REGIONAL GREEN BELTS IN THE RUHR REGION A PLANNING CONCEPT REVISITED IN VIEW OF ECOSYSTEM SERVICES

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With 7 figures, 6 tables and 1 supplement
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Summary: The idea of regional green belts in the Ruhr region (Germany) dates back to 1912, but only 60 years ago, the term regional green belt appeared in official German spatial planning, and ever since, regional green belts as a theoretical concept and a planning category form an integral part of regional planning in the area. This paper tracks back the changing concepts, functions of the regional green belts, it analyzes their present state and proposed future. From the starting point of their formal existence in the Regional Development Plan as of 1966, the original regional green belts (RGBs) significantly lost open space and consequently areas providing ecosystem services diminished. Parts of RGBs were transformed into settlement and areas for traffic and technical infrastructure, whereby the loss is spatially unevenly distributed. New delineations of the regional green belts are currently under discussion for the forthcoming regional plan. The green belts would be substantially enlarged from formerly 281 km² (1966), over 696 km² (2004) to 1103 km² by extending them into the less densely populated outer zones. In the crucial central parts of the Ruhr region, where the original RGBs are located, an 'adaptive' reduction will take place as a sacrifice to the already happened change to urban, non-open space land cover. Open spaces will be attached to the original RGBs and form green circles surrounding the cities of the Ruhr region's core area. We assess the potential ecosystem services provision of the 23 parts of the proposed new regional green belts based on the present land cover. We criticize the planning category regional green belt as indistinct and inappropriate to express the requirements of optimal protection of areas providing ecosystem services. Regional green belts need to be better backed-up by overarching legally binding planning of built-up areas and open space.

Zusammenfassung: Die Regionalen Grünzüge des Ruhrgebiets wurden im Gebietsentwicklungsplan (1966) erstmals rechtskräftig ausgewiesen. Sie gelten international als ein vorbildliches Planungsinstrument. Der Beitrag skizziert den Wandel der Bedeutungs- und Funktionszuschreibungen der Grünzüge, analysiert deren Landnutzungsstruktur, diskutiert die für den zukünftigen Regionalplan Ruhr vorgeschlagenen Erweiterungen und interpretiert deren potentielle Ökosystemleistungen. Während der vergangenen Jahrzehnte haben substantielle Teile der ursprünglichen Grünzüge ihren Freiraumcharakter und somit ökologische Funktionen (Ökosystemleistungen) zugunsten von Siedlungs- und Verkehrsflächen verloren. Dieser Verlust wird durch frühere und die im Regionalplan in Aussicht stehenden Vergrößerungen von ehemals 281 km² (1966), über 696 km² (2004) auf 1103 km² verschleiert. Die Analyse zeigt die – entgegen anderslautender Äußerungen – eingeschränkte Wirksamkeit regionaler Grünzüge für den Freiraumschutz im Ruhrgebiet, was zum Teil mit der unscharfen Definition des Planungsinstruments „Regionaler Grünzug" zusammenhängt. Dieses lässt im Zusammenwirken mit anderen gesetzlichen Regelungen Nutzungen und Nutzungsänderungen zu, die dem Ziel, Natur und Landschaft zu schützen, zu pflegen und zu entwickeln, entgegenstehen.

Keywords: Ruhr area, urban landscape, protection of nature and environment, regional planning, regional green belt, ecosystem service

1 Regional green belts: effective preventive measures against land consumption and securing ecosystem services?

Regional green belts represent a special type of green and open spaces in metropolitan areas, because regional planning authorities aim at protecting significant contiguous open space against uncontrolled land consumption on the local scale. Open spaces, in contrast to sealed surfaces, provide ecosystem services. Artmann (2013) analyzed spatial dimensions of soil sealing in urban areas on multiple scales and asked which strategies have the potential to control land consumption and related loss of ecosystem services. The multiple influential factors contributing to open space consumption in Germany were also discussed by Kretschmer et al. (2015). They suggest an analytical framework for further multi-dimensional

studies and include regional planning as a tool for reducing land consumption (loc. cit. 274). Focusing on regional green belts in Germany, the few available studies acknowledged their contribution to reducing land consumption. Einig et al. (2011) confirmed positive effects for the Düsseldorf and Hanover region. Siedentop et al. (2016, 80) proved the effectiveness of regional green belts in protecting open space in metropolitan regions. They concluded that in the case of four regional plans, namely Düsseldorf, Hanover, Stuttgart and Middle Hesse, "greenbelts seem to be efficient in the preservation of the entire open space that falls within the greenbelt" (loc. cit. 80). Diller et al. (2015) examined green belts in 42 German regional plans and stated that, despite large regional differences, regional green belts are one of the most universal and effective elements of spatial planning. None of the studies treated the special situation of the regional green belts of the Ruhr region, North-Rhine Westphalia (Germany), one of Europe's largest conurbations. We therefore fill the gap and comprehensively examine the development, state, effects and future development of regional green belts in the polycentric Ruhr region (cf. Fig. 1).

The key term of this study, 'regional green belt', needs some clarification, considering the highly diverse and inextricably use of related terms such as green space (Taylor and Hochuli (2017). Pahl-Weber and Henckel (2008, 195) express the current understanding of a regional green belt in the German planning system: "A regional green belt is a continuous expanse of land reserved for ecological functions or recreational purposes and accordingly forbidden for settlement or other functionally incompatible uses". Due to their larger area and longitudinal shape, regional green belts contrast with small scale green spaces whose benefits to residents are treated in several recent publications (Rusche 2012; Sang et al. 2016; Akpinar 2016; Keith 2016; Mell et al. 2016; Hong and Guo 2017). Our understanding of regional green belts corresponds to the highest level of the hierarchical greenway system that Liu et al. (2016) examined at the neighborhood, city and regional level in Shenzhen (China). We see regional green belts as elongated open spaces that separate settlement cores of a polycentric urban area. In the specific case of the Ruhr region, the regional green belts represent both a planning category and instrument on the regional scale under the jurisdiction of regional authorities. Though regional green belt planning in the Ruhr region looks back on a history of one hundred years, there is no paper available that synoptically and critically analyzes the history and planning discourse, as well as the physical changes of the regional green belts. Planners who are not familiar with the region may assume green belts to be extended parks that were carefully designed by landscape architects and uncritically repeat narratives treating the green belts in the Ruhr region as a success story, for instance Gälzer (2001) in a textbook on green planning. Other studies (Erzner 1995; Finke 2010) consider only rather short periods of observation or analyze the status-quo at a given time. In metropolitan regions with decelerated economic development and population decline, as the Ruhr region, land consumption is a slow but steady process displaying islands of growth amidst areas with zero development and persistent land cover, or even given-up areas such as brownfields, at the same time. Hence, long term observations are necessary to judge the spatial effects on the urban green and especially of the regional green belts. We will satisfy this demand in a quantitative and spatially explicit way.

Benefits of regional green belts in terms of spatial structure and ecosystem services can be effective on all scales. Open spaces, such as forests within a regional green belt, provide multiple benefits, as for instance air purification, carbon sequestration, and water retention, and possess recreational potential on the regional as on the neighborhood scale. It is thus meaningful to consider, even on a regional scale, a broad spectrum of ecosystem services, irrespective of their respective outreach. For the last 15 years, evaluations of green spaces have been done applying the ecosystem services concept. "Ecosystem services (ES) include all ecosystem functions and processes people and society benefit from in economic terms or related to their quality of life" (Breuste et al. 2013, 87, referring to Costanza et al. 1997 and de Groot 2002). The new interest in landscape's and ecosystems' beneficial effects on human well-being inspired the international scientific and planning community (Wolch et al. 2014; Bertram and Rehdanz 2015; Inostroza et al. 2017). Up to now, the ES concept was not introduced into the legal base of spatial planning at the local and regional levels, such as the Federal Building Code (BauGB 2017), the Federal Spatial Planning Act (ROG 2004), or the Act on Nature Conservation and Landscape Management (BNatSchG 2009). In formal planning, it is still not mandatory to interpret the aims of landscape and open space planning by making use of the ES concept though its application to substantiate vague legal concepts is recommended by experts in collaboration with public agencies

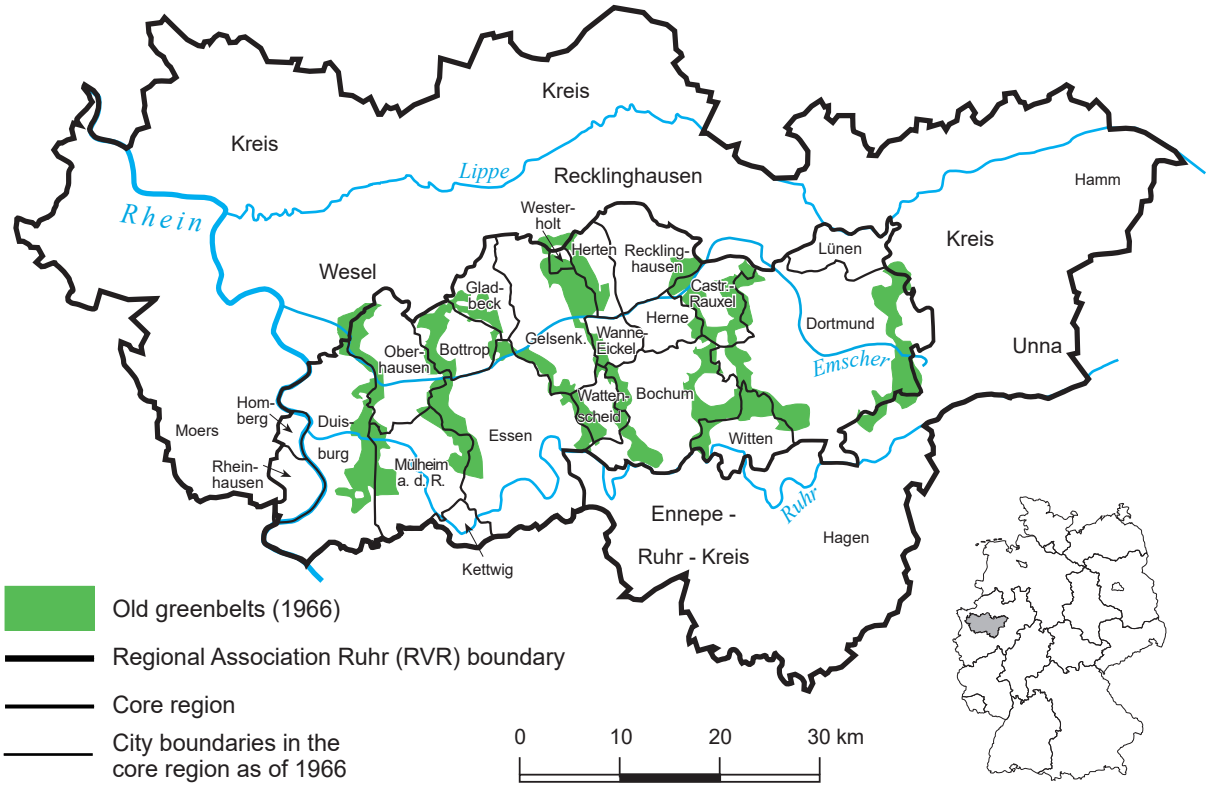

Fig. 1: RGBs and cities of the Ruhr region's core area according to the Regional Development Plan (SVR 1966)

(Kowarik et al. 2017). On the other hand, Central European scholars of landscape ecology argue that methods for evaluating capacities and potentials of ecological landscape units to fulfill human needs had been extensively elaborated, published, and applied in spatial planning since the 1970s (Bastian et al. 2012) before the term ES was introduced. As older concepts and the ES concept serve the same purpose, it is justified to consider the first-named when dealing with the existing green belts and the ES concept to evaluate future plans. The limited yet conceded advantage of the ES concept is its potentially more detailed approach considering a larger number of benefits.

- Following the introduction of the study area, related green belts, and open space planning in the Ruhr region (chapter 2), this paper examines the green belts from the early context of justification to the current preparations of the regional plan (chapter 4). In tracing back the change of rationales for the establishment and protection of the green belts in the Ruhr region during their one hundred year long history, we maintain, as mentioned previously, the original wording used at the respective period.
- The spatial configuration and changing extent of the legally binding regional green belts (chapter 5) is closely connected with the functions they were thought to fulfill.
- The plans for the future regional green belts are presented in chapter 6. The 23 parts of the intended new green belt system will be characterized in terms of their land cover classes and internal spatial structure. We evaluate the relevance of the regional green belts against the background of the region's total open and green spaces inside and outside the densely settled areas. To link to up-to-date terminology in science, we evaluate the potential ES of the anticipated future regional green belts.
- In chapter 7, we will discuss how issues of terminological clarity and the changing understanding of regional green belts are crucial to understand land cover change within the limits of green belts depicted in chapter 5. Furthermore, we try to elucidate some reasons for the planning deficits connected to multi-scale open space planning in the polycentric Ruhr region. In this context, we come back the opening question if the regional green belts of the Ruhr region were effective in protecting open space.

2 Study area and retrospect on regional green belts and related open space planning in the Ruhr region

2.1 Ruhr region

The Ruhr region is a conurbation of roughly 5.1 million inhabitants in Germany (Fig. 1). The first transformation of the preindustrial area that later became Europe's largest polycentric industrialized region started in the 19th century when coal mining and subsequent steel production boomed. Development began in and near the Ruhr valley and spread to the north after exploitation of hard coal reservoirs at great depth was possible. Urban expansion during the 20th century seized the whole area between the rivers Ruhr and Lippe. New cities, especially along the river Emscher, rose as greenfield development or from villages. Population grew from less than 0.3 million (1820) over 0.9 million (1871) to 5.7 million in 1961 (RVR 2006, 29). At the turn of the 19th to the 20th century the need for spatial planning was obvious due to bad living conditions and bad management of natural resources. Especially the Emscher zone of the Ruhr region had been heavily affected by mining and industrialization lacking coordinated spatial planning and environmental protection. Land subsidence and subsequent flooding with contaminated Emscher water caused diseases. As a countermeasure, from 1899 onwards, the Emscher and its tributaries were channelized and transformed into open sewers by the newly founded *Emschergenossenschaft* (Emscher Water Board). The river Ruhr, formerly used for shipping coal, was protected and managed from 1899 on by the Ruhr Water Authority to provide drinking water for the region. To fight against uncoordinated urban sprawl, in 1920 the *Siedlungsverband Ruhrkohlenbezirk* (SVR) was founded as the regional planning authority of municipalities. The SVR and follow-up authorities have ever since been responsible for regional green planning. The second transformation of the Ruhr region began in 1958 with the decline of the coal and steel industries, bringing about structural change in the economy and leaving behind vast industrial brownfields (estimated to be around 10,000 ha; Dosch and Porsche 2008), adverse environmental heritages as well as demographic and societal challenges. Approximately 660,000 workers were set free in the coal mines and steel factories between 1958 and the turn of the century (RVR 2006). Especially in the Emscher zone, unemployment rates peaked to around 20% and have ever since been significantly higher than the national and provincial average. The international building exhibition (IBA) Emscher Park was carried out between 1989 and 1999 as a programme of the province of North-Rhine Westphalia to support structural change (IBA Emscher Park 1996, 1999). Aiming at the economic and ecological restructuring of the Emscher zone, the Emscher Landscape Park was one of the IBA key projects. Rehabilitation of brownfields and thus creating green settings for companies providing jobs, spaces for recreation and putting up land marks for a new identity were prominent activities. Up until now and locally, remediating soil, surface and groundwater pollution remains a challenge for landscape development, whereas in other parts the value of primary succession on industrial brownfields is appreciated among ecologists (Keil 2005). In view of the closure of last remaining coal mine in 2018, the regional discourse in politics and planning on how to develop the region to be competitive in a globalized economy continues. In this context, the debate on regional green belts is high on the agenda again.

2.2 Regional green belts and related open space planning: a retrospect

60 years ago, the term 'regional green belt' (RGB) first appeared in official German spatial planning. According to Erzner (1995), in the 1970s Gottfried Schmitz and Joachim Gadegast claimed having been the first using the expression 'regional green belt' (*Regionaler Grünzug)* that appeared in the Regional Development Plan (RDP; SVR 1966) for the Ruhr area. The RGBs were defined and delineated by the SVR, which at that time was the planning authority of the Ruhr industrial conurbation. Earliest ideas to provide green belts for the Ruhr region appeared in 1912 by the later foundation director of the SVR (Schmidt 1912) and ever since then, green belts as a theoretical concept and a planning category have formed an integral part of regional planning in the Ruhr region (cf. Pflug 1970).

The Planning Atlas of SVR (1960) was a milestone in what was later termed open space protection in the Ruhr region (cf. Tab. 1). It included a regional system of green areas in the core area, similar to those depicted in Fig. 1. In the polycentric Ruhr region, the green belts were the historically leftover territories between the densely settled industrial and residential areas that had developed during a period of more than one hundred years. In 1964, a memorandum of the provincial government of North-Rhine Westphalia stated the disorderly mix of residential and industrial areas with only few green spaces (Erzner 1995, 33). Only in 1966, were plans for the regional green belts laid down in the above mentioned legally binding plan, the RDP (SVR

Tab. 1: Milestones of regional green space planning in the Ruhr region excluding regional plans after 1975

Year	Instrument / Plan	Area	Responsibility
1912	Memorandum	Ruhr region	R. Schmidt
1960	Planning Atlas	Ruhr region	*Siedlungsverband Ruhrkohlenbezirk* (SVR)
1966	Regional Development Plan *(Gebietsentwicklungsplan)*	Ruhr region	*Siedlungsverband Ruhrkohlenbezirk* (SVR)
1985	Regional Open Space System Ruhr Region *(Regionales Freiraumsystem Ruhrgebiet)*	Ruhr region	*Kommunalverband Ruhrgebiet* (KVR)
1989	IBA Emscher Park and Ecology Programme Emscher-Lippe	Emscher region	*Landesregierung Nordrhein-Westfalen*
2005	Master Plan Emscher Landscape Park	Emscher region: Emscher Landscape Park	*Projekt Ruhr GmbH*
2009	Open Space Concept Ruhr Metropolis *(Freiraumkonzept Metropole Ruhr)*	Ruhr region	*Regionalverband Ruhr* (RVR)
2010	Regional land use plan *(Regionaler Flächennutzungsplan)*	City region Ruhr 2030 (Bochum, Essen, Gelsenkirchen, Herne, Mülheim an der Ruhr, Oberhausen)	*Städteregion Ruhr*
in prep.	Regional plan	Ruhr region	*Regionalverband Ruhr* (RVR)

1966; cf. Fig. 1). Deviations between the Planning Atlas (SVR 1960) and the RDP (SVR 1966) are small. The green belts as of 1966 are slightly smaller in width than that of the plan from 1960 (cf. Erzner 1995, 36).

The RGBs[1)] as delineated in the RDP (SVR 1966; Fig. 1) crossed the core area (total population: 4.1 million; population density 2889 inhabitants/km²; data as of 1964, SVR 1966, 79) from North to South in parallel bands. For practical reasons, the RGBs are commonly labeled A to G, from west to east. These labels did not yet appear in the RDP from 1966 and green belt G was not denominated until 1986 (RPA 1986). The RGBs include agricultural, forestal and recreation areas, and a system of green spaces. These green belts also comprise sparsely settled areas and allowed for land use categories that are not conform to present understandings of urban green spaces, such as technical infrastructure (transformer stations, power lines, wastewater treatment plants, freeways), landfills, spoil tips. In this respect, the planning category RGB is indistinct and inappropriate to express the requirements of optimal protection of areas providing ES.

In 1975, the responsibility for regional development planning and hence for the RGBs was devolved from the SVR to the three superior administrative regions (*Regierungsbezirke*) Arnsberg, Düsseldorf and Münster within the state of North-Rhine-Westphalia. All subsequent regional development plans enlarged the extent of the RGBs in comparison to the initial design in the RDP 1966 (SVR 1966). These new delineations were accepted in the informal 'Regional Open Space System Ruhr Region', developed by the *Kommunalverband Ruhrgebiet* (Municipal Association Ruhr Region; KVR), the follow-up authority of the SVR (KVR 1986; Schwarze-Rodrian 1988). On the scale 1:100,000 the 'Regional Open Space System Ruhr' served as a mission statement for all open space related services of the KVR.

From 1989 on, the most ambitious endeavors in the Emscher Landscape Park as part of the IBA Emscher Park was and until 2020 still will be the transformation of the river system into restored creeks and semi-naturalized river reaches (Emschergenossenschaft 2006; Stemplewski 2010) as well as the rehabilitation of vast brownfields. These targets were financially backed up by the Ecology Programme Emscher-Lippe from 1991 onwards[2)] launched by the provincial government, co-financed by the EU Regional Fund since 1996 and between 1997 and 2013 as part of the European Regional Development Fund (ERDF)[3)]. During the first

[1)] In the following, the abbreviation RGB signifies the formal regional green belts of the Regional Development Plan 1966.

[2)] http://www.rvr-spd.de/oepel-nachfolge/ [26.05.2016]; this program officially terminated at the end of 2016.

[3)] https://www.umwelt.nrw.de/natur-wald/natur/foerderprogramme/oekologieprogramm-emscher-lippe/ [26.05.2016]

decade of the Emscher Landscape Park, in 1991 all three regional governments incorporated the northern parts of the RGBs into their respective RDPs. In the second decade following the IBA Emscherpark, the informal Master Plan Emscher Landscape Park (Projekt Ruhr GmbH 2005) adapted the regional belts within the boundaries suggested by the cities.

Whereas these plans focused on the Emscher region, the whole Ruhr region was covered by the informal 'Open Space Concept Ruhr Metropolis' from 2009 (Mann 2012; Mann and Bartkowiak 2012). It served as a long-term strategy for the further development of green and open spaces. Although the Master Plan Ruhr (SRR 2008) underpins the significance of urban green infrastructure, contains a Master Plan Ruhr Valley (loc. cit., 112-113), refers to the Master Plans Emscher Landscape Park (Projekt Ruhr GmbH 2005) and the New Emscher Valley (Emschergenossenschaft 2006), it does not use the terminology RGBs.

The regional land use plan (*Regionaler Flächennutzungsplan*; SRR 2010) of the cities Bochum, Essen, Gelsenkirchen, Herne, Mülheim an der Ruhr, and Oberhausen is the formal land use plan according to the Federal Building Code and at the same time is the regional plan in line with the Federal Spatial Planning Act (ROG 2004). It delineates RGBs on the scale 1:50,000. In contrast to most of the above mentioned plans, the minimum size of map units is 5 ha.

To conclude the retrospect on the RGBs in formal and informal regional planning, all formal plans include RGBs. Following the re-devolvement of the planning responsibility to the Regional Association Ruhr (*Regionalverband Ruhr*; RVR) in 2009, these RGBs will merge into the regional plan in the future (RVR 2017).

3 Methodology

3.1 Green belts and land cover data

Regional plans, official documents and relevant accompanying critical literature on open space planning in the Ruhr region were analyzed to trace back the changing justifications and concepts of regional green belts in the Ruhr region. The RGBs as of 1966 (RGB) were published on the scale 1:100,000, avoiding sharp delineations in preference to bordering transition zones. Erzner (1995) used planimetry to determine area sizes on the basis of ordnance survey maps and aerial photos. For our analysis, RVR provided ArcGIS vector files of the border lines that had been digitized from the printed plan enlarged to the scale 1:30,000 (pers. communication, Regina Mann, RVR). RVR also made available a digital resource of the new, suggested delineations of the green belts for the regional plan (RGP[4]). The minimum size of spatial units of the regional plan will be 10 ha.

Land cover information is based on the Urban Atlas (EEA 2014). This database is available for all conurbations in the EU, providing regional scale information covering 19 land use classes. We used the data base from 2006. The data sets are downloadable as vector data in ESRI shapefile format. The data was derived mainly from earth observation data backed by other reference data, such as COTS navigation data and topographic maps on the scale 1:50,000 or larger (EEA 2014). The minimum mapping unit varies from 0.25 ha for settlement areas and 1.0 ha for agricultural land, forests, and water bodies. Hence, the spatial accuracy does not allow statements on single properties (Meirich 2008). Erzner (1995) determined land use within the regional green belts on the basis of ordnance survey maps and aerial photos. According to the terminology as of today, basically he quantified land cover. There surely is some fuzziness in the change detection, because the initial RGBs from 1966 already included some low density settled areas, which could potentially be equated with the Urban Atlas land cover categories 'Discontinuous Low and Very Low Density Urban Fabric' (sealed surface < 30, resp. < 10%). We excluded them in our definition of open space, but on average, these areas amount to less than 1% of each RGP. Erzner's (1995) statements were reinterpreted after new calculations and compared to own findings. The different methods (planimeter vs. GIS) for measuring area sizes between Erzner (1995) and this study may cause only minor conflicts. We used ArcGIS 10.1 to determine patch sizes of land cover classes and V-LATE 2.0 beta (2012) to caclulate further landscape metrics.

[4] In the following, the abbreviation RGP signifies the parts of the regional green belt network suggested in the technical contribution to the regional plan in preparation.

3.2 Ecosystem Services

Zepp et al. (2016) presented a method for the preliminary assessment of Urban Ecosystem Services (UES) based on land cover data. The land cover classes stand for the urban structural types in the sense of Pauleit and Breuste (2011). These are relevant to rate major regulating services, such as micro- and regional climate regulation and all services related to (surface) water partitioning and flows. Furthermore, land cover classes indicating near natural or surfaces composed of natural materials (soil, water, plants) hint at usable resources whereas biodiversity cannot be assessed on land cover alone. Simple look-up tables have frequently been used to link ES with land use in studies, in which land cover, e.g. derived from Corine land cover, is equated with land use. Burkhard et al. (2012) suggested look-up tables for predominantly open space landscapes. Kroll et al. (2012) investigated a rural-urban gradient of ES supply and Bastian et al. (2010) assess the potential ES in FFH areas in the Ore Mountains (Germany) using tables and rough ordinal ratings. Urban Atlas land cover categories reflect the degree of surface sealing and the spatial arrangement of the built environment by differentiating classes of urban fabric. Several studies used the Urban Atlas data base for investigations of ES (Bertram and Rehdanz 2015; Maes et al. 2013; Zepp et al. 2016). The level of UES potential (Tab. 2) is based on several discussions between A. Mizgajski and H. Zepp, senior-authors of a comparative study of Poznan and Bochum (Zepp et al. 2016). Characteristic settings of the Ruhr region are reflected in that assessment scheme. For each of the eight provisioning and six regulating ES, potential UES supply was valued in four categories: P – Priority; S – Significant; I – Insignificant, N – Non-relevant. We then counted the number of priority or significant potential UES assigned to each land cover unit, calculated a weighted sum both for provisioning and for regulating services:

$$\text{USE } \textit{Significance} = \sum_{s=1}^{n} \cdot ws + \sum_{p=1}^{n} \cdot wp$$

with weight of significant services $ws = 0.5$
weight of priority services $wp = 1.0$

Lastly, we indicated the potential overall ES supply of each land cover unit by adding the calculated values for provisioning and for regulating services (cf. Tab. 3). The results are shown on small scale overview maps.

Tab. 2: Classification of areas with provisioning and regulating ecosystem services

	UES *Significance*
1st class UES	> 7.5
2nd class UES	≤ 7.5; > 3.0
3rd class UES	≤ 3.0; > 0.5
no significance	≤ 0.5

4 Changing functions, principles and development goals for the regional green belts in the 20th century

Adopting a common understanding of the term function, we are able to compare old and current designations of expected benefits from open spaces (Tab. 4). Thus, this wording is by no means attuned to the terminology of landscape ecology that paralleled functions with land capabilities or ecosystem functioning. The functions of the green areas according to the Planning Atlas of SVR were the following: separation between, e.g., industrial and residential areas, structuring, and amelioration of air quality, recreation, protection of areas for water production (groundwater and surface water). The explanatory report of the RDP (SVR 1966) sees the RGBs as priority areas for agriculture and forestry. These land uses were regarded as important for the conservation and configuration of the landscape. In the second half of last century, the dimensions 'public health' and 'oxygen production' that had been at the front in Schmidt's (1912) memorandum disappeared, but 'amelioration of air quality' still was a priority in the 1960s. Later, parallel to the decline of coal mining and steel industries, climate regulation and air quality amelioration by open green spaces were investigated intensively and the knowledge and conceptual analysis of landscape functions and potentials of open spaces were elaborated (Panteleit 1984; collections in Marks et al. 1989; Bastian and Schreiber 1994; in English language, concepts are reported in Bastian and Steinhardt 2002; Bastian et al. 2012; Krönert et al. 2001).

During the 1980s, parts of green belts were no longer designated for conservation only, rather for ameliorating open space (*Entwicklung*, development) and the rehabilitation of brownfields. This sheds light on the partial deterioration of the green belts and is to a large extent due to the inclusion of ad-

Tab. 3: Linking land cover classes with provisioning and regulating ecosystem services in urban areas (after Zepp et al. 2016)

Ecosystem services selected from CICES v.4.3 Haines-Young and Potschin (2013) → **Land cover classes after Urban Atlas (EEA 2014) ↓**	**Provisioning services**									
	Cultivated crops, Reared animals and their outputs	Wild plants, algae and their outputs	Wild animals and their outputs	Surface water for drinking	Fibers & other materials from plants, algae & animals for direct use or processing	Materials from plants, algae and animals for agricultural use	Surface water for non-drinking purposes	Plant-based resources	*Sum of significant provisioning services*	*Sum of priority provisioning services*
Continuous Urban Fabric (S.L. > 80%)									0	0
Discontinuous Dense Urban Fabric (S.L.: 50% - 80%)									0	0
Discontinuous Medium Density Urban F. (S.L.: 30% - 50%)									0	0
Discontinuous Low Density Urban F. (S.L.: 10% - 30%)									0	0
Discontinuous Very Low Density Urban F. (S.L.: < 10%)									1	0
Isolated Structures									0	0
Industrial, commercial, public, military and private units									0	0
Construction sites									0	0
Fast transit roads and associated land									0	0
Other roads and associated land									0	0
Railways and associated land									0	0
Airports									0	0
Land without current use									0	0
Sports and leisure facilities									0	0
Green urban areas									0	0
Agricultural + Semi-natural areas + Wetlands									1	5
Forests									0	4
Water bodies									1	3
Mineral extraction and dump sites									0	0

Legend: The potential level of ES supply: – Priority; – Significant; – Insignificant, – Non-relevant

Regulating services								**Overall ecosystem services**		
Filtration/sequestration/storage/ accumulation by ecosystems	Hydrological cycle and water flow maintenance	Pollination and seed dispersal	Ventilation and transpiration	Global climate regulation by reduction of greenhouse gas concentrations	Micro and regional climate regulation	*Sum of signifiant regulating services*	*Sum of priority regulating services*	*Sum of signifiant services*	*Sum if priority services*	**Overall weighted prominence of provisioning and regulation services; Sum (Weight for significant services: 0,5; weight of priority services: 1,0)**
						0	*0*	0	0	**0**
						0	*0*	0	0	**0**
						2	*0*	2	0	**1**
						3	*0*	3	0	**1.5**
						2	*2*	3	2	**3.5**
						0	*0*	0	0	**0**
						0	*0*	0	0	**0**
						0	*0*	0	0	**0**
						0	*0*	0	0	**0**
						0	*0*	0	0	**0**
						0	*0*	0	0	**0**
						2	*0*	2	0	**1**
						2	*0*	2	0	**1**
						4	*0*	4	4	**6**
						3	*3*	3	3	**4.5**
						3	*3*	4	8	**10**
						0	*6*	0	10	**10**
						1	*4*	2	7	**8**
						1	*0*	0	0	**0**

ditional areas in the ecologically deprived Emscher zone. Up to now, there have been extensions of the original green belts within the multiple regional plans and the regional land use plan that for reasons of compendiousness are not listed in Tab. 4. These documents assigned functions reflecting the respective contemporary discussions (cf. FINKE 2010).

Current plans, such as Landscape Plans at the local level and the Master Plan Emscher Landscape Park (PROJEKT RUHR GmbH 2005) at the regional level, explicitly express restoration, rehabilitation, development, and qualification as key principles in open space and green space planning of the Ruhr. Additional key concerns of the Open Space Concept Ruhr Metropolis (*Freiraumkonzept Metropole Ruhr;* MANN and BARTKOWIAK 2012) are to increase the contiguity and to depict search areas that might potentially be amalgamated to the green belts, thus enlarging them in future. Interestingly, follow-up plans of the RDP (SVR 1966) for the western part of RVR (e.g. RPD 1986, BZD 1999) mention the capability of increasing the residential and recreational value. Increasing the residential value might be interpreted as an economic benefit of green spaces, which became a part of later discourses under the slogan 'creating a setting for investment'.

5 Present status of regional green belts and land cover change

We made up a balance of land cover (Tab. 5) on the basis of the EU Urban Atlas (EEA 2014) for the RGBs as of 1966. We interpreted the land cover classes forests, agricultural areas, semi-natural areas and wetlands, water bodies and green urban areas to indicate open space. Its proportion (column 7) is lowest in RGB B, followed by D, whereas it remarkably exceeds the average of 61.2% in the case of the RGB E and G. Roughly 20 years before, ERZNER (1995) quantified the percentage of open space to be 88.9% of all RGBs, varying from 81.6 to 97.6% (Tab. 5, column 5) whereby sparsely populated areas within green belts were excluded. He also in-

Tab. 4: Common functions, explicitly attributed to the regional green belts in the Ruhr region

Functions in a common understanding towards benefits for people and nature	**SCHMIDT 1912**	**Planning Atlas (SVR 1960)**	**Regional Development Plan (SVR 1966)**	**Technical contribution to regional plan (MANN and BARTKOWIAK 2012)**
General functions in terms of spatial organization: structuring, separating, connecting				
Structuring		■		■
Separating conflicting land uses (for example industrial and residential areas)		■		■
Connecting		■		■
Specific functions in terms of land use and ecology				
Oxygen production ('urban green lungs')	■			
Amelioration of air quality		■	■	
Climatic balance (*klimaökologischer Ausgleich*)			■	■
Public health care and prevention *(Sozialhygiene)*			■	
Public health	■			
Recreation	■	■	■	■
Water production		■		■
Forestry	■		■	■
Agriculture			■	■
Habitat				■

Tab. 5: Size of regional green belts (RGB) within the borders of the Regional Development Plan (SVR 1966) and respective proportions of open space in 1995 and 2011

1	2	3	4	5	6	7	8
Regional green belt (RGB)	Total area RGB SVR (1966) GIS km²	Open space within RGB Erzner (1995) planimetrized km²	Sparsely populated areas within RGB Erzner (1995) planimetrized km²	Open space Erzner (1995) in relation to total area [col. 3 + col. 4] in %	Open space 4 land cover classes in 2011 (EEA 2014) GIS km²	Open space (2011 [col. 6]) within RGB (1966 [col. 3]) %	Relative loss of open space [col. 3 - col. 5] (%)
A	47.6	40.5	5.0	89.0	26.9	56.4	33.7
B	41.8	24.0	5.4	81.6	18.3	43.8	23.7
C	26.2	24.6	0.6	97.6	16.5	63.1	32.7
D	50.3	35.6	6.8	84.0	29.1	57.9	18.2
E	35.4	27.2	1.2	95.8	26.4	74.5	3.0
F	44.2	33.8	4.7	87.8	29.0	65.5	14.3
G	35.5	29.4	3.1	90.5	25.9	73.0	11.9
Total	281.0	215.1	26.8	88.9	172.1	61.2	20.0

Column 2: including sparsely populated areas, area size determined by means of GIS, data source RVR 2016; columns 3 and 4: area size determined by planimetry, source Erzner (1995); column 5: area size determined by means of GIS, open space made up of 4 land cover classes from EEA (2014); for technical details, refer to chapter 3.1 Methodology)

vestigated land cover change in the RGBs between 1966 and 1995 observing continued settling in areas with a previously low density urban fabric and at the fringes of the green belts, whereas large contiguous settlements had extremely rarely developed as isolated islands within the green belts (Erzner 1995, 181). Furthermore, he noted visual impairment from power lines, pipelines and roads.

Finke (2010) re-examined the land cover structure based on the unpublished land use map of KVR (2004/2005). He estimated the proportion of open space within in the regional green belts at 90%. He referred to the regional green belts that were meanwhile substantially enlarged and trimmed in some parts, thus comprising an area of 696 km² as opposed to the 281 km² in Erzner (1995).

The loss of the open space within the RGBs between 1966 and 2011 is obvious (Tab. 5, column 8; Fig. 2). Extraordinary decrease is observed in the RGBs A and C, whereas E, F, and G suffered less. Further differentiating the land cover classes (Fig. 3) reveals that RGBs A, B and D have equal proportions of agricultural land and forest, and in RGBs E to G, agricultural fields dominate land cover. In figure 3, we summarized all land cover classes indicating settlement (urban fabric > 30%, industrial and commercial areas) and areas occupied by traffic infrastructure. Approximately half of the initial area of RGB B is now covered by settlement and transportation areas.

6 Current reshaping the regional green belts for the regional plan

6.1 Redesign and land cover change

In the context of the preparations for the regional plan of the Ruhr district (RVR 2017), the RGBs were examined by RVR and new delineations are currently under discussion considering recent land cover changes as well as competing claims of the economic sector in search of new development areas and demands for nature protection. Here, we refer to the delineation of the technical contribution to the regional plan (Mann and Bartkowiak 2012; Fig. 4). It has not yet come into force and may be corrected in the further weighting process of the regional discourse. The eligible area (*Gebietskulisse*) was enlarged compared to the core area of 1966. It was delineated by criteria of settlement density including a densely populated area and an outer transition zone to the rural zone. Whereas the core area defined for the RGBs in 1966 adapted administrative boundary, the new delineation of the eligible area considers the present land use and land cover (Supplement A) and statutory provisions specified by the provincial planning of North-Rhine Westphalia. It now extends over 2790 km² as opposed to the previous 1429 km² (SVR 1966, 79). The planning category 'regional green belt' is restricted to that eligible area, which means it relates

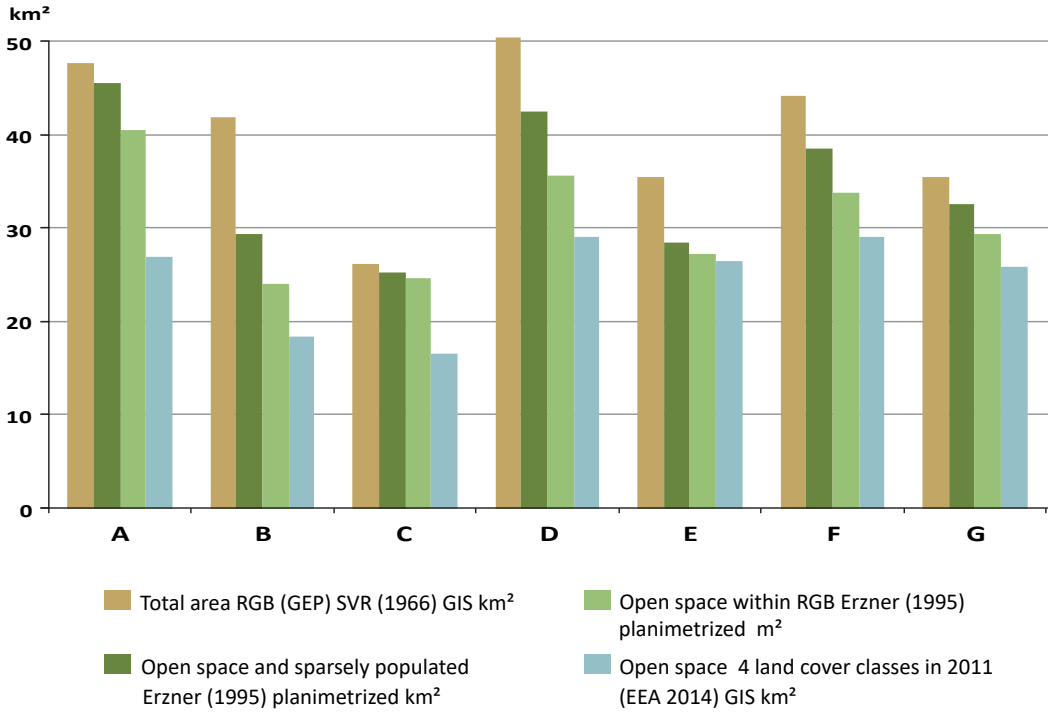

Fig. 2: Decline of open space in the RGBs A–G between 1995 and 2011

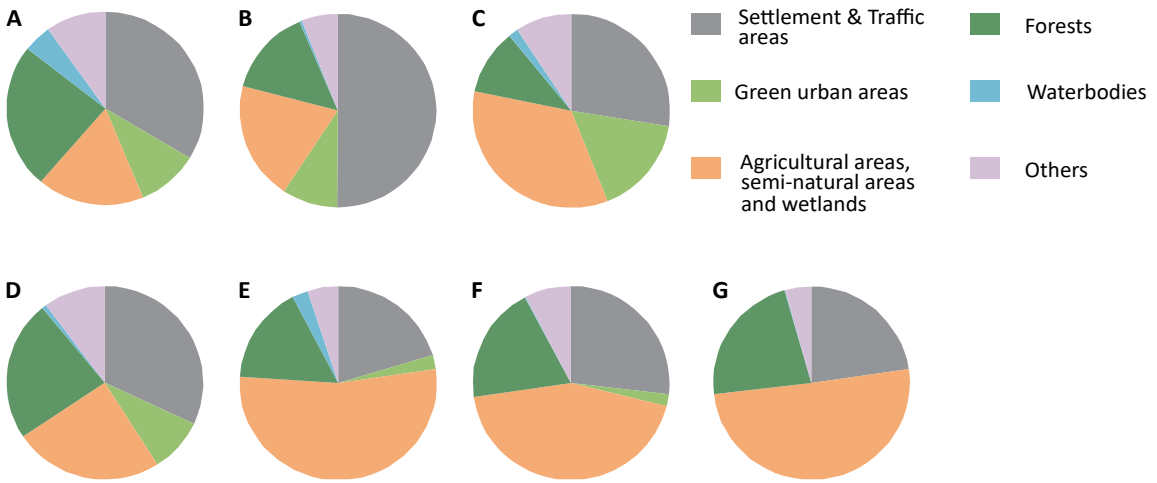

Fig. 3: Land cover (2011) in the RGBs as of 1966

to the densely populated area only. The proposed regional green belts are designed to represent a contiguous network of open space. As in the RDP of 1966, non-open space is included to an extent of approx. 10-15% (pers. communication, Regina Mann, RVR). This refers to technical infrastructure such as streets, electrical substations and settlements with less than 2,000 inhabitants.

Comparing the land cover change in the area of the former RGBs A-G, substantial corrections are prominent (Tab. 6). On the one hand, the regional green belts are trimmed in order to eliminate areas that in comparison to the state of 1966 had been transformed to built-up areas. RGB E would lose 12.8% and RGB B even 42.7% of its former extent. These cut off-areas comprise substantial percent-

Tab. 6: Trimming of the RGBs (1966) in the context of redefining the green belts for the regional plan (RVR 2017)

Regional green belt (SVR 1966)	A (%)	B (%)	C (%)	D (%)	E (%)	F (%)	G (%)
Cut-off area	23.4	42.7	18.6	25.5	12.8	22.3	21.3
Land cover class other than open space within cut-off area	83.3	91.0	83.3	87.2	78.3	82.2	69.0

ages of land cover classes other than open space. Between 69 and more than 90 percent of the cut-off areas exhibit areas for settlement and traffic, mainly by conversion during the past 50 years. Land cover in the total eligible area includes 47% open space as opposed to 74% in the newly designed green belts; for summarized land cover characteristics refer to supplement B.

On the other hand, the green belts would be substantially enlarged from formerly 281 km² (1966), over 696 km² (2004) to 1103 km². The new regional green belt network (Fig. 4) is split into 23 green belt parts (RGPs 1–23; supplement B). Consequently, the former designations from A-G are given up. Undoubtedly, the new design takes up the above mentioned informal open space plans prepared by KVR and interim extensions in previous formal plans.

6.2 Character of the future green belt parts and ecosystem services

Based on prominent below and above average proportions of land cover (Supplement B) and taking into account strikingly fine or coarse textured spatial patterns, the green belts can be characterized on a map (Fig. 5). Rather fine-grained patterns can be found in the central and western parts, whereas the fringes show coarse grained textures (Supplement C). This is connected with differences in the dominant land cover. In nearly all RGPs, maximum patch sizes are found among the open space patches. The corresponding correlation coefficient between the maximum patch size (all land cover classes) and the maximum size of open space patches amounts to 0.99. Relatively larger medians for open space patches in comparison to the median patch size of all patches

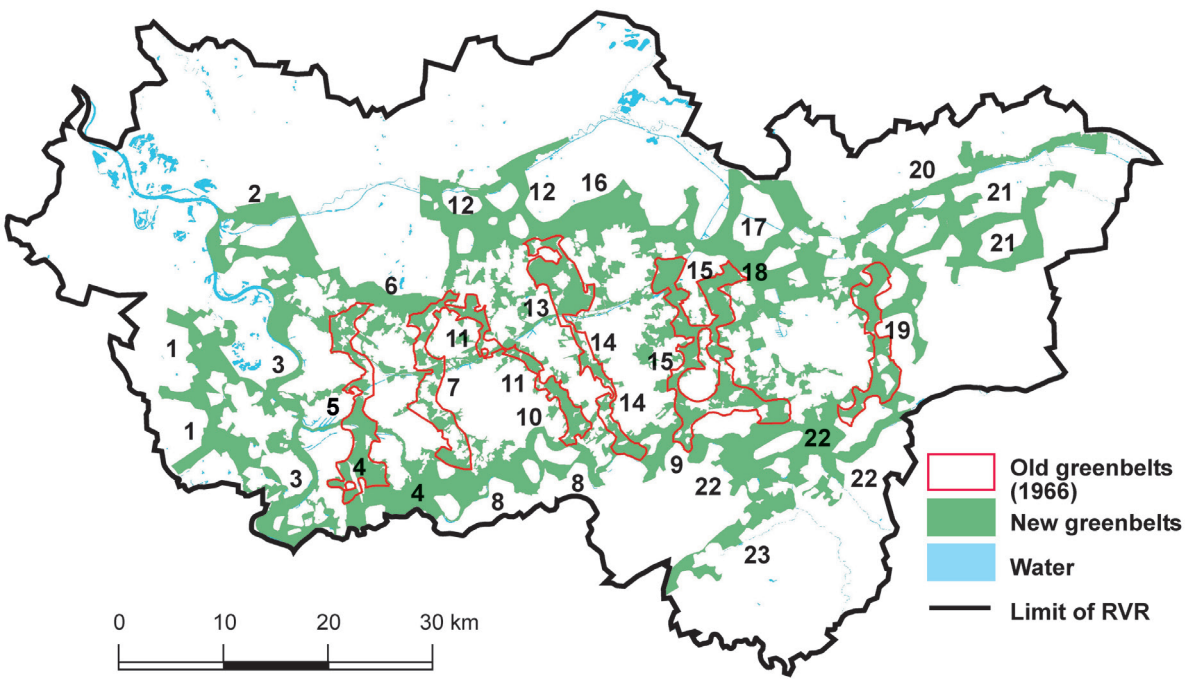

Fig. 4: Regional green belt parts 1–23 (RVR 2016) and regional green belts (SVR 1966). Sources: delineation of green belts according to the technical contribution to the regional plan under current discussion, RVR; water: data from EEA (2014)

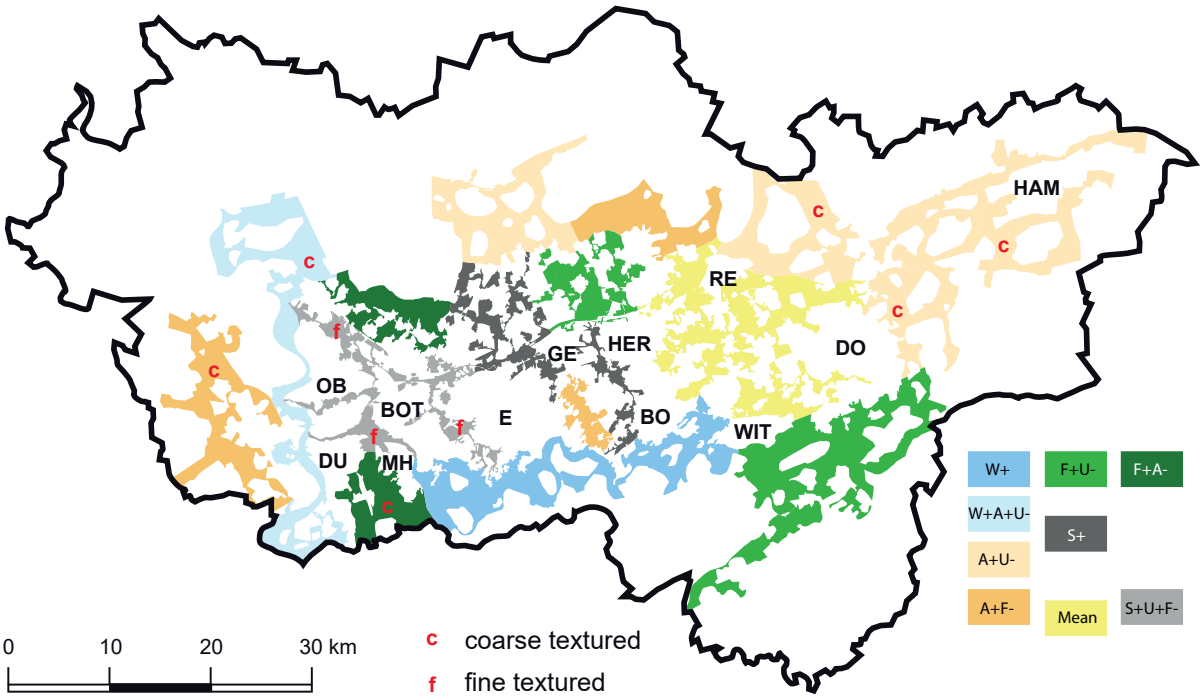

Fig. 5: Classification of the regional green belt parts. Abbreviations in the legend signify proportions of land cover above (+) or below (-) average (W: water; F: forest; U: urban green; A: agriculture; S: settlement).

are prominent in those RGPs that have high percentages of agricultural land (RGPs 10, 19, and 16) or forests (RGPs 3, 6, and 23). This underlines the fact that the less dissected spaces are situated at the fringe of the eligible area.

Whereas the inner parts of the green belt system, containing what is left from the former RGBs A–D, show high percentages of non-open space (Fig. 6), the northern parts are apparently uniform with large portions of open space. This is the agricultural northern rim of the eligible area. In the west and south as well as around the city of Dortmund, rather uniform percentages of open space are encountered. In RGPs 7 and 14 (former RGBs B and D), we find the largest proportions of green urban areas (> 25%), followed by RGPs 11 and 5 with more than 15% (former RGBs C and A). This is in line with the overall high percentages of non-open space. Mean patch size correlates with the percentage of non-open space ($R^2 = 0.81$; Supplement D)

Figure 7 illustrates the weighted overall significance of provisioning and regulating services. The spatial pattern of the provisioning services (Supplement E) reveals low significance in the western central parts of the eligible area. This is due to the assignment of noteworthy ecosystem services to agricultural areas and forests only. Regulating services (Supplement F) are widespread in all RGPs. The distribution is more homogeneous than that of the provisioning services. Here, water bodies, urban green areas, and low and very low urban fabric contribute to the regulating ES. The vast majority of legally binding natural reserves within the eligible area is incorporated into the regional green belts. Few exceptions sum up to less than 1 km². Based on their usually outstanding biological quality (biodiversity, endangered species etc.), they signify areas with a high significance of regulating functions.

The deficits of ES provision in the central western RGPs are obvious. In many sections, the width of the green corridors is very small. There are sections in which the contiguity of areas providing ES is lacking. Though the formal status of green belts still exists in some of the central parts, land cover without ES significance lowers their value.

7 Discussion

This paper tracks back the changing concepts, assigned functions as well as the present state and future of the regional belts in the Ruhr region.

Changing functions, principles and development goals: The RDP (SVR 1966) protected RGBs because of

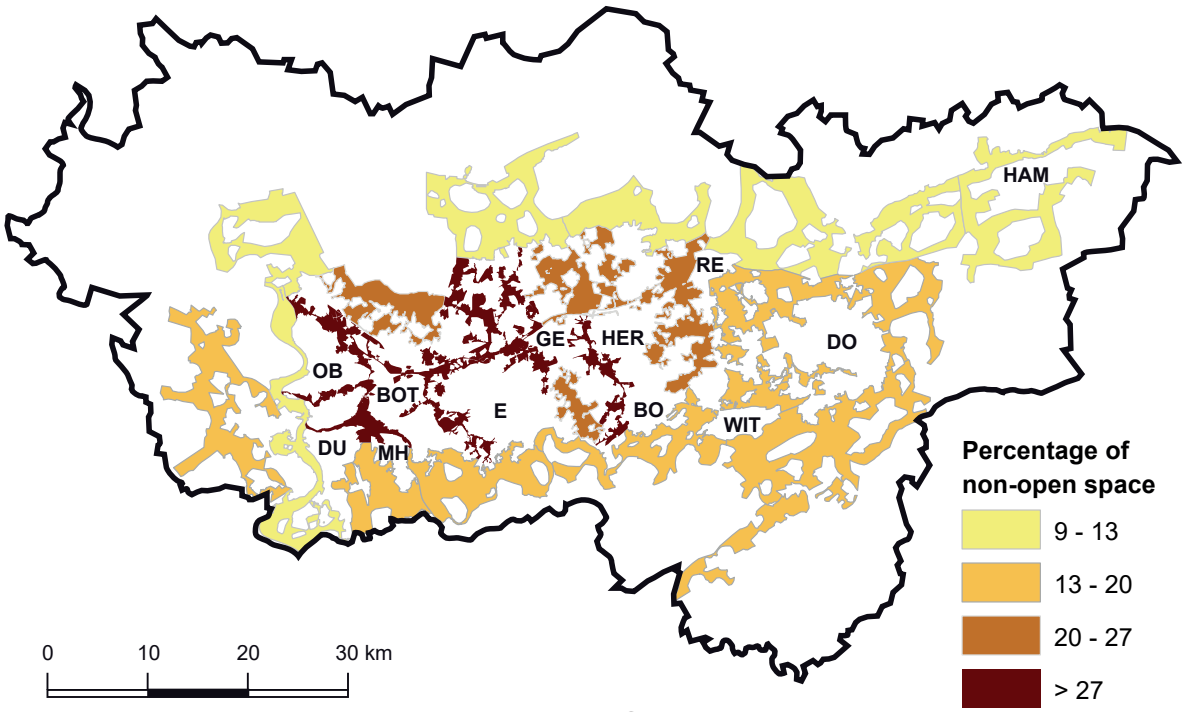

Fig. 6: Percentage of non-open space within green belt parts (RGP)

their health supporting functions (clean air, recreation), supply services (timber supply, food production), ecological functions, and as instruments of spatial organization. Expectations towards the quality of the green belts have increased over time. With the upcoming environmental awareness during the 1970s, ideas of nature conservation merged into primarily utilitarian purposes. As legislation developed further, aspects of flood water protection and water production supplemented the expectations towards the regional green belts. Concerning the functions of the new green belts, we can state a diversification: forestry and habitat functions are explicitly mentioned. Landscape functions in the sense of regional functions of planning legislation still form the prominent arguments in the discourse of planners, even in the recent discourse on the regional plan. This contrasts to the changed wording and intense discourse on ES in the scientific community.

Present status and land cover change: From the starting point of their formal existence in the RDP as of 1966 until the recent discussions on reshaping the regional green belts within the framework of the forthcoming regional plan, the original RGBs significantly lost open space. Even in areas in which the RGBs formally still exist, their open space quality has deteriorated. In the central parts of the region, the proportion of open space constantly declined and patch sizes of open space land cover are small. Time series 1966 – 1996 – 2011 reveals that after 50 years of formal existence, only a faint silhouette of the original RGBs is still detectable. This can be seen as a limited success, clouded by deplorable developments. Increasingly, the RGBs have lost substantial areas to settlement, traffic areas, and technical infrastructure, whereby the loss is spatially unevenly distributed. Depending on the spatially differentiated pressure of land use change exerted on parts of the RGBs, the degree of landscape fragmentation in the RGBs of the Ruhr region differs.

Our findings are in line with previous older observations. The German Council of Landscape Conservation (DRL 1972) criticized that the RGBs were seen as potential areas for the future demand of roads, public infrastructure and similar urban development and postulated a stricter enforcement of open space protection in the Ruhr region. Hommel (1975) attributed only limited recreational value to the regional green belts, but saw that, after all, they had prevented the cities of the core region from extensive coalescence. The discussion about the actual or fictional relevance of the RGBs fluctuated between stressing the need of further protection and planning measures, dissent of the agricul-

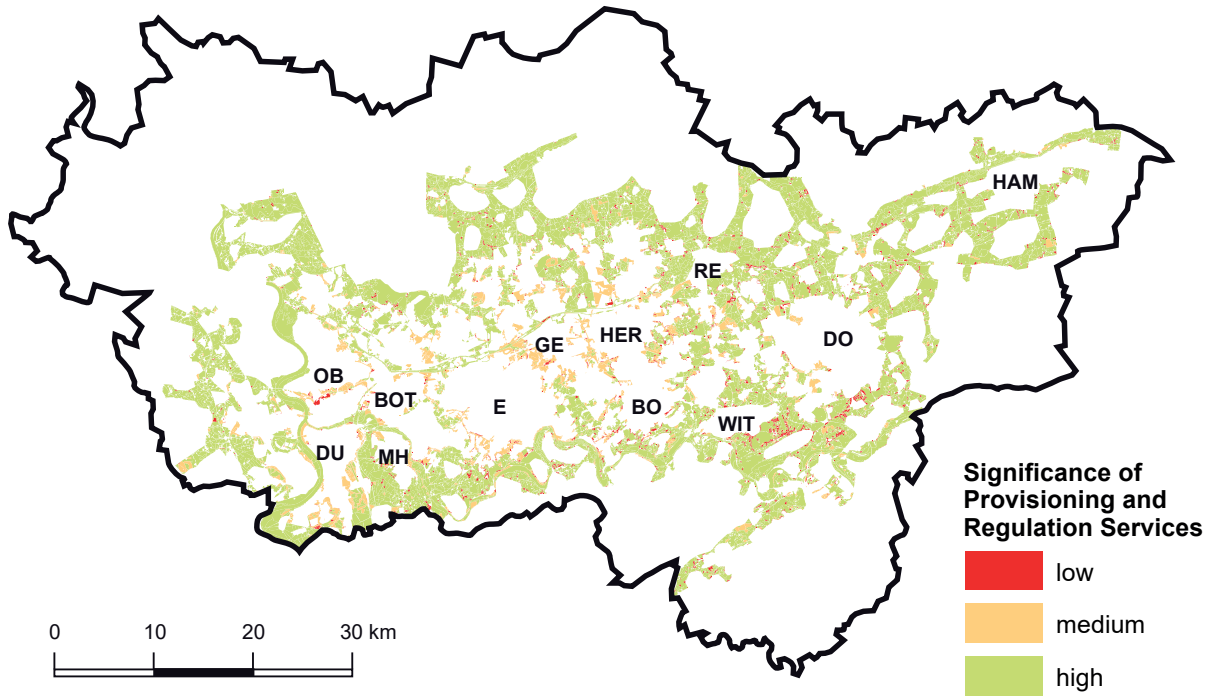

Fig. 7: Provisioning and regulating services, based on land cover of Urban Atlas and an assessment scheme by Zepp et al. (2016)

tural and silvicultural value and the potential of the green belt for future ('non-green') urban development (Einsele 1963; Beckmann 1975; Höing and Panteleit 1979) or the ecological quality and relevance (Trent-Forschungsgruppe 1985/86; Gondolf et al. 1977; Finke and Panteleit 1981). The Nature Conservation Program Ruhr Region (MURL 1987) saw the conservation and development of existing open space as a central goal. Nevertheless, some people have even disputed their actual existence (Kunzmann 1987) based on the ongoing change of land cover from open space to infrastructure facilities. Erzner (1995) stated that even in the 1980s, the RGBs were out of the focus of urban planners at the city level. Paradoxically, the decrease of open space in the initial RGBs is conform to the enduring indistinct definition of the RGBs and compliant with the Federal Building Code (BauGB 2017, § 34 and 35) that, e.g., allows for construction in the outer zones of cities. How can this bias be understood? Taking land cover to describe the physical landscape, our analysis focuses material world categories rather than the indistinct planning category of regional green belts (cf. 2.2). From the land cover distribution and the interpreted ES within the regional green belts, we have to draw a more negative picture of the effectiveness of the RGBs than if we adopted a base line from planning laws and regulations.

Northern parts of the RGBs were included in the 'Emscher Landscape Park', one of the flagships of the International Building Exhibition (IBA Emscher Park 1996, 1999) which gained international reputation (Projekt Ruhr GmbH 2005). Also, the total area of regional green belts increased by incorporating new area, and doubtlessly huge efforts were undertaken to rehabilitate brownfields. In this way, the textbook statement on the success of the green belts in the Ruhr region (Gälzer 2001) can be understood. In 2010, Finke concluded that the regional green belts can be seen as an effective instrument to protect open space. This evaluation was based on the high proportion of open space (90%) within the re-tailored and extended green belts that covered approximately three times the area of the 1966 RGBs. If we compare our analysis of open space according the technical contribution to the regional plan, we end up with roughly the same figure (91%). These figures camouflage the proven actual loss of open space. Also, Germany's latest contribution to the International HABITAT Conference holds optimistic and encouraging statements on the Ruhr region: "In recent years, a trend was visible towards a region with many green open spaces and recreation areas, green belts, creation of new green spaces on former brownfields, and limiting open space consumption" (WI 2013,

285; translation HZ). In the light of our analysis, we need to qualify this statement. It is questionable that the continued loss of open space in the green belts is counterweighted by creating green space in between the regional green belts. This remains subject for future research.

Addressing the Ruhr region, WBGU (2016, 297) states that "concerning ecology, polycentrism creates green areas, climatic cooling zones and opportunities for small scale agricultural production". From the analysis of four German regional plans in less pronounced polycentric metropolitan areas, Siedentop et al. (2016, 80) conclude that green belt policies have been successful in protecting "valuable agricultural, forest, conservation, and recreational areas from urbanization and therefore provide ecosystem functions to residents in metropolitan regions". Examining 42 regional plans in Germany, Diller et al. (2015) corroborates the value of green belts in protecting open space. We argue that, in the Ruhr region, polycentrism and regional green belts do not necessarily prevent developments that are inconsistent with the label 'green' as it is commonly and internationally understood (Searns 1995; Ahern 1995). This is partly due to the inherited indistinctness of the planning category regional green belt in the Ruhr region.

Future green belts and ecosystem services: Reshaping the green belts is on its way in the context of the regional plan. The green belt area will almost be doubled, but in the crucial central parts where the RGBs according to the RDP (SVR 1966) are located, an 'adaptive' reduction will take place as a sacrifice to the already completed change to urban, non-open space land cover. Green spaces will be attached to the original RGBs and form green circles surrounding the cities of the Ruhr region's core area. Notwithstanding minor corrections that may occur within the political weighing process, this will not change the core messages on the extent and qualities of the regional green belt system.

Assessing the provisioning of ES based on land cover data allows for preliminary evaluations on a regional scale. The results corroborate the statement that corridors of areas providing ES are interrupted, in many places contiguity is threatened or lost by infrastructure and urban expansion. Our method neglects the underground infrastructure and the integrity of soils, and would in future need to incorporate the built-up dimension as an integrative part of the urban ecosystem (Inostroza 2014; Zepp et al. 2016). In future, sound analyses of the most relevant services on large map scales are advisable, especially for the most contested sections of the green belt system. Among the services, the recreational benefit of open space has always been of major concern for the justification of green belts. Special consideration would have to be given to the accessibility of suitable areas, their identificational and symbolic values, and the recreational infrastructure. Nevertheless, the pure existence of open spaces is a definite decisive factor for an area's recreational value, already covered by our analysis.

8 Conclusions

Our findings from the Ruhr region indicate that firstly the higher the degree of built-up areas, the more intense is the fragmentation of the landscape, and that secondly there has been lack of implementation of legal instruments at the city level. To really improve ES provision, the regional green belts need to be backed-up by legally binding planning allowing for precise definition of land use, protection, remediation, amelioration, and enrichment of the green and blue infrastructure. In parts of the Emscher Landscape Park, this was realized with a special focus on postindustrial areas (brownfields) (cf. von Haaren and Reich 2006). Following the present regional discourse on the regional plan (RVR 2017), it is obvious that regional green belts have become even more contested environments in quest for economic development though they are protected as priority areas according to the Germany's Federal Spatial Planning Act (ROG 2004) and thus they are binding for the municipalities. Nevertheless, some regulations in Germany's Federal Building Code (BauGB 2017, e.g. § 34 and 35) allow circumventing a strict enforcement of planning intentions developed at the regional level. The planning responsibility for open spaces of RVR outside of the regional green belts is limited. It is a peculiarity of the North Rhine-Westphalian planning system that the so-called landscape plan is set up only for the cities' outer zones and not for densely built-up areas. This causes a lack of coherence between the planning levels as far as green infrastructure and ES planning are concerned. There are international examples for coherent multi-scale urban green space planning (Wolch et al. 2014; Bertram and Rehdanz 2015). From the scientific point of view, detailed and context-related definition and assessment of ES covering the total conurbation, or at least critical sections with a need for action, should accompany integrated green infrastructure planning.

Recently, Meerow and Newell (2017) stated a lack of stakeholder-informed, city-scale approaches in Detroit (USA) to systematically identify ES tradeoffs, synergies, and 'hotspots' associated with green infrastructure and its siting. The awareness of politicians, policy makers and residents towards ES of green spaces could support integrated multi-scale green infrastructure planning (cf. Casado-Arzuaga et al. 2013). Actually, the principles of spatial planning laid down in the Federal Spatial Planning Act (ROG 2004, § 2) include everything that is needed. With a view to nature and open space, protecting, securing, fostering, and developing are mentioned in order to "fulfill ecological functions" for the society. Essentially, this is what ES are about, inside and outside of metropolitan areas. After all, implementation is needed.

Acknowledgements

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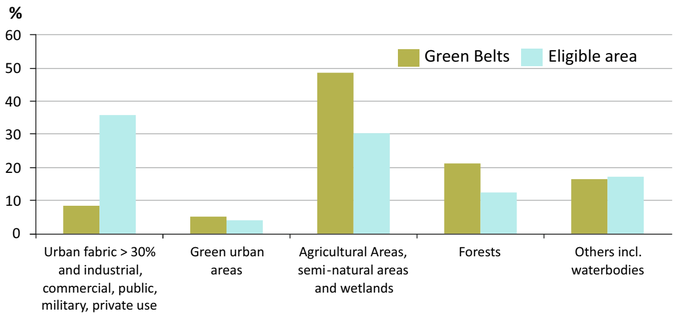
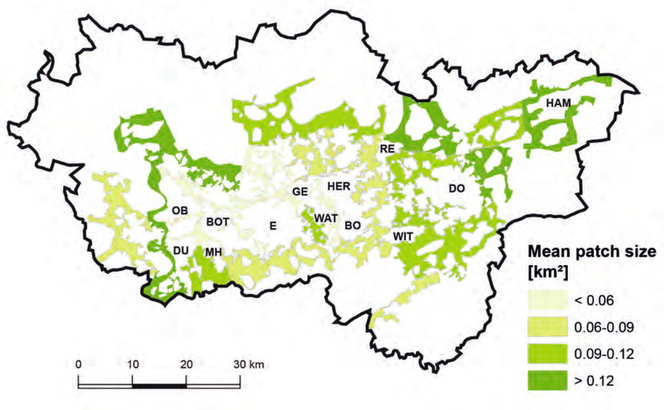
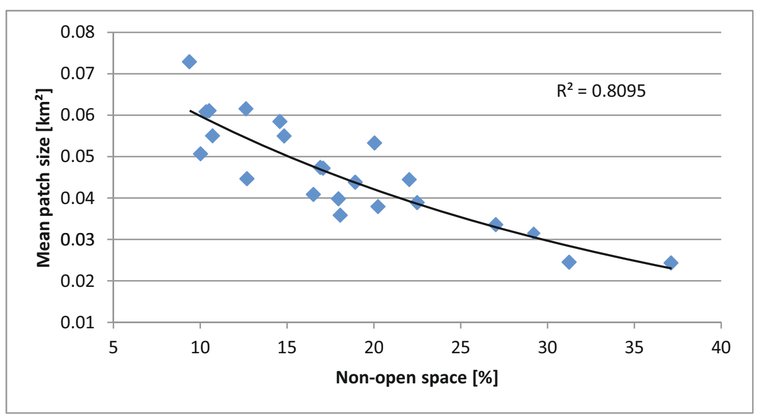
Regional green belts in the Ruhr region. A planning concept revisited in view of ecosystem services



A: Land cover in the RGP 1-23, discussed for the Regional Plan in preparation and in the eligible area for which the green belts should provide benefits



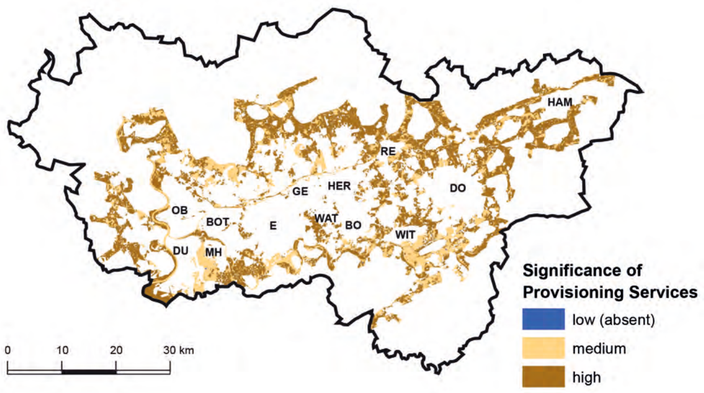
C: Mean patch size (all land cover classes) in RGP 1-23



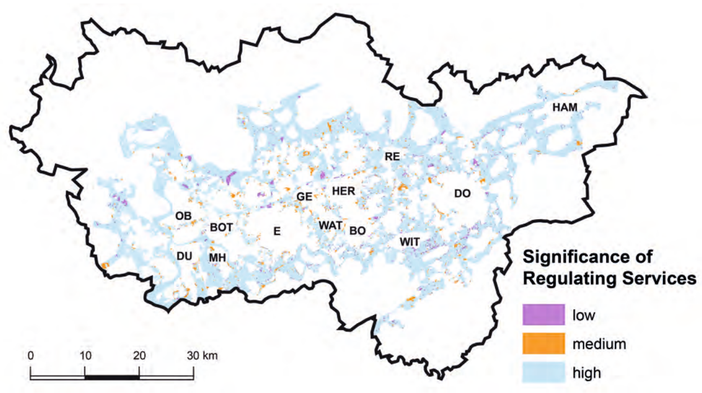
D: Mean patch size as a function of the greenbelts' (23 RGP) proportion of non-open space (all land cover classes)

B: Green belt parts (RGP) 1-23. Land cover and landscape metrics

No. of green belt parts	Land Cover						Landscape metrics (all LCC)								Landscape metrics [open space patches]				
	Forest	Agri-culture	Green urban areas	Water Bodies	Traffic	Non-opensp ace	Maxi-mum patch size	Median patch size	Mean patch size	Stand. deviation of patch size	Skew-ness of patch size	Total Edge	Edge Density	Mean Patch Edge	Maxi-mum	Median	Mean	Stand deviation	Skew-ness [-]
	[% of total area]						[km²]				[-]	[m]	[m/ha]	[m]	[km²]				[-]
1	10.7	57.8	3.9	5.7	5.0	16.9	1.11	0.012	0.047	0.11	0.33	2085510	1373	290	1.11	0.033	0.088	0.15	0.37
2	20.1	55.9	0.3	8.9	2.1	12.6	2.76	0.012	0.062	0.20	0.25	1191248	1420	231	2.76	0.040	0.130	0.29	0.31
3	4.6	49.0	8.2	26.3	2.6	9.4	5.53	0.010	0.073	0.33	0.19	1078435	1477	203	5.53	0.034	0.168	0.53	0.26
4	50.5	16.0	7.9	5.6	5.1	14.8	0.94	0.011	0.055	0.12	0.37	1051531	1524	277	0.94	0.039	0.109	0.16	0.44
5	5.9	35.5	16.4	6.3	6.7	29.2	0.68	0.009	0.031	0.06	0.34	1241571	1116	355	0.68	0.022	0.054	0.08	0.40
6	53.0	20.9	2.6	0.3	3.1	20.0	4.21	0.009	0.053	0.24	0.18	774532	1119	210	4.21	0.040	0.131	0.41	0.22
7	9.0	26.2	24.6	3.1	5.9	31.2	0.39	0.009	0.025	0.04	0.35	803220	1008	411	0.35	0.025	0.049	0.06	0.40
8	23.2	41.7	6.4	7.9	4.4	16.5	2.37	0.010	0.041	0.12	0.26	1715262	1303	319	2.37	0.027	0.081	0.17	0.32
9	21.7	43.7	4.2	7.3	4.9	18.1	1.20	0.011	0.036	0.09	0.29	1812538	1234	344	1.20	0.029	0.070	0.12	0.34
10	6.6	56.7	10.7	0.0	3.5	22.5	1.03	0.010	0.039	0.10	0.30	435275	1142	294	1.03	0.036	0.098	0.16	0.39
11	16.1	31.3	18.5	2.1	5.0	27.0	1.01	0.008	0.034	0.08	0.30	1347976	1100	327	1.01	0.006	0.031	0.09	0.30
12	19.6	64.0	0.3	2.9	3.2	10.0	1.66	0.010	0.051	0.13	0.30	1738627	1295	255	1.66	0.028	0.098	0.19	0.38
13	31.4	27.6	11.7	2.3	4.9	22.0	1.72	0.010	0.044	0.13	0.27	1096249	1242	279	1.72	0.029	0.081	0.18	0.29
14	2.7	19.7	35.0	0.0	5.5	37.1	0.48	0.009	0.024	0.05	0.33	580463	955	392	0.48	0.025	0.056	0.07	0.41
15	16.9	48.0	9.8	1.3	3.8	20.2	2.45	0.010	0.038	0.11	0.26	1448962	1147	302	2.45	0.031	0.078	0.16	0.29
16	8.5	74.5	0.2	0.1	4.0	12.7	1.95	0.008	0.045	0.11	0.33	1268692	1212	271	1.95	0.036	0.099	0.17	0.37
17	18.6	65.1	0.0	2.8	3.0	10.5	2.27	0.011	0.061	0.18	0.28	1400220	1390	228	2.27	0.034	0.121	0.25	0.35
18	21.8	48.6	4.9	1.0	4.7	18.9	1.59	0.010	0.044	0.11	0.32	2170776	1207	275	0.87	0.031	0.105	0.16	0.47
19	15.3	66.3	0.0	0.6	3.2	14.6	2.54	0.011	0.058	0.17	0.27	909207	1301	218	2.54	0.049	0.134	0.26	0.32
20	19.9	60.4	1.9	3.7	3.4	10.7	3.32	0.012	0.055	0.19	0.22	960970	1377	251	3.32	0.037	0.112	0.29	0.26
21	14.2	69.4	0.4	2.8	2.8	10.3	2.84	0.011	0.061	0.17	0.29	1661720	1387	228	2.84	0.037	0.128	0.25	0.37
22	38.9	34.7	0.4	4.0	4.9	17.1	3.17	0.011	0.047	0.16	0.23	2763375	1308	277	3.17	0.031	0.111	0.25	0.32



E: Provisioning Services. Assessment, based on land cover of Urban Atlas and an assessment scheme by ZEPP et al. (2016)



F: Regulating Services, based on land cover of Urban Atlas and an assessment scheme by ZEPP et al. (2016)