


CASE STUDY

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Urban sprawl and growth management – drivers, impacts and responses in selected European and US cities

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Abstract

Urban growth management has become a common term to circumscribe strategies and tools to regulate urban land use in metropolitan areas. It is particularly used to counteract negative impacts of urban sprawl but also to frame future urban development. We discuss recent challenges of urban growth in 6 European and 2 US American city-regions. The paper compares the urban development focusing on a quantification of drivers and effects of urban growth and a qualitative analysis of the applied urban growth management tools. We build our analysis on findings from the EU-FP6 project PLUREL. The cities have different success in dealing with urban growth pressure - some can accommodate most growth in existing urban areas and densify, others expand or sprawl. Urban growth management is no guarantee to contain urban growth, but the case studies offer some innovative ways how to deal with particular challenges.

Keywords: Growth management, Urban containment, Regional planning, Spatial strategies, Europe, USA, Land use change, Area efficiency, Urban sprawl

Background

Around the world urban areas are growing, increasingly consuming open space [1] and Europe is no exception from this trend [2]. From 1990 to 2006 urban areas in Europe grew by ca. 15000 km² [3], an increase of urban land of half the size of Belgium within 16 years. There is a long tradition of management of urban growth in Europe, but just as the diversity in geography and history on the continent, also the issues and challenges of urban growth and its management vary a lot. However, as urban sprawl was recognized in the USA several decades ago, it is also worth while to look at how American cities have dealt with that phenomenon and how European cities could learn from the US experience. At least since the late 1980s, management of urban growth has become an important issue in the USA since the impacts of urban sprawl on environmental sustainability, quality of life and the local economy got recognized [4].

On the background of these developments the term urban growth management has emerged in planning.

In this paper we explore urban growth and growth management in 8 city-regions which were studied with in the European FP6 project “PLUREL” [5]. The six European cases are quite distinct, rooted in their diverse histories [6]: From different western planning traditions (Manchester in the UK, The Hague in The Netherlands and Copenhagen in Denmark) to new planning regimes in Eastern Europe (Warsaw in Poland), from cities with high population growth (Montpellier in France) to regions characterised by shrinkage (Leipzig in Germany). However, urban sprawl is an issue in all cases, and city administrations recognize the need to counteract it. The two US cases, Seattle in Washington State and Portland in Oregon, have experienced strong urban growth in recent decades and have been working with urban growth management for many years. Grounds for planning are different in the USA than in Europe, e.g. regarding planning responsibilities of the public sector but also settlement structure, population development and land resources. Still, problems such as sprawl and infrastructure

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costs are similar, and good tools and instruments to tackle these are rare. A comparison of the different issues and solutions across the different contexts can provide new insights on the relation of urban growth and planning policies. As this relation is depending on many factors related to the regional context, we will reflect on the challenges of urban growth and analyse the different elements of urban growth management in the eight city regions.

The term growth management originates from planning in the US in the 1970s, although the idea of controlling urban growth to optimize land use is as old as spatial planning itself. However, first with the rapid expansion of cities after World War II, uncontrolled sprawl of urban areas and the emerging paradigm of sustainable development in recent decades, growth management became an explicit goal in spatial planning in Europe and in the USA.

One of the longest established explicit growth management policies in the USA began with the adoption of Senate Bill 100 in Oregon in 1973, which established a framework for comprehensive land use planning throughout the state [7]. The implementation of this bill was due to an increasing concern over the loss of agricultural and forest land to sub-urbanisation, threatening local farming and the timber industry. Following the new legislation, state-wide planning goals were rewritten, requiring all cities to adopt urban growth boundaries. The use of urban growth management in the US increased during the 1990s. Still, besides Oregon only a few other states, including Florida, Maryland, New Jersey and Washington, require or encourage growth management and only a few metropolitan areas in other states have used such policies [8–10].

In the European context ambitions towards management of spatial development are present at all policy levels from the structural and territorial cohesion policies at EU level to the national, regional and local levels. The first urban growth management policies go as far back as to 1900 when the first green belts were designated [11], following the garden city movement as well as the preservation of green areas around major European cities [12]. Today some variety of growth management is part of a 'standard mode of operation' in spatial planning. There are however large national and regional differences regarding competences, administrative delineations, systems and public interests between different parts of Europe. Still, the need to control urban sprawl is widely accepted [13, 14]. Except for a few cities, sprawl stays a general challenge in Europe [2, 15].

Methods and case description

Our main interest are the different forms of urban growth management in Europe and the USA as applied

in the recent years. We approach this by an explorative, comparative case study of eight city regions, using quantitative and qualitative methods. Key statistics were derived from public registers (Eurostat, US Census Bureau, US Bureau of Economic Analysis) and studied together with actual land use changes, derived from the CORINE Land cover database [16] and the National Land Cover Data [17].

Planning (re)actions were studied by document analysis of plans and other written official documents supported by stakeholder interviews and previous research on the respective case. We base our study on the extensive work done during the EU-FP6 project PLUREL [5], with special focus on the following Deliverable reports:

- D2.4.1 Urban growth Management - Effectiveness of instruments and policies
- D3.3.1-D3.3.6 Regional spatial planning and decision making strategies and their impact on land use in the urban fringe
- D3.3.8 Governance patterns and performance of regional strategies in peri-urban areas
- D3.4.3-D3.4.8 Reports on enhanced planning strategies and decision making for urban fringes including scenarios for future land use development

While the first report (D2.4.1) covers all case studies included in this paper, the other reports do not include Copenhagen, Seattle and Portland. In these cities the authors undertook additional research and conducted 21 interviews with key stakeholders, including local politicians, planning officials on different levels and representatives from local NGOs. All reports are available on the PLUREL homepage (www.plurel.net), and partially published in Nilsson et al. [18].

Table 1 provides an overview of population, urban area and economic performance in the 8 city-regions. The data is hereby referring to the rural-urban region (RUR) each city is located in. The RUR includes both the 'Functional Urban Area' (zone of daily commuting), and the surrounding rural hinterland [19] and was elaborated in PLUREL for the whole of Europe. For the two US cases we have used the Metropolitan Statistical Area as defined by the US Census Bureau [20]. By aggregating the collected land use data into broad five categories (urban, other, agriculture, nature and water) a rough comparison of European and US data is possible. In all cases, urban area expanded with an annual growth rate between 0.1% (Manchester-Liverpool) and 1.0% (Leipzig-Halle, including a considerable airport extension). In the case of Seattle this meant, despite a relatively low growth rate (0.4%) an additional 800 ha of urban land each year.

Table 1 Population and urban area in the 8 city-regions

Case city	CC	Rural-Urban-Region (RUR)	Population		Urban area		GDP
			2012 (pers.)	2006–2012 (annual %)	2012 (ha)	2006–2012 (annual %)	2006–2012 (annual %)
The Hague	NL	The Hague-Rotterdam	3 552 407	0.4%	73 318	0.8%	1.3%
Manchester	UK	Manchester-Liverpool	6 570 809	0.5%	155 898	0.1%	– 0.9%
Montpellier	FR	Montpellier	1 077 627	1.2%	39 358	0.6%	3.4%
Warsaw	PL	Warsaw	3 258 938	0.5%	106 260	0.4%	6.9%
Leipzig	DE	Leipzig-Halle	1 499 876	– 0.3%	66 238	1.0%	2.8%
Copenhagen	DK	Copenhagen	1 920 263	0.8%	59 974	0.4%	2.8%
Seattle, WA	US	Puget Sound Region ^a	3 752 820	1.4%	208 106	0.4%	4.1%
Portland, OR	US	Portland Metro ^a	2 100 199	1.2%	114 877	0.2%	5.0%

^aFor the two US cases, urban area data refers to 2011 instead of 2012

The cases vary in size and population and context-dependent issues such as historical development and cultural values, geographic features, and political and administrative decisions taken at levels superior to the city or region [21] are important to consider for this comparative perspective. We cannot study all contextual aspects in detail. However, we will discuss issues regarding national planning systems and local motivations which are an important basis for growth management in the cases.

Planning responses related to urban growth management encompass a wide variety of policies, tools and goals and have been categorized in various previous studies including PLUREL (see e.g., [22–24]). We will structure our review and comparative analysis of growth management in the cases by the following key terms: (1) Urban containment visions and plans, (2) policies enhancing urban attraction and accommodation capacities, (3) policies supporting rural and agricultural structures, (4) market-based tools and incentives and (5) co-ordination between and co-operation across jurisdictions; we will structure the case review by these broad categories, while focusing on the relations between the drivers and land use change and the planning policies in the discussion section.

Growth management policies in 8 city-regions

Containing urban land use

The main goal in many urban growth management programmes is the containment of urban land, i.e. the implementation of a containment strategy through a vision or a plan. This includes often zoning regulations in the form of green belts, which are typically very tight, containment boundaries or also urban service areas, which are more loose in their character [10]. However, in practice the differences between these three strategies are not that clear and they are often used in combination.

One example of a combination of an urban containment boundary (UCB) and a green belt is Copenhagen's

Fingerplan, first developed in 1947 [25]. It proposed a future urban development of the metropolitan area of Copenhagen along five suburban railroads. The areas between should be kept free from buildings, forming green wedges and supplying the urban population with close recreational areas. The latest version, the "Fingerplan 2007" is a national directive which structures the region into 4 zones, each with different regulations for urban development. Only in the "palm of the hand" (core area) and the "fingers" urban development of regional importance is allowed. In the remaining metropolitan area only minor developments are allowed while the green wedges must be kept free from any development [26].

The classic example for the use of an UCB in the US is Portland, Oregon. The boundary was first introduced in 1979, delineating urban from rural land. The regional government is required to maintain a 20-year inventory of developable land within the urban growth boundary, which – due to the narrow delineation – is regularly amended [27]. Recent analyses indicate however, that if certain policy changes and investments are put in place, "it is possible to support the high range of demand without changing current zoning or expanding the [boundary]" [28] in the next 20 years. The Portland growth boundary is broadly accepted and even part of the city identity, much in the same way as the Fingerplan of Copenhagen.

In Washington growth management started in 1990 with the adoption of the Growth Management Act. UCBs are constituted following the same ideas as in Oregon. However, differently to Portland, the Puget Sound Region's "Urban Growth Area" is relatively broadly defined and includes a considerable share of agricultural areas. The remaining area is further split into rural areas and "Natural Resource Land", which is specially protected. Some local planners perceive this line as the real containment boundary.

In Leipzig, Manchester and Montpellier urban containment policies are implemented via green belt strategies,

i.e. green areas in the surroundings of cities are protected from urban growth. In Leipzig this is done since 1996 with the “Green Ring”-Strategy to preserve the cultural landscape around the city. The cooperation between 13 municipalities, progressive promotion to citizens via the internet, partnerships with private firms and the inclusion of recreation and cultural issues ensures a good anchorage of the strategy in the region [29]. Opposite to Leipzig, Greater Manchester’s green belt policy restricts farm diversification, landscape maintenance and rural economic activities. Its social and economic impacts are therefore questionable, not least because of the effect of urban development leaping over the green belt [30].

In the regional plan for the agglomeration of Montpellier (SCoT) the concept of “sight inversion” was used, meaning that landscapes with particular qualities were defined first to support their characteristics and protect them from urban development – similar to a green belt policy. Landscape, nature and agricultural areas, considered as city qualities, are the basis of the SCoT [31].

The Hague region is located in the agglomeration Randstad, which surrounds the Green Heart, the Dutch version of a green belt introduced in 1956 [32]. The Hague region itself is using a Regional Structure Plan to guide spatial development in the region. It is not spatially explicit; instead, the plan coordinates and implements a wide range of regional policies and plans. It is politically supported which is shown by the adoption of joint infrastructure goals for the nine municipalities, a limitation of housing outside the city and other strategic goals. The opposite of this widely integrated approach can be seen in Warsaw. Warsaw has been growing strongly in population and even more in urban area during the period of transition, with most growth taking place in suburban areas [33]. Although demanded by national law since 2003, no spatial development plan for any metropolitan area, including Warsaw, has been developed [34] and the municipalities within the region mainly plan independently. A result of this is an immense oversupply of land designated for future development in the city’s periphery [33].

The maps in Fig. 1 reveal the diversity of urban form and urban change in the 8 city-regions. The existing urban structure is of considerable importance regarding past and future transport infrastructure and potential new urban development. Copenhagen, Warsaw and also Montpellier appear more monocentric, while The Hague, Manchester and partially also Leipzig have several centres within their Rural-Urban-Region. The two US cities are very large (see also Table 1), with especially the Seattle-Tacoma agglomeration extending all along the Puget Sound coast. The maps also illustrate the changes during the past few years, which are though difficult to

see, but, as indicated also in Table 1, still of significant extent. The Hague and Warsaw experienced the urbanisation of several bigger patches. The urban land take in the other cities is less visible, but as around in Seattle of considerable volume, just spread in many smaller patches.

Enhancing urban attraction and accommodation capacities

A complementary strategy to mere urban containment is the improvement of the attractiveness and quality of life in the urban centres. Many cities implement or support urban renewal projects and install long running programmes for deprived areas. Projects are financed by public authorities often in co-operation with private home-owners or investors. Also the EU is supporting urban renewal, e.g. by the URBAN II programme, which has a strong focus on governance and learning. In Leipzig URBAN II co-financed the greening of the urban centre. Combined with other revitalisation measures it should make the shrinkage of population less apparent and the city centre more attractive and thereby counteract urban sprawl. The urban centre of Leipzig is today growing in population and reurbanising [35], however, the rest of region is lacking behind.

The huge investments in urban renewal in Copenhagen changed the city considerably during the last three decades. Besides the development of the central harbour and the new district of Ørestad through designated urban development corporations, many districts in the city centre underwent area-based renewal programmes. The city of Copenhagen is today experiencing a phase of reurbanisation [36], though accompanied by gentrification effects in some areas [37]. In Montpellier the inner city development Antigone, finished after more than 20 years in 2000, also implied a symbolic revitalisation and included attractive waterfront locations. As in Copenhagen, the new district was connected by an effective public transport service to the city [31].

Infrastructure plays an important role for urban renewal as well as for the implementation of urban development strategies. Many cities use infrastructure projects to trigger urban development in particular areas (and take pressure from others). In Oregon the principle of “transportation concurrency” demands on a state-wide basis, that any needed transportation infrastructure has to be in place or secured when an area is developed. In the Copenhagen region urban development is closely tied to the accessibility of public transport by the so-called “station proximity principle” which restricts offices above 1500 m² floor area to be located within 600 m of a railroad station.

Zoning and land use planning in general are common measures to influence urban form – and are much cheaper than e.g. infrastructure development. However,

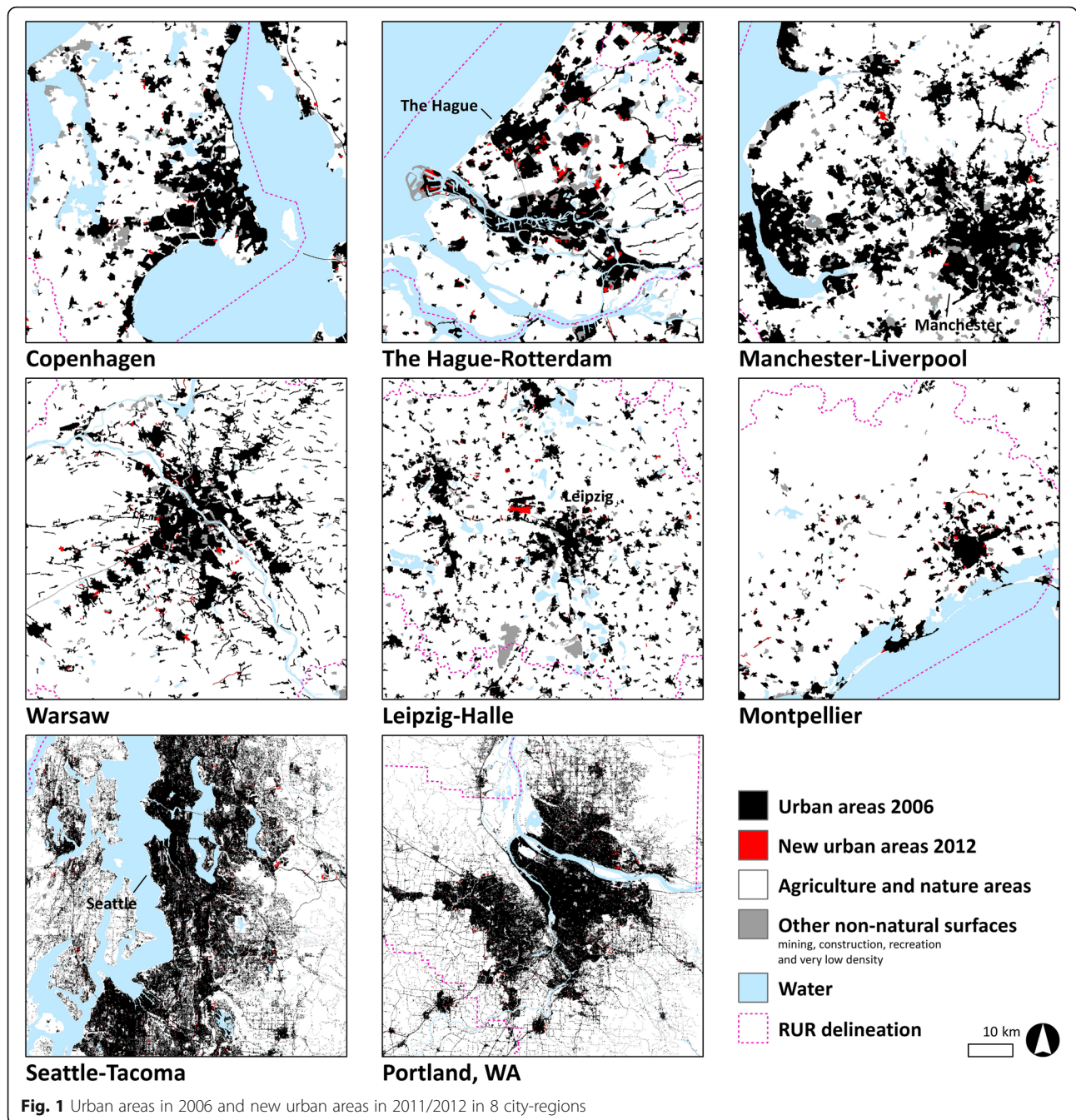


Fig. 1 Urban areas in 2006 and new urban areas in 2011/2012 in 8 city-regions

they require a great deal of law enforcement and commitment to be useful in growth management. Besides rules for the location of certain land use, (re)zoning (e.g. regarding density allowances) can be used to shift urban pressures. The Seattle “Urban Village Strategy”, running since 1994, proposes a polycentric development of the city whereas several existing areas were rezoned to higher densities and mixed use development. Seattle has a great potential for densification because 65% of Seattle’s area is zoned as single family residential area. Opposite to typical urban renewal projects, the

depicted areas are not deprived, but relatively well functioning suburban areas. The specific plans for densification are to be provided by the local governments in dialogue with the citizens. A recent evaluation [38] attested that 75% of all new housing sprang up in the designated urban villages in the past 20 years. A less spatially explicit, but nevertheless strongly committed goal was adopted in The Hague Region. The nine municipalities agreed to the joint objective to construct 80% of all new buildings within the existing urban fabric [32].

Urban renewal projects, infrastructure upgrades and urban design measures were traditionally not developed to hinder urban sprawl. However, in many of the cases they are integrated in a general urban development strategy, supposing to take development pressure away from green fields and supporting reurbanisation tendencies. In the US the term “Smart Growth” is a typical metaphor for this way of thinking.

A simple indicator for this development is to look at densities. Figure 2 illustrates the average number of inhabitants per hectare urban land use in the eight city-regions. Densities reach from about 18 inhabitants/ha urban land in the two US cases up to almost 50 in The Hague-Rotterdam. Still, looking at the development since 1990, the ratio decreased considerably in the region, caused by a strong increase of urban area but only a minor increase in population. In Warsaw and Leipzig similar effects can be observed for the 1990s. However, the two cities also illustrate different impacts of the transition from socialist to market economies. The urban sprawl around Leipzig was very much driven by public policy and support for home ownership from the early 1990s, while in Warsaw suburbanisation was driven by a only slow renewal of the inner city and a later economic revitalization [6, 39]. In general, despite the Leipzig-Halle case which still faces population decline, we can speak of a densification or at least a decrease in dispersion in all cases in the most

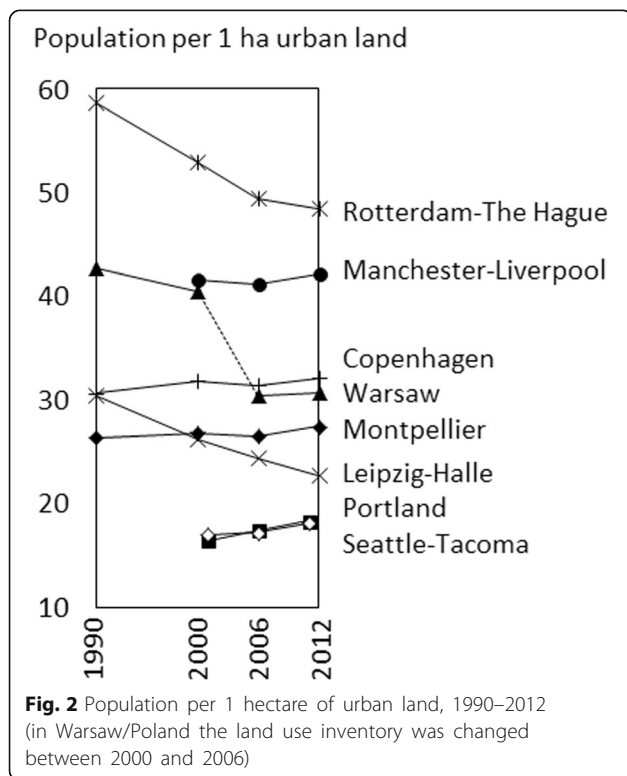
recent years, opposing a general trend of urban dispersion in Europe over the last decades [2]. Also the two US cases, Portland and Seattle, became denser over time; they also have the biggest potential due to the historically very low density.

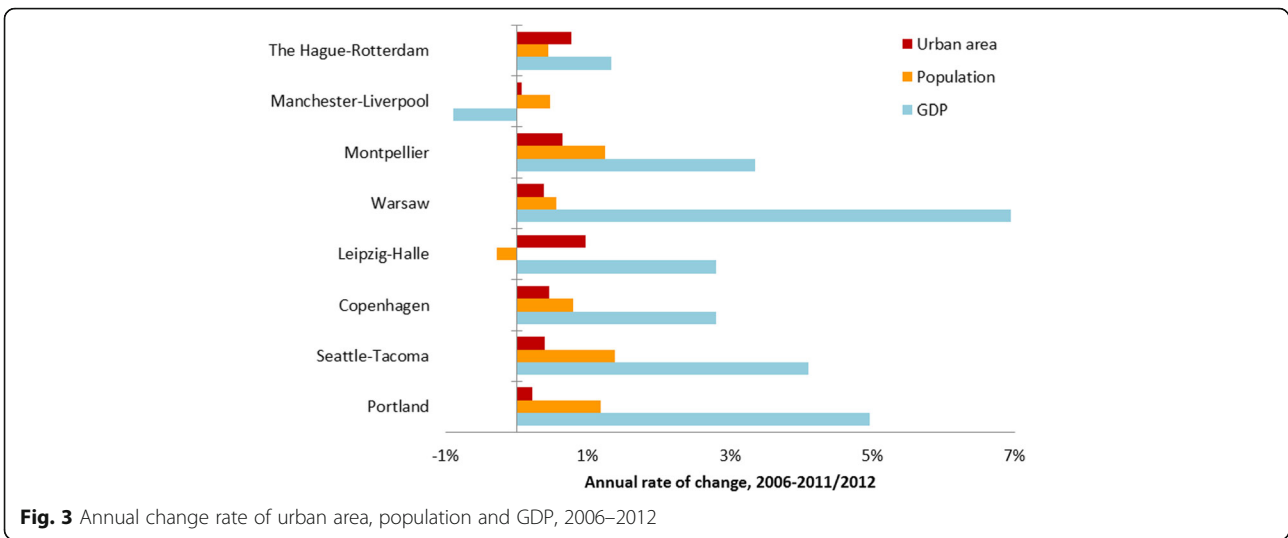
Urban areas include not only urban cores and residential areas but also commercial areas as well as transport infrastructure as ports and airports. It is therefore remarkable that The Hague-Rotterdam, despite the port area of Rotterdam, which serves a huge hinterland, still has the highest density of the eight regions. But also some of the other regions have big ports or airports, especially the two US cases. Leipzig-Halle has extended its airport considerably in 2008, contributing to an increasing urban land take despite stagnating population numbers. Figure 3 compares the most recent change in urban area, population and GDP in all eight cases. Also this figure shows a trend towards densification, at least compared to the general trend of urban dispersion the years before, where urban land grew twice as fast as population in Europe and the US [5]. However, we cannot derive obvious relations between the three indicators based on the eight cities. Still, despite of Manchester, economic growth seems to be an important driver for urban growth in all case areas.

Supporting rural and agricultural structures

Rural areas close to urban agglomerations are considerably different from remote rural areas. E.g. farms may be smaller and more diversified, and full time farming and increased farm sizes is potentially rendered economically unviable at the urban fringes because the land rents are higher than production outcome [40]. In some areas, policies go towards promoting increased farm sizes and thus competitiveness (e.g. the Netherlands), while in other cases (e.g. Denmark) the trend goes towards more “urbanized” part-time farming activities [41].

Rural development in Europe is influenced to a great deal by the EU’s rural and agricultural policies and therefore can only be influenced to a minor degree by regional and city authorities. However, the funding is typically administered by national or regional bodies and some regions also combine the funding with other programmes for rural development. The rural development plan for Greater Manchester supports agricultural activities by adding value to products through the processing and diversification of the rural economy. In The Hague Region, the “Green-Blue-Service” initiative supports the creation of ecosystem services by strengthening sustainable agriculture. Farmers get compensated for the provision of ecosystem services. The funding comes from neighbouring municipalities and even from private sources, which shows the wide awareness of having functioning rural areas close to towns in the region.



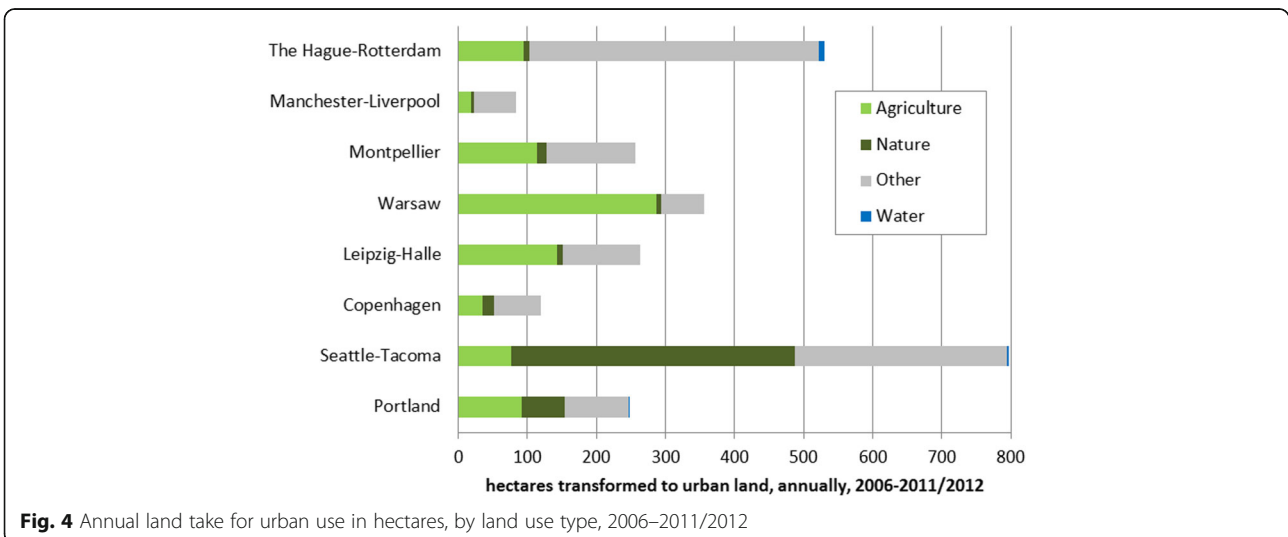


Activities eligible for funding include nature protection, preservation of rare livestock, historical buildings and educational activities [32]. However, the subsidies often cannot compensate for the increase of land rents due to urbanisation pressures which is a real threat for farming in peri-urban areas [40].

Land use regulation in the form of zoning, subdivision or protection acts are therefore important instruments regarding the support of rural and agricultural structures in urban regions. Provided that the rules and plans are clear and can be effectively implemented, it can prevent urban development and avoid speculation on land. The land use regulation of rural land is thereby usually integrated in an urban containment strategy. In Oregon and Washington specific regulations were added to protect against urbanisation of rural land: The size of housing parcels in rural areas has considerably increased in recent decades, and in Oregon “Exclusively Agricultural

Land Use” areas were designated which require a minimum lot size and a minimum income from agricultural activities. The latter is sometimes undermined by using high value crops where a few hectares are enough for the income while the housing unit is rent out or sold. There are also a number of exceptions as e.g. the development of second homes. Exceptions are also a problem in many other regions as e.g. in the Warsaw region the local level can easily give dispensation from the land use plans.

Figure 4 shows that agriculture is in many regions the main land use which was lost to urbanisation. Only in Seattle the majority of urbanised land was nature before (forests, wetlands, semi-natural areas). However, the share of nature lost annually was only 0.3% of the total nature land cover in the region, while 0.6% of the agricultural area was lost. In this sense, agricultural area is still the most threatened land use type. In The



Hague-Rotterdam nature areas experienced even a net growth, while, agricultural areas were reduced by some 2% with about a quarter of it going directly into urban use, the rest of it transformed to nature or other areas. ‘Other’ areas comprise in the European cases mainly recreation (golf courses but also summer houses), mining and construction sites – at least the latter would be a typical category, as also seen in Fig. 4, to be transformed into urban areas over time. However, the percentages should be taken with a grain of salt as they depend on the delineation of the wider region. In general, though, pure nature areas seem to be less endangered by urban growth. A reason might be that agricultural areas are more dominant in proximity to urban centres than nature areas, which moreover may tend to be protected.

Market-based tools and incentives

Market-based mechanisms are often seen as having great potential to shift development pressures and to contain urban growth. However, they are not widely used, often only for particular, time-restricted projects. Nuijs et al. [42] name three economic tools which are used to contain growth: Taxes, subsidies and transferable development rights (TDR, sometimes also called transferable planning permits, TPP). Taxes and subsidies are usually subject to national legislation and are harder to employ for a specific problem. They are however important for the general conditions for urban growth and the functioning of the planning system. TDRs instead can be applied to specific areas or regions. Among our case studies they are only used in the two US regions.

TDRs are market-based programmes, allowing to separate and trade the right to develop a certain piece of land in a free-market system of willing sellers and buyers [43]. The property receiving the development right usually gains an additional allowance in built-up density, while the sending site will be preserved through a conservation easement. Besides the income through the sale, sending site owners often also profit from a reduced property tax.

In Portland a few TDR programmes were designed for specific areas. Additional development in some areas was allowed in 1991 and 1996 in return for the preservation of important open spaces [44]. In a current TDR programme parts of the major urban greenway, the Willamette River Greenway are to be preserved in exchange to additional building densities. In Seattle TDRs are used in all four metropolitan counties. Activity is very dependent on the general economic growth, dropping to zero transfers in 2008 in King County [45]. Receiving sites usually gets a higher density allowance than taken from sending sites. However, the programme expands slowly and in 2011 a “Regional

TDR Alliance” was formed to coordinate the trade within the whole metropolitan region.

The use of TDR is not widely spread in Europe, though its potentials are discussed [46, 47]. One reason might be that many local administrations are more actively purchasing and thereby controlling land in Europe than in the US. E.g. in the municipality of Køge in the southern part of the Copenhagen region, agricultural plots considered to be transferred to urban land use are almost always bought by the municipality and prepared for development, before they are sold to private investors. In the city of Copenhagen, the new metro was financed by selling the plots in the new development area of Ørestad.

Dutch municipalities can borrow money from the national government to cover the costs of land acquisition and servicing. In The Hague Region land purchasing is mentioned as successful strategy to prevent areas from urbanization [32]. It implies public compulsory land purchase, followed by the development of recreational functions or leased at long term by farmers for agricultural use. The difference between the lease price and the actual interests will be paid by the public, who instead stays in “control” with the land. It is thus heavily based on public funding, and probably only viable in areas where it is of essential public interest to protect certain areas of agricultural land. However, as agricultural land is very scarce in the region and important for recreation and ecosystem services, it is an effective policy in the case area. But also in our two US cases land purchase was used to protect natural areas [44].

Several other public measures can function as economic incentives by changing the value or economic potentials of land, including infrastructure development or the inclusion/exclusion of certain areas in an urban development plan. E.g. in Portland the designation of urban and rural reserves for the next 40–50 years was done to provide investors with a better outlook – and incentives or disincentives for development. Such policies are also related to the issue of increasing the attractiveness of the existing urban area as discussed in one of the previous sections.

We do not have data directly related to the impact of market-based tools and incentives. However, a related land use proxy is land fragmentation, as an expected result is a more efficient use of land. Looking at the characteristics of the new urban areas established between 2006 and 2011/2012 in the 8 cases, we can see quite a different pattern between them. Table 2 shows the number of new patches and their size. As a proxy for fragmentation, we calculated the number of patches which got established adjacent to existing urban areas which were at least the same size as the new patch (the latter to include urban extensions of small rural towns).

Table 2 Statistics on new urban patches, 2006–2011/2012

Rural-urban-region	Total no.	Total size (ha)	Avg. size (ha)	Patches adjacent to existing urban area and smaller than it		Change of Shape Index
				(by count)	(by area)	
Copenhagen	47	719	15.3	96%	96%	.42%
Leipzig-Halle	70	1582	22.6	64%	68%	.89%
Manchester-Liverpool	15	504	33.6	93%	78%	.04%
Montpellier	137	1541	11.2	87%	85%	.04%
The Hague-Rotterdam	117	3183	27.2	92%	94%	–.25%
Warsaw	125	2131	17.1	77%	81%	.18%
Seattle-Tacoma	1861	3985	2.1	93%	93%	.50%
Portland	580	1235	2.1	94%	94%	–.08%

We also calculated a global Shape index describing the perimeter of all urban areas in relation to their size. The index was calculated with the software tool ‘Map Comparison Kit’ [48]. In Table 2 the change of the index is shown: The higher the increase, the more fragmented urban areas developed. According to the Shape Index, the biggest fragmentation took place in Leipzig-Halle, while The Hague-Rotterdam got a more compact urban form. However, the changes are not very big, not least because it is a global index.

The numbers only indicate general patterns and have to be interpreted with caution across cases because of different base data. Furthermore, they do not tell about some case specific land use change characteristics. For example, in the Warsaw region some of the biggest patches are new single-family housing development areas (e.g. 20 km south-west of Warsaw near Kozaków and near Książenice) which could be defined as urban sprawl. In the Leipzig-Halle region some of the biggest new patches, which were not adjacent to cities, are new photovoltaic power stations or solar parks (e.g. south of Brona, north and south of Roitzsch, east of Ermlitz). About 20 km east of Leipzig the solar park “Waldpolenz” with almost 140 ha got established, though, on a former airfield and therefore not included in our change statistics. In the Manchester-Liverpool region, a big new patch is the Daresbury Park Hotel & Spa in Warrington about 30 km south-west of Manchester. The small average patch size in the two US cities is caused by a different mapping method of changes, where many new patches are a transformation of former very low density areas or small extensions around the existing urban patches.

Co-ordinating and co-operating across administrative boundaries

Urban growth pressures seldom stop at administrative boundaries. Inter-jurisdictional cooperation is therefore essential in growth management [24]. The cases and literature [23] show that at least three conditions must be

fulfilled to carry out efficient planning and ensure a balanced development: There must be a legal body with regional competences; there must be compliance between different levels of planning; and there must be consensus on a strategy and will to carry it through.

In most of the cases special regional administrations exist, though in very different forms regarding representation, purpose, competences, budget and spatial coverage. Typical are associations of local authorities as “Haaglanden” in The Hague Region or the “Puget Sound Regional Council” (PSRC) around Seattle. In Manchester, after more than 20 years of voluntary association, the “Greater Manchester Combined Authority” was established in 2011 and from 2017 it will have an elected mayor. Some are moreover equipped with budget and delegated competences from the national/regional government as the “Montpellier Agglomeration” or the “Regionalplanungsverband Leipzig-West Sachsen”. Another type exists in Portland, where the metropolitan council members are directly elected. In Copenhagen the regional authority “HUR” was abolished in 2006 and replaced by an elected regional council which however has only very limited resources, so regional planning in Copenhagen was moved to the national government. In the Warsaw region, where the regional authority of Mazovia is responsible to take charge of regional planning since 2003, no steps were undertaken yet [34].

Also the spatial coverage of the regional bodies is quite different. The regional bodies of urban agglomerations in France (as Montpellier Agglomeration) do not always cover the outer part of the peri-urban areas, which are therefore “out of regional control”. In rural areas, a SCoT is not to be prepared, and like in the case of urban growth boundaries in Portland and Seattle, this may lead to leap-frog development. The Rural-Urban Regions (RUR) used for the analysis of land use changes in this article, are usually far bigger than the existing regional bodies responsible for growth management. So the growth management efforts might have the problem to

go not far enough in geographic terms and thereby push development to places outside of the region.

Another important issue besides the form of representation and the spatial competences is budget. Especially for the purpose of land purchase to preserve certain areas from urbanisation, adequate financial resources are essential. The regional authority of Portland co-finances its activities by the disposal of solid waste services. Just as the PSRC in Washington, it is also the official Metropolitan Planning Organization, which means it allocates the federal infrastructure money in the region. Furthermore, as written in the previous section, the city funds big land acquisitions by bonds. Many of the other regional bodies have a budget for the implementation of various activities. Often though, like in The Hague Region, the power is based on the municipalities taking part in the regional co-operation. In this way the decisions should be anchored within the municipalities, but on the other hand it might be difficult to push the strategies in directions which some of the partners do not like.

In all cases there are demands or expectations of compliance between planning levels. However, local municipalities decide the legally binding land use plans, and in some cases municipalities have a considerable freedom within the regional framework – which is usually also intended. More generally we can distinguish two issues relevant for growth management. The first one is the already mentioned top-down compliance, i.e. the grade to which overall visions and plans are taken into local level planning. In the Warsaw region this is a big problem because the competences of the regional level are unclear and the local level has the possibility to give building permissions on demand. The other issue – which is supporting the first one – is the participation of the local level in the vision or strategy making process. A joint strategy making may improve the local levels' commitment to the regional vision considerably, though sometimes at the cost of a very stringent plan [49]. Clear visions and strategies seem to be a key to successful

compliance between the different levels of administration in our case studies.

Discussion and evaluation

The relationship between pressures of urban growth and growth management efforts

The eight cases face diverse urban growth challenges and approach them also differently. Table 3 summarizes drivers and main policy themes in the cases. In the last column the major effects of urban sprawl are summarized, based on the indicators presented in the results section. As there are many contextual as well as data issues affecting the indicators, we evaluate them only in categorical terms. Following that there are three regions which experience no or little sprawl and five which have some negative development in one or more of these indicators.

Manchester, Copenhagen and Portland are in the first group. Besides Manchester, they all experienced strong growth in population and GDP between 2006 and 2012 which put considerable urban development pressure on the regions. All three have a strong focus on containment in their growth management and experienced a relatively low increase of urban areas. In Manchester and Copenhagen, but also in The Hague, over 90% of the new urban patches were developed adjacent to existing bigger urban areas. The US cities reach similar levels. This, however, has to be seen in the light of the relative fragmented existing urban area (most new urban areas are infills) and the different basis data with other mapping units.

The second group, Montpellier, Warsaw, The Hague, Seattle and Leipzig, is quite diverse. Different combinations of drivers can be found. Leipzig had the special situation with a shrinking population (although the urban centre is reurbanising), which is decreasing land and infrastructure efficiency. The focus of growth management policies also varies more in this group and includes containment, attraction and rural preservation. Market-based tools and incentives are only regularly

Table 3 Summary of significant drivers, policies and impacts in the eight cases, 2006–2012

	Main drivers	Main growth management policies	Urban sprawl effects ^a
Manchester	Population	Containment, rural preservation, co-ordination	little
Copenhagen	Population and economy	Containment, attraction, co-ordination	little
Portland	Population and economy	Containment, attraction, co-ordination	little
The Hague	Economy	Attraction, rural preservation, co-ordination	Expansion, weak area efficiency
Montpellier	Population and economy	Containment	Expansion, small patches
Warsaw	Economy	Co-ordination	Expansion, leapfrogging on agricultural land
Seattle	Population and economy	Containment, market incentives, co-ordination	Small patches, leapfrogging on nature areas
Leipzig	Economy, (Population)	Attraction, rural preservation	Weak area efficiency, leapfrogging

^aRelative to its own urban structure and the other cities

applied in Seattle with a regional TDR-system. Although in all of these policies the co-operation aspect is important, only a few actively use it in a broader perspective as e.g. The Hague with its deep co-operation between the 9 municipalities.

Our small sample does not assert any pattern regarding urban growth and growth management. Neither does strong population or economic growth necessarily lead to (relative) dispersion (Copenhagen, Portland), nor is urban growth management a guarantee to avoid it (Montpellier, Seattle). Also, urban sprawl does not automatically trigger the establishment of strong growth management, even if the problems are recognized (Warsaw). On the other hand, Manchester, Copenhagen and Portland seem to successfully condemn urban dispersion and their urban growth management policies can be considered making an important contribution to that. However, further knowledge of the context is necessary to evaluate the influence of the growth management policies.

Context related differences

A regional driver like population increase can result in very different pressures, related to historical, geographical or cultural settings. E.g. the increase in population in Seattle, which traditionally is characterised by low density and one-family housing, puts a different pressure on land development than the same population increase in Montpellier, where denser structures are more common. But we can also see some 'extreme' disparities between average population per urban land in a city and most recent land consumption. For example, The Hague-Rotterdam had the highest inhabitant per urban area ratio of the eight cities with around 50 inhabitants per hectare in 2012. On the other end of the scale are Seattle and Portland with 18 inhabitants per hectare (see Fig. 2). Still, looking at the incremental change, i.e. the ratio of new inhabitants per new urban area from 2006 to 2012, The Hague-Rotterdam had a rather low 28 new inhabitants per added urban ha 2006–2012, while in Portland this was 97. This also illustrates the different conditions and possibilities in the regions, assuming that a city with low density like Portland has considerable potential to densify its existing urban area, while in The Hague the only option is expansion, reaching limits in terms of 'sustainable' levels of density [50]. Still, in Manchester, the number even gets as high as 304, indicating that much population increase must have taken place in renewed existing urban areas, probably taken place in former industrial areas.

Besides these region-specific contexts, the administrative and governance system in the countries is of crucial importance regarding conditions for and potentials of growth management policies [51]. This includes the legal framework and thereby especially the planning law as

well as the allocation of responsibilities for spatial planning [52]. The legal framework also includes legal plans from higher levels. In most of the case studies some kind of national planning strategy exists, that regional and local planning has to comply with. However, those are often very loose regulations, seldom spatially explicit. In the smaller countries though, we can see more direct involvement of national planning at local level. Another issue which can be very different in the cases is the institutional fragmentation. For example, Washington and Oregon both consist of several counties, which are further divided into self-administered municipalities and 'unincorporated' land, directly governed by the county. Several sector policies are often delegated to special districts, which are independent governmental units. The area covered by these districts does not necessarily coincide with other administrative boundaries, which is, together with the dispersed responsibilities, an obstacle for comprehensive planning [53].

Approaches to growth management

The basis for growth management in most cases is some kind of urban containment plan or simplified vision. Several of them only deal with few ideas and distinctions – such as Copenhagen with four, Montpellier with three and Portland even with only two categories in the plan: urban or non-urban. They are thus easy to grasp, but they do not deal in any detail with existing urban structures or topography. This often leads to a number of amendments over the years. In Portland, for example, the very rigid boundary approach was now extended by a more long-term and flexible element of "urban reserves". Seattle instead implemented a very generously laid out containment boundary, but tries to concentrate growth around growth poles. One could say that Portland and Seattle have become more similar in their approaches in recent years, trying to find a balance between flexibility vs. a boundary set in stone.

The other type of growth management deals more specifically with place related problems and priorities like in The Hague. They are more complex and perhaps more useful for prioritizing. But they are less iconic and might rather be seen as a registration of the current problems and values than as a vision for the future of the urban region. In that case it can be more difficult to gather political will and the citizens' commitment to support the plan. These are however crucial in fragmented administrative conditions with many local authorities. In Copenhagen the early and clear vision of the principles for urban development with the first Fingerplan from 1947 has probably stimulated a relative consensus among planners and politicians of the necessity of regulating urban development and how the city should grow.

Regarding other policies to support the general goals, supporting urban attraction are among the most used ones. Although they fulfil a lot of other goals, they should be considered as important parts of urban growth management. By making inner-cities more attractive, these policies take pressure from the urban fringe. Rural policies are in particular used to preserve cultural heritage and provide recreation functions. The European Structural and Agricultural Policies are important sources for funding of these activities, as can be seen in The Hague and Manchester.

In general, we can assert that the integration of different policies is less developed in the two US cases. The different tools – be it a containment boundary, a TDR or an infrastructure establishment – have often one single particular purpose. However, with the adoption of long term strategies in recent years, the two cities also integrate their policies more. However, as we can also see in the European cases, integrated policies often get very complex and difficult to evaluate in detail.

Conclusions

We explored urban growth in terms of land use change and the use of growth management to steer it in six European and two US city regions. How urban growth is manifested in each of the regions depends very much on the regional context, including historical, geographical or cultural factors. We discussed some of the issues regarding different urban form as well as the political and legal framework for spatial planning. More details on some of the cases which go beyond this study can be found in Nilsson et al. [18], while this paper focuses on main tendencies across these cities. Despite local variation, urban sprawl is still a major challenge for them. Some cities experience strong population or economic growth, putting a high pressure on urban development. However, also cities with less growth are experiencing urban dispersion along with increasing per capita land consumption.

A dense built-up area like The Hague has less potential for densification of its existing urban area, than a city characterised by many low density areas or former brownfields like Seattle. This trend might lead to a harmonization of urban density between the two types of cities in the remote future, but there is still a huge gap regarding consumption of urban area with below 20 inhabitants per hectare of urban area in Portland and Seattle opposite to 50 in The Hague-Rotterdam and more than 40 in Manchester. The areas relatively most under pressure from urban growth are agricultural areas close to the city, while pure nature areas are less endangered by urban growth.

All the case city administrations have recognized the problems with urban sprawl and are working with urban

growth management – though not always depicted as such. Copenhagen, Portland and Manchester experienced least effects of sprawl between 2006 and 2011/2012 despite some development pressures. They all have a strong focus on containment in their growth management. Other cities focus on urban attraction and rural preservation. Market-based tools and incentives are only regularly applied in Seattle with a regional TDR system.

A major issue for growth management policies in the eight cases is to find a balance between a firm delineation of urban areas and a certain flexibility for future development. Some cities implement therefore only general guidelines for urban growth at the regional level, keeping some flexibility for the local level. Portland determined urban reserves to increase the flexibility of its containment boundary. A crucial basis for that is a common vision for future development. Simple and iconic spatial visions like the green belts of Manchester and Leipzig or the Fingerplan in Copenhagen are possibilities to gain support from stakeholders and citizens, though place-specific regulations should be used to anchor and implement the vision locally. A policy mix of economic and planning policies and the right cooperation within and between levels seems to be effective in implementation of regional visions.

Authors' contributions

All authors read and approved the final manuscript.

Competing interests

The authors declare that they have no competing interests.

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