Exploring ‘beyond-food’ opportunities for biocultural conservation in urban forest gardens

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Abstract
Urban agroforestry efforts have focused primarily on food production, but these dynamic, multiple-strata systems can host a much broader set of functions. This exploratory synthesis describes opportunities and considerations for urban forest gardens’ (UFG) capacity to include diverse, biologically important, and culturally relevant nontimber forest species that have medicinal properties, provide decorative and landscaping products, supply raw material for crafts, and other valuable outputs. Literature relevant to social and ecological aspects of design for ‘beyond-food’ specialty forest crops in urban forest gardens reveals a need for collaborative, participatory, and culturally relevant UFG decision making that addresses access inequities, potential contamination from urban pollutants, and a continued need for education and awareness of UFG multifunctionality. These production spaces can serve as both a biological and cultural repository for species that may be otherwise overlooked in a narrowly oriented food garden, though case study examples indicating contextual elements of implementation are needed to understand specific cultural and health sovereignty benefits. Currently, traditional tropical homegardens serve as a model for biocultural diversity in small-scale urban green spaces. Incorporating conservation goals into urban agroforestry initiatives at varying scales holds potential for growing interest in and commitment to building capacity for this emergent land use.

1 | INTRODUCTION

Urban homegardens (Nair, 1993), forest gardens (Hart, 1996), and food forests (Bukowski, 2015) fall on a spectrum of multistrata production spaces associated with urban agroforestry. What is termed ‘urban forest gardens’ (UFGs) in this manuscript can be defined as human-managed urban green spaces that include harvestable species occupying multiple strata and mimic the structure of an early or mid-succession forest ecosystem such as those defined in Bukowski and Munsell (2018) and Jacke and Toensmeier (2005). This category of land use varies in scope and scale from domestic or community spaces to public urban forests managed for human harvest among other possible site objectives. A mature UFG may include both annual and perennial species including trees and shrubs, vines, herbaceous plants and tubers, fungi, and wild and sometimes domesticated animals (Hart, 1996; Jacke & Toensmeier, 2005; Nair, 1993). While gaining greater public attention in temperate climates in recent years (Clark & Nicholas, 2013; Rosso et al., 2017), these urban agroforestry systems have long proved to be multifunctional systems.

Abbreviations: CIS, critical interpretive synthesis; NTFP, nontimber forest product; UFG, urban forest garden

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yielding sociocultural, economic, and ecological outcomes (Lovell, 2010; Nair, 1993).

Despite the extent of UFG multifunctionality, food-oriented objectives dominate the current discourse as illustrated by the predominance of ‘food forest’ or ‘edible forest’ terminology that describes temperate urban forest gardens. The emphasis on food products in UFGs is not surprising given the history of urban agriculture movements. In population-dense areas, food gardening has historically been in response to food insecurity, war, and political and economic unrest. As early as the 1890s in the United States, community gardens emerged on vacant lots in Detroit, New York, and Philadelphia to supply food to nearby residents and were further used during the Great Depression era (Lovell, 2010). Following the collapse of the Soviet Union, urban agriculture grew 38% in Havana, Cuba, annually between 1997 and 2003 (Koont, 2009). Victory gardens, heavily promoted by the U.S. Government during WWII rationing, also exemplify this trend. Today, many temperate urban agriculture and food forest initiatives seek to combat food apartheid, increase nutrition access, promote local food production, and improve human health (Lovell, 2010; Penniman, 2018).

Food is a valuable community contribution but not the only benefit of UFGs. Potential benefits beyond food, including environmental and social effects as well as medicinal plant uses and decorative harvests, can be observed in the structure and function of traditional tropical homegardens (Kumar & Nair, 2004). Additional benefits are also present in some UFG initiatives in temperate climates but are much less common and generally unincorporated into functional planning and structural species selection (Bukowski & Munsell, 2018). Forest gardens and homegardens are structurally synonymous yet are specific to their climate and cultural contexts. These managed, multistrata gardens are among the oldest known agroforestry production systems developed and maintained through generations of innovation and experimentation (Kumar & Nair, 2004). As a model of multifunctionality, homegardens commonly include medicinal plants, ornamentals, fuel and fodder crops, and food and nonfood forest products (Kumar & Nair, 2004). Nontimber forest products (NTFPs), including plants and plant parts (e.g., roots, leaves, berries, seeds, cones, flowers, sap), fungi, mosses and lichen, and nontimber wood products (e.g., firewood, garden stakes, bark, and other craft wood) (after Chamberlain et al., 2018) account for many of these niche biological and social functions.

While NTFPs exist within urban ecosystems in parks, along roadsides, and on domestic property, many products and the species that provide them have been overlooked in the context of urban food forests as forest gardens. As a reflection of the emphasis on food production, UFGs have been researched most extensively for their contribution to human nutrition, with ancillary ecosystem and cultural services (as in

Core Ideas
- Ecological constraints may restrict urban cultivation of NTFPs for human consumption.
- Biocultural conservation is relevant at varying scales of human-mediated environments.
- Equity, access, and community involvement are critical for urban agroforestry planning.

Bukowski & Munsell, 2018; Clark & Nicholas, 2013; Lovell & Taylor, 2013; McLain et al., 2012). Thus, the incorporation and management of culturally and biologically important forest crops that provide medicinal and craft materials is generally an overlooked opportunity in UFG spaces. Where mature trees provide adequate light reduction, and where soil quality is not limiting, intentional integration of beyond-food forest species could increase species diversity and conservation, wildlife habitat, and human health sovereignty.

Expanding the structural and functional focus of UFGs to include medicinal, decorative, and handicraft NTFP species can contribute to biocultural conservation, which involves intentional design and management “in the service of sustaining the biophysical and sociocultural components of dynamic, interacting, and interdependent social-ecological systems” (Gavin et al., 2015). This approach is contrary to management tactics that exclude human-dominated environments, instead recognizing people as an essential component to effective conservation activities (Buizer et al., 2016; Gavin et al., 2015; Wilshusen et al., 2002). Biocultural conservation efforts are grounded in local knowledge and practice, recognizing human needs, economies, and cultural values, especially those that are otherwise marginalized and at risk, while simultaneously protecting those habitats and species that contribute to social and ecological vitality. Urbanization can result in biocultural homogeneity where displaced or migrated peoples have lost contact with regional biological and cultural diversity (Rozzi, 2013). As the world’s population continues to shift toward greater urbanization (United Nations, 2014), cultural and biological conservation objectives are simultaneously required for urban planning (FAO, 2015).

The integration of NTFP species, such as contextually relevant at-risk forest botanicals, shade-obligate edible plants and fungi, and other specialty forest crops, in UFGs could increase functionality by providing opportunities for human education and awareness, diversifying ecosystem services, and sustaining culturally meaningful species with integrative design. In diverse, heterogeneous urban environments, cultivation of culturally relevant and health-promoting plants and fungi may also empower urban gardeners with important skills and resources that resist homogeneity (Rozzi, 2013). However, urban contexts include myriad circumstances that
warrant an analysis of the ways in which beyond-food species may be more or less effective in UFGs. For instance, how does the urban built environment affect the quality and usefulness of NTFPs? What aspects of access, equity, and awareness might be considered for effective biocultural conservation efforts of diverse nontimber species? And what can be learned from tropical homegardens that are relevant in a temperate context? By specifically addressing these questions, this exploratory review describes how opportunities and challenges associated with the inclusion of NTFPs for medicinal, decorative, and craft uses are currently embedded in the body of literature on human-managed, multistrata urban ecosystems. Biocultural conservation is, by necessity, context and culture specific (Armitage et al., 2009; Gavin et al., 2015). As such, this inquiry is intended to provide meaningful, but not prescriptive, insights about UFG diversification.

2 METHODS

Critical interpretive synthesis (CIS) served as the methodological framework for this review. Applied most commonly in the health sciences field, CIS involves developing concepts and interpreting themes in narrative form (Noblit & Hare, 1988). Unlike an integrative synthesis, which summarizes and describes pooled data, CIS focuses on the intersection of findings from literature that address different angles of an overarching construct. In this case, biocultural conservation in UFGs is the construct used to develop thematic pillars of inquiry. Evidence and intersections of biocultural conservation in UFGs were identified and synthesized along three lines:

1. Effect of urban built environments on NTFP quality and usefulness in UFGs;
2. Aspects of access, equity, and awareness in UFG biocultural conservation efforts; and
3. Lessons from tropical homegardens in a temperate UFG context.

The sequence of CIS involves first identifying the intellectual interest that a literature synthesis might inform and determining what is relevant to this interest. These formative steps are followed by selecting and reading relevant literature, interpreting intersections between them, and synthesizing the interpretation and expressing the synthesis in narrative or tabular matrix form (Noblit & Hare, 1988; Flemming, 2010). Critical interpretive synthesis methodology, which incorporates a qualitative tradition of inquiry, is appropriate for addressing complex questions associated with context-dependent decision making, as in health care (Dixon-Woods et al., 2005, 2006; Flemming, 2010) and in urban land-use planning (Alberti et al., 2003; Sampson, 2017; Pretty et al., 2009). The CIS approach used in this synthesis involved a reflexive review strategy undertaken by a single researcher with subsequent collaborative concept review.

As the focus of intellectual interest, UFGs were defined as any ‘urban green spaces that are human-managed and that include harvestable species occupying multiple strata, mimicking the structure of an early or mid-succession forest ecosystem’ and inclusive of those spaces identified uniquely for multiple types of harvests including food, medicine, craft, aesthetic, or decorative harvests, in addition to nonmaterial social-behavioral ‘yields’ such as education, community gathering, and recreation. Based on this breadth of land-use objectives, search terms relevant to this set of inquiries for the potential role of NTFPs in UFGs are numerous. A preliminary literature search using keywords associated with multistrata urban production spaces included ‘urban’ + ‘forest garden,’ ‘homegarden,’ ‘edible forest,’ and ‘food forest’ within the University of Missouri Ellis Library’s academic database, Web of Science, and Google Scholar revealed an initial set of literature largely exclusive of urban cultivation and harvest of NTFPs, though revealing in terms of related themes in current UFG objectives.

Within the first 500 results from each database, inclusion criteria encompassed any literature whose content in titles, abstracts, and keywords addressed the research questions, were written in English, and available as full texts using the University of Missouri’s institutional access. In response to the paucity of texts relevant to NTFPs, a secondary search of keyword terms ‘urban’ + ‘nontimber forest products,’ ‘medicinal,’ and ‘craft’ within the same databases was completed to identify publications highly relevant to the current context of NTFPs in urban green spaces using the same inclusion criteria. From each of these searches, publications relevant to questions regarding the biological and sociocultural elements of the urban environment that influence, are influenced by, and might be considered for NTFPs in UFGs were reviewed and thematically aggregated for this interpretive synthesis.

To address content-specific gaps in themed concept development from this set of publications, emergent themes based on opportunities and challenges expected in association with cultivation of or management for medicinal and craft NTFPs in multiple-strata urban ecosystems prompted citation chains narrowed to specific topics such as urban soil contamination, urban foraging, and urban plant conservation. To visually depict CIS findings, concepts that emerged from the intersections of the pool of reviewed publications are presented categorically according to thematic data intersections. Additionally, a graphical illustration of search term frequency for UFG yield types referenced in this literature demonstrates the extent and nature of related information. Scope and scale of CIS findings are indicated by the magnitude of frequency across a range of intersecting CIS topics in bar graph form.
3 | RESULTS

3.1 | Characterizations of UFG scope and yield

The potential for integration of medicinal and craft or decorative forest products addressed in this synthesis includes a breadth of land use types from domestic gardens and community food forests to public and private urban forests. However, they do not equally recognize yields of medicinal, decorative, and craft NTFPs. Within-text search term counts for a limited set of relevant UFG yield types (‘food,’ ‘medicine’ and ‘medicinal,’ ‘craft,’ and ‘decorative’) averaged by article focus (e.g. food forests vs. urban foraging) reveals overwhelming emphasis on food in every category (Figure 1). Publications focused on homegardens and urban foraging or gathering are most inclusive of medicinal, craft, and decorative products. Even where medicinal herbs are included in UFG plant lists, for instance, in food forest articles, their edible or nutritive qualities were described rather than explicit mention of their medicinal uses (e.g. Bjorklund et al., 2019). Still others, such as Kumar (2011), typical of homegarden references, cite diverse uses beyond the limited set of NTFP yields included in this search such as fodder, fuel and charcoal, fibers, glues and resins, dyes, spices, poisons and repellants, waxes, and others.

While food products are by far most commonly associated with UFG yield (as food forests, edible forest gardens, and edible urban forestry), they often are designed to achieve additional community benefits including education, civic change, food literacy, human health, ecosystem rehabilitation, biodiversity and conservation, and environmental awareness (as in Castro et al., 2018; Kowalski & Conway, 2018; Riolo, 2019; and others). Food production can be a compelling gateway for marketing UFGs and as a springboard for incremental shifts in urban landscape planning, though design for the breadth of multifunctionality that is possible in these spaces can increase support, access, and permanence of UFGs (Park et al., 2018). This multifunctionality is highlighted in Kowalski and Conway’s (2019) analysis of food forest considerations in Canadian urban forest management plans, where the inclusion of food trees for human consumption (in 14 of the 47 municipalities’ plans) were primarily aligned with the opportunity for these food species to simultaneously address biodiversity objectives. Likewise, in their analysis of 30 urban forest plans, Clark and Nicholas (2013) found that wildlife habitat objectives far outweighed food security despite the fact that these goals might well coincide.

Where food production may not otherwise be a goal based on perceived or practical management constraints, as in larger-scale, public green spaces, foraging or gathering of NTFPs and other underutilized or culturally relevant species for food, medicine, decorations, and crafts is a more commonly cited practice (Hurley & Emergy, 2018; McLain et al., 2012; Poe et al., 2013; Robbins et al., 2008). In aesthetically valued urban green spaces deemed off-limits for productive management (also described as the “museumification” of nature by Gobster, 2007), grassroots and ‘guerilla’ initiatives employ productive gleaning and propagation practices (McLain et al., 2014). Locations where the gathering of urban NTFPs take place include vacant lots, open parks and roadides, institutional properties, and other public or private urban forests (McLain et al., 2012). These spaces may be more likely to contain sufficient canopy cover for shade-obligate species, although as intensively managed homegardens and food forests mature, the inclusion of specialty forest crops for harvest and propagation need not be limited to incidental urban habitats.

With few but growing numbers of exceptions (e.g. George Washington Carver Edible Park in Asheville, NC) (Bukowski, 2015), urban parks and other public forested spaces are not typically designed for cultivation of harvestable products. Tree fruit litter, edible or otherwise, is considered a problem and a liability where pedestrians may slip and fall or vehicles may be subject to messy or even damaging impact (Barker, 1986; Stefferud, 1949). As a result, male trees have been selected over female trees among urban plantings, although the seasonal abundance of pollen from male trees is a growing concern for air quality as a human allergen (Ogren, 2015). However, food, medicine, and decorative materials derived from trees, shrubs, herbaceous plants, fungi, mosses, and lichens that share canopied urban green spaces are valued by those who gather, with or without permit, permission, or municipal acknowledgement, of such practices (Short Gianotti & Hurley, 2016; McLain et al., 2012; Poe et al., 2013). In some cases, harvest from public urban forests plays an important role in cultural subsistence and tradition (Poe et al., 2013; Wehi & Wehi, 2010). In these cases, intentional management of NTFPs, in collaboration with harvesters, has the potential to advance biocultural conservation in those places where
foraging or gathering is otherwise taking place (Vaughan et al., 2013).

3.2 | UFG ecological site considerations

Urban landscapes are typically highly simplified, intensively developed ecosystems with low levels of native biodiversity (Lin & Fuller, 2013). The complexity of a diversified, multiple-strata production space that can accommodate shade-obligate forest species may be well suited to optimize ecosystem services otherwise observed in existing urban forests and forest gardens. Documented ecosystem services from multiple-strata urban green spaces include pollution mitigation (Escobedo et al., 2011), carbon sequestration (Lehmann et al., 2019; Kumar, 2011), biodiversity for wildlife habitat, microclimate control, and runoff reduction (Dobbs et al., 2011; Lovell & Taylor, 2013; Sperling & Lorrie, 2010; Russo et al., 2017). The extent and quality of urban agriculture’s ecosystem services are dependent, in part, on the diversity and vegetative structure of the system (Drescher et al., 2006). Woody perennial vegetation, in particular, has a greater potential to reduce surface and air temperatures, increase carbon sequestration and storage, provide storm attenuation, and ultimately reduce energy costs from indoor temperature control (Drescher et al., 2006). The management of UFGs for NTFP trees, shrubs, and understory plants and fungi both encourages the persistence of large woody vegetation and supports often overlooked ecosystem services generated beneath the canopy toward greater biodiversity and its associated benefits (Doody et al., 2010; Lehmann et al., 2019).

Urban green spaces support biodiversity not only within the boundaries of vegetation but also as ‘spill-over’ energy, resources, and organisms across habitats that may be an important process for the persistence of wildlife populations in human-dominated landscapes (Lin et al., 2015). Intensified management practices, such as pesticide application, extensive pruning, frequent mowing, and other anthropogenic disturbances, limits the capacity of gardens to maintain rare or sensitive species, especially where the full lifecycle of target wildlife is not considered (Matteson & Langellotto, 2011); therefore, UFG practices that seek to promote biodiversity should explicitly plan for management toward this goal. Tree-dwelling arthropods, ground-dwelling arthropods, web spiders, bees, and ground-dwelling beetles species richness and abundance has been shown to be predicted by plant diversity at small spatial scales, although species richness decreases with increasing impervious surface and intensive management in urban green areas (Sattler et al., 2010). Varied vascular structures and multiple-strata systems exemplified by complex forest gardens in multiple urban contexts, as in parks, forests, and home or community gardens, might therefore provide connectivity and extent of scale necessary to support plant, insect, and vertebrate biodiversity.

Management for specialty forest crops associated with increased ecosystem complexity may contribute to UFG ecosystem services; however, urban environments are also host to unique ecological constraints. Water access, safety and rights, soil compaction and contamination, air-borne pollutants and an ‘urban heat-island effect’ contribute to difficult-to-measure and often expensive-to-address barriers to cultivation for human consumption (Lin et al., 2015; Wortman & Lovell, 2013). Wortman and Lovell (2013) assessed some of these factors in terms of urban contaminants and cost-effective solutions including lead (Pb) levels, where “soil concentrations of Pb in a natural soil are typically near 20 mg kg⁻¹, whereas a heavily contaminated urban soil may contain concentrations near 2,000 mg kg⁻¹ (Wortman & Lovell, 2013). Lead levels in soil did not correlate to the same levels in the fruits and vegetables themselves; in fact, the most likely source of human health risks from contamination by both Pb and polycyclic aromatic hydrocarbons would be from direct ingestion of soil in airborne particles or on unwashed fruits, leaves, or roots (Wortman & Lovell, 2013). Forest products, including medicinal roots and leaves, as a result, may be more prone to contamination if not sufficiently cleaned. In Aba city, Nigeria, Princewill-Ogba and Ogbonna’s (2011) analysis of heavy metal concentrations in urban soil and medicinal plant samples also indicates that accumulation of Zn and Pb from vehicle emissions could be a serious impediment to the quality and safety of specialty forest products intended for human consumption. Based on vegetable crop research, best practices for reducing trace metal contamination to safe levels for consumption in urban soils include the use of woody vegetation buffers and cultivation at greater distance (>10 m) from high-traffic roads (Antisari et al., 2015; Saumel et al., 2012).

While UFGs are particularly well suited to improve urban storm water management by increasing infiltration and reducing hazardous runoff as a result of their structural complexity and deep root systems (Evanylo et al., 2008; Schultz et al., 2009), some urban sites may be particularly prone to runoff from roads, parking lots, and industrial sites where heavy metals from vehicle pollutants may be deposited (Aryal et al., 2010). Additionally, the use of composts, fertilizers, and, in nonorganic urban agriculture, the use of pesticides, also presents a risk of concentrated contamination of water and soil, where higher volumes and velocities of stormwater runoff in urban areas—a result of high-density impervious surface area—contribute to increased flood frequency, duration, and magnitude. While urban areas cover only 3% of the United States, it is estimated that their runoff is the primary source of pollution in 13% of rivers, 18% of lakes, and 32% of estuaries (Capiello, 2008). Among the urban Aboriginal Maori (New Zealand) harvesters who participated in Wehi & Wehi’s (2010) analysis of culturally relevant urban gathering,
questions about the quality and safety of foraged medicinal plants revealed concerns about contamination from runoff, herbicides, and other substances in public parks and other urban sites (Wehi & Wehi, 2010); however, craft and decorative use NTFPs (not intended for consumption) may reduce risk where contamination is a concern. For Indigenous peoples whose ancestral lands have become heavily populated, or who have relocated to urban areas, the contamination of lands where food and medicine are harvested is reflective of a litany of environmental justice concerns and inequities associated with access to and harvest from urban forests and forest gardens.

3.3 Access and equity considerations

Various categories of urban forest and garden land use have been considered for their usefulness toward plant conservation, habitat connectivity, human harvest, and economic contributions. Both domestic gardens and public forests are identified as underrated and understudied spaces where specialty forest products for food, medicine, and other cultural uses are cultivated and harvested (Gulinck et al., 2020; Poe et al., 2013; Wehi & Wehi, 2010). Each of these land-use types is also subject to inequities. Planted urban trees are unevenly distributed commodities, in constant flux of “unequal patterns of maintenance and neglect” (Heynen, 2003) where upper-middle-class dominant areas benefit most from an urban canopy (Donovan, 2017; Greene et al., 2018). Heynen (2003) makes the case that there is enough available urban land, primarily in lower-income areas where vacant lots and brownfields are more common, that substantial reforestation is possible. Where communities desire and can accommodate an urban forest garden approach to reforestation, benefits beyond the ecosystem services of urban trees might also be realized. The presence of urban trees is associated with improved public health and reduced crime rates in addition to productive trees’ capacity to ameliorate food insecurity (Clark & Nicholas, 2013; Kuo & Sullivan, 2001; Nowak et al., 2006). With sufficient existing canopy cover, understory plantings present further potential for cultural and biological benefits.

Inequities of urban canopy concentrations are compounded by limited access to specialty forest crops via regulatory codes that either prohibit or require a permit to harvest on public land. While these codes may be intended for protection of species and habitats, urban foraging practitioners have been found to be generally knowledgeable and environmentally aware (Short Gianotti & Hurley, 2016; Shackleton et al., 2017; Wehi & Wehi, 2010) and can in fact reduce impact on more sensitive habitats (Wehi & Wehi, 2010) where the power dynamics of urban harvest regulation decisions can otherwise restrict rights to cultural expression (Poe et al., 2013). Indigenous communities have suffered a unique set of circumstances in the wake of increased urbanization and harvest policies. For example, Wehi and Wehi (2010) examined contemporary traditional Maori plant harvesting in urban contexts where ecosystem fragmentation and restrictive regulations have affected access to and abundance of culturally relevant species. Community-based forestry models offer an alternative whereby local ecological knowledge holders, including under-represented groups and immigrant and native harvesters, can become empowered as collaborators in conventional management conversations (Ballard et al., 2008).

In their study of gathering practices in Massachusetts, Short Gianotti and Hurley (2016) identified that gathering activities take place both on public and private property including on one’s own urban (or suburban) lot. Given that 60–90% of urban forests are privately owned, the objectives of sustainable urban forest management depend, in large part, on civic investment in a common vision (Clark et al., 1997; Clark & Nicholas, 2013). In an urban environment, private forest ownership includes universities, business parks, corporate campuses, and commercial real estate for which “maintaining the largest wildlife habitat possible could conflict with other services, such as limiting economic development from property development” (Clark et al., 1997). Urban land holders’ perspectives on the value of forest garden goods and services, especially as a tradeoff for development, is yet undocumented. From a civic engagement standpoint, the move toward urban sustainability is sewn with the same race and class inequalities that affect private property ownership (Sampson, 2017).

The Seattle, WA, urban forest plan is based on a forest valuation model that helps to regulate urban growth in relation to the removal of green space, although, even in an urban context with significant support for forest garden areas, it fails to incorporate the sociocultural, psychological, and economic values associated with the gathering and use of urban forest products for food, medicine, or other cultural uses because of the lack of scientific data on these dimensions of urban forest activities (McLain et al., 2012). The ambiguity of economic impact from urban foraging and homegarden harvest is restrictive for research and documentation purposes, but ultimately, these harvests are considered non-capitalist, whereby urban foragers’ and gardeners’ livelihood value of urban NTFPs is derived primarily from nonmarket strategies (McLain et al., 2014). Confirming this observation, in Robbins et al.’s (2008) analysis of urban gathering in New England, the great majority of respondents harvested NTFPs for their own use (88%), and very few (<3%) sold the products they gathered. For the urban foragers interviewed in McLain et al.’s (2014) qualitative research on the subject, the value of foraged products took the form of health benefits, satisfaction of eating something they had picked themselves, and joy in the flavors of wild foods. Urban gardening also includes production that never reaches a market but which may also supplement a household’s nutrition, thereby reducing food costs,
and may go unnoticed in the calculated economic benefit of urban production (Taylor & Lovell, 2014). As a result of this elusive productivity, Taylor and Lovell (2014) note that urban “community agriculture” receives considerably more public support, as a more accessible and quantifiable activity, where produce is often shared between garden operators and food distribution agencies. Where community-run forest gardens have the capacity to include specialty forest crops, further documentation of these yields and benefits may be realized.

### 3.4 How traditional homegarden practices can inform UFG expansion

Homegardens in Africa, Central America, and the Pacific Islands are assumed to be some of the oldest intentional cultivation spaces (Kumar & Nair, 2004). Because of their longevity, many of these homegardens (which align with our definition of UFGs though they are associated exclusively with households [Drescher et al., 2006]) have reached a state of maturity, as evidenced by their long-standing complexity and canopy coverage. In the humid, tropical lowlands of Javanese homegardens, a 75% or greater canopy cover is typical, where shade-obligate and shade-tolerant forest crops, including food, medicine, and craft products, fill an important niche in the lowest stratum (Jensen, 1993). Research on homegardens in African and Asian countries further identifies that medicinal plants constitute at least one-quarter of the total homegarden species and serve an important role as biocultural repositories (Kumar et al., 1994; Mpoyi et al., 1994). The maturity of tropical homegardens may lend to more suitability for NTFPs at this time compared with contemporary UFG installations; however, they can serve as a source of inspiration and understanding for a future vision of temperate forest gardens with similar objectives.

Where food production is a primary objective in UFGs, light requirements for understory perennial vegetables may in fact be incompatible with shade obligate forest crops. A recent analysis of the biodiversity of perennial vegetable crops worldwide sheds light on the shade suitability of the species that might otherwise be common to the herbaceous component of a forest garden, where only 9% of the perennial vegetables studied (n = 613) are suited to full shade and 46% to partial shade (Toensmeier et al., 2020). In forest gardens with an explicit food production objective, design for partial shade or greater sunlight exposure for food production may inhibit the capacity of these spaces to host shade-obligate forest plants and fungi. However, in a forest garden with sufficient canopy, niche habitats may still allow for the biodiversity reflective of a full suite of species with various functions, which ultimately can lend to greater species richness (Galluzzi et al., 2010).

Species diversity, composition, and use of traditional homegardens is a function of place and culture, where plants may be selected for cultivation based on food, fodder, fuel, medicine, religion, or aesthetic needs and preferences in addition to site suitability (Eichemberg et al., 2009; Kumar & Nair, 2004). Smaller-scale urban homegardens have been shown to have the greatest species richness and greater incidence of ornamental and aesthetic species than more extensive rural sites (Drescher, 2006; Kumar et al., 1994), indicating potential for human and wildlife objectives beyond food production in an environment that may otherwise lack connectivity. The traditional practice of cultivating diverse native food, medicine, craft, and decorative species also serve to resist the pressures of large-scale agriculture and urban development, which have had a detrimental impact on the persistence and diversity of local vegetation (Eichemberg et al., 2009). Scaled forest gardens may be restricted in species richness because of the complexity and efficacy of management, although, potential exists for innovative design allowing for multiple-strata systems that support higher density plantings suitable for shade-obligate species.

As long-term cultivation spaces, homegardens have attained a great degree of sustainability. Elements of their design, including the abundance of N₂-fixing trees and high root-length densities, in addition to incomplete harvest practices and return of tree biomass, contribute to their nutrient cycling capacity (Kumar & Nair, 2004; Nair et al., 1999). Their high agrobiodiversity also yields high potential for carbon sequestration (Kumar, 2011). By mimicking the structure and functions of local forests, temperate forest gardens might also attain ecological sustainability and longevity.

The diversity of products harvested from these long-term perennialized gardens also contributes to social and economic development, where women, in particular, participate in and benefit from the homegarden culture as stewards of knowledge, seeds, and harvests (Galluzzi et al., 2010; Kumar & Nair, 2004). However, in recent decades, the persistence of agrobiodiversity in homegardens (and associated traditional knowledge) has become a concern with greater incidence of commercialized monocultures and fragmentation of landholdings (Negri, 2005). Questions of land tenure, scale, and biocultural diversity are relevant aspects of any comparison between traditional homegardens and the growing interest and practice of forest gardens in North America.

### 3.5 Education and awareness for biocultural conservation

The incorporation of specialty forest crops in both public and private forest gardens holds promise not only for its potential contribution to improved ecosystem services, plant and habitat conservation, and diversity of harvestable products but also as a tool for biological and cultural
understanding. A recent case study of homegarden owners’ knowledge of ecological, economic, and sociocultural home-garden multifunctionality in Tabasco, Mexico, illustrates the positive feedback created by this understanding. In their study, Avilez-Lopez et al. (2020) identified a positive relationship between homegardeners’ awareness of the multifunctionality of agrobiodiversity in their growing spaces (how home-gardens contribute to ecosystem services, the domestic economy, and local culture) and the species richness and diversity present in those same spaces. Where knowledge leads to greater multifunctionality, the reverse can also be true—that demonstrated multifunctionality can result in growing awareness. Experiential and social learning in particular are available in forest gardens where observation and exchange promote an adaptive approach (Galluzzi et al., 2010; Park et al., 2018). More broadly, the human–nature interactions that take place in urban gardens increase exposure to environmental processes that can result in a feeling of interrelatedness and biophilia (Lin et al., 2018). Among the 114 temperate climate forest gardens included in Remiarz’ (2017) survey, several were dedicated more to education and tours than to production and sales, highlighting the recognized value of this service.

Beyond the forest garden, where education about sustainable propagation, cultivation, and harvest of specialty forest crops might take place, those who engage with these plants and fungi must also become aware of appropriate use and consumption practices. Several of the species on United Plant Savers’ at-risk list are not appropriate for raw consumption; they require that the consumer of an unprocessed product understand toxicity and techniques for preparation and dosage for medicinal use. Likewise, for those NTFPs that contribute to craft and other cultural uses, awareness of traditional applications can lend to a respectful relationship with people and place (Poe et al., 2013). Urban foragers are abundant and likely to already have some awareness of stewardship and ethics (McLain et al., 2012; Robbins et al., 2008). The extension of these stewardship efforts from parks to gardens opens a spectrum-like view of opportunities for urban conservation and harvest at various levels of management that can further contribute to local ecological knowledge (McDaniel & Alley, 2005).

According to Bowness and Wittman’s (2020) concept of urban agrarianism and its associated ethics, the education and growing awareness of biological health and cultural sovereignty in urban cultivation spaces is a collective responsibility, particularly for those whose privilege enables power in urban landscapes. Ultimately, this responsibility can yield the kind of consumer awareness that might facilitate the conservation of valuable at-risk forest species in urban and rural locations alike by generating a willingness to pay for the price premiums associated with sustainable cultivation practices (Burkhart & Jacobson, 2009). With understanding, gardeners and foragers alike can also play an important role in conservation of local urban biodiversity (Doody et al., 2010, 2014).

4 | DISCUSSION

Results of this literature synthesis highlight thematic opportunities and considerations that define important biocultural facets of contemporary UFGs. Findings help shape the evolving narrative pertaining to UFG structure and function, with a key inference being that they are better positioned to support healthy ecosystems and human communities when culturally relevant species that supply products beyond food are incorporated. From education and technical transfer to outdoor access and recreation, as well as medicine, decoratives, and wood fiber products and services such as soil remediation and habitat, the spectrum of UFG benefits is best defined by community and ecosystem needs within the limits of biophysical constraints. Indeed, UFGs that successfully integrate culture and ecology are those with the greatest likelihood for permanence and community impact (Bukowski & Munsell, 2018).

Despite emphases on ecosystem mimicry and complex social and ecological characteristics in the UFG literature internationally (e.g., Avila et al., 2017; Galluzzi et al., 2010; Kumar & Nair, 2004), discourse associated with harvestable products from these agroforestry systems, especially in temperate regions, has focused almost exclusively on food production. The benefits of food production in built environments are abundantly clear and readily understood (e.g., Clark & Nicholas, 2013; Park et al., 2018; Russo et al., 2017). Food is recognized as an iconic entryway into the consciousness of communities and a common pathway for generating excitement and building momentum around UFGs (Bukowski & Munsell, 2018); however, forest ecosystems provide more than food, and addressing cultural connections to other products and services can increase the meaning and magnitude of associated civic and environmental outputs (Munsell et al., 2018). The scope of UFG yields necessarily expands within a biocultural framework. Design is intentionally shaped by a range of species palettes and performance expectations that adequately reflect a broad range of possibilities and community preferences. With appropriate community participation that reflects the interwoven nature of society and ecology (Armitage et al., 2009), opportunities exist to expand management for NTFPs in both food-oriented, intensively managed UFGs and incidental urban green spaces dedicated to other functions (i.e., urban parks or private forested land valued for recreation or aesthetics).

Where UFG objectives favor structural and biological diversity, as is expected with inclusion of NTFP management, ecosystem services including habitat connectivity and native plant conservation are likewise enhanced (Doody et al., 2010;
Lin et al., 2015). However, a potentially toxic load of pesticides and fertilizers in stormwater runoff, lead contamination of soil, and other anthropogenic disturbances pose a barrier to safe cultivation and consumption of these additional crops (Princewill-Ogbonna & Ogbonna, 2011; Wortman & Lovell, 2013). Nontimber forest product species that may be found less likely to accumulate dangerous concentrations of pollutants, and that are safe for consumption with minimal processing, are more apt for immediate UFG applications. Given that those plants and fungi harvested without soil contact are less likely to carry those contaminants embedded in urban soils (Rosen, 2002), a focus on aboveground forest products and best practices for safe consumption may be a path of least resistance, although this substantially limits options for those forest botanicals most at risk since many are root crops. When sufficient buffers, distance, or postharvest processing is not adequate to address these concerns, potential for NTFP crops not intended for human consumption and the safety of edible and medicinal NTFPs warrants further study.

The unequal distribution and maintenance of urban trees and their associated social and public health benefits (Donovan, 2017; Heynen, 2003; Kuo & Sullivan, 2001) is a manifestation of deeper-seeded inequities beyond the scope of this review but which affect access to those sites suitable and safe for cultivation. In light of health sovereignty concerns accentuated by the COVID-19 pandemic, access to alternative plant medicines and health-promoting foods is now also of great concern as a component of urban harvests (Poe et al., 2013). Where health care access is tenuous, especially among low-income populations, opportunities for gathering or growing medicinal plants and fungi, awareness of their usefulness and toxicity can bolster preventative health measures (Kassam et al., 2010; Poe et al., 2013; Wartman et al., 2018).

A call for civic engagement in UFG planning initiatives does not replace the essential resolution of safe land and harvest access inequities but it does provide an opportunity for marginalized groups to be heard (Ballard et al., 2008; Poe et al., 2013). Inclusion of knowledgeable foragers and gardeners in community forestry decision-making processes, and the recognition of livelihood value from NTFP harvests are likely to improve awareness of this culturally important component of the urban landscape (McLain et al., 2014). The recommendation for collaborative planning is well suited to Buizer et al.’s (2016) proposal of biocultural diversity as an alternative measure of conservation, where an urban ecosystem services orientation otherwise neglects to “ask ‘for whom’ something is a service (or potentially a disservice).” To understand this dimension of biocultural relevance, additional inquiry is needed on the distribution of UFG benefits and ways greater participation and access can be achieved for expanded UFG benefits.

Land-use valuation and decision making also affects traditional homegardens in tropical regions. As examples of mature, long-lived production spaces, homegardens are a model of integrated multifunctionality. They demonstrate that small-scale home or community growing spaces may serve an important role for biocultural diversity (Galluzzi et al., 2010; Kumar & Nair, 2004). While unique in their cultural and climatic situations, the pressures of development and commercialized agriculture on homegarden agrobiodiversity and persistence are familiar; colonized lands worldwide have been subject to this trend (Holt-Gimenez & Altieri, 2013). By acknowledging the potential and current value of UFG structure and functions (both cultural and biological), temperate and tropical UFGs alike may yet resist these pressures. Awareness of this value plays a role in the drive to create and sustain multifunctional UFGs (Avilez-Lopez et al., 2020), which can extend an educational capacity to demonstrate social and ecological synergy (Doody et al., 2014; McDaniel & Alley, 2005). Any education and awareness efforts toward the integration of culturally important NTFPs in UFGs calls for attention to ethics of respectful relationship (Poe et al., 2013) in addition to a collaborative planning and design process that reflects cultural heterogeneity.

Ultimately, these efforts can contribute to the achievement of an “urban forest justice framework” that “recognizes the rights of urban people to control their own appropriate food and health systems” (Poe et al., 2013) and is dependent on the sustained conservation of culturally relevant species. Urban forests alone may not be adequate to meet this need; Kowarik and Von Der Lippe (2018) identified that while natural remnant ecosystems serve as important host sites for native species in cities, these habitats are not necessarily self-sustaining if those species are excluded from human-mediated novel ecosystems. The scaled conservation of specialty forest crops in urban landscapes will therefore be advanced where habitat connectivity, from domestic gardens to urban forests, is a consideration. This is particularly relevant for those valued, at-risk species that are appropriate both in urban forests designed for human use and in home- or community-scale forest gardens.

As the prevalence of human-dominated ecosystems continues to rise, UFGs at every scale are a model of the potential symbiosis between human-oriented and nature-oriented objectives. In fact, these objectives are inextricable, though not always easy to simultaneously balance (Sanderson & Huron, 2011). Cities are host to unique social and biophysical dynamics, are spatially composed of highly heterogeneous mosaics, and they are here to stay, calling for the intentional management of an emergent urban ecology (Alberti et al., 2003). The richness of nonnative and native species, interacting within anthropogenic communities, does not necessarily lend itself to greater stability (Alberti et al., 2003). Thus, the resilience of urban ecosystems depends on human awareness, design, and management for conservation objectives that
complement human needs and appreciate cultural diversity (Pretty et al., 2009).

Drawing from multiple disciplines with relevant insights about potential for biocultural conservation in UFGs with NTFPs, this synthesis is limited in its capacity to interpret specific attributes of and recommendations for this practice in unique community contexts. It is instead intended as an opening to encourage further inquiry that is inclusive of multiple scales and types of UFG implementation that consider the full extent of harvestable yields beyond food. In order to effectively address health and cultural sovereignty with UFG initiatives that include NTFPs, more research is recommended specifically on (a) safety and adaptability of specific forest species of interest (as determined by community residents), (b) who benefits from UFGs and how greater equity can be achieved so that harvests are relevant and accessible, and (c) outcomes of current UFGs that illustrate the implications of diverse functions and structure. Case study examples illustrating specific approaches to achieve this goal in UFGs at various scales ranging from domestic gardens and community food forests to public urban forests will also contribute important insights to this emerging dialog.

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AUTHOR CONTRIBUTIONS
Hannah L. Hemmelgarn: Conceptualization; Data curation; Formal analysis; Investigation; Methodology; Writing—original draft. John F. Munsell: Supervision, Validation, Writing—review & editing

CONFLICT OF INTEREST STATEMENT
The authors declare that there is no conflict of interest.

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