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Measuring fragmentation of open space in urbanised Flanders: an evaluation of four methods

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Part of the methods that were described in this paper draws from research conducted within the Policy Research Centre on Regional Planning and Housing – Flanders 2007-2011, funded by the Flemish Government. We would like to thank Kirsten Bomans and Valerie Dewaelheyns for the lively discussions and their input in developing our research ideas.

Introduction

1 This article addresses the specific large-scale fragmentation of open space in Flanders, the northern administrative region of federal Belgium and a small part of polycentric North-West Europe. The European Environment Agency's report on urban sprawl in Europe (2006) defines Belgium as one of the areas in Europe with the most visible impacts of urban sprawl as a result of high population density and economic activity. Urban sprawl is mainly situated in the northern region Flanders (450 inhabitants/km²), which contrasts sharply with the less densely populated Walloon region in the southern part of Belgium (200 inhabitants/km²). Flanders is often described as 'one big city', with residential dwellings all over and a patchwork of open space fragments in between, which makes 'urban sprawl' almost synonymous to Flanders' settlement structure (De Meulder, Schreurs, Cock & Notteboom, 1999; Van Eetvelde & Antrop, 2005; Poelmans & Van Rompaey, 2009). The Flemish suburbanisation process resulted in ribbon development that made Flanders a highly fragmented area with the most 'American-like' spatial pattern of urbanisation in Europe (Holden & Turner, 1997). Spatial planning in Flanders is

often criticised for not being able to manage its urbanisation process more efficiently or coherently (De Decker, 2011; Halleux, Marcinczak & van der Krabben, 2012).

2 In landscape sciences and spatial planning, fragmentation is considered as a negatively interpreted spatial heterogeneity of spaces, landscapes and land use systems (Gulinck & Wagendorp, 2002). This landscape fragmentation, due to scattered urban development and transportation infrastructure, threatens human and environmental well-being by noise and pollution from traffic, disturbs heritage landscapes and impairs the scenic and recreational qualities of the countryside (Jongman, 2002; Jaeger *et al.*, 2008). For example, ribbon residential development along roads generates visual barriers in the landscape (Di Giulio, Holderegger & Tobias, 2009). From an agricultural perspective, fragmentation also affects production capacity (Brabec & Smith, 2002; Gulinck & Wagendorp, 2002; Jongman, 2002). Small, irregular and isolated parcels, reduced field access and dispersion of fields belonging to the same farm cause reduction of production efficiency (Carsjens & van der Knaap, 2002). Indirectly, the urbanisation related to fragmentation often puts pressure on farming systems due to reduced expansion possibilities of farm units, influences on land prices and more restrictive rules on farming when non-rural inhabitants pose other priorities to the landscape (Vandermeulen *et al.*, 2006). Within strongly fragmented landscapes like the urban fringe, the agricultural sector has to compete with several other functions that claim open space, such as horse keeping, garden centres, recreation facilities and non-agricultural economic activities (Fry, 2001; Jongman, 2002; Bomans, Steenberghen, Dewaelheyns, Leinfelder & Gulinck, 2010; Tempels & Pisman, 2013).

3 Some empirical research suggests already that private use of fragmented rural land, mainly for gardening or horse keeping, is a current phenomenon in Flanders. Research by Verbeek *et al.* (2010) showed that private rural land use is more frequent on small parcels adjacent to residential development. Furthermore, phenomena of higher private land use more frequently occur at the backside of ribbon developments, in the most fragmented rural areas. These lots are often difficult to access, making them less interesting for productive agriculture and more attractive for private users. Another recent study of Bomans *et al.* (2011) analysed the spatial importance of the horse sector. Based on a random field survey they concluded that small parcels close to gardens and/or woods have a significantly higher chance to be used for (mainly private) horse keeping. These two examples show that fragmented open spaces with small parcels certainly are under great pressure and very susceptible to the transformation to other (private) land uses.

4 However, detailed research on the fragmented state of Flemish open space was lacking until recently (Bomans *et al.*, 2010; Tempels & Pisman, 2013). This means that notwithstanding the scarcity of open space in Flanders, it is particularly difficult for spatial planners to plan for open space. In stark contrast, there are many metrics available in ecological and environmental sciences for measuring landscape fragmentation in relation to natural habitats and ecosystems (Bogaert, Van Hecke, Eysenrode & Impens, 2000; Fernandes, 2000; van Langevelde, 2000; Fahrig, 2001; Jongman, 2002). Fragmentation here refers to the dissection of the habitat of a species, ecosystem or land type into a series of smaller and spatially separated fragments (Forman, 1995; Geneletti, 2004), which sometimes leads to the destruction of the habitat. However, due to the slightly different interpretation of fragmentation in spatial planning, and the unique highly fragmented state of the Flemish open space, with different dissecting infrastructures and specific building morphologies (‘residential ribbons’), an adapted approach was necessary.

5 In this article, we consider fragmentation as a spatial morphological condition, i.e. the dissection of open space by physical, man-made infrastructures like roads, buildings and railroads. Open space is understood as a generic term for unbuilt spaces, both in urban and rural contexts, and an important concept for spatial planners. It encompasses different levels of scale from gardens to parks in cities to extensive agricultural areas and forests (van der Valk & van Dijk, 2009). This paper however focuses on larger open spaces outside cities and residential areas.

6 We will introduce two new spatial metrics, based on an evaluation of existing metrics, knowledge about actual spatial phenomena in Flanders and available data. In addition we describe two already existing spatial metrics developed by Bomans (2011). The four methods give an indication of fragmentation and are founded in the specific morphology of the Flemish countryside, but each of the four methods has its specific characteristics. By comparing them it will be made clear what the strengths of each method are, and for which purposes the methods are suited. In the discussion, the relevance for Flemish spatial planning policy will be considered.

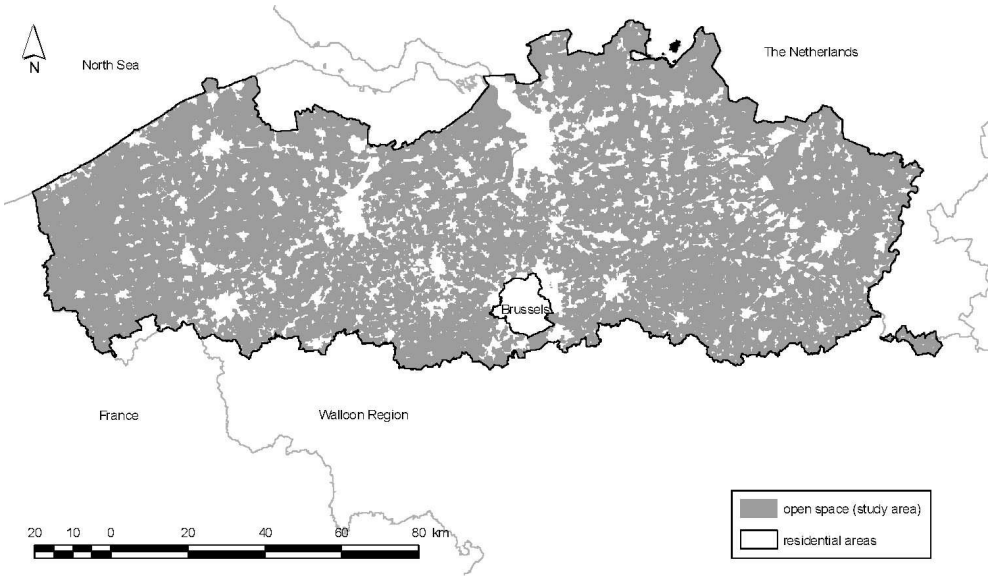
Methods

7 Four methods are discussed, all making intensive use of GIS techniques and available high-resolution land-use data. They are grouped in two pairs, with the first two methods leading to a representation of general fragmentation, and the second pair of methods assessing the enclosure of open space fragments. Within each pair of methods, a newly developed method is compared with an existing method. Both existing methods were adopted from Bomans (2011), but were slightly adjusted to allow for a comparative analysis.

Study area (Flanders)

8 The four methods are adapted to the specific spatial context of Flanders, the northern part of Belgium. It is one of the most densely built areas of Europe, with widespread urban sprawl and a high degree of fragmentation. As this research focuses on rural open space fragments in Flanders, purely residential areas were excluded from the analysis, based on the definition of residential statistical sectors by Statistics Belgium (Figure 1).

Figure 1. Study area: Flanders without residential statistical sectors, defined by Statistics Belgium (2001).



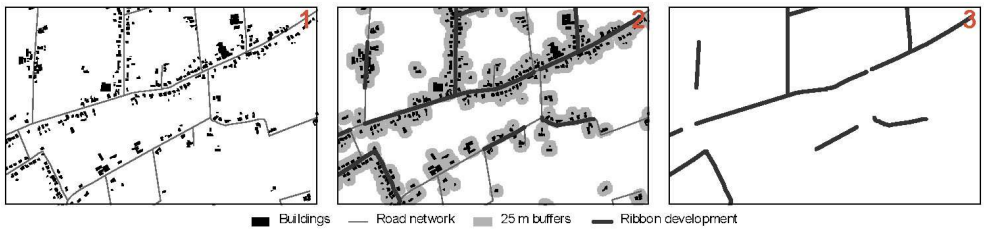
General fragmentation – density of fragmenting structures method

9 This method calculates a 'density' of morphologically fragmenting structures, per statistical sector. The indicator consists of a combination of three metrics: the density of paved roads, the density of ribbon development, and the density of scattered development.

10 The density of paved roads is easily worked out using a road network data set provided by the company TeleAtlas, which is used in route planners. It contains all roads in Flanders and an attribute concerning road conditions (paved vs. unpaved).

11 To calculate a density of ribbon development, more complicated GIS techniques are needed, which are described in detail in Verbeek *et al.* (2014) and presented in Figure 2. Ribbon development consists of roads, or parts of roads, along which a continuous strip of built-up lots is situated. Thus, next to a road network file, building stock data is required. The land registry administration provided these detailed spatial data, with a recent file dating from early 2012. In order to determine whether a built-up structure is considered ribbon development, two selection methods are combined. First, a buffer of 25 meter is offset around all buildings in the data set. Those buildings of which the buffer overlaps with buffers of adjacent buildings are considered being part of a line-shaped cluster. Such a cluster is considered a ribbon if the length of the cluster exceeds 200 meter or if the ratio between the length of the cluster and the adjoining road segment exceeds 80%. The threshold values of 25 meter buffer size, 200 meter minimum length and 80% minimum ratio result were decided on by an expert panel, also further elaborated on in Verbeek *et al.* (2014).

Figure 2. Selection of ribbon development.

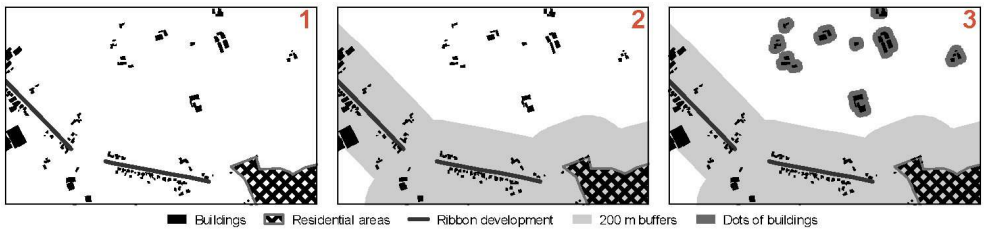


1-2: DRAWING OF 25 METER BUFFERS AROUND ALL BUILDINGS; 2-3: SELECTION OF RIBBON DEVELOPMENT BASED ON LENGTH OF RIBBON AND RATIO OF RIBBON LENGTH COMPARED TO ROAD SEGMENT LENGTH

DATA SOURCES: CADMAP 2012, TELEATLAS ROAD NETWORK

12 The third metric, the density of scattered development, is calculated starting from the defined ribbon development. What is left over after defining the ribbons are scattered built elements or dots of buildings. To distinguish the dots, 200 meter buffers are drawn around the selected ribbons and the residential statistical sectors. Buildings situated within these buffers are assumed to belong morphologically to these ribbons or to the residential settlements. The remaining buildings are clustered in discrete groups, by merging overlapping 25 meter buffers, offset around these buildings. Figure 3 shows this selection of dots of buildings. As for the ribbon development method, the two threshold values were determined based on expert knowledge. Exploratory analyses with other threshold values yielded similar patterns.

Figure 3. Selection of scattered development.



1-2: DRAWING OF 200 METER BUFFERS AROUND RIBBON DEVELOPMENT AND RESIDENTIAL STATISTICAL SECTORS; 2-3: CLUSTERING OF REMAINING BUILDINGS BY MERGING OVERLAPPING 25 METER BUFFERS

DATA SOURCES: CADMAP 2012, TELEATLAS ROAD NETWORK

13 To compose the indicator of morphological fragmentation per (non-residential) statistical sector, the values for these three metrics are ordered in five classes (0-1-2-3-4) using quartiles, with the null classification for zero values. The quartile values are listed in Table 1.

Table 1. Thresholds for three composing metrics of indicator 'density of fragmenting structures'.

Variable	Quartile values		
	Q1-Q2	Q2-Q3	Q3-Q4
Density of paved roads (m/km²)	1,973.09	2,801.67	3,848.59
Density of ribbon development (m/km²)	104.37	352.64	809.48
Density of scattered development (#groups/km²)	1.64	3.55	6.00

14 The classification scores (from 0 to 4) are combined by a weighted sum, with following relative weights according to their supposed fragmenting impact on landscapes. Although these weights are based on estimation, they reflect common ideas on landscape fragmentation in Flanders and in international literature (Di Giulio *et al.*, 2009; Llausas & Nogue, 2012).

- Density of paved roads: 1
- Density of ribbon development: 4
- Density of scattered development: 2

15 Based on the final score, in the interval from 0 to 28, a classification can be made, from 'less fragmented' to 'highly fragmented'. An example is given in Table 2, with a resulting final score of 14.

Table 2. Example of weighted sum for indicator 'density of fragmented structures'.

Variable	Classification score	Weight	Weighted sum
Density of paved roads: 2,500 m/km²	2	1	2
Density of ribbon development: 100 m/km²	1	4	4
Density of scattered development: 8 groups/km²	4	2	8
			14

General fragmentation – average patch size method

16 The *average patch size method*, described in Bomans (2011), was used to make up the second indicator. It defines patches as spaces that are externally bounded, but internally not crossed by urban infrastructure or barriers. The delineation of these patches is based on different types of barriers: roads, railroads, waterways and built development. These barriers are similar to the generic barriers as defined by Jaeger *et al.* (2008). Narrow waterways that are easily crossed or bridged are not considered as barriers; neither are minor and unpaved roads, unless they are aligned with built developments.

17 To locate barrier-type roads, railroads and waterways, data covering the whole of Flanders are available. The approach used to identify fragmenting built developments is different from the one used in the *density of fragmenting structures method*. The identification is based on the combination of a land use map (NGI, 2004), a road map and an empirical buffer operation. A buffer of 100 meter is drawn around the land use class 'building' and all road segments that fall completely within this buffer are considered to be built road segments. The distance of 100 meter was decided on by Bomans (2011) because lower distances resulted in many gaps in the road segments, which meant that they will eventually not be considered as a barrier, whereas through wider buffers many road segments with widely dispersed buildings would be included.

18 The different discerned barriers (all line-features) are used to split Flanders into patches. The total area of each patch is then calculated as an indicator of fragmentation. The smaller the area, the higher the fragmentation. This indicator corresponds to the effective mesh (or patch) size as a simple indicator of fragmentation (Jaeger, 2000; Girvetz, Thorne, Berry & Jaeger, 2008; Jaeger *et al.*, 2008; Li *et al.*, 2010).

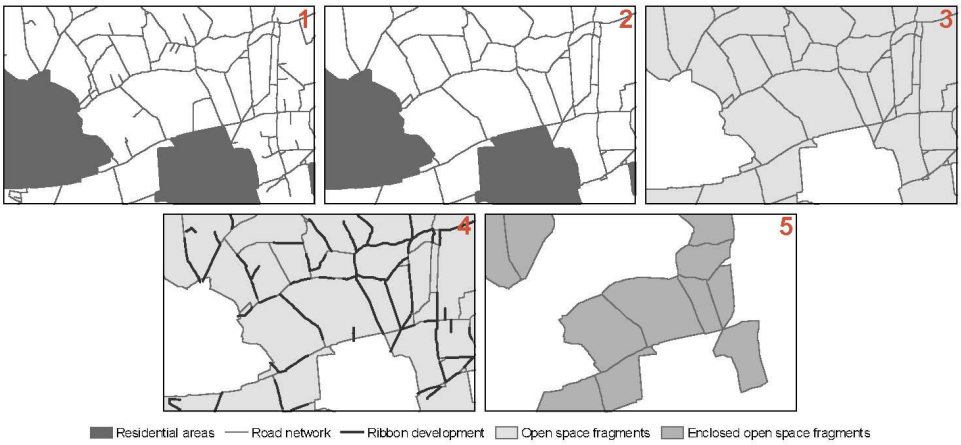
19 Because this method determines patches for all statistical sectors, and not only for non-residential ones, some additional calculations were needed to get the results comparable to the *density of fragmenting structures method*. To this purpose, a GIS overlay was made between the selection of non-residential statistical sectors and the patches. Subsequently, the average area of all intersecting patches per non-residential statistical sector was calculated. This value is a measure for fragmentation: the higher the value, the larger the patches, the lower the degree of fragmentation, and vice versa.

Enclosed open space fragments – ribbon method

20 This method detects open space fragments enclosed by ribbon development, and internally not crossed by road infrastructure. The resulting polygon fragments can be simply represented or a density can be calculated.

21 The enclosed open space fragments, lying outside demarcated residential areas, are defined starting from a road network data set and the boundaries of residential statistical sectors (Figure 4). By deleting all dead end streets, a 'closed' network file is created. This file is converted to polygons and the polygons corresponding to the residential areas are deleted. For each fragment, the area is calculated and it is computed how many per cent of the perimeter is occupied by ribbon development – see density of fragmenting structures method – or the boundaries of residential areas. Using threshold values of 100,000 m² area and 60% built perimeter, the enclosed open space fragments are selected. The threshold values were decided on after a trial-and-error sequence. The threshold value of 60% is relatively low, because completely enclosed fragments of unsealed land are rare and it is assumed that also a partially enclosed open space fragment runs a higher risk of privatisation.

Figure 4. Selection of enclosed open space fragments.



1-2: DEAD END STREETS ARE DELETED FROM THE ROAD NETWORK; 2-3: THE BOUNDARIES OF THE RESIDENTIAL AREAS ARE CONVERTED TO LINE OBJECTS; 3-4: LOCATION OF RIBBON DEVELOPMENT IS ADDED; 4-5: ENCLOSED OPEN SPACE FRAGMENTS WITH A PERIMETER THAT IS LESS THAN 60% BUILT, ARE DELETED.

Enclosed open space fragments – built perimeter method

22 The last method is an adapted version of the *average patch size method* described by Bomans (2011). Again fragments of open space are defined, but this time only buildings are considered as fragmenting structures. Here also the 100 meter buffer around buildings is used. In rural areas, this method results in fragments of open space enclosed by buildings with a distance of maximum 200 meter between them.

23 Because the method was applied to the whole of Flanders, also fragments in densely built residential cores were defined as enclosed fragments. The outcome thus needed some adaptations to be comparable to the results of the *ribbon method*: only fragments that overlapped with non-residential statistical sectors were retained.

Comparing the maps

24 Both the *density of fragmenting structures method* and the *average patch size method* give a general image of fragmentation, whereas the *ribbon method* and the *built perimeter method* go more deeply into the enclosure of open space fragments by built (ribbon) development. Therefore the results of the four methods will be compared in pairs. To facilitate the comparison, a map is created for both pairs that shows the difference. For every method a case area with a high score is briefly discussed in more detail, illustrated by aerial views. Based on the comparative analysis and the case studies, the methods are characterised and evaluated in the discussion section.

Results

General fragmentation

25 The results of the *density of fragmenting structures method* and the *average patch size method* are shown in Figure 5 and Figure 6. Only non-residential statistical sectors are included in the maps. The outcomes of both calculations are represented per statistical sector in four quantiles, from a low degree of fragmentation (light grey) to a high degree of fragmentation (dark grey). Residential statistical sectors are shown in white. Figure 7 shows the comparison between the two maps.

26 The *density of fragmenting structures method* puts a higher emphasis on densely built open space areas. For example the semi-rural area around the regional cities Kortrijk and Roeselare (1), known for its scattered developments, is clearly visible on Figure 6 and in general has a higher score on this method (Figure 7). On the other hand, the *average patch size method* puts more emphasis on major infrastructure lines like highways, railroads, major rivers and canals. For example the highway (E40) and railroad infrastructure in the south of Flemish Brabant (2), or the river Scheldt (3) can be easily discerned on Figure 5 and in general have a higher score on this method (Figure 7).

Figure 5. General fragmentation – density of fragmenting structures method. Classification scores are represented in quartiles.

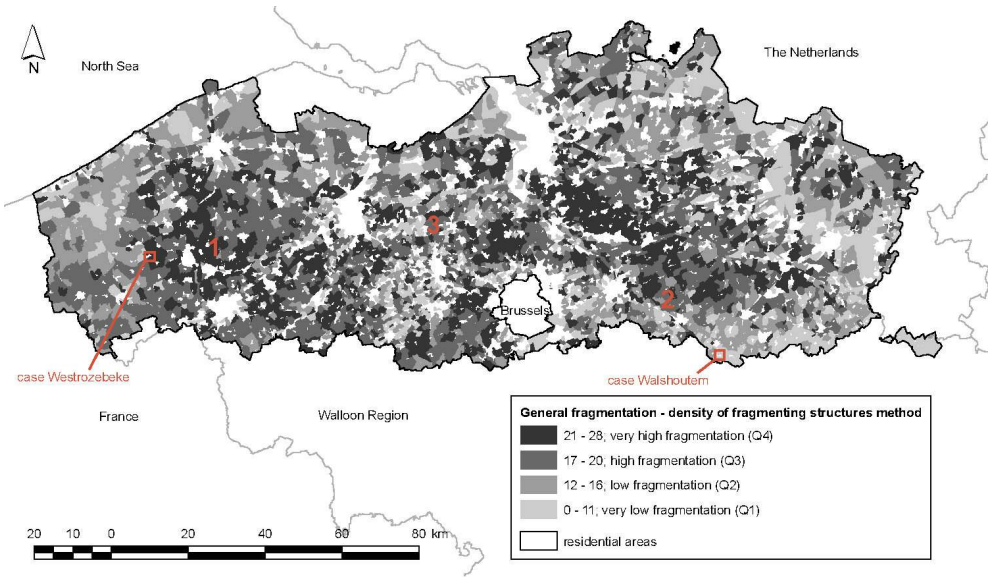


Figure 6. General fragmentation – average patch size method. Classification scores are represented in quartiles.

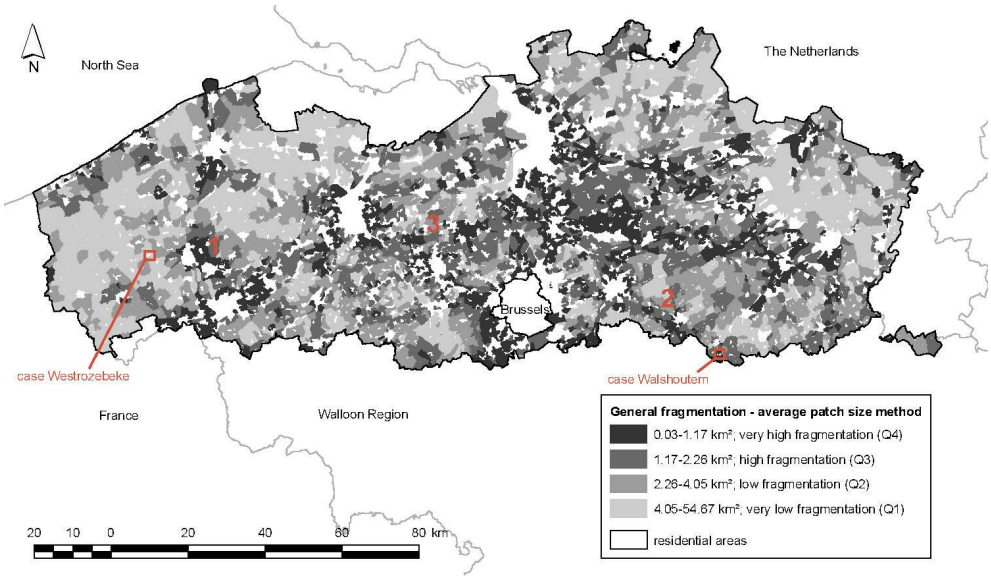
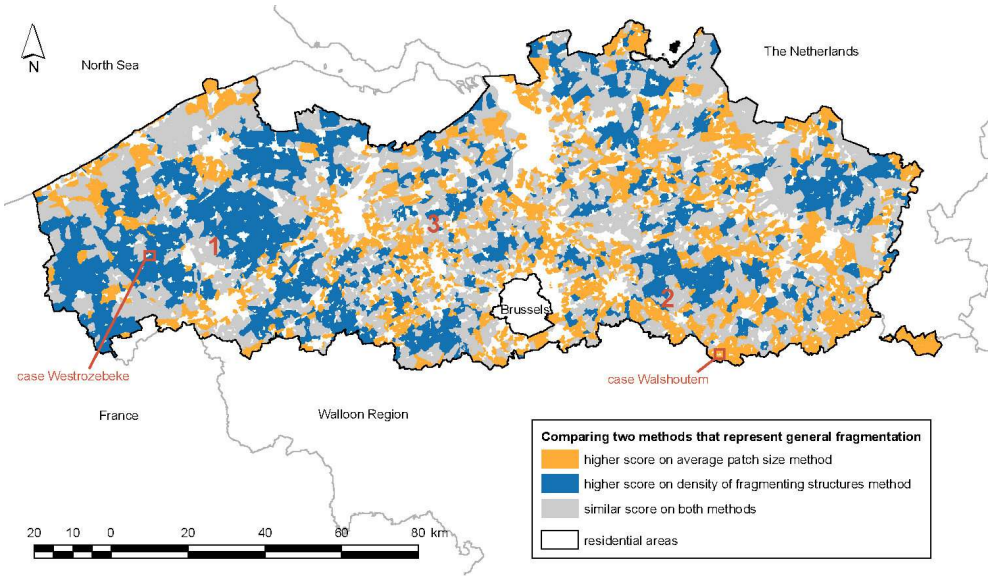


Figure 7. Comparing two methods that represent general fragmentation based on quartile classification.



27 Figure 8 compares an aerial picture of the case area 'Westrozebeke', with a high score on the *density of fragmenting structures method,* with the case area 'Walshoutem', with a high score on the *average patch size method.* The first is located on the western side of the city of Roeselare in West-Flanders, a rural region with many scattered buildings. Intersecting line infrastructures are rare, except for some regional roads and a high-tension line. On the contrary, 'Walshoutem', situated nearby the E40 highway in the south of Flemish Brabant, shows a very sparsely built area with large agricultural parcels around the village centre. However, the area is crossed by major line infrastructures: a dominant highway, another major road and a high-speed railroad.

Figure 8. Left: case area 'Westrozebeke', with a high score on the density of fragmenting structures method; right: case area 'Walshoutem', with a high score on the average patch size method.

SOURCE: AGIV AERIAL PICTURES 2014

Enclosed open space fragments

28 The results of the *ribbon method* and the *built perimeter method* are respectively shown in Figure 9 and Figure 10. With the *ribbon method* a strict selection of enclosed open space fragments is obtained. All these fragments have an area of at least 100,000 m² and their perimeter is built for at least 60%. The *built perimeter method* uses a broader definition of fragmenting built development by using buffers of 100 meter around buildings to select road segments. If a fragment is completely surrounded by these buffers, it is selected as enclosed open space fragment.

29 The resulting fragments of both methods were classified by natural breaks into four groups, on the basis of their area (Figure 9 and Figure 10). The darker a fragment is coloured, the smaller it is and the larger the degree of fragmentation.

30 In general the *built perimeter method* gives a more extensive image of enclosed open space fragments than the *ribbon method*. The fragments that are only detected by the *built perimeter method* are concentrated in three regions: the southern Campine area around Heist-op-den-Berg/Tremelo/Bonheiden (1), the region Kortrijk-Roeselare (2) and the region around the city of Aalst (3). Despite the more limited definition of enclosed open space fragments in the *ribbon method*, a few open space fragments can be found that do not appear in the *built perimeter method*, for example between the cities of Brussels and Leuven (4).

Figure 9. Enclosed open space fragments – ribbon method. Fragments classified into four groups on the basis of their area, using natural breaks.

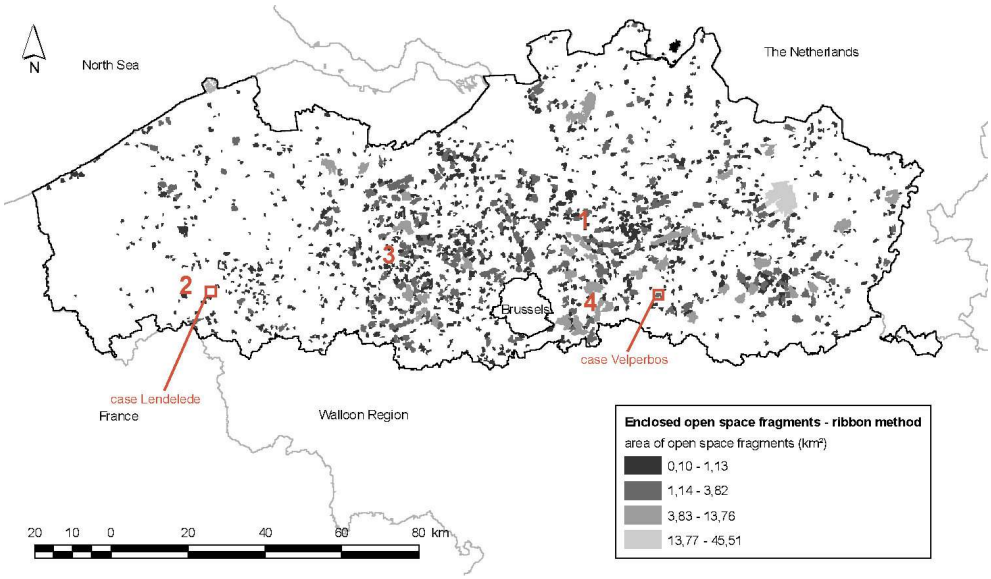


Figure 10. Enclosed open space fragments – built perimeter method. Fragments classified into four groups on the basis of their area, using natural breaks.

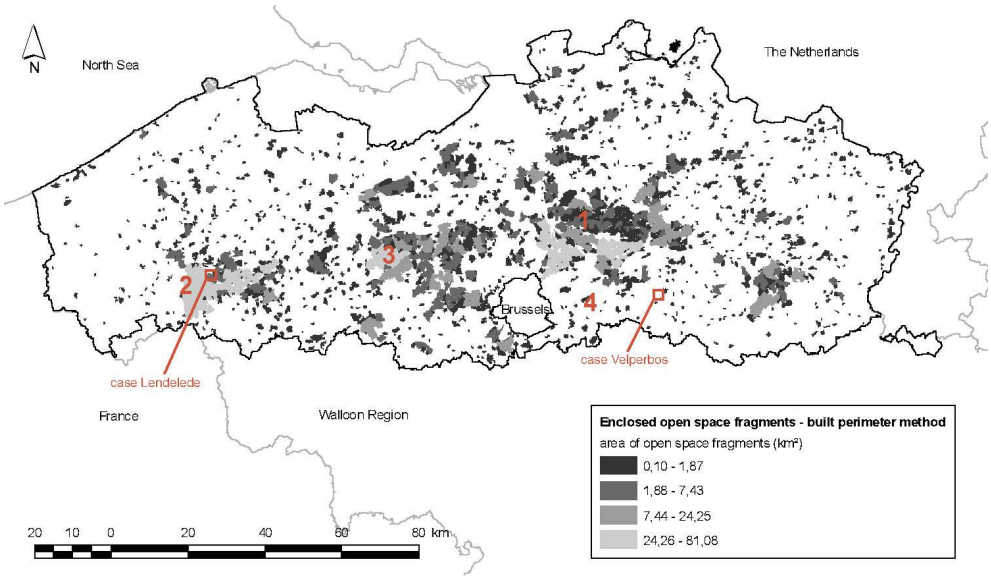
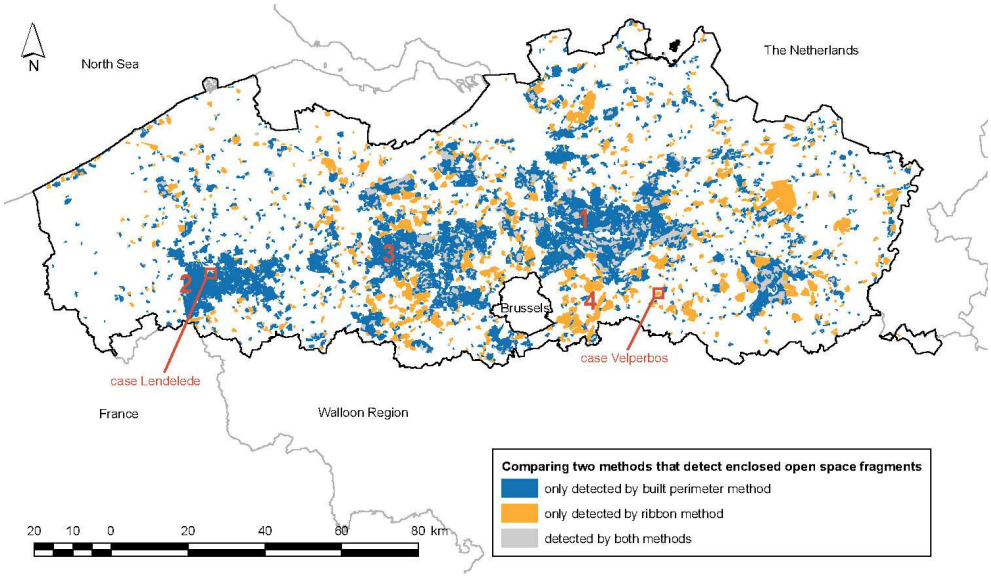
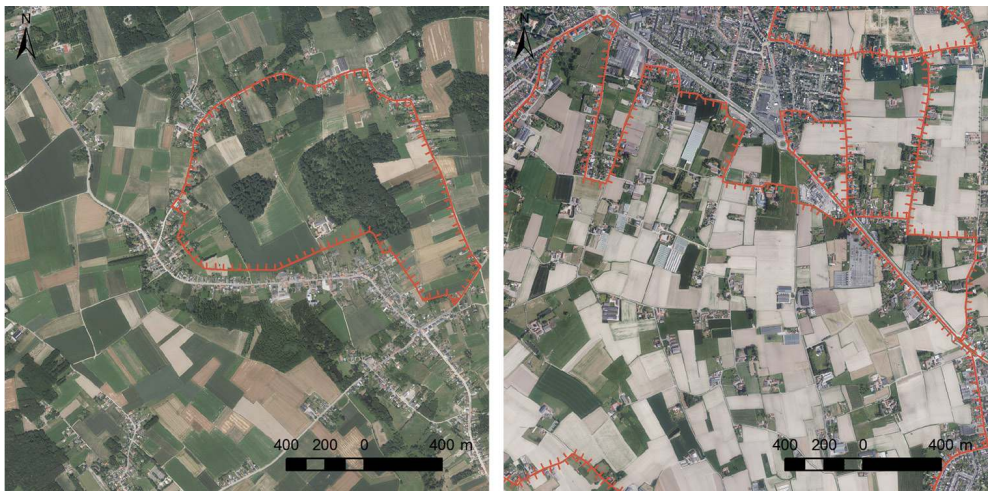


Figure 11. Comparing two methods that detect enclosed open space fragments.



31 Figure 12 compares the case area 'Velperbos', near the city of Tienen in the province of Flemish Brabant, with the case area 'Lendelede', in the region of Kortrijk-Roeselare. The enclosed open space fragment in 'Velperbos' is only selected by the *ribbon method*. The fragment is almost completely surrounded by ribbon developments, relatively close to each other. Only at the eastern side a gap can be found where, over a larger distance (approximately 300 meters), no buildings are present. In 'Lendelede', a quite densely built rural area between two village centres, several enclosed open space fragments are detected. Although buildings are very present along the rural roads, a ribbon pattern is difficult to discern, because of the large average distance between the buildings.

Figure 12. Left: case area 'Velperbos', an enclosed open space fragment only detected by the ribbon method; right: case area 'Lendelede', with several enclosed open space fragments only detected by the built perimeter method.



SOURCE: AGIV AERIAL PICTURES 2014

Discussion

32 The different outcome of the four methods can be easily traced back to the composition of the methods used. In the *density of fragmenting structures method*, only paved roads are considered as fragmenting infrastructural line elements; railroads and waterways are not included. Conversely, ribbon and scattered developments contribute greatly to the indicator. The *average patch size method*, on the other hand, puts a high emphasis on major infrastructure lines (highways, major roads, railroads, major canals and waterways). In contrast, buildings contribute relatively less to the indicator, except for fragmenting built developments along roads.

33 Similar explanations can be given for the differences between the results of the *ribbon method* and the *built perimeter method*. The latter gives a much more extensive image of enclosed open space fragments, because of the broader definition of fragmenting built development. In the *built perimeter method*, buffers with a radius of 100 meter are drawn around buildings, whereas in the *ribbon method* this buffer distance is only 25 meter. This allows gaps between buildings as large as 200 meter in the *built perimeter method*, which explains the abundance of fragments in some areas. However, it does not clarify why some enclosed open space fragments appear only in the *ribbon method*. This can have two reasons. First, other data sets were used: the *ribbon method* makes use of land registry data whereas the *built perimeter method* uses topographical map data. Second, a difference in the selection process can add to the varying results. In the *built perimeter method,* parts of roads between two nodes of the road network have to be completely selected, and thus need to have buildings along the full length, albeit with large distance buffers. In the *ribbon method*, on the other hand, road segments between two nodes of the road network can be clipped into smaller pieces. Based on these road fragments, and the boundaries of residential statistical sectors, it is calculated what proportion of the perimeter is built – with a limiting value of 60%. This explains why the selection of the *ribbon method* contains enclosed open space fragments, with densely built ribbon developments on all sides, except for one 'gap', while the selection of the *built perimeter method* contains fragments with built development along the roads but with great distances in between (see Figure 12).

34 The observed differences raise questions on the definition of fragmentation. From an ecological point of view, line infrastructures are certainly more fragmenting than scattered buildings (Coffin, 2007; Shilling & Girvetz, 2007), because they form a physical barrier for ecosystems and wildlife populations. However, from the perspective of landscape conservation, agriculture and spatial planning, line infrastructures are not always the main fragmenting elements in open space areas. If buffered and/or well fitted in the local morphology, the impact of line infrastructures (even highways or railroads) can be minimised. From a landscape point of view, major waterways (and sometimes even canals) can even have a positive impact on landscape cohesion. Scattered developments, however, can have a larger visual impact on landscapes than linear infrastructures and be more disturbing for visitors and particularly for agriculture. As Carsjens and van der Knaap (2002) mentioned, small, irregular and isolated parcels, reduced field access and dispersion of fields – possible consequences of scattered developments – cause a reduction of production efficiency. The definition of fragmentation as 'negatively interpreted spatial heterogeneity of spaces, landscapes and land use systems' by Gulinck

and Wagendorp (2002) does not include line elements as basic characteristic of fragmentation. While it is likely to be a good definition of fragmentation from the perspective of a spatial planner or landscape scientist, the definition of fragmentation by a visitor or resident can differ. Some people might perceive a highway as more disturbing than a patchwork of scattered buildings. Landscape perception research (Lothian, 1999; Tveit, Ode & Fry, 2006; Sevenant & Antrop, 2009) goes more deeply into people's aesthetic preferences towards landscapes. The question of which proposed method is the best to analyse fragmentation is thus left unanswered, as other methods come into view depending on the spatial issues that are being addressed, and therefore the appropriate definition of fragmentation. Moreover, the methods presented here can also be flexibly adapted to a specific purpose.

35 When it comes to enclosed open space fragments, the main question is: when can a part of open space be considered as enclosed? In the given methods, only enclosure by buildings was assessed, with one method giving a more focused selection of enclosed open space fragments than the other. The methods were developed because enclosed open space areas are often referred to as the most vulnerable parts of open space (Verbeek *et al.*, 2010; Tempels & Pisman, 2013). Especially when these fragments are quite small and completely surrounded by (residential) development, the survival of these open spaces is threatened, because they are too split up and too difficult to access for modern (large-scale) agriculture (Carsjens & van der Knaap, 2002; Vandermeulen *et al.*, 2006). Surrounding residents on the contrary increasingly try to claim these lands, in order to enlarge their private garden or to keep horses or other domestic animals (Bomans *et al.*, 2010; Verbeek *et al.*, 2010; Tempels & Pisman, 2013). Leinfelder & Allaert (2010) conclude that these small open spaces, surrounded by residential development, often lack the economic, ecological or cultural values that can ensure preservation. Without a firm policy or a new function for these threatened open spaces, their future can be endangered. To this purpose the *ribbon method* seems to be most useful, since it works with a stricter definition of continuous – often residential – ribbon development.

36 It should be noted that none of the developed methods are statistically founded nor tested on accuracy by random checks on the ground. All methods make use of buffering distances and thresholds that were obtained through a trial-and-error sequence and recommended or checked by expert panels, as is the case for the relative weights for the three metrics of the *density of fragmenting structures method*. This raises questions about the representativeness of the results.

37 Although better methodological foundations are thus necessary, this paper opens new views on the structure of the Flemish open space and fosters the discussion on the definition of fragmentation. The methods can make a valuable contribution to Flemish spatial planning policy. If further elaborated, they can help to determine where the survival of open space is at stake and where policy actions might be necessary. Besides, at a more general level, the methods can be useful to underpin a differentiated spatial policy for rural areas.

38 Instead of a conservative and protective approach, aimed at an unrealistic maintenance of traditional farming, it is better to think about new functions for these threatened open spaces, to ensure their 'openness'. Leinfelder and Allaert (2010) suggest that enclosed spaces in the urban-rural interface might be considered as new public spaces in the Flemish network city. They believe this can be realised through stimulating multiple land use and inserting peripheral attractors. Also for the agricultural sector, there are

opportunities within strongly fragmented and urbanised landscapes. According to Vandermeulen *et al.* (2006), the impact of fragmentation on farming is not necessarily only negative but rather a combination of opportunities and threats the farmer has to deal with. A shift towards more multifunctional farming systems, with new activities like landscape maintenance, agro-tourism, care farming or production for a local market, might help dealing with existing pressures (Meert, Van Huylenbroeck, Vernimmen, Bourgeois & Van Hecke, 2005; Wilson, 2008). Finally, from a resident's point of view, the fragmentation process might not at all be negatively interpreted. A fragmented landscape is often considered as an attractive living and working environment, due to the combination of urban, natural and rural features (Jongman, 2002). The fragmented urban fringe holds more green 'healthy' space, offering pleasant views, place for recreational activities and contact with nature. Altogether, the methods described in this paper can be helpful tools in the difficult search for a sustainable spatial policy for the Flemish open space.

Conclusion

39 In this study, we discussed four basic methods that give an insight into fragmentation of the Flemish open space. Based on knowledge of the specific Flemish landscape morphology, two methods to measure fragmentation were developed and confronted with two existing methods developed by Bomans (2011). One pair of methods calculates a general indicator for fragmentation of open space, whereas the other detects enclosed open space fragments. By comparative analysis some general similarities but also many differences appeared. For each method a representative case area was briefly studied to give more insight into the outcomes of the different methods.

40 All four methods have proven useful, since from the perspective of spatial planning and landscape science there is not just one interpretation of fragmentation. If major line infrastructures are considered as the most fragmenting landscape elements, the *average patch size method* – developed by Bomans (2011) – comes into view. If fragmentation is interpreted as spatial heterogeneity, also scattered built elements are fragmenting elements, in which case the newly developed *density of fragmenting structures method* is more suitable. The two methods to detect enclosed open space fragments give different results depending on the data and methods used. Moreover, the two methods can be easily adjusted with different buffer distances and built perimeter thresholds. Nevertheless, if the aim is to detect open space fragments that are under threat of privatisation tendencies, the *ribbon method* is more appropriate since it works with a stricter definition of continuous ribbon development.

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ABSTRACTS

The open space in Flanders, the northern part of Belgium, can hardly be seen as really open. From the Middle Ages onward this area has been known for its spread out development pattern, which has even strengthened in recent decades. Especially the residential ribbon development and the omnipresent infrastructure are widely recognised. These developments have led to an intense fragmentation of open space. In this paper we present two new methods to analyse and quantify this fragmentation of open space from a spatial planning perspective, and compare them with two existing methods. This comparative analysis evaluates the different methods and connects them to different definitions of fragmentation. The average patch size method is more appropriate to describe general fragmentation if the focus is on major line infrastructures, whereas the density of fragmenting structures method matches with the interpretation of fragmentation as spatial heterogeneity. The two described methods to detect enclosed open space fragments as signs of fragmentation give different results depending on the data and methods used. The ribbon method however is more appropriate to detect open space fragments under threat of privatisation, since it works with a stricter definition of continuous ribbon development. All four methods are relevant for Flemish spatial planning policy, as they indicate where actions are needed to safeguard open space from further urbanisation tendencies. Furthermore, they can support a differentiated spatial policy and add to the scientific basis of the debate on alternative interpretations of Flemish open space.

De open ruimte in Vlaanderen, het noordelijke deel van België, kan niet echt als volledig open beschouwd worden. Sinds de Middeleeuwen is de regio bekend voor haar verspreide bebouwing, een patroon dat in de voorbije decennia zelfs nog versterkt werd. Vooral residentiële lintbebouwing en infrastructuurlijnen zijn alomtegenwoordig in het Vlaamse landschap, wat heeft geleid tot een intense fragmentatie van de resterende open ruimte. In dit artikel stellen we twee methodes voor om fragmentatie van open ruimte te analyseren en kwantificeren, vanuit het perspectief van de ruimtelijke planner. De twee nieuwe methodes worden vergeleken met twee bestaande methodes om de vier methodes te evalueren en te koppelen aan verschillende definities van fragmentatie. De *average patch size* methode ("gemiddelde grootte van een lap open ruimte") is meer geschikt om algemene fragmentatie te beschrijven als de focus op grote infrastructuurlijnen ligt, terwijl de *density of fragmenting structures* methode ("dichtheid van fragmenterende structuren") meer geschikt is wanneer fragmentatie wordt geïnterpreteerd als ruimtelijke heterogeniteit. De twee methodes die ingesloten openruimtefragmenten detecteren als teken van fragmentatie, geven verschillende resultaten, afhankelijk van de gebruikte data en berekeningswijze. De *ribbon* methode ("bebouwingslint") is echter meer geschikt om openruimtefragmenten te detecteren die ernstig bedreigd worden door privatisering, omdat ze

werkt met een striktere definitie van aaneengesloten bebouwing die een fragment omringt. Alle vier methodes zijn relevant voor het Vlaamse ruimtelijke planningsbeleid, omdat ze aanduiden waar acties nodig zijn om open ruimte te vrijwaren van verdere verstedelijking. Daarnaast kunnen de methodes een gedifferentieerd ruimtelijk beleid ondersteunen en objectieve informatie toevoegen aan het actuele debat over de betekenis van open ruimte in Vlaanderen.

INDEX

Keywords: open space, fragmentation, spatial indicators, GIS, Flanders
motsclesnl open ruimte, fragmentatie, ruimtelijke indicatoren, Vlaanderen

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