Challenges **2011**, *2*, 55-72; doi:10.3390/challe2040055

OPEN ACCESS

challenges

ISSN 2078-1547

www.mdpi.com/journal/challenges

Article

The Metacity: A Conceptual Framework for Integrating Ecology and Urban Design

Brian McGrath [1],* and S. T. A. Pickett [2]

[1] Parsons The New School for Design, 25 East 13th Street, New York, NY 10003, USA

[2] Cary Institute of Ecosystem Studies, Baltimore Ecosystem Study, 2801 Sharon Turnpike, P.O. Box AB, Millbrook, NY 12545-0129, USA; E-Mail: picketts@caryinstitute.org

* Author to whom correspondence should be addressed; E-Mail: mcgrath@newschool.edu; Tel.: +1-973-817-9057.

Received: 31 August 2011; in revised form: 29 September 2011 / Accepted: 29 September 2011 / Published: 20 October 2011

Abstract: We introduce the term *metacity* as a conceptual framework that can be shared by ecologists and designers and applied across the wide variety of urban habitats found around the world. While the term *metacity* was introduced by UN-HABITAT to designate hyper cities of over twenty million people, for us it is not limited to large urban agglomerations, but rather refers to the proliferation of new forms of urbanization, each with distinct ecological and social attributes. These various urban configurations when combined with new digital sensing, communication and social networking technologies constitute a virtual meta-infrastructure, present in all cities today. This new metacity has the potential to integrate new activist forms of ecological and urban design research and practice in making the transition from *sanitary* to *sustainable* city models globally. The city of Baltimore, Maryland will be used both as a site to illustrate these recent urban trends, and also as an example of the integration of ecology and urban design pursued by the two authors over the past seven years [1,2]. Metacity theory is drawn from both an architectural analysis of contemporary forms of urbanism, new forms of digital monitoring and communication technologies, as well as metapopulation and metacommunity theories in ecology. We seek to provide tools and lessons from our experiences for realizing an integrated metacity approach to achieving social sustainability and ecological resilience on an increasingly urbanized planet.

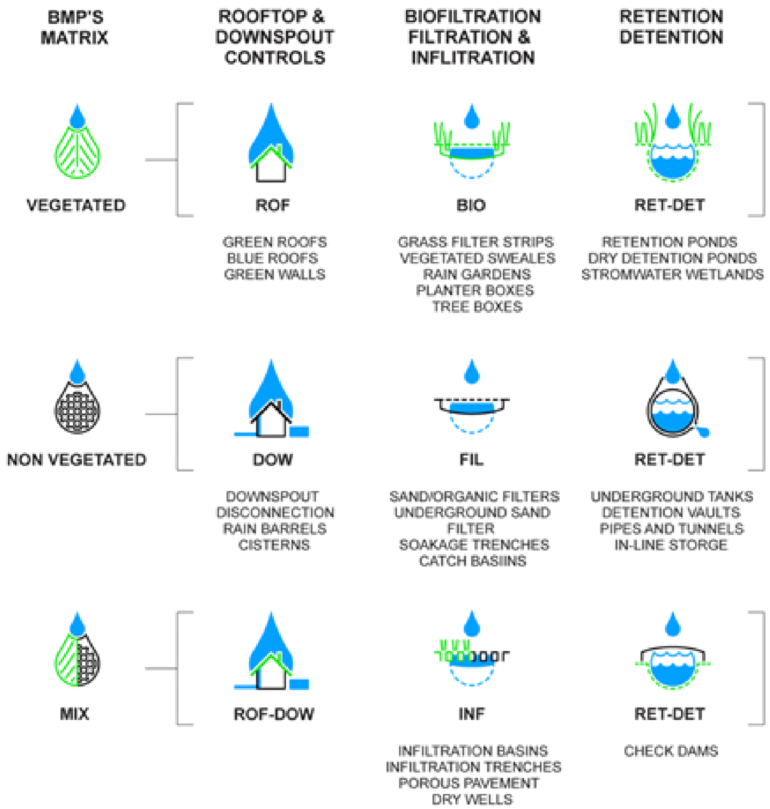
Keywords: ecology; urban design; metacity; metapopulation; metacommunity; metamosaic; patch dynamics; sustainable city

1. Introduction: Metacity definition

UN-HABITAT's *State of the World's Cities* report designated a new class of urban form in 2006, the *metacity,* defined as "massive sprawling conurbations of more than 20 million people" [3]. The term metacity was coined when the term megacity—designated as cities of over ten million people—became inadequate. Most interestingly, metacities are described as polycentric and with diffuse governance, and hence they have no centralized management apparatus. Multiple local voices, such as bicycle activists, slum dwellers or community gardeners, often have more in common with other similar groups around the world via virtual communication networks than with neighbors with physical proximity. Megacity as a term had come to be understood as large unplanned or semi-planned agglomerations marked by large in-migrations from the countryside, and the primary concern for UN-HABITAT is those urban agglomerations in Asia and Africa with little planning and infrastructure in place to keep pace with urbanization [4]. UN-HABITAT, however does not dwell on the phenomena of suburban sprawl [5], shrinking cities [6] and urban poverty and migration in the cities of the developed world. (Figure 1 and Figure 2) UN-HABITAT also recently noted that, in fact, most urbanization will occur in cities between one and ten million—cities not covered by either their mega- or metacity designations.

Clearly, population size is not an adequate measure to capture the wide range of urban forms, issues and solutions for urban growth and ecological balance. This umbrella designation lumps together highly developed, efficient and planned cities such as Tokyo, and huge informal agglomerations like Lagos. This is highly problematic since cities like Tokyo, New York and Paris have had large periods of planned growth and centralized planning from a century ago, and can be seen as models of "Sanitary Cities" [7], while the rapidly growing cities today often do not have the capacity to construct the necessary infrastructure for basic public health, comfort and well-being [8]. Likewise the maintenance of century old sanitary infrastructure of older, often shrinking, metropolitan centers are no longer affordable, nor even desirable, as we move from the sanitary city to the new paradigm of sustainable cities [9-11]. We illustrate as a case study work in the Baltimore Ecosystem Study to explore how the metacity concept can link ecological research and urban design practice in this new urban situations. United by patch dynamic theory and a watershed framework (Figure 1), the work in Baltimore covers a range of urban sites from outer periphery estates, the older suburban ring, and the depopulated neighborhoods in the center (Figure 2).

Figure 1. A matrix of best management practices for design scenarios as part of a socio-ecological feedback loop between neighborhood preferences, vegetation and water management options and nitrogen flux, Baltimore Ecosystem Biocomplexity Project, which can be applied in any urban situation across the region. (Courtesy of urban-interface)



We define the metacity as a conceptual framework for understanding socio-ecological relationships and adaptive processes within specific neighborhood situations in all cities of whatever size and density, whether shrinking or growing. It is a way of understanding any city as a patchy “system of systems”, and therefore related to metapopulation and metacommunity theory in ecology. Our definition of the metacity will therefore emerge from a discussion of both the ecology and architecture of the city as currently lived in, across a wide range of urban habitats today. In contrast, many assessments from both ecologists and designers come with only one particular type of city in mind. From this preliminary definition we can begin to outline a prospectus for integrating design and ecology in the metacity without ideological biases privileging one type of urban conception. As cities evolve, regardless of size, the metacity concept may provide a tool for advancing sustainability in all urban situations. Metacity theory focuses attention on the spatial heterogeneity and dynamism of local neighborhood patches, connecting these with regional fluxes that affect ecosystem services. These regional and local concerns are connected globally through virtual social networks, enhancing urban life through planetary stewardship.

Figure 2. The Gwynn's Falls Watershed framework of the Baltimore Ecosystem Study cuts across political boundaries and links sites as diverse as reserve forestlands, posh suburbs, older ranch house neighborhoods, row house blocks, and industrial brownfields. (Courtesy of urban-interface)

2. The Ecology of the Metacity

In the science of ecology, the prefix "meta" refers to collections of spatially dispersed, but similar, entities that interact though the processes of establishment, migration, and extirpation. Thus, members of a population of one species, say peregrine falcons, are born, disperse, reproduce, and die. But for peregrine falcons, whose habitats originally included cliffs, and now extend to skyscrapers, their populations are not continuously distributed in space. Each discrete population may experience its own dynamics. A patch may be occupied by peregrines for a time, and then under some stress or disturbance, the population in that patch may go extinct. This indeed did happen with peregrine populations exposed to DDT in the past. However, other populations of the species may escape the catastrophe, and migrants can sometimes establish new populations in unoccupied, but suitable habitat. The example of the peregrines, in which different, spatially discrete populations of a single species experiences their own demographic changes, the different populations together constitute a metapopulation. It is in essence a "population of populations" [12], in the same way that a population in the usual sense is an aggregation of individual organisms of a single species in one location. Because the different populations within the larger aggregation of populations are geographically distributed and distinct from each other, each one can experience different threats, opportunities, and responses [13]. One will grow more rapidly because it has access to a large pool of resources, while another may struggle due to scarcity. The first, well-positioned population may persist for a long time, unless it is obliterated by some large physical disturbance such as a hurricane, while the population of strugglers may wink out when resources are finally reduced below the minimum requirements for survival. The habitat between the individual populations that is unoccupied may not support a population simply because the locales are unsuitable for the species for some reason, or because the migrants have not arrived at the spot. Some vacant patches that are in fact suitable to the species may have supported a population in the past. They may do so in the future as well. In addition, some areas that now support a population of the species may become vacant if resource levels change, stresses that limit the population increase, or catastrophic disturbances kill all the occupants of the patch.

The metapopulation concept recognizes great dynamism and spatiality in clusters of some biological populations. Individual populations in a metapopulation may, for a time, exhibit relatively unconnected dynamics. However, from time to time, there may also be exchange of genes or of information between them. It is the spatial discreteness and the relative isolation of individual subpopulations that characterizes a spatially complex, yet differentially connected metapopulation [14]. Not all population units within a metapopulation are equally well connected with each other. Furthermore, an individual patch may periodically support a population of the species or may be vacant. This dynamism of vacancy is also a key characteristic of metapopulations. Metapopulations are spatially dynamic arrays of occupied and unoccupied patches, and the relationships of the relatively isolated populations. Individual species of butterflies in isolated pine barrens patches, or of orchids in the canopies of a particular kind of isolated tropical rainforest tree, are examples of metapopulations.

Meta-level dynamics can also appear in communities. A community is a collection of all the individuals of different species that occupy an area. Like populations, communities may occupy distinct and spatially distant patches. A metacommunity is, thus, the set of spatially dispersed patches of a particular kind of community. For example, communities of amphibians in temporary woodland ponds that persist only during the spring, or animals occupying isolated caves, or the collection of plant communities on high mountains are all potential metacommunities. The metacommunity consists of islands of the particular kind of community in question. The individual communities may be established in vacant sites by colonization from islands of the same community elsewhere, and they may be obliterated by changes in resources or stress factors.

Both metapopulations and metacommunities are examples of spatial differentiation and partially discrete dynamics among the spatial isolates. Thus, they both are cases of *patch dynamics*, the creation, alteration, and function of spatial heterogeneity through time [15,16]. In biological ecology, patches can be created by numerous means. The establishment and growth of a large tree in a meadow, the burning of an extensive patch of dry, coniferous forest, and the expansion of a rigid coral head are all examples. The patches may shrink or be destroyed as well. For example, as a large tree grows old it may lose branches reducing canopy extent; an open burned area gradually fills in as new plants grow or as small surviving plants expand, to produce a closed forest canopy; and a coral head can regrow. Each of these kinds of patch thus can change in structure and species composition. In addition, their relationship to adjacent patches can change as a result of both internal dynamics and of influences and organisms that move in from other patches [17,18].

The functional significance of patch dynamic mosaics is particularly important ecologically. The spatial arrangement of patches in a watershed can determine the amount of water that flows into larger catchments. Hotspots of nutrient conversion can either exacerbate or reduce pollution, depending upon the element in question. Patch mosaics with increased edge can harbor more generalist and colonizing species than those with less fragmentation. In other words, assessment of composition or function via averages, rather than by the explicitly spatial differentiation that exists in a landscape may yield misleading results. The processes affected by structure are a part of understanding patch dynamics.

In parallel with the concepts of metapopulation and metacommunity, another way to summarize the importance of spatial heterogeneity in ecological landscapes is as mosaics of different kinds of patches. The overall, aggregate structure consists of relatively discrete patches or elements, each of which can change due to its internal dynamics and due to its relationship with the rest of the mosaic. Because the composition, spatial configuration, and resultant functioning can all change as a result of the shifts in patches and relationships, we can label this kind of structure a metamosaic. "Meta" because the landscape is a dynamic aggregate of changing components linked by fluxes of matter, energy, organisms, and information. It is important here that ecologists use the term landscape to indicate any kind of heterogeneous spatial array, whether the components are natural or artifactual [19-21]. This is how we use the term landscape in the remainder of this section.

Figure 3. The urban meta-mosaic as a hierarchy of constituent mosaics or kinds of landscapes. The highest, most inclusive level both labels and describes the nature of a metamosaic for cities, suburbs, and exurban systems. The inclusive metamosaic comprises landscapes of process, landscapes of choice, and landscapes of outcome. Each kind of landscape is divided into specific realms and contributing phenomena. Courtesy of BES-LTER.

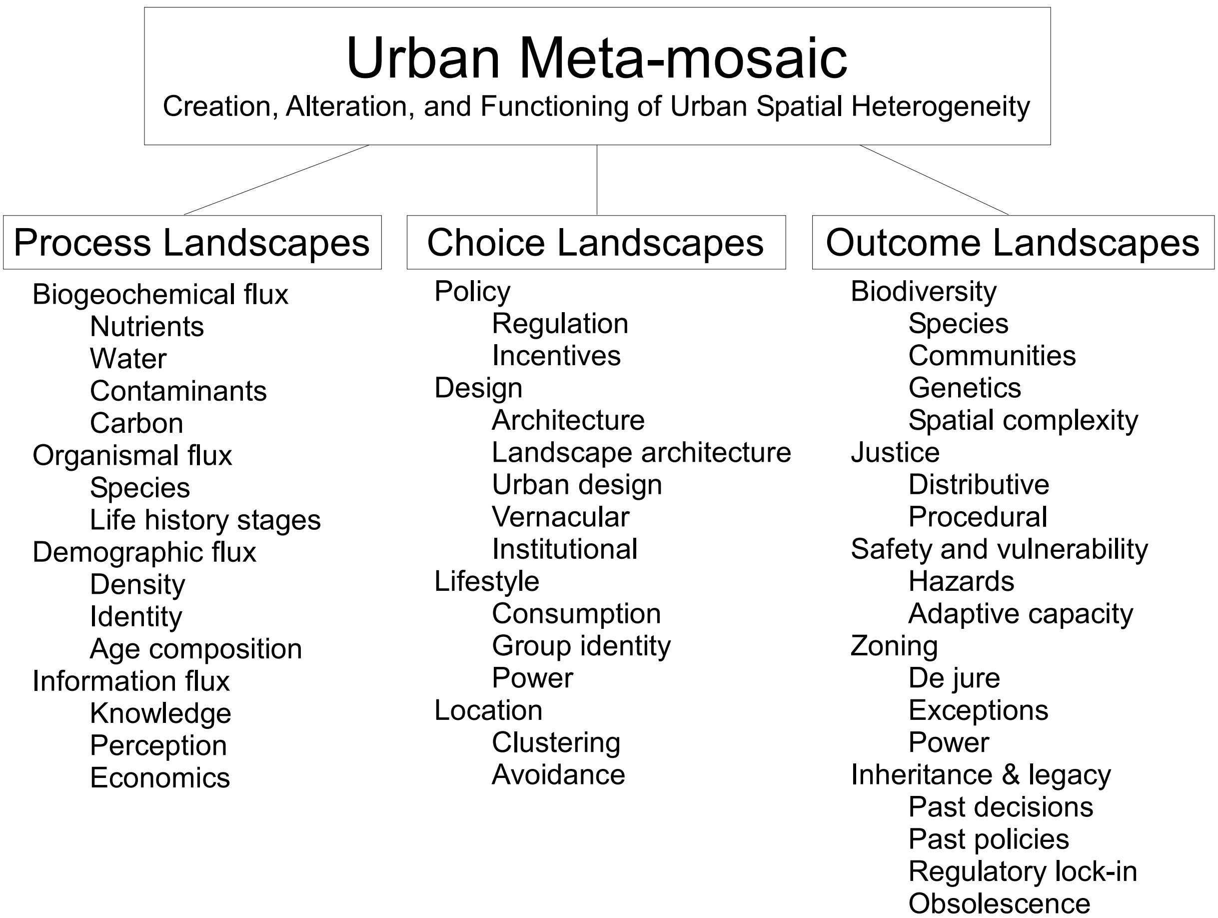
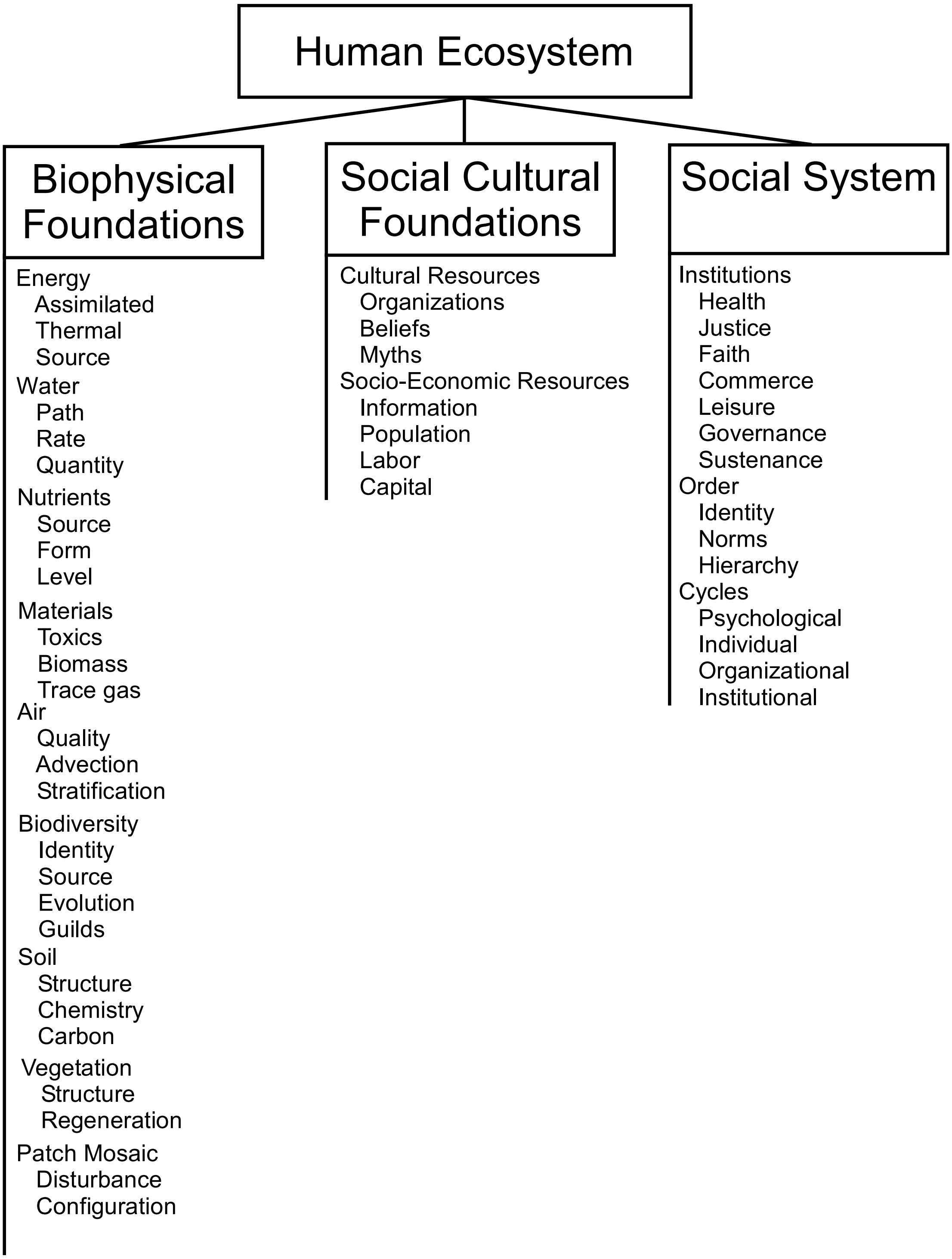


Figure 4. The human ecosystem framework as modified for use in the Baltimore Ecosystem Study, Long-Term Ecological Research project. Like the metamosaic concept, this is a nested hierarchy. Courtesy of BES-LTER.



The metamosaic is an appropriate conception for cities as well. In addition to the kinds of mosaics that were used to illustrate bioecological patch dynamics, above, there are clearly human, social, and institutional mosaics that are crucial for understanding urban ecosystems [22]. Metamosaics in the urban realm consist of more finely resolved, constituent mosaics or landscapes (Figure 3). There are three kinds of constituent mosaics, landscapes as spatial arrays of process, choice, and outcomes.

Processes include the fluxes of nutrients, organisms, life history stages, and information, including financial information. Choices include policies, design, lifestyle, and spatial location. Landscapes of outcome include biodiversity, justice, safety and vulnerability, zoning, and legacies from the past. Each of these constituent landscapes includes a number of more specific features and contributing attributes. We do not specify those here. However, the human ecosystem framework [23,24] is a good candidate conception for detailing the kinds of structures and interactions that would contribute to the constituent landscapes (Figure 4).

The metacity concept can be considered shorthand for a socio-ecological urban metamosaic. It suggests, as the prefix meta does in ecological science, spatial complexity, differential connectivity across space, and an important focus on fluxes of phenomena within and across the mosaic. The next section explores the connection between ecology and design based on applying the concept of the metamosaic to the structures and processes in cities, suburbs, and exurban systems. The potential for integration using this concept is great.

3. The Architecture of the Metacity

In the classic book, *The Architecture of the City,* Aldo Rossi redirects attention from the single building as the object of architecture *in* the city, to the collective cultural process of constructing cities over time—the architecture *of* the city [25]. While single urban artifacts, such as historical monuments, may concentrate meaning within a single place in a city, it is more the city itself as an overall artifact constructed by many actors over time that constitutes the architecture of the city. Rossi uses a scientific morpho-typological classification system to understand the complexity of the city as an artifact constituted by an evolutionary process of adapting building types over time, where old forms can take on new meaning, as a critique of modernism where form followed function.

The focus of Rossi's analysis is the historical European city, and the metabolism for this type of city can be described as regionally self-sufficient. The small Italian cities that Rossi uses as examples were compact urban habitats built in response to the need for food, water and human security. They demonstrate remarkable ingenuity about energy conservation and the creation of artificial microclimates and legible social coherence, all of which are evident in the hierarchy and order of building forms and types. Cities of this type are situated within an integrated city region, connected yet set apart from the essential support life support systems of agricultural, forestlands and water systems that dominate and surround them. There are many different examples of the micro-politics and social agency in the city-state with varying degrees of despotism and civic participation in governance, where a prince, religious orders, mercantile class, craftsmen and peasants interacted at close-quarters.

In contrast, Rem Koolhaas, in his book *Delirious New York* analyzed the "culture of congestion" produced by modern technology and the skyscraper architecture of Manhattan [26]. He and his colleagues named their firm the Office of Metropolitan Architecture in order to create new design models for contemporary urban life. Metropolitan architecture's density produces new social relations, but also new problems. While it is dependent on much more intensive resource extraction than Rossi's traditional city, it is able to achieve great efficiencies based on mass transportation and high-density living. The metropolis is a highly organized and bureaucratic sanitary machine, and accompanies the rise of the bourgeoisie and an educated technocracy designated to maintain strict social hierarchies and a separation of rural and urban space and people, especially in the colonial world where ruling and "native" populations were rigorously separated.

As William Cronon has vividly demonstrated in his study of Chicago, the metabolism of the metropolis has always been based on extracting natural resources from vast areas outside of the city. The metropolis substituted the loss of contact with nature with the design of gardens and parks [27]. Wood, coal and steam-powered machines, factories, ships and railroads propelled and connected colonial enterprises across the globe through a network of metropolitan centers and peripheries. As recent climate change data has shown, while the financial benefits of this world system flowed primarily to the capitals of these vast colonial empires, it was at the expense of the biodiversity and environmental balance of the entire planet. It was also the presence of noxious industry and the squalid housing poor laborers in the industrial metropolis that produced utopian social and anti-urban movements such as the "Garden City" of Ebenezer Howard [28] and the Anglo-American suburb.

Figure 5. Baisman Run is a forested sub-catchment in Baltimore County where residential development is highly regulated to protect downstream drinking reservoirs. This outer periphery sub-catchment includes large houses on six-acre lots with septic systems built along wide winding cul-de-sacs set back from open streams. (Courtesy of urban-interface)

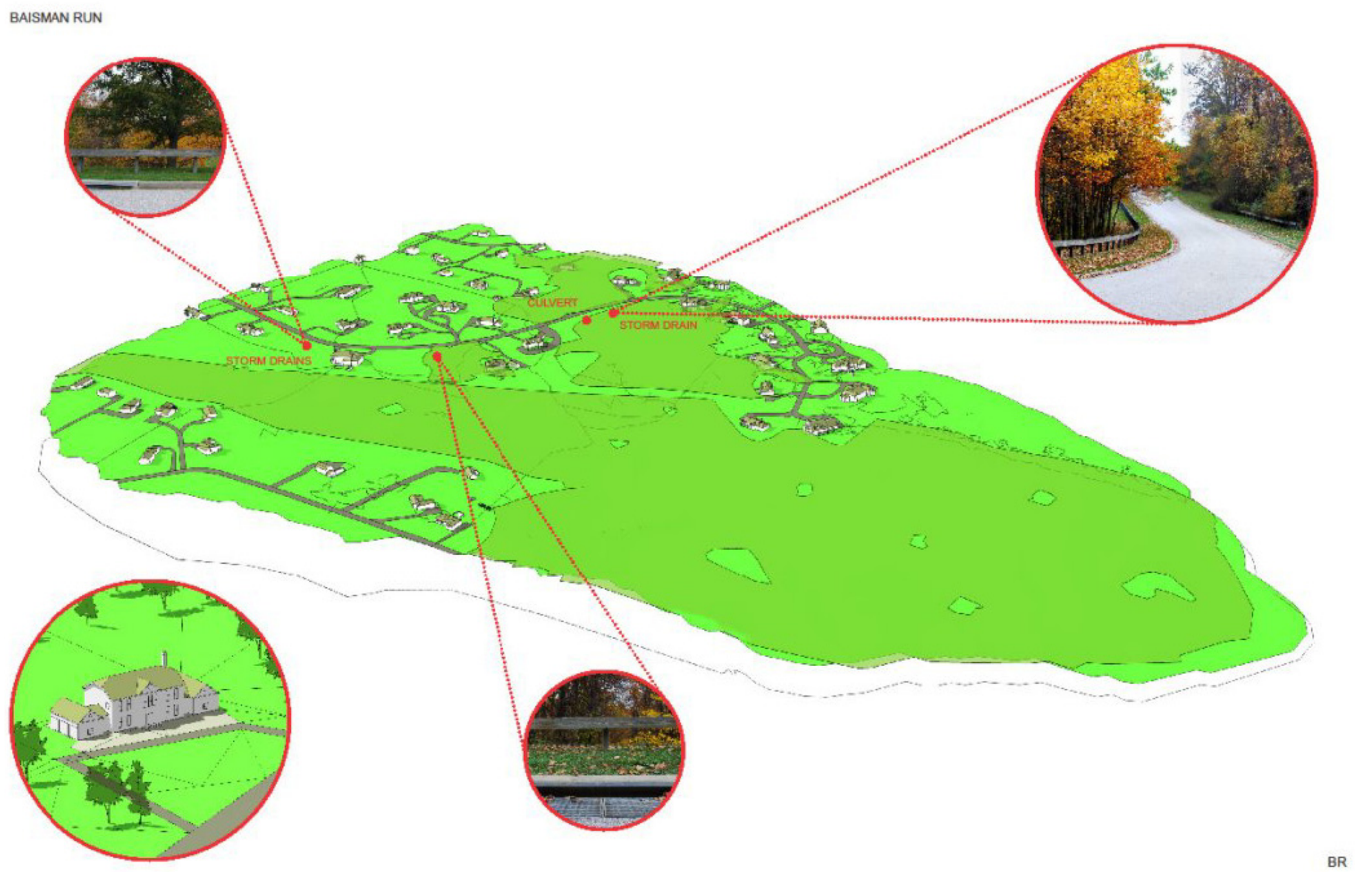
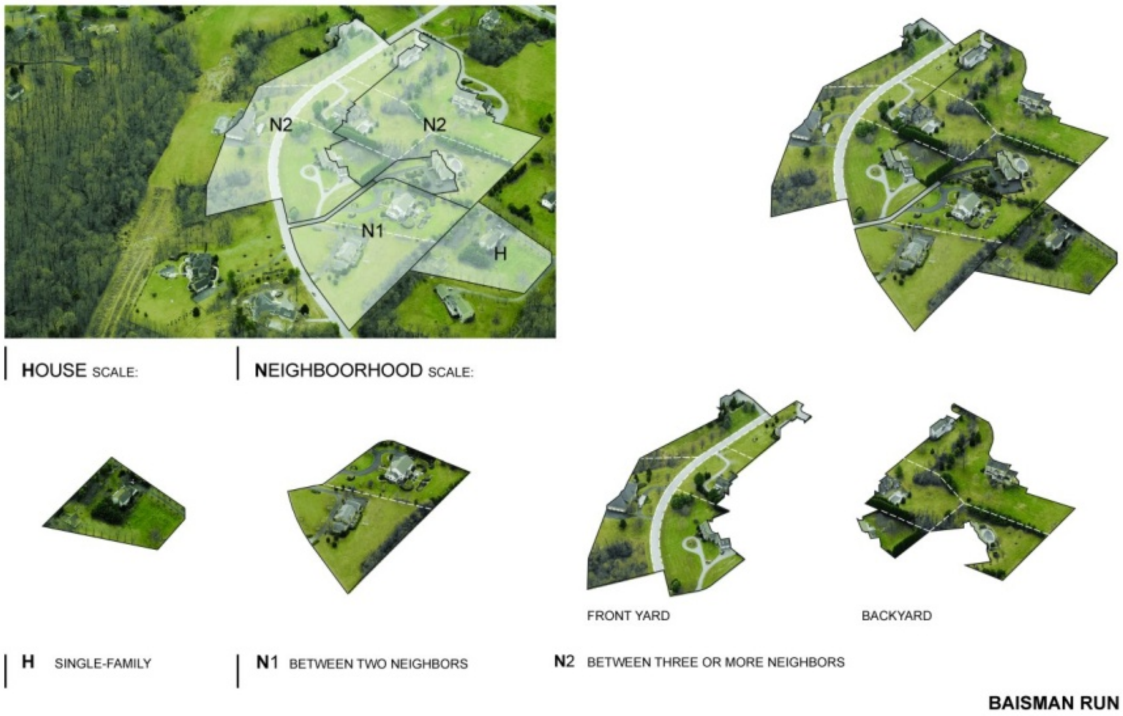


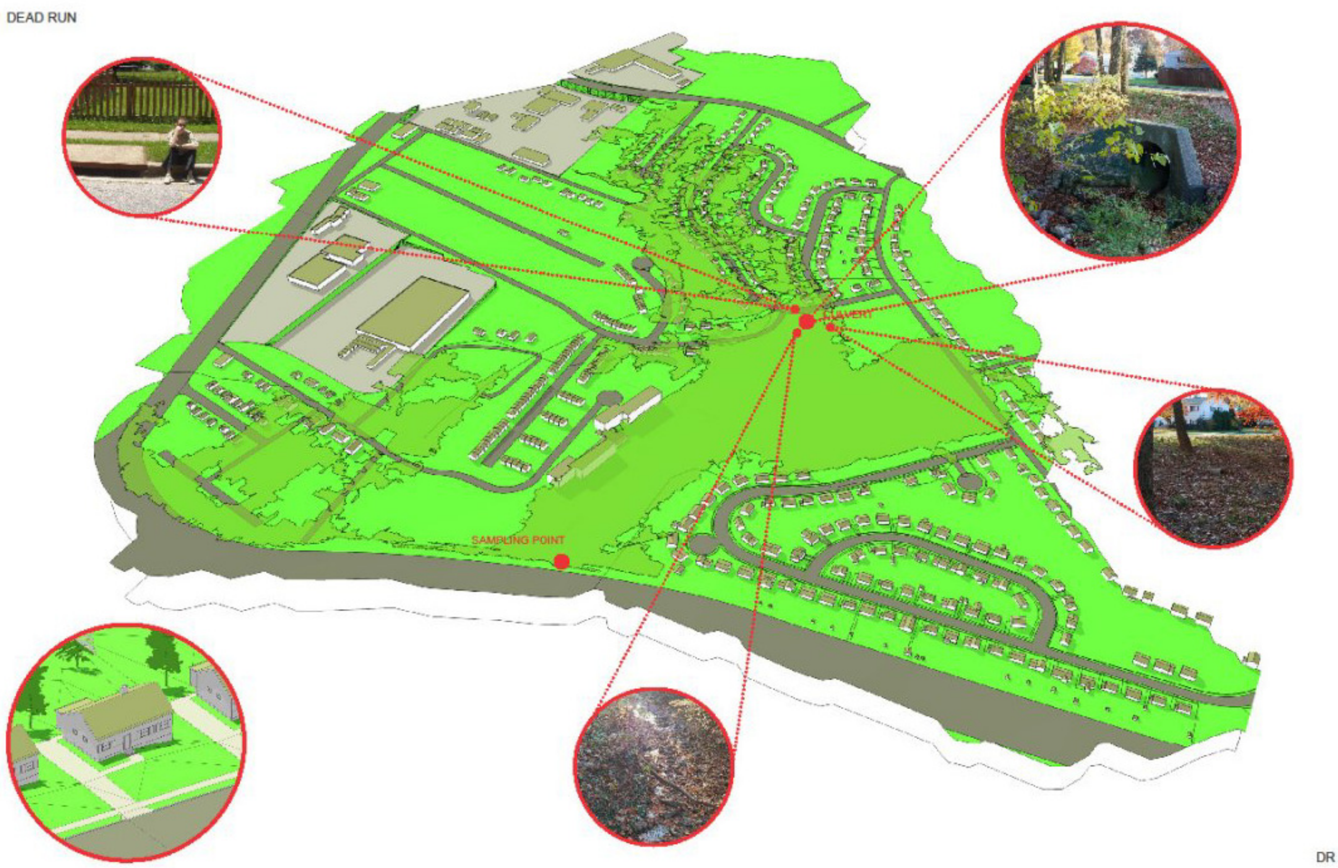
Figure 6. Vegetation and water management in Baisman Run was studied along the road right-of-way and front yards, within individual parcels, and in-between parcels. Storm water flows rapidly off the excessive paved surfaces into the headwaters of an open stream network, incising the streams and exporting nitrogen leaching from the septic system. (Courtesy of urban-interface)



While the high density clustering of contemporary metropolitan architecture has experienced a revival at the beginning of the 21st century, especially in China and the Gulf States, it is the low density exurban sprawl of what geographer Jean Gottmann identified as the megalopolis that is rapidly urbanizing most of the surface of the planet [29] (Figures 5−7). This car-dependent urbanization occurs in, around and between cities of all sizes, and mixes freely with forest and agricultural land [30]. It is a patchy continuously dispersed city that constitutes the mega-regions of urbanization that is currently having the greatest environmental impact on biodiversity and hydrological structures around the world.

If the coal powered metropolis produced the polluted industrial city, the modern oil economy has shifted sites of manufacturing far away from consumption, and has linked producers and consumers by networks of airplanes, trucks, automobiles and super container ships—all dependent on burning oil as well as cyber-logistics. The interconnected electrical and communication grids that keep these networks active 24/7 are likewise predominantly coal, natural gas or oil powered. The car and the suburb provided a new American life style based on the ideals of freedom and mobility. The nuclear family is the core social unit, and private home ownership in a garden suburb as the social ideal. The public realm fell into sharp decline and those that could afford or opt out of suburban enclaves are relegated to urban ghettos in a fragmented metropolis (Figures 8−10).

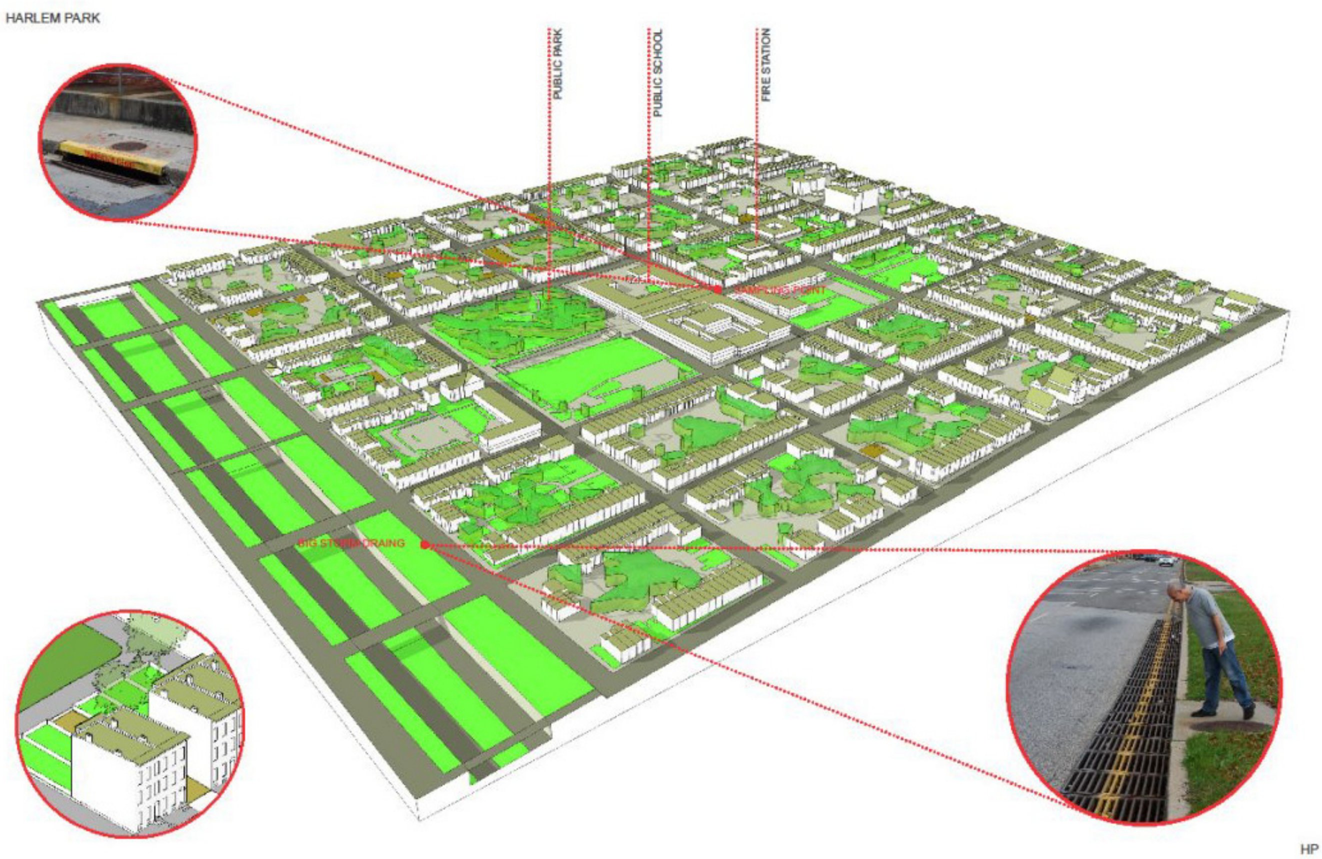
Figure 7. Dead Run is a sub-catchment consisting of mid-20th century suburbs with small ranch houses, strip shopping centers, and neighborhood parks with open streams. The neighborhood has both storm and sanitary sewer systems. (Courtesy of urban-interface.)



The term "megacities," was originally coined in the 1970s to define urban settlements of eight million inhabitants or more, and later revised to ten million. It has come to refer to the rapid informal settlements that have defined urbanization in the developing world since. For us, therefore, like metacity, the term does not refer to the size of a city, but to a particular aspect of urbanization —large-scale in-migration of formally rural dwellers into urban economies—that can occur anywhere the rural poor migrate to in search of low skilled jobs. While attempts such as those in China and the Gulf States have been made to confine such migrant labor to dormitory enclaves, for any place with freedom of movement, affordable housing rarely can be provided for these new urban inhabitants, and they often remain undocumented and "floating" in a legal sense.

The megacity is a return to the self-sufficient model in many ways, but on a vast unsustainable scale. At least in some enclaves, self-sufficiency, that is, the local capacity to supply food, water and human security is prioritized. For example, a mega slum such as Dharavi in Mumbai is a highly efficient urban system, which reprocesses and recycles much of the solid waste of the city. Social life in Dharavi is highly self-organized, but its informal status subjects slum residents to mafias, rent abuses, and police bribes. As outsiders to the political system of the formal city and economy, slum residents rely on community organization and activists, non-profit and non-governmental organizations, and voting in blocks to pressure decision makers and secure their rights to the city.

Figure 8. Harlem Park is a row house neighborhood comprising a piped sub-catchment called Watershed 263. Open space consists of historical parks, vacant lots, and sites cleared for parks, schools and highways during the period of Urban Renewal following World War II. (Courtesy of urban-interface.)

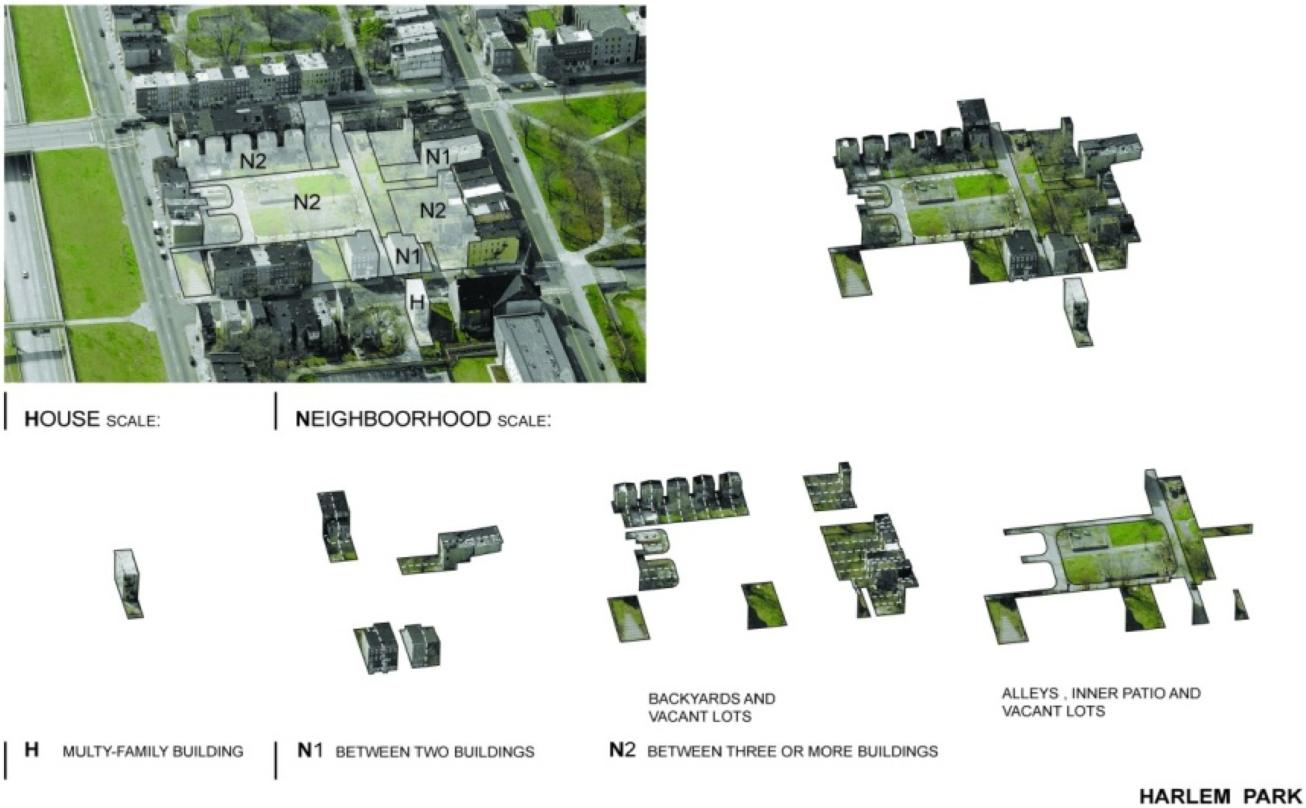


For us, theorizing the metacity is first, the acknowledgement that all the urban forms outlined above coexist in highly volatile and contested mixes in the contemporary urban landscape, and second, that these urban patches consists of socio-ecological processes that are interconnected at a more inclusive meta-level. If infrastructure, by definition, refers to the unseen buried support systems for cities, metastructure is that which sits above and beyond everyday urban forms and activities. It is therefore connected directly with the fundamental principles of the science of ecology, as well as the way designers think.

Baltimore, Maryland is the site for the Long Term Ecological Research project called the Baltimore Ecosystem Study (BES). While BES conducts research on *metropolitan* Baltimore as an ecological system, the urban area that comprises the research cannot be conceived as limited to the type of uniform and centralized metropolis described above. BES, in fact, covers many of the architectural habitats of the metacity as described. Although first urbanized as part of a colonial plantation resource-extraction world trade system, early Baltimore was compact, and comprised an example of an American typo-morphological rationalization of the self-sufficient European city as described by

Rossi. Baltimore was established as a row-house city incrementally planned with a square gridiron with streets and alleys supporting a variety of social classes living in close proximity [31].

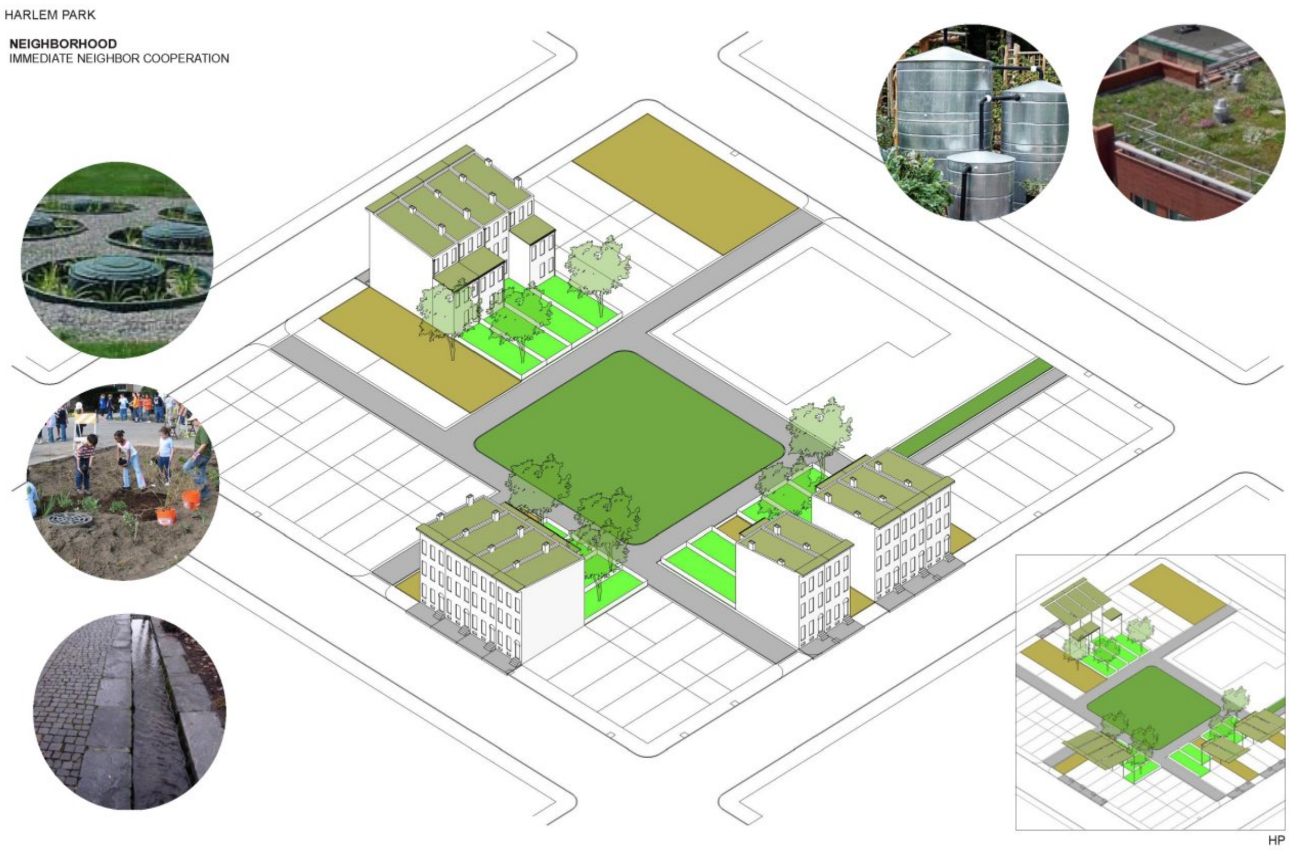
Figure 9. The row house grid in Harlem Park provides many areas for new vegetation management strategies: street side tree belts, alleyways, vacant lots, community gardens and green roofs. The inner block alley houses were demolished to make way for back-yard parks in the 1950s. (Courtesy of urban-interface)



Baltimore experienced its architectural “metropolitan” moment from the first expressions of a monumental city in a number of remarkable public squares and monuments from the 1820’s up until the Great Depression. From the mid-19th century, the city also developed a municipal park and sanitary system, regional light rail transit, green streetcar suburbs and art deco towers in a concentrated downtown. This metropolitan regional city was remade by the spatial dynamics of the Bos-Wash megalopolis after World War II, as inner city Baltimore, emptied by new access to inexpensive land, the GI Bill, cheap mortgages and the lure of single-family suburban life [32].

While inner American cities experienced large out-migrations following the end of World War II, in some ways they share similar problems as the fast growing developing world megacities. In both urban contexts, municipal governments struggle to construct or maintain existing sanitary infrastructures. Often community groups and activist emerge in the absence of municipal maintenance. Non-profit groups in Baltimore, such as Parks & People Foundation, have emerged in this area, much like the non-government organizations around the world. With the decline of the formal economy, most dramatically, the loss of manufacturing jobs in Baltimore, informal economies have attempted to cope with this absence of jobs, whether in handyman, car wash, tire or car repair, or the more elaborate economies of the drug trade as chronicled in the infamous television program *The Wire.*

Figure 10. Water management strategies in the inner block sites of Harlem Park incorporate city parks, vacant lots and private properties. (Courtesy of urban-interface)



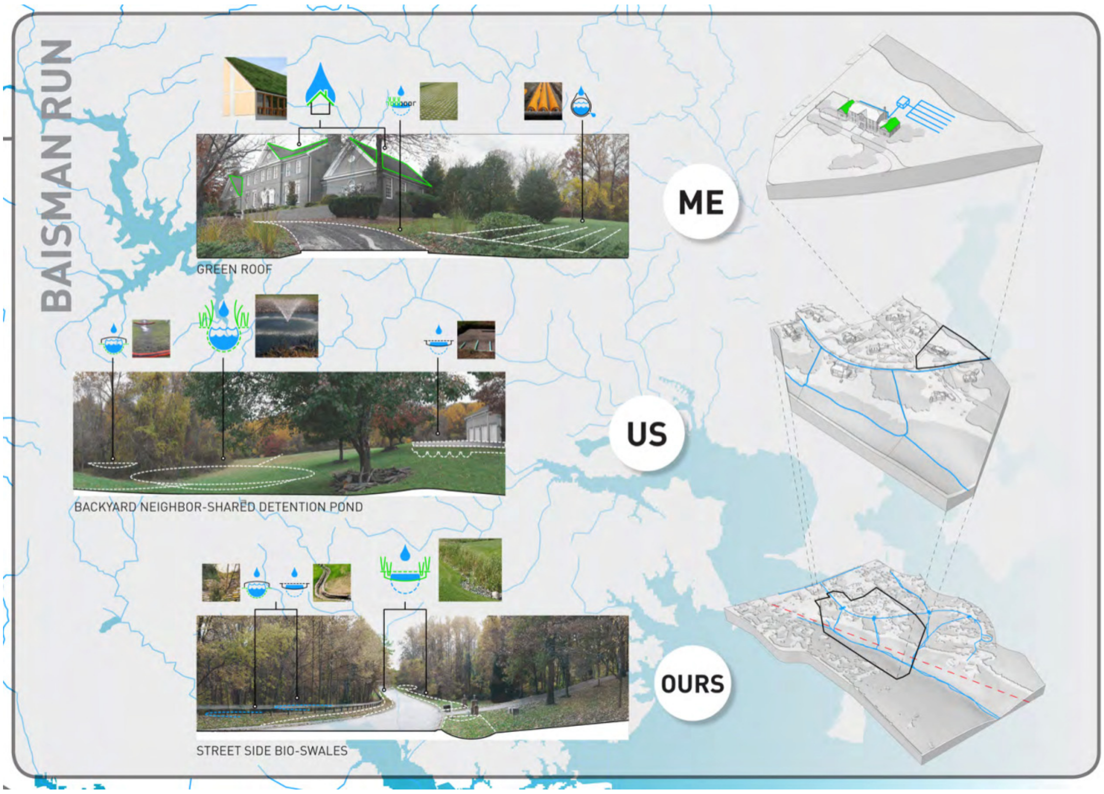
4. Conclusion

The metacity designation seeks to identify an inclusive set of tools for integrating ecology and urban design in all urban situations by linking on the ground transformative action and knowledge with remote monitoring and sensing technologies [33]. The architecture of the metacity can no longer be described by formal analysis of the physical historical fabric of the city alone. In his spatial analysis of the Situationist International art movement, Thomas McDonough [34] describes the importance of atmospheres, emotions and feelings situated in the city rather than the physical description of the city alone. The Situationists employed techniques such as the *dérive* and *détournement* to create new events in the city, not through physical planning, but through political art and performance activities. The movement draws from social geography from the period that emphasized how the city is produced through the agency of human activity.

This virtual realm has only multiplied exponentially in the wired Situationist metacity of the 21st Century. This technologically enhanced socially networked space provides new forms of collective human agency and intelligence. Tweets, blogs, community sensing and mapping projects, games for change, smart mobs, festivals, crowd source solutions and flash events all point to an increasing demand for citizens everywhere to have a greater stake in participating in the next urban transformation. At the global scale, countless meta-organizations measure, monitor, analyze and attempt to shape urbanization by linking global discussions to local actors. In addition to the

UN-HABITAT, mentioned above, various other branches of the UN, the World Bank and the International Finance Agency, regional organizations such as the European Union, Asia Development Bank, the African Union, BRICS, *etc.* have urban and environmental policies and agendas. Important global summits in Vancouver in 1976 and Rio de Janeiro Earth Summit in 1992 have established protocols. Non-military satellite and remote sensing programs have provided new tools in space in addition to the ubiquity of the cell phones on the ground.

Figure 11. The final design scenarios for Baisman Run offer neighborhood residents the opportunity to choose not only the type of vegetation and water management they prefer, but also the scale in which they would like to act: as an individual property owner, in cooperation with their immediate neighbors, or through change in the municipal infrastructure. (Courtesy of urban-interface)



An example of the importance of a new meta-structure is the Metrocard system in New York City. By moving from a token to a magnetic card, the city's century old subway system became not just a physical transportation network, but also an information network. Cities like Hong Kong use their Octopus system well beyond the Metrocard, and one finds it linking from regional transportation networks to the local 7-11 convenience store. Google traffic, where users of information are also information providers, is another example. But what is the *architecture* of such invisible systems of systems and how does it shape our understanding of the *ecology* of the city; and likewise with is the *ecology* of this virtual system and how does it shape our understanding of the *architecture* of the city?

In the metacity, the spatial units or patches appear as neighborhoods and districts. Each neighborhood has its own kind of use, such as commercial, industrial, or residential, or represents some mixture, such as street level commerce and upper story residence. Furthermore, the patches can be characterized by the specific land cover elements, including the kind and amount of vegetation, the presence and condition of paved and bare surfaces, and the configuration, height, and density of built structures. In Baltimore, ecologists, together with the designs, have developed collaborative methodologies to develop design scenarios linked to ecological research in the wide variety of urban habitats of metacity Baltimore (Figure 11).

As mentioned above, in defining the metacity, the UN did note that they had multiple centers, and due to spatial extent, that governance was likely to be spread over many jurisdictions. Governance is further complicated by the devolution of many functions from formal government to non-governmental organizations, community groups, and private enterprise. As cities evolve, the functional metacity concept—regardless of size—may provide a tool for advancing the sustainability. The spatial heterogeneity and dynamism of metacities focuses attention on local amenities and ecological processes, as well as on connecting these with regional fluxes that affect ecosystem services, and designing anew or restoring patches to enhance the contribution of biological ecosystem processes to urban life.

The fact that so many cities are now being built or are poised for revitalization means that there is the opportunity to put them together differently than in the past. Better integration of ecological processes is possible in cities now emerging compared to existing cities. Greater attention to environmental equity among citizens is also possible. But such benefits can accrue to existing cities as well. As older city cores adapt, there is an opportunity to reinvigorate ecological processes within their boundaries in ways that benefit citizens as well as the environment. In other words, all cities can exploit the metacity model as a tool with which to become more sustainable.

References and Notes

1. Baltimore Ecosystem Study, www.beslter.org, a Long Term Ecological Research project funded by the National Science Foundation.
2. *Designing Patch Dynamics*; Marshall, V., McGrath, B., Towers, J., Plunz, R., Eds.; Columbia University Graduate School of Architecture, Preservation and Planning: New York, NY, USA, 2007.
3. United Nations. *Urbanization: Mega & Metacities, New City States*; UN-HABITAT: State of the World's Cities 2006/7; United Nations: New York, NY, USA, 2006.
4. United Nations Population Fund. *State of World Population 2007: Unleashing the Potential of Urban Growth*; United Nations Population Fund: New York, NY, USA, 2007.
5. Andersson, E. Urban landscapes and sustainable cities. *Ecology and Society* **2006**, *11(1)*, 34.
6. Bontje, M. Facing the challenge of shrinking cities in East Germany: The case of Leipzig. *GeoJournal* **2004**, *61(1)*, 13-21.
7. Melosi, M.V. *The Sanitary City: Urban Infrastructure in America from Colonial Times to the Present*; Johns Hopkins University Press: Baltimore, MD, USA, 2000.
8. Boone, C.G.; Modarres, A. *City and Environment*; Temple University Press: Philadelphia, PA, USA, 2006.

9. Grove, J.M. Cities: Managing densely settled social-ecological systems. in *Principles of Ecosystem Stewardship: Resilience-Based Natural Resource Management in a Changing World*; Chapin, F.S., III, Kofinas, G.P., Folke, C., Eds.; Springer: New York, NY, USA, 2009; p. 281-294.
10. Pincetl, S. From the sanitary to the sustainable city: Challenges to institutionalizing biogenic (nature's services) infrastructure. *Local Environ.* **2010**, *15(1)*, 43-58.
11. *Growing Greener Cities: Urban Sustainability in the Twenty-First Century*; Birch, E.L., Wachter, S.M., Eds.; University of Pennsylvania Press: Philadelphia, PA, USA, 2008.
12. Levins, R. The strategy of model building in population biology. *Am. Sci.* **1966**, *54*, 421-431.
13. Hanski, I. Patch-occupancy dynamics in fragmented landscapes. *Trends Ecol. Evol.* **1994**, *9*, 131-135.
14. Hanski, I.; Gilpin, M.E. *Metapopulation Biology: Ecology, Genetics and Evolution*; Academic Press: San Diego, CA, USA, 1997; p. 512.
15. Pickett, S.T.A.; Cadenasso, M.L.; Jones, C.G. Generation of heterogeneity by organisms: Creation, maintenance, and transformation. In *Ecological Consequences of Habitat Heterogeneity, the Annual Symposium of the British Ecological Society*; Hutchings, M.L., John, E.A., Stewart, A.J.A., Eds.; Blackwell: London, UK, 2001.
16. Wu, J.; Loucks, O.L. From balance of nature to hierarchical patch dynamics: A paradigm shift in ecology. *Q. Rev. Biol.* **1995**, *70*, 439-466.
17. Cadenasso, M.L.; Pickett, S.T.A.; Weathers, K.C.; Jones, C.G. A framework for a theory of ecological boundaries. *BioScience* **2003**, *53*, 750-758.
18. Turner, M.G. Landscape ecology: What is the state of the science? *Ann. Rev. Ecol. Evol. Syst.* **2005**, *36*, 319-344.
19. Cadenasso, M.L.; Pickett, S.T.A. Urban principles for ecological landscape design and management: Scientific fundamentals. *CATE* **2008**, *1(2)*, Article 4.
20. Cadenasso, M.L.; Pickett, S.T.A.; Groffman, P.M.; Band, L.E.; Brush, G.S.; Galvin, M.F.; Grove, J.M.; Hagar, G.; Marshall, V.; McGrath, B.P.; *et al.* Exchanges across land-water-scape boundaries in urban systems: Strategies for reducing nitrate pollution. *Ann. N. Y. Acad. Sci.* **2008**, *1134*, 213-232.
21. Forman, R.T.T. Some general principles of landscape and regional ecology. *Landscape Ecol.* **1995**, *10*, 133-142.
22. Pickett, S.T.A.; Cadenasso, M.L.; Grove, J.M.; Boone, C.G.; Groffman, P.M.; Irwin, E.; Kaushal, S.S.; Marshall, V.; McGrath, B.P.; Nilon, C.H.; *et al.* Urban ecological systems: Scientific foundations and a decade of progress. *J. Environ. Manage.* **2011**, *92*, 331-362.
23. Force, J.E.; Machlis, G.E. The human ecosystem. 2. Social indicators in ecosystem management. *Soc. Nat. Resour.* **1997**, *10(4)*, 369-382.
24. Machlis, G.E.; Force, J.E.; Burch, W.R. The human ecosystem. 1. The human ecosystem as an organizing concept in ecosystem management. *Soc. Nat. Resour.* **1997**, *10(4)*, 347-367.
25. Rossi, A. *The Architecture of the City*; MIT Press: Cambridge, MA, USA, 1984.
26. Koolhaas, R. *Delirious New York*; Oxford University Press: New York, NY, USA, 1978.
27. Cronin, W. *Nature's Metrolopolis: Chicago and the Great West*; W. W. Norton & Co.: New York, NY, USA, 1992.

28. Howard, E. *Garden Cities of To-Morrow*; Farber and Farber: London, UK, 1902
29. Gottmann, J. *The Urbanized Northeastern Seaboard of the United States*; The Twentieth Century Fund: New York, NY, USA, 1961.
30. Theobald, D.M. Land-use dynamics beyond the American urban fringe*.* *Geogr. Rev.* **2001**, *91*, 544-564.
31. Hayward, M.E.; Belfoure, C. *The Baltimore Rowhouse*; Princeton Architectural Press: Cambridge, MA, USA, 1999.
32. Olson, S. *Baltimore*; Ballinger: Cambridge, MA, USA, 1976.
33.. McGrath, B.; Shane, D.G. Sensing the 21st century city: Close-up and remote. *Archit. Design* **2005**, *75*, No. 6.
34. McDonough, T. "Situationist Space", October 67, Winter 1994.