confirm the earlier assumptions regarding occurrence of palaeosols in the particular places.

Therefore, a research question how to estimate probable occurrence of residual fossil soil horizons in the particular place basing on a small amount of qualitative data (proving their existence or lack in a given place) has appeared. The southern part of the Błędowska Desert, which like the Toruń

Basin is "rich" in fossil soil, was chosen as a research site. According to the Polish physiographic regionalisation by J. Kondracki (2000), the Błędowska Desert is located within the Garb Tarnogórski (Tarnowskie Góry Ridge) (341.12), which is a part of the Silesian Upland (341.1). The fossil soil level not only underlays podsol here but it is also exposed on the surface forming a relict soil level. Numerous works related to the nature of the Błędowska Desert have been published so far (Alexandrowiczowa 1962; Bukowska-Jania 1986; Kozioł 1952; Szczypek & Wika 1984; Szczypek *et al*. 1994; Szczypek *et al.* 2001; Rahmonov 2007; Rahmonow 1999; Trembaczowski 1986; Zarychta A. & Zarychta R. 2012). However, no attempts have been taken so far to apply geostatistics to estimate probable occurrence of palaeosols in the area.

Hence, this article is devoted to presentation of maps of the probable occurrence of palaeosols located in the southern part of the Desert Błędowska prepared with the use of selected geostatistical tools.

Material and research methods

Before preparation of the maps presenting the probable occurrence of palaeosols in the Błędowska Desert, in-depth studies of specialized literature relating to geostatistics had been conducted (Badura *et al* 2012; Bostan *et al* 2012; Davis 2012; Kokesz 2006, 2010a, b; Krieg 1951; Lin *et al* 2002; Marmol 2002; Mucha *et al* 2011; Mucha & Wasilewska 2006; Namysłowska-Wilczyńska 2006, 2007; Szubert 2003, 2007, 2008; Zawadzki 2011; Zarychta A., Zarychta R. 2013a; Zarychta R., Zarychta A. 2013b).

A thorough analysis of aerial pictures taken in 2006 and 2009 (available from Google Earth) allowed to identify potential locations of fossil levels within the southern part of the Błędowska Desert. They were further verified during a field reconnaissance. Two research plots located in the south-eastern and south-western part of the discussed area were chosen for the analysis. Within them, a total of 27 soil exposures were made (fossil levels were found in 16 of them) and their geographical coordinates were determined by means of a GPS receiver: GARMIN CX60. Thus the quality data were acquired (i.e. information on the location of fossil levels in a particular exposure or their lack thereof) which were further converted into quantitative data – presented in a binary system (0-1) (where 1 represents the presence of fossil soil, and 0 – absence). In order to generate maps of the probable occurrence of buried soils, the binary data were transformed to percent values (where 0 was 0%, and 1 was 100% of occurrence of fossil soils). Based on the source materials prepared in that way, the maps of probable occurrence of palaeosol within the two research plots in the Błędowska Desert were prepared (Fig. 3, 5). The maps can help to locate fossil soils in the other plots which have not been pedologically studied yet. Geostatistical procedure applying ordinary – block kriging was conducted using a computer software Surfer 11. Additionally, a digital terrain model (DTM) of the Błędowska Desert (Fig. 1) was generated by means of the same programme. It was based on a topographic map of Katowice voivodeship at a scale of 1:25 000, sheet Dąbrowa Górnicza-Strzemieszyce (1986), a topographic map of Katowice voivodeship at a scale of 1:25 000, sheet Chechło (1990) and a topographic map of Katowice and Kraków voivodeships at the scale of 1:25 000, sheet Olkusz (2001). A DTM of plots 1 and 2 (Fig. 6, 7), based on height points measured in the field by means of the GPS receiver, was also generated.

Results

Two research plots with fossil soils were located in the southern part of the Błędowska Desert (Fig. 1).

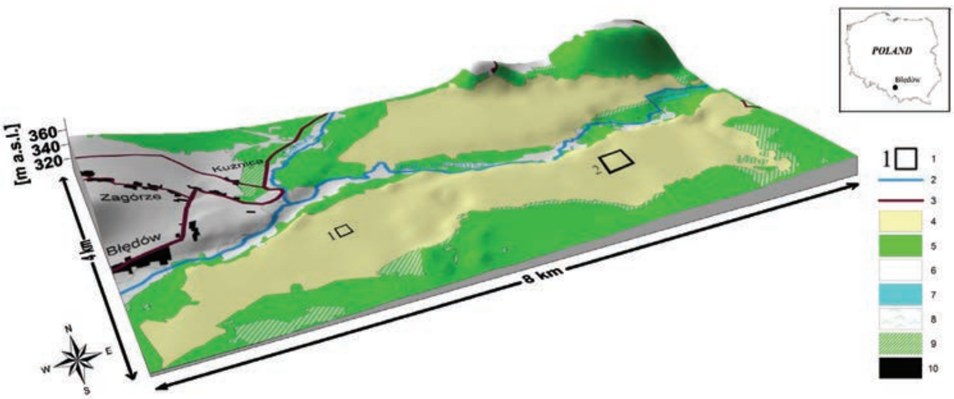


Fig. 1. Digital Terrain Model of the Błędowska Desert with research plots (prepared by the author, based on: Topographic map of Katowice voivodeship... 1986, 1990; Topographic map of Katowice and Krakow voivodeships... 2001)

1 – number of a research plot, 2 – watercourse, 3 – road, 4 – area of the Błędowska Desert, 5 – forest, 6 – wasteland, 7 – settling tank, 8 – meadow, 9 – shrubbery, 10 – buildings

Plot 1 is located on the deflation field (in the north-eastern part it covers also a fragment of a dune forefield) of the western fragment of the southern part of the Błędowska Desert (Fig. 2, Photo. 1). The area of this plot, which reaches 1,476 m², is marked by the following geographical coordinates: 50°20'28.53"N 19°29'9.63"E (Zarychta A. & Zarychta R. 2012). 13 profiles of genetic soil horizons were made in the plot. Occurrence of fossil horizons was identified in 8 of 13 profiles. In the remaining 5 exposures there were no traces of formation of fossil podzol horizons (Tab. 1, Fig. 3).

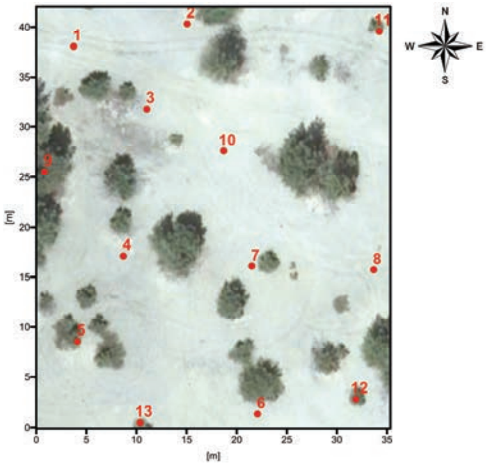


Fig. 2. Plot 1 (Zarychta A. & Zarychta R. 2012 – changed)

Photo. 1. Part of the plot 1 (photo. A. Zarychta)

Table 1. Basic data on the occurrence of soil outcrops in the plot 1
(Zarychta A. & R. Zarychta 2012 – with additions)

No of soil profile	Fossil soil occurs – YES; does not occur – NO	Latitude	Longitude
1	YES	50°20'29.30"N	19°29'9.20"E
2		50°20'29.40"N	19°29'9.80"E
3		50°20'29.10"N	19°29'9.60"E
4		50°20'28.60"N	19°29'9.50"E
5		50°20'28.30"N	19°29'9.30"E
6		50°20'28.10"N	19°29'10.30"E
7		50°20'28.60"N	19°29'10.30"E
8		50°20'28.60"N	19°29'10.90"E
9	NO	50°20'28.87"N	19°29'9.11"E
10		50°20'28.98"N	19°29'10.04"E
11		50°20'29.41"N	19°29'10.87"E
12		50°20'28.17"N	19°29'10.83"E
13		50°20'28.03"N	19°29'9.65"E

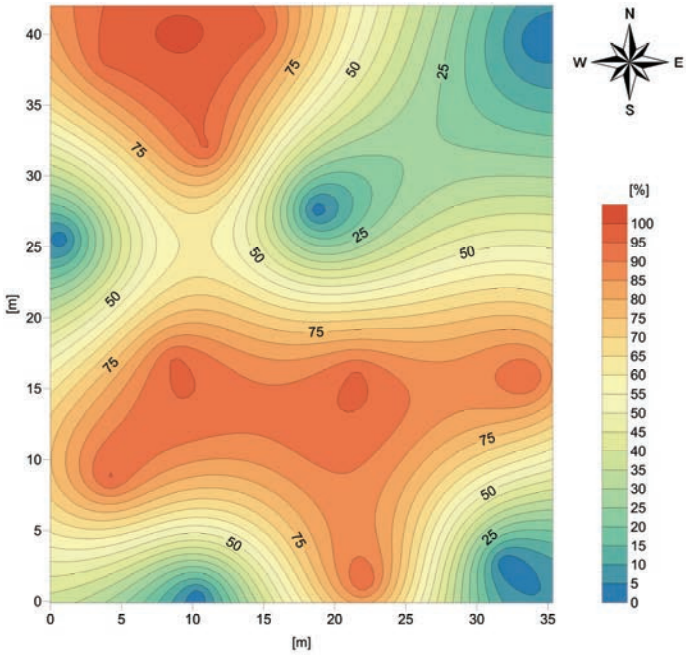


Fig. 3. Map of probable occurrence of fossil soils in the plot 1

Plot 2 covers the area of 19,500 m² and it is located in the place that includes the western part of the dune (most likely it is a transverse dune) formed in the eastern part of the analysed fragment of the "Polish Sahara" (Fig. 4, Photo. 2) (Zarychta A. & Zarychta R. 2012). The discussed research plot is marked by the following geographical coordinates: 50°20'35.97 "N 19°31'52.51" E. 14 soil exposures were made within its borders. Fossil horizons were recorded only in 8 of them (Tab. 2, Fig. 5).

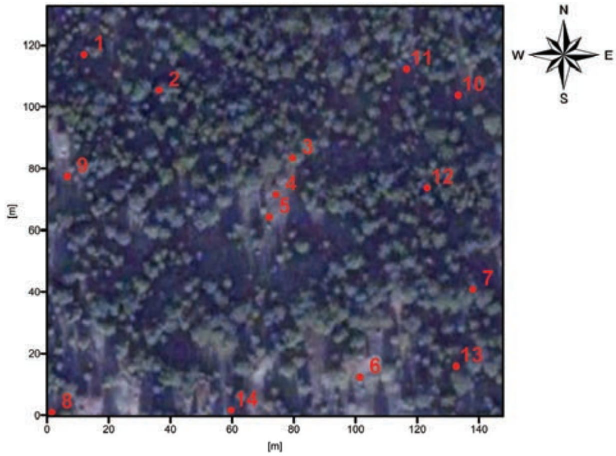


Fig. 4. Plot 2
(Zarychta A. & Zarychta R. 2012 – changed)

Photo. 2. Fragment of the plot 2 (photo. R. Zarychta)

Table 2. Basic data on the occurrence of soil exposures (outcrops) in the plot 2 (Zarychta A. & R. Zarychta 2012 – with additions)

No of soil profile	Fossil soil occurs – YES; does not occur – NO	Latitude	Longitude
1	YES	50°20'38.40"N	19°31'48.76"E
2		50°20'38.00"N	19°31'50.20"E
3		50°20'37.26"N	19°31'52.80"E
4		50°20'36.84"N	19°31'52.56"E
5		50°20'36.54"N	19°31'52.38"E
6		50°20'34.68"N	19°31'54.30"E
7		50°20'35.82"N	19°31'56.34"E
8	NO	50°20'34.11"N	19°31'48.50"E
9		50°20'36.89"N	19°31'48.57"E
10	YES	50°20'38.10"N	19°31'55.86"E
11	NO	50°20'38.39"N	19°31'54.99"E
12		50°20'37.00"N	19°31'55.39"E
13		50°20'34.83"N	19°31'56.12"E
14		50°20'34.25"N	19°31'51.92"E

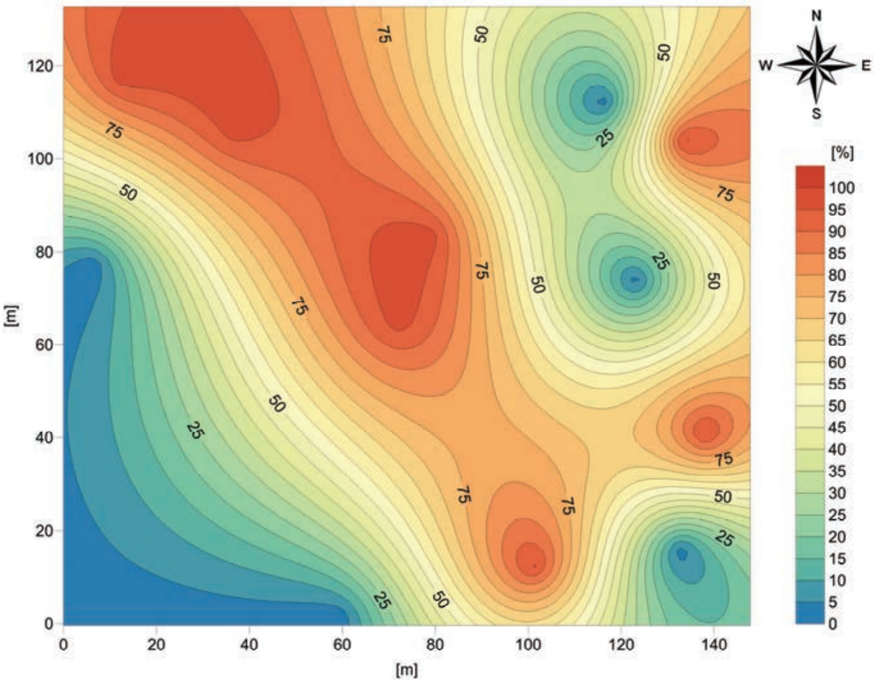


Fig. 5. Map of the probable occurrence of fossil soils in the plot 2

Discussion

An analysis of the potential locations of fossil soil within the two plots was based on the figures 3 and 5 as well as the knowledge of origin and soil-botanical features of the analysed two research plots (see. Zarychta A., Zarychta R., 2012)

There are probably two patches of buried soil in the plot 1. Possibly, one of them is situated in the northern part of the entire research plot. It is estimated that the probability of its occurrence in the mentioned part of the area varies from 85% to 95%. The second patch running latitudinally was probably formed in the central part of the plot 1. It extends from west to east and "deviates" to the south (the probability of its occurrence there is equal to 85-95%). It can be assumed that fossil soils are unlikely to occur in the north-east part of the area which is confirmed by the probability rate equal to 5-15%. According to the authors of the study (when taking the relief of the plot 1 into consideration), "some time ago" fossil soil horizons covered the whole discussed area. However, due to aeolian activity, including western wind, they were partially dispersed. Sandy-soil material was transported by wind and built up the dune which foreground can be seen in Fig. 6. Thus, in its vicinity and in the western and southern parts of the plot 1, probability of occurrence of fossil soil patches is very low (Fig. 6) (Zarychta A., Zarychta R., 2012).

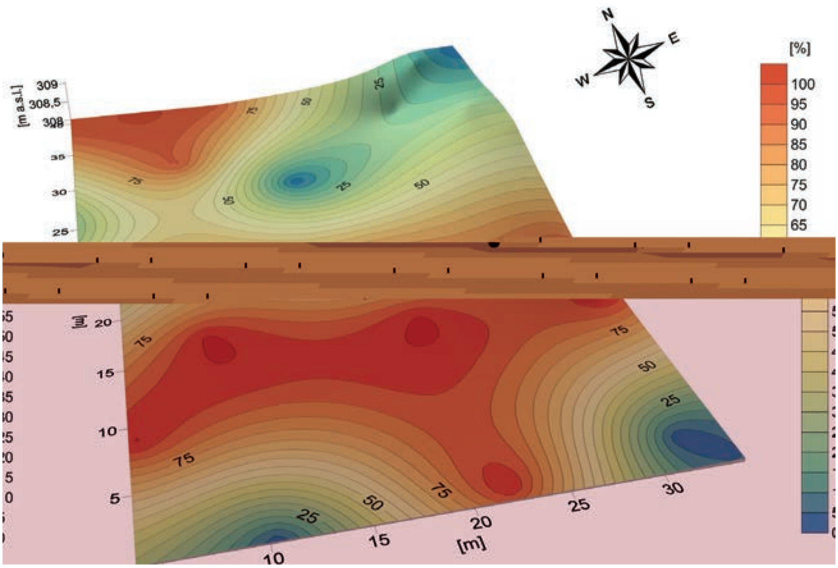


Fig. 6. Digital terrain model with a superimposed map of probable occurrence of palaeosols in the plot 1

It can be assumed that, like in the first one, there are two patches of fossil soil within the second analysed plot. One of them – covering a larger area runs from north-west to south-east. The second one has been formed in the eastern part of the plot 2. In both cases, it is possible that palaeosol stretches longitudinally (probability of its occurrence there is equal to 75-95%). Fossil soil is not likely to occur in the south-western part of the plot 2, hence, its occurrence probability is estimated at 5-15%. It is the result of activity of winds blowing from west and north-west which transport sand and soil material building up the dune face (well visible in the central part of the plot 2) (Fig. 7). Low probability of finding fossil soils within the discussed plot is also observed in its north-east and south-east parts. This is due to anthropogenic degradation of palaeosols occurring there "some time ago" (evidenced by traces of treading) (Fig. 7).

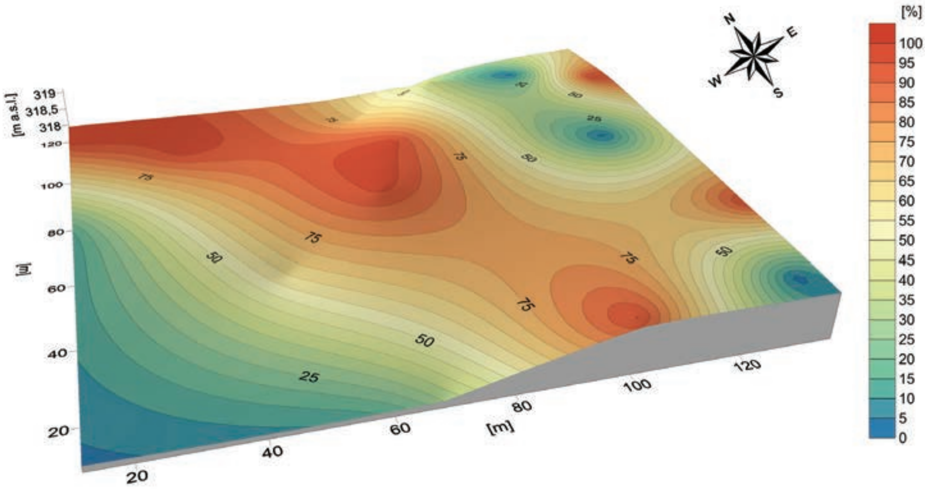


Fig. 7. Digital terrain model with a superimposed map of probable occurrence of palaeosols in the plot 2

Conclusions

Palaeosol is difficult to locate in the field without application of specialized measuring equipment e.g. devices using electro-resistance. Geostatistical methods and tools which enable generation of maps of probable occurrence of buried soil genetic horizons might help in this case (the only limitation may be insufficient knowledge of geostatistical methods and the lack of appropriate software). Probability maps can be used to identify potential sites of occurrence of palaeosols (based on information on the location of fossil soils in selected soil exposures obtained from literature or previously conducted pilot studies) at the points where no soil exposures were previously made. Such graphic representations make excellent material for researchers involved in the search for fossil layers. However, analysis of such images should be treated with some reserve because estimated probability of occurrence of palaeosols, even at the level of 90%, does not reflect the real state with absolute certainty.

Therefore, the knowledge acquired by analysis of the maps of probable occurrence of palaeosols should be verified in the field.

References

ALEXANDROWICZOWA Z. 1962. Piaski i formy wydmowe Pustyni Błędowskiej. Ochrona Przyrody. 28: 227-251. PAN, Kraków

BADURA H., ZAWADZKI J. & FABIJAŃCZYK P. 2012. Kriging blokowy oraz metody GIS w geostatystycznym szacowaniu metalonośności w kopalniach węgla kamiennego. Roczniki Geomatyki, Polskie Towarzystwo Informacji Przestrzennej, X, 3(53): 17-26.

BOSTAN P.A., HEUVELINK G.B.M. & AKYUREK S.Z. 2012. Comparison of regression and kriging techniques for mapping the average annual precipitation of Turkey. International Journal of Applied Earth Observation and Geoinformation, Vol. 19: 115–126.

BUKOWSKA-JANIA E. 1986. Charakterystyka geomorfologiczna koryt i sieci rzecznej dorzecza Przemszy. Geographia, Studia et Dissertationes. 9: 7-30. UŚ, Katowice.

DAVIS J. 2002. Statistics and data analysis in geology. 638 pp. John Wiley & Sons, New York, Chichester, Brisbane, Toronto, Singapore.

KOKESZ Z. 2006. Trudności i ograniczenia w geostatystycznym modelowaniu zmienności złóż i szacowaniu zasobów metodą krigingu. Gospodarka surowcami mineralnymi, 22(3): 5-20.

KOKESZ Z. 2010a. Uwarunkowania stosowania krigingu zwyczajnego do sporządzania map izoliniowych. Biuletyn Państwowego Instytutu Geologicznego, 439: 403-408.

KOKESZ Z. 2010b. Sporządzanie map izoliniowych procedurą krigingu zwyczajnego – korzyści i ograniczenia. Zeszyty Naukowe instytutu Gospodarki Surowcami Mineralnymi i Energią Polskiej Akademii Nauk, 79: 363-382.

KONDRACKI J. 2000. Geografia regionalna Polski. 243-248. PWN, Warszawa.

KOZIOŁ S. 1952. Budowa geologiczna Pustyni Błędowskiej. Z badań czwartorzędu w Polsce. 1 Biul. PIG 65: 383-389.

KRIEGE D.G. 1951. A statistical approach to some mine valuation and allied problems at the Witwatersrand. Master's thesis. University of Witwatersrand, Witwatersrand, South Africa.

MATHERON G., 1962. Traité de Géostatistique Appliquée. Editions Technip. Paris.

LIN Y-P., CHANG T-K., SHIH CH-W. & TSENG CH-H. 2002. Factorial and indicator kriging methods using a geographic information system to delineate spatial variation and pollution sources of soil heavy metals. Environmental Geology, 42(8): 900-909.

Mapa topograficzna województwa katowickiego i krakowskiego, 1:25 000, Arkusz Olkusz (532.12), 2001. Główny Geodeta Kraju. PPGK, Rzeszów.

Mapa topograficzna województwa katowickiego, 1:25 000, Arkusz Chechło (522.34), 1990. Główny Urząd Geodezji i Kartografii. PPGK.

Mapa topograficzna województwa katowickiego, 1:25000, Arkusz Dąbrowa Górnicza-Strzemieszyce (532.1), 1986. Główny Geodeta Kraju. PPGK.

MARMOL U. 2002. Modelowanie reprezentacji powierzchni topograficznej z wykorzystaniem metody geostatystycznej. Geodezja, 8(2): 259-270.

MUCHA J., KOTLIŃSKI R. & WASILEWSKA-BŁASZCZYK M. 2011. Metodyka szacowania parametrów zasobowych złóż konkrecji polimetalicznych w obszarze Interoceanmetal na Pacyfiku. Zeszyty Naukowe instytutu Gospodarki Surowcami Mineralnymi i Energią Polskiej Akademii Nauk, 81: 137-145.

MUCHA J. & WASILEWSKA M. 2006. Nieparametryczne geostatystyczne metody interpolacji parametrów wybranych złóż. Przegląd Górniczy, 62(1): 24-31.

NAMYSŁOWSKA-WILCZYŃSKA B. 2006. Geostatystyka. Teoria i zastosowania. 356 pp. OWPW, Wrocław.

NAMYSŁOWSKA-WILCZYŃSKA B. 2007. Analizy przestrzenne z zastosowaniem metod geostatystycznych – Modelowanie 3D porfirowego złoża miedzi Rio Blanco w Peru. Roczniki Geomatyki, Polskie Towarzystwo Informacji Przestrzennej, Tom V(1): 91-103.

PRUSINKIEWICZ Z. 2004. Podstawowe wiadomości o glebach. Gleby i procesy glebotwórcze jako przedmiot badań ekologiczno-gleboznawczych. Specyfika gleby jako obiektu badań. In: R. BEDNAREK, H. DZIAŁDOWIEC, U. POKOJSKA, Z. PRUSINKIEWICZ. Badania ekologiczno-gleboznawcze, p. 48. PWN, Warszawa.

RAHMONOV O. 2007. Relacje między roślinnością i glebą w inicjalnej fazie sukcesji na obszarach piaszczystych. 198 pp. UŚ, Katowice.

RAHMONOW O. 1999. Procesy zarastania Pustyni Błędowskiej. 72 pp. UŚ, Sosnowiec.

SZCZYPEK T. & WIKA S. 1984. Wpływ wiatru i działalności człowieka na krajobraz Pustyni Błędowskiej. Wszechświat. 85, 6: 137-139.

SZCZYPEK T., WACH J. & WIKA S. 1994. Zmiany krajobrazów Pustyni Błędowskiej. 87 pp. WNoZ UŚ, Sosnowiec.

SZCZYPEK T., WIKA S., CZYLOK A., RAHMONOW O. & WACH J. 2001. Pustynia Błędowska fenomen polskiego krajobrazu. 72 pp. Kubajak, Krzeszowice.

TREMBACZOWSKI J. 1986. Wpływ procesów eolicznych na zmiany powierzchni ziarn kwarcu piasków Pustyni Błędowskiej. Geographia, Studia et Dissertationes. 9: 58-77. UŚ, Katowice.

SZUBERT M. 2003. Cyfrowy model wysokości powierzchni podczwartorzędowej na Wyżynie Woźnicko-Wieluńskiej. Archiwum Fotogrametrii, Kartografii i Teledetekcji, Materiały Ogólnopolskiego Sympozjum Geoinformacji „Geoinformacja zintegrowanym narzędziem badań przestrzennych" Wrocław – Polanica Zdrój, 15-17 września 2003 r. Vol. 13 A: 233-242.

SZUBERT M. 2007. Geoinformatyka w geomorfologii na przykładzie badań geomorfologicznych na Wyżynie Wieluńskiej i Częstochowskiej. Archiwum Fotogrametrii, Kartografii i Teledetekcji, Vol. 17b: 759-768.

SZUBERT M. 2008. Geomatyka w badaniach geomorfologicznych. Dokumentacja Geograficzna, 47: 7-13.

ZAWADZKI J. 2011. Metody geostatystyczne dla kierunków przyrodniczych i technicznych. 132 pp. Oficyna Wydawnicza Politechniki Warszawskiej, Warszawa.

ZARYCHTA A. & ZARYCHTA R. 2012. Paleogleby jako źródło rekonstrukcji reliefu „polskiej Sahary". Rocznik Świętokrzyski. Ser. B – Nauki Przyr. 33: 139-154.

ZARYCHTA A. & ZARYCHTA R. 2013a. Zastosowanie „korekty efektu wygładzenia” w badaniach form geomorfologicznych. Archiwum Fotogrametrii, Kartografii i Teledetekcji, wydanie specjalne: Monografia „Geodezyjne Technologie Pomiarowe”: 119-132.

ZARYCHTA R. & ZARYCHTA A. 2013b. Zastosowanie krigingu zwyczajnego do rekonstrukcji i wizualizacji reliefu w miejscach odkrywkowej eksploatacji piasku. Archiwum Fotogrametrii, Kartografii i Teledetekcji, wydanie specjalne: Monografia „Geodezyjne Technologie Pomiarowe”: 133-146.

Any GIS system is only as good as the data that's in it. Data management capabilities within geodatabases help maintain the integrity of data and unlock its potential with applied geography.

GIS has a complete set of tools that allow flexibility to store, edit, and manage data in a way that fits existing processes of any organization. A geodatabase stores GIS data in a centralized location for easy access and management.

It can be leveraged in desktop, server, or mobile environments. It runs on top of an RDBMS, such as SQL Server, Oracle, or PostgreSQL, and supports all types of GIS data.

esri Polska

BioGIS

ISBN 978-83-232-2859-2
ISSN 0554-811X