Metropolitan landscape characterization
A typo-morphological approach

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Abstract

Dispersed urban regions are characterized by blurred boundaries between urban and rural areas resulting in complex new configurations of urban tissue and landscape space. These new hybrid landscapes challenge existing tools for landscape characterization, which are based on a traditional separation of urban and non-urban realms. This paper presents the results of the elaboration and testing of the method for character assessment using continuity and land-use for the study of the morphology of the metropolitan region of Rotterdam.

The applied method combines mapping as a classical tool for urban morphology with landscape character assessment. For this purpose specifically chosen combinations of data sets produced first-stage categorizations for metropolitan landscape types. Results indicate the existence of 100 landscape character types in the city-region of Rotterdam among which the "hybrid" ones draw the special attention. Data analysis also show an extensive disparity between in the planning practice assumed location of the urban periphery of Rotterdam, and one that came out of this study. Distribution of green and built-up elements that resulted from GIS analyses were used to further understand patterns of dispersion, diffusion, periphery and fragmentation. The method applied showed unexpectedly interesting results and can be highly recommended for morphological and comparative studies of other urban regions.

1. Introduction

The developing mosaic of large city-regions forms the spatial foundations of a new world system, whose internal and external relations and complex dynamics present a number of challenges to researchers and policy-makers (Scott, 2001, p.813). As a result, 'metropolis' and 'metropolitan area' are increasingly the lens for research into urban transformation by developments in mobility and communications technologies and new global and regional economies, as well as a frame for topics such as urban agglomeration, centrality, metabolism and sustainability. They are also an emerging lens for research into changing patterns of locality and identity, into demographic and migration patterns and into scales and methods of governance for large city-regions. A critical aspect in the challenges large city-regions present lies in their changing spatial conditions. In recent decades, research and debate on spatial developments in metropolitan territories have resulted in a range of new insights from varying perspectives on the form of the territory. A common theme in these concepts is the shifting relationship between city and countryside. In contrast to compact homogenous cities, large urban regions are characterized by an amorphous patchwork of urban fragments in which the distinction between rural and urban realms dissolves.

> "*The metropolitan region is not just a spatial form of unprecedented size in terms of concentration of population and activities, it is a new form because it includes in the same spatial unit urbanized areas and agricultural land, open space and highly dense residential areas: there are multiple cities in a discontinuous countryside. It is a multi-centred metropolis that does not correspond to the traditional separation between central cities and their suburbs"* (Castells, 2010, 2739).

This research intends to contribute to the theoretical discourse on spatial developments in metropolitan territories from the perspective of landscape and landscape architectural research. It aims to develop knowledge and insights into the form and character of urban landscapes in metropolitan regions and tools for planning and design, which actively engage with the spatial realities of metropolitan areas. This paper presents research specifically addressing "hybrid" landscapes within metropolitan areas. The project is the first phase of the broader research in landscape character assessment and new typology of metropolitan landscapes. The Metropolitan Region of Rotterdam was used as a test case. In the following chapters we will explain the theoretical context and main research questions, followed by an explanation of the methodology, obtained results and the preliminary conclusions.

1.1 Metropolitan landscape

Research into the physical, social, aesthetic and conceptual potential of landscape for understanding, ordering and acting in metropolitan territories has gathered pace in recent decades. Studies addressing formal structural characteristics of urban landscapes in relation to social, economic and environmental aspects of large urban regions have been published by Rowe (1992), Sieverts (1997), Giro et al. (2003) and Tress et al.(2004). Oswalt and Baccini (2003), Bolling and Sieverts (2004) and Lampugnani and Noell (2007) investigate the metropolitan landscape with networks and edge conditions as points of departure. Wooley (2003) and Thompson and Traviou (2007) focus on the importance of open spaces to society, individuals and urban life. Steenbergen and Reh (2011) address formal aspects of the urban landscape and elaborate on relevant landscape architectural principles for spatial development. Waldheim et al. (2006), Czerniak and Hargreaves (2007) focus on landscape infrastructures as spatial armatures for urban development while Forman (2008) elaborates on the landscape ecological conditions for urban landscapes. To what extent landscape, in the sense of a permanent underlying substructure, visual, physical and conceptual open space and as a conceptual and instrumental 'vehicle' of nature, has a bearing on the resolution of metropolitan problems is the broader aim of these inquires. A systematic understanding of the physical character of urban landscapes in metropolitan areas can help to define the role of landscape as an agent for the development of large urban regions.

1.2 Hybrid Landscapes

A central problem in the metropolitan landscape is that of hybridization. In addition to the patchwork of industrial, residential, agricultural and open space territories in metropolitan areas, we also see the development of extensive hybrid tissues within metropolitan territories themselves. The majority of industrial, residential, peri-urban and mixed-use urban tissues in metropolitan areas are characterized by varying densities and forms of built and unbuilt space which differ markedly from that of compact (historical) urban tissues and open countryside. Viewed from the perspective of the urban realm, these conditions challenge existing categorizations and qualifications of urban tissue. There is a need to map the contemporary urban landscape by including the study of rural areas and open areas within metropolitan areas since they are all part of this new urban structure (Pinzon Cortes (2009). Nevertheless the typologies of urban space mostly start from urban area and stop at the city fringe (European Urban Atlas - http://www.eea.europa.eu/data-and-maps/data/urban-atlas/mapping-guide; Ritsema van Eck, van Amsterdam and der Schuit, 2009). Like-wise, the transformation of rural areas through urban development results in hybrid tissues and forms, which defy abiding landscape characterization and qualifications (for instance Scottish, Dutch, and Belgium landscape typologies). Therefore, large areas of the territory in metropolitan areas literally 'disappear off the radar' of the spatial disciplines. The limitations of existing approaches to classify and qualify these hybrid landscapes limits our comprehension of the physical extent and character of the urban – and rural – realms in large urban regions. This becomes clear in topographical or land-use maps based on normative spatial and functional categories. Where these maps indicate the edge of the city for instance, invariably conflicts with the actual visual form of the territory on the ground. It is clear that we need a more sophisticated understanding of the spatial reality of metropolitan areas, to start by answering the following questions:

- How extensive are these hybrid landscapes?
- Where do they occur?
- What is their morphological and typological definition?
- How are these landscapes read and valued by inhabitants?

The results of the research presented in this paper give the answer to the first two questions and is to be concerned as the first stage of the research. The second two we plan to answer in the follow up of this research.

2. Methodology

Given the hybrid nature of metropolitan territories, analysis tools for the research have been sourced from both urban and landscape fields: morphology analysis from urban studies and landscape character assessment from the field of landscape studies.

The method applied in this research combines the two approaches. Landscape character assessment is used as a background technique in the design of the research method. Mapping, in this case GIS supported mapping, was used as a tool for morphological analysis. Mapping is chosen as this medium is a useful instrument to combine and visualize information, especially for purposes of understanding complex situations and revealing new relationships. Mapping is also a suitable method for analysis at a large scale and for desk study, which was the situation in our case.

For this stage we focussed on the regional scale using datasets that are available commercially: the so-called Top10 maps (TOP10nl, Kadaster, 2011) and BBG (*Bestand Bodem Gebruik*, Centraal Bureau voor de Statistiek 2008) and GIS as a powerful tool that integrates and visualizes multiple data sets on different scales. An important distinction to other studies is the choice of boundaries for the study area. In order to ensure the inclusion of all possible hybrid landscapes, the study area was set as twice the extent of the existing urban area (calculated on the basis of existing administrative, planning and geographic border data).

2.1 Case study –Rotterdam Urban Region

The metropolitan region of Rotterdam lies in the south of the Randstad conurbation in the Netherlands, the so-called "South Wing". The region is also called Rotterdam-Rijnmond (literally Mouth of the Rhine) and is an official region of the province of South Holland. It refers to the city of Rotterdam and its surrounding suburbs and municipalities. Another term used in this context is Stadsregio Rotterdam (literally Rotterdam Urban Region or more conventionally, Greater Rotterdam Area). The region consists of the following municipalities: Lansingerland, Albrandswaard, Barendrecht, Ridderkerk, Capelle aan den Ijssel, Krimpen aan den Ijssel, Rotterdam, Voorne-Putten, Bernisse, Brielle, Hellevoetsluis, Spijkenisse, Westvoorne, Maassluis, Schiedam and Vlaardingen. The population of the Rotterdam urban region - "Rotterdam-Rijnmond" - is approximately 1.3 million. The Rotterdam urban region is a suitable case for the research as it is demonstrates all of the conditions described in the introduction, without being too large and complex to unnecesarily complicate the research methodology.

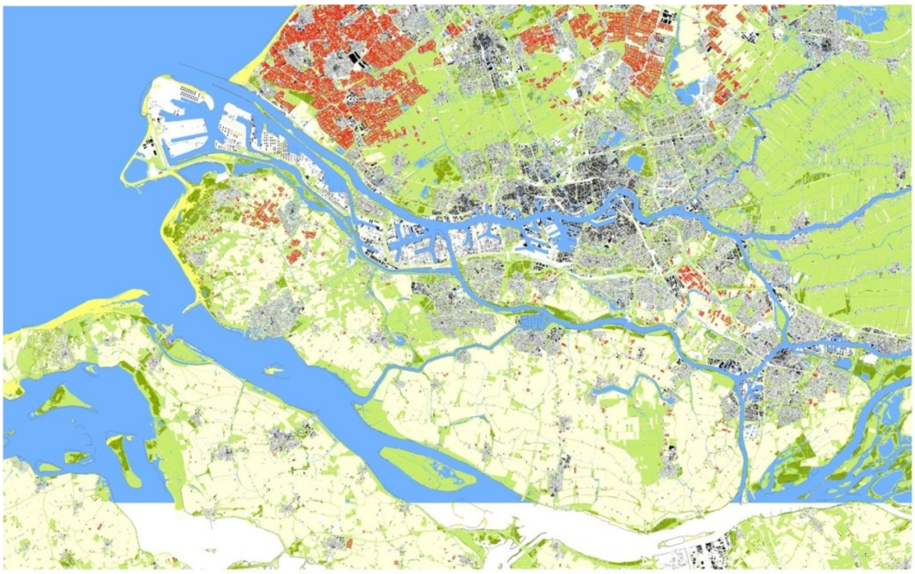


Figure 1. Topographic map of the metropolitan region of Rotterdam

2.1 Data selection and adjustments

The first step in the landscape characterisation involved selection of elements that will be used to define the landscape types. The process of selection and aggregation of data and spatial analyses is shown in Figure 2.

In the terms of traditional landscape characterisation methods "elements are individual components that make up the landscape" (The Countryside Agency and Scottish Natural Heritage, 2002). For this study, element categories were sourced from the topographic map (TOP10nl, 2011). Top10nl is highly detailed vector topographical database of the Netherlands. The information in this dataset has been derived directly from aerial photos with a high positional accuracy, making it very suitable for statistical and spatial analysis.

In this research, TOP10nl has been used to define a first stage categorization of both urban and rural landscape in four categories: green, blue (water), red (built-up space) and gray (infrastructure). Because almost the half of the area covered by the topographic map was classified as "remaining space" in order to get 100% coverage for each cell we reclassified the remaining area into four classes: in-between space residential area (mixed paved and green areas); in-between space business district (mixed paved and green areas); construction sites; and remaining areas. After that we celled the layers using a resolution of one metre, then we made a mosaic of these cells with the dominant value on top, removing any overlapping areas. As a next step we aggregated each category in cells with a resolution of one hundred metres, resulting in eight cell layers with percentages of each of the eight categories (red, green, blue etc.) per hectare.

For the further analyses we only used layers with information about the red and green cells. Red comprises all categories of built form (residential, offices, industrial, agricultural and glasshouses).

Green comprises natural and recreational areas such as forests, heathlands, wetlands, dunes, beaches and parks, agricultural areas such as orchards croplands, nurseries, meadows and urban spaces such as parks and gardens, cemeteries, sports fields, allotment gardens and verges. Red and green layers have been classified and outputed as black and white images for visual assessment.

The second input was the Land Use Map (BBG, 2008). Here we reduced the thirty-eight categories in the dataset to ten: residential, infrastructure, services, industry and offices, functional green, agriculture, glasshouses, nature, water and remaining area. This data has been celled with a resolution of one hundred metres; the value of the largest combined surface of the ten categories has been assigned to the grid cells, resulting in a map with the dominant function per hectare. With the combination of the two input layers the share of green and share of red per land use category have been calculated, and visualised as the two images on the bottom of figure 2.

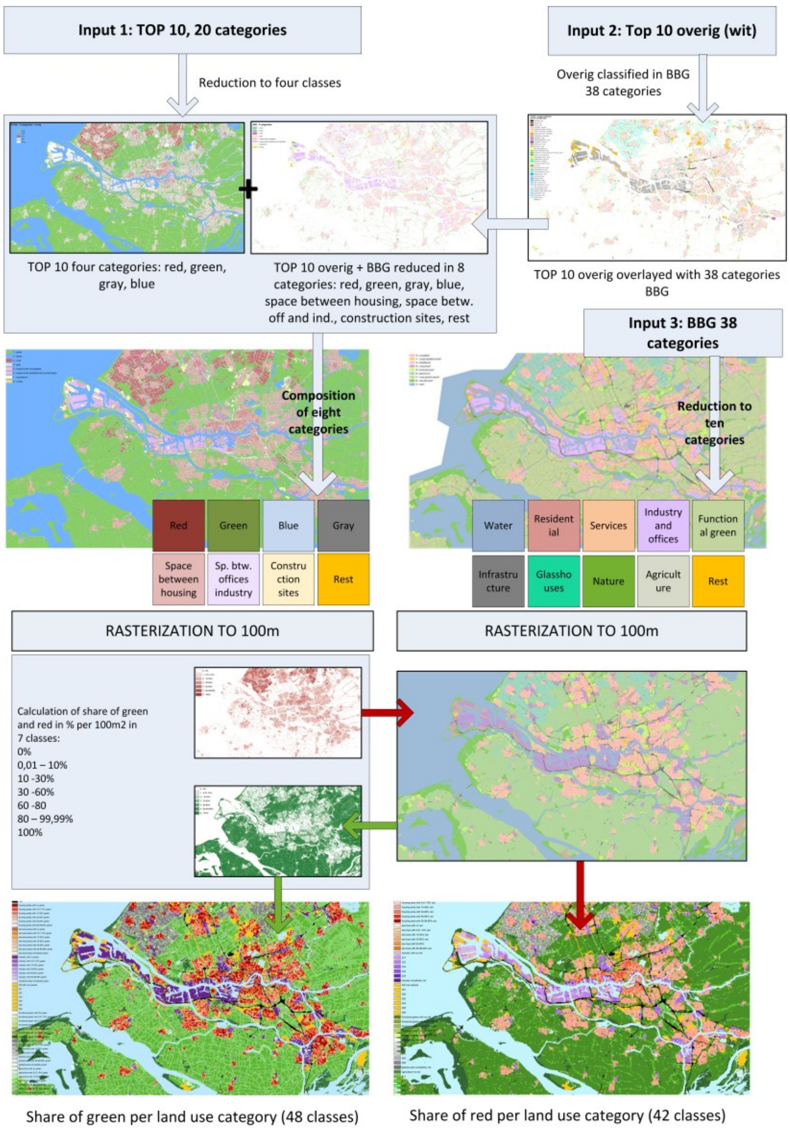


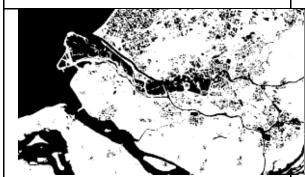
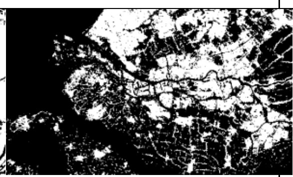
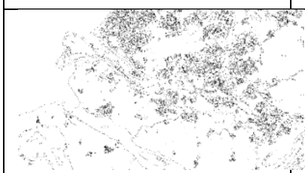
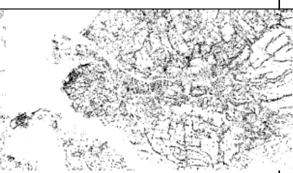
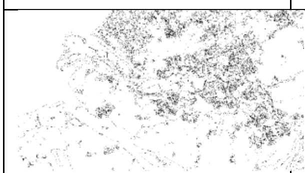
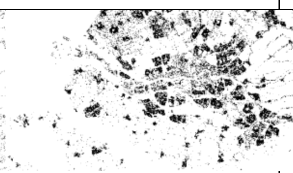
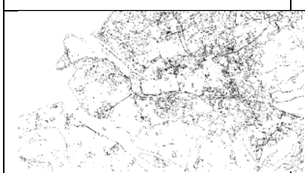
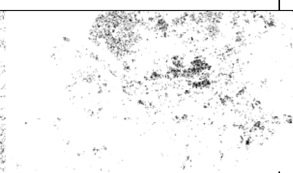
Figure 2. Process of selection and modification of datasets, GIS analyses and final results

3. Results and discussion

This chapter presents the first results of the desk study. We looked firstly at the patterns of red and green by mapping the distribution of cell percentage categories across the territory. This was followed by the analysis of the percentage of red or green per cell. Following this, the analysis of the share of red and green per land use category gives insights into penetration of red into green space and of green into red space.

3.1 Patterns of red and green

Patterns of red and green are analysed by means of the distribution of the cells with different percentage of red and green taken from the 1:10.000 map, over the study area (figure 3). We can conclude that there are extensive variations in patterns of cells depending on which percentage category of is isolated.

GREEN	**RED**	**%**	
		0	There are large areas with no green; they are mainly where water is. Areas with no red occupy much more space than those with no green, also where 100% water is, but also in agricultural area.
		0,01-10	Green: low concentrations of green are mainly in urban areas and glasshouses. Red: scattered in low concentrations throughout the whole area. The patterns of ribbon buildings, villa districts, nature areas and industrial areas are partly visible.
		10-30	Green: scattered in urban areas, glasshouses and in a large parts of rural area except 100% agriculture is. Red: pattern clearly shows low density housing areas on the periphery of Rotterdam, Delft and Dordrecht and other smaller settlements.
		30-60	Green: city fringe is clearly seen, and the green along larger waterways and infrastructure. Red: centre of Rotterdam becomes very recognizable, but the glasshouses are dominating.

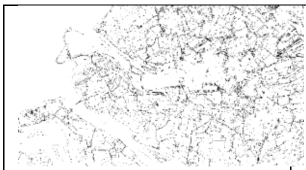
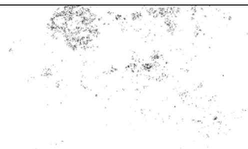
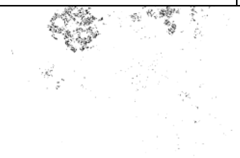
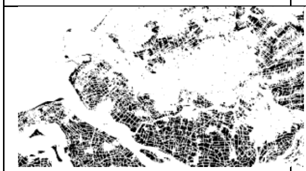
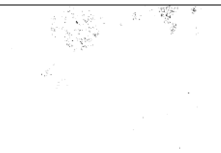
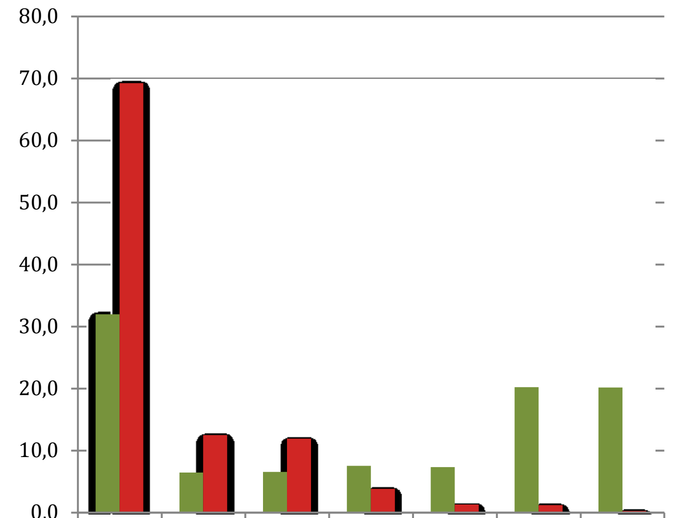
		60-80	Similar as previous but in a smaller extent.
		80-99,99	Green becomes dominant and shows the pattern of local roads and larger nature areas and forests. Red with this concentration occurs only in glasshouse area.
		100	Completely green spaces are mainly present in agricultural area, next to that there are some parts of forests and nature areas that are 100% green. Completely red cells are only found in glasshouse areas.

Figure 3. Analysis of patterns of red and green

The distribution of cells in the categories 10-30%, 30-60% and 60-80% for instance, differ markedly from the categories 0-10% and 80-100% and reveal patterns contrary to existing data-sets. In terms of continuity, analysis shows that the study area also still has a high percentage of “pure” green ((80% - 100%) cells. This is due to large areas under agricultural production and the legacy of the rigorous urban planning culture in the Netherlands which until recently set and controlled urban boundaries. It may also be a reflection of the ample boundaries of the study area.

In a graph illustrating the percentages of red or green per cell in the study area, we can conclude that the continuity of “pure “ red is very low compared with very high scores for “pure” green (figure 4). “Red” is on the other hand, present throughout the whole area in different densities and concentrations. We can conclude that there is a high occurrence of red in green areas. The spread of “red” cells results in a large amounts of “hybrid” spaces where green and red mix (categories 10 to 80%). This penetration of “red” results in a large amount of scattered “hybrid” spaces where green and red mix (categories 10 to 80%).



Percentage red or green per cell	0%	0.01-10%	10-30%	30-60%	60-80%	80-99.99%	100%
% of green cells in the city region	32,0	6,4	6,5	7,5	7,3	20,2	20,1
% of red cells in the city region	69,2	12,5	11,9	3,8	1,3	1,2	0,2

Figure 4. Percentage of green and red cells in the total area of the Metropolitan Region Rotterdam

3.2 Share of red and green – hybrid landscapes

In these analyses we looked at the share of green and share of red per lands use category. This resulted in the two maps (at the bottom of the figure 2) showing respectively the penetration of red in green space and the penetration of green in red space. The colours that represent housing, industry, services, and glasshouses are ordered so to get darker as there is less green or more red in the cells, and lighter as there is more green and less red in them. In the green categories (functional green, agricultural and nature areas) the colours are ordered other way around – the more green or less red they have the darker they are.

Already at the first glance the image presented on the map “share of red” seems much darker and compact green than the image of “share of green”. The largest intact dark green colour represents agricultural land with some scattered lighter green elements in it. The darkest colour represents nature, which is as almost 100% green (contains a very few red cells). For the share of red it was interesting to look to the presence of built up elements in the spaces that are used for leisure and recreation (which we named functional green), nature and agricultural area. Statistics shows that there are no extremely red cells present in these categories, but very low concentrations of red (0,01-10%) are very much present in the whole rural area, mainly in agricultural area and functional green areas, and in very few cases in natural areas.

The image on the map “share of green” is still very green, but much lighter than the first one. Agricultural area is not co compact as in the “red” map anymore because the pattern of local roads is visible in it. Dominantly green are now only nature areas, but we see lot of "hybrid" categories in the city fringe and within urban green spaces. For the share of green is interesting to look at "urban" functions such as housing and services, and then at industry and glasshouses. The majority of housing areas and services are in the "hybrid category", while majority of industrial area and glasshouses have very little amount of green or no green (0 -10%).

3.3 Visualisation of the "hybrid" landscapes

The method of calculation of percentage of green or red per 100m2 cell results in overlapping cells, because each of the cells can have certain percentage of red or green, which are not complementary. Therefore the combination of the two maps can result in various other images, depending of the questions we want to answer. Figure 5 is one example of these possibilities. It represents combination of cells which have low densities of red and high density of green.

Figure 5. Hybrid landscapes with low density of red and high density of green

We can conclude that this map shows the extent of fragmentation of the green space because a small amount of red is present in all cells. We can also recognize blurred city fringe and scattered rural area with patterns of low-density housing, ribbon development, farms and recreational areas.

4. Discussion

The results of analyses support the opinion that "dispersed urban regions are characterized by blurred boundaries between urban and rural areas resulting in complex new configurations of urban tissue and landscape space" (Peres Cortes, 2009). The flow of green begins in rural agricultural area and dissolves gradually through the fringe and periphery towards the city centre. At the same time the flow of "red" starts from glasshouses and urban centre of Rotterdam and other cities and gradually dissolves in pure “green” through peripheral housing districts, and city fringe. Patterns of points, areas and lines are also visible in this “hybrid” category.

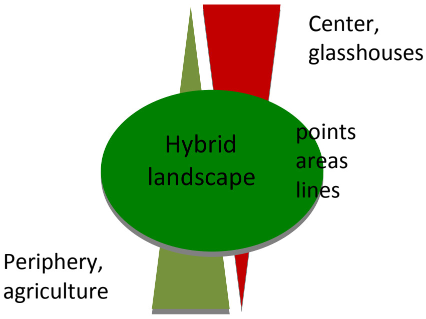


Figure 6. Flow of green in red and red in green results in various patterns which can have the form of points, areas and lines.

These “hybrids” can be a mix of different topographic entities and combine various spatial functions. Figure 7 shows some examples.

Figure 7. Various forms of "hybrid" landscapes

It is important to note that next to the large amount of hybrid landscapes we also detected considerable areas of green space. This pattern originates from agricultural land which is the dominant "green" element that marks the landscape of the Rotterdam metropolitan region (some examples are presented on figure 8). In that sense agricultural land of the region of Rotterdam can be considered as sustainable landscape element that can serve as this "binding" element.

The results of these analyses answer the questions about where and to which degree hybrid landscapes are present, put at the beginning of the research. But at the same time these results open other questions. As "mapping refers to a process not to a completed document" (Abrams and Hall, 2006) it implicitly means that the research needs to continue exploring the "hybrids" in more details.

Midden Delfland: Protected rural landscape between Delft and Schiedam

Zoetermeer, view from the ski hill

Figure 8. Examples of typical rural areas with open landscape of large pastures and small-scale landscape elements like farms, villages and woods.

5. Conclusions

The result of this study is twofold. Firstly a methodological/theoretical framework for metropolitan landscape character assessment for further study of hybrid landscapes is defined. Secondly, its first version is implemented in the Rotterdam Urban Region which produced a preliminary morphological characterization of this metropolitan area.

The results of this study have shown that there is a large amount of “hybrid” landscapes in the metropolitan region of Rotterdam. These “hybrid” landscapes are present through the whole territory, in different configurations and concentrations, which causes blurring of the edges of Rotterdam and other smaller cities and fragmentation of the rural landscape. Nevertheless, there is still large area occupied with mono-functional agricultural ground, which can be considered as a possible binding landscape element of this metropolis.

The results of this study are preliminary but are actually the starting point for the new typology of metropolitan landscape as a mix of urban and rural elements. An important conclusion at this stage is that the method is very appropriate for quick scan and desktop analyses of large city- regions. The method is suitable to detect a mix of functions and densities and can be used on different spatial scales.

The choice to avoid borders between urban and rural areas in this research had the purpose to test the theory of the dispersed metropolis, and indeed has proved that this is happening in the region of Rotterdam. Nevertheless, the large amount of “hybrid” landscapes we have detected needs further refinement and understanding. We need to know whether these “hybrids” include open areas and functions like tourism and leisure activities, traces of infrastructures, leftover space and abandoned industrial areas, these new metropolitan landscapes are often referred to in the literature. This is the subject of further research on a lower scale with more detailed datasets accompanied with the field studies.

The role of hybrid landscapes in the valuation of metropolitan environment can be an important aspect of planning, policy and design praxis but it is restricted if they are not sufficiently described and valued. “Hybrid” landscapes can also be a challenging new areas of work for urban designers and landscape architects. And given that the number of citizens living in these areas, the metropolitan landscape is their everyday landscape and it is important to recognize and understand how it is used and perceived.

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