Understanding the whole city as landscape. A multivariate approach to urban landscape morphology

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Abstract

The European Landscape Convention implies a requirement for signatory states to identify their urban landscapes which goes beyond the traditional focus on individual parks and green spaces and the links between them. Landscape ecological approaches can provide a useful model for identifying urban landscape types across a whole territory, but the variables relevant for urban landscapes are very different to those usually addressing rural areas. This paper presents an approach for classifying the urban landscape of Vienna that was developed in a research project funded by the Austrian Ministry for Transport, Innovation and Technology: 'Urban Fabric and Microclimate Response'. Nine landscape types and a number of sub-types were defined, using a multivariate statistical approach which takes into account both morphological and urban climate related variables. Although the variables were selected to objectively reflect the factors that could best represent the urban climatic characteristics of the urban landscape, the results also provided a widely plausible representation of the structure of the city's landscapes. Selected examples of the landscape types that were defined in this way were used both to simulate current microclimatic conditions and also to model the effects of possible climatic amelioration measures. Finally the paper looks forward to developing a more general-purpose urban landscape typology that allows investigating a much broader complex of urban landscape functions.

Key words

urban landscape; urban morphology; landscape classification; urban landscape typology; multivariate statistics

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1. Introduction

An increasing hierarchy of levels of organisation can be identified within different fields of scientific endeavour. In the field of botany, one important jump in scale took place between the study of the flora – the occurrence and distribution of plant species within a particular geographic area, and the study of vegetation – which grew out of the realisation that particular species tend to occur in relatively constant groupings, and that these tend to map on to geomorphological patterns and the distribution of soil types (e.g. Braun-Blanquet, 1932).

A further critical step up the ladder of organisation levels in the landscape field took place with the systematic application of vegetation ecological methods at the landscape scale, in particular in the context of the definition of 'land classes' for Great Britain (e.g. Bunce et al, 1996). This approach has been applied to the whole area of Great Britain. However, because it was always intended primarily as a means of structuring ecological surveys, urban areas were excluded from the classification and left 'white', or at best were all lumped together as one homogenous urban class. Studies which have built on this tradition at the European level (e.g. Mücher et al, 2003) have similarly treated 'urban' as a single, undifferentiated landscape type. Other European level approaches to looking at land use within a consistent framework have not really addressed the issue of resolving the inner structure of urban areas. Instead the focus has been more on delineating the edges of towns and cities from both a structural and a functional point of view, e.g. with the definition of Urban Morphological Zones – UMZs (European Environment Agency, 2006) or Functional Urban Areas (Espon, 2007).

Within urban areas, the landscape tradition has, at best, taken a 'patchy' view of towns and cities. While rural areas are generally considered to be 'all landscape', albeit with embedded buildings and structures, the landscape focus on urban areas is generally directed primarily at parks, public gardens and other 'classic' open spaces such as squares. Although other mono-functional green spaces such as allotment sites, sports grounds, cemeteries or outdoor swimming baths are frequently also considered as part of the urban landscape, in all cases attention has tended to concentrate on a series of isolated 'green' spaces within the wider urban fabric.

This view of the landscapes of urban areas is frequently complemented by attempts to identify and create links and connections, both between these individual green spaces and between these and the surrounding rural landscape. Classic 'point' green spaces are thus joined by linear features such as green links, green wedges and green corridors. Together these 'points' and 'lines' helped to fill out the landscape view of urban areas, but the intervening matrix of the urban fabric, which accounts for the great majority of urban areas remained largely excluded from the 'urban landscape'.

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This article will first discuss the larger context that is provided by the European Landscape Convention (which celebrates in 2014 the tenth anniversary of its coming into force), and the 'Urban Fabric and Microclimate Response' project in which the results were produced. Next, it describes the methodology, based on the definition of urban landscape units, and the selection of attributes and variables with which the urban landscape types of Vienna are defined. The article outlines briefly the main spatial characteristics of the Austrian capital which serves as case-study. This is followed by the presentation of the urban landscape classification that was the outcome of the research: the urban structure of Vienna, and the overall pattern of urban landscape types. The landscape types form the basis for simulating the microclimate. The article closes off with discussion and conclusions.

2. Context

Urban implications of the European Landscape Convention

The European Landscape Convention, ELC (Council of Europe, 2000), defines the whole territory of the signatory states as landscape, and thereby explicitly includes urban areas. But the Convention does something else very important too: it calls upon signatory states to identify their landscapes, and explicitly includes urban and peri-urban landscapes, in addition to the 'natural' and 'rural' ones (ELC Article 2).

Taking the Convention seriously requires doing more than simply divide the territory into four classes to correspond to the above four landscape 'types'; and in the case of most signatory states detailed landscape classifications have been or are being prepared. These generally break down the rural and natural landscape into a series of landscape types, which are described in terms of their landscape character, but have little to say about urban or peri-urban landscapes (Swanwick, 2002). As a result there is clearly a need for an analogous approach to urban areas which identifies urban landscape types in a territorially comprehensive manner.

While landscape ecology inspired approaches, such as those pioneered by Bunce, can provide important inspiration and methodological models for addressing the urban landscape, it is clearly evident that the natural ecological structure of the landscape is significantly 'overwritten' by the patterns of built development during the urbanisation process, and its role in towns and cities must, as a result, be considerably diminished. If we accept this, then it is necessary to take a holistic approach and consider the urban landscape as a phenomenon which includes the buildings and structures that now 'obscure' the underlying landscape structure, as well as the open spaces.

In a possible response to these considerations, the idea of 'landscape urbanism' (Waldheim, 2006), with its implied promise to apply landscape ideas to the whole city, might appear to present itself as the answer for which the discipline has been waiting. But despite the enthusiasm with which this rather nebulous concept has been taken up by many architects and urban designers, there remain a lot of question marks as to what it actually represents and how helpful it actually is. Thompson's critical analysis of the claims of landscape urbanism provides an excellent overview of the issues involved (Thompson, 2012). Its shortcomings are particularly overt with regard to its potential for the treatment of existing towns and cities: its 'blindness to pre-existing structures, urban ecologies and morphological patterns' is even pointed out by one of the contributors to the seminal Landscape Urbanism text (Shane, 2006).

If, instead, one continues with the vegetation science analogy, urban landscapes might be considered as being analogous to what ecologists describe as azonal vegetation types (e.g. Breckle, 2002, p. 73). Here one specific eco-factor (such as water in the case of riverine ecosystems or altitude in the case of alpine ecosystems) over-rides the local environmental conditions to impose a consistent form of vegetation that ignores other environmental boundaries. In the case of urban landscapes it can be said to be the interaction of built fabric and open space structure that is critical for understanding the city as an urban landscape, and not the traditionally studied ecological factors. Such configurations tend to be consistent across most towns and cities, largely irrespective of their (bio)geographical location. Urban areas in general can therefore be seen as an azonal landscape type, but approaches to defining the finer sub-division of this broader type need to be developed, not least to fulfil the requirements of the European Landscape Convention 'to identify (urban) landscapes' at a resolution which is more meaningful from a planning perspective. Some interesting local examples already exist of attempts to map the urban structure or the urban biotopes of particular cities, but these tend to be based on narrower land use designations and not on broader landscape considerations (e.g. the Berlin Environmental Atlas). Other approaches aim to classify urban areas from an urban ecological point of view based on land use and land cover mosaics (e.g. Pauleit and Breuste, 2011).

The Urban Fabric and Microclimate Response project

The idea that different urban landscape types will have different microclimatic characteristics, which will affect the way in which they react to climate change and affords different potentials for the amelioration of the effects of global warming, provided the impetus to develop an urban landscape typology for the city of Vienna as the first stage of a study into the impacts of global warming on urban microclimate.

The study 'Urban Fabric and Microclimate Response – Assessment and Design Improvement' is part of the Austrian Climate Research Programme (ACRP) and took place in the thematic area 'understanding the climate system and consequences of climate change'. The ACRP-programme was funded by the Klima- und Energiefonds, of the Austrian Ministry for Transport, Innovation and Technology. Stiles et al. (2014) published the outcomes of the project in an extensive final report consisting of eight chapters written in the German language, supplemented by a summary report that was published both in German and English.

Before developing the typology, it was necessary to operationalise the concept of urban landscape in a manner that was relevant for the purposes of the project. The purpose of developing a typological approach as a starting point, was to be able to identify the various landscape types within the city boundaries, in terms of the factors which were likely to have an impact on the urban climate, and to be subsequently able to make specific recommendations for climate adaption measures tailored to the specific urban landscape types in question. While the typology had to make sense both in the context of Vienna's urban structure and in relation to the factors which are likely to influence the urban climate, it was clearly also desirable to develop an approach which could also have a wider applicability to other aspects of the urban landscape and to urban areas in general. It offers the possibility of, for example, undertaking future comparative studies of the landscapes of different European cities.

3. Method

Definition of urban landscape units

In order to be able to collect the relevant data to characterise and map urban landscapes, it was necessary first to decide on appropriate units and a scale for the study. Some studies have made use of land use maps as a basis for defining urban landscape units – the Berlin Environmental Atlas (Berlin, 2002) is a good example of this approach – but this was felt to be unsatisfactory, as landscapes are by their nature characterised by consistent mixes of different land use types and are not made up of mono-functional areas. The analogy of vegetation mapping is useful here: vegetation types can be seen as a level of organisation below that of landscapes, and these do not consist of species monocultures but of characteristic and repeated mixtures of groups of species. Much the same can be said for urban landscapes, which can be thought of as characteristic combinations of land use, built fabric and open space structure. Note: this is in stark contrast to most approaches to landscapes in rural areas, which tend to be primarily defined in terms of their 'natural' characteristics such as geology, soils, hydrology, vegetation etc. Sampling vegetation is typically undertaken using sample quadrats within which the percentage cover of the different species, together with relevant environmental data are recorded. These commonly range from one metre square for grassland vegetation to considerably larger plots for sampling forest areas. This approach has already been successfully scaled up and adapted to the landscape scale, most notably in the context of the definition of 'land classes' for Great Britain (e.g. Bunce et al, 1996). The land classes were defined by sampling land use and environmental information at a scale of 1 x 1 km across the British Isles, whereby urban areas were specifically excluded from the study, which was intended primarily as a means of structuring ecological surveys. While the UK land classification provides a valuable model for the overall approach of developing an urban landscape typology, the scale of the landscape units and the environmental and land use data used needed to be reviewed and adapted for the Vienna study.

For a number of reasons it was decided that a one quarter kilometre square quadrant (500 x 500 metres) would be the most appropriate scale at which to collect the information. To some extent the size of the landscape unit will always be a compromise between practicality and ideal optima. The size of the unit must make sense in the context of the study area as a whole and the granularity of the landscapes it contains, but it also needs to reflect the level of internal diversity to be expected. Furthermore, as landscapes are 'areas as perceived by people' the human scale and perspective was also a consideration. However, the importance of practicality cannot be underestimated, and a simple square grid could not be more straightforward and easier to work with. Seen from the scale of the city as a whole, an individual landscape unit of 500 metres by 500 metres, giving it an area of 25 hectares, allowed a sufficiently fine scale to be represented within the texture of the urban fabric of a city which has an overall area of 415 km^2, while at the same time giving a manageable overall number of landscape units within the city boundaries. Viewed from the perspective of an individual quarter kilometre square quadrant, the level of detail which could be resolved allowed individual streets, open spaces, land parcels and the buildings and open spaces within them to be easily identified and mapped. This was important, as the ultimate purpose of the study was to focus on making recommendations for ameliorating the impacts of climate change for the main urban landscape types identified, based on simulations of specific interventions in the open space structure, and these needed to be implemented at the level of the individual street or plot. Consequently, identifying the typical patterns of land use and open space which are characteristic of each urban landscape type was an important precondition for the second phase of the study. Finally, the idea of neighbourhood as expressed by 'easy walking distance' is also approximately embodied within a quadrant of 500 x 500 metres, which can be traversed on foot in about five minutes. This means that, whatever the diversity of its internal structure, it can be considered as an urban landscape unit that can be easily perceived by a person moving within it at the pedestrian scale.

Selection of attributes and variables with which to define urban landscape types

It is important to bear in mind that the purpose of this study was to look at the relationship between urban fabric and microclimate, in order to be able to make recommendations regarding the possibilities for the mitigation of the impacts of climate change. The classification was therefore not intended primarily to be a general purpose one, but one which would generate an urban landscape typology that was influenced by factors affecting urban climate and microclimate. A wide range of variables reflecting six main groups of attributes was initially considered. These were:

- (Micro)Climatic factors
- Topography
- Land use
- Buildings and structures
- Roads and streets
- Open spaces

The availability of data in a suitable and sufficiently detailed digital form for the city as a whole was clearly also an essential practical precondition to be considered, as was the need to limit the possible variables to a practicable number. The above were simplified down to four groups of attributes, which were agreed on as the basis for generating the typology. Each was represented by a number of key variables. Data relating to the following variables were collected for each of 1458 quadrants which were located fully within the city's administrative boundaries :

- (Micro)Climatic factors
  - Severity of winters (average number of days with average minus temperatures)
  - Summer warmth (average number of days with average temperatures > 20°C)
  - Summer days (average number of days with max temp > 25°C)
  - Hot days (average number of days with max temp > 30°C)
  - Hot nights (average number of days where min temp did not fall below 20°C)
  - Annual precipitation (in mm)
- Topography
  - Absolute altitude (at centre of quadrant in metres)
  - Difference between the highest and lowest point in each quadrant (in metres)
  - Vertical position relative to neighbouring quadrants (in metres)
  - Average slope gradient (in degrees)
  - Average aspect of slope (in degrees)
- Open spaces
  - Proportion of impermeable surfaces (as a percentage)
  - Proportion of vegetation per quadrant according to height classes
  - < 0.5 m (grass and perennials)
  - 0.5 – 3.5 m (shrubs and small trees)
  - 3.5 – 15 m (e.g. street trees)
  - > 15 m (individual specimen trees)
  - Proportion of water surface per quadrant (as a percentage)
  - Vegetation shadow at 3 times of day on June 21st (as a percentage)
- Buildings and structures
  - Proportion of quadrant built up (as a percentage)
  - Median building height (in metres)
  - Roughness (building height difference in metres)
  - Length of external facades (in metres)
  - Length of internal facades (in metres)
  - Length of external facades where distance to street is > 5 metres (metres)
  - Main orientation of streets in relation the main prevailing winds (NE-SW and E-W)
  - Area shaded by buildings at 3 different times of day on 21.6. (mid-summer) and 21.12 (mid-winter) (as a percentage)

These data were computed for each of the quadrants which lay entirely within the city boundaries. Subsequently a factor analysis was carried out in order to ascertain which of these variables were potentially correlated with one another. This resulted in a simplification to nine significant factors: one for climate, two for topography, three for open spaces and three for buildings and structures (see Fig 1.).

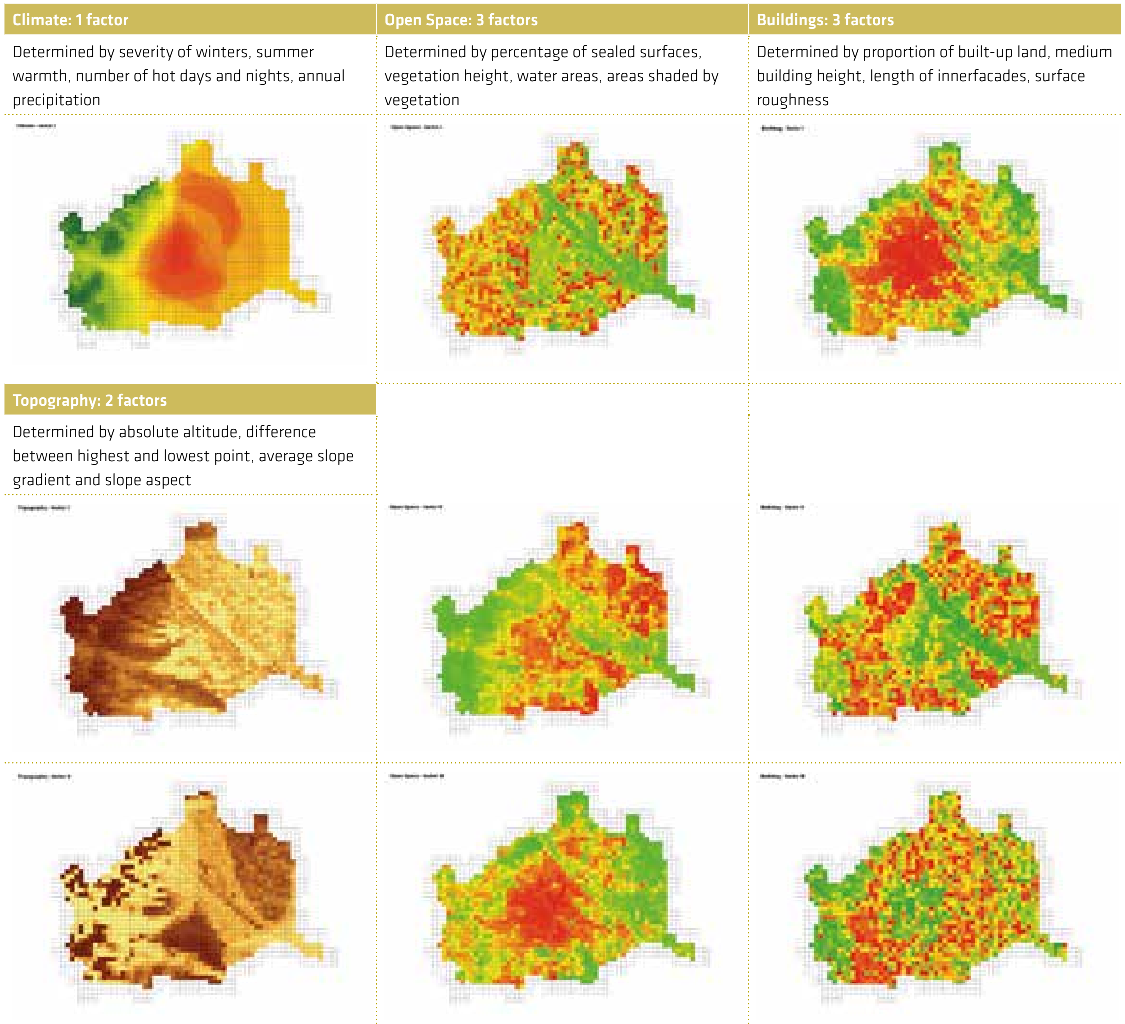

Figure 1

Results of factor analysis for the selected variables.

Finally an iterative two step cluster analysis was carried out, as a result of which the nine variables which had been identified by the factor analysis were grouped to place each of the quadrants considered into one of nine different clusters, each of which represented a different urban landscape type (urban fabric – to use the terminology of the project in question). Plotted on the map of Vienna they gave the picture seen in Figure 2. For someone who is familiar with the urban structure of Vienna, the result is immediately recognisable and convincing.

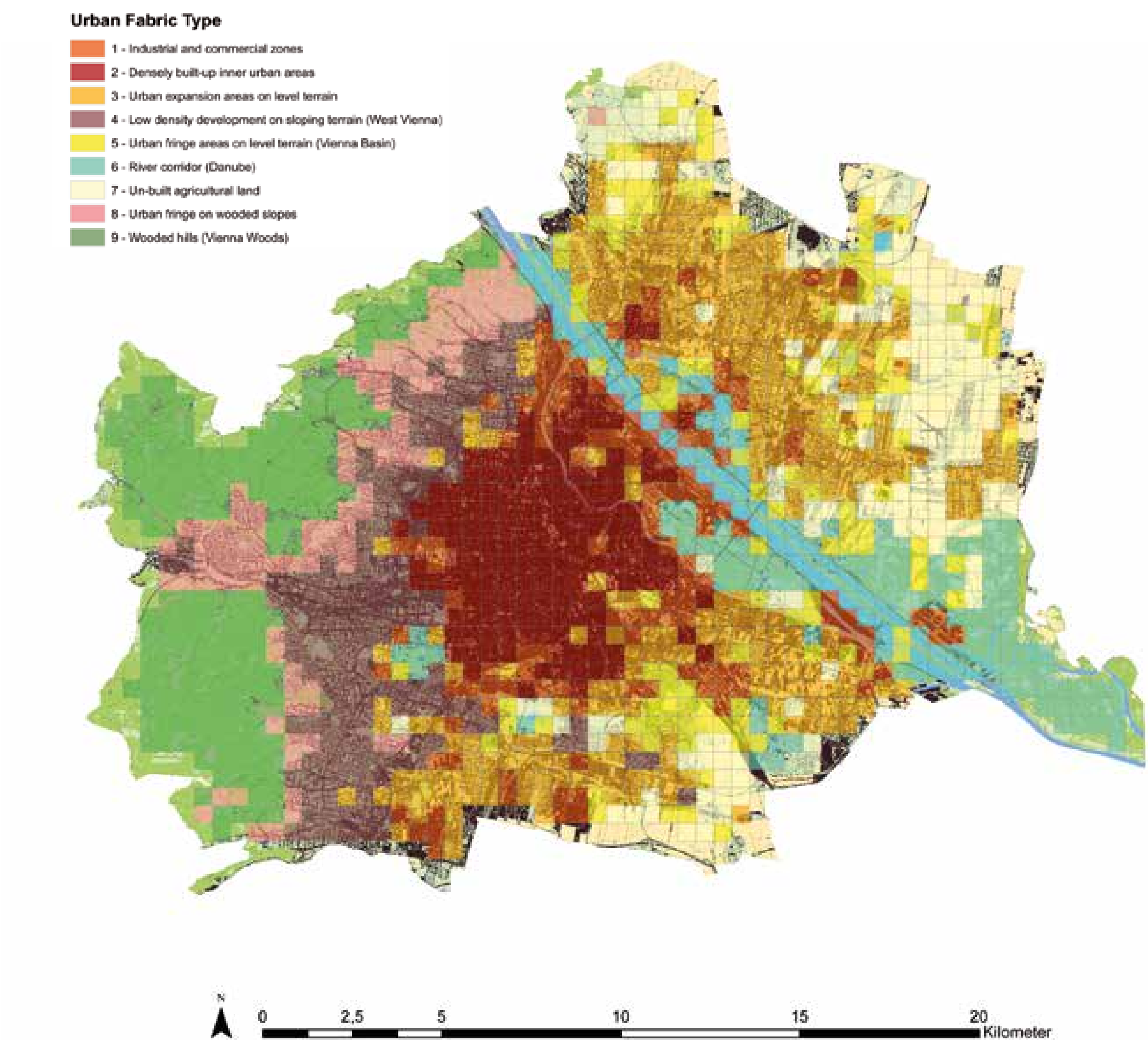

Figure 2

Distribution of the nine main urban landscape types identified for Vienna.

The urban structure of Vienna

The selection of attributes and variables on which the classification of the 500 x 500 m quadrants was based was done solely on an objective basis. Variables were selected to represent the factors which were felt to be those which would best reflect and influence the microclimate of the urban area. If the approach was to be convincing for a wider lay public, however, it was also important that the resulting urban landscape classes and their geographic distribution looked subjectively 'right' and appeared to reflect the overall urban morphology of the city which was familiar to its residents and politicians.

According to Article 2 of the European Landscape Convention 'Landscape means an area as perceived by people [...]' This can perhaps in part be interpreted as emphasising the importance of generating a landscape classification which is ideally broadly in tune with the overall perceptions of the general public. Vienna is a relatively compact city, which in fact has a very clear and easily recognisable 'image' in the sense of Kevin Lynch (Lynch, 1960).

The city's administrative boundaries roughly describe an ellipse broader in the east-west direction than in the north-south direction. This is cut through by the corridor of the Danube, which runs roughly from the centre of the northern boundary in a south-easterly direction, dissecting the city into two parts. To the north and east of the river lies about one third of the land area, which is broadly flat, while to the south and west of the Danube the remaining two thirds of the city include the historic core and the highland of the Vienna Woods which fringe the city along its western and north-western borders. Within this 'natural' landscape structure the development of the city has radiated out from a point close to the centroid of the city boundary, which lies to the southwest of the Danube. From there, on the southwest side of the river, the city has grown outwards in broadly concentric circles, with the oldest and densest development in the centre and increasingly low density and low rise building towards the edges. The north-east side of the Danube, which did not become part of the city until after 1918, has a different and much more patchy urban form comprising a series of former village centres interspersed with an infill of housing developments dating for the most part from the 1960s onwards. This area still has the greatest 'expansion' potential for the city and is also characterised by significant areas of remaining agricultural land, largely in the form of arable fields. Finally, the Danube corridor widens out towards the south-eastern edge of the city to form extensive riparian woodlands, which are part of the Danube National Park.

4. Results

The overall pattern of the resulting urban landscape classification (urban fabric types)

Figure 2 illustrates the outcome of the cluster analysis of the nine variables. The fact that it resulted in nine landscape types is a coincidence, but – as noted above – the way in which these nine landscape (or urban fabric) types are distributed within the boundaries of the city does indeed appear to capture the structure of the city, as described above, in a familiar and recognisable pattern. The western fringe of the Vienna Woods is clearly to be seen in the form of urban fabric type 9, coloured in green (where urban development is essentially absent), while the other main natural feature, the Danube corridor (class 6), also cuts familiarly across the city from northwest to southeast, broadening out to form the National Park in the southeast. The concentric structure of the built form is also clearly visible, with the dense urban core (class 2), picked out in dark red, grading out through brown, while the rings of less dense development can be seen as a dark brown (class 4) and a pink (class 8) band. Between these two groups of urban landscapes one can recognise three other classes whose distribution is slightly more difficult to interpret: dark orange (class 1), scattered broadly around the main urban core, pale orange (class 3), more recently built up areas to the east of the Danube, and to the south of the urban core, yellow (class 5), individual areas on the edges of this newer development; and finally the beige quadrants (class 7) represent the remaining areas of broadly open agricultural land to the east and south of the city.

While this pattern provided a good reflection of the familiar urban structure, and the granularity of the 25 ha quadrants respects the distribution of the landscape (urban morphology) types in an acceptable manner, it was felt that there was perhaps scope for further refinement in the context of three of the classes identified. As a result a second cluster analysis using the same method, preceded by a factor analysis, was undertaken on the three classes in question. The inner urban core (class 2), accounting for some 10% of the overall area of the city, appeared to have a coverage of an area which in fact was felt to be more heterogeneous in terms of its built form and open space patterns, than the classification currently suggested. The relatively diffuse area (class 3), broadly representing the more recent post-war development across the Danube and to the south of the old urban core, accounted for some 19% of the city, and also appeared to be a candidate for further refinement, as did the overall smaller but also diverse Danube corridor class (11% of the city), which included both the river corridor itself as well as parts of the surrounding land.

The results of this further analysis are shown in Figure 3, and the nine new sub-classes generating clearly indicate that the further subdivision of these three urban fabric types also results in a better resolution of the structure of the urban landscape. Two of these classes: 2 (urban core) and 3 (post-war development), were also seen as representing the more critical areas of the city in terms of the potential impacts of climate change, both from the point of view of the density of their built structure and, partly as a consequence, the number of residents likely to be affected. The former class 2 was broken down into sub-classes 2a, 2b and 2c. Sub-class 2a corresponded to the dense perimeter block development of the late 19th century on sloping terrain, sub-class 2b identified less dense areas of development with more open space mainly to the north and south of the main urban core, while sub-class 2c was left as representing the historic old city centre with its mediaeval street pattern. Class 3 was further refined to distinguish the main areas of post-war new development to the east and the south of the old city (3a), as well as older former village centres within this (3b) and some scattered quadrants west of the Danube with single family homes on the slopes of the Vienna Woods (3c). The last class subjected to the secondary cluster analysis, the landscapes of the Danube corridor, was able to be sub-divided clearly into two main well-recognisable sub-classes and a third which was harder to characterise and which accounted for only 10% of the cluster. The two main sub-classes (each accounting for more than 40% of the area) comprised the riparian woodlands of the National Park (6a - the 'Lobau'), and the meadows to the west of the Danube (6c - the 'Prater').

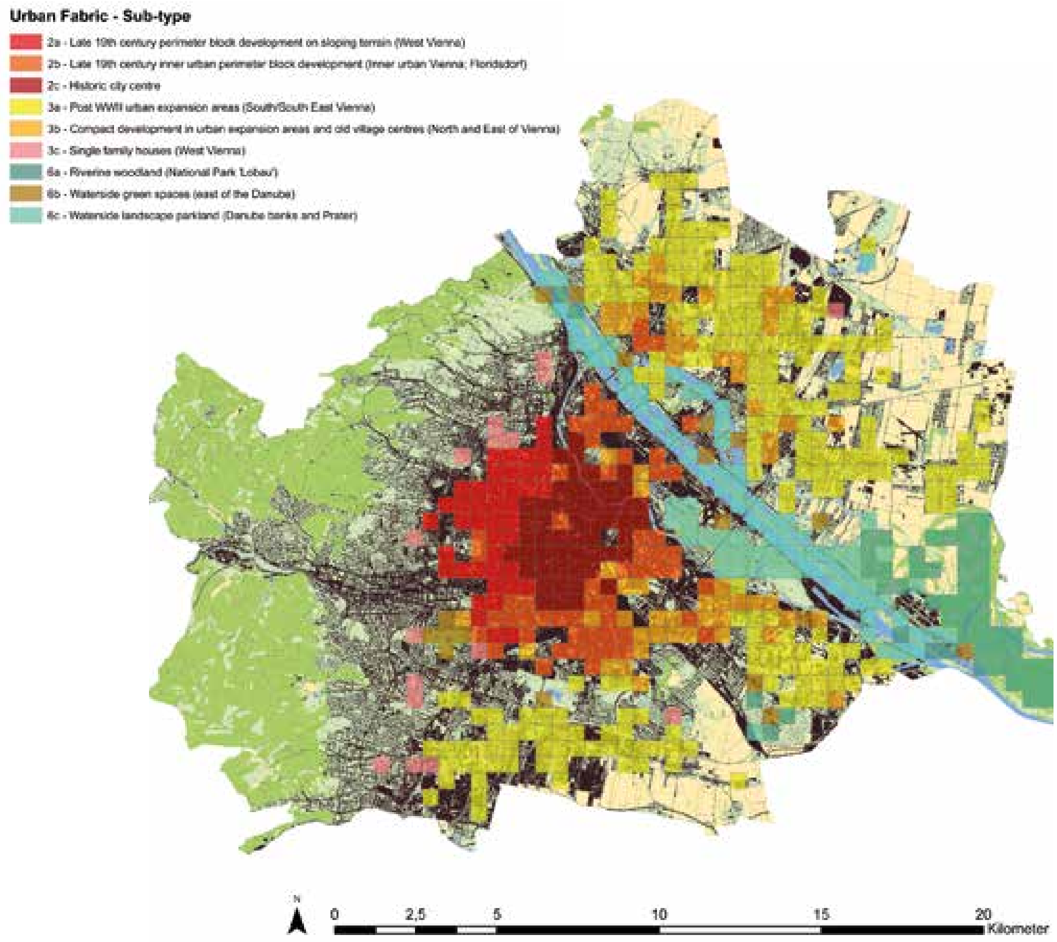

Figure 3

Further sub-division of urban landscape types 2, 3 and 6

Thus at the level of the city as a whole, the pattern of landscape types (urban fabric types) resulting from the classification was the outcome of a multivariate statistical procedure which aggregated the data felt to be objectively important to provide the best reflection of the factors likely to influence the urban climate. At the same time, however, the resulting pattern also presented a subjectively plausible representation of the widely perceived structure of Vienna's urban landscape. The next phase of the study was to look 'within' the individual urban fabric types and to characterise them in terms of their typical urban fabric and open space patterns.

Characterising the urban landscape types as a basis for simulating the microclimate

Generating an urban landscape typology is, of course, not an end in itself, but a means of better understanding various aspects of the way in which the urban landscape functions. As mentioned above, the purpose of generating the nine urban fabric types and the nine sub-types in the context of this project, 'Urban Fabric and Microclimate', was to provide a basis for considering both their existing and potential performance in microclimatic terms. This is being undertaken using the ENVI_met software package, developed by Michael Bruse and his team at the University of Mainz (Bruse, 2004). It is not proposed to go into this issue in detail here, except to demonstrate the way in which typical example quadrants of the main urban fabric (landscape) types have been identified and used to model their microclimatic characteristics.

The first step was to take the whole population of the urban landscape (fabric) types regarded as having both the most potential problems with regard to climate change and the most potential for its amelioration, and to identify 'typical' individual quadrants in each case. This was followed with a series of simulations of different aspects, both the current microclimatic conditions, including wind speed, potential air temperature, mean radiant temperature and relative humidity, as well as the perceived thermal comfort (predicted mean vote - PMV). These were modelled both for the status quo situation as well as for the evaluation of the potential impacts of a range of possible amelioration measures (see Figure 4).

Figure 4
Microclimate simulations for a sample quadrant from landscape sub-class 2b.

To identify a sample of 'typical' examples from each of the key urban fabric classes, a series of random samples were selected from each of the classes in question, the number of which depended on the overall proportion of each class within the urban landscape as a whole. These were then described in terms of their characteristic open space structure, with reference to GIS-information from a number of datasets that had not previously been available at the time the urban fabric (landscape) types had been generated. These datasets related to the actual land use, biotope monitoring data and the detailed topographic plan of the city. This information was coordinated with the corresponding aerial photographs, and a series of six examples of urban fabric (landscape) types were selected, which represented two of the main urban landscape types and four of the sub-types (see Figure 5).

Figure 5
Selected 'typical' quadrants representing two urban fabric types and four sub-types.

A total of 15 open space structures were identified across the six sample quadrants. These were found to occur in characteristic amounts and combinations in each of the urban fabric types represented by the selected sample quadrants. Having simulated a range of status quo microclimate conditions for the six typical examples of the urban landscape types identified, a series of specific micro-climatic amelioration measures were then proposed for each of the urban landscape types in question and their impacts were again simulated using ENVI_met. The measures concerned included different combinations of strategic tree planting in particular streets which had been identified as critical, the retrofitting of green roofs, as well as measures to reduce the areas of sealed surface within important areas, and to increase the vegetation cover in inner courtyards. An example of the approach taken is illustrated in Figure 6.

On the basis of the results of the simulations, specific packages of micro-climatic amelioration measures were proposed for the six urban landscape types investigated; each set of measures was prioritised and tailored to the specific conditions represented by the landscape types in question. As the urban landscape typology rather than the micro-climatic aspects of the study are the main focus of this paper, the proposed amelioration measures will not be elaborated upon in more detail here. Instead, it can be instructive to reflect critically on how effective the approach has been and to consider what future improvements may be valuable.

Urban fabric (landscape) type 2a - Quadrant 723		
Aerial photo	**Noteworthy existing issues**	**ENVI-MET Input file**
	• Hernalser Gürtel (central boulevard) cooler than the surroundings despite its extreme width • Higher relative humidity in areas of unsealed surfaces or vegetated courtyards • Inner courtyards of the perimeter block development with limited areas of sealed surfaces are effective as cooling areas • Closed courtyards with sealed surfaces heat up significantly (e.g. School courtyard to the east of the Gürtel) • Streets running East-West cause the greatest problems during the hottest part of the day	 

Figure 6

Input data for simulation of different climate change amelioration measures.

5. Discussion and outlook: Structure and function of the urban landscape

There is an implicit assumption behind the work of all planners and designers: this is not that 'form follows function' in the words of Mies van der Rohe, but that 'structure enables and indeed promotes function'. The ultimate goal of all planners and designers is, of course, to optimise the long term functioning of the environment, but they only have indirect means to pursue this goal by adjusting the structure (design, configuration, spatial organisation etc.). This suggests that in constructing an approach to define urban landscape typologies that seek to meet multi-purpose objectives, it might be preferable to separate factors which are relevant from a structural point of view from those influencing the wide range of functions that the urban landscape can potentially carry out.

The basis for the generation of the urban landscape typology that has been presented here, took the form of a hybrid between more general aspects of structure (e.g. buildings and structures and topography) and specific aspects of function in relation to variables relating to urban microclimate (e.g. annual precipitation, severity of winters). Despite this, the resulting urban landscape typology is one which seems to closely reflect the perceived morphology of the city.

The close relationship between the urban landscape (fabric) typology generated and wider characteristics of the urban landscape which were not initially used to generate the typology was illustrated by the way in which the selected 'typical' quadrants, that were chosen to represent the six landscape types to be investigated further, could also be described in terms of other characteristic open space features, such as different types of streets, courtyards, squares and green spaces, as well as other open areas including railway corridors and agricultural land. By making use of additional data sets that provided information on both vegetation types and on the general topographical features of the city, it was possible to identify combinations of types of open space and vegetation patterns which were typical for the urban landscape (fabric) types in question, thereby suggesting that the urban landscape types can also have a predictive potential. This also opens up the future possibility of this and other relevant information being integrated into the process of generating the initial landscape typology, which in turn begs the question as to what form such 'relevant' information might take.

Given the relationship between landscape structure and function alluded to above, any approach which aims to further develop and improve upon the typology described here, would ideally focus on identifying urban morphological features, represented by combinations of indicators for built structure and open space patterns, which can act as proxies for a much broader range of possible urban landscape functions than just those of influencing the urban (micro)climate considered here. Three broad groups of urban landscape functions can be identified: social and societal, structural and symbolic and biological and ecological. Ameliorating the micro-climate belongs to the last group, but – depending on how one breaks them down – it can be regarded as only one of some 12 possible functions, ranging from stormwater management and facilitating social contact to establishing a sense of place sense of place (Stiles, 2010). It can be surmised that many of these at least, might be represented by urban morphological proxies as expressed by characteristics of built structure and open spaces. This will in turn define the need to both identify these wider functions and to operationalise them in terms of possible elements of the urban landscape structure which can help to enable and promote them.

6. Conclusions

The authors place the outcomes of the 'Urban Fabric and Microclimate Response' project in the framework of the European Landscape convention. By doing so, they stress the need for a new approach for the development of typologies that describe cities as urban landscapes. The typology that was developed in the 'Urban Fabric and Microclimate Response' project should be read as such a new urban landscape typology. It considers a large number of indicators including aspects of climate as well as topography, built-up area and open space.

Data feeding these indicators was gathered for quadrants of 500 x 500 metres in the Austrian city of Vienna. A multivariate statistical procedure was used to treat the data. This resulted in a pattern of nine urban landscape types. The outcome provides the best reflection of the factors likely to influence the urban climate. At the same time the pattern presents a subjectively plausible representation of the widely perceived structure of Vienna's urban landscape.

A range of microclimate conditions was simulated for typical examples of the Vienna urban landscape types. Based on this a series of specific micro-climatic amelioration measures were then proposed for each of the urban landscape types in question and their impacts were again simulated using ENVI_met. On the basis of the results of the simulations, specific packages of micro-climatic amelioration measures were proposed for the six urban landscape types investigated; each set of measures was prioritised and tailored to the specific conditions represented by the landscape types in question.

One important finding was that the microclimate conditions showed a high level of variation between the different urban fabric types but also within individual quadrants across relatively small distances.

While the approach that was developed in the 'Urban Fabric and Microclimate Response' project has been successful and has both met the needs of providing the basis for microclimatic simulations as well as what may be seen as a proof of concept of generating an urban landscape typology, it also leaves open considerable potential for refining the approach to the generation of more 'general purpose' urban landscape typologies based on the morphological structure of the urban landscape.

Finally, if this potential is to be realised to the full extent, then it is important that the typologies identified are not just the result of 'local' patterns, but types which can be recognised within a larger context, and ideally with international validity.

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