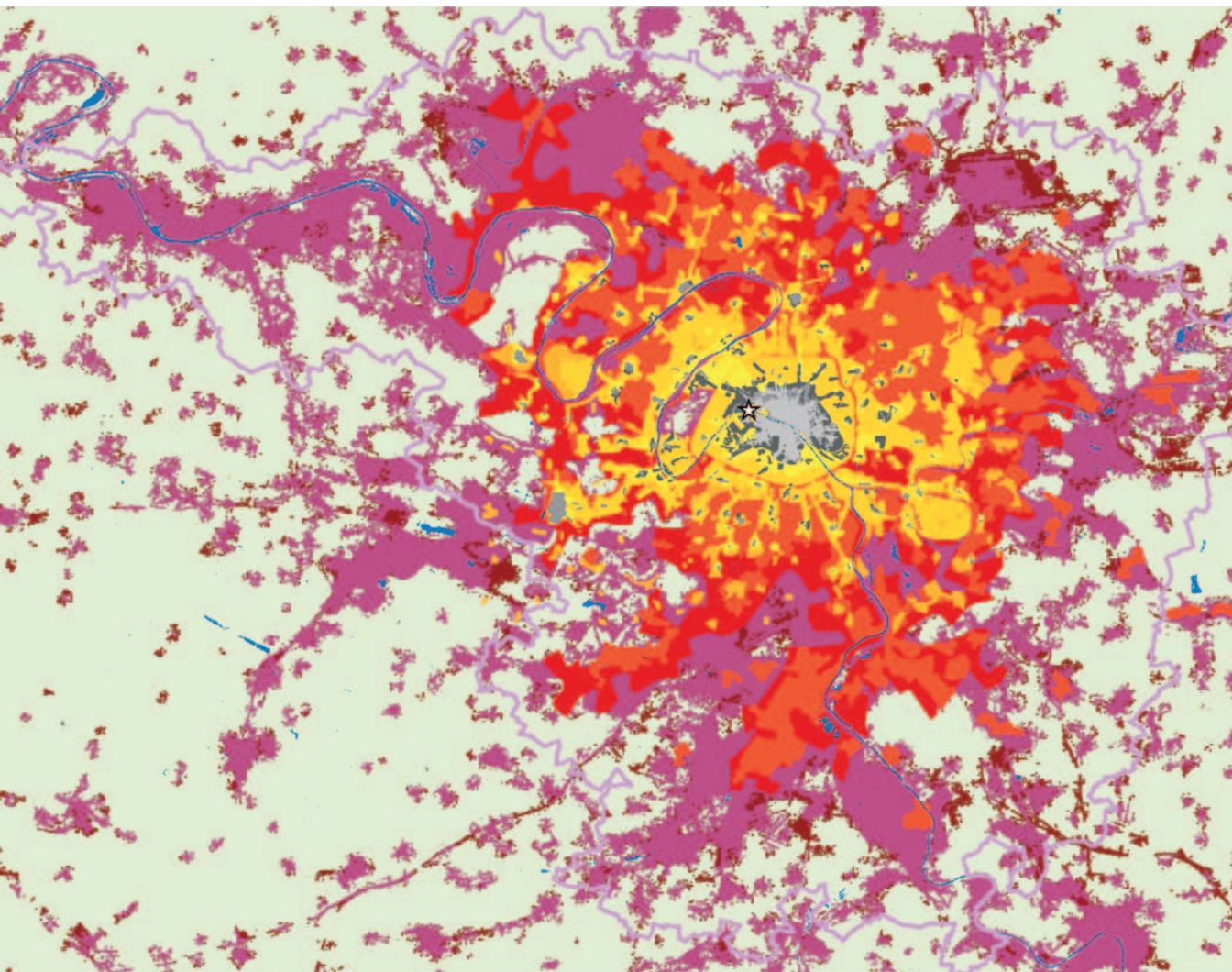


Atlas of Urban Expansion



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CHAPTER 1

The Dynamics of Global Urban Expansion

Our planet is becoming a planet of cities. By 2010 more than half of the world's total population lived in cities, and this share is expected to increase to 70 percent or more by 2050. The world's urban population is expected to increase from 3.5 billion in 2010 to 6.2 billion in 2050, and almost all of this growth is expected to take place in less-developed countries. Cities in developed countries will add only 160 million people to their populations during this period. Cities in the developing countries will need to absorb 15 times that number, or close to 2.6 billion people, thereby doubling their total urban population of 2.6 billion in 2010 (United Nations Population Division 2010, files 2 and 3). Given the expected decline in urban densities, these cities are likely to more than triple their developed land areas by 2050.

Increased global awareness is needed to better understand and plan for this massive expansion of cities in developing countries. Local and national governments, civic institutions, international organizations, and concerned citizens will need to advocate for and implement at least minimally adequate preparations. For example, it is vital that cities acquire the rights-of-way for arterial roads that can carry public transport and trunk infrastructure and protect selected open spaces from encroachment in advance of the coming expansion (Angel 2008a; 2008b; Angel et al. 2011).

The main objective of this atlas is to increase awareness and help residents, policy makers, and researchers around the world come to terms with the expected global urban expansion in the coming decades. This call for action is timely because the urbanization process now underway will be largely completed by the end of the twenty-first century. Most people who desire to live in urban areas will already be in them by 2100, but by that time it will be too late to act. If the land required for public works or public open

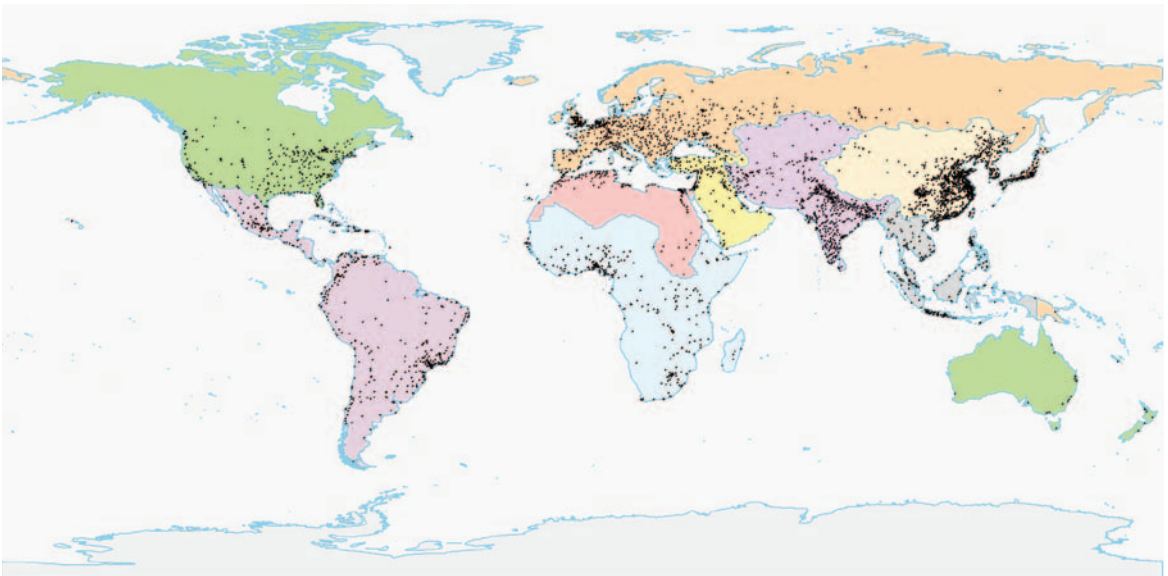
spaces is not protected from encroachment before it is developed, it will be next to impossible to ensure the orderly development of cities to make them more efficient, more equitable, and more sustainable.

THE UNIVERSE OF 3,646 CITIES

In recent years various academic, governmental, and commercial groups have created no fewer than eight global maps and two related maps of the built environment, most of them at a relatively coarse resolution with pixel sizes of 250–1,000 meters. These maps identify impervious surfaces (e.g., pavements, roofs, and compacted soils) that are closely associated with urban development. It has been quite difficult to determine the accuracy of these eight maps, however. Individual map estimates of the total area of built environment in the world vary by as much as a digital order of magnitude: from 276,000 square kilometers (km²) in Vector Map Level 0 (VMAPO) to 3.532 million km² in the Global Rural-Urban Mapping Project (GRUMP) (Potere et al. 2009).

Potere et al. (2009) set out to test the accuracy of these global maps with a two-tiered assessment. The first tier compared each of these eight maps to a set of 30x30-meter resolution maps of cities based on Landsat imagery. The second tier tested the Landsat-based maps for accuracy with 10,000 Google Earth validation sites. The central conclusion of their paper states: “Among the eight maps examined for accuracy, the Mod500 map was found to be the most accurate by all three accuracy measures employed” (Potere et al. 2009, 6553). Our estimates of urban land cover in the universe of cities, as well as our projections, are therefore based on this Mod500 map, which provides the most complete, reliable, and realistic estimates of global urban land cover

FIGURE 1.1
Nine World Regions and the Universe of 3,646 Cities, 2000



at the present time. We refined the Mod500 map to include 311 new urban clusters for large cities with 100,000 people or more that had no corresponding clusters, but we did not change any of the original clusters.

As a result, we now have a global map of urban clusters on a Google Earth platform with a 463x463-meter pixel size. The clusters are associated with a total of 3,646 named large cities and metropolitan areas in all countries (figure 1.1). These cities had a total population of 2.01 billion people in 2000, largely based on estimates from Brinkhoff (2010). The estimates are associated with the name of the city or metropolitan agglomeration, but are not populations within a well-defined administrative boundary. According to our calculations, the urban clusters associated with large cities had a total built-up area of some 340,000 km² in the year 2000 (Angel et al. 2010e).

THE URBAN EXPANSION PROJECT

This *Atlas of Urban Expansion* is part of a long-term research project that includes a series of related publications and online resources. The first phase of the research that led to the creation of this atlas focused on the collection and analysis of satellite imagery and census data in a global sample of 120 cities. The second phase involved the administration of a survey by local consultants in each of these cities. It included questions on the latest census; the status of metropolitan area planning, regulation, and enforcement; general housing market conditions; informal settlements; and financial institutions that provide mortgage loans.

In the third phase of the project, the research team created a set of metrics for measuring urban spatial structure and a python script (a powerful computing procedure) for calculating these metrics with ArcGIS software. The fourth phase involved the collection, geo-referencing, and digitizing of historical maps of the built-up areas of cities at 20 to 25 year intervals for the period 1800–2000 for a global representative sample of 30 cities; the analysis and mapping of census data for 20 U.S. cities for the 1910–2000 period and 65 cities for the 1950–2000 period; and the statistical modeling of the results of all the phases.

The results of this work culminated in the fourth phase with completion of three Lincoln Institute of Land Policy working papers (Angel et al. 2010a; 2010d; 2010e); the policy focus report *Making Room for a Planet of Cities* (Angel et al. 2011); and the online version of the *Atlas of Urban Expansion*. All of these materials are available for free downloading on the Lincoln Institute's website. Scholars, public officials, planners, those engaged in international development, and concerned citizens can access the maps and data tables presented here, as well as additional material that is available online.

With ArcGIS or other Geographic Information System files, users can download the GIS data analysis and the maps. For each of the 120 cities in the main sample, these data include: two urban land cover maps, circa 1990 and 2000; the administrative boundary shapefile; two maps of the urban landscape categories, circa 1990 and 2000;

and the map of new development categories (infill, extension, and leapfrog). For each of the 30 cities in the subsample, these data include the urbanized area shapefiles for each time period.

The Lincoln Institute website also provides an urban land cover map of the universe of 3,646 cities that had populations in excess of 100,000 in the year 2000. Associated information is provided on their population, urban land cover, and average density in that year. This urban land cover map is in a .kml format, which can be viewed by first downloading Google Earth.

The fifth phase of the project involved revising the three working papers for peer-reviewed journals and preparing two companion volumes—this book version of the *Atlas of Urban Expansion*, and a book titled *Planet of Cities*, which offers a comprehensive and original analysis of the quantitative dimensions of past, present, and future global urban land cover. It culminates in a proposed new paradigm for preparing for explosive growth in the world's cities.

This *Atlas of Urban Expansion* addresses the geographic and quantitative dimensions of urban expansion and its key attributes in 120 cities throughout the world. The empirical evidence presented here should help form the backbone for an intelligent discussion of plans and policies to manage urban expansion in the future.

The atlas presents two sets of maps and raw data. The first map section (chapter 3) contains pairs of urban land cover maps from circa 1990 and 2000 for a global sample of 120 cities. The second map section (chapter 4) includes composite maps of a global representative sample of 30 cities, showing the historical expansion of their urbanized areas from 1800 to 2000. In both sections, the maps shown are paired with numerical data and contain various metrics associated with the maps, making it possible to compare cities in terms of their metric values on key attributes of urban expansion. The third section (chapter 5) contains four extensive tables of urban, national, and regional data for each of the 120 cities.

Atlas of Urban Expansion, 2016 edition. Volume 1: Areas and Densities (PDF 649 Mb) Volume 2: Blocks and Roads (PDF 932 Mb). Methodology. The Global Sample of Cities (PDF) Understanding and Measuring Urban Expansion (PDF) Understanding and Measuring Urban Layouts (PDF). Tables. Areas and Densities CSV, Xlsx Blocks and Roads CSV, Xlsx Historical Data for Blocks and Roads CSV, Xlsx.