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Misconceptions or misunderstandings? On the standardization of basic terms and definitions in urban ecology

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ABSTRACT

Urban ecology is a promising research field that could generate important information to be transferred into practical applications for urban landscape planning and management. However, the lack of homogeneity in technical terms used to describe urban-related sampling sites makes generalizations difficult to establish. After the substantial effort to standardize procedures for quantitatively determining major points along urban gradients using large scales ten years ago, recent studies have proposed novel definitions to define terms related to both habitat and landscape levels with the aim of describing specific study sites within urban systems. In this essay, I discuss the definition of several terms related to sites within urban systems (e.g., urban, suburban, peri-urban, non-urban, ex-urban, rural) and propose straightforward ways to standardize and accurately describe them. Undoubtedly, the use of well-defined terms in urban ecology studies will not only permit a better understanding of the nature of study sites across urban ecology studies and grant the possibility to perform robust comparisons among urban ecology studies, but could also aid policy makers and urban landscape planners and managers to enhance the ecological quality of urban systems around the globe.

Urban ecology is a growing discipline with a high potential for applications through urban management and planning policies across the globe. However, the lack of homogenized technical terms used to describe specific conditions of sampling sites within urban areas and their surroundings make ecological generalizations virtually impossible. After the leading effort of Marzluff et al. (2001) to standardize the procedure for quantitatively determining major points along urban gradients using relatively large scales (>1 km^2) ten years ago, others have proposed novel definitions to describe terms related to both site-specific (i.e., habitat) and landscape levels with the aim of categorizing study sites within urban systems (Clergeau et al., 2006; MacGregor-Fors, 2010).

In spite of such efforts, synonyms of basic urban ecology terms have been used by researchers to describe different environmental conditions, while similar conditions are often described using diverse terms. For example, urban ecologists have used the term 'rural' for referring to: (1) 'non-urban' areas, (2) sites following suburban areas in a landscape level urbanization gradient, and (3) sparsely settled areas with individual homesteads, recreational developments, small towns, and villages surrounded by an agricultural matrix (e.g., Clergeau et al., 2006; Marzluff et al., 2001; Niemelä, 1999). This phenomenon of uncertainty and lack of standardization of definitions occurs with almost all general urban ecology terms (e.g., 'urban', 'suburban', 'peri-urban', 'exurban'), which leads to important misunderstandings when interpreting the location and nature of sampling units used by urban ecologists. Thus, in an attempt to standardize some basic urban ecology terms, I here propose some straightforward definitions that could aid in the precise description of study sites in urbanized systems.

First of all, I believe that a clear line between 'urban' and 'non-urban' needs to be drawn. To do so, the term 'urban' needs to be clearly defined. As pinpointed by Nilon et al. (2003), 'definitions of urban vary among countries and often are specific to the political, social, and economic context in which they are utilized' (p. 1). 'Urban' is often used to describe: (1) populated regions with a human density greater than 1600 inhabitants/km^2, (2) places with a total human population of 2500 inhabitants, (3) built-up areas with various structures (e.g., housing units, schools), or (4) areas where the majority of the land is covered by buildings (with >50% built cover, >10 buildings/ha, and >10 inhabitants/ha) (Marzluff et al., 2001; Niemelä, 1999; Nilon et al., 2003). Although these definitions could apply to specific study areas, they do not fit all possible urban conditions in the globe. Thus, such definitions could be merged and widened to include a higher spectrum of possibilities into a new definition, as follows: 'urban' = populated areas provided with basic services (e.g., homesteads, electricity and water supply, drainage), where more than 1000 people/km^2 (>10 inhabitants/ha; following

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Marzluff et al., 2001) live or work, and an important proportion of the land (>50%), in a "city-scale", is covered by impervious surfaces (e.g., buildings, streets, roads). Consequently, 'non-urban' areas comprise all other conditions excluding the above described, including other human-disturbed areas, such as agricultural fields, abandoned cropfields, and natural habitats.

When describing study areas, urban ecologists tend to omit a great amount of valuable information, often avoiding to state the obvious (from their particular point of view). For example, urban ecologists state that their surveys were carried out in: a great 'metropolis' or 'megacity', 'city', 'town', 'human settlement', or 'ranch', among other descriptive terms. Although labeling urban study areas does not represent an incorrect practice, more information is often needed in order to correctly understand the nature of urban study areas, and thus prevent misunderstandings. One important issue to be aware of is that readers are generally not familiar with the wide array of urban conditions present around the world, and thus interpret unknown conditions in relation to their own. Thus, I strongly suggest that urban ecologists should always report at least the following data regarding their study area: (1) the geographical location of the study area in lat/long format to facilitate comparisons (reporting the location of the geographical center of the urban study site), (2) total number of inhabitants at the time when the study was conducted, (3) updated human population growth rate (in a percentage scale to allow comparisons), (4) size of the urban area (in square kilometers; see MacGregor-Fors, 2010 for a method to delimit city polygons), (5) main urban land uses (even though the study may not explore them), (6) the biogeographic (e.g., zoogeographic, phytogeographic) region in which the urban area is settled, (7) type of habitats present prior to the establishment of the urban area, and (8) principle habitats and land uses currently surrounding the urban area.

When describing specific sampling sites, urban ecologists tend to use a wide array of terms (e.g., 'suburban', 'peri-urban', 'exurban', 'urban core', 'center', 'peri-center', 'urban fringe', 'periphery', 'satellites', 'metropolis', 'residential', 'commercial', 'industrial'). Apparently, there are three main components determining the labels used to describe a particular sampling site within an urban area: (1) its location within the urban area, (2) its site-specific characteristics, and (3) its human-use designation. Clergeau et al. (2006) used a hierarchical approach to represent an urbanization gradient, including a city's: (a) 'center', (b) 'pericenter', (c) 'urban' fringe, (d) 'suburban' area, and (e) 'rural' areas. Some uncertainties arise regarding such classification. First, the delimitation between the center and the 'pericenter' of an urban area is not clear enough to establish a limit between them. Second, as reviewed in a recent study (MacGregor-Fors, 2010), urban ecology studies tend to use the terms 'pericenter', 'peri-urban', 'urban periphery', 'urban edge', and 'urban fringe' for referring to similar urban conditions (e.g., Boischio et al., 2006; Tjallingii, 2000).

Recently, an easy-to-use method was proposed to delimit the 'peri-urban' area of human settlements (MacGregor-Fors, 2010). In such study, 'peri-urban' areas are defined as the region where the urban core ('intra-urban' area) intermingles with adjacent 'non-urban' systems. The boundaries of 'peri-urban' areas can be established following the method proposed in the paper, robustly separating 'intra-urban' areas from adjacent 'non-urban' systems ('extra-urban' areas). The latter are defined as systems located within the direct area of influence of a city, such as the micro-watershed in which it is located, including smaller urban areas, other human-disturbed systems, and natural habitats. In this sense, the 'urban fringe' is defined as the border of an urban area, where cities sprawl, delimiting the polygon of a city (which boundaries can be delimited following the method proposed in the paper). Thus, this geographical approach allows one to quantitatively separate 'intra-urban' areas (also known as 'inner-urban', 'inner-city', 'urban core', and/or 'center') from 'extra-urban' areas (including 'wildlands', 'countryside', 'exurban', and 'rural' areas).

Among 'extra-urban' areas, several functional units exist. Regarding this point, I strongly believe that natural habitats and agricultural fields located within the direct area of influence of a major urban area should be considered as such, and described in as much detail as possible, avoiding the use of other terms, such as 'rural', to define them. This aside, two of the most commonly populated extra-urban scenarios are 'rural' and 'exurban'. As Marzluff et al. (2001) state, 'rural' and 'exurban' areas are 'sparsely settled [areas comprised] by individual homesteads, recreational developments, small towns, and villages' (p. 12). However, they state that 'rural' and 'exurban' areas are distinguished by the matrix surrounding them, with agricultural fields surrounding 'rural' areas, while 'exurban' areas are embedded in a natural habitat matrix. Although I believe that these definitions are straightforward and useful, 'rural' and 'exurban' areas can be immersed within the direct area of influence of a major urban area or not. Such 'rural' and 'exurban' areas are often considered 'satellites', metaphorically describing the presence of a component in the orbit of a greater one. Thus, I suggest the use of the term 'rural satellite' and 'exurban satellite' when a given settlement is located within the same micro-watershed where a major urban area is present, has well defined economic and social links in relation to a major urban area, and its size is smaller than 1/2 of the adjacent major urban area (e.g. 'our study area is an exurban satellite of Barcelona').

Moving on to a site-specific (habitat level) approach, ecologists need to perceive and measure urban systems as they would other natural and human-disturbed habitats. Thus, detailed descriptions of sampling units could aid in the comprehension of the role that non-vegetation urban components have on wildlife species. Several studies have shown that numerous non-vegetation urban components, such as the type and height of buildings, can shape urban-dwelling bird diversity (reviewed in MacGregor-Fors et al., 2009). When describing sampling sites in a site-specific level, it is crucial to define which human activities are carried out within them, following an urban land use classification. Although the latter could be difficult to standardize, main categories could be considered, such as: 'residential', 'commercial', 'green area', 'industrial', and/or 'conservation'. Subsequently, these categories could be narrowed in detail as much as the study objectives demand. Additionally, two main variables should always be reported: (1) the intensity of urbanization, generally assessed through built cover as a surrogate, and (2) human activities, generally measured as noise, and pedestrian/vehicle activities. While noise is often measured in decibels (average, maximum, and minimum), pedestrian/vehicle activities are commonly reported in relation to a time-scale (e.g., pedestrians/min, vehicles/hr). With the aim of standardizing urbanization intensity in a general way, I suggest using three categorical values when measuring the proportion of impervious urban surfaces: (1) sparsely developed (0–33% built cover), (2) moderately developed (34–66% built cover), and (3) highly developed (67–100% built cover). This classification would set the 'suburban' term aside from urban ecology studies, as should be replaced by sparsely to moderately developed urban areas. As urban areas tend to be highly heterogeneous, I believe that measuring the proportion of built cover in a 1 ha area would be sufficient to understand the specific conditions of the surveyed area. Also, the probability of including adjacent areas with different characteristics would be reduced, yet should be taken into account when measuring this variable.

In this essay I have attempted to underline important misconceptions, misunderstandings, and misuse regarding basic urban ecology terms used in the current literature. Obviously, the terms and definitions proposed here are subject to further debate and can be improved through standardized methods that allow describing

the nature of urban areas and their components, rather than arbitrary categorizations. As part of this refinement process, I strongly believe that studies focused in the generation of new conceptual frameworks and methodological procedures at different scales aimed to standardize urban-related terms and sampling techniques are to be encouraged. Undoubtedly, the use of well-defined standardized terms and the complete description of urban study areas and site-specific sampling sites will not only allow a better understanding of the nature of study sites in urban ecology studies, but will also grant the possibility to perform robust comparisons among urban ecology studies carried out in different regions. Ideally, generalities suggesting urban ecology fundamental principles could aid policy makers and urban planners to enhance the ecological quality of urban systems from around the globe.

Although homogenizing terms and definitions within the urban ecology literature will be a difficult task, specialized journals such as *Landscape and Urban Planning* and *Urban Ecosystems* can play a crucial role in making it happen. By adding a few new points to their author guidelines, with specifications regarding the minimum required information to describe study sites and the use of well-defined urban-related terms, journals would successfully amend the current issues regarding lack of term and definition homogeneity outlined throughout this essay. Also, journals could facilitate comparisons among urban ecology studies by requesting the authors to input the basic information of the studied urban area when submitting their manuscripts. Furthermore, such information could be uploaded into an open-access database, that in conjunction with a geographic software (e.g. Google Maps http://maps.google.com), could allow identifying specific case studies in relation to the characteristics of any given set of urbanized areas.

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