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Assessing residential front yards using Google Street View and geospatial video: A virtual survey approach for urban pollinator conservation

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ABSTRACT

Google Street View and geospatial video mapping have been successfully employed to inventory neighborhood environments in a variety of disciplines. However, virtual survey approaches have yet to be leveraged fully for fine-scale auditing of ecological characteristics in urban contexts. Here we propose a method combining Google Street View and geospatial video mapping to virtually inventory vegetation composition over time in residential front yards to assess habitat for native pollinator conservation. As a proof of concept, it bolsters the feasibility and effectiveness of virtual approaches to conduct fine-scale street-level audits of neighborhood environments. Additionally, the findings inform future science-based education and outreach interventions at two study sites.

1. Introduction

In the coming decades, rapid urbanization and growth is predicted in some of the most biodiverse areas of the world (Raven, Hassenzahl, Hager, Gift, & Berg, 2015). Urban expansion permanently alters wildlife habitat, biogeochemical cycles, and ecosystem functioning leading to the reduction and extirpation of native plants and animals (Alberti et al., 2017; Kowarik, 2011). It is estimated that 60% of future urban land requirements—including land allocated to residential yards—are not yet met, so understanding how established cities can conserve biodiversity is vital to the sustainable development of new cities (Threlfall et al., 2017).

In the United States, approximately 83% of the population lives in urban areas (Raven et al., 2015). From 1990 to 2000, U.S. urban development annexed over 1.4 million hectares (ha) of undeveloped land into cities (McDonnell & Hahs, 2013) and is expected to convert an additional New England-size area to residential landscapes over the next 15 years (Raven et al., 2015). A significant portion are allocated to residential lawns, encompassing 25–35% of the overall urban area and nearly 50% of its green space (Minor, Belaire, Davis, Franco, & Lin, 2016). With so much land allocated to residential yards, how these areas as managed ecosystems are configured and cultivated becomes important to a city's sustainability (Lowenstein & Minor 2016; Peterson et al., 2012). Yard vegetation design and composition impacts urban soil and water quality, stormwater runoff, heat island effects, noise pollution, carbon sequestration, biodiversity conservation, as well as human health and well-being (Ramalho & Hobbs, 2012).

1.1. The ecological value of residential yards for native pollinators

Turfgrass is the predominant feature in U.S. residential yards. It accounts for a total of 16.4 million ha and is expanding at an estimated annual rate of 23% of new urban lands (Peterson et al., 2012). It plays a key role in urban biogeochemical cycling. Its management and maintenance fuels widespread use of lawn irrigation, chemicals in the form of fertilizers, herbicides, and pesticides, and carbon dioxide emissions from mowing, all of which contribute to reduced water, soil, and air quality (Robbins, 2007). It also negatively impacts wildlife, as it displaces vegetation necessary to support and conserve biodiversity. Residential landscapes dominated by turfgrass lack habitat features to support wildlife (Minor et al., 2016). Native vegetation, complex vertical and horizontal understory attributes, and sufficient local tree cover are important determinants of successful foraging, nesting, and breeding for urban wildlife populations, including insect pollinators (Threlfall et al., 2017).

Humans strongly influence urban biodiversity (McDonnell & Hahs, 2013). Because residential yards constitute a significant portion of U.S. urban landscapes, private citizens as decision-makers profoundly modify the urban environment (Aronson et al., 2016). How they configure urban vegetation composition at the parcel level and collectively at the block, neighborhood, and city-wide levels matters (Minor et al., 2016; Peterson et al., 2012).

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This extends to the distinct ways residents manage front versus backyard spaces. Front yards are treated as contiguous public spaces with planting decisions shaped by various social influences and pressures, while backyards are private spaces where individual choices are implemented (Nassauer, Wang, & Dayrell, 2009).

Urban ecology research explores the services social-ecological systems (SES) provide and highlights the potential ecological value of urban contexts (Childers et al., 2015; Hall et al., 2017; Pickett et al., 2011). Native bee diversity and conservation in cities has received increased attention due to growing awareness of global pollinator declines. Native bees, along with other insect pollinators, are critical to global food production, generating approximately $215 billion in value annually (Goulson & Nicholls, 2016). Projections estimate that many pollinator species are either under threat, endangered, or declining (Goulson, Nicholls, Botias, & Rotheray, 2015). Scientists and practitioners are investigating the diversity and abundance of insect pollinators to benchmark populations, as their declines threaten global food supply and local ecosystem resilience (Camilo, Muniz, Arduser, & Spivak, 2018; Goulson & Nicholls, 2016).

Pollinator declines and losses are attributed to habitat fragmentation and loss, agriculture intensification, lack of foraging resources, pesticides, pests, and disease (Cariveau & Winfree, 2015; Goulson et al., 2015). Habitat fragmentation and loss due to human land-use change is implicated as the leading cause of species declines globally (Cariveau & Winfree, 2015). Areas of extreme land-use change and/or intense urbanization (high levels of concrete, buildings, impervious surfaces, with ≤5% of intact natural habitat) have been linked to significant decreases in bee species abundances and richness (Cariveau & Winfree, 2015; Plascencia & Philpott, 2017).

Although pollinators tend to be less abundant in anthropogenically-disturbed landscapes (Williams et al., 2010), cities can contain unexpectedly diverse and abundant native bee communities (Baldock et al., 2015; Hall et al., 2017; Matteson, Ascher, & Langellotto, 2008; McFrederick & LeBuhn, 2006; Threlfall et al., 2015; Tommasi, Miro, Higo, & Winston, 2004). This includes St. Louis, MO, where bee diversity is comparable to natural and restored Midwest prairie systems (Camilo et al., 2018). Species dispersal and foraging abilities are affected by the extent of urban landscape change, intensity, and diversity, impacting community and regional populations (Egerer et al., 2017). Due to the fine-scale heterogeneity of vegetation and nesting resources across urban landscapes, native bees are thriving in them (Normandin, Vereecken, Buddle, & Fournier, 2017). While recent studies examine the contributions urban parks, cemeteries, community gardens, and other public green spaces make to pollinator health (Leong & Roderick, 2015; Matteson & Langellotto, 2009; Matteson, Grace, & Minor, 2013; McFrederick & LeBuhn, 2006; Tonietto, Fant, Ascher, Ellis, & Larkin, 2011), there has been less focus on residential yards.

A variety of native bees with different body sizes and nesting strategies are influenced more by local factors than landscape-scale ones (Quistberg, Bichier, & Philpott, 2016). In neighborhood yards, habitat diversity, native plant species richness, low canopy vegetation, management intensity, and surrounding housing density are shown to influence native bee species richness and diversity (Smith, Warren, Thompson, & Gaston, 2006). Further, plant species diversity and abundance is found to be the most significant driver of bee health (Baldock et al., 2015; Sirohi, Jackson, Edwards, & Ollerton, 2015), even more so than the level of impervious surface (Hulsmann, von Wehrden, Klein, & Leonhardt, 2015). The once overlooked value of suburban and urban yards is now being examined to establish baseline populations for long-term monitoring and conservation practices (Camilo et al., 2018; Threlfall et al., 2015).

Citizens, as small-scale land managers with a diversity of plant preferences, can improve native pollinator diversity and abundance by increasing vegetation resources (forage, habitat) in residential yards (Threlfall et al., 2015). Individuals planting for bees can collectively affect urban populations (Lowenstein, Matteson, Xiao, Silva, & Minor, 2014; Minor et al., 2016). This suggests conservation efforts, such as science-based community education and outreach, aimed at increasing habitat and foraging resources in cities positively impacts bee species richness and abundance (Hall et al., 2017). Consequently, engaging citizen stakeholders plays an important role in combating native bee losses.

Below, urban residential front yards are assessed to develop understanding of land use, decision-making, and management practices to inform research for pollinator conservation. It offers a proof-of-concept case to numerically characterize front yard vegetation heterogeneity useful for pairing with urban bee species monitoring (e.g., Camilo et al., 2018). This approach is tested within two study sites over time using fine-scale virtual auditing methods. First, the virtual inventorying approaches are discussed as a means to characterize vegetation attributes and diversity in residential front yards. Then the methods used to examine front-yard vegetation are detailed, offering findings of field research and analysis of the sites. Finally, we discuss the transferability and scalability of the methods, as well as the implications of this approach for assessing fine-scale ecological characteristics in urban settings.

2. Materials and methods

2.1. Study site characterization

This research case study was conducted in St. Louis, Missouri, USA. Research sites were selected based on a spatially explicit understanding of bee species diversity and abundance from weekly aerial net sampling at urban farms, community gardens, vacant lots, and prairie pockets located across the city (Camilo et al., 2018). Two community gardens with consistently low bee diversity were selected to benchmark and characterize the neighborhood vegetation to investigate drivers of low species diversity and abundance. Located in south St. Louis, the sites are 5 km apart (Fig. 1). Residential properties within a 500-m radius of each sampling site were included. The 500-m radius was selected as it is the average native bee foraging range (Leong & Roderick, 2015), although smaller-bodied bees forage and live in the size of a typical city front yard. Understanding the availability of nesting and foraging resources as fine-scale drivers of pollinator health is key, not only for current species populations but to shape conservation efforts.

Esri's Community Analyst web application was used to characterize neighborhood demographics within 500-m of each sampling site. Community Analyst data reflects the range of similarities and differences between the two neighborhoods (Tables 1 and 2). S1 has a lower total population (−17.99%), number of households (−7.28%), rentals, and vacant housing, with higher median (28.17%) and average household incomes (7.34%), and higher homeownership than S2 (Table 1). Both neighborhoods are predominantly Caucasian, categorized as thirty something (> 86%) and middle-aged lifestyles (< 14%) (Esri, 2016). In terms of housing stock, the residential properties were built between 1920 and 1960 (St. Louis City, 2010). The typical lot is narrow in width but deep, with a detached garage abutting an alley behind the properties (Figs. 2, 3A and 3B).

2.2. Fine-scale virtual inventory methods

Street-level audits are traditionally done by physically inventorying study sites (Rundle, Bader, Richards, Neckerman, & Teitler, 2011). This approach holds logistical challenges. It is time and resource intensive (Curtis, Blackburn, Widmer, & Morris, 2013a), making it expensive (Rundle et al., 2011) and often curtails sampling frequency (Curtis, Blackburn, et al., 2013). It tends to be narrowly focused and limited in scope (Curtis, Blackburn, et al., 2013). Physical inventorying often entails research staff safety concerns (Montoya, 2003), as well as privacy and cultural sensitivity implications (Elwood & Leszczynski, 2011; Mills, Curtis, Kennedy, Kennedy, & Edwards, 2010).