



Public food forest opportunities and challenges in small municipalities

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Abstract

The opportunities and challenges associated with public food forest initiatives in small municipalities are understudied compared with large metropolitan counterparts. Research in small population centers is needed to identify and understand factors affecting the growth of public food forests where resources more commonly available in cities often are lacking. To study these factors, we surveyed mayors in Virginia, United States, serving communities with populations under 25,000. Out of 176 mayors who received a paper survey through the mail, 68 (39%) responded. Mayors perceived long-term maintenance as the greatest barrier to public food forests and education, recreation, and spiritual experience as the most desirable benefits. Nearly 70% noted that their town has some form of food production on public land but only one-fifth include food-producing trees and shrubs. Most municipalities (78%) do not have food-producing trees and shrubs land use codes. Summated variables representing mayoral ratings of public support and physical space for food forests in their municipalities were used in a *k*-means cluster analysis to group towns into four types: (a) ambivalent and resource-poor, (b) optimistic and capable, (c) doubtful and unsupported, and (d) unsure with potential. Each community has unique challenges and opportunities, but mayors stressed that providing sociocultural programs and education rather than food access is the most compelling aspect of a public food forest.

1 | INTRODUCTION

Food production generally has not been an explicit goal of contemporary urban and community forest management (McLain et al., 2012). However, food forests, which consist of multiple perennial and annual food-producing species in multistoried arrangements, provide canopy cover that is a priority of present-day urban forestry while also addressing resident needs such as food security and health (Clark & Nicholas, 2013; Jurikova et al., 2012). Food forests also

can improve biodiversity, increase pollinator habitat, mitigate flooding events, reduce costs related to stormwater management, minimize the heat island effect, and deliver other valuable ecosystem services (Belmeziti et al., 2018; Clark & Nicholas, 2013; Costanza et al., 1997; Lovell, 2010; Raintree, 1986). Installing food forests on municipal land has grown in popularity in recent years, and the number of projects in cities and towns is on the rise (Bukowski & Munsell, 2018). A goal for many initiatives is shifting the locus of food and fiber production to communities while also enhancing ecosystem

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health and improving resident well-being (Russo et al., 2017; Clark & Nicholas, 2013).

Public food forests, among other forms of multifunctional green space, provide community services including food and nutrition education, places for social gathering and civic activity, and open space for recreation and sport (Bukowski & Munsell, 2018; Lovell, 2010). Initiatives that build community, such as food forests, increase social connectivity between residents and improve their ability to shape the future of the places where they live (Weil, 1996). They also can enhance the aesthetics of public spaces and neighborhoods, which often inspire greater rates of resident connections to open greenspace (Belmeziti et al., 2018; Lovell, 2010). Additionally, municipalities can provide jobs or volunteer opportunities for people to steward public food forests (Russo et al., 2017), and residents who glean food can reduce the amount of produce they purchase (Clark & Nicholas, 2013).

Public food forests in North America and Europe are typically found in population-dense urban areas and larger towns (Bukowski & Munsell, 2018; Hübner et al., 2018; Clark & Nicholas, 2013), but some smaller municipalities are known to have them. However, public food forest research is largely limited to city centers with high population densities; thus, little is known about the challenges and opportunities associated with applications in smaller municipalities. This has important implications for the field of urban green space management given half of the global population lives in towns or villages whose residents, like those living in large population centers, depend upon vibrant and healthy ecosystems (Forman, 2019).

Improving insights into the factors affecting public food forests in smaller municipalities in the United States is critical if comprehensively understanding the potential, purpose, and availability of these systems is a goal. For instance, 61% of the U.S. population lives in municipalities with 50,000 or fewer residents and over three-fourths of the nation's incorporated places have fewer than 5,000 inhabitants (United States Census Bureau, 2020). These communities stand to offer meaningful contributions to ecosystem health and productivity, and residents deserve access to healthy and functional greenspace. Understanding the ways in which public food forests in small municipalities are currently constrained and preferences regarding their structure and function will help inform ongoing and future initiatives in small municipalities in the United States and beyond.

Regardless of municipality size, however, the literature points to several factors that are highly likely to affect public food forest initiatives. Liability is an important factor that may hinder widespread use on municipal land. For example, food safety is a concern, as are downed fruits and nuts that are often viewed as unsightly and a danger in frequently traveled places (Bukowski & Munsell, 2018; Lovell, 2010). The use of chemicals (e.g., pesticides and herbicides) to control com-

Core Ideas

- Small municipalities lack policies to support food forests in public spaces.
- Local leaders view maintenance as the greatest barrier to planting edible, woody perennials.
- Small municipalities vary in their interest and ability to support food forest initiatives.
- Emphasizing cultural benefits may be an important for increasing food forests in the United States.

petition during establishment also is a worry for fear of risks to resident health (Russo et al., 2017). Large wildlife seeking to forage and insect allergies also are issues, as are matters of planning and management equity, access for community members with disabilities, and crime (Bukowski & Munsell, 2018).

A germane struggle faced by many municipalities is finding and securing approval for space that is suitable for a public food forest, which often is in competition with other land use goals like new sport fields and nature parks and trails (Belmeziti et al., 2018; Haaland et al., 2015; Lovell, 2010). Tenure is another challenge that municipalities must overcome (Horst et al., 2017; Konijnendijk & Gauthier, 2006), which is especially pertinent for growing and managing woody perennials (Raintree, 1986). The allocation of financial resources for long-term maintenance of perennial woody species presents another substantial barrier for municipalities, many of whom consistently deal with tight budgets and limited flexibility for new allocation (Russo et al., 2017;). This is compounded by the fact that permanence of public food forests not only requires a detailed plan but also continued investments in financial, human, and built capitals (Bukowski & Munsell, 2018).

Municipal policies specific to food forests are one mechanism for improving the likelihood and ease of adoption. Policies can regulate and incentivize human behaviors, thereby influencing human–environment interactions (Orach & Schlüter, 2016). For example, zoning laws and codes help regulate and direct land use, which can lead to ecological change (Orach & Schlüter, 2016; Fernandez et al., 2013; Altieri, 2009). When applied to the context of public food forests, most municipalities in the United States are at a disadvantage because they do not have land use codes that promote the use of food-producing trees and shrubs in public places (Bukowski & Munsell, 2018; Lovell, 2010). If residents of smaller municipalities aim to establish a food forest on public land, then understanding the legal and social constraints is a necessary step, and mayors and other elected government officials are necessarily involved when it comes to such matters.

To study the status and potential for public food forests in small municipalities, we researched perspectives and beliefs among mayors of municipalities with fewer than 25,000 people in Virginia, United States. Urban greening and food forest literature informed our study design and hypotheses. We sought to test whether mayors equally value environmental, social, economic, and health-related opportunities associated with food forests on public land and whether they think there are differences in how constraints like physical space and long-term maintenance affect the potential for public food forests in their respective municipality. Lastly, we compared mayoral perspectives regarding the acceptability of food forests and ease of implementation, including opinions on the decision-making processes and policy pathways that are best for the residents of their municipality.

Understanding mayoral perspectives regarding the role and potential of public food forests in small municipalities, the challenges and opportunities associated with implementation, and the necessary processes and procedures define key benchmarks affecting implementation in communities with smaller resident numbers and public space. They also provide insight into the characteristics of communities that are associated with varying levels of interest and government support for public food forests. We use our findings to discuss how smaller municipalities can capitalize on prospects and overcome barriers if food forests are a goal.

2 | MATERIALS AND METHODS

2.1 | Study area

Virginia is the 12th largest state in the United States, with over 8.4 million people. The majority (89%) of its incorporated municipalities have fewer than 25,000 residents, which is similar to the percentage of all U.S. municipalities (91%) with populations under the same threshold (United States Census Bureau, 2019). The designation of a town or city in Virginia is independent of population size. An incorporated municipality is considered a town if it is seated within a county, whereas cities are independent from counties. In this study, smaller municipalities (defined as having less than 25,000 people) are referred to as ‘towns’ even if they technically are cities to distinguish between them and larger, more developed areas. There are 177 municipalities under 25,000 in Virginia, and all were included in this study.

2.2 | Mayoral perspectives

We studied mayoral perspectives to research the limitations and opportunities of food forest implementation in the study area. Mayoral data have been used before when studying

issues affecting small municipalities (Lewis & Boulahanis, 2008; Hart et al., 1991). For example, Lewis and Boulahanis (2008) surveyed mayors to assess urban forest practices and importance in southern towns with populations between 5,000 and 25,000. In a different study, Hart et al. (1991) asked mayors of rural municipalities to report perceived causes and effects of hospital closures on their communities. The authors used responses to inform policy recommendations for improving public health in rural communities across the United States.

We surveyed mayors to understand the factors affecting food forests in small municipalities for two reasons: (a) they are an easily identifiable population; and (b) they typically have a long history of community service, thereby affording historical insight into issues affecting their community and an in-depth understanding of constituent perceptions and attitudes (Hart et al., 1991). Also, in small municipalities (populations between 2,500 and 25,000), mayors tend to dedicate more time to public relations than city and town managers because they are elected by constituents and have a greater responsibility for understanding public views than managers, who are appointed by a council (French, 2005).

2.3 | Survey instrument

Mayors were first provided with a summary of the study and relevant definitions and examples to improve comprehension. They were then surveyed about their perspectives regarding the costs and benefits, pertinence, and ease of implementation of green infrastructure and associated policymaking processes. They also were asked how long they have been mayor and to respond to demographic questions such as sex, age, education, and political views. Respondent opinions about public food production and food forests also were measured, in addition to perspectives on project implementation in their municipality.

A pilot survey was developed, tested, and modified using input from a panel of researchers, as well as two mayors in Virginia who were not included in the sample. The mayors who took the pilot survey commented that public green space and food production have become increasingly popular discussion topics within their towns and at statewide conferences for mayors and other municipal leaders, indicating that mayors are typically attuned to these issues. Mailings were sent using physical addresses posted on official government websites. If they were not posted, town hall offices were called to confirm an address. Four mailings were used to complete the survey following Dillman and Witey’s (2009) tailored design method. The first mailing was a solicitation letter including survey details and an invitation to participate via mail or phone. Ten days later, a cover letter was mailed, along with a paper survey, a response card to fill out if a phone surveyed was preferred,

TABLE 1 Response options included in a survey of mayors of small municipalities in Virginia, United States (<25,000 residents). Options are listed for each of three categories. Food production systems includes possible responses for the types of food production in existence as well as zoning codes or other legal constraints that specifically reference these systems

Benefits of public green spaces	Barriers to planting food-producing trees and shrubs in public spaces	Types of food production
Social gathering or community-building	Long-term maintenance	Community gardens
Beautifying the environment	Lack of space	Public orchards
Providing places for recreation/sports	Hazards related to fallen fruits/nuts	Fruit and nut trees
Connecting people to nature	Competing land use interests	Edible plants in rights-of-way
Improving public health	Food safety concerns	Rooftop gardens
Educational opportunities	Changing the aesthetic of the town	Community food forests
Benefitting pollinators and wildlife	Reduced visibility hazards	Other
Improving stormwater management	Nothing	–
Providing spaces for food production	–	–
Providing jobs	–	–

and a preaddressed, stamped envelope. Two weeks later, a reminder postcard was mailed and a final cover letter, paper survey, response card, and preaddressed, stamped envelope were mailed 2 wk after to mayors who had not responded.

The ‘wave’ method (after Rogelberg & Stanton, 2007) was used to address nonresponse. This method treats late respondents as representative of nonrespondents based on research findings published by Groves et al. (2001). A *t* test was used to determine if demographics and summated dependent variables differ significantly between late respondents and early respondents ($\alpha = 0.05$). A *t* test also was used to determine if municipal population differed significantly between respondents and nonrespondents ($\alpha = 0.05$). Test results were not significant in all cases.

The survey prompted mayors to select all possible benefits from a discrete list that they believe are associated with public green space, all potential barriers associated with planting food-producing trees and shrubs in public spaces, and the types of public food production systems in existence, relevant zoning codes and other legal restrictions in their municipalities (Table 1). Mayors were also prompted to indicate the extent to which they agree with 18 statements about the role and importance of public green space, generally, and the potential for incorporating food-producing trees and shrubs into public space in their municipality. Likert-type agreement response options were provided on a unipolar ordinal scale ranging from 1 to 5, where 1 indicates not at all, 2 indicates a little bit, 3 indicates somewhat, 4 indicates mostly, and 5 indicates completely. Open-ended questions included what kinds of public green space should be protected (e.g., parks, greenways, forests) and why they believe zoning is or is not the best way to encourage food production on public land in their municipalities.

2.4 | Data analysis

To decrease the number of Likert-type ordinal response variables while sufficiently accounting for data variance, exploratory factor analysis was conducted using principal component analysis and varimax rotation. Eigenvalues indicate the magnitude of variance explained by each factor, which consist of groupings of survey item responses that meaningfully explain a portion of overall variance. Acceptable factor groupings have an eigenvalue score greater than one (Spector, 1992). Factor loadings show how strongly individual survey item responses correlate with each factor, and weak (i.e., loading < 0.60) or cross-loaded survey items in each factor grouping were eliminated.

Mean scores were calculated for each underlying factor to generate averages representing a summated construct variable. Summated constructs provide a more accurate parametric mean score when measuring latent variables such as opinions and beliefs using ordinal response options (DeVellis, 2003). Out of the 18 Likert-type agreement item responses, 14 with loadings ≥ 0.60 grouped into five underlying factors with eigenvalues greater than one (Table 2). Factors also grouped broadly along two thematic lines, one being summated constructs representing mayoral perspectives on social and physical support for public food forests and the other being assessments of support from local governments, including financial means and policy and political intention in their municipality.

The three factor loadings representing mayoral perspectives about public support and physical space were used in a *k*-means cluster analysis to group municipalities into different types. Variables used included (a) the availability of public space for food-producing trees and shrubs, (b) how strongly the public supports green space development, and (c) public

TABLE 2 Rotated component matrix with factor loadings in an exploratory factor analysis of ordinal survey item responses among mayor respondents in Virginia, United States ($n = 68$). Out of 18 statements, four were removed, resulting in 14 variables that grouped into five factors. Item variable means, minimum and maximum responses, and total variance explained are reported

Variable	Item \bar{x}	Social and physical support			Government support	
		Public green space support	Available space	Implementation attitudes	Political intention	Financial means and policy
Public green space visited often	3.68	0.71 ^a	-0.13	0.04	-0.05	0.09
Conducive codes for public green space	3.17	0.74	0.14	0.07	-0.24	0.26
Budget for public green space	2.97	0.76	0.25	0.11	0.21	0.29
Physical resources for public green space	2.98	0.71	0.20	0.08	0.38	0.19
Community allies for public green space	3.06	0.68	0.30	0.18	0.23	0.03
Public green space to produce food	2.94	0.01	0.85	0.34	0.06	0.04
Ample public green space	3.16	0.37	0.80	-0.18	0.08	0.05
Ease of food forest implementation	2.75	0.06	0.11	0.60	-0.17	0.44
Pertinence of food forest implementation	3.35	0.39	-0.18	0.61	0.06	-0.26
Cost of food forest implementation	3.52	0.07	0.24	0.78	0.25	0.13
Priority of planting edible perennials	2.61	0.02	0.17	0.34	0.71	0.05
Current effort to increase edible perennials	1.38	0.16	0.02	-0.03	0.78	0.19
Policy to support edible perennials	2.68	0.16	0.04	-0.01	0.09	0.88
Budget to support edible perennials	2.55	0.40	0.03	0.21	0.24	0.69
Factor \bar{x} (scale)		3.14 (1–5)	3.05 (1–5)	3.19 (1–5)	2 (1–4.5)	2.6 (1–5)
Min., max.		2, 5	1, 5	1, 5	1, 5	1, 5
Total variance explained		–	–	–	–	65.5%

^aValues in bold highlight loading of 0.60 or greater, which indicates that the survey items loaded onto a particular factor, which was used to construct the five variables.

attitudes about the implementation of food-producing perennials in public green space. The k -means cluster procedure was used to create groups that maximize response differences between clusters and minimize differences within clusters (Ding & He, 2004). Resulting clusters were used as factors in a one-way ANOVA and Tukey's HSD post-hoc test to determine whether mayoral perspectives on financial means and supporting policies, as well as political intention to implement public food forests, differ significantly between the types of municipalities identified in the k -means cluster analysis ($\alpha = 0.05$).

Descriptive statistics and frequency distributions for the mayors' sex, age, education level, length of time in office, and political orientation, as well as the town's population size, demographic region, and political orientation according to the mayor, were compiled. Descriptive statistics for these survey variables also were collected for each cluster for comparison. Population size and demographic region were collected independently of mayors' responses. Regions developed by the University of Virginia Weldon Cooper Center were used (Figure 1). Communities within these eight regions (central, west central, valley, northern, eastern, Hampton Roads, southside, and southwest) have common geographic, economic, and social characteristics (University of Virginia Weldon Cooper Center, 2017).

Mayors were asked to provide a response (yes or no) to whether they think zoning is the best way to encourage food-producing perennials on public land and whether public green spaces should be protected in land use codes. For both, they also were asked to explain why they hold these opinions, and open-ended responses were coded and grouped into common themes by a single coder. Results provide a deeper understanding of mayoral responses particularly in terms of policy constraints and opportunities to protect public green space and multiple-strata food-production systems.

3 | RESULTS

3.1 | Mayoral characteristics and beliefs

One-hundred seventy-seven paper surveys were mailed to mayors of municipalities in Virginia with populations under 25,000. One mayor did not receive the survey despite reconfirmation of the address and multiple mailing attempts. Sixty-eight of 176 mayors responded, resulting in an adjusted response rate of 39%. Two mayors (3%) opted to take the survey over the phone. Approximately 70% of respondents were male, and more than 60% had a bachelor's degree or higher. More than one-third of mayors served municipalities with

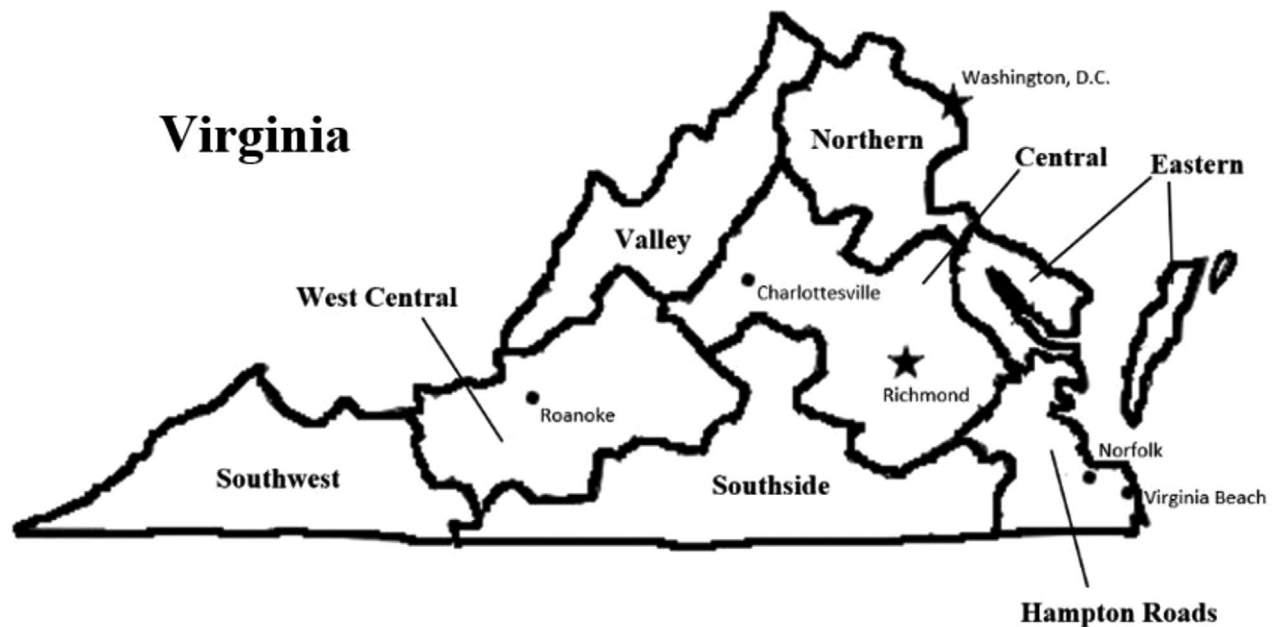


FIGURE 1 The eight demographic regions of Virginia (central, west central, valley, northern, eastern, Hampton roads, southside, and southwest) developed by the University of Virginia's Weldon Cooper Center. Communities within regions share economic, social, and geographic traits

populations between 1,000 and 4,999, and 14% had populations between 10,000 and 25,000. Approximately one-fourth of respondents were from the southside region and another one-fourth were from the southwest region. The next greatest percentage (16.9%) of respondents were from the valley region (Table 3).

More than 80% of mayors believed that promoting social gathering and community building, beautifying the environment, and providing places for recreation or sport were benefits of public green space (Table 4). Food production and providing jobs were seen as benefits by approximately 40 and 25% of mayors, respectively. Nearly four out of five mayors indicated that long-term maintenance is a significant barrier to planting food-producing perennials in public space. The next greatest barriers were lack of space (44%) and concern over fallen fruits and nuts (39%).

3.2 | Mayoral assessments of town characteristics and types

The most prevalent form of existing food production in public space was community gardens (45%), though one-third reported having nothing at all (Table 4). Approximately one-fifth of mayors reported having woody perennial species (i.e., individually planted fruit and nut trees, orchards, and community food forests) in public areas. Among them, only one mayor noted that they had a community food forest. Nearly 80% indicated that food production systems were not included

in the zoning codes for their municipalities. When they were included, the majority (60%) pertained to community gardens. Approximately 75% of mayors indicated that there were no legal constraints affecting food-producing trees and shrubs in public green space, and almost all others were unsure if any constraints existed.

Fourteen survey variables were grouped into five factors with eigenvalues over one in the rotated matrix, which explained 65.5% of the overall variance (Table 2). Four of the original 18 survey items did not load onto any factor and therefore did not represent an underlying construct. Five items measuring the extent to which mayors believed public green space was supported were averaged, and the summated variable was labeled 'public green space support.' Two items measuring the degree to which mayors felt their municipalities intended to plant food-producing trees and shrubs in public space were likewise averaged and the resulting variable labeled 'political intention.' 'Implementation attitudes' consisted of three items that were averaged to measure mayoral perspectives pertaining to the use of edible, woody perennials in public green space. Two items measuring how confident mayors were that their municipal governments could support food-producing trees and shrubs in public space were averaged and labeled 'financial means and policy.' Two items that measured the extent to which respondents believed there was adequate public green space to plant edible, woody perennials were averaged and labeled 'available space.'

The *k*-means cluster analysis resulted in four municipal types based on available space, implementation attitudes, and

TABLE 3 Demographics based on survey responses of mayors of municipalities with populations <25,000 in Virginia, United states. Breakdowns are shown for all mayors ($n = 68$) as well as each respondent type (ambivalent and resource-poor, optimistic and capable, doubtful and unsupported, and unsure with potential) according to the k -means cluster analysis

Demographics	Categories	Mayors' responses				
		All mayors ($n = 68$)	Ambivalent and resource-poor ($n = 18$)	Optimistic and capable ($n = 16$)	Doubtful and unsupported ($n = 18$)	Unsure with potential ($n = 14$)
		%				
Sex	Male	70.3 (45)	77.8 (14)	61.5 (8)	62.5 (8)	81.3 (13)
	Female	29.7 (19)	22.2 (4)	38.5 (5)	37.5 (5)	18.7 (3)
Education	High school	9.2 (6)	5.9 (1)	21.4 (3)	5.9 (1)	6.2 (1)
	Some college	27.7 (18)	29.4 (5)	21.4 (3)	35.3 (6)	25.0 (4)
	Bachelor's	36.9 (24)	35.3 (6)	7.1 (1)	41.2 (7)	56.3 (9)
	Graduate	26.2 (17)	29.4 (5)	50.0 (7)	17.6 (3)	12.5 (2)
Age	<50	16.1 (10)	11.8 (2)	14.3 (2)	21.4 (3)	18.8 (3)
	50–59	27.4 (17)	35.3 (6)	21.4 (3)	28.6 (4)	25.0 (4)
	60–69	33.9 (21)	47.0 (8)	21.4 (3)	21.4 (3)	37.5 (6)
	70–79	12.9 (8)	5.9 (1)	21.4 (3)	14.3 (2)	12.5 (2)
	≥80	9.7 (6)	0.0 (0)	21.4 (3)	14.3 (2)	6.3 (1)
Population	<500	16.9 (11)	5.9 (1)	7.7 (1)	41.2 (7)	12.5 (2)
	500–999	16.9 (11)	29.4 (5)	0.0 (0)	17.6 (3)	18.8 (3)
	1,000–4,999	35.4 (23)	35.3 (6)	38.5 (5)	29.4 (5)	43.7 (7)
	5,000–9,999	16.9 (11)	17.6 (3)	30.8 (4)	5.9 (1)	18.8 (3)
	10,000–24,999	13.9 (9)	11.8 (2)	23.1 (3)	5.9 (1)	6.2 (1)
Region	Central	4.6 (3)	0.0 (0)	7.7 (1)	0.0 (0)	12.5 (2)
	West central	6.2 (4)	17.6 (3)	0.0 (2)	5.9 (1)	0.0 (0)
	Southside	23.1 (15)	23.5 (4)	15.4 (3)	35.3 (6)	12.5 (2)
	Hampton Roads	6.2 (4)	0.0 (0)	15.4 (4)	5.9 (1)	0.0 (0)
	Eastern	7.7 (5)	5.9 (1)	0.0 (5)	11.8 (2)	12.5 (2)
	Southwest	23.1 (15)	23.5 (4)	15.4 (6)	35.3 (6)	18.8 (3)
	Northern	12.3 (8)	17.6 (3)	7.7 (7)	5.9 (1)	18.8 (3)
	Valley	16.9 (11)	5.9 (1)	38.5 (8)	0.0 (0)	25.0 (4)
Years as mayor	<2	17.9 (12)	27.8 (5)	0.0 (0)	22.2 (4)	18.8 (3)
	2–5	34.3 (23)	33.3 (6)	28.6 (4)	27.8 (5)	50.0 (8)
	6–10	32.8 (22)	16.7 (3)	64.3 (9)	33.3 (6)	18.8 (3)
	>10	14.9 (10)	22.2 (4)	7.1 (1)	16.7 (3)	12.5 (2)
Mayor's political orientation	Very liberal	1.8 (1)	0.0 (0)	8.3 (1)	0.0 (0)	0.0 (0)
	Liberal	9.1 (5)	21.4 (3)	0.0 (0)	7.7 (1)	6.7 (1)
	Slightly liberal	10.9 (6)	7.1 (1)	16.7 (2)	0.0 (0)	13.3 (2)
	Moderate	32.7 (18)	35.7 (5)	41.7 (5)	23.1 (3)	33.3 (5)
	Slightly conservative	9.1 (5)	7.1 (1)	0.0 (0)	23.1 (3)	6.7 (1)
	Conservative	30.9 (17)	28.6 (4)	25.0 (3)	46.1 (6)	26.7 (4)
	Very conservative	5.5 (3)	0.0 (0)	8.3 (1)	0.0 (0)	13.3 (2)
Town's political orientation	Very liberal	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)
	Liberal	8.9 (5)	7.1 (1)	8.3 (1)	15.4 (2)	6.3 (1)
	Slightly liberal	8.9 (5)	0.0 (0)	8.3 (1)	7.7 (1)	12.5 (2)
	Moderate	23.2 (13)	21.4 (3)	25.0 (3)	15.4 (2)	31.3 (5)

(Continues)

TABLE 3 (Continued)

Demographics	Categories	Mayors' responses				
		All mayors (<i>n</i> = 68)	Ambivalent and resource-poor (<i>n</i> = 18)	Optimistic and capable (<i>n</i> = 16)	Doubtful and unsupported (<i>n</i> = 18)	Unsure with potential (<i>n</i> = 14)
	Slightly conservative	17.9 (10)	21.4 (3)	25.0 (3)	15.4 (2)	12.5 (2)
	Conservative	35.7 (20)	42.9 (6)	25.0 (3)	38.4 (5)	37.5 (6)
	Very conservative	5.4 (3)	7.1 (1)	8.3 (1)	7.7 (1)	0.0 (0)

public green space support: (a) ambivalent and resource-poor, (b) optimistic and capable, (c) doubtful and unsupported, and (d) unsure with potential. The ANOVA post-hoc analysis indicated that respondents in 'optimistic and capable' and 'unsure with potential' clusters more strongly believed that their municipalities have the physical space needed to support food-producing trees and shrubs (available space) when compared with other groups. 'Optimistic and capable' were significantly most confident that public green space is supported in their municipalities (public green space support) and those in 'doubtful and unsupported' were significantly least confident. Regarding support for public green space, respondents in 'ambivalent and resource poor' and 'unsure with potential' were less confident than 'optimistic and capable' and more confident than 'doubtful and unsupported.' Respondents in 'optimistic and capable' reported significantly more favorable attitudes regarding the implementation of edible perennials (implementation attitudes) in their municipalities compared with other clusters.

Available space, public green space support, and implementation attitudes differed significantly across the four clusters. The ANOVA post-hoc analysis using Tukey's HSD indicated that summated mean scores for political intention and financial means and policy were significantly higher ($\alpha = 0.05$) for 'optimistic and capable' than for 'doubtful and unsupported' (Table 5). 'Ambivalent and resource-poor' and 'unsure with potential' were not significantly different from any clusters.

3.3 | Characteristics by respondent type

'Ambivalent and resource-poor' generally had less conservative and younger mayors than other groups, and approximately half had between 1,000 and 9,999 residents (Table 3). 'Ambivalent and resource-poor' had the highest percentage of liberal mayors (over 28% reported themselves as liberal or slightly liberal) and less than 6% were over the age of 70. Similar to overall trends, one-fourth of respondents from this group were from the southside region and another one-fourth were from the southwest region.

'Optimistic and capable' generally had mayors who were older and relatively less conservative than other groups (Table 3). Interestingly, this group had the greatest percentage (nearly 40%) of mayors from the valley region. They also had the highest percentage of senior mayors (>40% were 70 years or older) and the largest populations (50% were over 5,000, and nearly 25% were over 10,000).

In contrast, respondents in 'doubtful and unsupported' had the smallest populations, with over 40% having fewer than 500 residents (Table 3). None were from the valley region, and over 70% were from the southside or southwest regions. This group had more conservative mayors than 'optimistic and capable' and 'ambivalent and resource-poor,' as nearly 70% reported being conservative or slightly conservative.

Lastly, 'unsure with potential' consisted primarily of conservative and middle-aged mayors from mid-sized towns (vs. others in this study), as three out of five had between 1,000 and 9,999 residents (Table 3). This group also had the highest percentage of respondents who reported their political orientation as very conservative. Exactly one-fourth of respondents were from the valley region, and nearly 40% of the remaining respondents were from the southwest or northern regions.

3.4 | Mayoral views on policy

Open-ended comments (*n* = 40) regarding the types of public green space that should be protected in land use codes were coded and grouped into 13 categories (Table 6). The most common responses were (a) parks (58%), (b) trails (15%), and (c) forests or woodlands (15%). Only 8% specifically mentioned food production systems, for which they all wrote 'community gardens.' There were also five (13%) mayors who felt that all green space should be protected, supported by statements such as, "any and all green space should be protected," "any and all; we are an old town and somewhat landlocked, so all opportunities are important," "all green space should be protected," and "any town-owned parcels."

Open-ended responses explaining mayors' stances on whether zoning is the best way to promote food production on public land were coded and grouped based on common

TABLE 4 Mayors' perspectives on benefits of public green spaces and barriers to planting edible perennial species, as well as what types of food production systems exist in public space, are included in zoning codes and are impacted by legal constraints in their small municipalities (<25,000 people) in Virginia, United States

Issue	% (n)
Benefits of public green spaces	
Promoting social gathering and community building	87.9 (58)
Beautifying the environment	87.9 (58)
Providing places for recreation and sports	84.8 (56)
Connecting people to nature	78.8 (52)
Improving public health	74.2 (49)
Providing spaces for educational opportunities	72.7 (48)
Benefitting pollinators and wildlife	69.7 (46)
Improving stormwater management	62.1 (41)
Providing spaces for food production	42.4 (28)
Providing jobs	24.2 (16)
Barriers to planting edible perennials in public spaces	
Long-term maintenance	78.8 (52)
Lack of space	43.9 (29)
Hazards related to fallen fruits and nuts	39.4 (26)
Competing land use interests	24.2 (16)
Food safety concerns	18.2 (12)
Changing the aesthetic of the town	13.6 (9)
Nothing	9.1 (6)
Reduced visibility hazards	7.6 (5)
Existing food production systems in public space	
Community gardens	45.1 (23)
There are none	33.3 (17)
Public orchards or fruit and nut trees	19.6 (10)
Edible plants in rights-of-way	5.9 (3)
Rooftop gardens and gardening along buildings	3.9 (2)
Community food forests	2.0 (1)
Food production systems included in the zoning codes	
None	77.8 (49)
Community gardens	14.3 (9)
Fruit and nut trees and public orchards	4.8 (3)
Edible plants in medians or rights-of-way	3.2 (2)
Rooftop gardening and gardening along buildings	1.6 (1)
Community food forests	0.0 (0)
Food systems impacted by legal constraints	
None	72.7 (48)
Not sure	24.2 (16)
Public orchards and fruit and nut trees	1.5 (1)
Community food forests	1.5 (1)
Edible plants in medians or rights-of-way	1.5 (1)
Community gardens	0.0 (0)
Rooftop gardens and gardening along buildings	0.0 (0)

themes. Of the 57 mayors (84%) who responded, 36 (63%) were against zoning and 25 (37%) were in favor of zoning. Mayors were against zoning because (a) food production is not a priority for the public, (b) there is a lack of public space and available resources, (c) education and awareness are better first steps, and (d) they were opposed to a regulatory approach (Table 6). Reasons for zoning included (a) government support provides guidance on implementation, (b) it creates opportunities for education and raising awareness, and (c) if there is sufficient public interest.

A reason cited in opposition to zoning was that food production on public land was not a priority in their town from lack of interest or need: “they want parks and open space—not food producing on the limited space we have,” “food production is already happening on private property, so there is no need,” “we are a farming town and county—no interest.” On the other hand, some thought that being an agricultural town is advantageous because there already is a clear interest in food production: “we are fortunate to have an abundance of agriculture in our region and gardening is fairly common among residents,” explained one mayor who favored zoning.

Other mayors against zoning cited a lack of physical and fiscal resources: “we just don’t have the space to do it,” “the zoning codes are likely not the major impediment to this use—funding or lack of open space is likely the primary impediment here,” and similar statements were common. Yet, there were mayors in favor of zoning who thought supportive policy would be helpful, even if space were lacking. One wrote, “if people see it is supported [in zoning codes], it is more likely to happen,” and another, “[zoning] would assist with [the] lack of physical space question to be able to point to by right areas.”

Education and awareness were cited both as reasons for and against zoning. There were mayors who believed that greater awareness and education were needed before making changes to the zoning codes: “education and awareness would be more appropriate” and “encourage the use through community volunteer efforts first, and if it catches on, then look at the codes for future protections.” Yet some mayors in favor of zoning thought that educational opportunities could result from the zoning process. They referenced the learning that might take place from the process of policy change: “by looking at zoning, the public has a chance to discuss food production with council and [the] mayor,” and “including food production systems in zoning codes would raise awareness and start the conversation.” Another wrote, “I believe it might help people understand the importance of food and green space and teach children and adults about their food.”

There were discrepancies in mayoral opinions about the role that government should play in defining these uses on public land. Some mayors against zoning disagreed with a regulatory approach: “public support would [need to] come first; we do not lead through forced change” and “I would prefer a nonregulatory approach.” Others thought that government

TABLE 5 Means ANOVA test results for significant differences in available space, public green space support, implementation attitudes, political intention, and financial means and policy among mayor respondent types in Virginia, United States. Three social and physical support variables were used in the *k*-means cluster procedure creating four respondent types (ambivalent and resource-poor, optimistic and capable, doubtful and unsupported, and unsure with potential), while government support variables were not. Scale: 1 = not at all, 2 = a little bit, 3 = somewhat, 4 = mostly, 5 = completely. Mean scores in columns with the same letter do not differ significantly using Tukey's HSD post hoc test ($\alpha = 0.05$)

Respondent type (<i>n</i>)	Social and physical support			Government support	
	Available space \bar{x} (SE)	Public green space support \bar{x} (SE)	Implementation attitudes \bar{x} (SE)	Political intention \bar{x} (SE)	Financial means and policy \bar{x} (SE)
Ambivalent and resource-poor (18)	2.25 ^a (0.12)	3.48 ^a (0.13)	3.35 ^a (0.14)	2.25 ^{ab} (0.21)	2.78 ^{ab} (0.22)
Optimistic and capable (14)	4.03 ^b (0.17)	4.33 ^b (0.14)	4.06 ^b (0.16)	2.36 ^a (0.26)	3.14 ^a (0.30)
Doubtful and unsupported (18)	1.97 ^a (0.15)	1.95 ^c (0.14)	2.70 ^a (0.17)	1.53 ^b (0.15)	2.00 ^b (0.18)
Unsure with potential (16)	4.19 ^b (0.15)	3.05 ^a (0.19)	2.92 ^a (0.16)	1.93 ^{ab} (0.19)	2.60 ^{ab} (0.25)
<i>F</i>	62.56	41.25	13.22	4.25	3.29
<i>P</i>	.00	.00	.00	.03	.01

TABLE 6 Open response frequencies based on mayors' views on the protection of public greens space and food-producing, woody perennials

Issue	Frequency
Public green space that should be protected by codes (<i>n</i> = 40)	
Parks	23
Trails	6
Forests and woodlands	6
Wetlands and places along the water	6
All green spaces	5
Recreation areas	4
Flower gardens	3
Community gardens	3
Spaces for farmer's markets	3
Greenbelts and greenways	2
Historical sites	2
Conservation lands	2
Department of Transportation land	1
Reasons against zoning for food-producing trees and shrubs (<i>n</i> = 25)	
Not a priority for the public	9
Lack of public space and resources available	7
Education and awareness needed first	5
Do not agree with regulatory approach or forcing the issue	4
Reasons for zoning for food-producing trees and shrubs (<i>n</i> = 13)	
Government support provides needed guidance	5
Raises awareness and provides educational opportunities	4
If there is public interest	4

support could provide guidance on implementation and long-term protection: "we don't specify what types of plants or trees are required in our zoning codes, so food-producing trees and shrubs are allowed but not commonly planted. I think council should set policy to encourage those types of plantings." Another explained, "it must be in the code and comprehensive plan. If it's not in the code, when [the] current council or mayor leaves, the next generation would not know what to do. These codes and plans ensure that they will be allowed for a long period of time (unless the people want to re-zone)."

4 | DISCUSSION

In this study, we expected that mayors of municipalities with less than 25,000 people would similarly value the environmental, social, economic, and health-related opportunities associated with public food forests, and that a lack of physical space and long-term maintenance and liability would be equally challenging in terms of public food forest projects in the towns they serve. Overall, we found that mayors of small municipalities place a higher value on social and health-related benefits, followed by environmental services. Economic benefits were not identified as an opportunity tied to public food forests, and long-term maintenance was by far the greatest challenge, followed by lack of space and liability related to falling and downed fruits and nuts.

Our comparison of mayoral perspectives regarding the acceptability of food forests and ease of implementation for their municipalities resulted in four mayoral-based municipality classifications, differing in levels of support, attitudes, and available space for food bearing trees and shrubs on public land: (a) ambivalent and resource-poor, (b) optimistic and capable, (c) doubtful and unsupported, and (d) unsure with potential. 'Optimistic and capable,' with the highest means

in each category, were characterized as having significantly greater capacity related to financial means and policy as well as political intention to plant woody perennials than those in ‘doubtful and unsupported,’ with the lowest means in each category. If mayors’ reports of their towns are a reliable indicator, this suggests that the likelihood of public food forest initiatives and complementary policies and procedures in small towns are likely to be influenced by the amount of available space, support for existing public green spaces, and town attitudes regarding implementation.

It is worth noting that ‘optimistic and capable’ contained the greatest number of towns with large population sizes (>10,000) and ‘doubtful and unsupported’ had the most towns with smaller populations (<500). Larger towns, therefore, might be more likely to adopt food forestry as a strategy to manage public lands. This coincides with what has been observed regarding greater use of public land for food production in cities, where populations are denser (Wu, 2014) and access to large private parcels is rare (Heynen et al., 2006). Moreover, larger towns, like cities, likely have greater resources (e.g., social, fiscal, physical) to support these initiatives on public land. Another trend worth exploring in future research is the geographic variation observed within groups. Nearly 40% of ‘optimistic and capable’ towns were located in the valley region vs. none for ‘doubtful and unsupported,’ which suggests that regional differences may also influence the potential for growth of public food forests.

Our findings suggest that mayors of small municipalities value preservation of public green space, and nearly 60% of respondents provided open-ended comments explaining the types of green space that they believed should be protected by land use codes. They primarily value green space for benefits other than job creation and food production, and key reported benefits were largely along the lines of cultural and community services, such as recreation and aesthetics. These results support what is known about long-standing views of public food forests among municipal leaders, in that they largely are recognized for civic functions, and communities often prioritize these services over food production (Bukowski & Munsell, 2018; Clark & Nicholas, 2013). Thus, emphasizing civic and cultural benefits may be a more salient strategy for public food forest initiatives, wherein designs favoring those objectives also fold in functions such as nutrient cycling, microclimate and flood regulation, and food and fiber production.

Educational goals can potentially play an important role in advancing public food forest production, given that nearly three-fourths of the mayors in our study indicated that they support outdoor education. Food forests differ from other forms of green space by functioning as classrooms for topics like growing food, nutrition, and cooking (Lautenschlager & Smith, 2007). Since U.S. municipalities spend the most on education and the least on environmental services (Congressional Budget Office, 2010), framing public land use such

as food forests, edible hedges, and public orchards as holistic centers for community education, nutrition, and wellbeing rather than singular food-producing hubs could be a compelling pathway for increasing and shaping complementary land use policies.

Still, one-third of municipalities in this study lack food production systems on public land, and almost none have policies outlining which species and practices are permitted and where. Mayors explained that one basic impediment is a general lack of public space but most also believed there is widespread lack of interest in the public sphere because residents already grow food on private property. In contrast, many residents in larger urban areas do not have private land apt for food production, especially forms that include woody perennials because of spatial and temporal requirements (Heynen et al., 2006). This may also explain why food production on public land, as well as the creation of supportive policies, has been more popular in cities than in towns.

Where food production exists on public land in towns, mayors reported that most were community gardens rather than multiple-storied systems including woody perennial food-producing species for public access. The intentional use of food trees and shrubs is largely absent, yet around three-fourths of mayors indicated that there are no legal constraints to their implementation. Perhaps this could be viewed as counterintuitive where nothing is specifically prohibited; it is likely more reasonable to suggest that an uptick in use is contingent on policies that define possibilities and outline implementation (Orach & Schlüter, 2016; Fernandez, 2013).

Some mayors believe that municipal governments “can push people in the right direction” using policy mechanisms but others are opposed to “forcing an issue” through a regulatory approach, especially if there appears to be no public interest. If policy formation proceeded in earnest, it would be important to consider how the structure and function of food forests would complement other more common uses and visions of public green space. In other words, focusing on tangible benefits rather than abstract concepts likely would generate more favorable public interest (Busch & McCormick, 2014). For example, language like ‘ecosystem services’ may seem obscure to residents of small towns, but emphasizing educational and recreational opportunities would more likely resonate with the public.

Along these lines, food forest production can be integrated into town landscapes without increasing pressure on classic green space, about which most mayors in this study were quite protective. For example, edible shrubs and trees can be implemented along existing greenways in towns (Bentrup et al., 2001). Additionally, current forest patches can be transformed into edible landscapes by planting food-producing understory species (McLain et al., 2012). Towns also can make use of unusual or underutilized areas (e.g., rooftops, medians, or streets), especially if competition for public land

use is high (Lovell, 2010). This integration is an asset, and some larger U.S. municipalities have started to retrofit, or ‘agrifit’, extant grey and green infrastructure along these lines (Clark & Nicholas, 2013; House, 2009).

According to mayors, the greatest barrier to implementing food bearing trees and shrubs in public spaces is maintenance. Confounding this challenge is that municipal policies explicit to food production on public lands are rare according to mayors, thus the permissible structure, function, and locus of such initiatives are largely undefined. Establishing comprehensive plans and land use codes may alleviate concerns related to long-term maintenance by specifying design relative to placement and scale. It also would ensure that when political turnover occurs, established processes and practices carry forward, as some mayors have suggested. Mayors in favor of formal zoning mechanisms argued that policies are necessary for guiding municipalities if other assets (e.g., physical or financial) are lacking, whereas those who were opposed felt that awareness and education were best practices. Either way, community-wide dialogue may be needed as a precursor to policy change to better understand public interest and preferences and to weigh associated costs and benefits. In open-ended comments, mayors pointed out that educational opportunities for residents and town councils could arise from such discussions.

Governments or community members who are interested in implementing food-producing trees and shrubs in public spaces also would do well to consider the type of municipality wherein their efforts will occur. For example, ‘optimistic and capable’ towns, which were characterized as having the most area available and greatest support for public green space and the most favorable attitudes regarding implementation, might consider larger initiatives like community food forests or public orchards. ‘Unsure with potential’ towns may have ample space, but a better understanding of how they could sustain support would be needed before taking steps like changing land use codes. ‘Ambivalent and resource-poor’ towns may be space limited, but they could try agrifitting or making use of underutilized spaces. ‘Doubtful and unsupported’ towns lack physical space and support needed for implementation, and, therefore, may decide that adding food production to what little public space they have is not currently feasible. Ultimately, the needs and limitations of U.S. towns are unique, thus public food forest implementation and design will differ.

5 | CONCLUSION

Public food forests offer many potential benefits for towns, which can be prioritized in various ways to achieve unique municipal goals and meet resident needs. Municipal governments and residents would benefit from assessing possible

opportunities and challenges together. By doing so, and when public food forests gain traction in the public sphere, they will be more likely to find an approach that optimizes collectively valued ecological, educational, and public health benefits.

For towns in this study, some residents are likely interested in public food forests or other forms of perennial food production, but a lack of policy, government support, and other resources may deter them from taking action. The use of multiple stakeholder processes, including government officials, community members, and scientific or technical experts, is a strategy that towns could adopt when making such determinations and decisions (Dubbeling & Mertzthal, 2006). Involving communities in decisions over public land use builds crucial social capital, or the “trust, networks, and norms of reciprocity that enable people to effectively work together” (Butterfoss & Kegler, 2018, p. 314).

Small municipalities are changing worldwide, and this has implications for managing green space in built environments (Forman, 2019). Ecosystems likely will be strained in coming decades as human population growth continues, thus heightening the need to strengthen local resilience. Access to private land could increase for some and decrease for others, which may influence the extent to which communities prioritize the use of public land for food production. If this study is an indicator, then the majority of communities with small populations (and thus most incorporated municipalities) in the United States and likely the world over have not developed policies to promote food production, let alone food forests, in public spaces. Planning to do so would demonstrate progressive policymaking on behalf of local governments.

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AUTHOR CONTRIBUTIONS

Sarah E. Coffey: Conceptualization; Data curation; Formal analysis; Investigation; Methodology; Project administration; Resources; Supervision; Validation; Visualization; Writing-original draft; Writing-review & editing. John F. Munsell: Conceptualization; Formal analysis; Funding acquisition; Methodology; Project administration; Resources; Supervision; Validation; Visualization; Writing-original draft; Writing-review & editing. Rico Hübner: Methodology; Supervision; Validation; Writing-review & editing. Curtis R. Friedel: Methodology; Supervision; Validation; Writing-review & editing.

DATA AVAILABILITY STATEMENT

Survey data are available at <https://doi.org/10.5061/dryad.5hqbzkh5j>

CONFLICT OF INTEREST

The authors declare no conflicts of interest.

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