A disciplinary divide in the framing of urbanization’s environmental impacts

John H. Armstrong1 | Anna C. Nisi2 | Adam Millard-Ball3

1Environmental Studies, Seattle University, Seattle, Washington, USA
2Environmental Studies Department, University of California Santa Cruz, Santa Cruz, California, USA
3Urban Planning, UCLA Luskin School of Public Affairs, Los Angeles, California, USA

Correspondence
John H. Armstrong, Environmental Studies, Seattle University, 901 12th Ave, Seattle, WA 98122, USA.
Email: jarmstrong@seattleu.edu

Abstract
We identify a disciplinary divide in how the environmental impacts of urbanization are presented in ecology and urban planning journals. We analyzed the sentiments expressed in 202,900 journal articles and found that articles in ecology journals discuss urbanization three times more negatively relative to urban planning journals. Articles in both disciplines identified the negative local impacts of urban growth on biodiversity, habitat, and other ecological outcomes. However, urban planning research also considered the positive global-scale benefits of cities in enabling more efficient settlement patterns that reduce greenhouse gas emissions and energy consumption. These diverging perspectives are likely due to the different scales and scopes of the two disciplines, but also because of different counterfactuals: the alternative to urbanization might be car-dependent exurbs, or simply no new development within the focal study area. Interdisciplinary collaborations may provide a path to reconcile the different perspectives and boost sustainability.

KEYWORDS
biodiversity, conservation, ecology, efficiency, interdisciplinarity, sustainability, urban planning

1 | INTRODUCTION

With the accelerating scale and pace of urbanization (Bai et al., 2017), ecological research has documented biodiversity loss, land conversion, and other environmental and ecological impacts (e.g., McKinney, 2002; Turner et al., 2004). The Global Assessment Report on Biodiversity and Ecosystem Services (IPBES, 2019) finds unprecedented rates of species loss and ecosystem decline. Land use change, including habitat loss and conversion to agriculture, forestry, and urbanization, is a primary driver of biodiversity loss (Sala et al., 2000). However, while conversion of open space to urban development is certainly a source of habitat loss and fragmentation, ecological research has also documented potential larger-scale benefits to urbanization, including a slower rate of human footprint expansion in countries with higher urbanization (Venter et al., 2016).

The field of urban planning often emphasizes the benefits of urbanization for efficiency and sustainability, noting reduced per capita greenhouse gas (GHG) emissions and smaller footprints (Dodman, 2009; Hoornweg et al., 2011). Compared to rural residents with similar incomes, urban residents live in smaller homes, drive less, and use shared or more efficient resources such as public transportation and efficient buildings (Ewing & Cervero, 2010; Poumanyvong & Kaneko, 2010). In Europe, urban areas have carbon footprints that are 7% lower than those in rural areas, after controlling for income and demographic characteristics.
Vehicle travel accounts for much of these differences: in the United States, rural residents drive 38% more than their urban counterparts (Pucher & Renne, 2005). Certainly, there are wide differences across national contexts and within urban and rural areas as well—residents of the urban core typically drive much less than those in suburbia—but in general, urbanization tends to lower energy consumption and greenhouse gas emissions on a per-capita basis.

Perhaps as importantly, while inequities and poor conditions exist in cities throughout the world, scholars in the urban planning field focus in part on cities as crucial places and areas of opportunity to make progress on environmental and social sustainability objectives with policy initiatives such as climate mitigation plans and affordable housing programs (Ahern, 2011; Hoornweg et al., 2011; Krumholz & Hexter, 2018). Notably, this is a priority in the United Nations’ (2020) sustainable development goals, particularly goal 11 which is to make cities inclusive, safe, resilient, and sustainable. Angelo and Wachsmuth (2020: 16) identify a “movement from ‘less city’ to ‘more city’ in sustainability thinking—from cities being understood as environmental problems towards cities being understood as the solution to environmental problems on a global scale.” There has sometimes been a tendency to ascribe emissions and impacts to cities without fully considering the processes (e.g., agriculture, deforestation) that emanate from them (Satterthwaite, 2008; Tzaninis et al., 2021).

Urbanization has negative environmental impacts, often at the local scale, but can confer larger-scale efficiency benefits if it enables denser development. While concentrating people in dense urban areas results in intense local resource use, and while conversion of open space to developed areas in any form necessitates habitat loss, urbanization can reduce overall resource use and impacts from a global perspective. These differential local and global impacts parallel the land-sharing versus land-sparing debate, of whether to intersperse development with natural space (sharing) or to concentrate compact development separate from natural space (sparing) (Green et al., 2005; Stott et al., 2015). At a local scale, there is little question that urbanization negatively affects critical habitats, landscapes, ecosystems, and biodiversity. These issues are exacerbated by the fact that many cities lie in biodiversity hotspots such as coastlines, floodplains, and estuaries (CBD, 2012). Thus, a difference in the empirical emphasis of the two disciplines would not be surprising—ecology and urban planning scholars study different phenomena.

However, views of urbanization may also be reflected in the framing of an article, and the hooks that authors use to draw in readers may be much broader than the empirical content. For example, characterizations of urbanization such as this are common: “The degradation and loss of vital ecosystem functions and services have been an uncontested result of urbanization.” Similar statements can be found in articles that do not even study urban environments. Such framing language provides a window into what the authors perceive as mutual values or common knowledge in the field, or a shared point of departure for their readers. Although urbanization is often framed as the culprit of environmental degradation and ecological impacts, many ecologists have acknowledged the tradeoffs and focused on opportunities for solutions. For example, urban ecologists have investigated human–ecological interactions and how to encourage sustainable development (e.g., Alberti et al., 2003; Alvey, 2006). Others have noted that the effects of urbanization are dependent on context and whether it is undertaken in a proactive manner to minimize negative outcomes and maximize sustainability objectives (e.g., Grimm et al., 2008; Seto et al., 2017). Soanes et al. (2019) have attempted to correct what they identify as a “pervasive narrative” that urban environments are of little conservation value. It is unclear, however, whether sub-disciplines outside of urban ecology similarly emphasize the context-dependence of urbanization impacts.

To analyze how researchers present outcomes of urbanization in ecology and urban planning articles, we quantify disciplinary framing of urbanization by examining a large base of literature. Specifically, we address two research questions: (1) how do authors characterize the environmental implications of urbanization in ecology journals compared with urban planning journals? And (2) what are the common negative and positive environmental characteristics associated with urbanization in ecology and urban planning journal articles?

The concept of urbanization has many formulations. For some, urbanization is people-based: it refers to the increasing concentration of population in cities, regardless of whether that arises through higher densities or urban expansion (e.g., Berry, 1980). For others, urbanization is land-based: at least implicitly, urbanization is synonymous with urban expansion (e.g., Alig et al., 2004). Still others, particularly sociologists, see urbanization in terms of socio-political forces affecting the entire planet (Brenner & Schmid, 2014). In this paper, we employ the first conceptual framework, and follow the United Nations (2018) in defining urbanization as an increase in the proportion of the population living in urban areas. Urbanization may result from intensification within the existing urban footprint and/or expansion of urban areas, although the former option is likely to have greater energy efficiency and greenhouse gas benefits and fewer consequences for natural habitat. By focusing on the
proportion of people in cities, we can separate the process and environmental impacts of urbanization from those of overall population growth. However, we emphasize that the authors of the papers we examine may conceptualize urbanization in a different way, and in most cases do not define it precisely or at all.

2 | METHODS

We compared the sentiment of sentences about urbanization in ecology and urban planning journals. Our dataset consists of articles published in the top 46 journals in each discipline, which we identified from Web of Science and Google Scholar journal rankings (Table S1). We classified journals as interdisciplinary based on whether they were listed as such in the journal rankings and a review of their aims and scope. We used the CrossRef Text and Data Mining API to download 202,900 of the 207,135 articles published in those journals from 2000 through 2019. We extracted author affiliations where available from the CrossRef API.

We used the Python Natural Language Toolkit library (Bird et al., 2009) to parse each article to obtain sentences that contain a filter word or phrase: urbanization, urbanisation, sprawl, urban growth, urban development, urban expansion, city growth, city development, city expansion, urban densification, smart growth, urban compaction, compact growth, metropolitan growth, metropolitan expansion, growth of cities, expansion of cities, expansion of urban. To provide more context, we combined the filtered sentences with the preceding and subsequent sentences. We trained a logistic regression model to screen out irrelevant sentences such as reference lists and article metadata, leaving us with a dataset of 215,604 sentence samples (i.e., trios of sentences).

Sentiment analysis techniques based on machine learning and lexical databases have grown in power and popularity in recent years. However, algorithms are typically trained on movie reviews, tweets, and similar corpora, and are ill-suited to quantify sentiment in the less opinionated style of scientific writing (Yousif et al., 2017). Therefore, we adopted a more robust approach that scores sentences based on a substantive indicator word (such as biodiversity or habitat) and a link word (such as increasing or loss) within five words of the indicator. Each is coded with a polarity of +1 or −1, and the sentence-level score is expressed as \( \sum_{j} l_j i_j \), where \( i_j \) and \( l_j \) are the polarities of each pair \( j \) of indicator and link words within a sentence. For example, “reduction” (−1) of “deforestation” (−1) would be scored as \( -1^* - 1 = +1 \), while “destruction” (−1) of “habitat” (−1) would be scored as \( -1^* + 1 = -1 \). Table S2 lists the indicator and link words and their polarities. Since most of our filtered sentences lack a link/indicator pair, our final sample consists of 9196 sentence samples with non-zero scores.

We compared mean scores between ecology and urban planning journals using a t-test. Next, we used analysis of variance (ANOVA) and Tukey HSD post-hoc tests to compare mean sentence scores between ecology and urban planning journals, taking into account whether the journal was interdisciplinary, whether the indicator word was related to conservation (e.g., “biodiversity” or “habitat fragmentation”) or efficiency (e.g., “greenhouse gas”), and what filter word was used (e.g., “sprawl” vs. “densification”). For the filter word analysis, the data were first subset to exclude sentences that included multiple filter words. We also used linear regressions to examine changes over time. We considered whether authors discussed urbanization differently in the introduction relative to other sections by computing position in the article for each sentence and then comparing mean scores between sentences in the beginning 25% and the remaining 75% of the article using ANOVA and Tukey HSD. Finally, we conducted several sensitivity analyses to evaluate the robustness of our results (Supplementary Methods). Analyses were calculated in R version 3.6.0 (R Core Development Team).

3 | RESULTS

Overall, sentence scores were significantly more negative in ecology journals compared to urban planning journals \( (p < .001, \text{Figures 1a and S1}) \). Interdisciplinary urban planning journals discussed urbanization more negatively than disciplinary urban planning journals \( (\text{adjusted } p \text{ value } = .0005, \text{Figure 1b}) \), but there was no difference in mean sentence scores between interdisciplinary and disciplinary ecology journals \( (\text{adjusted } p = .9975, \text{Figure 1b}) \). Similarly, for ecology papers, there was no difference in scores between sentences discussing conservation versus efficiency impacts of urbanization \( (\text{adjusted } p = .4582) \), while papers in urban planning journals discussed conservation and efficiency differently \( (\text{adjusted } p < .001) \), with conservation impacts portrayed negatively and efficiency impacts positively \( (\text{Figure 1c}) \). Finally, filter words, or different terms used related to the concept of urbanization, produced different sentence scores between ecology and urban planning \( (\text{all adjusted } p \text{ values } < .05) \), with sentences in urban planning journals consistently less negative across all words and significantly positive for “densification.” In contrast, papers in ecology journals discussed efficiency impacts of urbanization much less frequently \( (\text{Figure 1c}) \) and did not consider the environmental impacts of denser urban development \( (\text{Figure 1d}) \).
Mean scores did not change over time for conservation sentences ($p = .80$, $R^2 < 0.001$) or efficiency sentences ($p = .207$, $R^2 = 0.017$) in ecology journals, or for conservation sentences in planning journals ($p = .397$, $R^2 < 0.001$). Sentence scores decreased slightly over time for efficiency sentences in urban planning journals, but the effect was very weak and explained very little of the variance ($p = .0115$, $R^2 = 0.005$). Position in article, reflecting whether statements were made in the introduction or in discussion of results, did not strongly impact sentence score for papers in ecology journals (adjusted $p$-value = .104), but sentences in the beginning 25% of urban planning papers discussed urbanization more negatively than those in the remaining 75% (adjusted $p$ value < .0{01; Figure S2}.

Our results were robust to a large number of sensitivity analyses (Figures S3–S7). These robustness tests often reduce the sample size, sometimes substantially, but in all cases a large and statistically significant difference between ecology and urban planning journals remains.

4 | DISCUSSION

We find a disciplinary divide in negative and positive sentiments used to portray urbanization between academic articles in ecology and urban planning journals. Ecological studies document and emphasize the negative environmental impacts of urban expansion, while urban planning research identifies both the ecological consequences and the efficiency benefits of denser human settlement patterns.

The disciplinary divide we identified likely stems from several explanations, reflecting differences in focus and framing, among other factors. In our dataset, a great deal of ecological research focused on local land conversion and habitat destruction to make room for urban expansion. Negative sentiments in ecology journal articles toward terms such as densification and development (Figure 1d) certainly make sense when considering associated loss of plants, animals, habitats, and even species. While urban planning journal articles may note such local-scale negative conservation impacts (Figure 1c),
they are more likely to consider the efficiency benefits of closer living or certain forms of development (Figure 1d).

This disciplinary division in focus likely extends across scales. Given that the local-scale conservation impacts of urbanization occur throughout the world, ecological articles focusing on those effects at both local and global scales would likely portray them negatively. Whereas globally focused urban planning articles may still note ecological impacts, they may be even more likely to portray positive efficiency effects, particularly in the context of global resource use and climate change. The production of greenhouse gas emissions may be simply outside the scope of most ecological research, so those benefits may not be captured in ecology journal articles. While we found that urban planning articles portray conservation impacts negatively, the difference with ecology articles indicates that more attention to ecological impacts in urban planning articles may be warranted.

The difference in focus may also be related to the education that scholars in different fields receive. Many urban planning scholars may get little if any instruction in ecological systems and how humans affect them. Many ecologist scholars, by contrast, focus precisely on such matters and how to assess related impacts, and may have little exposure to other implications of urbanization and urban planning priorities. Similarly, shared values among scholars in given fields, originating from education and social environments, that place greater emphasis on the natural world or social concerns may be a factor in differences in focus (Ives & Kendall, 2014).

Amidst differences in focus, some scholars also use urbanization as a framing device to stand in for a wide range of ecological degradation drivers, even in papers that have little to do with cities and their environmental impacts. While some articles provide specificity and nuance to the claims about urbanization, others use it in a vague manner to situate impacts in broader trends of environmental decline. One example from the first two sentences of a paper: “In the last few decades, the exponential growth of urban areas has become of major environmental concern worldwide. Fast-growing human populations have derived in the uncontrolled expansion of urban areas and the creation of new human settlements, representing a threat for biodiversity and often reducing human welfare.” Others include urbanization in a catch-all list of causes along with globalization, agriculture, and mining, such as this statement from the second sentence of a paper: “One of the major drivers of habitat loss and biodiversity declines is land-use change related to urbanization or resource extraction.” Especially for articles that make policy recommendations, either implicit or applied, avoiding catch-all claims and taking a critical approach to the effects of urbanization is important. Certainly, many articles provide much more nuanced analysis of the tradeoffs between different environmental goals and the context-specific nature of the impacts—urban ecology being a case in point. However, scholars in any discipline should avoid characterizing urbanization with a sweeping brush.

The need for balance in considering urbanization points to a tension in the face of increasing global resource use and climate change. While urbanization can cause significant local ecological impacts, climate change is a primary threat to myriad species and ecosystems worldwide, and well-planned cities offer significant global-scale efficiency benefits (Dodman, 2009; Hoornweg et al., 2011). As the world grapples with increasing resource use, the alternative to urban growth should be discussed. For some, it may be car-dependent exurbs, or rural development that encroaches onto natural habitat and agricultural lands. Under such a comparison, while urban development certainly has negative ecological impacts, they are less severe than a more sprawling alternative (Wilson & Chakraborty, 2013). While many ecology and planning articles may avoid addressing alternatives—or implicitly imagine no new development within a study area—common ground between the disciplines might be found if researchers were more explicit about where development would otherwise occur.

The specific patterns of urban development strongly determine environmental impacts at both local and global scales. We do not intend to portray urbanization as a monolithic process, and car-dependent sprawl, while notionally “urban,” may offer little or no efficiency benefits over rural development. Rather than painting urban expansion with a broad brush, researchers in all disciplines might usefully distinguish between sprawl and unplanned development versus urban growth that tries to respect the ecological contours of the land. For example, cities from Stockholm to Singapore have sought to integrate ecological principles in their planning, providing both habitat and access to nature throughout their urbanized area (Beatley, 2011). While urban expansion in any form certainly has some negative local impacts, these efforts represent an advance on business-as-usual from both a local conservation and global climate perspective.

The 2019 United Nations Global Sustainable Development Report points to the fact that much of the looming urbanization will take place in areas where new infrastructure is being built, “freeing cities from path dependencies and allowing for novel, sustainable solutions” (Messerli et al., 2019, p. xxviii). The report’s authors, and others, call for significant planning in urban development that considers a broad range of sustainability objectives together, relying on scientific
knowledge and expertise from many disciplines (Ahern, 2013; Niemelä, 1999; Wu, 2014). While doing this is a great challenge, so is it an opportunity not only to protect ecosystems but also to make social progress. Cities can be a critical place to prioritize policies and programs to further equity and advance multiple sustainability goals together, such as with access to education, better-paying jobs, social justice, and medical care (Dempsey et al., 2011; Corburn, 2017; Armstrong, & Kamieniecki, 2019).

Greater attention to interdisciplinary collaborations can provide a way forward, helping to incorporate both local- and global-scale perspectives on the environmental impacts of urban development—including its negative impacts as well as its potential for improved efficiency and sustainability. Indeed, we find that interdisciplinary journals offer a middle ground between the sentiments of urban planning and ecological research. Disciplinary divides silo conversations and research, which may negatively affect policy prescriptions and work to enhance conservation efforts. As Wu (2014) noted, urbanization can be considered a global experiment in sustainability. The outcome depends in no small part how well scholars and policymakers alike can approach overlapping and conflicting challenges. While we found a disciplinary divide in the framing of urbanization, we were encouraged to observe—across disciplines—a profound common commitment to seeking out solutions and protecting the environment.

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CONFLICT OF INTEREST
The authors declare no conflict of interest.

AUTHOR CONTRIBUTIONS
The three authors all contributed to the study's design, data analysis, and manuscript preparation.

DATA AVAILABILITY STATEMENT
Data used in this manuscript are available upon reasonable request to the authors.

ETHICS STATEMENT
Data were collected from online database sources noted in the paper's methodology. No ethics approval was required for this study.

ORCID
John H. Armstrong https://orcid.org/0000-0002-3279-500X
Anna C. Nisi https://orcid.org/0000-0003-0286-3187
Adam Millard-Ball https://orcid.org/0000-0002-2353-8730

ENDNOTES
1 Note that we omit the parenthetical citation for this quote. The reference is available from the authors; we do not cite the paper here as our intent is to illustrate a broader practice rather than implicitly criticize specific authors.
2 Aggregating the sub-disciplines in the two fields (e.g., landscape ecology, transport planning) is a limitation of the study in that it neglects nuances among specific areas of focus, but it serves the study’s primary aim in comparing broad disciplinary perspectives.
3 Note that these quotes omit parenthetical citations. References are available from the authors; we do not cite these papers here as our intent is to illustrate a broader practice rather than implicitly criticize these specific authors.

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**SUPPORTING INFORMATION**

Additional supporting information may be found in the online version of the article at the publisher’s website.

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