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CONNECTION BETWEEN ECOSYSTEM SERVICES OF WOODY PLANTS IN THE MUNICIPALITY OF CZERWONAK AND ADMINISTRATIVE DECISIONS ON FELLING TREES AND SHRUBS

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WPŁYW ZEZWOLEŃ NA WYCINKĘ DRZEW I KRZEWÓW NA USŁUGI EKOSYSTEMOWE ŚWIADCZONE PRZEZ ROŚLINNOŚĆ DRZEWIASTĄ W GMINIE CZERWONAK

STRESZCZENIE: Drzewa i krzewy odgrywają kluczową rolę w środowisku przyrodniczym obszarów wiejskich i miejskich, ze względu na bezpośredni kontakt społeczności lokalnych z nimi. Zapewniają one szeroki zakres usług ekosystemowych, które mogą być zaklasyfikowane do wszystkich głównych kategorii (wspierających, zaopatrujących, regulacyjnych i kulturowych). Celem badań jest identyfikacja usług ekosystemowych świadczonych przez drzewa i krzewy w gminie Czerwonak (woj. wielkopolskie) oraz zbadanie wpływu decyzji, zezwalających na wycinkę, na usługi ekosystemowe świadczone przez drzewa i krzewy.

SŁOWA KLUCZOWE: usługi ekosystemowe na terenach zurbanizowanych, mapowanie partycypacyjne, gminne tereny zielone, zezwolenia

Introduction – trees in urban and peri-urban areas

Trees and shrubs in urban and peri-urban areas provide a number of benefits to people. Besides their aesthetic value, they deliver tangible environmental benefits, that often are unrecognized and taken for granted. In recent years, there has been an increased interest of researchers in ecosystem services – the direct benefits that natural system provide to people[1]. In this paper we focus on trees and shrubs in urban and peri-urban areas and on ecosystem services they provide. In particular, we investigate whether cutting off trees and shrubs in accordance with administrative permissions undermine ecosystem services. The task undertaken in this paper involves two questions: firstly, which types of ecosystem services are provided by trees and shrubs, and secondly, do felling trees/shrubs diminish ecosystem services' provision?

Trees belong to the permanent vegetation in urban and peri-urban areas[2], shaping landscapes over the centuries. They give the characteristics of identity and unique character of places, they are dominant elements of visual shape of a territory and play substantial functional role in cleaning the environment. They also improve people's health, enhance more active lifestyle, reduce stress, stimulate social interaction, create spatial order, mask unattractive places, create the conditions for privacy and comfort[3]. Loss of these services caused by woody plants felling are often irreversible. For instance, services provided by old trees are irreplaceable due to their old age.

Benefits provided by trees and shrubs in cities contribute to all main types of ecosystem services (supporting, provisioning, regulating and cultural services[4]). These benefits can be recognized, and quantified, together

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1 R.T. Watson, A.H. Zakri (eds), *Ecosystems and human well-being, Millennium Ecosystem Assessment*, 2005.

2 N. Larondelle, D. Haase, *Urban ecosystem services assessment along a rural–urban gradient: A cross-analysis of European Cities*, "Ecological Indicators" 2013 no. 29, p. 179–190.

3 K. Beil, D. Hanes, *The influence of urban natural and built environments on physiological and psychological measures of stress–A pilot study*. "International Journal of Environmental Research and Public Health 10(4), 2013, p. 1250–1267; C.W. Thompson, *Activity, exercise and the planning and design of outdoor spaces.* "Journal of Environmental Psychology" 2013 no. 34, p. 79–96.

4 P. Bolund, S. Hunhammar, *Ecosystem services in urban areas*, "Ecological Economics" 1999 no. 29(2), p. 293–301; D.E. Bowler et al. , *Urban greening to cool towns and cities: a systematic review of the empirical evidence*, "Landscape and Urban Planning" 2010 no. 97, p. 147–155; Á. Takács et al., *Microclimate modification by urban shade trees an integrated approach to aid ecosystem service based decision-making*, "Procedia Environmental Sciences" 2016 no. 32, p. 97–109; F. Baró et al., *Contribution of ecosystem services to air quality and climate change mitigation policies: the case of urban forests in Barcelona*, "Ambio" 2014 no. 43(4), p. 466–79.

with an indication of their relation to the costs needed to maintain trees. Such information allows city planners and managers to assess investment projects in the integrated way, in order to protect natural resources, including trees. The negative impact on the environment and human health, exerted by the increasing volume of traffic and industry, grows. It negatively affects a quality of life in urban and peri-urban areas, deepening the social problems[5].

In addition to disturbance to the life of trees and shrubs in cities, related to the development of transport and infrastructure (e.g. salinity and drying of soil and air pollution), the institutional causes of these phenomena (administrative and social context) are important. Negative development can be countered by improving the quality of trees in cities and by trees management based on ecosystem services that they provide[6].

In Poland the potential for the ecosystem services provided by trees and shrubs in urban and peri-urban areas is substantial, higher than the European average[7]. Nevertheless, the number of trees in the central areas of Polish cities is decreasing, and it deteriorates the possibility of using nature as a source of ecosystem services for inhabitants. An important part of management is related to cutting off, replacing and planting trees and shrubs. In particular, cutting off trees is regulated by law (Code of Administrative Procedure[8] and Nature Conservation Act[9]). It defines procedures and conditions needed to obtain specific permissions. Felling trees and shrubs takes place in various private and public/municipal areas. Every year the large number of trees are removed from cities' green areas. The impact on the local biota and local society is not known though. In the paper we investigate whether falling trees occur in the areas, where the ecosystem services are present and whether felling off trees deteriorates them.

Research on ecosystem services in urban areas focuses mostly on environmental quality and the quality of life in densely populated areas and services provided by ecosystems, which are usually endangered by human pressures[10]. Ecosystem services in urban areas (mostly at the level of a city) are

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5 J. Kronenberg, *Barriers to preserving urban trees and ways of overcoming them*, "Sustainable Development Applications" 2012 no. 3, p. 31–49.

6 Ibidem, p. 31–49.

7 N. Larondelle, D. Haase, N. Kabisch, *Mapping the diversity of regulating ecosystem services in European cities*, "Global Environmental Change" 2014 no. 26, p. 119–129.

8 Ustawa z dnia 14 czerwca 1960 r. Kodeks postępowania administracyjnego (Dz.U. z 2016 poz. 23).

9 Ustawa z dnia 16 kwietnia 2004 r. o ochronie przyrody (Dz.U. z 2015 poz. 1651).

10 B. Hunhammar, *Ecosystem services in urban areas*, "Ecological Economics" 1999 no. 29(2), p. 293–301; D. Haase et al., *A quantitative review of urban ecosystem service assessments: concepts, models, and implementation*, "Ambio" 2014 no. 43(4), p. 413–33.

analysed via standards and environmental indicators[11]; and by the institutions regulating ecosystem services management[12].

In Poland, the problem of ecosystem services provided by trees and shrubs in urban and peri-urban areas has got attention only recently[13]. However, the influence of the administrative decisions on felling trees and shrubs for ecosystem services has not been an object of investigation.

The research aim and hypothesis

The aim of the paper is to investigate whether cutting off trees and shrubs in accordance with permissions may undermine ecosystem services in the municipality of Czerwonak. In particular we test the hypothesis that administrative decisions (permissions) on felling woody plants affect all the ecosystem services equally. In order to accomplish this task two questions need to be asked: firstly, which types of ecosystem services are provided by trees and shrubs, and secondly, does felling of trees/shrubs diminish ecosystem services' provision? The task involves identification of ecosystem services related to trees in the Municipality of Czerwonak and exploration of administrative decisions on felling trees.

Czerwonak – case study area

Municipality of Czerwonak is a commune of mostly rural character, bordering however with the City of Poznań (a half a million inhabitants regional center). Czerwonak is located in the Wielkopolska province and lies in the geobotanical region referred to as the landscape of mixed forests and hornbeam associations. The West border of the municipality goes on the Warta River. Forests cover about 42% of its area as the municipality lies on the Puszcza Zielonka Landscape Park, the largest natural forest complex in the central Wielkopolska region of great natural, scenic, historical and scientific

11 F. Baro et al., *Mismatches between ecosystem services supply and demand in urban areas: A quantitative assessment in five European cities,* "Ecological Indicators" 2015 no. 55, p. 146–158.

12 J. Kronenberg, *Why not to green a city? Institutional barriers to preserving urban ecosystem services*, "Ecosystem Services" 2015; M. Artmann, *Assessment of soil sealing management responses, strategies, and targets toward ecologically sustainable urban land use management*, "Ambio" 2014 no. 43(4), p. 530–41.

13 M. Giergiczny, J. Kronenberg, *How to assess the value of nature? Valuation of street trees in Lodz city center*, "Sustainable Development Applications" 2012 no. 3, p. 73–88; H.B. Szczepanowska, *Wycena wartości drzew na terenach zurbanizowanych*, Warszawa 2007.

values. The dominant tree species is Scots pine (*Pinus sylvestris* L.) constituting 83% of the forests. There are seven nature reserves, three sites of landscape protection and several monuments of nature (i.e. the Bartek Oak in the Owińska village) in the municipality of Czerwonak. The municipality's green areas play a recreation function for its inhabitants and for inhabitants of Poznan. The municipality, a rural and forested area close to Poznan, is under a pressure for urbanization facing demand for housing development. It is only partially covered by the local development plans.

Materials and methods

In order to investigate the issue of administrative decisions influence of felling trees on ecosystem services provided by trees and shrubs in the Municipality of Czerwonak, we applied two research methods: 1) participatory mapping, and 2) quantitative data analysis from administrative decisions on felling trees and shrubs. The procedure of participatory mapping was adapted from the research on ecosystem services in protected areas in Poland[14]. During the participatory mapping, firstly experts were asked the series of questions concerning ecosystem services provided by trees in the Municipality of Czerwonak. Secondly, they were asked to identify and locate (using cards prepared by the researchers) important ecosystem services provided by trees on the municipality map, using the preliminary list of 24 ecosystem services. It was prepared on the basis of ecosystem services provided by trees in the cities[15]. Finally, participants were asked to explain choices they made. The participatory mapping took place on July 2nd 2016 in the Municipality Office of Czerwonak and lasted two hours. Participants were representatives of Czerwonak Municipality, responsible for environmental issues and issuing administrative decisions on feeling trees and shrubs.

Concerning the administrative decisions on felling trees and shrubs, information was collected for the period of January to July 2015. The period was the most recent, for which information was accessible. Two hundred decisions were reviewed and coded to the database, containing information on the decisions (number of trees, species, compensations, reasons of the applications etc.). After removing incomplete data, 188 decisions for felling trees or shrubs were included to the analysis. The forests in the municipality governed by the Regional Direction of State National Forest Holding were

14 A. Pietrzyk-Kaszyńska et al., *Usługi ekosystemów na obszarach cennych przyrodniczo z perspektywy różnych grup interesariuszy: podsumowanie wyników projektu*, 2016.

15 J. Kronenberg, *Urban ecosystem services*, "Sustainable Development Applications" 2012 no. 3 (Special Issue: Polish TEEB for Cities), p. 14–28.

excluded from our study as they are managed via the internal procedures of the Forest Holding.

The analysed cases were introduced to the map of ecosystem services indicated by experts. It allowed for further spatial analysis.

Results

The outcome of experts' participatory mapping workshop was the identification of most important ecosystem services provided by trees on the Czerwonak municipality map using preliminary list of 24 ecosystem services. The preliminary list was prepared on the basis of ecosystem services provided by trees in the cities.[16] Experts identified eight types of services from the preliminary list which were: habitat for animals and their nutritional base; regulation of air quality; noise reduction; protection from snowdrifts; strengthening social bonds; places of recreation; trees as a witness to history, e.g. monuments of nature; business benefits (table 1). They covered mostly the western part of the municipality along the Warta River.

Concerning the decisions on the cutting off trees, analysis of 188 administrative decisions showed that in 177 cases the Municipality of Czerwonak issued a permission on felling trees or shrubs, while in 11 cases applications were refused. In 17 cases, a permission involved an obligation to make the surrogate plantings.

The majority of entities applying for permission on felling trees and shrubs were natural persons (171 cases). In 29 cases applying entity was a legal person. The most frequent reason for cutting off, stated in applications were: a threat to life or property (31,5%); construction of a building or other object or demolition (14,5%); a threat to the functioning of the devices, such as power lines, sewers etc. (12,5%).

Taking into account trees and shrubs species' origin of the permissions there is the dominance of native species: 63,76%. In terms of tree species the most frequent in decisions were the following: Scots pine (*Pinus sylvestris* L.) – 541; silver birch (*Betula pendula* Roth) – 288; and trees from genus poplar (*Populus* L.) – 138. Shrubs species dominating in administrative decisions were the following: bird cherry (*Prunus padus*) – 215 m^2, shrubs from genus thuja (*Thuja* L.) – 46,5 m^2, shrubs from genus spruce (*Picea* A. Dietr.) – 30 m^2.

16 J. Kronenberg, op. cit., p. 14–28.

Table 1. List of ecosystem services provided by trees (grey colour – most important services provided by trees according to workshop participants)

Ecosystem services type	Ecosystem services name
Supporting (habitat-related)	Habitat and nutritional base for animals
	Photosynthesis
	Retention of water in the land
Provisioning	Provision of wood and mistletoe
	Provision of fruits and nuts
Regulating	Regulation of air quality (dust retention, absorption of pollutants such as sulfur and nitrogen oxides, carbon dioxide, sulfuric, hydrochloric and nitric acid fumes, heavy metals)
	Enrichment of air and soil with moisture
	Air circulation (enhancement of vertical and horizontal convection)
	Protection from wind
	Creating "cold and humidity islands", especially in the summertime
	Shade regulation
	Noise reduction
	Secretion of antibiotic substances (phytoncides) with bactericidal, fungicidal and protozoacidal properties
	Biological field (electric charges emitted by assemblages of greenery that are beneficial to human health)
	Protection from snowdrifts
Cultural	Socio-educational role (active and passive recreation, raising awareness)
	Contribution to space aesthetics (camouflage of unsightly elements, accentuation of architectural beauty)
	Positive influence on health
	Cultural inspiration
	Strengthening social bonds (especially in the case of planting trees by communities and collaboration in caring for them)
	Place of recreation
	Psychological bonds between people and trees, a sense of place
	Trees as witnesses to history, especially legacy or veteran trees
	Business benefits (e.g. increased sales in trading districts with trees)

A decision was taken as a unit of analysis. A decision can refer to trees only, to shrubs only or to a combination of trees and shrubs, as requested by an applicant. The application varied significantly in terms of number of trees, from 1 to 1377 specimen, and in terms of shrubs from 1 m^2 to 215 m^2.

The areas where ecosystem services were identified and the location of each tree/shrubs cut off are presented in figure 1.

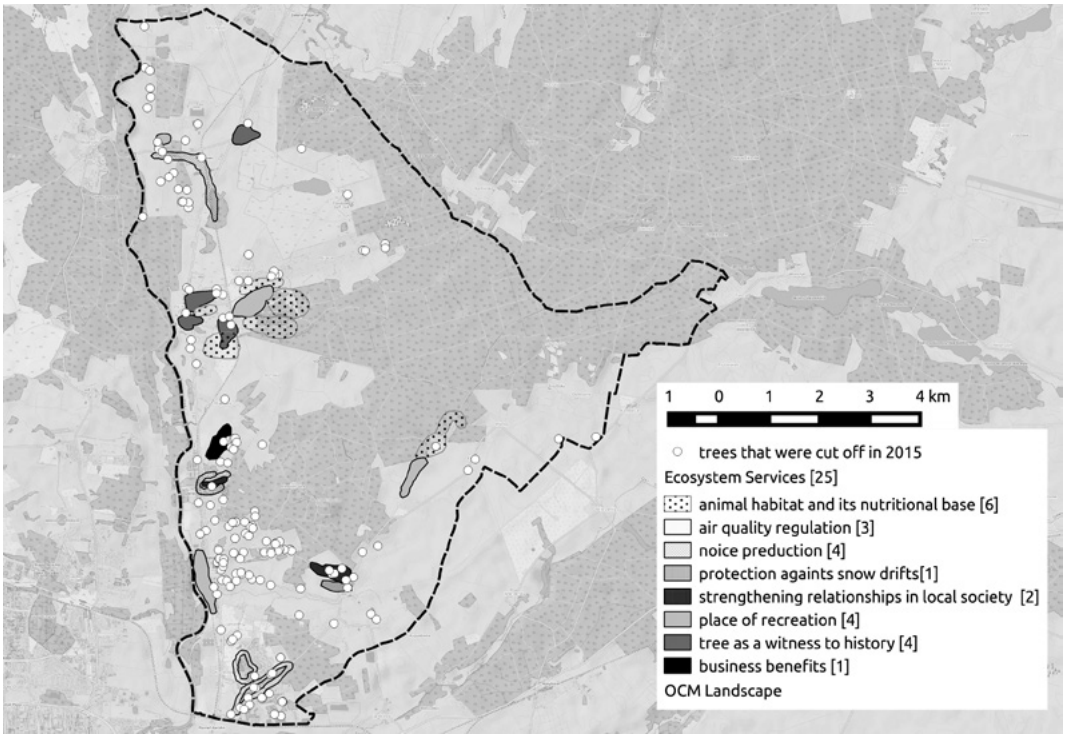

Figure 1. Map of ecosystem services areas and trees' felling locations. Numbers of areas of each ecosystem service are indicated in the brackets

In order to determine whether cutting off trees influences the ecosystem services, we measured distances of trees'/shrubs' felling locations from each identified areas, where particular types of ecosystem services were identified. We attributed the trees/shrubs into four categories: located directly in the ES areas, as identified by experts; located in the distance < 500 meters (23% of all cases); 500–1000 meters (22% of all cases); 1000–2000 meters (52% of all cases). Proposed intervals are related to the percentage of all trees/shrubs counted in given buffer. Only a small number of cut off trees/shrubs appear in the very location of an ecosystem service – about 3% of all cases (table 2).

Table 2. Number of cut off trees taking into account the distance from the ecosystem services areas.

	Ecosystem services								
Category of distance	**k_1**	**k_12**	**k_15**	**k_20**	**k_21**	**k_23**	**k_24**	**k_6**	**Total**
No. of trees in the area	2	4	1	7	2	3	2	4	25
No. of trees max. 500 m from the border area	18	39	8	10	44	10	8	25	162
No. of trees 500–1000 m from the border area	4	33	9	38	37	7	6	23	157
No. of trees 1000–2000 m from the border area	17	73	43	43	62	30	30	64	362
Total	41	149	61	98	145	50	46	116	

Codes of ecosystem services: k_1: habitat for animals and their nutritional base; k_6: regulation of air quality; k_12: noise reduction; k_15: protection from snowdrifts; k_20: strengthening social bonds; k_21: places of recreation; k_23: monuments of nature; k_24: business benefits.

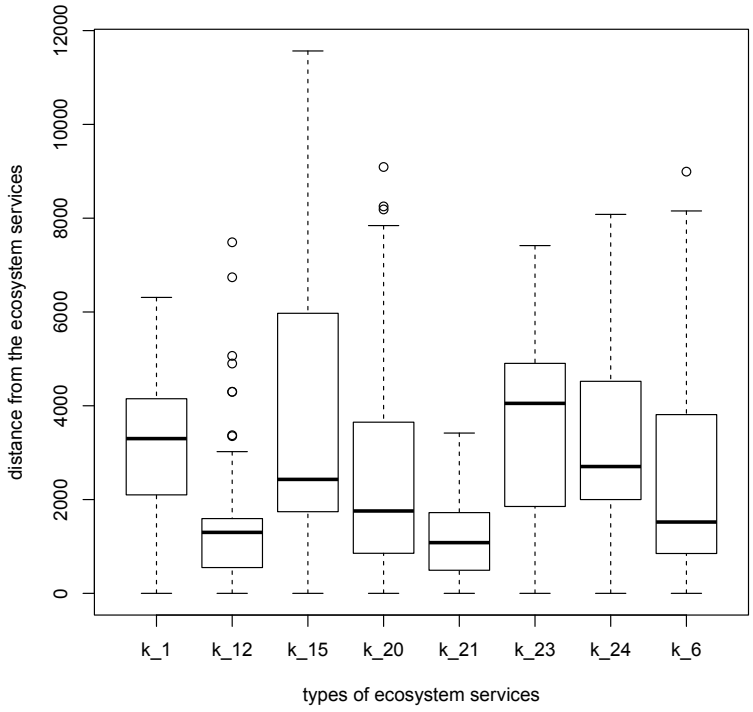

Figure 2. Distance from each type of ecosystem services related to trees and shrubs. The figure presents: median, first and 3rd quartile, minimum and maximum of values and outliers

Codes of ecosystem services: k_1: habitat for animals and their nutritional base; k_6: regulation of air quality; k_12: noise reduction; k_15: protection from snowdrifts; k_20: strengthening social bonds; k_21: places of recreation; k_23: monuments of nature; k_24: business benefits.

Although only a few cut off trees/shrubs were located within the identified areas of ecosystems services, cut offs done further also have certain impact. Euclidean distance from the areas where ecosystem services were indicated was measured for each tree or shrub. Only a distance to the closest area was taken if more than one areas of a particular an ecosystem service were identified. The results of distance analysis is presented in figure 2.

The analysis shows that each type of ecosystem services is influenced by trees/shrubs, that were cut off near their locations. However, average distance from the ecosystem services locations differs. Cutting off trees/shrubs has the biggest impact on areas dedicated to recreational purposes (K_21) as the median distance of the cut off trees to that area is the shortest one (1081,7 meters). Although only two trees were cut off in the very area of influence of the ecosystem services, 44 cut off trees were located in the vicinity (within 500 m).

The least influenced service is the cultural one related to monuments of nature (K_23), with the distance median of 4051 meters. For this service the distances are more dispersed compared with the recreational services.

Two services, noise reduction (K_12) and protection from snowdrifts (K_15) present peculiar characteristics. Both are related to roads, and therefore they are concentrated and linear in space. Noise reduction (K_12) has significant number of outliers, meaning several cases do not fit the model. For protection from snowdrifts (K_15) there is no outliers but the distance between the minimum and maximum distances is the biggest compared with all other ecosystem services.

Summary

The study enabled to identify and map ecosystem services provided by trees and shrubs in the Municipality of Czerwonak. Trees and shrubs cut off in accordance with the administrative decisions in the Municipality of Czerwonak do not affect all the ecosystem services equally. The felling have the biggest impact on places for of recreation in the municipality, and the smallest one on the areas with cultural ecosystem services, such as monuments of nature. The overall impact for all identified ecosystem services can be however assessed as small and felling trees and shrubs do not affect a particular ecosystem service.

This research has an exploratory character, and its limitation is related to the assumption that the influence scopes of all ecosystem services are the same. The results show however that this assumption requires refining. Two services which are spatially concentrated and of relatively short distance

impact (noise reduction, and protection from snowdrifts) are either having significant number of outliers (noise reduction) or are more dispersed in term of distances compared with other services. It suggests that spatial scope of ecosystem services impact requires scrutiny in further studies.

Conclusions and recommendations

Conducted research enabled to identify spatial distribution of ecosystem services provided by woody plants in the Municipality of Czerwonak. Dominant services identified with experts during participatory mapping can help in understanding management of municipal green areas, taking into account ecosystem services in particular areas of a municipality and adjust conservation actions to requirements. Our study contributes to a knowledge of municipality green areas' management, by consideration of trees and shrubs felling on the ecosystem services. Location of ecosystem services can enhance the actions to raise local society's awareness of the role of municipal green areas.

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