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ECOSYSTEM SERVICES OF ABANDONED LAND IN A CITY. AN EXAMPLE FROM POZNAŃ

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USŁUGI EKOSYSTEMÓW TERENÓW ODŁOGOWANYCH W MIASTACH. PRZYKŁAD POZNANIA

STRESZCZENIE: Tereny odłogowane pojawiają się w wielu miastach na świecie. Ich liczba oraz charakterystyka zależna jest od warunków środowiskowych oraz społeczno-gospodarczych. W Poznaniu obszary nieużytkowane przez człowieka obejmują 10% powierzchni miasta, większość z nich stanowią tereny pokryte roślinnością, a co za tym idzie dostarczające usługi ekosystemowych. Ich powierzchnia jest porównywalna do obszaru zieleni urządzonej w Poznaniu i stanowi istotnym elementem ekosystemu miasta. Odłogi szczególnie efektywnie dostarczają usług regulacyjnych. W niniejszej pracy zbadano skalę tych usług w zakresie zasilania wód podziemnych i retencji, oczyszczania powietrza oraz magazynowania węgla. Obszary te często zagrożone są przez nową zabudowę. Wykazywanie skali dostarczanych przez nie świadczeń może być wykorzystywane jako narzędzie pomocne w ochronie najcenniejszych z tych terenów.

SŁOWA KLUCZOWE: odłogi, roślinność spontaniczna, świadczenia ekosystemów

Introduction

Abandoned land constantly appears and disappears in cities. It is usually a part of almost every process of land use change, at least temporary. When land is unused by people the nature starts to use it for processes of vegetation growth. When land is unused for long periods of time natural succession usually tends to create ecologically valuable ecosystems. Such ecosystems could be an important part of green infrastructure in cities and provide variety of services for inhabitants of these cities.

It is important for researchers and policy makers to take into account areas of abandoned land and its ecological functions. They should know the extent of abandoned land in cities and its functions so protection of most valuable areas could be introduced. Decision makers in Poznań do not have data and knowledge about abandoned land in the city so this research was carried out to fulfil this gap. The aims of this study were to identify the area of abandoned land in the city and examine types and a scale of their ecosystem services.

Abandoned land

Abandoned land could be defined as land which is not in use in a direct and formal way by people¹. This broad definition includes areas such as wasteland, ruderal urban forests, previous gardens and parks or brownfields. Depending on a state and an appearance the abandoned land in this study was grouped in two types: semi-natural with vegetation cover and built-up. These classes depend on a type of previous use, recultivation treatments and a period of not being used. For example, previously built-up area after recultivation planned by humans or self-made by nature could end up as a semi-natural area. Use of such a classification results from the aim of the study in which semi-natural areas play a crucial role.

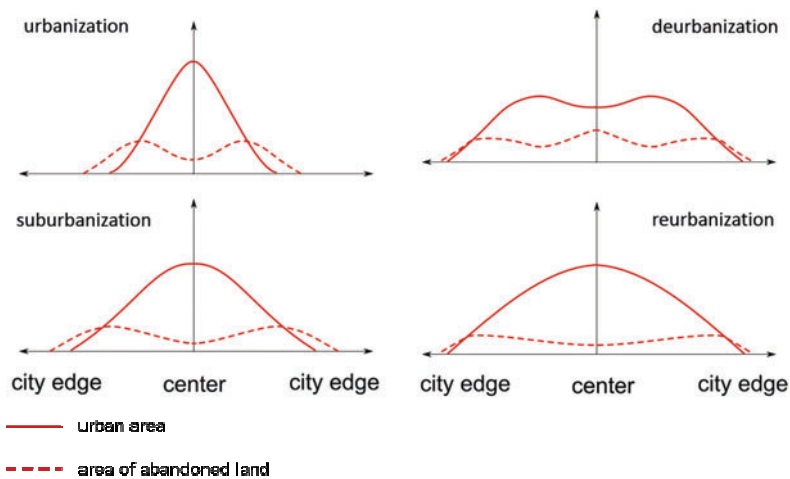
This definition of abandoned land includes also very small and only temporal areas, so two additional criteria were used. The first was a minimal area of two hectares so only sites big enough to be significant in context of the whole city was taken in consideration. The second condition was five years as a minimal period of not being in use which allows to study only long-term unused land.

¹ J. Zatonski, *Miejsce i rola odłogów miejskich w strukturze przestrzennej Poznania*, rozprawa doktorska, Poznań 2013.

Abandoned land in cities

Abandoned land are present in almost every city in the world². But there are differences in their characteristics depending on an environment type and socio-economic drivers³. Two main reasons causing the appearing of abandoned land seems to be deindustrialization and changes in agricultural land use around cities. Changes in industry, technology and localization make old industrial buildings and sites unsuitable and they became abandoned brown-fields. More and more people living around cities stop cultivating their agricultural land and urban sprawl leads to converting this land into residential areas so this land is not in use between time of cultivation stop and new development. During periods of cities growth most of abandoned land appears on city edges with progressing urbanization, during deurbanization more of abandoned land emerges closer to the city center (Figure 1).

Figure 1
Location and area of abandoned land in different stage of city life cycle 1



Source: own elaboration.

² J. Liu et al., *Study on spatial pattern of land-use change in China during 1995-2000*, "Science in China Series D: Earth Sciences" 2003 no. 46, t. 4, p. 373-384; Department for Communities and Local Government, *Previously-Developed land that may be available for Development: England*, London 2005, 2006, 2007; D. Bartlett, P. Quine, *Approaches to urban renewal in the US and UK*, Berkshire 1987; A.O'M. Bowman, M.A. Pagano, *Urban vacant land in the United States*, Boston 1998.

³ A. Pagano, A. O'M Bowman, *Vacant land in cities. An urban resource*, The Brookings Institution, Survey Series, Washington 2000, p. 8.

In spite the fact that abandoned land has a significant share in an area of some cities, they are often ignored in ecological studies⁴. There is also lack of understanding of „urban wilderness” which occurs on such areas as additional and valuable aspect of urban green⁵.

Abandoned land in Poznań

During research aerial and satellite imagery analyses and ground truthing were used to identify abandoned land and their basic characteristics in city of Poznań. In result 208 abandoned sites was identified. They cover area of 25.3 km² which is around 10% of city. The median size of such site is 5.37 ha (Table 1).

The main type of abandoned land is semi-natural and it accounts for 66% of all abandoned land. Usually it is previously agricultural land located on edges of the city or around streams and in rivers valleys. Built-up abandoned land takes only 4% of the whole abandoned land area. Previously industrial, railway and military sites do not have a significant area in the city so their reclamation should not be very problematic. Mixed areas which have both anthropogenic structures and large areas of vegetation accounts for around 30% of abandoned land area. The most important example of mixed abandoned land are ponds in excavation pits left over by sand and clay mines and their surroundings in south-west of the city.

Vegetation on abandoned land covers 2373,9 ha, which represents 94% area of abandoned land and 9% area of the city. It is almost the same area as main-

Table 1
Types, amount and area of abandoned land in Poznań city

Type	Amount		Area	
	[number]	[%]	[ha]	[%]
Built-up	27	12.4%	104.04	4.2%
Mixed	56	25.8%	722.30	29.4%
Semi-natural	134	61.8%	1627.81	66.3%
Total	217	100.0%	2454.15	100.0%

Source: own elaboration.

⁴ T. McPhearson, P. Kremer, Z.A. Hamstead, *Mapping ecosystem services in New York City. Applying a social-ecological approach in urban vacant land*, "Ecosystem Services" 2013 no. 5, p. 11-26; E.G. King, R.J. Hobbs, *Identifying linkages among conceptual models of ecosystem degradation and restoration: towards an integrative framework*, "Restoration Ecology" 2006 no. 14(3), p. 369-378.

⁵ J.H. Breuste, *Decision making, planning and design for the conservation of indigenous vegetation within urban development*, "Landscape and Urban Planning" 2004 no. 68, p. 439-452.

tained greenery which in Poznań covers an area of around 2250-2650 ha⁶ (not counting urban forests). Trees and shrubs canopy on abandoned land have an area of 805 ha (33% of abandoned land). An analysis of aerial imagery from 1998 had shown that an area of trees and shrubs canopy had 440 ha during that time, so it almost doubled during next fourteen years. Natural succession in environment of Poznań usually leads to forming trees areas, so it can be expected that an area of canopy will grow in the future. Water bodies and wetlands account for 5% of abandoned land area and sealed grounds and buildings take only 1% of it.

Ecosystem services

Green areas in cities provide a wide variety of important ecosystem services⁷. But ecosystem services of vegetation on abandoned land differ from those from parks, allotment gardens and other maintained greenery in city. In most cases people do not benefit from direct provisioning services like energy, food or materials provision because spontaneous vegetation is not cultivated to provide them. Also cultural services are not easy to identify because people have mixed feeling about "wild nature" in the city and use it relatively rare and less intensive than the urban parks⁵. On other hand, on abandoned land occurs processes which are similar to natural areas and biodiversity is much higher than in urban parks. These conditions cause that such land provides regulation and supporting services on higher level than in well maintained greenery. This services include:

- Regulation: groundwater recharge and water retention, climate regulation, air purification, oxygen production, carbon sequestration, erosion regulation;
- Supporting: habitat provision, population and biodiversity maintaining, pollination.

In this study water retention, air purification and carbon sequestration were chosen for detailed research.

Ecosystem services can be quantified either as biophysical units of the service or the social value of the service, for example, monetary⁸. The first approach was used in this study.

⁶ B. Hoffmann et al., *Zieleń, Środowisko naturalne miasta Poznania*, part I, Poznań 1996, p. 123-139; Bank Danych Lokalnych, www.stat.gov.pl [10-09-2014].

⁷ H. Akbari, *Shade trees reduce building energy use and CO₂ emissions from power plants*, "Environmental Pollution" 2002 no. 116(Suppl.), p. S119-S126; P.T. McPhearson et al., *Assessing the effects of the urban forest restoration effort of million trees, NYC on the Structure and Functioning of New York City*, "Ecosystems Cities and the Environment" 2010 no. 3(1), p. 1-21; D.J. Nowak, D.E. Crane, *Carbon storage and sequestration by urban trees in the USA*, "Environmental Pollution" 2002 no. 116, p. 381-389.

⁸ F. Müller, L. Willemsen, R. DeGroot, *Ecosystem services at the landscape scale: the need for integrative approaches*, "Landscape Online" 2011, p. 1-11.

Ecosystem services of abandoned land in Poznań

Abandoned land in Poznań has in most cases unsealed ground which allows infiltration of rainwater. Also areas with a concrete or asphalt layer on abandoned land due to not maintaining the rain drainage system cause that rainwater runoff is not getting to the city's central drainage system.

The average annual precipitation in Poznań is 508 mm⁹. So it is easy to calculate that on the whole area of abandoned land around 12,8 billion litres of water is falling which is not discharged into the drainage system.

This ecosystem service causes significant savings in a city's budget because intercepted rainwater does not have to be transported through the drainage system. Moreover thanks to water infiltration, groundwater is easier accessible by plants and reduces the need for watering them. Water retention is especially important in Poznań because it is one of the regions with the smallest amount of precipitation in Poland.

For determining a scale of air purification as well as carbon sequestration, literature research was undertaken. Based on parameters established for an area of trees and vegetation by other authors¹⁰ there were calculated tones of intercepted pollution and carbon. Unfortunately, there is lack of such studies focused on spontaneous vegetation on abandoned land which probably having more vegetation layers, higher tree density and biodiversity has bigger potential for removing pollution and carbon from an atmosphere than maintained greenery.

In case of air purification especially removal of particles with diameter of 10 micrometres or less is important because the results of monitoring made by the

Table 2
Pollution and carbon spontaneous by vegetation on abandoned land

Elements	Parameters		Results	
	Trees	Vegetation	Trees [t]	Vegetation [t]
SO₂ removal	1.32 g/m ² yr	0.65 g/m ² yr	10.7	10.4
NO₂ removal	2.54 g/m ² yr	2.33 g/m ² yr	20.5	37.2
PM₁₀ removal	2.73 g/m ² yr	1.12 g/m ² yr	22.1	17.9
O₃ removal	3.06 g/m ² yr	-	24.7	-
CO removal	0.58 g/m ² yr	-	4.7	-
Carbon sequestration	0.12 kgC/year/m ²	-	97	-
Carbon storage	9.25 kgC/m ²	0.18 kgC/m ²	7480.3	287.1

Source: D.J. Nowak, D.E. Crane, op. cit., p. 381-389; H. Jo, G. McPherson, *Carbon storage and flux in urban residential green-space*; "Journal of Environmental Management" 1995 no. 45, p. 109-133; H. Zimny, *Ekologia miasta*, Warszawa 2005; M. Czerwieniec, J. Lewińska, *Zieleń w mieście*, Kraków 2000.

⁹ R. Farat, *Klimat Poznania. Środowisko naturalne miasta Poznania*, cz. I, Poznań 1996, p. 123-139.

¹⁰ D.J. Nowak, D.E. Crane, op. cit., p. 381-389; H. Jo, G. McPherson, *Carbon storage and flux in urban residential green-space*; "Journal of Environmental Management" 1995 no. 45, p. 109-133; H. Zimny, *Ekologia miasta*, Warszawa 2005; M. Czerwieniec, J. Lewińska, *Zieleń w mieście*, Kraków 2000.

Regional Inspectorate of Environmental Protection in Poznań shows that an acceptable level of this parameter (averaged over 24 hours) was exceeded 47 times from January to August 2014¹¹. As for carbon, it is a major cause of global climate change so allowing it to be stored in plants, could be used for mitigation of this process.

Conclusion

Land is non-renewable resource and should be used in an efficient way. Meanwhile in cities large areas are permanently or temporarily not in use by man. On these areas ecological succession is ongoing which could lead to formation of ecologically valuable ecosystems. An area on abandoned land in Poznań is significant because it covers about 10% of the city. Vegetation on abandoned land in Poznań is an important part of the whole city ecosystem similar to maintained greenery. It has also crucial role in providing ecological services. Especially, regulation services as groundwater recharge and water retention, climate regulation, air purification, oxygen production, carbon removal and erosion regulation.

This study shows that vegetation on abandoned land by providing ecosystem services could be an important ally in reduction of local problems with groundwater resources and air pollution. It could also be used as a local tool for mitigation to a global climate change.

Unfortunately, areas of abandoned land with their valuable resources and services are disappearing from cities. There is need for more detailed research on this topic which should lead to developing tools to diagnose this area and provide reasons to preserve some of them.

¹¹ www.poznan.wios.gov.pl [10-09-2014].