



Does Nature Need Cities? Pollinators Reveal a Role for Cities in Wildlife Conservation

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It is well-established that cities need nature for critical ecosystem services—from storing carbon, to reducing temperatures, to mitigating stormwater—and there is growing momentum to seek out strategies for how these services can intersect with urban design and planning efforts. Social scientists and conservation planners increasingly point to urban residents' need to breathe fresh air, encounter the natural world, and have room to play. It is less obvious, perhaps, whether nature needs cities in order to thrive. The evidence from both urban planning and conservation planning is increasingly “yes.” As changes in land use and land cover sweep the planet, cities are becoming important refugia for certain wildlife populations. In recent years, urban planning has embraced the concept of “green infrastructure” as a way to embed green space across metropolitan landscapes to draw on the inherent benefits nature provides to cities, as well as to create habitat for wildlife. We explore this evolving view of cities and nature in the fields of urban and conservation planning. We argue the time is ripe to bring these worlds together, and, using our empirical work, establish that cities matter for monarch butterflies, other pollinators, and at-risk wildlife species.

Keywords: urban, ecology, wildlife, conservation, culture, monarch, pollinators

WHY FOCUS CONSERVATION EFFORTS IN CITIES?

More than 80% of Americans live in urban areas¹, as does over half the world's population (UN DESA, 2018). In contrast, in 1960 twice as many people in the world lived in rural areas (2 billion) as urban (1 billion)². This trend is expected to continue, with nearly 70% of the world's population living in urban areas by 2050 (UN DESA, 2018). However, a striking 60% of the additional land projected to become urban by 2030 is *yet to be built* (GFDRR World Bank, 2015). Each day in the US more than 4,000 acres of open space are lost to development, the equivalent of more than three acres per minute (Williams, 1975).

As changes in land use and land cover sweep the planet, converting grasslands, forests, wetlands, and other available habitat into agricultural fields and developed landscapes, cities are becoming increasingly important refugia for an array of wildlife populations, including threatened and endangered species (Aronson et al., 2014; Ives et al., 2016). This pattern reflects, in part,

¹ U.S. Census Bureau. (2010). Available online at: <https://www.census.gov/geo/reference/ua/urban-rural-2010.html>

² *Our World in Data*. Available online at: <https://ourworldindata.org/urbanization>

the propensity to locate urban development in biologically diverse areas such as coastal and riparian locations (Luck, 2007). Indeed, populations of many species are reappearing in force across urban spaces—from fishers (LaPoint et al., 2015) and coyotes (Morey et al., 2007) to bullfinches (Audet et al., 2016) and peregrines (Caballero et al., 2016). Other urban wildlife dwellers include migratory species of birds, dragonflies and butterflies that rely on habitat patches in cities to move through landscapes dominated by large-scale agriculture (Seewagen et al., 2011; Goertzen and Suhling, 2013; Tam and Bonebrake, 2016). Significantly, several American cities support a higher diversity of native bee species—including the endangered rusty patched bumble bee (*Bombus affinis*)—than do adjacent rural areas (Hall et al., 2017; U.S. Fish Wildlife Service, 2017). These examples of wildlife species utilizing urban habitat illustrate that developed areas can be important in the conservation of species of high concern.

Given these trends, we have a small but critical window of time to develop and implement strategies that create highly functional urban landscapes with benefits for both people and nature (Intergovernmental Science-Policy Platform on Biodiversity Ecosystem Services (IPBES), 2019). Understanding how habitat can best be embedded in urban landscapes is important to help curb a potential “sixth mass extinction” (Ceballos et al., 2015, 2017). This situation cannot be overstated: recent studies reveal that the number of mammals, birds, fish and reptiles on Earth has been reduced by 60% in <50 years (World Wildlife Fund, 2018). In Germany, flying insect populations have plunged by 75% in the last 25 years (Hallmann et al., 2017), and a similar trend has been observed in Puerto Rico (Lister and Garcia, 2018).

Powerful urbanization trends have understandably been accompanied by a sense that nature has been displaced in urban landscapes and can only be found where cities don't exist (Hartig and Kahn, 2016). On the one hand, urban life has been characterized as “distanced from nature” (Tuan, 1978) accompanied by an “extinction of experience” (Pyle, 1978, 1993) as people move to urban settings (Miller and Hobbs, 2002; Turner et al., 2004; Zhang et al., 2014; Soga and Gaston, 2016). On the other hand, the conservation community has achieved huge victories in places far from the urban world, and a side effect has been to reify the notion of “wilderness” in the American mind (Nash, 1967). Large protected areas have “increasingly become the means by which many people see, understand, experience, and use the parts of the world that are often called nature and the environment” (West et al., 2006, p. 255).

As we'll discuss, our work on monarch conservation surfaces new ways to bring the potential for urban conservation into sharper focus. This new way of “seeing” cities includes: valuing new potential partners for nature, many of them historically excluded from the conservation narrative (Finney, 2014; Taylor, 2016); applying finer scales of analysis, with the aid of new data and geospatial tools; and recognizing other practices now being adopted to create sustainable cities for people. A main takeaway from our research is that the places called “urban”—in all their size, density, and heterogeneity (Wirth, 1938)—do contain powerful voices, activities, and opportunities for conservation. In spite of the perception that racial minorities

and low-income Americans—who are often well-represented in urban regions—are considered to have little concern for nature, a recent study reports their higher concern for nature than white and higher-income respondents (Pearson et al., 2018). Activating that concern for conservation may entail folding “nature” into the broader set of priorities that residents and community-based organizations have.

From backyards to rooftops to parks, urban residents have seen to it that nature has a place in the city, from the ground up. Improvements in technology have made this activity increasingly visible from the sky down. Wherever possible, our monarch research employed high-resolution imagery, enhanced by technology such as LiDAR³, which enabled precise characterization of land cover at the sub-meter scale. This helps us to visualize what is happening in the urban area with greater precision than the commonly used National Land Cover Database (NLCD), a 30-meter resolution dataset most appropriate to use when studying county-level units or larger (Wickman et al., 2014). When NLCD is applied to highly heterogeneous metropolitan landscapes, large swaths of land are classified as high, medium and low intensity developed land cover classes. While “low intensity developed” and “medium intensity developed” indicate a moderate proportion (20–79%) of the land cover is impervious, higher resolution data are needed to quantify and visualize the remaining land that is permeable and usable as green space. **Figure 1** demonstrates a sample area in Chicago's urban core viewed using NLCD, aerial imagery with LiDAR, and plantable space. Finer grain analysis can support the growing recognition that cities are ripe with opportunity and interest to create spaces where both people and wildlife benefit (Rosenzweig, 2003). This new perspective helps us to appreciate nature abounding in a multitude of contexts that intersect with how people live, work and play in urban areas, including in churchyards and school yards, along boulevards, and amidst corporate campuses, residential yards and community gardens (Beatley, 2011; Van Horn and Aftandilian, 2015; Johnston et al., 2019).

Much of what can be seen, and what exists as an opportunity to enhance urban biodiversity going forward, comes in the context of burgeoning “green infrastructure” efforts (Benedict and McMahon, 2006; Hostetler et al., 2011; Ahern, 2013). The uptick of interest in green infrastructure relates to how well it supports a number of needs in urban areas, including: enforcement efforts to bring municipalities into compliance with the pollution control provisions of the federal Clean Water Act⁴; nature-based solutions to reduce climate impacts such as flooding in urban landscapes (Derby Lewis et al., 2015); public interest in native landscaping (McMahan, 2006); the growing sector of

³LIDAR, or Light Detection and Ranging, is a “remote sensing method that uses light in the form of a pulsed laser to measure ranges (variable distances) to the Earth.” Available online at: <https://oceanservice.noaa.gov/facts/lidar.html>

⁴Technical Report: Tools, Strategies and Lessons Learned from EPA Green Infrastructure Technical Assistance Projects. Available online at: <https://www.epa.gov/green-infrastructure/tools-strategies-and-lessons-learned-epa-green-infrastructure-technical>

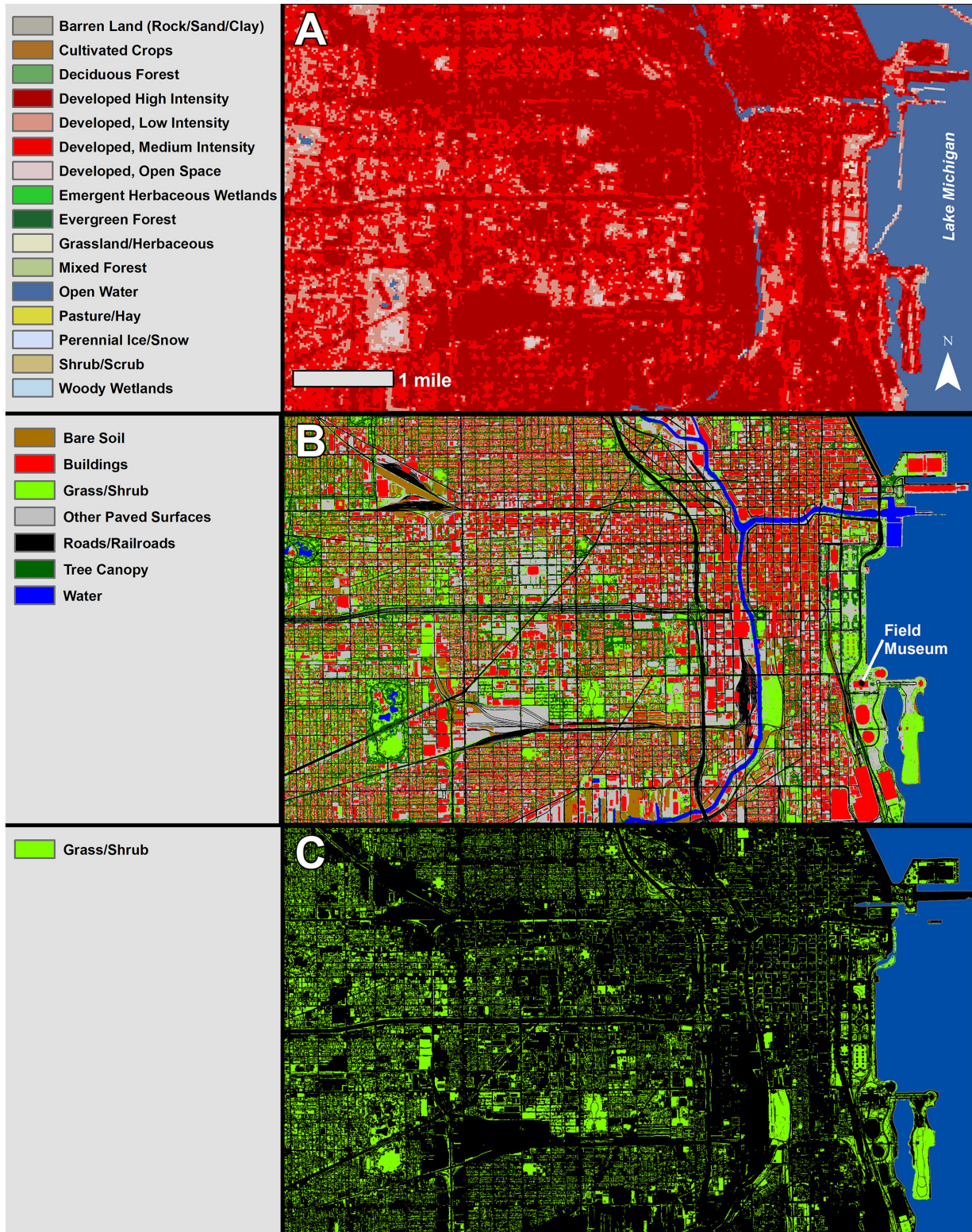


FIGURE 1 | Comparison of land cover data as classified when applying **(A)** the National Land Cover Dataset derived from 30-m spatial resolution Landsat satellite data, **(B)** higher spatial resolution land cover data derived using 2-foot spatial resolution multispectral aerial imagery and LiDAR data, and **(C)** grass-shrub land cover class in isolation (i.e., plantable space). This scale reveals the many opportunities that exist even under highly developed conditions. Sources: Multi-Resolution Land Characteristics Consortium (U.S.). “National Land Cover Dataset (NLCD)” and University of Vermont Spatial Analysis Lab “Chicago Urban Tree Canopy.”

urban farming (Jarosz, 2008; Lovell, 2010); and increased access to nature, particularly in marginalized neighborhoods (Wolch et al., 2014).

We propose that pollinator-focused efforts can help to find alignment between conservation goals and concerns important to cities and urban dwellers. Pollinators are small organisms that interact with households and neighborhoods, but operate in the larger landscape scale—and their associated habitats can leverage a variety of design and management activities that are underway in cities and offer pathways to connect nature and cultural heritage in urban communities. In short, monarchs (and other pollinators) point to new ways to “see” the city as a space for conservation, with new partners, new tools, and new practices.

HOW CAN THE MONARCH BUTTERFLY HELP US TO UNDERSTAND THE ROLE CITIES CAN PLAY IN CONSERVATION?

While many pollinators in general have wide public appeal, the monarch butterfly (*Danaus plexippus*) is arguably an ideal ambassador to engage the public on conservation issues. Monarchs are an iconic animal with a well-known migration and striking orange and black coloration. They also represent a powerful cultural symbol that facilitates people talking about conservation—and to one another (Gustafsson et al., 2015). Monarchs have been referred to as a convener: a species able to connect people across a continent who witness the stunning migration in their own backyard. Currently, there is heightened public awareness that monarchs, like many pollinators locally and globally, are declining rapidly. Over the last two decades, the eastern monarch population has decreased by more than 80% (Semmens et al., 2016), while the western population has declined by a staggering 97% (Schultz et al., 2017). The public interest in monarchs and a growing awareness of their plight create an opportunity to translate attitudes into practices that can help a range of pollinators across the urban landscape. Through our efforts and those of others, we are beginning to discover how monarchs are relevant to the future of conservation, as well as different entry points—from social justice and cultural history to sustainable food initiatives—for engaging people in creating urban habitat (Gustafsson et al., 2015; Derby Lewis et al., 2018).

A MONARCH'S VIEW OF THE CITY

A combination of efforts such as the creation of a Federal Strategy to Promote the Health of Pollinators⁵ and an assessment to determine whether monarchs need Endangered Species Act protection⁶, along with a variety of current urban monarch

initiatives (e.g., Mayors' Monarch Pledge⁷ and Monarch Watch⁸), led the U.S. Fish and Wildlife Service and the Field Museum in Chicago to collaborate in assessing the role cities could play in helping to increase the amount of habitat available to support eastern monarch butterflies. While this research does not apply to the Western monarch population, whose numbers have declined so dramatically (Schultz et al., 2017) that individuals are not frequently observed in the urban landscape, lessons can be drawn to support broader pollinator habitat efforts in metropolitan landscapes throughout the United States.

The aim of this effort was (1) to evaluate how much the urban sector, which is the second largest land use sector in the eastern monarch's Midwestern breeding range (Thogmartin et al., 2017), could contribute to the national goal of adding 1.8 billion milkweed stems (Semmens et al., 2016) and (2) to identify best practices for engaging a diversity of urban stakeholders in the creation of monarch habitat. Our team of ecological and social scientists then translated this information into a suite of spatial and social planning tools to help decision makers identify where the biggest opportunities exist to increase monarch habitat, and guidance on how to turn potential into reality. Details of the methods used to estimate the number of existing and potential milkweed stems occurring in urban landscapes, and to identify strategies to engage stakeholder groups to create habitat, have been published elsewhere (Johnston et al., 2019). For the purposes of this perspective, we provide a high-level summary of the approach and key findings, and discuss implications of this work in a broader context.

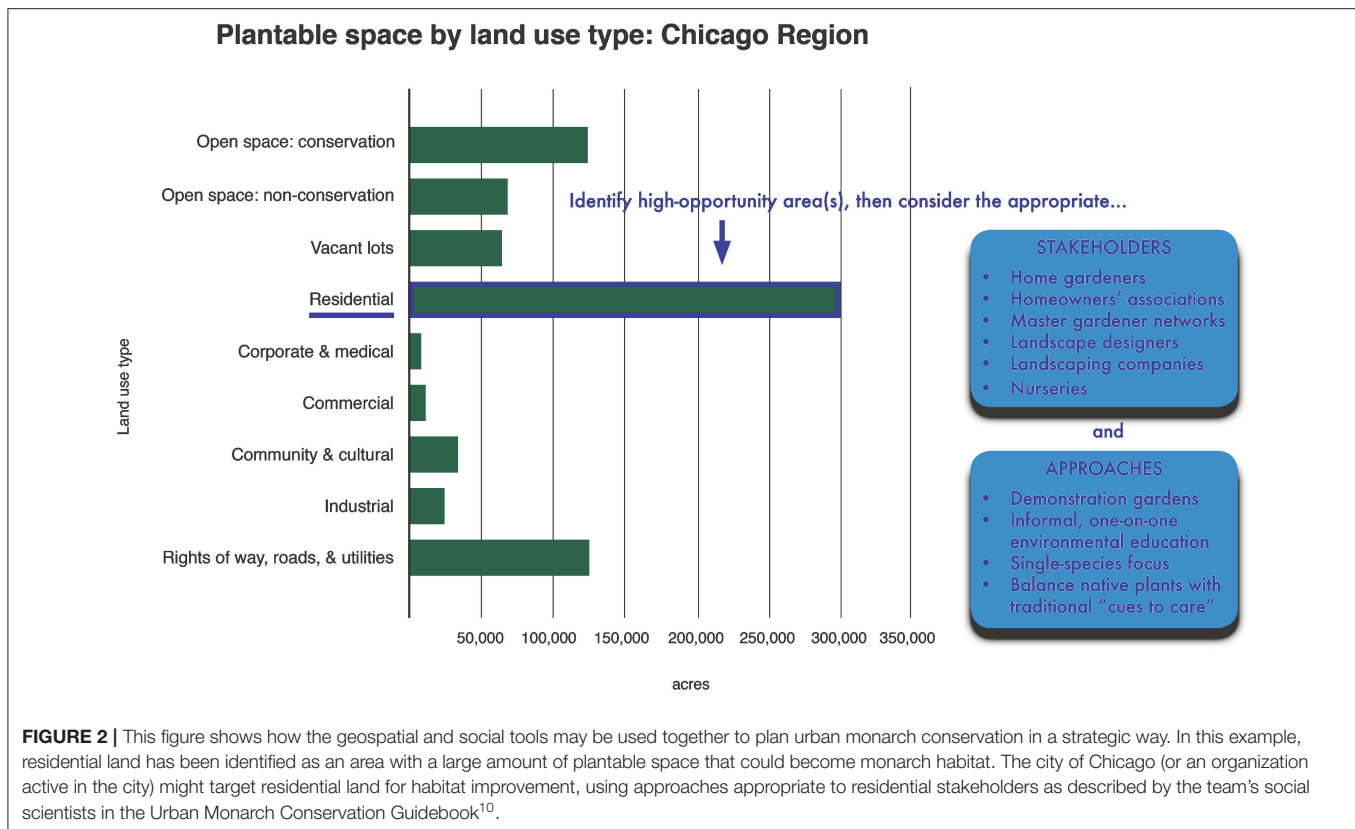
To understand the ecological landscape from a monarch's perspective, we conducted field sampling to estimate how much milkweed is currently on the ground and quantified the potential space for planting additional monarch habitat (i.e., the amount of grass/shrub land cover identified using high-resolution imagery and LiDAR data⁹) in different land use classes within four major metropolitan regions: St. Paul–Minneapolis, Chicago, Kansas City and Austin. For comparison purposes, land use types were consolidated into 16 classes based on land management (e.g., residential-single family, community and cultural, open space conservation, etc.). Milkweed stems were counted in three ways: (1) randomly sampled census blocks located at staggered distances along transects extending through the metropolitan area, (2) targeted sampling of open space conservation and non-conservation areas, and (3) targeted sampling of locations where milkweed was intentionally planted. Based on the density of milkweed present in each of the land use classes, we extrapolated the amount of milkweed that is currently present and the potential to add additional milkweed stems in metropolitan areas across the US eastern range of monarchs. Our findings indicate the collective impact of this potential contribution could provide

⁵ *Pollinator Partnership Action Plan*. Available online at: https://www.whitehouse.gov/sites/whitehouse.gov/files/images/Blog/PPAP_2016.pdf

⁶ *Assessing the Status of the Monarch Butterfly*. Available online at: <https://www.fws.gov/savethemonarch/SSA.html>

⁷ Mayors' Monarch Pledge is a program designed to support U.S. cities, municipalities, and other communities committing to create habitat for the monarchs and other pollinators. Available online at: <https://www.nwf.org/Garden-For-Wildlife/About/National-Initiatives/Mayors-Monarch-Pledge.aspx>

⁸ Monarch Watch is “a nonprofit education, conservation, and research program based at the University of Kansas”. Available online at: <https://monarchwatch.org/>
⁹ *Urban Tree Canopy Assessment*. Available online at: <https://www.nrs.fs.fed.us/urban/utc/>



nearly a third of the additional 1.8 billion milkweed stems needed in the Midwest to stabilize the eastern monarch's population (Johnston et al., 2019).

Additionally, we looked at the potential plantable space across each land use class to provide a more detailed characterization of the urban landscape. For example, in the Chicago region, we found that residential land had one of the highest amounts of potential plantable space. Using a land use lens allowed us to link high-potential areas with the stakeholders that would need to be engaged to increase monarch habitat. We were then able to pair those stakeholders with evidence-based approaches to enhance uptake (**Figure 2**).

To identify appropriate approaches for different stakeholder groups in an urban setting, we conducted social science research to assess the motivations, concerns, interests, challenges, and strategies of those both directly and indirectly involved in making their city's landscape more hospitable to monarchs. We surveyed people engaged in different environmental practices (e.g., planting/managing land, designing landscapes, monitoring the natural environment) and within the different land use classes laid out by the team's geospatial analysts. With people who had extensive knowledge or experience relevant to monarch conservation, we conducted semi-structured interviews, as they make efficient use of the participant's time and are well-suited to

the exploratory phase of research (Schensul and LeCompte, 2013). For participants drawn from the "interested public," we used an online survey, which allowed us to reach more people. We collected and analyzed 734 online surveys and 75 semi-structured interviews in the four pilot metropolitan areas and found that interest in creating monarch habitat was present to varying degrees across all groups, but it took different forms. For example, while some stakeholder groups are singularly focused on the monarch, others may be more interested in broader habitat creation and/or wary of the regulations that single-species conservation can bring. This information was used to highlight best practices for engaging urban stakeholders and to develop approaches that connect to community interests and assets (e.g., social justice initiatives, green infrastructure planning, urban farming efforts, public art) in engaging a wide cross-section of urban residents to take actions aligned with wildlife conservation goals.

DOES NATURE NEED CITIES?

Our results add to a growing body of literature showing that metropolitan areas matter for wildlife conservation (Morey et al., 2007; LaPoint et al., 2015; Caballero et al., 2016). Despite being developed, these landscapes have high potential to maintain functional habitat for a variety of species, including migratory and threatened endemic species. Habitat within and between US

¹⁰www.fieldmuseum.org/monarchs

cities can help connect the dots for monarchs, other pollinators, and birds along migratory pathways from Mexico to Canada and back.

The importance of cities for maintaining insect pollinators is particularly noticeable, given the relatively small spatial and temporal requirements for functional pollinator habitat that can be satisfied in urban green spaces. Although urban habitats are highly heterogeneous, with habitat often occurring in isolated patches, evidence suggests there is sufficient opportunity for pollinators to use these spaces (Tommasi et al., 2004; Glaum et al., 2017; Hall et al., 2017)—sometimes even greater opportunity than in surrounding rural areas.

As is the case with any land use sector, however, there are considerations that need to be addressed. For example, the wide-scale use of pesticide and herbicide in urban landscapes (Hladik and Kolpin, 2015) by public entities and private landowners poses a threat to insect population health. To ensure a net gain for pollinator populations utilizing urban habitat, approaches that limit insecticide exposure in urban areas are recommended.

Interdisciplinary methods that bring together the insights of social, natural and spatial sciences can shed light on the conservation approaches with the most ecological and social potential to scale effective solutions. Our work suggests that the collective impact of conservation-related actions by urban stakeholder groups can play a fundamental role in supporting wildlife—including nearly a third of the milkweed needed for the eastern monarch (Johnston et al., 2019). By identifying the ecological potential and understanding the social perspectives and interests of different stakeholder groups, it is possible to enhance the uptake of conservation strategies within urban areas, where these practices are important for threatened species.

Metropolitan areas also offer the opportunity to engage millions of people in conservation efforts. Despite urban areas' representing only 3% of the total landmass in the US, these areas have a disproportionate influence on the landscape, and investments must be made to turn the urban conservation potential into a reality. Expanding the functional habitat within these urban centers and increasing the commitment of urban stakeholder groups to conservation goals could greatly contribute to the achievement of those goals.

This means we must identify the different entry points where conservation goals can include input from urban partners and overlap with community values and concerns. Embracing community values as assets in conservation planning creates more opportunity for habitat and fosters meaningful new

partnerships that are essential in highlighting conservation relevance in a rapidly expanding urban world.

A broader vision of what conservation is, what nature looks like beyond protected lands, and who is included in the conservation community is long overdue. Acknowledging that there are different ways that heritage and history shape how people experience the natural world, or see nature as a part of their lives, is an important first step in broadening the conservation community (Campbell, 2015). Our research indicates that cities can play a critical role in species and habitat conservation and that interdisciplinary approaches that engage urban stakeholders can have an outsize impact on wildlife conservation.

AUTHOR CONTRIBUTIONS

ADL, MB, AW, AH, DS, MJ, and CZ contributed to the conception of the design and the study. ADL wrote the first draft of the manuscript. ADL, MB, and AW wrote sections of the manuscript. All authors contributed to manuscript revision, read, and approved the submitted version.

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