ON ECOLOGY AND DESIGN: HERITAGE AND EMERGING PERSPECTIVES ON BRUSSELS' URBAN METABOLISM

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The paper aims to highlight the interrelation between ecological studies and urban design, in particular with regard to the Brussels case, given both its pioneer works and the current revival on urban metabolism. As early as the '70s of the last century, the ecologist Duvigneaud studied Brussels as an ecosystem, integrating a scientific and socio-natural understanding of urban metabolism. Afterwards, further studies have flowed into industrial ecology, the study of the material and energy circulation, narrowing the scope of investigation on urban space and nature. More recently, there has been a strong return on the debate of the Brussels' urban metabolism. However, it remains to better understand how and to which extent the discipline of urbanism can actually draw from and bring to urban metabolism studies. In response to the question, we look back to the relations between ecological studies and urban design in the recent history of Brussels. On the one hand, until now results show that, design and planning practice, in Belgium, seems to have little learnt from urban metabolism studies. On the other hand, it emerges that stronger socio-natural perspective is needed in order for urban design and planning to steer the transformation towards more resilient urban metabolism.

Keywords
Ecology, urban design, urban metabolism, Brussels

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INTRODUCTION

Ecology since its definition as discipline has influenced spatial design[1]. As ecology studies the relationships between living organisms and their environment, it always concerns space and context. Recently, Reed and Lister[2], have discussed the strong relation between ecology and design studies considering their "parallel genealogies" when referring to the landscape field. On the one hand, ecology is at the heart of landscape ecology, an applied science developed since the 1980s drawing its research tools by remote sensing and geographic information systems and which has enabled large spatial and temporal scale of analysis. On the other hand, ecological thinking has provided landscape and urban designers with innovative spatial conceptualizations, modeling and design tools.

Today, a number of design studies are flourishing that integrate the ecological perspective while investigating around the concept of urban metabolism[3]. However, except for some few cases[4] there is still little about how this emerging interest in urban design and planning for urban metabolism can be regarded within the longstanding relationship between ecology and urban design. This paper aims to contribute to unfolding the history of ecology in urban design and planning focusing on the case of Brussels, since it was the case study of pioneer works on urban metabolism and it is currently the object of a revival on the same subject. In the first part, it briefly traces the historical context placing the contribution of the Brussels School to the study of urban metabolism with respect to regional and urban planning. In the second part, it describes the recent resurgence of debate on the Brussels' urban metabolism by urban planning and programs. Finally, the conclusion highlights some knowledge transitions and missing links between urban metabolism and design practice.

THE BRUSSELS SCHOOL

At the end of 1970s, the population of the Brussels' agglomeration (19 municipalities with more than 1 million inhabitants) grew by three times more respect the beginning of the century[5]. At the same time, a process of transformation of the city in the capital of Europe brought the introduction in the central neighborhoods of new mobility infrastructures and high-rise buildings with little concerns for urban and environmental quality. This process, known as "Brussellization", is commonly accounted for a lack of urban planning and predominant laissez-faire politic at the regional level[6]. As explicit reaction to the Brussellization stand the creation of the Atelier de Recherche et d'Action Urbaines (ARAU), in 1969, and Inter-environnement Bruxelles. The first was an association of architects and urban designers engaged to promote a different, inclusive urban development. The second a confederation of citizens' committees gathered to arose their voice against the lack of political representation in urban planning and management.

1 See for instance the work of Ian L. McHarg, Design With Nature (Turtleback Books, 1995); Anne Whiston Spirn, The Granite Garden: Urban Nature and Human Design (Basic Books, 1985).

2 Chris Reed and Nina-Marie Lister, "Ecology and Design: Parallel Genealogies," Places Journal, April 14, 2014, https://placesjournal.org/article/ecology-and-design-parallel-genealogies/.

3 See for instance C. Kennedy, S. Pincetl, and P. Bunje, "The Study of Urban Metabolism and Its Applications to Urban Planning and Design," Environmental Pollution 159, no. 8–9 (August 2011): 1965–73, doi:10.1016/j.envpol.2010.10.022.; but also the 6th Interantional Architecture Biennale Rotterdam, "Urban by Nature" (IABR 2014).

4 See for instance Matthew Gandy in conversation with, Daniel Ibañez, and Nikos Katsikis, "On Circulations and Metabolisms: Challenges and Prospects," Grounding Metabolism, New Geographies, 6 (August 2014): 174–83.

5 Jacques Aron, Le Tournant de L'urbanisme Bruxellois : 1958-1978, Librairie "Du Monde Entier" (Bruxelles, 1978).

6 Katarzyna M. Romańczyk, "Transforming Brussels into an International City – Reflections on 'Brusselization,'" Cities 29, no. 2 (April 2012): 126–32, doi:10.1016/j.cities.2011.08.007.

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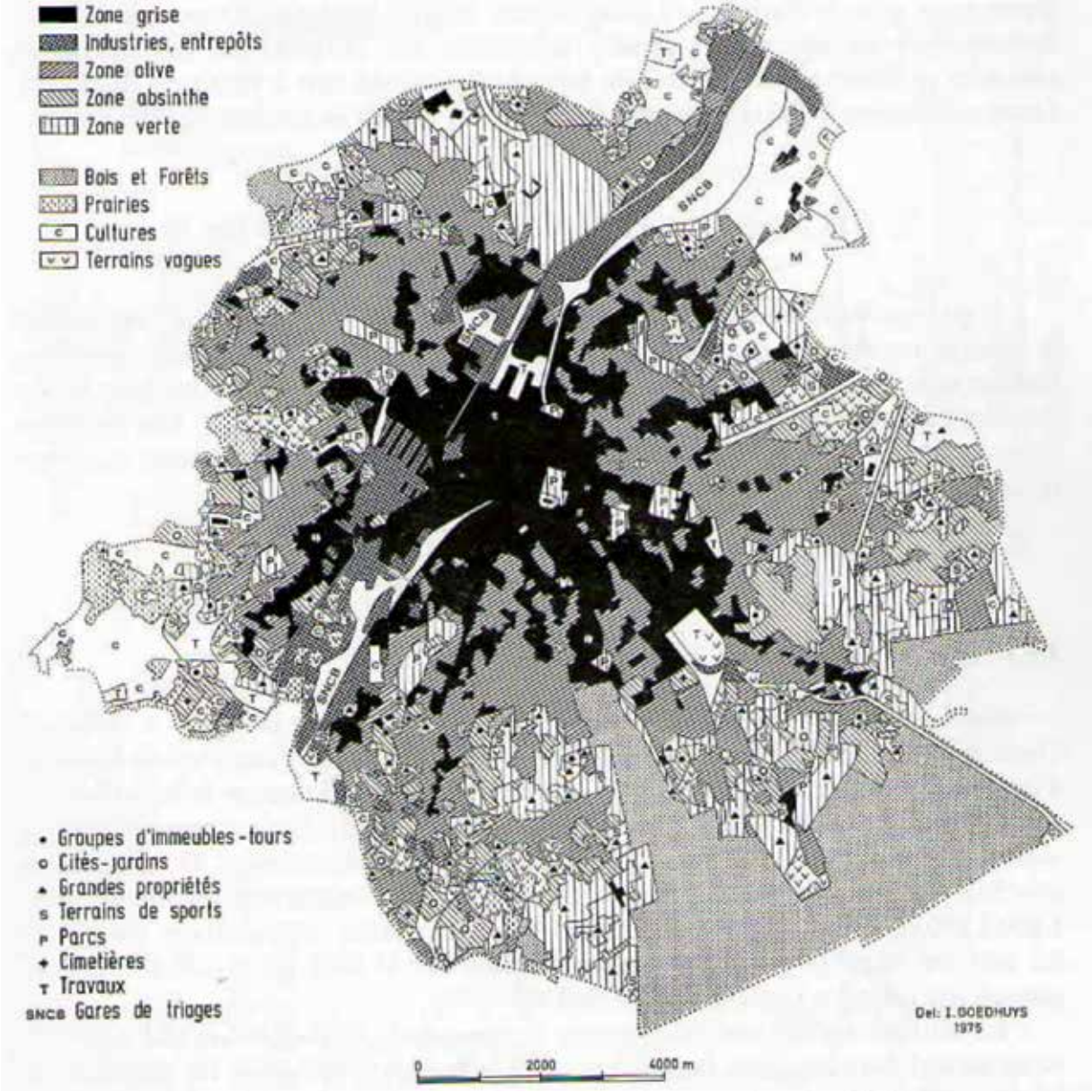

FIGURE 1 Ecological map of land cover and land use of the Brussels Agglomeration, 1977. Based on green cover ratio, it defines the main sub-systems of the Brussels' ecosystem

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A third contribution was provided in the '70s, by the ecologist Duvigneaud and his colleagues who began to study Brussels as an ecosystem[7]. At the Faculty of Science of the University of Brussels (ULB), within the framework of the global environmental concern of the time[8], they set up the centre for the study of the urban environment. In 1977, with the support of the Regional Environmental Agency, the group published the results of their work on Brussels: a detailed cartography [Fig. 1] and report the metropolitan green and open spaces, completed with management prescriptions[9].

The main purpose of Duvigneaud at that time was both scientific and pedagogic. Also for this reason, the studies on the Brussels' ecosystem were enriched by iconic drawings of the Brussels' metabolism at the territorial scale and section.[Fig. 2].

The work of the Brussels School was one of the first attempts to perform a visualization of the exchanges between the city and the biosphere. Moreover, it deepen the study on the urban environment using biological indicators such as the urban flora[10]. Duvigneaud and his colleagues investigate for the first time the spontaneous vegetation of infrastructural buffers, abandoned train stations, and cemeteries of Brussels[11], pioneering the study of the *terrain vague*, which only later will be of interest for urban planners and designers[12]. Duvigneaud, was deeply influenced by the urban planning culture. One of his main references were the early XX century hygienist and modernist principles of Le Corbusier 'Ville Radieuse' (presented at the CIAM of Brussels in 1930 and published in 1935). However, Duvigneaud was also fascinated by 'ekistics', the Doxiadis' science for human settlements, which integrated geographical, ecological and anthropological discourses at the global scale and through the use of statistics and cartographic representations[13]. According to Gandy[14], the regard of Duvigneaud to the city combined the organicist approach of Geddes and the system-based engineering of Wolman. On the one hand, speaking of the city as an ecosystem, Duvigneaud refers to its different components or "subsystems", such as the climate, soil, human and non human communities. On the other hand, speaking of the city as an organism, he refers to its process of growth, and flows- of food, energy, water and waste - which sustain it.

7 Paul Duvigneaud, "Études Écologiques de l'Écosystème Urbain Bruxellois: Contribution No 1 À 4: L'écosystème 'Urbs'," Mémoires de La Société Royale de Botanique de Belgique 6 (n.d.): 5–35; Martin Tanghe, Paul Duvigneaud, and M. Jouve-Barbezat, "Études Écologiques de l'Écosystème Urbain Bruxellois: Contribution No 2: Premier Aperçu Des Facteurs Écologiques Du Métabolisme de L'agglomération Bruxelloise," Mémoires de La Société Royale de Botanique de Belgique 6 (n.d.): 37–56; Paul Duvigneaud and Simone Denayer-De Smet, "L'ecosystéme Urbain Bruxellois," in Productivité Biologique En Belgique, Editions Duculot, Travaux de La Section Belge Du Programme Biologique International (Paris, Gembloux: P. Duvigneaud and P. Kestemont, 1977), 608–13.

8 such as the Mab - Man and Biosphere - study program promoted by UNESCO in 1971.

9 Paul Duvigneaud, Simone Denaeyer-De Smet, and Martin Tanghe, "Carte Écologique de L'occupation Du Sol et Des Degrés de Verdurisation de L'agglomération Bruxelloise : Situation Mars 1975" (Agglomération de Bruxelles, Service de l'environnement, 1977).

10 Martin Tanghe, Paul Duvigneaud, and M. Jouve-Barbezat, "Études Écologiques de l'Écosystème Urbain Bruxellois: Contribution No 2: Premier Aperçu Des Facteurs Écologiques Du Métabolisme de L'agglomération Bruxelloise."

11 Paul Duvigneaud, Les Sites Semi-Naturels de L'écosystème Bruxelles : Interpénétration de L'environnement Physique et de L'environnement Sémiotique, Centre d'études Jacques Georgin, 1990.

12 See for instance Ignasi de Solà-Morales Rubió, "Terrain Vague," Anyplace, MIT Press, 14 (1995): 118–23; Gilles Clément, Le Jardin En Mouvement : De La Vallée Au Jardin Planétaire, Sens & Tonka, vol. 5, Calepin 11/24 (Paris, n.d.).

13 Constantinos A. Doxiadis, EKISTICS: An Introduction to the Science of Human Settlements, First Edition edition (Oxford University Press, 1968).

14 Matthew Gandy, "Marginalia: Aesthetics, Ecology, and Urban Wastelands," Annals of the Association of American Geographers 103, no. 6 (November 1, 2013): 1301–16, doi:10.1080/00045608.2013.832105.

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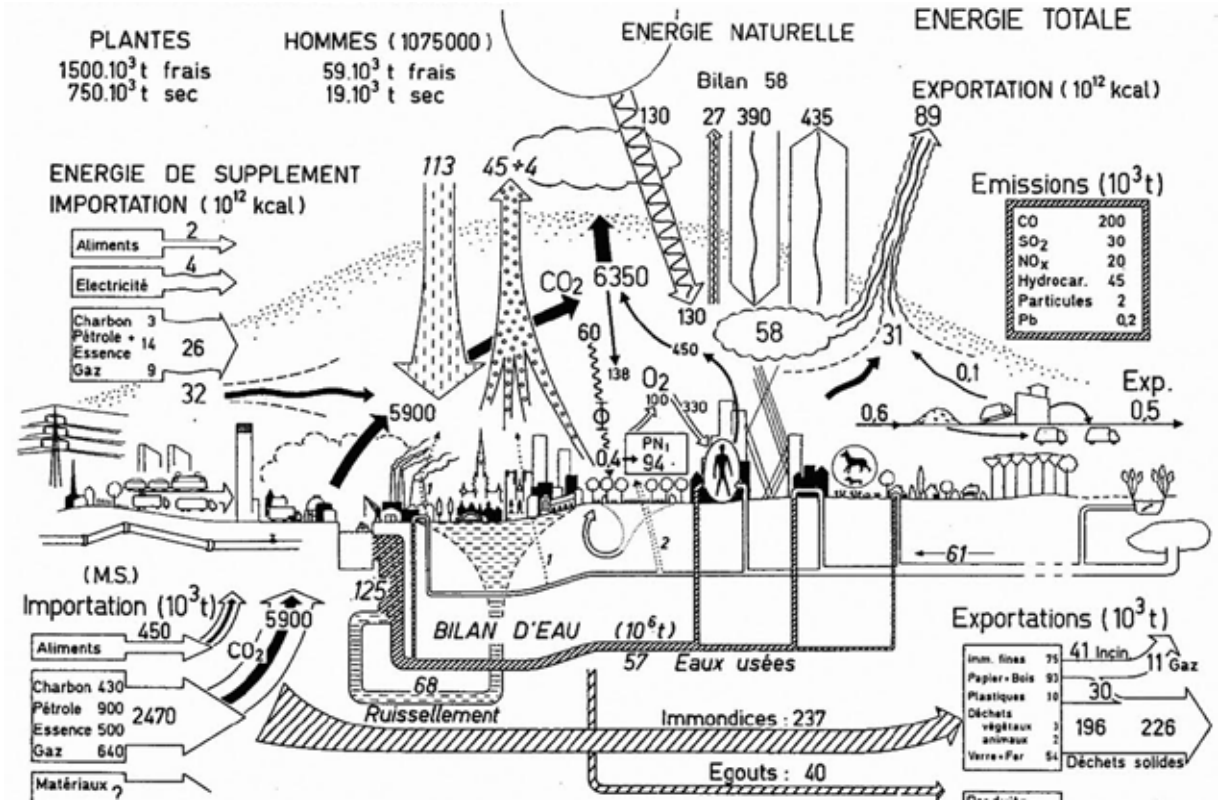

FIGURE 2 The Brussels' urban ecosystem, 1977. It represents the energy and material input and output on an ideal territorial section along the main Brussels' valley

One of the main contributions of the Brussels School is to have coupled the analysis of the whole urban material and energy flows with a detailed investigation of the urban space and ecology. Urban blocks and industrial areas, high rise building complexes and single house neighborhoods, parks and wastelands where catalogued with respect to their vegetation cover (and related capacity in term of C_2 absorption and O_2 release). This inventory was meant to become a real asset for balancing the urban metabolism of Brussels. Despite that, the comprehensive regard on both technical and natural flows of the city remains an exception in urban metabolism studies. Further remarkable works in Brussels focused on industrial ecology, the study of the energy and material flows [15], narrowing the scope of investigation on the urban space and environment.

For instance, the collective work 'L'Ecosystéme Belgique, Essai d'écologie industrielle'[16], published in Brussels in 1983, extended the ecosystem study approach to the whole national industrial system, collecting data on material and energy input and output in Belgium. One of the co-author was a former student of Duvigneaud. Differently from Duvigneaud, results were not spatialized on the Belgian territory but rather illustrated through schemes of material and energy flows. The study questioned the efficiency of material circulation in six main productive chains (iron, glass, plastic, lead, wood, and food). The results shown the predominant linearity and sectorialization of the industrial production, implicitly arguing the need for a more integrated policy. Despite the original approach, the study didn't have further developments, and as reported by Erkman[17], left to its authors the impression of being "a voice preaching in the desert".

15 Suren Erkman, Vers une écologie industrielle (ECLM, 2004).

16 Gilles Billen et al., "L'Ecosystème Belgique : Essai D'écologie Industrielle" (Bruxelles : Centre de recherche et d'information socio-politiques, 1983).

17 Robert U. Ayres and Leslie Ayres, A Handbook of Industrial Ecology (Edward Elgar Publishing, 2002), 31.

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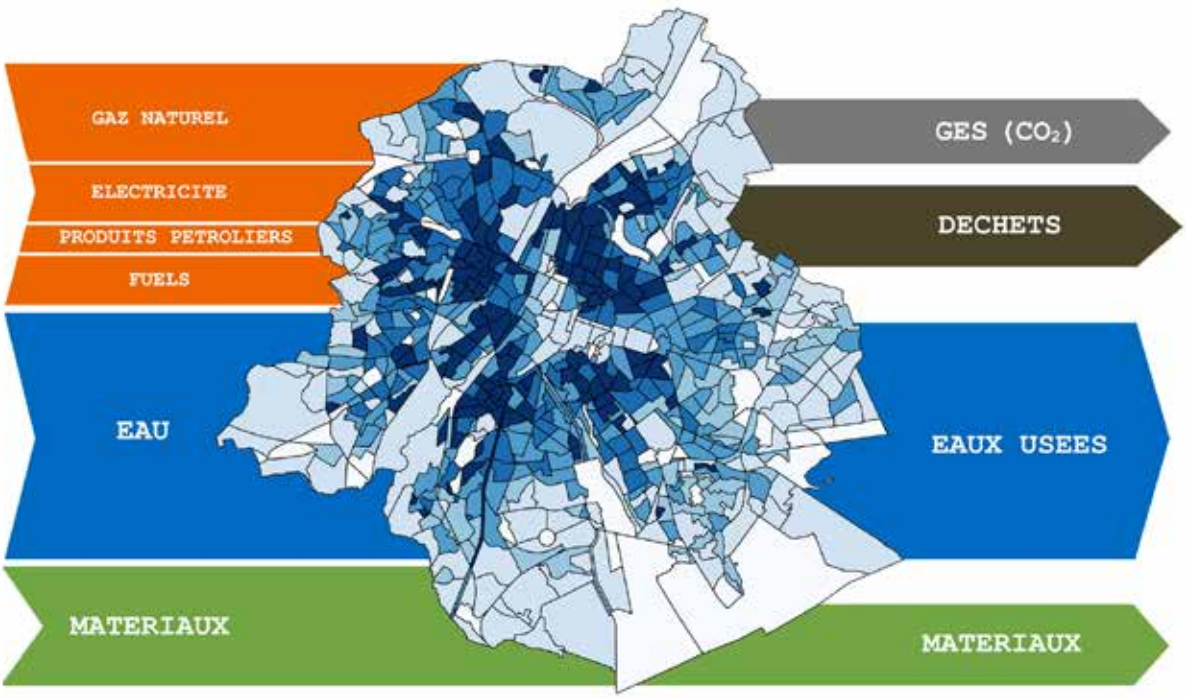

FIGURE 3 Metabolism of the Brussels Capital Region (BCR), 2015. The image is taken from the current research of BATir (ULB) which investigates the functioning of urban systems in terms of direct and indirect resource requirements and resulting environmental impact

The work of Duvignead, claiming the need for fundamental research on urban ecosystem in urban planning, provided a remarkable contribution to the rising environmental planning discipline[18]. However, in the years that followed his studies, what clearly has emerged from the Brussels context is a striking dichotomy between the trajectories taken by planning and ecology discourses. On the one hand, a general lack of vision and interest in regional and environmental planning, and on the other, a gradual politicization of ecology by counterculture movements active at the very local scale of single neighborhoods and municipalities. Whether these movements brought remarkable successes in the preservation of certain part of the city, according to Vermeylen[19], in the following years they also multiplied into small counter powers unable to maintain a common vision.

18 : "[…] la planification du développement de la ville, qui doit régler les rapports futurs entre la ville et les campagnes environnantes et entre les divers sous-système urbains nécessite l'étude approfondie de ces phénomènes de croissance". Paul Duvigneaud, "Études Écologiques de l'Écosystème Urbain Bruxellois: Contribution No 1 À 4: L'écosystème 'Urbs'," 7.

19 IEB, Bruxelles En Mouvements, January 2015, Périodique édité par Inter-Environnement-Bruxelles, Fédération de Comités de Quartier et Groupes d'Habitants edition, 34.

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ECOLOGICAL RESURGENCE IN BRUSSELS' URBAN PLANNING AND DESIGN

Recently, there has been a strong return of debate on the Brussels' urban metabolism. Since the end of 2000s, observers from the academic and civic society of Brussels[20] use the term "urban metabolism" to claim the need for an ecological restructuring of the city. Two main references can be traced in their discourses: industrial ecology principles[21] and the experience of sustainable neighborhoods developed in Europe since 1990s. These principles are extended in the provision of urban services and infrastructure, touching key governance questions such as citizens' behavior and participation. Also spatial concerns reappears in the line of argument: in order to tackle the spatial and functional fragmentation of the city, Vanderstraten underlines the need to reclaim the geographical value of the Brussels' valleys, for instance with respect to water drainage and slow mobility functions[22] .

In addition, new regional programs and plans are asking the urban projects to integrate a strong metabolic perspective in order to boost the regional economic and social development as well as to meet the urban environmental challenges. The Regional Plan of Sustainable Development (PRDD) of 2014 integrates the issue and makes use of the term "urban metabolism" when addressing environmental management and resource efficiency within a regional perspective (:14). Similarly, the term "ecology" is explicitly used referring to "industrial ecology" (:156), and when addressing the economic development through principles such as clustering productive zones. In the plan, besides the use of the two terms, there is no any specification concerning what is meant by ecology nor about in which terms urban design should actually integrate an ecological perspective. The ecological questions posed by the PRDD simply remain close to those provide by the EU 2020 strategy for a smart, inclusive and green development.

As is apparent, beyond the case of Brussels, urban metabolism has lately known resurgence and it is accounted for multiple reasons such as accounting for greenhouse gas emissions, the measure of the urban resource efficiency, and the design of new sustainable, low-carbon, neighborhoods[23]. In this line of studies, fits another recent work concerning Brussels' urban metabolism. Within the framework of the new Regional Circular Economy Programme (PREC), a detailed study on the urban metabolism of the Brussels Capital Region (BCR) has been recently published[24] [Fig. 3].The report is thought for decision-making and collect exhaustive data on actors and flows of the Brussels' metabolism.

Despite that, it does not concern the urban space quality and structural specificities. Criticisms to these approaches, indeed, pointed out the constrains given by working on the concept of circular metabolism considering exclusively the flows and not their underpinning urban structure, which remains fixed at the modernist stage of discrete separation of functions and land uses[25]. Moreover, also the use of the metaphor which regards energy and material urban flows as a metabolism has been pointed as misleading[26]. Even if considered a valuable tool for quantifying the city use of natural resources, flows and stocks do not provide a comprehensive analysis of the urban ecosystem.

20 See for instance Pierre Vanderstraeten et al., "Brussels, a Sustainable City," accessed April 5, 2016, http://brusselsstudies.be/medias/publications/EN_72_CFB4.pdf; Eric Corijn et al., Où va Bruxelles? Visions Pour La Capitale Belge et Européenne, ASP Academic and Scientific Publishers, Cahiers Urbains, 2013.

21 Erkman, Vers une écologie industrielle.

22 Pierre Vanderstraten in Corijn et al., Où va Bruxelles? Visions Pour La Capitale Belge et Européenne.

23 Roland Clift et al., "Urban Metabolism: A Review in the UK Context" (Foresight Future of Cities Project, September 2015).

24 EcoRes, ICEDD, and BATir, "Métabolisme de La Région de Bruxelles-Capitale" (IBGE, 2015).

25 J. Karakiewicz, "Urban Metabolism of Low Carbon Cities," in 47th ISOCARP Congress (Liveable Cities – Urbanising World, Meeting the Challenge, Wuhan, China, 2011).

26 Nancy Golubiewski, "Is There a Metabolism of an Urban Ecosystem? An Ecological Critique," Ambio 41, no. 7 (November 2012): 751–64, doi:10.1007/s13280-011-0232-7.

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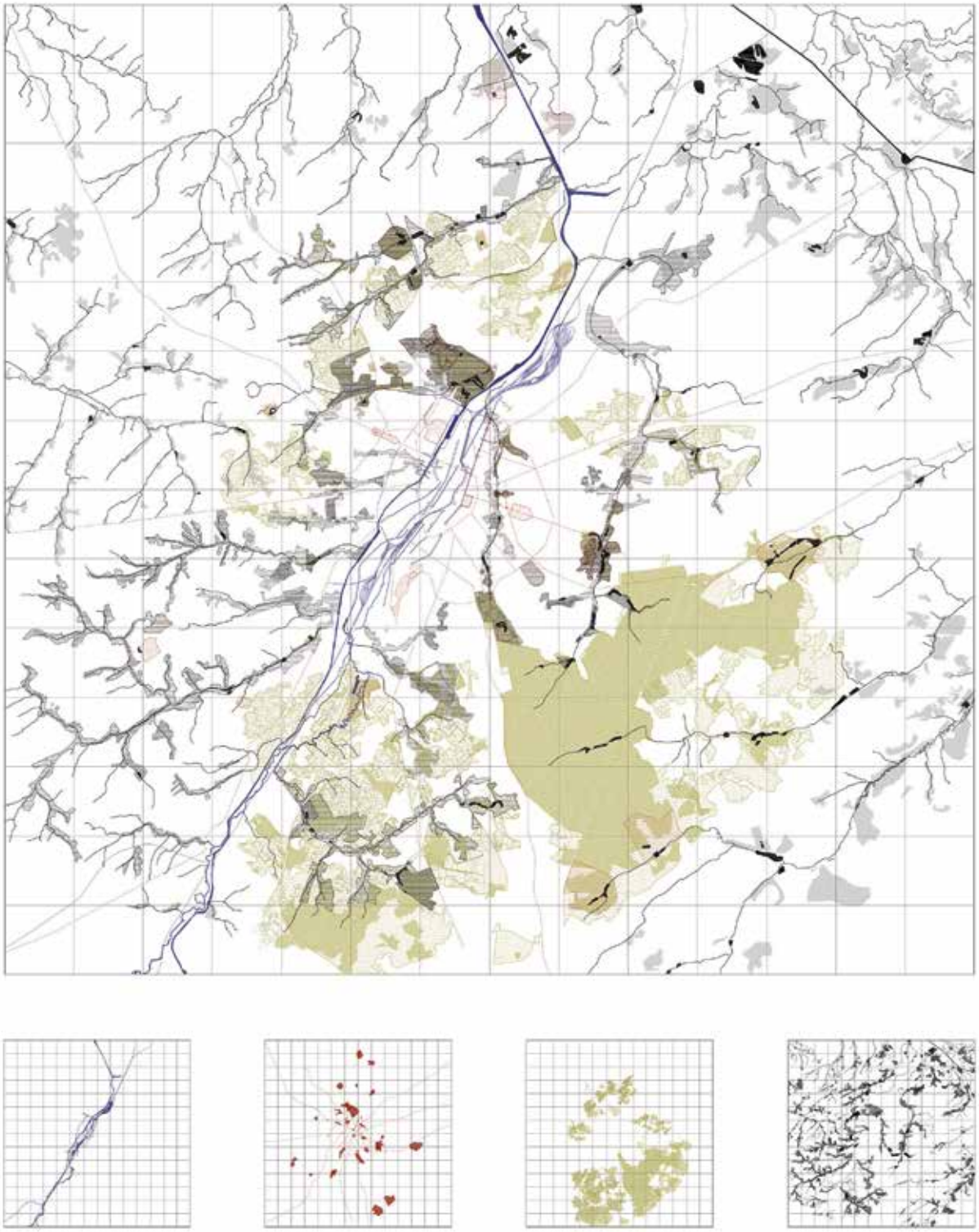

FIGURE 4 Four ecologies of the Brussels' metropolitan area, Bureau Bas Smet & LIST, 2015. The "valley of infrastructures", "constructed landscapes", "parks' system" and "wet landscapes"

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Finally, *Metropolitan landscapes*, a strategic design study launched by the Region in 2014, provides some interesting insights on the state of the art of ecology and design in the Brussels agenda. *Metropolitan landscapes* is composed through a series of research-by-design explorations, which aim to test hypothesis of urban transformation at the metropolitan scale, involving various design teams and large public steering committees. The main objective is to enhance the dialogue and collaboration among urban stakeholders while providing a set of rule-based design tools to face complexity and conflicts inherent to large-scale urban projects. In the studies, even though not explicitly mentioned, urban metabolism concept results taken considering the socio-ecological and economic relationships between BCR and its surrounding. The interrelation is described via the figure of the "metropolitan landscapes". Quite interestingly, these metropolitan landscapes are tackled starting from the residual open spaces which interested also Duvignead in his late work[27], and which border the urban area. They are potential reservoirs of urban expansion but also rich and diverse structural ecological spaces for the city [Fig. 4].

The study's presumptions are four "ecologies" - taken from the Reyner Banham's lecture of Los Angeles[28]- or structural landscapes. Each ecology is defined by a territorial figure: the "valley of infrastructures", the "constructed landscapes", the "parks' system", and the "wet landscapes". As known, in the urban design discipline, the figure is a key rhetoric tool widely used as a frame within which maintain a larger view on the long-term and large-scale objectives while coordinating the intervention at the small scale[29]. It integrates the long temporality of the urban (metropolitan) project, commonly built up by gradual additions operated by variety of actors through time. In *Metropolitan landscapes*, "ecosystem" and "figure" merge as the base of a discourse with multiple meanings and connections able to integrate complexity and variables within workable synthesis. In conclusion, they provide insights for a political discussion based on alternative future urban metabolisms based on qualitative data. Although it has to be said that the studies does not explicitly aspire to contributing the debate on the urban metabolism of Brussels, the metabolic perspective seems reversed when compared to that used in the Regional Circular Economy Programme and the quantitative insights are totally ignored.

CONCLUSION

In the paper, we looked at the most relevant studies on the Brussels' urban metabolism, focusing on how the interrelation between design and ecology has been operated on a case-by-case basis. Both, the attempts of the ecological studies to influence the organization of the urban arrangements, and the effort since recently produced by urban planning and design to integrate a more ecological perspective are promising signals. However, the results show that still little knowledge has been transferred from ecology in urban design and practice and vice versa. On the one hand, in the pioneering studies of the '70s, man and nature, political and environmental issues were equally present in the description of the production and reproduction trajectories of Brussels but actual design was not contemplated [Tab. 1]. Later, Brussels' metabolic studies have taken a much more technical turn. The industrial ecology perspective has taken over and design has been narrowed to the quantitative characterization of flows and stocks. On the one hand, despite the rising interest in the subject of urban metabolism, until now, in Brussels, design and planning practice seems to have little drawn from the substantial heritage of the Brussels School. Although the urban studies recognize 'nature' as a key element for the 'urban', there is still much to do especially in engaging a more critical perspective on the ways urban space and biophysical processes are mutually produced.

27 Duvigneaud, Les Sites Semi-Naturels de L'écosystème Bruxelles : Interpénétration de L'environnement Physique et de L'environnement Sémi-otique.

28 Reyner Banham, Los Angeles : The Architecture of Four Ecologies., Penguin Books, 1973.

29 See for instance Bernardo Secchi, "A New Urban Question 3: When, Why and How Some Fundamental Metaphors Were Used," in Metaphors in Architecture and Urbanism: An Introduction, Transcript Verlag (A. Gerber & B. Patterson, 2013), 123–32.

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Urban design and ecology can capitalize from the significant deposit of knowledge regarding the Brussels' urban metabolism. However, it seems clear that, first of all a further understanding about what is ecology is still needed. This forces to take a decision whether nature remains a fundamental external component of our societies – as it is the case of industrial ecology - or it is simply integral part of it – as claimed by political ecology[30]. Secondly, the key role of the planning and urban design discipline for the organization of the city and its circulatory dynamics has to be practically acknowledge[31]. Finally, more tools and design procedures have to be explored that allow working out socio-natural patterns of urban development.

TIME	AUTHOR/STUDY	FOCUS	APPROACH TO THE CITY
1977	Duvigneaud and Denaeyer-De Smet / L'ecosystéme Urbain Bruxellois	The Brussels' urban ecosystem	The city as a subject
1983	Billen et al. / L'ecosystéme Belgique. Essai d'écologie industrielle	The Belgian industrial ecology	The industrial chain as a subject
2015	Ecores sprl, ICEDD, BATir (ULB) / Métabolisme de la Région de Bruxelles-Capitale	The Brussels Capital Region urban metabolism	The city as an object
2016	Vlaams Bouwmeester / Metropolitan Landscapes	The Brussels' metropolitan landscapes	The urban as a subject open to interpretation

TABLE 1 Year, name, focus and approach of the main studies on the Brussels' urban metabolism.

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Marco Ranzato is architect and holds a PhD in Environmental Engineering. He has worked and collaborated with different academic contexts as the Delft University of Technology, the Tongji University and the Université Libre de Bruxelles. His research interests are ecology in urban design and, since recently, co-design processes and co-production of services.

30 David Wachsmuth, "Three Ecologies: Urban Metabolism and the Society-Nature Opposition," The Sociological Quarterly 53, no. 4 (September 1, 2012): 506–23, doi:10.1111/j.1533-8525.2012.01247.x.

31 Gandy in conversation with, Ibañez, and Katsikis, "On Circulations and Metabolisms: Challenges and Prospects."

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Figure 1: Duvigneaud, Paul, Simone Denaeyer-De Smet, and Martin Tanghe. "Carte Écologique de L'occupation Du Sol et Des Degrés de Verdurisation de L'agglomération Bruxelloise : Situation Mars 1975." Agglomération de Bruxelles, Service de l'environnement, 1977.

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