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Urban Gardens as a Space to Engender Biophilia: Evidence and Ways Forward

Brenda B. Lin[1]*, *Monika H. Egerer*[2] *and Alessandro Ossola*[3]

[1] CSIRO Land and Water, Aspendale, VIC, Australia, [2] Environmental Studies Department, University of California, Santa Cruz, Santa Cruz, CA, United States, [3] Department of Biological Sciences, Centre for Smart Green Cities, Macquarie University, Sydney, NSW, Australia

Cities are losing green space, driving an extinction of nature experiences for urban communities. Incremental green space loss can trigger a ratcheting-down effect where individuals' expectations of nature continually decrease through time. This loss of everyday nature experiences may produce a citizenry with reduced knowledge and appreciation of biodiversity and the environment. In this review, we examine how urban gardens, as urban spaces that bring people into close contact with nature in an otherwise built environment, can combat this ratcheting-down effect by encouraging interactions and knowledge of nature. Although the primary purpose of urban gardening may be food production, they also represent areas of social and recreational value as well as environmental education and knowledge sharing. We review three ways urban gardens may engender greater: 1) the provision of natural elements to expose urban dwellers to the diversity of plants, animals, soils that they would otherwise not encounter in their daily life; 2) fostering a greater understanding of natural processes that affect food production (e.g. climate processes, pest control, pollination) and thus the natural world; and 3) the provision of a safe space in which humans can corporeally interact with nature elements to develop greater fascination with nature. Urban gardeners, by interacting with soil, plants, and animals in these spaces, come into direct contact with a range of environmental elements. The practice of growing food and plants means that gardeners learn about environmental processes, such as pollination or changes in precipitation, and how they affect plant growth. Thus, urban gardens can engender biophilia for their participants by increasing exposure, positive interactions, and knowledge of nature, potentially changing people's attitudes to nature. We present examples from a variety of urban gardens to show how these spaces can be designed using biophilic thinking to enhance people's everyday nature experiences and their drive to interact with the natural world.

Keywords: nature relatedness, nature exposure, urban green space, environmental attitudes, urban lifestyle

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***Correspondence:**
Brenda B. Lin
bbclin@gmail.com;
brenda.lin@csiro.au

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URBAN GREEN SPACE LOSS AND THE EXTINCTION OF NATURE EXPERIENCES

Urbanization is a major driver of global land cover change (Grimm et al., 2008; McDonald et al., 2008), and urban dwellers now exceed 50% of the global population. Urban areas are predicted to absorb the majority of the continued population growth over the next four decades (United Nations, 2010). However, cities are relatively nature-poor because the built environment

is optimized for human constructs rather than for nature (Ossola and Niemelä, 2018). Research has documented a widespread loss of green space in cities, especially under compact development plans. Urban densification processes, including consolidation and infill development, can threaten urban green space and thus human health and well-being (Jim, 2004; Haaland and Van Den Bosch, 2015).

Opportunities to interact with urban nature have decreased over time because of green space loss, potentially driving an extinction of nature experiences for many urban dwellers (Pyle, 1978; Turner et al., 2004). This is true for the general population and potentially more so for the younger generations as more children grow up in increasingly nature-poor cities (Turner et al., 2004; Zhang et al., 2014; Soga and Gaston, 2016). Additionally, greater engagement with technology has led to more indoor and sedentary lifestyles (Pergams and Zaradic, 2006; Ballouard et al., 2011), and busy and overscheduled lives allow for less leisure time in green spaces (Clements, 2004; Hofferth, 2009).

Urbanization has also greatly homogenized urban ecosystems in their flora, fauna, and ecosystem function (McKinney, 2006; Grimm et al., 2008; Groffman et al., 2014). The departure from more natural or wild systems may lead to a "shifting baseline syndrome" where people continually ratchet down their expectations of the quality and ecological function of natural areas because they are no longer exposed to high quality natural areas (Pauly, 1995; Papworth et al., 2009). Thus, individuals' expectations of nature decrease through time and may decrease the value and relevance of nature for many people (Pyle, 2002). Educational theory suggests that biophilia and nature orientation are encouraged by early everyday nature experiences, whereby children have physical contact with and exposure to the natural world (Stokes, 2006). Children with more outdoor nature routines are more cognitively aware of the human-nature interdependence (Giusti et al., 2014), and feeling emotionally connected to nature increases environmental concern (Mayer and Frantz, 2004; Dutcher et al., 2007). Yet the loss of everyday nature experiences can reduce knowledge and appreciation of biodiversity and the environment by the urban citizenry that may further facilitate a greater detachment from nature (England, 2009).

The extinction of everyday nature experience can have important consequences for the well-being of urban populations (Morris, 2003a). Exposure to and interaction with nature can provide a wide range of physical and mental health benefits, such as improved cognition, social interaction, recreation, and physical activity that may reduce chances of cardiovascular disease, diabetes, and obesity (Kaplan and Kaplan, 1989; Ulrich et al., 1991; Williams, 2001; Sacker and Cable, 2006; Shaw et al., 2006; Thomas et al., 2006; Keniger et al., 2013). Wilson (1984) "biophilia hypothesis" suggests that humans possess an innate tendency to seek connections with nature and other forms of life. Positive past and present nature experiences can create emotions including affinity, interest, and indignation that result in nature-protective behaviors (Nisbet et al., 2009). These tendencies are significant contributors to promoting emotional and psychological well-being (Morris, 2003b; Fuller and Irvine, 2010; Keniger et al., 2013). Because of the growing recognition that experiencing nature is important for many human and environmental health outcomes (Morris, 2003a), it is urgent to understand how to promote and enhance urban green spaces that encourage everyday interactions with nature.

Most research on nature-human interactions has used a broad definition of what is meant by the word "nature" (Shanahan et al., 2015). This includes aspects related to indoor environments (foliage plants), urban spaces (public green spaces, gardens and roadside vegetation), fringe ecosystems (peri-urban nature reserves), production landscapes (agricultural land), and wilderness (beach/ocean, river, mountains, forest/woodland, national parks) (Keniger et al., 2013). In this review, we present how a specific urban green space, urban gardens, has the potential to bring urban dwellers into closer contact with natural elements to attain the benefits of interacting with nature and to grow biophilia. We first present a brief introduction to urban gardens to then discuss three ways in which urban gardens can increase biophilia in urban communities: (1) the provision of natural elements to expose urban dwellers to the diversity of plants, animals, soils that they would otherwise not encounter in their daily life; (2) fostering a greater understanding of natural processes that affect food production (e.g., climate processes, pest control, pollination) and thus the natural world; and (3) the provision of a safe space in which humans can corporeally interact with nature elements to develop greater fascination with nature. We conclude by examining how the intentional design of urban gardens can incorporate the various elements presented to create gardens that effectively improve human well-being and human-nature connections. These spaces scattered across the built environment can develop affinity of and connection to urban nature and ecosystem processes to combat the ratcheting-down effect of experiential loss by providing everyday nature to people. Urban gardens can thereby increase biophilia potential across urban landscapes.

THE POTENTIAL ROLE OF URBAN GARDENS TO COMBAT THE EXTINCTION OF NATURE EXPERIENCES

Urban gardens can include the cultivation of vegetables, medicinal plants, spices, mushrooms, fruit trees, and other productive plants, as well as the keeping of livestock for eggs, milk, meat, wool, and other products (Lovell, 2010). The different types of urban gardens allow for a diverse set of vegetation structures to contribute to the edible landscape across the city in both public and private lands (McLain et al., 2012). Urban gardens are highly heterogeneous in size, form, and function (Lin et al., 2015), and can provide different types of nature experiences and human benefits (Egerer et al., 2018b). The variety of garden spaces include community or allotment gardens, home gardens, easement gardens, roof-top gardens, urban orchards, and more (Lin et al., 2015). Many urban garden systems may fit into more than one category. For example, both private gardens and community gardens may exist as rooftop gardens, and community orchards may exist within community gardens.

Communities around the world are attempting to utilize urban gardening projects as a mean of improving the health and sustainability of cities (Wakefield et al., 2007; Kingsley et al., 2009; Beniston and Lal, 2012; Colasanti et al., 2012). Urban gardens are popular green spaces that can increase fresh food access by enhancing food availability and quality (Alaimo et al., 2008; Ober Allen et al., 2008; Zezza and Tasciotti, 2010). These spaces have also been shown to support mental and physical health (Armstrong, 2000; Wakefield et al., 2007). For example, one study reported that survey respondents on the younger and older spectrum of allotment gardeners had higher levels of physical activity during the summer than non-gardening neighbors in corresponding age categories, leading to greater health and well-being benefits (Van Den Berg et al., 2010). They are also places to build community cohesion and social networks by allowing people a space to meet and exchange ideas, encourage cross-cultural connections, and promote environmental stewardship (Shinew et al., 2004; Glover et al., 2005; Kingsley and Townsend, 2006; Andersson et al., 2007; Ossola et al., 2018b).

The time that people spend in and around urban gardens can contribute to their time interacting with and learning about nature (also referred to as "dose"), although the effectiveness of this interaction may depend on the quality of the "naturalness" of the urban garden (Shanahan et al., 2015). Rosenzweig (2003) proposed that in order to conserve natural areas, we may need to bring nature to people rather than have people come to nature, especially in urbanized environments. Instead of restoring and maintaining natural spaces to be more representative of previously existing habitats, we may need to design places, such as urban gardens, that are already dedicated to human activities to become more natural or to achieve novel combinations of natural elements that assist in developing human biophilic associations. In this way, urban gardens can be retrofitted by using biophilic design thinking to provide gardeners a regular dose of nature to not only foster biodiversity conservation and environmental stewardship, but to also support human well-being (Miller, 2005). Thus, urban gardens represent ideal spaces in which multiple generations of urban dwellers can come together to interact with nature through food, the ultimate biophilic element.

HOW URBAN GARDENS CAN INCREASE BIOPHILIA FOR URBAN COMMUNITIES

Urban gardens can bring back, conserve, and promote biophilia in modern and future urban systems (Lin et al., 2015; Ossola et al., 2018a). The variety of urban garden types allow for considerable variation in the complexity and diversity of elements and processes that can enhance an individual's interaction with nature. Gardeners and visitors can reconnect and experience different types of nature elements, from forest-like urban orchards to small garden beds on easements, allowing for different types of entry points of interaction. Additionally, because urban gardening spaces are becoming common across cities worldwide and gaining community support, they present an excellent opportunity to attract people back to the outdoors and leave behind the technological distractions as well as hustle and bustle of daily life. We discuss below three ways that urban garden design can bring urban dwellers back into nature and enhance purposeful interactions to build nature connections (**Figure 1**):

1. **Providing natural elements to engender biophilia**—Gardens, as semi-natural systems in the built environment, can be designed and enhanced to represent highly diverse and complex spaces that mimic those in natural systems. Incorporating biophilic elements through garden design provides a means to expose urban dwellers to the diversity of plants, animals, soils that they would otherwise not encounter.
2. **Fostering an understanding of natural processes**—The practice of growing food and plants means that gardeners learn about environmental processes, such as pollination or changes in weather patterns, and how they affect plant growth. This provides participants with a medium to increase their knowledge and appreciation of natural processes, thus fostering biophilia.
3. **Increasing human-nature interactions**—Urban gardeners come into direct contact with a range of natural elements through interactions with soil, plants, and animals in gardens. This corporeal interaction of handling soil and touching plants can be important for gardeners to experience and gain benefits from natural spaces as well as develop continued curiosity and fascination for the natural world.

We review examples from a variety of urban gardens to show how the design of urban gardens can achieve multiple benefits that will enhance urban nature experiences, bringing urban dwellers back into nature to further their understanding and knowledge of the natural world.

Providing Natural Elements to Engender Biophilia

Gardens exist on an agrobiodiversity continuum. Some gardens have little plant diversity and structure (e.g., mowed lawns with little other vegetation), while other gardens have high levels of biodiversity and structure (e.g., home gardens, urban orchards). When designed with nature in mind, urban gardens can support a high level of plant and animal biodiversity that may lure people back into nature. Although gardens are highly managed spaces that provide a specific urban nature experience, adding more plant structural diversity and complexity (e.g., trees and shrubs with varying phenologies and functions) that mimic wild spaces may improve urban nature experiences and support biophilia. Intentional biophilic design can play an important role in enhancing the "sense of extent" or scope of nature for the users (Kaplan, 1995). For example, more vegetatively complex elements of the environment are more intriguing and challenging to understand than simple ones. As such, complex elements can transport people into a new world, lengthen time spent in the garden interacting with nature, and thereby promote lifelong connections to nature (Wells and Lekies, 2006). We present a number of nature elements that can enhance the biophilic capacity of gardens.

A Increasing the variety of natural elements

Increasing structural diversity

Photo credit: Joanbanjo, CC BY-SA 4.0

Providing floral diversity

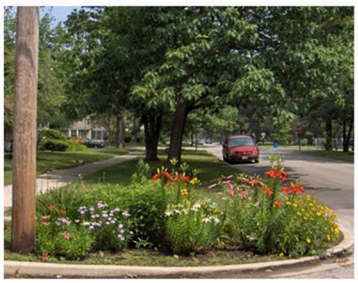

Photo credit: I'm nonpartisan, CC BY 3.0

Supporting associated invertebrate and vertebrate diversity

Photo credit: CSIRO Entomology, CC BY 3.0

B Fostering an understanding of natural processes

Understanding plant-soil-water processes and interactions

Photo credit: Ryan Dickey, CC BY 2.0

Sharing knowledge and understanding through intentional learning

Photo credit: Joe Mabel, CC BY-SA 4.0

Recognizing processes such as natural pest management

Photo credit: CSIRO Science Images, CC BY 3.0

C Increasing human-nature interactions

Encouraging human fascination and demystifying the natural world

Photo credit: Joschagah, CC BY-SA 3.0

Encouraging corporeal interactions with soil and plants

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Photo credit: Lynn Betts (NRCS Photo Gallery), Public domain

FIGURE 1 | Reimagining gardens with biophilic design thinking requires **(A)** Bringing in more natural elements to increase the variety of experiences, **(B)** Fostering human understanding of environmental processes to appreciate natural systems, **(C)** Considering design methods that encourage greater human-nature interactions. All images are reproduced in this figure based on a Creative Commons license or recognized as public domain. Photo credit and the type of Creative Commons license for each image is found below each image.

Biodiversity

Gardens can be designed to increase the biodiversity within them, exposing people to a wider range of plants and animals than they would otherwise encounter. A study of a home gardens in Santarem, Brazil found that home gardeners supported high levels of plant species richness −98 plant species—including a

range of fruit trees and shrubs, ornamentals, vegetables, herbs, and medicinal plants (Winklerprins, 2002). Similarly, allotment and community gardens can be designed to support biodiversity. In Stockholm, allotment gardens are often rich in plant diversity, with >440 plant species recorded in a single 400 m^2 allotment garden (Colding et al., 2006). Such systems often have high levels of floral diversity that mimic natural grasslands in a small allotted space. The element of rich floral diversity can positively correlate with invertebrate abundance. For example, species-rich community gardens in New York City were found to support a large number of bee species (54 bee species), including species that nest in cavities, hives, and wood (Matteson et al., 2008).

Structural Complexity

The ability to establish and maintain complex structural elements may be difficult in gardens depending on the management rules and regulations of the garden. In private spaces, such as residential yards or home gardens, the potential to provide structural complexity increases as individuals can intentionally design with biophilic thinking. Structural complexity can benefit both humans and animals. Greater vegetation structure can help create visual complexity that improves attention restoration for those immersed in the space as well as those viewing it from inside the home (Grinde and Patil, 2009). Maintenance of these complex spaces can also invite animal species to use a garden space by providing the "wild" three dimensional structure necessary for habitat, an additional nature element to provide a broader nature experience (Goddard et al., 2013). In many garden studies, invertebrate and vertebrate abundance and diversity positively relates to vegetation complexity, especially woody plant structure (Smith et al., 2006; González-García et al., 2009; Sperling and Lortie, 2010). The studies indicate the value of trees and shrubs for boosting ecological complexity. Practices, such as planting fruit/seed-bearing plants and constructing compost heaps can also add elements that promote bird and vertebrate abundance and diversity (Good, 2000).

Native Species

The planting of native species can be an important nature element to consider in urban gardens. Adding native vegetation within gardens boosts the abundance of bees (Pardee and Philpott, 2014), butterflies (Burghardt et al., 2009), and bird species (Daniels and Kirkpatrick, 2006). Native vegetation may be an especially important element because it can better support native fauna to exist in the built environment (French et al., 2005). Native plants and animals can also create specific links between people and place, thus increasing emotional attachment and sense of belonging (Brook, 2003).

Culturally Appropriate Food Crops

On the other hand, place attachment may yield a different type of biodiversity in gardens, as displaced/migrant people may plant crops that are known or familiar to them in order to attain a sense of home (Brook, 2003). Growing culturally appropriate food may be needed to match the food needs of ethno-culturally diverse communities (Gichunge and Kidwaro, 2014; Glowa et al., 2018), presenting a different type of nature element to ecologically diversify urban gardens. Surveys of urban gardens in Toronto, where Asian populations are deeply involved in urban gardening, showed that besides the typical local vegetables (cabbage, tomatoes, peppers, and eggplant) farmers grew an additional 16 vegetable crops to supply the local community with foods unavailable in local grocery stores. These crops included Asian vegetables, such as bok choy, long bean, hairy gourd, and edible chrysanthemums to substantially increase the types of crops seen in the urban garden (Baker, 2004).

Thus, a wide range of natural elements, from more vegetation structure, higher species diversity, the addition of woody trees and shrubs, native plants, and culturally appropriate crops are all additions that can amplify the biophilic draw to urban gardens. Such elements increase the variety of nature exposure to urban dwellers.

Fostering Human Understanding of Natural Processes

Urban gardens foster diverse types of learning by bringing individuals together to socially share skills and knowledge (Krasny and Tidball, 2009). Both the restorative and social aspects of urban gardening provide the mental space to learn about the natural world, thereby promoting biophilia. Through gardening and sustained interaction with natural elements of gardens, people can generate a cognitive understanding of the complexity and interrelatedness of different components of nature. Gardens provide a platform for humans to learn about interactions between organisms, the interplay between biotic and abiotic factors, and spatial-temporal processes (Andersson et al., 2007). We discuss four key natural processes centered in urban gardens that enhance an understanding of the natural world in individuals: soil forming processes, plant-soil-water feedbacks, climatic change, and species interactions (pollination and pest control). This experiential learning engenders in people knowledge about managing biotic and abiotic factors that affect crop production in the built environment.

Soil Formation Processes

Soils are the medium through which many human-nature interactions take place in gardens. Human-soil direct contact may promote perceived well-being improvements through connection to natural elements (Egerer et al., 2018b). But soils are also a way that people learn about nutrient cycling, decomposition, and the moisture retention capacity of their soils (Gregory et al., 2016; Egerer et al., 2018a). Urban garden soils often require significant remediation due to soil contamination and compaction (Pouyat et al., 2010; Ossola and Livesley, 2016; Lorenz, 2017). Thus, learning about how to support these soil processes is necessary for gardeners to boost crop production and may be a way for people to better connect with the earth below. Most gardeners recognize that practices, such as cover cropping and crop rotations improve soil quality and nutrient management. However, educational programs focused on how certain practices affect natural processes of soils can further enhance gardening success by improving people's appreciation of intricate soil processes (Gregory et al., 2016). Literacy of soil processes can strengthen connections to soils and importantly

translate to biophilic design of garden plots from the ground up, centering on composting, decomposition, and nutrient cycling.

Plant-Soil-Water Processes

Interactions among plants, soils, and water are one of the primary platforms for increasing knowledge of natural processes in garden systems. By actively making watering decisions for their plants (Egerer et al., 2018a) gardeners can observe how water flows through the system and how it affects crop growth. Further, gardeners are encouraged to pay particular attention to plant-soil-water processes because water is of concern in many urban agricultural systems in arid regions (Lin et al., 2018). Monitoring water usage, for example, is a mean through which gardeners become more aware of their water use and learn about water conservation strategies (Egerer et al., 2018a). Local water conservation as an individual and collective endeavor can also facilitate connections to larger resource conservation initiatives at the regional scale. These monitoring initiatives and learning processes should be incorporated as a biophilic design strategy.

Climate Patterns

Urban gardens are central for understanding human biophilic responses to local microclimate and rapid climate changes, including drought and extended periods of extreme heat. Garden plants are affected by local fluctuations in temperatures (Eriksen-Hamel and Danso, 2010) most likely because of high evapotranspiration and soil moisture loss (Craul, 1992; Pickett et al., 2011). In response, gardeners must monitor weather patterns to make informed decisions on how to best manage their crops. Gardeners must gain knowledge about climate and become more sensitive to the physical environment because it concerns timing of flowering, seasonality of crop plants, and general plant phenology. However, urban gardens are often surrounded by built environment and impervious surface that create an urban heat island in and around the urban gardens. Urban areas generally register 5–11°C warmer than surrounding areas due to urban heat effects (Kalnay and Cai, 2003), and gardens surrounded by more impervious land cover exhibit higher temperatures for longer periods than gardens surrounded by less urbanized areas with more natural vegetation (Lin et al., 2018; Egerer et al., 2019). Thus, managing the potential climate effects on plants may promote biophilia as gardeners need to learn how to adapt to climate change by altering their water use behavior, plant care, and soil management practices (Avolio et al., 2015; Lin et al., 2018; Egerer et al., 2019). Gardeners become more conscious of plant needs and help plants respond to plant stress by providing supplemental water and nutrients or protecting plants from solar radiation using shade cloth (Egerer et al., 2019). These examples show how human management may be a biophilic response to changing weather patterns and extreme conditions.

Pollination and Pest Control Processes

Pollination and pest control processes help humans to understand the role of the associated biodiversity of bees, birds, beetles, and spiders in maintaining agroecosystem functions. By observing bees in garden systems, people become aware of pollinator communities and how they respond to vegetation management and design (Burr et al., 2016). This accumulated knowledge may lead people to adapt their urban gardens to support the bee population. This could include intentionally incorporating native flowering plants, installing bee hotels, allowing weeds to grow, and constructing novel habitats like urban prairie pocket gardens to support pollinators at key life history stages (Andersson et al., 2007; Burr et al., 2016). Natural enemies could similarly be important for gardeners to understand food webs and ecological processes like predation, competition, and parasitism to control garden pests through natural pest control processes. Insect pest damage is one of the most common challenges for gardeners (Gregory et al., 2016). By understanding natural pest control by beetles, wasps, and birds, gardeners can adapt the garden to support the habitat requirements of these natural enemies, thus providing greater natural pest control to their plots (Philpott and Bichier, 2017). Master gardener programs are also a way to improve people's knowledge of pollination and pest control processes. Workshops and educational programs provide a unique opportunity for people to learn from "experts" in horticultural design and garden ecology (Dirks and Orvis, 2005; Strong and Harder, 2010). As humans better understand pollination and pest control through individual and collective experiences, they become local stewards of vulnerable urban biodiversity conservation (Andersson et al., 2007) and gain an important sense of connection to broader conservation initiatives (Burr et al., 2016)—fundamental to deepening biophilia.

Through the process of growing crops within urban gardens, people will have the opportunity to observe and appreciate key natural processes essential to environmental systems. A greater understanding how abiotic and biotic processes interact will provide people with a greater appreciation of the complex feedbacks amongst soils, plants, and animals. A greater understanding of climate and weather processes will provide greater insight into the balance between water provision and use. Such learning is essential to develop an urban population that appreciates and desires to conserve nature.

Increasing Human-Nature Interactions

Studies of human participation and behavior in nature suggest that physical connections with natural elements are often related with an emotional connection to nature that influence environmental decision making (Scott et al., 2014). Immersive and corporeal interactions with natural elements are the ultimate expression of biophilia, whereby the human drive to nature is expressed through all human senses—smelling, touching, hearing (Kellert, 2003). Biophilia manifests itself along a nuanced continuum, ranging from positive driving tendencies (e.g., attraction, curiosity, etc.), neutral behaviors (e.g., indifference), to negative repulsive feelings, sometimes also referred to as biophobic feelings (e.g., discomfort, fear, etc.) (Orr, 1994). For instance, people are often afraid or put off by some natural elements, such as spiders, snakes, germs, or dirt as they are thought to be dangerous, ugly,

or smelly. These negative tendencies are driven through cultural and empirical influences ("mediated biophilia") (Nabhan and St Antoine, 1993; Kellert, 1997) as well as based on human evolutionary theory and the learned behaviors of survival (e.g., savannah or forest hypothesis) (Heerwagen and Orians, 1995; Han, 2007; Falk and Balling, 2010). Despite having an innate foundation, many of these preferences are reinforced by social norms, attitudes, and beliefs of some modern societies (Ulrich, 1993). Because of these tendencies, urban gardens could benefit from biophilic design thinking by promoting more genuine and safe interactions between humans and natural elements. In particular, urban gardens can increase people-nature interactions by providing the following:

Fostering Physical Interactions With Natural Elements

Biophilic design thinking of urban gardens should find an optimal blend of positive biophilic elements (e.g., plants with attractive shapes and colors, water elements), while reducing biophobic elements (e.g., unpleasant smell, thorny plants, garden waste). Garden design facilitates physical and tactile interactions, for example, by encouraging people to touch and cultivate soils or to physically care for plants. Biophilic design thinking within gardens could help create biophilic analogs to natural ecosystems (e.g., ponds, running water features, rocky outcrops) that are rarely found in the modern built environment. Such features can increase natural elements within the system while eliciting curiosity, attraction, and interaction.

Enhancing the "Biophilic Urge" and "Fascination" for the Natural World

Urban gardens can provide spaces that trigger innate biophilia and human curiosity for the natural world. While triggering this curiosity may be easier in children due the instinctual drive to discovery and play, eliciting these emotions in adults requires a more targeted and designed approach focused on cultural backgrounds and established values (Ulrich, 1993; Delavari-Edalat and Abdi, 2010). Thus, gardens with multiple natural elements may be able to attract and trigger these feelings of curiosity for a greater number of people. Additionally, surveys of gardeners have found high levels of satisfaction and quality of life from their experiences in gardens, and these experiences encourage the continued participation in urban gardening (Armstrong, 2000; Egerer et al., 2018b). The incorporation of gardens into the urban landscape can therefore provide a biophilic refuge from the dense built environment where individuals can appreciate and enjoy ever-more scarce natural elements in cities (e.g., silence, sunlight, breeze).

Demystifying and Correcting Negative Conceptions About Nature and Its Elements

Urban gardens are unique places in the built environment where people socially come together to cultivate crops (Kingsley and Townsend, 2006). Knowledge is generated and transmitted through shared practice and knowledge exchange. This offers an opportunity to demystify and correct negative preconceptions and notions about unpleasant natural elements. Fear of animals and outdoor threats can drive people away from the outdoors. This is often linked to the "biological preparedness hypothesis," where man evolved to fear potential threats as a means of survival (Ulrich, 1993; Ohman and Mineka, 2001). However, urban gardens can bring people back into nature through safe interactions to reduce these fears by offering an opportunity to learn about them. Further, "cues to care" (e.g., a scarecrow, a manicured footpath) provide an orderly framework to a nature space that can lessen negative perceptions of natural elements and offer more secure and positive interactions for many individuals (Nassauer, 1995).

Ensuring Future Interaction Through Biophilic Stewardship and Memory

Urban gardens are not only important for modern cities and towns, but are likely to have an important role in cities into the future. Urban gardens can help to conserve a positive and genuine biophilic drive for future generations likely to live more distanced from the natural world (Ossola et al., 2018a). They offer places where socio-ecological memory can be retained within a community and to build resilience to future changes (Barthel et al., 2010). The socio-ecological framework that is created through long-term connections through urban gardens not only connects gardeners through knowledge, but maintains connections for economic trade, organizational partnerships, and legal institutions that maintain urban garden systems in cities (Barthel et al., 2010).

Thus, urban gardens can be valuable spaces to increase human-nature interactions by reducing the barriers of entry and creating a safe space for humans to immerse themselves in nature and develop a greater appreciation for the complexity of nature. Encouraging curiosity and fascination for the natural world is essential to develop nature relatedness and greater desire to further learn about the natural world.

CONCLUSIONS

With human populations becoming more urbanized and cities often under greater land constraints, it will be more challenging for urban systems to provide both environmental and human well-being needs for society. Urban gardens are multifunctional spaces in which employing biophilic design thinking can enhance the interaction between humans and nature. In this review, we highlight three ways in which urban gardens, green spaces that are embedded within communities, can be designed to increase biophilia. Designing urban gardens that encompass more nature elements, provide multiple opportunities to learn about environmental processes, and, increase the potential for corporeal interaction with nature will help urban dwellers develop a deeper and sustained connection with nature. Designing these spaces with the purposeful intention of bringing people closer to nature could

be an important step toward increasing biophilia in urban communities.

AUTHOR CONTRIBUTIONS

BBL led the writing with significant contributions from MHE and AO.

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