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THREE ECOLOGIES: Urban Metabolism and the Society-Nature Opposition

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This article is an intellectual history of two enduring binaries—society-nature and city-countryside—and their co-identification, told through evolving uses of the concept of "urban metabolism." After recounting the emergence of the modern society-nature opposition in the separation of town and country under early industrial capitalism, I interpret "three ecologies"—successive periods of urban metabolism research spanning three disciplines within the social sciences. The first is the human ecology of the Chicago School, which treated the city as an ecosystem *in analogy* to external, natural ecosystems. The second is industrial ecology: materials-flow analyses of cities that conceptualize external nature as the source of urban metabolism's raw materials and the destination for its social wastes. The third is urban political ecology, a reconceptualization of the city as a product of diverse socio-natural flows. By analyzing these three traditions in succession, I demonstrate both the efficacy and the limits to Catton and Dunlap's distinction between a "human exemptionalist paradigm" and a "new ecological paradigm" in sociology.

INTRODUCTION

Louis Wirth opened his celebrated article "Urbanism as a Way of Life" with the observation that "nowhere has mankind been farther removed from organic nature than under the conditions of life characteristic of great cities" (Wirth 1938:1–2). Historically, this has been a common sentiment, but one we now know is wrong. Nature is as much present in city concrete as in a farmer's field. Indeed, Wirth's statement eloquently expresses the society-nature opposition—the idea that the social and the natural are distinct and perhaps opposed realms of reality. This article is an urban intellectual history of that opposition, told via one specific concept that is particularly expressive of the evolution of the theme over time: urban metabolism.

The term "metabolism" was coined in the early 19th century to describe chemical changes within living cells. Within 50 years, its use was widespread in biology and what would become biochemistry to characterize processes of organic breakdown and recomposition, within individual organisms (at a cellular scale) and between organisms and their environment. Ever since, metabolism has lived a dual existence in the natural sciences, referring both to processes by which bodies change and reproduce themselves and to more holistic conceptions of ecosystem relations (Fischer-Kowalski 1998; Foster 1999).

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It was in the latter register that the metabolism concept entered the social sciences, via Karl Marx, who appropriated it to describe first the human transformation of nature through labor and second the capitalist system of commodity exchange. Marx was also the first to use the concept of social metabolism to question the apparent separation between human beings and their environment:

> What requires explanation is not the unity of living and active human beings with the natural, inorganic conditions of their metabolism with nature. . . . What we must explain is the *separation* of these inorganic conditions of human existence from this active existence. (Marx 1964:86–87; emphasis in original)

This is the society-nature divide, which Marx elsewhere referred to as a "metabolic rift" (Foster 2000). In this article, I reexamine it as a distinctively *urban* phenomenon. I begin by recasting familiar arguments about the production of nonhuman nature to emphasize that the society-nature opposition took its modern form in the separation of town and country under the emergence of industrial capitalism. The co-identification of these two oppositions—society-nature and city-countryside—is the rubric I use to interpret changing uses of the metaphor of urban metabolism. I analyze "three ecologies": three successive periods of urban metabolism research spanning three disciplines within the social sciences.

The first is the human ecology of the Chicago School. In what was to become the dominant sociological understanding of the city for much of the 20th century, Robert Park and Ernest Burgess treated the city as an ecosystem *in analogy* to external, natural ecosystems, and conceptualized urban metabolism as a process of social (i.e., nonnatural) change internal to the city. The second era of the urban metabolism concept is that of industrial ecology: materials-flow analyses of cities, following Wolman's (1965) foundational text "The Metabolism of Cities." Like the Chicago School, it locates society spatially within cities, but adds external nature as the source of raw inputs and the destination for social wastes. The final era is the rise of urban political ecology (UPE), a hybrid approach to studying urban natures premised on an analytical dissolution of the society-nature division. These scholars explicitly reconceptualize the city as a product of diverse socio-natural flows.

The succession of the three ecologies demonstrates a progressively greater awareness of the role of nature within urbanization and thus within human society, but also a changing real relationship between these terms. Nature begins as entirely absent from the city, proceeds to inhabit its outside, and ends up profoundly implicated in its production and reproduction. The history I present here thus offers a qualification to Catton and Dunlap's (1980) influential elaboration of a break in sociology between a "human exemptionalist paradigm," which holds human society to be exempt from natural forces and constraints, and a "new ecological paradigm," which incorporates natural forces into its analysis. On the one hand, I demonstrate that a similar break occurred outside the domain of mainstream sociology, lending support to their argument that changing material conditions have driven changing awareness of the role of

environmental factors in the social world. But on the other hand, the limits of the new ecological paradigm are illustrated by further developments in urban metabolism research in recent decades that have been slow to occur in either environmental or urban sociology. I return to these considerations in the conclusion.

THE URBAN ORIGINS OF THE SOCIETY-NATURE OPPOSITION

The city is now frequently presumed to be the future proving ground for the relationship between human beings and their natural environment. Here, for example, is a recent edition of UN-HABITAT's influential State of the World's Cities report:

> From a sustainable development perspective, the welfare of future generations depends on how well present generations tackle the environmental burdens associated with urban living. Environmental harmony—between rural and urban areas, and within cities—is a growing concern among urban planners, policymakers and environmentalists. (UN-HABITAT 2008:122)

Many such statements are contextualized with reference to a dawning urban age: 50 percent of the world's population now live in cities. This is a round number, but ultimately not a very compelling *quantitative* justification for an apparently *qualitative* shift in the relationship between cities, society, and the environment. If urbanization has indeed provoked a metabolic rift in the social relation to nature (Foster 2000), it is hard to see how any particular demographic threshold could be decisive. In fact, this relationship is not as novel as contemporary discourse often assumes: the modern form of the society-nature opposition is to a large extent a consequence of the separation of town and country under 19th-century capitalism.

The basic proposition is that modern Western understandings of nature were set in the emergence of industrial capitalism. In particular, what I take to be the most important feature of the society-nature opposition—the idea that nature is a realm external to human society and in some sense even antithetical to it—owes its modern, recognizable existence to the social transformations wrought by the industrial revolution. This argument is a common one, in some form or another (e.g., Polanyi 1944; Williams 1973, 1980; Berger 1980; Cronon 1995; Foster 2000; Smith 2008). The scholars who have made it have persuasively demonstrated the role that the society-nature opposition has played in (1) legitimizing both the human domination of nature in the name of progress, and (2) naturalizing socially produced injustices such as inequality, racism, sexism, war, and imperialism.

But much of this research has tended to downplay the specific aspect of industrial capitalism most responsible for the setting the terms of the modern society-nature opposition: the separation of town and country.[1] We see this clearly in William Cronon's brilliant article on the creation of "wilderness"—another term for external, nonhuman nature. Echoing the seminal work of Nash (1967), Cronon (1995:69) argues that wilderness is "quite profoundly a human creation—indeed, the creation of very particular human cultures at very particular moments in human history," and locates

this creation in 19th-century North America and Western Europe. He identifies two important causes of the production of external nature: the "sublime" and the "frontier." The former is a Romantic sense of spiritual wonder imbued in certain remote landscapes, common, according to Cronon, to European and American imaginaries of nature. The latter is a more distinctively American concept of promise and renewal outside the bounds of civilization.

Cronon demonstrates the *positive* origin of wilderness as both sublime and frontier, but only hints occasionally at its *negative* origin. That is, what was wilderness being defined *in contrast to*, beyond industrial civilization in general? The closest we get in his account is the following line: "The dream of an unworked natural landscape is very much the fantasy of people who have never themselves had to work the land to make a living—urban folk for whom food comes from a supermarket or a restaurant instead of a field, and for whom the wooden houses in which they live and work apparently have no meaningful connection to the forests in which trees grow and die" (Cronon 1995:80). But of course there were urban folk who did not grow their own food long before either the sublime or the frontier separated the idea of nature from the idea of society. So what changed?

The answer is the separation of town and country into distinctive and apparently autonomous social realities, a process ushered in by the new spatial division of labor of European industrial capitalism. As Sennett (1969:3) observes of Western Europe, "up to the time of the Industrial Revolution, the city was taken by most social thinkers to be the image of society itself, and not some special, unique form of social life." We find a paradigmatic example in the first book of Rousseau's *Social Contract*, where the term "city" simply describes the body politic. Such a usage does not imply a contrast of city with any other social sphere, and certainly not with an agricultural or pastoral countryside. Indeed, it would have been strange had Rousseau drawn such a contrast. For historically, as Weber (1958:70) notes concisely, "The relation of the city to agriculture has not been clear cut."

In England by the 19th century, however, manufacturing (previously dispersed throughout the countryside in so-called "cottage industries") was concentrating along with a growing working class in the cities (Polanyi 1944; Thompson 1963). And embattled rural communities, increasingly finding their ways of life threatened by the new political and economic weight of the cities, engaged in radical acts of resistance that paralleled the better known urban oppositional movements such as Luddism (Calhoun 1982). The result was a widespread (i.e., both intellectual and popular) imaginary of town and country as opposing but inextricably linked forces in English society. The new industrial cities were not contrasted with smaller towns (as, for instance, Rousseau earlier contrasted the metropolis with the town [Ellison 1985]) but with the countryside. And the fate of the countryside was held to be a question of reining in the destructive influence of the city (Spirn 1985).

In other words, within the city–country relationship, the city came to occupy the socially decisive position by the late 19th century. (This despite the fact that the majority of the English population continued to reside in villages and small towns.) The city

became the active, social subject—the place where society "really" is located—while the countryside was progressively reduced to a dominated, nonsocial "other" (Haila 2000:157).

This is the context that Cronon was no doubt aware of but did not emphasize in his account of the creation of wilderness. When he quotes Wordsworth's *Prelude*, with its solemn depiction of sacred nature, he might plausibly have paired it with William Blake's "And Did Those Feet in Ancient Time," a poem composed in 1804, within a few years of Wordsworth's:

> And did those feet in ancient time.
> Walk upon England's mountains green:
> And was the holy Lamb of God,
> On England's pleasant pastures seen!
>
> And did the Countenance Divine,
> Shine forth upon our clouded hills?
> And was Jerusalem builded here,
> Among these dark Satanic Mills? (Blake 1994:114)

Here, wilderness—external, nonhuman nature—is put in its proper historical context, next to the "dark Satanic Mills" of the newly industrializing city. We might likewise juxtapose Walt Whitman's *Leaves of Grass*—its reflections on external nature readily locatable within the American transcendentalist tradition—with his later, modernist work about New York City. It is the same coin: on one side, society in the city; on the other, nature in the countryside.

Finally, here is Ebenezer Howard, writing in 1898, describing the "magnets" of town and country that pull on individuals:

> But neither the Town magnet nor the Country magnet represents the full plan and purpose of nature. Human society and the beauty of nature are meant to be enjoyed together. The two magnets must be made one. As man and woman by their varied gifts and faculties supplement each other, so should town and country. (Howard 1965:9)

Notice with how little hesitation Howard moves between "town and country" and "society and nature" as expressions of the same opposition. Such an attitude was perfectly sensible in England by the end of the 19th century, but would have been nearly incomprehensible 150 years earlier. This is the fundamental development I wish to identify: the social separation of town from country in the rise of industrial capitalism, and as a consequence, the perceived separation of human society from nonhuman nature. In this sense, both the society-nature opposition and its manifestation in mainstream sociology as the "human exemptionalist paradigm" are constitutively urban phenomena (Dunlap and Catton 1994:6; Clement 2010:292).

HUMAN ECOLOGY: URBAN METABOLISM WITHOUT NATURE

The metaphor of metabolism was present almost from the very beginning of urban sociology, in Burgess's (1925) article on "The Growth of the City." Although Burgess did not use this language, his concept of urban metabolism can be readily restated along the lines of the society-nature opposition; like human ecology more generally, he spatially mapped the social onto the city while relegating nature to an unspecified outside.

Burgess's "The Growth of the City" is most famous for its concentric-circle model of urban growth, whereby socioeconomic zones tend to expand outward and thus invade neighboring zones in a process of succession (a term borrowed, like "metabolism," from the natural sciences). But the way Burgess characterizes the process of growth is what concerns us here:

> [Questions about the growth of the city] may best be answered, perhaps, by thinking of urban growth as a resultant of organization and disorganization analogous to the . . . processes of metabolism in the body. (Burgess 1925:53)

Burgess emphasizes two features of urban metabolism. First, he identifies the specific process at work in the metabolism as *mobility*, which he defines as nonroutine movement, in contrast to later traditions in urban sociology that have tended to emphasize the importance of routine commuting patterns for constituting the urban social fabric. Second, he distinguishes between two metabolic pathways—disorganization and organization—and argues that mobility leads to the former, while consistency leads to the latter. While he holds some disorganization to be necessary for subsequent reorganization (à la creative destruction), a surplus of disorganization—that is, too much mobility and not enough consistency—will unbalance the city's metabolism and manifest as "areas of demoralization, of promiscuity, and of vice" (Burgess 1925:59).

Despite the wide attention Burgess's article received as one of the foundational documents of Chicago School human ecology, his specific treatment of urban metabolism has been overshadowed by the accompanying concentric-circle model of the city. Little more than scattered applications of Burgess's metaphor appeared over the decades after he published the article (e.g., Terpenning 1928; Hansen 1954), and an otherwise comprehensive history of metabolism in the social sciences does not mention or cite Burgess (Fischer-Kowalski 1998). Meanwhile, one recent study of exactly Burgess's conception of urban metabolism as the mobility of people and their interactions, despite using the metabolism terminology, fails to mention Burgess at all (Townsend 2000).

Despite its relative obscurity, Burgess's urban metabolism speaks eloquently to the human ecology project in general. To a significant degree, Burgess simply applied a plausible metaphor to the theme of social order and disorder that was already emerging as a major concern of the Chicago School. But the very use of biological metaphors

is telling: there was always a tension within the Chicago School—as in early 20th-century sociology more generally—about which were appropriate, and about how far to take them. In the first pages of his seminal article, Park (1915:577–78) proposes to study the city as a "mechanism," but immediately hedges by suggesting it might also be characterized as a "growth." In Burgess's "The Growth of the City," there is a basic incompatibility between the metabolism metaphor, which implies that the city should be treated as an organism (a sort of scaling down of Herbert Spencer's conception of society as an organism), and the succession metaphor, which implies that the city should be treated as an ecosystem.

Human ecology was above all an investigation of how humans adapt to their environment, with the city serving as the privileged environment for the Chicago School's research program. But, as Burgess's urban metabolism demonstrates, the relevant environment was conceived of as entirely a social one (for the same tendency in subsequent mainstream sociology, see Catton and Dunlap 1980:22). All the biological metaphors remain just that—metaphors. Burgess uses the concept of metabolism in *analogy* to natural metabolism, but "nature" itself makes no appearance in Burgess's account whatsoever, nor does it figure significantly into human ecology more generally.

The lack of a real role for nature—whether as resources, local flora and fauna, landscape, weather and climate, and so on—in Burgess's explanatory agenda leads to some remarkable tensions. For Burgess, the city is a self-contained system, within which people and their social ties circulate, integrate, and disintegrate with no reference to the outside world except ongoing human immigration. But at the same time, he is studying the *growth* of the city: he understands urban metabolism to be a process of transformation, not simply reproduction, and growth itself is a premise rather than something to be explained. In other words, Burgess approaches the city as (1) a self-contained system (either in analogy to an organism or an ecosystem) (2) that is ceaselessly growing. These two attributes are, of course, mutually exclusive. Any plant ecologist who found a bounded system that grew indefinitely would be surprised indeed.

This is the society-nature opposition mapped onto town and country in its barest form. The study of society is the study of the city, while nature lurks as an unmentioned backdrop, at best to inform the study of primitive "folk societies" in the countryside. There could be no clearer example of Catton and Dunlap's (1980) "human exemptionalist paradigm" in action. But to observe the absence of a substantive role for nature from human ecology is not to retrospectively accuse Burgess and the rest of the Chicago School of incompetence or blindness. These scholars sought to understand a novel social system—the industrial city—that appeared to be operating under its own autonomous, self-perpetuating logic. In this sense, urban metabolism—and human ecology more generally—follows directly from the separation of town and country discussed above. A purely social urban metabolism, endlessly growing but nevertheless self-contained, only became a plausible idea once cities were sufficiently large as a result of rural-urban migration, sufficiently autonomous as social realms, and sufficiently significant in the general course of social life.

INDUSTRIAL ECOLOGY: URBAN METABOLISM FUELED BY NATURE

While Burgess's use of urban metabolism ended up an orphan, the next time the concept surfaced it made a considerable impact on scholarly understandings of urbanization and society-nature relations. This was via industrial ecology: the discipline concerned with materials and energy flows through industrial systems. Although industrial ecologists study systems at a variety of scales—from individual factories and industrial districts up to national economies and the entire globe—a distinctive subfield has grown up around measuring materials flows through cities and urban regions. It is here that the concept of urban metabolism made its second important appearance (Fischer-Kowalski 1998; Fischer-Kowalski and Hüttler 1999). Like human ecology, industrial ecology uses the concept of metabolism to understand the growth of cities; but unlike the former, the latter explicitly grounds its understanding of urban growth in resource consumption and environmental constraints. Emerging in the 1960s and 1970s, industrial ecology thus expressed the beginnings of Catton and Dunlap's "new ecological paradigm" in parallel to similar developments within environmental sociology.

The story begins with Wolman's (1965) "The Metabolism of Cities," in which he pioneered the practice of studying the city as a machine for converting natural resources into wastes. Fresh water enters the urban metabolism and exits as sewage; iron enters the urban metabolism and exits via the scrapheap. Wolman's study was stylized with respect to "a hypothetical US city with a population of one million," but it inspired a number of more detailed investigations. Although difficulties with data collection and comparability have limited the pace of this research, subsequent metabolic studies have managed to quantify flows of water, materials, energy, and nutrients into and out of a growing number of metropolitan regions (Decker et al. 2000; Kennedy, Cuddihy, and Engel-Yan 2007). And while most of these studies have simply been tallies of materials and energy, Newman (1999) has tentatively extended the metabolism idea to encompass other dimensions of sustainability, such as livability and health, thus bringing the industrial ecology model of urban metabolism closer to the social concerns of Burgess's original formulation.

The theoretical underpinnings of the industrial ecology approach to urban metabolism have best been elaborated by the environmentalist Girardet (1996), who for decades has banged the drum for urban sustainability. Most significantly, he draws a distinction between "circular" and "linear" metabolisms: the former supposedly characterizes the natural world—one organism's waste is another's sustenance—and the latter characterizes the urban world—resources in, waste out. Girardet thus understands the dawning global environmental crisis to be an over-proliferation of linear metabolisms as cities grow and spread.

Environmental sociologists may recognize the similarity between this diagnosis of environmental crisis and that of Foster (1999, 2000), whose theory of "metabolic rift" has become increasingly influential in the last decade. Foster builds on Marx's observation that the concentration of industry (and population) in cities that accompanied

early industrial capitalism opened a rift in the circulation of soil nutrients. Nutrients still left the soil as food, and yet, since this food was consumed far from its point of origin, the waste products were no longer returned to the soil as fertilizer but were simply expelled out the sewers. What had previously been a circulatory metabolism was becoming a one-way flow. Foster generalizes this idea into a critique of capitalism's tendency to undermine the conditions for its own survival (although one still rooted in the imbalance between the city and the countryside), and other researchers have fruitfully applied the concept of metabolic rift to a variety of environmental questions (e.g., Moore 2000; Clark and York 2005). In all cases, the basic formulation resembles Girardet's distinction between linear metabolism and circular metabolism, although the etiology differs and the political thrust is more radical.

Girardet presents the underlying conception behind these approaches to urban metabolism in an unusually clear form:

> Cities transform raw materials into finished products. They convert food, fuels, forest products, minerals, water, and human energy into buildings, manufactured goods, and financial and political power: all the components of civilization. (Girardet 1996:20)

In other words, urban metabolism is the conversion of nature into society. Likewise, in Newman's model of urban metabolism—the most holistic of the empirical studies within industrial ecology—natural resources remain the sole inputs, to be metabolized through "dynamics of settlements" into both "livability" and "waste outputs" (Newman 1999:220–21). Correspondingly, from Wolman's initial intervention to the present, industrial ecology has approached urban sustainability specifically as the need for cities to consume fewer natural resources—that is, consume less nature. (Not surprisingly, the focus of urban metabolism studies has increasingly shifted from resources to carbon emissions [e.g., Chen and Chen 2012], reflecting the larger transition in environmental concern from limits to growth to climate change.)

The consequence is that industrial ecology implicitly maps the society-nature opposition onto town and country in the same fashion as human ecology, although nature's role is elaborated. The country is the geographical area where nature—raw materials—is located, while the city is the geographical area where the society that metabolizes this nature is located. The difference is that for human ecology, the object of investigation was the growth of the city in social terms, so Chicago School sociologists could import analogies with nature into a purely social account of city growth, while for industrial ecology the object of investigation is the sustainability of urban resource use, so for Wolman, Girardet and the rest the city is only understandable in relation to the external natural environment that supplies the raw materials for its growth.

If industrial ecology gives a greater role in its urban metabolism to nature than does human ecology, it gives a lesser role to humans. This is hardly surprising—that

materials science would pay more attention to materials, and sociology would pay more attention to the social—but it is worth emphasizing, because it strongly informs the way that both environmental problems and their potential solutions are approached. The industrial ecology approach is ultimately technocratic: it presents environmental problems as technical problems rather than social ones. Girardet (2008:124), for example, after discussing the imperative for cities to adopt circular metabolisms, asks "What does a circular metabolism mean in practice?" The answer, it turns out, is a discussion of cooperation on waste diversion between corporations and the municipal government in a Danish town. We are told that such cooperation is desirable and that other cities should emulate it. But what led the corporations and municipality to cooperate? What were the politics at work? The power structures and forms of contestation? In other words, where are the social and the historical?

For Girardet, the problem of linear urban metabolisms and thus unsustainable urban society is one of insufficient local will. Nature stands at the ready, in a static fashion, to be used in more or less harmonious ways. Cities (consistently and uncritically imbued with agentic properties in his account) each need to adopt more sustainable environmental practices with respect to that static nature to convert their linear metabolisms into circular ones—to close their individual metabolic rifts and thereby reduce the resource pressure they put on the earth. But this raises the question: why should we look for municipal solutions to the pathologies of urban metabolism when the environmental pressures are universally understood to be regional or indeed planetary? Are problems *in* the city necessarily problems *of* the city?

Throughout the industrial ecology literature on urban metabolism, we frequently find self-consciously global environmental questions mapped onto the city. Wolman (1965:179; emphasis added) is paradigmatic in this regard, introducing his foundational text with the observation that the "*planet* cannot assimilate without limit the untreated wastes of *civilization*," and then pivoting to a discussion of the city. Where there is a justification for such logical leaps in more contemporary scholarship, it is usually an invocation of the "urban age" thesis discussed briefly above. Our global society is now an urban society, so solutions to our global problems must be urban solutions. It is worth noting that Foster, whose diagnosis of the pathologies of contemporary urban metabolism has a lot in common with Girardet, makes no such assumption. For Foster, the metabolic rift is a feature of global capitalism, and repairing the rift means confronting capitalism at a global scale. Marshaling the local will of cities may well be part of such a confrontation, but cannot be the confrontation itself. Still, Girardet's assumption, widely shared as it is, demonstrates the potency of the conflation of the society-nature and town-country oppositions. Society is in the city, nature is in the country, so if there is a crisis in the relationship of society to nature, the thinking goes, we must look for solutions in the city. The same tendency is present in environmental sociology, where many analyses of urbanization have treated it as a source of environmental degradation (Clement 2010:294)—cities consuming nature.

URBAN POLITICAL ECOLOGY (UPE): THE SOCIO-NATURAL METABOLISM OF THE CITY

The final phase in the history of urban metabolism belongs to urban political ecology (UPE), a hybrid field at the intersection of political ecology and urban geography. While Wolman and industrial ecology developed the metabolism concept independently of Burgess and human ecology, from the outset, UPE's leading practitioners have analyzed industrial ecology metabolism and have developed their own distinctive position to some extent as a critique of industrial ecology (e.g., Gandy 2004:374; Keil and Boudreau 2006:41–42; Swyngedouw 2006:33–34). The key transition has been from the proposition that social worlds—including cities—are constructed on natural foundations and subject to natural constraints (the "new ecological paradigm" perspective) to the proposition that nature does not stop at the foundations: the city is constitutively social *and* natural from the bottom to the top, and urban nature is just as political as urban society. In this regard, UPE holds valuable lessons for environmental and urban sociology, which still generally treats nature as a fuel in urban society's engine.

Political ecology—the study of the politics of environmental degradation and environmental rehabilitation—emerged in the same "post-exuberant" 1970s moment (Catton and Dunlap 1980) of increasing environmental awareness as did industrial ecology and environmental sociology. By the late 1990s the field was undergoing a poststructuralist reassessment, in the midst of which Swyngedouw (1996) made his initial call for a UPE. Until then, political ecology, like its cognate field of rural sociology, had concerned itself more or less exclusively with rural and wilderness areas. In a sense, with respect to the relationship between the town-country and society-nature oppositions, political ecology was the inverse of Chicago School human ecology: an insightful analysis of the production of nature, but spatially mapped exclusively onto the countryside, just as the Chicago School's analysis of the social was mapped onto the city. It is no coincidence, then, that Swyngedouw's argument for a UPE was simultaneously an attempt to rethink the society-nature opposition in general.

The concept of urban metabolism that Swyngedouw (1996, 2006) develops borrows heavily from Marx's original formulation of social metabolism as the human transformation of nature through labor—a creative and social process that produces and reproduces both human life and the natural world. But to avoid the traps of the society-nature and material-discursive binaries, Swyngedouw introduces the neologism "socio-nature," insisting upon the ubiquity of nature in social realms (including the city), while denying that nature can ever be independent of the social. The implication is that we do not need—and indeed cannot have—specific conceptual or methodological tools for investigating the place of nature in the city, as industrial ecology assumes. *All* the features of modern urbanization are socio-natural, including "the production of dams, the re-engineering of rivers, the management of biodiversity hotspots, the transfiguration of DNA codes, the cultivation of tomatoes (genetically modified or not) or the construction of houses" (Swyngedouw 2006:27).

Swyngedouw focuses particularly on water, one of the natural resources Wolman included in his initial metabolism study. And while he endorses the basic insight of industrial ecology—that natural resources flow through cities to be transformed into the conditions of urban life—he expands the metabolic analysis to include political, economic, and cultural dimensions that Wolman and his successors largely did not. The result is that, whereas industrial ecology metabolism studies see the city as a specific, fixed site for the conversion of resources into products and wastes—something like a distributed factory—Swyngedouw argues that the city, in the broadest sense of the term, is itself a product of socio-natural metabolism. So while the UPE approach to urban metabolism builds on industrial ecology in some senses, it discards the latter's relegation of nature to nothing more than raw materials—an inert participant in urban metabolism (Keil and Boudreau 2006). Instead, UPE gives a process-oriented account of metabolism that emphasizes the interplay of local, regional, and global socio-natures (e.g., respectively, urban heat-island effects, a river system and its hydroelectric infrastructure, and international commodity trade flows) in constituting any specific city or urban space (Heynen, Kaika, and Swyngedouw 2006:5).

We can thus see in UPE at least a tentative unraveling of the intertwining of city and countryside with society and nature. Of course, simply renaming "society and nature" "socio-nature" does not make the binary disappear through force of will, but in substantive terms urban political ecologists have been more successful at dismantling the persistent conflation of society with the city and nature with the countryside than any other research program in the social sciences. By drawing on political ecology's insights about agency and political struggle in the production of socio-nature, UPE offers a means of escaping the "either humans or nature" dilemma represented in the two poles of human ecology and industrial ecology.

Against the Chicago School's view of urban society—in analogy to nature and thus with urban power structures and injustices "naturalized"—UPE demonstrates the often unexpected ways in which nature intervenes in the urban social order. In his analysis of something as apparently banal as the suburban lawn, Robbins (2007) is able to document not just a sprawling political economic web of "grasses, weeds, and chemicals" but a *two-way* process of subject formation linking lawns and the people who own the lawns: just as we make the lawns, the lawns make us who we are. Such arguments build on the insights of actor-network theory about distributed agency (Callon 1986), but do so within a political economic framework that remains attentive to questions of power and inequality (Brenner, Madden, and Wachsmuth 2011).

And against the technocratic implications of industrial ecology's urban metabolism—where flows of materials are neutral objects to be mobilized in more or less sustainable ways—UPE asserts the importance of history and politics. The industrial ecology perspective on urban nature is a general (ontological) proposition that cities metabolize nature and an analysis of in what quantities they do so. Urban political ecologists, by contrast, have explored the historical struggles that have caused the

urban socio-natural landscape to take the form it does, and the differential environmental impacts that landscape has on different classes and groups within the city (Gandy 2003; Domene and Saurí 2007).

To assess the potential contributions for environment and urban sociology of UPE's approach to urban metabolism, we can compare it briefly to what is probably the most influential work on urban and environmental change in recent decades: Cronon's (1991) *Nature's Metropolis*. Like UPE, Cronon's history of Chicago and its agricultural hinterland foregrounds the role of nature in constituting the city, in his case by tracing the flow of commodities from raw materials to social institutions such as railroads and the Chicago stock exchange. But there are two features of Cronon's work that place him more comfortably in the tradition of "new ecological paradigm" environmental sociology and industrial ecology. First, he treats nature and the environment overwhelmingly as the fuel for the development of the urban social system (although in his case the system spans city and hinterland). This is by design, of course—the book sets out explicitly to chart commodity flows—but the consequence of this design is that while Cronon is able to document the role of nature in the production of the social, he fails to grapple with the social production of nature (Smith 2008), which has been a major emphasis of UPE and is slowly filtering into urban sociology (Čapek 2010). Second, *Nature's Metropolis* is largely silent on the class politics and power relations corresponding to the transformations of nature that it documents. Again, Cronon acknowledges that he deliberately left these questions aside, but this will not likely be a satisfactory response to urban and environmental sociologists, for whom power relations are key concerns, and who would do better in this regard to follow UPE's lead in investigating not just urban nature but the politics of urban nature.

There are still some gaps in the UPE project though. Most notably, there is a contradiction between the most influential UPE theorizations of urbanization—which stress its planetary dimensions and its juxtaposition of the global and the local (Swyngedouw 1996; Keil 2003; Heynen et al. 2006)—and the nearly exclusive empirical focus on cities, traditionally understood (but see Pellow [2006] for an insightful exception). This is "methodological cityism": the city is taken to be the privileged analytical lens for studying contemporary processes of urban social transformation that are not necessarily limited to the city (Angelo and Wachsmuth 2012). So, while scholars working within the UPE tradition have produced insightful analyses of cities as products of global socio-natural processes, they have largely failed to investigate noncity products of those same processes. In this respect, Cronon's mutual investigation of the city and the countryside has not yet been equaled within UPE, where the city is richly theorized and investigated in socio-natural terms, but the countryside remains inert by default, inasmuch as it is not explored in these same terms.

Still, UPE has advanced a notion of urban metabolism that manages in important respects to overcome the limitations of the human ecology and industrial ecology models that came before. It does so while being in some ways a hybrid of the two, com-

bining in the concept of socio-nature the social and political concerns more traditionally associated with urban sociology and the attention to the natural world associated with ecology.

CONCLUSION: NATURE'S STEADY MARCH ON THE CITY

The intellectual history I have told about urban metabolism is a story of nature's steady march on the city. For human ecology, urban metabolism is analogous to nature, but only analogous—the natural environment itself is simply a backdrop to a purely social process of urbanization. For industrial ecology, nature is the source of the urban metabolism's fuel and the destination for its wastes. In both cases, the two terms of the society-nature opposition are mapped exclusively onto the city and the countryside. For UPE, by contrast, urbanization is a constitutively socio-natural process, where the city is not merely the site of urban metabolism but rather its product. These successive understandings are summarized graphically in Figure 1.

But there have been, in fact, two armies marching. On the one hand, conceptions of urban metabolism have changed as social scientists have become better at thinking about nature and the city. This somewhat modernist notion is, I think, undeniable, and while the story as I have presented it here inevitably has imposed some measure of

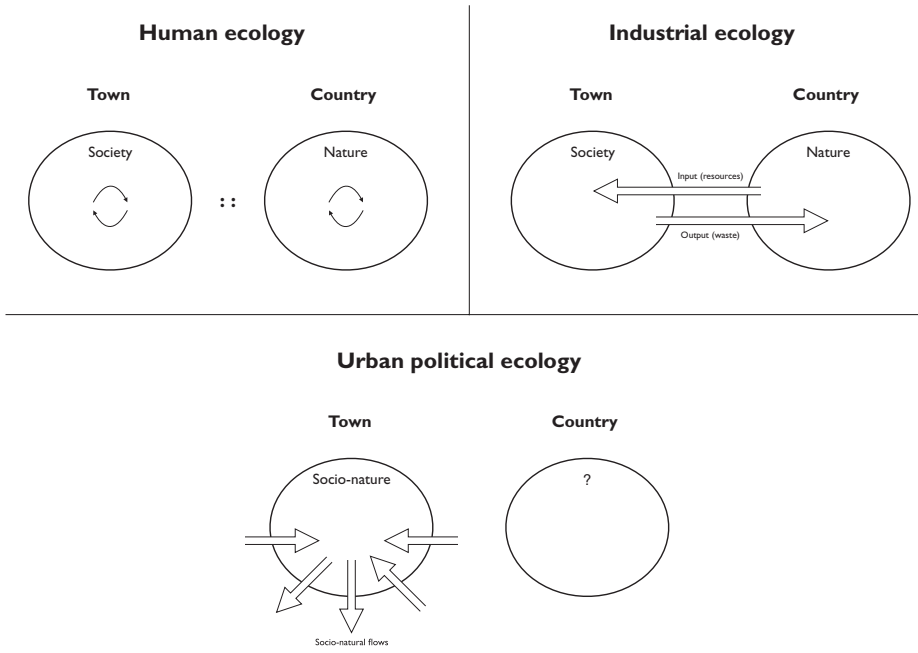

FIGURE 1. Varieties of the Intertwined Society-Nature and Town-Country Oppositions in Different Models of Urban Metabolism.

simplifying linearity, there is no harm in acknowledging that urban political ecologists have an overall more adequate conception of urban nature than the Chicago School did. Conversely, and more importantly: *conceptions of urban metabolism have changed as urban metabolism has changed*.

Roger Keil and John Graham argue that successive transformations in capitalist urbanization have historically led to new societal relationships to nature. They identify three periods of the city-nature relationship in modern capitalism: the early industrial period, where the city "pretends to shed its dependency on natural metabolisms," the Fordist period, where "the separation of the city and the countryside became most deeply implicated in the destructive trajectory of capitalist urbanization," and the post-Fordist period, where " 'nature' is no longer exiled from the city, but becomes the key element of the current era of urban growth" (Keil and Graham 1998:102–105).

We do not have to strain very hard to see this periodization in the intellectual history of urban metabolism. The Chicago School developed the metabolism concept when urbanization seemed to have become untethered from the natural world, when the social had become a realm unto itself. Wolman and his successors in industrial ecology, meanwhile, developed the materials-flow analysis of cities in the context of apparently out of control urbanization and suburbanization, and the challenges these self-evidently appeared to pose to the world's natural resource base and capacity for absorbing wastes. UPE, finally, is the social science for the global urban age, where nature can no longer be tenably understood as outside the city, but is fundamentally incorporated into its further development.

Periodizing the urban metabolism *concept* thus helps us periodize urban metabolism itself. What is more, the first two stages in this periodization correspond closely to Catton and Dunlap's (1980) "human exemptionalist paradigm" and "new ecological paradigm." The fact that there is a third stage in the periodization should give sociologists a pause. The "new ecological paradigm" recognition that human society is built on natural foundations is necessary but arguably no longer sufficient to understand the contemporary production of nature, and in particular the production of urban nature. As the above discussion of UPE has indicated, one potentially fruitful way forward for sociologists is to more explicitly connect environmental and urban research. For, although this is starting to change, environmental sociology has historically had little to say about urbanization except to treat it as a machine for consuming nature (Clement 2010), and urban sociology has had little to say about nature except as a background or a metaphor (Čapek 2010). Neither has been in sustained dialogue with UPE or other fields associated with geography, where research into the production of urban nature is now relatively mature. Such conversations will only be more pressing as scholars work to untangle the society-nature and town-country oppositions, which still loom over the social sciences and over the planet, and thus help dispel what Williams (1973:96) called "the last protecting illusion in the crisis of our own time: that it is not capitalism which is injuring us, but the more isolable, more evident system of urban industrialism."

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NOTES

[1]Two exceptions are Berger's (1980) brief account of capitalist urbanization's relegation of animals to the domestic sphere as pets, and Foster's (2000) elaboration of Marx's theory of metabolic rift. But the former has overwhelmingly been read as an animal studies intervention, while the latter is focused specifically on the soil-nutrient cycle between farms and cities. Neither is commonly read as a general account of the relationship between the separation of town and country and the society-nature divide. Williams's (1973) *The Country and the City*, by contrast, is highly influential but places less emphasis on the discontinuities of the Industrial Revolution and more on the long and ambiguous historical lineage of rural enclosure and social transformation in England, and thus stands as a partial dissent from my argument here.

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