Megapolitan Political Ecology and Urban Metabolism in Southern Appalachia*

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Drawing on megapolitan geographies, urban political ecology, and urban metabolism as theoretical frameworks, this article theoretically and empirically explores megapolitan political ecology. First, we elucidate a theoretical framework in the context of southern Appalachia and, in particular, the Piedmont megapolitan region, suggesting that the megapolitan region is a useful scale through which to understand urban metabolic connections that constitute this rapidly urbanizing area. We also push the environmental history and geography literature of the U.S. South and southern Appalachia to consider the central role urban metabolic connections play in the region's pressing social and environmental crises. Second, we empirically illuminate these human and nonhuman urban metabolisms across the Piedmont megapolitan region using data from the Coweeta Long-Term Ecological Research (LTER) program, especially highlighting a growing "ring of asphalt" that epitomizes several developing changes to patterns of metabolism. The conclusion suggests that changing urban metabolisms indicated by Coweeta LTER data, ranging from flows of people to flows of water, pose a complicated problem for regional governance and vitality in the future. **Key Words: megapolitan region, southern Appalachia, urban metabolism, urban political ecology.**

本文运用大都会带地理、城市政治生态以及城市代谢作为理论框架, 在理论上和经验上探讨大都会带的政治生态学。首先, 我们在南阿巴拉契亚、特别是皮埃蒙特大都会带区域的脉络中阐明理论框架, 指出大都会带区域, 是可藉此理解构组该地区快速城市化的城市代谢连结的实用尺度。我们同时推进美国南方以及南阿巴拉契亚的环境历史与地理文献, 考量城市代谢连结在该区域迫切的社会与环境危机中所扮演的核心角色。再者, 我们运用考威塔长期生态研究 (LTER) 计画中的数据, 经验性地描绘在皮埃蒙特大都会带之中人类与非人类的城市代谢作用, 并特别凸显出增加中的"沥青圈", 该圈象徵着代谢形式中几个发展中的变化。结论部分指出, 由考威塔的 LTER 数据所显示的改变中的城市代谢, 包含人口流动到水的流动, 对未来的区域治理和活力而言, 引发了复杂的问题。 **关键词: 大都会带区域, 南阿巴拉契亚, 城市代谢, 城市政治生态学**。

Utilizando como marcos teóricos las geografías megapolitanas, la ecología política urbana y el metabolismo urbano, este artículo explora teórica y empíricamente la ecología política megapolitana. Primero que todo, dilucidamos un marco teórico en el contexto de los Apalaches meridionales y, particularmente, de la región megapolitana del Piedemonte, sugiriendo que la región megapolitana es una escala útil para entender las conexiones metabólicas urbanas que constituyen esta área en proceso de rápida urbanización. También traemos a cuento la historia ambiental y la literatura geográfica del Sur de los EE.UU., y de los Apalaches meridionales para considerar el papel central que cumplen las conexiones metabólicas urbanas en las apremiantes crisis sociales y ambientales de la región. En segundo lugar, empíricamente ilustramos estos metabolismos urbanos de naturaleza humana y no humana, a través de la región megapolitana del Piedemonte, utilizando datos del programa de la Investigación Ecológica a Largo Plazo de Coweeta (LTER), destacando especialmente un "anillo de asfalto" en expansión que epitomiza varios cambios en desenvolvimiento hacia patrones de metabolismo. La conclusión sugiere que los cambiantes metabolismos urbanos indicados por los datos de la LTER de Coweeta, que van desde los flujos de gente hasta los flujos de agua, presentan un problema complicado para la gobernanza y vitalidad regional en el futuro. **Palabras clave: región megapolitana, Apalaches meridionales, metabolismo urbano, ecología política urbana.**

Complex socioecological issues like climate change and exurbanization call attention to the relations between highly urbanized areas and their wider regional contexts. In the rural and urban areas surrounding southern Appalachia, for example, total population is expected to grow by more than 45 percent from 2000 to 2030 (Lang and Dhavale 2005), accompanied by continued conversion of forested land to developed areas (Napton et al. 2010) and increasing infrastructural, economic, and cultural connections between the region's cities and the exurban, mountainous, and historically rural hinterlands of southern Appalachia (Spectorsky 1955; Lamb 1983; Blumenfeld 1986; Lessinger 1987; A. C. Nelson 1992; Davis and Nelson 1994; A. C. Nelson and Sanchez 1997; Gragson, Bolstad, and Welch-Devine 2008).

These accelerating regional dynamics parallel recent theoretical calls in political ecology to consider how engagements with urban and regional geography can transform research questions to explore the linkages between urbanization and environmental change (see Walker 2003). Accordingly, this article

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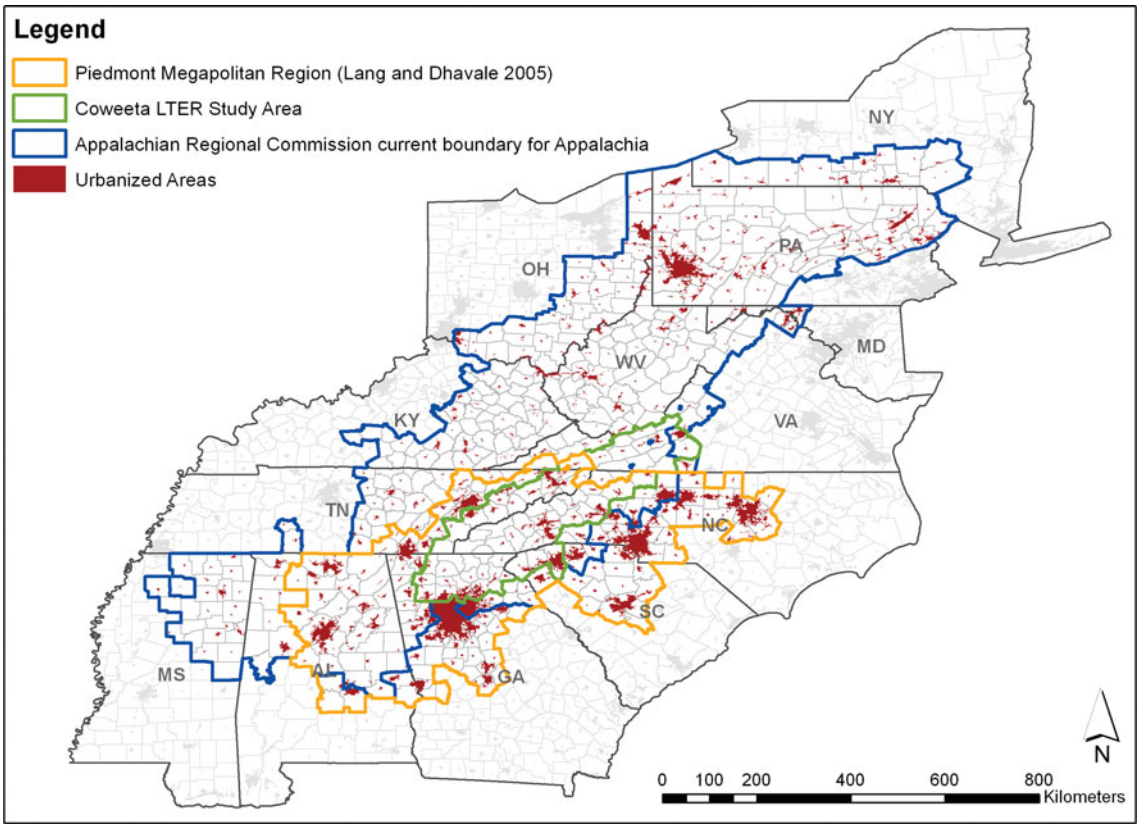

Figure 1 *The spatial extents of the Piedmont megapolitan region, Coweeta Long-Term Ecological Research (LTER) study area, and the Appalachian Regional Commission's current boundary. Source: Lang and Dhavale (2005), Coweeta LTER (2012), and Appalachian Regional Commission (2012). (Color figure available online.)*

describes a "megapolitan political ecology" approach that works across the nature–society and urban–rural matrix to account for the flows of people, objects, resources, and knowledge that constitute regional urbanization. We introduce a megapolitan political ecology that considers our increasingly "urban society" as discussed by Lefebvre (2003), taking seriously the social and environmental processes of metabolism.

We proceed in two major sections, the first a conceptualization of megapolitan political ecology bringing together exurban political ecology, megapolitan geographies, ideas of urban metabolism in political ecology, and global cities. We draw specifically on the ways in which megapolitan regions, urban growth, and ecological changes can be framed within the context of urban metabolism. We then highlight the regional need for these connections through a critique of the urban ecological scholarship of the U.S. South and southern Appalachia, noting that changes in urban–Appalachian metabolism are central to some of the region's most vexing socioecological issues. The second section empirically grounds our conceptual explorations with research from the Coweeta Long-Term Ecological Research (LTER) project. We explore the rapid urbanization of southern Appalachia and, more specifically, climate change drivers and a "ring of asphalt" emerging within the Piedmont megapolitan region (see Figure 1)[1] as we argue that new spatial forms of urban, regional, and ecological issues should expand the theoretical and empirical horizons of urban or, in this case, megapolitan, political ecology.

Urban political ecological questions in southern Appalachia are pressing, especially given the Coweeta LTER's ecological research findings, the recent economic crisis, and the rapid urban growth of the period between 1980 and 2007. These metabolic patterns connect regional ecological and social systems, binding places and ecosystems together. A dialectically oriented approach like this enables us to articulate how humans and nonhumans do not merely acclimate to their local ecologies, but instead affect those ecologies in unpredictable and numerous ways (Levins and Lewontin 1985).

Megapolitan Political Ecology: Metabolizing the Urban(izing) Region

Urban political ecology illustrates understanding urbanization as a sociospatial process "predicated

upon the circulation and metabolism of physical, chemical, and biological components" that "are never socially or ecologically neutral" (Heynen, Kaika, and Swyngedouw 2006, 12). Where this scholarship elucidates the connections between urbanization of nature, socioenvironmental change, and uneven power relations, it has remained mostly focused on larger cities. Urban–hinterland connections are often mentioned, but the impacts of urban metabolism on regional communities are rarely articulated.

To address this issue, we first argue that the megapolitan region is a helpful scale for understanding the function and flows of urban metabolism. This regional scale is relevant for the emergence of global cities shaped by processes of urbanization, which extend into even the most rural areas. Although often overlooked in urban political ecology approaches, these rural places, intimately connected to urbanizing landscapes via socioecological processes, shape flows of global capital and continue to define notions of planetary urbanism (Lefebvre 2003; McCarthy 2008; Brenner and Schmid 2012).

Megapolitan Regions

Megalopolis originally described the densely populated conurbation of the northeastern United States, including the entire corridor from Washington, DC, to Boston (Gottman 1966). Although the included metropolises are distinct jurisdictional entities, their connections, agglomeration, and exurban expansion comprise a unique spatial formation. Most recently, megapolitan research has taken an applied turn through scholarly work in policy, planning, and urban studies (Lang and Dhavale 2005; Ross and Danner 2010).[2] Very little, if any, critical research exists on megapolitan regions.

We suggest using the megapolitan region as a way to examine broader scale urban development dynamics that have significant, although often underemphasized, impacts in historically rural areas. This spatial unit is useful because at its core, the notion of a megapolitan region captures the connections between multiple cities of varying sizes and their rural hinterlands. Walker (2003) proposed reinvigorating a regional approach in political ecology sensitive to the perils of regional geography but rich in potential: "Certainly, particular regional frames should not be merely accepted as given, but that is precisely the kind of critical perspective that political ecology could bring to these questions" (13). In other words, the critique of regions as arbitrary and imbued with power is important, but a political ecology approach, with its emphasis on the connections between social power and ecological change spanning scales, is particularly well suited to consider the spatialities of urbanization and ecological change. Using a region functionally is qualitatively different from using region as an a priori given. The benefits of cautiously using a regional political ecology approach are that it recognizes spatially bounded phenomena while tracing the emergence of and changes in the region itself.

We see three advantages to using the megapolitan region as a unit of analysis: Its relative underuse avoids the connotations of other more frequently used regional terms, it cuts across assumed and conventional regional boundaries, and it offers helpful insights from a politics of scale perspective (Smith 1996; Swyngedouw 1997). Our approach also corresponds with Neumann's (2010) regional political ecology intervention, where he notes that political ecology has used the notion of region inconsistently and irregularly, conflating theoretical conceptions of regions with popular conceptions. He advocates "a more universal and theoretically robust [regional political ecology], which builds on the central insight in human geography that regions are historically contingent processes, wherein the reproduction and transformation of society is inseparable from the transformation of nature within prevailing relations of power" (372). Our approach furthers this advocacy by examining in a single, metabolism-centric framework (1) urban–rural relations and flows, (2) ecological change manifesting as localized impacts and regional (perhaps even global) connections, (3) urbanization processes constituted by regional infrastructural networks and economic linkages, and (4) regionally distinct cultural, social, and political histories. This resonates with an understanding of urban–hinterland relationships already present in the literature (e.g., Cronon's [1991] *Nature's Metropolis*).

Metabolism

Although *Nature's Metropolis* (Cronon 1991) does not explicitly mention metabolism, the book's central point is the enormous implications of Chicago's metabolization of capital, grain, animal products, and labor from its surrounding region. Metabolism in Chicago's case meant that massive quantities of these regional resources were processed, transformed, financed, capitalized, traded, dispersed, and accumulated in Chicago, resulting in the city's leading regional status. Metabolism as used in the urban political ecology literature, too, approaches socionatural processes by focusing on the circulation of physical, chemical, and biological components (Swyngedouw and Heynen 2003). Cronon (1991) noted, "[metropolitan expansion] imposed on the land a new geography of second nature in which the market relations of capital reproduced themselves in an elaborate urban–rural hierarchy that would henceforth frame all human life in the region" (378).

Relatedly, as Foster (1999) discussed, Marx raised fundamental issues about the town–country antagonisms forming under capitalism. Marx himself implicitly addressed the need for ecological sustainability through the metabolic relation of society and "nature" more broadly (Marx 1976). Through the theory of metabolic rift, Marx considered the co-transformation of nature and society. As Smith (2006)

suggested, however, there is creativity within the process of metabolism, implying that these processes are not necessarily path dependent:

> The notion of metabolism set up the circulation of matter, value and representations as the vortex of social nature. But, as the original German term, "*Stoffwechsel*," better suggests, this is not simply a repetitive process of circulation through already established pathways. Habitual circulation there certainly is, but no sense of long-term or even necessarily short-term equilibrium. Rather, "Stoffwechsel" expresses a sense of creativity in much the same way Benjamin talks about mimesis: the metabolism of nature is always already the production of nature in which neither society nor nature can be stabilized with the fixity implied by their ideological separation. (xiii)

This creativity implies that metabolism is not simply static recirculations of materials. Instead, metabolism is the dynamic process by which new socio-spatial formations, collaborative enmeshings of nature and society, and uneven social relations come into being.

Global Cities Versus Global Cities

Without using the urban political ecological language of metabolism, recent critical geographic interventions in what could be called exurban political ecology examine transformations of historically rural places through processes of exurbanization and amenity migration (see Brogden and Greenberg 2003; Woods 2009, 2012; Cadieux and Hurley 2011; L. Nelson and Nelson 2011; Abrams et al. 2012; Robbins et al. 2012; Cadieux and Taylor 2013). On the whole, this literature demonstrates via case study and rigorous empirics exurbia's city–rural flows (e.g., Walker and Hurley 2001), local socioecological changes (e.g., Hurley and Walker 2011), and regional political, cultural, and ecological distinctions (e.g., Hurley and Ari 2011; Hurley and Halfacre 2011; Walker and Hurley 2011). A megapolitan political ecology approach is quite complementary in its approach, given the shared socioecological concerns, critical political ecology roots, and significant overlap in interest in rural research sites. Where the exurban political ecology literature complements our approach most is that its investigations of capital flight to the countryside, ecological ramifications of exurban growth, and long-term regional particularities deeply affect and influence how urban metabolism takes shape, whether in the form of flows of amenity migrants or capital flight to the countryside. Likewise, our approach complements this literature by integrating these items into a singular framework.

A megapolitan political ecology perspective, though, is distinct. The preceding exurban political ecology literature rightly highlights enduring rural practices in urbanizing areas and the import of urban practices into historically rural places, noting that there are some important and mutually constitutive links between cities and hinterlands. Megapolitan political ecology, though, is a framework to understand the dynamic processes of metabolism. This is perhaps a subtle difference of empirical target, but it suggests a more fundamental point of distinction: Megapolitan political ecology prioritizes the urban condition insofar as it is constituted by metabolic relationships across space and time. In this sense, megapolitan political ecology is not interested in—nor is it used to think in terms of—"cities" and "rural" places as discrete entities, even if those categories are argued to be mutually constitutive and intertwined. Instead, metabolism investigates, describes, and critiques the connections of a variety of human and nonhuman elements that characterize urbanization; that is, the very stuff of the urban condition.

Similarly, Cronon's Chicago and related urban ecological studies of major urban centers (e.g., Gandy 2002) show the potent metabolic reach of large cities, where regional urbanization patterns are often driven by the development of world cities pushing into hinterlands as well as the growth of smaller, regionally important cities. This difference maps onto Luke's (2003, 12) distinction between "Global Cities"—those officially recognized and ranked as the command-and-control centers of the global economy—and "global cities"—those smaller and more peripheral urbanizing areas cumulatively accounting for the bulk of urban growth. Urban political ecologists are generally less concerned with Global or global city statuses and more concerned with the power relations and ecological transformations of both Global and global cities that are initiated through processes of urbanization (see GaWC Research Network 2010; see also Keil 1995; A. J. Scott 2001).

The global cities, not typically noted for their status as major nodes in the world urban system, represent important trends in the history of urbanization. According to Luke, global cities contain most of the world's roughly 3 billion urban dwellers in the early part of the twenty-first century and will account for the vast majority of worldwide natural resource consumption for generations (Luke 2003, 18). Thus, if Global Cities generally organize the core and periphery of the world economic and cultural production (Massey 2007), then global cities are significant sites of the metabolization of economy and culture. The dramatic rise of urban populations, Luke (2003, 19–21) wrote, not only will lead to increasing production of waste and pollution but also the extraction necessary to sustain urban consumption of food, water, electricity, infrastructure, and more. To understand the significance of regional urban metabolism, scholars must consider the processes that globalize cities across the world—including and especially those that do not make the official Global Cities lists.

Likewise, McCarthy (2008) noted that urban expansion exposes the countryside to global capital. Urban expansion, urban–rural metabolic linkages, and urban-sourced capital's claims to rural landscapes are nothing new, of course (Walker and Fortmann 2003; Hurley and Halfacre 2011), but McCarthy noted some new trends that characterize urbanization in the

countryside, focusing in particular on amenity migration to rural areas (McCarthy 2008, 129) and development in the Global North and South. Together, both McCarthy and Luke offer a conception of global city formation whereby global urban processes metabolize more land, capital, resources, and cultural assets. Because the notion of urban metabolism demands that economies, resources, politics, suburbs, and exurbs be seen as inextricably related, global city urbanization patterns necessarily influence the ecology of megapolitan regions.

Southern Appalachia and Urban Environmental Scholarship

Thick, interlocking connections between urban and rural areas, Global and global cities, and ecology and urbanization can be explored in many places, but we draw on these developments in the Piedmont megapolitan region to illustrate the importance of the megapolitan political ecology approach. The broader awareness of Appalachia's ecological and economic issues was articulated through Caudill's (1962) *Night Comes to the Cumberlands* and through the Appalachian Regional Commission's policy work beginning in the 1960s. These efforts spawned a generation of Appalachian scholarship (see The University of West Virginia Libraries [2008] *Appalachian Studies Bibliography*). Most urban historical and urban ecological scholarship on southern Appalachia, however, considers neither regional urban development nor U.S. Southern cities as significant to southern Appalachia (although see Gaventa 1982; Pudup, Billings, and Waller 1995; Lewis 2004), situating urban–rural relations in the U.S. South in the context of an Old South–New South division (see Woodward 1951; Ayers 1992). This presents a problem for understanding urbanization on the periphery of southern Appalachia, usually understood by scholars as historically and geographically oriented toward the rural South rather than rural Appalachia.

Contrary to this narrative, much of Appalachia's political ecology can be read as a legacy of its relationships with peripherally Appalachian cities. Prior to exurban development in southern Appalachia, because it did not have salt and coal present in central and northern Appalachia, proximal cities were instead primarily based on timber and tourism (Lewis 2004, 64). The railroad helped develop many regional cities like Atlanta, Asheville, and Knoxville into strategically located transportation and logistics hubs. After the timber boom and bust of the early to mid-twentieth century, exurban development initiated agricultural to residential land use changes and an economic transition to tourism and construction, as it has in many other locations (Theobald 2001; Irwin and Reece 2002; Wolman et al. 2005; Abrams et al. 2012).

Compounding the problem is environmental historians' and geographers' only recent consideration of the political ecology of the U.S. South (Sutter and Manganiello 2009; Hurley and Carr 2010; Manganiello 2010). Few older studies have taken the ecological manipulation of the Appalachian South as integral to the urbanization of the region, but the vital contribution of this new work is that it "merges the southern narratives about the New South, industrialization, and labor relations with a story of environmental change" (Manganiello 2010, 13). This synthesis of previously unconnected elements fills a gap in the historical and social science literature.

(Ex)Urban Metabolism in the Piedmont Megapolitan Region

Our interest in the megapolitan political ecology of the Piedmont megapolitan region is coupled with a large biophysical research effort funded by the National Science Foundation at the Coweeta LTER, whose research and data since 1980 address a range of ecological variables in southern Appalachia. Our megapolitan political ecology approach is an effort to better integrate social and ecological research of the LTER Project, focusing on how exurbanization establishes regional patterns of urban metabolism (Gragson and Grove 2006). In southern Appalachia, Gragson and Bolstad (2006) tracked land use changes as seen through Coweeta LTER research. Much of this research shows increasing urbanization of these areas, especially in the last several decades, and forecasts significantly more urban growth until 2030 (e.g., Wear and Bolstad 1998). Other relevant Coweeta LTER research highlights the settlement patterns (Kirk, Bolstad, and Manson 2012), bird populations (Lumpkin, Pearson, and Turner 2012), water quality issues (Webster et al. 2012), and stream fish populations (M. C. Scott 2006) intimately related to exurbanization in southern Appalachia. The exurban-themed research at the Coweeta LTER complements other urban ecological research from the greater network. The Central Arizona Project and the Baltimore Ecosystem Study are two explicitly urban LTER sites studying urban ecology (e.g., Pickett and Cadenasso 2006; Childers et al. 2011).

Our methods in this empirical section are multiple. Identification of the ring of asphalt as an analytical object is rooted in ethnographic experiences with southern Appalachian residents concerned with the long-term consequences of exurban development. We identified the Piedmont megapolitan region based on the megapolitan literature and used publicly available tax data for analysis of second-home owner origin patterns. The land cover change maps were created using data from the National Land Cover Database (NLCD), from Landsat satellite imagery, and from supplemental data sets. The NLCD is created by the Multi-Resolution Land Characterization (MRLC) consortium of federal agencies.[3] The maps for the ring of asphalt study as well as the percentage of increased urban area data for the 250-km buffer around the Coweeta LTER were created by areal analysis using geographic information system (GIS) software.

Southern Appalachian Exurban Metabolism

Coweeta LTER research, as well as other non-Coweeta research on exurban ecologies, gives examples of how exurban metabolism alters the pathways, connections, abundance, proliferation, and degradation of physical, biological, and chemical components ranging in size from the molecular to species populations (e.g., Hansen et al. 2005). This research bolsters our claim for urban metabolism in megapolitan political ecology, showing how urbanization at a regional scale has significant implications for how that region changes flows of chemical, biological, and physical components.

First, some of the human-oriented research at Coweeta LTER emphasizes how exurbanization metabolizes capital and land in many southern Appalachian communities. Southern Appalachian exurbs attract mostly the upper middle class, a few commuters and families, and many retirees. As an example, Macon County, North Carolina, home to the Coweeta LTER main research site, is undergoing many of these exurban changes. U.S. Census data show that over one third of the county's population is over the age of sixty; agricultural economic output has fallen to roughly 0.1 percent of the county's overall economy; and despite a natural population growth of negative 1.8 percent from 2000 to 2010, the county's overall population growth was a positive 13.8 percent (U.S. Census Bureau 2010). One forecast predicts that in Macon County, by 2030, "approximately 75 percent of new buildings will be constructed at urban and suburban densities and that 67 percent of all new buildings will be constructed in forested areas" (Kirk, Bolstad, and Manson 2012, 47).

Publicly available county tax data (Macon County, North Carolina 2010) confirm that nonlocal and out-of-state second homeownership are fueling exurban growth in Macon County. Forty-three percent of Macon County residences have an out-of-state owner and 74 percent of those owners' primary residences are in Florida and Georgia (see Figure 2). Interestingly, in-state and out-of-state homeownership changes with elevation. In valley bottoms less than 2,000 feet above sea level, the in-state/out-of-state percentage ratio is 58 percent to 42 percent, whereas closer to the mountaintops at elevations above 3,500 feet, the ratio is 33 percent in-state to 67 percent out-of-state. As a result of this growth, Maconians report increased traffic, smog, and other externalities commonly associated with exurban growth. Furthermore, some housing developments built on steep slopes in the county, fueled by the cheap land and easy credit of the late 1990s and early 2000s, lead to major erosion, landslide, and water quality issues. Many properties were subject to foreclosure after the 2008 financial crisis, leaving some in environmental disrepair.

Second, exurban ecological research at Coweeta LTER shows how urban metabolism impacts the flows of nonhuman environmental components. Research by Clinton and Vose (2006) and Price and Leigh (2006) shows that entry of increased sedimentation and nitrates into streams are related to road construction and deforestation. Sedimentation in streams resulting from road construction is also linked to decreases in dissolved oxygen in streams (Ferreira et al. 2010). Conductivity of stream water from potassium, sodium, calcium, and magnesium cations into stream water, as well as fecal coliform proliferation, is also related to exurban development (Clinton and Vose 2006; Price and Leigh 2006). Because southern Appalachia cradles headwaters of rivers flowing throughout the Southeast, exurban-influenced biological and chemical changes in upstream streams and rivers conceivably affect how the entire megapolitan region metabolizes water resources. Exurbanization in southern Appalachia also alters migration, movement, and reproduction of some species, leading to reduced populations and habitat losses (Turner et al. 2003).

Urban Climate Effects and the Ring of Asphalt

A third piece of Coweeta LTER research indicating the changes in Piedmont megapolitan metabolism is an emerging ring of asphalt initiating urban climatological changes, a useful corollary to Luke's (2003) discussion of global city formation. Cities themselves modify weather and climate at scales ranging from local to global. The most comprehensively studied effect of the built environment on climate is the urban heat island (UHI), defined generally as the increase in temperatures of urban areas relative to surrounding rural areas, with pronounced effects on nighttime temperatures, caused by the land use features of urban development. Some of the more common symptoms of the UHI affecting both humans and nonhumans are warmer air and higher tree canopy temperatures. Changes in air circulations induced by UHIs are driven by differential heat capacity and thermal inertia between rural and urban regions. UHI-related temperature gradients depend strongly on factors like developed to undeveloped land ratio, green-to-nongreen surface ratio, sky view factor, and more (see Oke 1987). A surplus of surface energy over urban regions can be traced to enhanced surface sensible heat flux, ground heat storage, anthropogenic heating, and reduced evapotranspirational cooling. For the Piedmont megapolitan region, the increased infrastructural growth of urbanization could mean an intensification in the UHI.

Whereas the UHI is relatively well understood, urban effects on the hydroclimate (i.e., clouds, precipitation, and land surface hydrology) still require additional scientific interrogation. Coweeta LTER researchers have investigated the role of urban, peri-urban, and exurban landscapes on the hydroclimate (Shepherd, Carter, et al. 2010; Shepherd, Stallins, et al. 2010; Shepherd et al. 2011). Their focus is on the spatiotemporal trends of hydroclimate variables, as well as understanding how varying degrees of urban land cover initiates UHI-related hydroclimate changes. This research uses synergistic observational and regional modeling approaches because they are

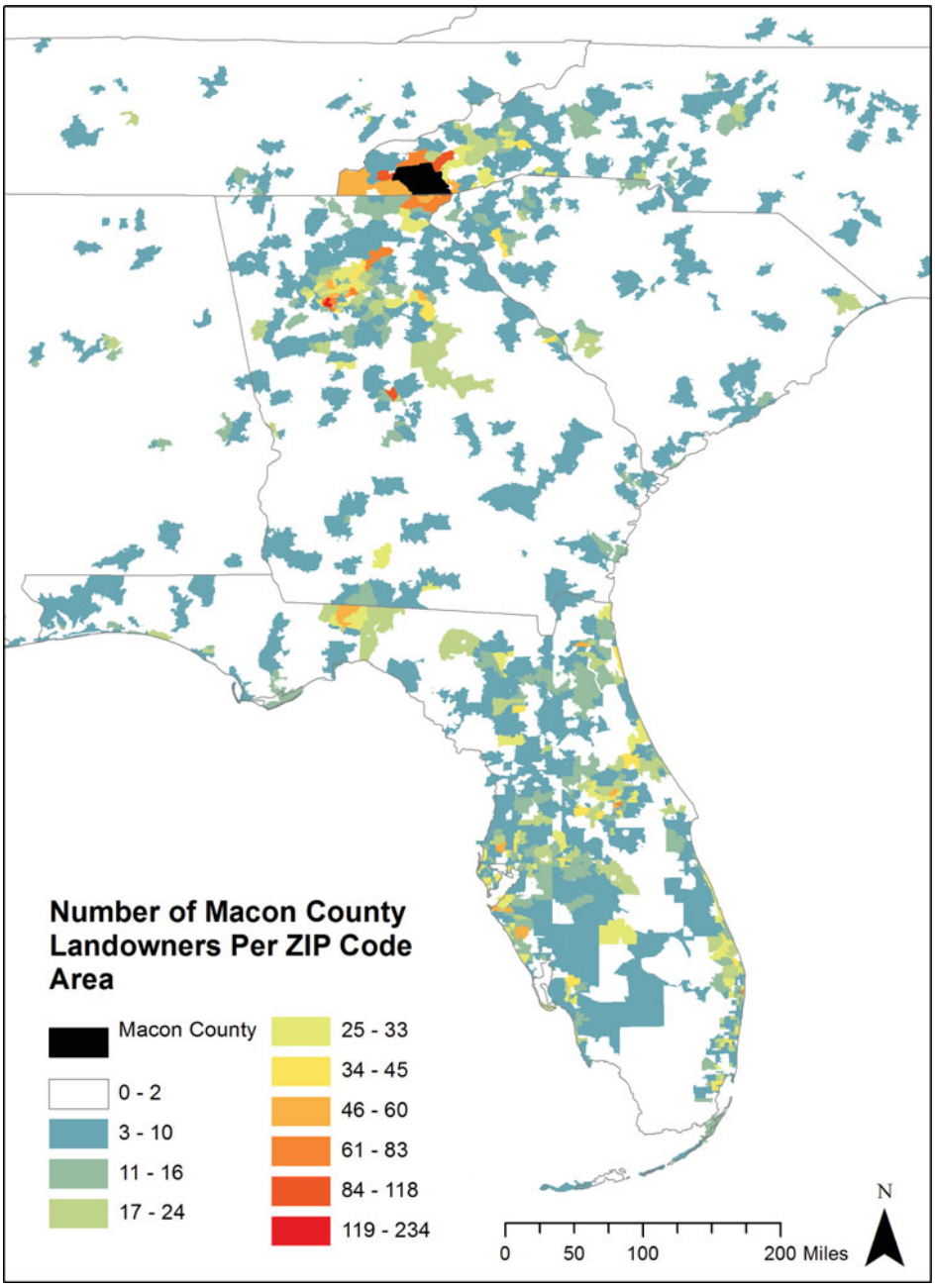

Figure 2 *Southeastern U.S. ZIP code tabulation areas with more than three entries in the Macon County, North Carolina Property Tax Database as a proxy for nonlocal property ownership. Source: Macon County, NC, Property Tax Database (Macon County, North Carolina 2010). (Color figure available online.)*

well situated to develop understanding of the complex interactions between exurbanization and climate change prevalent at regional scales, with a study area that encompasses Atlanta, Knoxville, Asheville, and Charlotte.

Results suggest some compelling findings in terms of the interconnected socioecological relations between the urbanization of the Piedmont megapolitan region and hydroclimatological changes. As displayed in Figure 3, urban land cover analysis reveals a very apparent "ring of asphalt" in southern Appalachia, with extensive encroachment into the interior region—places historically characterized by forest or other nonurban land uses. Given the increased exurbanization of the region, this infrastructural boom is unsurprising. Urban land cover increased roughly 8

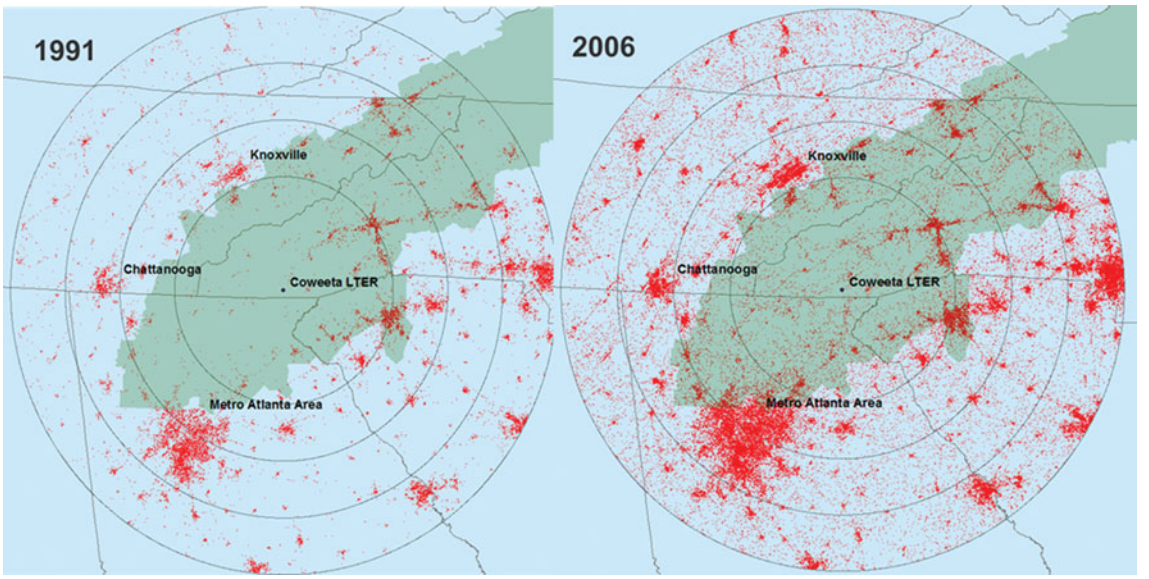

Figure 3 *Urban land cover in southern Appalachia, shown here in red, has increased by 15 percent from 1992 to 2006. Source: National Land Cover Database. (Color figure available online.)*

percent from 1992 to 2001 and 7 percent from 2001 to 2006 with an overall increase from 1992 to 2006 of 15 percent. Analysis of rainfall trends in rapidly urbanized areas of the region from the early 1950s to 2006 shows that rainfall from June to August has increased 1 to 2 percent per year. Another analysis of regional analysis data reveals an increase in rainfall in the urban corridor from Atlanta to Charlotte from 1992 to 2006 as compared to 1979 to 1991.

Rainfall in southern Appalachia is as much a function of changes at many scales, ranging from the greenhouse-enhanced global scale to the urbanized regional scale, but the UHI and regional hydroclimate analysis helps to understand how urbanization impacts the metabolic circulation of water and heat at a regional scale. Further, it introduces the potential for increased human vulnerability to heat-related illness, flooding, and landslide hazards. As regional growth furthers land use change and infrastructural growth, the intensification of the UHI and its consequences in other cities imply similar scenarios for the Piedmont megapolitan region.

Conclusions: Toward Piedmont Megapolitan Political Ecology

By offering the ring of asphalt in southern Appalachia as an empirical moment of investigation, we are suggesting, just as other scholars have, that low-density residential development, rapid expansion of road networks, and high rates of increase of impervious surface in historically rural areas are hallmarks of urbanization in the U.S. South. What, then, is the value added of a megapolitan political ecology approach, especially in the Piedmont megapolitan region?

The primary value added of megapolitan political ecology is its emphasis on regional urban metabolism, made possible by the growth of Global and global cities in a megapolitan region. Although individual urban metrics can be useful for measuring urbanization, urban metabolism is a more holistic framework capable of integrating these metrics while offering theoretical insight to the processes of urbanization at a functionally defined regional scale. Thus, our presentation of the ring of asphalt and other exurban ecological research indicates more than they otherwise would as simply another set of metrics of urbanization. Instead, we argue that a fundamental condition of urbanization is the set of changes in circulation of elements as diverse as water molecules, capital investment, heat energy, and second homeowners. In other words, the target of explanation for megapolitan political ecology, then, is not limited to the measurement of particular urban variables and is instead an investigation of the nature of the urban condition understood in part as numerous and impossibly complex metabolic relations.

Some important considerations for urban political ecology not addressed here are the regulatory regimes; historic land use and land management practices; and the economic, political, and cultural tools that govern or do not govern urban metabolism, mostly because the empirical data of exurban metabolism outmatch our current ability to assess Piedmont megapolitan environmental governance. Both Global cities and global cities have an important role to play within the unfolding of climate governance because of local governments' regulatory power over urban greenhouse gas emission sources, like transport and energy use (DeAngelo and Harvey 1998; Betsill 2001). Some cities in the United States, including Denver, Portland,

Seattle, and Salt Lake City, have pioneered new policies focused on climate mitigation, including energy efficiency requirements for the built environment, alternative transportation methods such as bike lanes and public transit, and land use policies to promote more dense and mixed used developments (Bulkeley and Betsill 2003; Schreurs 2008; Rice 2010).

Thinking about land-use regulations like these within the Piedmont megapolitan region, though, is challenging because of entrenched opposition to state regulation in areas exposed to McCarthy's globalization of the countryside. Even so, regional urbanization and the emergence of local governments as important state apparatuses necessitate deeper consideration of governance possibilities (Brenner 2004). Furthermore, scholars should consider the spatiality of political authority and the degree to which multiple sites and forms of power embedded in climate policy have "the potential to enable a more thorough understanding of the agents, processes and practices of governing climate change, and of its potential to make a difference to the global climate" (Okereke, Bulkeley, and Schroeder 2009, 74).

Inevitably, as the broader literature on urban political ecology suggests, these metabolic relations produce a series of both enabling and disabling socioecological conditions. For Cronon (1991), the emergence of Chicago as a center of metabolism meant changes in the livelihoods of laborers in urban Chicago and rural Michigan, social relationships of financial debt, and the rise of industrial meatpacking. Although place and time contingent, conditions like these lead to particular social formations and are often unevenly improved and worsened in some places and for some people. Given the long-standing extreme socioeconomic unevenness within the Piedmont megapolitan region, the hydroclimatalogical changes and the lack of regulatory response will likely more negatively affect the lives of the poor than the affluent through heat stress, water scarcity, and increased frequency and magnitude of severe weather events.

Through these and other related themes of spatial formation and the unevenness of environmental benefits and burdens, scholars can contribute to and benefit from a reconsideration of the megapolitan region. Although the term is underexposed, its reentry represents an opportunity for scholars working in urban political ecology to reassess its use. Geographers, in particular, are attuned to processes of urbanization and the changing politics, economics, and ecologies of rural areas in these processes. Geographers also stand to gain a compelling spatial unit of analysis describing the expansion of global cities and for discussions of uneven development.

The notion of megapolitan political ecology can bring interrelated ecological and social issues into a more complete framework for analysis. Given its usefulness in identifying some similarities between urban processes in a range of cities, understanding megapolitan processes of urban metabolism presents an opportunity for rethinking the urban–rural relationships of Appalachia. Not only would scholars studying processes in the Piedmont megapolitan region benefit, but urban political ecologists at large might also reconceptualize the nature of urban metabolism with an understanding of the megalopolis. As exurbanization poses radical challenges to historically rural places worldwide, a megapolitan perspective illuminates a scale of these changes that will affect the futures of cities, hinterlands, and their regional connections. ■

Notes

[1] The Piedmont megapolitan region includes southern Appalachia; areas of Alabama, Georgia, North Carolina, South Carolina, and Tennessee; five Metropolitan Statistical Areas with over 1 million people in them (Atlanta, Birmingham, Charlotte, Nashville, and Raleigh-Durham); and hundreds of smaller communities (see Figure 1).

[2] See Regional Plan Association (2012) for a map of megapolitan regions in the United States.

[3] Including Environmental Protection Agency, National Oceanic and Atmospheric Administration, National Aeronautics and Space Administration, United States Forest Service, United States Geological Survey, Bureau of Land Management, National Agricultural Statistics Service, National Park Service, United States Fish and Wildlife Service, and the United States Army Corps of Engineers.

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