The city as a refuge for insect pollinators

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Essay

The city as a refuge for insect pollinators

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Abstract: *Research on urban insect pollinators is changing views on the biological value and ecological importance of cities. The abundance and diversity of native bee species in urban landscapes that are absent in nearby rural lands evidence the biological value and ecological importance of cities and have implications for biodiversity conservation. Lagging behind this revised image of the city are urban conservation programs that historically have invested in education and outreach rather than programs designed to achieve high-priority species conservation results. We synthesized research on urban bee species diversity and abundance to determine how urban conservation could be repositioned to better align with new views on the ecological importance of urban landscapes. Due to insect pollinators' relatively small functional requirements—habitat range, life cycle, and nesting behavior—relative to larger mammals, we argue that pollinators put high-priority and high-impact urban conservation within reach. In a rapidly urbanizing world, transforming how environmental managers view the city can improve citizen engagement and contribute to the development of more sustainable urbanization.*

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La Ciudad como Refugio para Insectos Polinizadores

Resumen: *Las investigaciones sobre los insectos polinizadores urbanos están cambiando las percepciones sobre el valor biológico y la importancia ecológica de las ciudades. La abundancia y la diversidad de las especies nativas de abejas en los paisajes urbanos, que además están ausentes en los terrenos rurales cercanos, evidencian el valor biológico y la importancia ecológica de las ciudades y tienen implicaciones para la conservación de la biodiversidad. A paso lento detrás de esta imagen revisada de las ciudades están los programas de conservación urbana que históricamente han invertido en la educación y el alcance en lugar de los programar diseñados para adquirir resultados de conservación para especies de prioridad alta. Sintetizamos las investigaciones sobre la diversidad de especies de abejas urbanas y la abundancia para determinar cómo la conservación urbana podría ser reposicionada para alinearse de mejor manera con las nuevas visiones sobre la importancia ecológica de los paisajes urbanos. Debido a los requerimientos funcionales relativamente pequeños de los insectos polinizadores – extensión del hábitat, ciclo de vida, comportamiento de anidamiento - en relación con los mamíferos más grandes, argumentamos que los polinizadores colocan a la conservación urbana de alta prioridad y alto impacto dentro de nuestro alcance. En un mundo rápidamente urbanizado, transformar la forma en que los administradores ambientales ven a las ciudades puede mejorar la participación ciudadana y contribuir al desarrollo de una urbanización más sustentable.*

Palabras Clave: ciencia de la sustentabilidad, comunicación, ecología urbana, financiamiento y filantropía, gobernanza, planeación de la conservación, políticas y leyes, servicios ambientales

Natural resource management (NRM) investments in urban conservation are largely aimed at connecting people to nature. Historically, urban conservation directives have sought to garner broad public support by funding outreach, recreation facilities, and education rather than high-priority conservation efforts (McCleery et al. 2014; USFWS 2015). Cities are primarily viewed in terms of their political value (where the voters are) rather than for their ecological value. The inherited historical view of the general public, that urban environments are biological deserts, seems reasonable because research has shown how sprawling urban development is responsible for high rates of species' extinctions (McKinney et al. 2003; Luck 2007; McKinney 2008) and how large-scale transformation of landscapes (Ehrlich & Holdren 1971; Pejchar et al. 2007) are associated with extensive and persistent losses of native species (Pickett et al. 1992; Hansen et al. 2005). However, urban ecology routinely necessitates reassessing established ideas in biophysical ecology (e.g., linear responses of biodiversity to habitat destruction [Collins et al. 2010; Ramalho & Hobbs 2012; Grove et al. 2015]), and advances in this field are transforming the ecological importance of cities.

Since 2006, research on wild bees in cities shows that diverse populations of bees live in urban landscapes. In the midst of a pollination crisis, where insect pollinator populations are experiencing significant declines (Jaffe et al. 2010; Pleasants & Oberhauser 2013; Goulson et al. 2015), studies of native bee richness and abundance indicate that diverse communities of wild bees persist in cities in many parts of the world such as Berlin, Germany (Saure et al. 1998); Birmingham, Bristol, Cardiff, Dundee, Edinburg, Glasgow, Hull, Leeds, Leicester, London, Northampton, Reading, Sheffield, Southampton, and Swindon in the United Kingdom (Goulson et al. 2008; Baldock et al. 2015; Sirohi et al. 2015); Melbourne, Australia (Threlfall et al. 2015); Guanacaste Province, Costa Rica (Frankie et al. 2013); Vancouver, Canada (Tommasi et al. 2004); and Berkeley (Frankie et al. 2005; 2016), Chicago (Tonietto et al. 2011; Lowenstein et al. 2014), New York City (Matteson et al. 2008; Matteson & Langellotto 2009), Phoenix (Cane et al. 2006), San Francisco (McFrederick & LeBuhn 2006), and St. Louis in the United States. Bees in these cities include both solitary and eusocial species, especially species that are cavity nesters and pollen generalists (Hernandez et al. 2009; Cariveau & Winfree 2015; Sirohi et al. 2015) and specialized species indicative of high-quality habitat (e.g., pollen specialists and their cleptoparasites) (Tonietto et al. 2011; Sheffield et al. 2013). In several cases, more diverse and abundant populations of native bees live in cities than in nearby rural landscapes (Cane et al. 2006; Matteson et al. 2008; Osborne et al. 2008; Frankie et al. 2009; Verboven et al. 2014; Baldock et al. 2015; Sirohi et al. 2015) (for counter examples, see Bates et al. [2011], Geslin et al. [2013], and Deguines et al. [2016]). For bumblebees in particular, urban areas can harbor greater species richness than rural or natural areas (McFrederick & LeBuhn 2006; Winfree et al. 2007; Gunnarsson & Federsel 2014; Baldock et al. 2015). Cities often contain greater bee species diversity than expected under a traditional view of urban areas.

Loss of habitat has been a long-term contributor to pollinator declines (Goulson et al. 2008; Potts et al. 2010; Vanbergen et al. 2013; Harrison & Winfree 2015);

technological advances in agricultural efficiencies are increasingly homogenizing farmlands (Benton et al. 2003). Increasing losses of natural areas to farming expansion and transition of traditional agricultural lands to those less hospitable to pollinators (e.g., monoculture commodity crops or indoor livestock operations) mean there is less floral forage over shorter periods (Ollerton et al. 2014; Scheper et al. 2014). Habitat loss and homogenization, innovations in systemic pesticides and herbicides (chemicals applied to seed, absorbed by plants, and circulated throughout), and greater efficiency of chemical application have negatively affected wild pollinator populations in rural areas (Whitehorn et al. 2012; Simon-Delso et al. 2014; Goulson et al. 2015; van der Sluijs et al. 2015). Although the protection and restoration of undeveloped lands are important for conservation of wild pollinators and serve an obvious role in pollinator health (species diversity and abundance), urban landscapes must not be overlooked as habitat for pollinators. Surrounded by increasingly less hospitable rural and suburban landscapes, the city, with its variety of forage and nesting sites, can become a refuge for insect pollinators.

Advances in pollinator conservation in rural landscapes are proliferating across governance scales (President's Task Force Strategy on Pollinator Health of 2015, Xerces Society, Pollinator Partnership, Intergovernmental Platform on Biodiversity & Ecosystem Services review, National Pollinator Strategy for England 2015; All-Ireland Pollinator Plan; Wales Pollinator Action Plan, and others), but only a few governments are targeting urban landscapes and funding such efforts (Natural Environment Research Council, Welsh Action Plan for Pollinators, Living with Environmental Change Partnership; Urban Pollinators Project). As urban ecology advances the science of ecology, the role of NRM agencies should similarly update their understanding of the role of cities in landscape-scale conservation (IPBES 2016). Engaging city planners and residents in enhancing habitat of insect pollinators is a legitimate conservation practice and has well-understood educational value. Implementing relevant programs requires collaborations and programing that change the view of cities as biological deserts to one of cities as valuable habitat for declining insect species.

This shift in perspective offers direct conservation benefits across a diversity of pollinator populations (cf. Kleijn et al. 2015) and provides ecosystem services for humans (e.g., pollination of vegetables and fruit and cultural services associated with an interest in natural history [e.g., Peterson et al. 2010]), plants (e.g., increased reproductive success), and animals (prey for species from higher trophic levels such as birds). Furthermore, improving the wild pollinator populations in urban areas may also improve species richness and abundance in nearby agricultural lands via a spillover effect (Goulson et al. 2010), although the relative importance of cites as sources or sinks for pollinators is largely unknown (Gill et al. 2016).

Intensifying conservation efforts for urban insect pollinators constitutes an opportunity for meaningful urban conservation—conservation that moves beyond traditional education and recreation programing toward programing with cascading benefits throughout rural and urban landscapes. Matching conservation planning to the ecological complexity of cities benefits NRM agencies because it provides more direct connections to their constituency in population centers (Sanderson & Huron 2011). Conservation *for* the city garners an audience for agencies' other conservation efforts and likely, favor at the ballot box.

Pollinators put high-priority and high-impact urban conservation within reach. The relatively small spatial and temporal scales of insect pollinators in terms of functional ecology (for example, habitat range, life cycle, and nesting behavior compared with larger mammals) offer opportunities for small actions to yield large benefits for pollinator health. The approach for improving the habitat value within urban areas is relatively simple and easily understood by urban residents. Several analyses and meta-analyses of urban insect pollinators show the consistent variable correlated with pollinator health is forage (i.e., the presence of flowers) (Bates et al. 2011; Hennig & Ghazoul 2012; Cariveau & Winfree 2015). These findings extend to forage species planted on urban vacant lands (Gardiner et al 2013), and these plantings have similar effects on specialist and generalist insect pollinators (Williams et al. 2010). Urban residential spaces play a role in pollinator abundance and diversity. Thus, individual decisions concerning yard management can affect conservation of threatened and endangered species (Goddard et al. 2010; Shwartz et al. 2013).

The city as refuge for insect pollinators opens many potential areas of research. Inventorying and monitoring is an essential practice to validate, improve, and communicate results of conservation efforts among partners and taxonomic experts. Understanding what works well in various locations engenders transferable practices that could aid decision makers across multiple scales of governance. More research is needed to evaluate the effectiveness of pollinator seed mixes (Garbuzov & Ratnieks 2014). However, bees and other insect pollinators benefit from both native and nonnative plants (e.g., Matteson & Langellotto 2011; Hanley et al. 2014; Pardee & Philpott 2014; da Silva Mouga et al. 2015), although for managerial purposes natives are preferred (Williams et al. 2011). Other underexplored topics include social dimensions of self-organizing neighbors who transform lawns (and their affiliated cultural models) to attract bees and butterflies for conservation (van Heezik et al. 2012) and the effectiveness of different citizen conservation activities (Asah & Blahna 2013). Legal, political, and institutional questions regarding public land use, planting decisions, institutional policies, organizational norms, and municipal ordinances that affect actors' capacities to increase pollinator habitat also require further investigation.

Cities offer several advantages for exploring conservation practices, such as a lack of agriculture pesticides (Larson et al. 2013; Muratet & Fontaine 2015) (although home- and horticultural use of pesticides may be widespread) and few large herbivores (e.g., deer), factors that allow some sensitive plants to be grown. Restoration work is fostered by relevant institutions, resources (e.g., museum collections), expert personnel (e.g., staff at botanical gardens), and volunteers who can install and maintain restoration plantings. Many of these urban resources are absent in rural areas. Cities also have concentrations of philanthropic donors, funding resources, and development specialists who can mobilize resources for conservation projects.

Coupling insect-pollinator habitat enhancement with species monitoring is one of the goals of the long-term wild bee monitoring being conducted in Chicago, Illinois, Detroit, Michigan, and St. Louis, Missouri (U.S.A.) (Tonietto et al. 2011; Burr et al. 2016). These projects are exploring social and cultural drivers of wild bee diversity and abundance in green spaces across these cities. An increase in bee diversity in St. Louis seems to be associated with human population density and income. For example, bee diversity is higher in low-income neighborhoods with low population densities than in more densely populated high-income neighborhoods (Tonietto et al. 2011; Lowenstein et al. 2014). Low-income, less-populated areas contain more vacant lots and abandoned and crumbling infrastructure. Residential pesticide use is lower in low-income neighborhoods than in higher income areas (Cook et al. 2012). More research is needed to determine the relationships between bee diversity and patterns of residential land use across shrinking and growing cities. Partnerships among city planners, conservation scientists, and policy makers targeting pollinator conservation can improve local food security and community development. Improving global pollinator species diversity and abundance across landscapes requires attending to populations of urban pollinators.

Research on urban insect pollinators is changing how the biological value and ecological importance of cities is viewed. Conservation must be repositioned within this unfolding image of the city. Rather than treating urban conservation as solely outreach and education aimed to improve political capital, NRM agencies can develop programing that improves natural capital thereby engaging urban citizens in improving the quality of life for threatened species in cities. It is estimated that by 2050, 67% of the world's population will live in cities (United Nations 2014); much of these city landscapes have yet to be built (Grove et al. 2015). Attending to the needs of insect pollinators in conjunction with a suite of other conservation measures (e.g., green-infrastructure and environmental quality-of-life provision and climate-change mitigation) can inform current and future generations how to urbanize sustainably. To do so, requires an ecological understanding of the city and a requisite conservation that fits the city: conservation *for* the city.

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