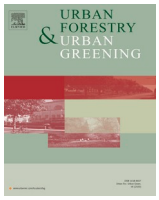
Urban Forestry & Urban Greening 69 (2022) 127490

Contents lists available at ScienceDirect

Urban Forestry & Urban Greening

journal homepage: www.elsevier.com/locate/ufug



Economic Contribution Analysis of Urban Forestry in the Northeastern and Midwestern States of the United States in 2018

Rajan Parajuli [a,*], Stephanie Chizmar [a], Morgan Hoy [a], Omkar Joshi [b], Jason Gordon [c], Sayeed Mehmood [d], James E. Henderson [e], Jagdish Poudel [f], Olivia Witthun [g], Laura Buntrock [g]

[a] Department of Forestry and Environmental Resources, North Carolina State University, Raleigh, NC, United States
[b] Department of Natural Resource Ecology and Management, Oklahoma State University, Stillwater, OK, United States
[c] Warnell School of Forestry and Natural Resources, University of Georgia, Athens, GA, United States
[d] School of Environment and Natural Resources, Ohio State University, Columbus, OH, United States
[e] Coastal Research & Extension Center, Mississippi State University, Biloxi, MS, United States
[f] Michigan Department of Natural Resources, Forest Resources Division, MI, United States
[g] Wisconsin Department of Natural Resources, Division of Forestry, WI, United States

ARTICLE INFO

Handling Editor: Dr. Richard Hauer

Keywords:
Employment
Industry output
Input-output modeling
Landscaping
Urban and community forestry

ABSTRACT

Urban and community forestry is an increasingly integral component enhancing the well-being of urban places. Along with providing aesthetic benefits and other critical ecosystem services, urban forestry contributes to local and regional economies by supporting jobs and economic activities through various businesses and industries. In this study, we estimated the economic contribution of urban forestry to the regional economy in terms of several economic and business metrics including jobs, labor income, value-added, and tax collections. To this end, we developed an extensive scope of urban forest industries and activities incorporating all private, public, and non-profit businesses and organizations involved in urban forestry in the Northeastern and Midwest states. Results from the input-output modeling suggest that in 2018, urban forestry in the Northeastern and Midwest states directly contributed $17.6 billion in industry output and $13.5 billion in value-added by supporting about 258,550 full- and part-time jobs in various businesses and activities. Including direct, indirect, and induced effects, urban forestry in the region had a total contribution of $34.7 billion in industry output to the regional economy, employing more than 357,200 people with a payroll of about $16 billion. These numbers are crucial to highlight the economic significance of urban forestry businesses and agencies as well as to educate the public, economic development professionals, and legislators about the importance of urban and community forestry in the Northeastern and Midwest states.

1. Introduction

Urban forests are an integral component of cities, towns, and communities because they provide critical ecosystem services to continuously increasing urban populations in the United States. Urban forestry involves various tree management and maintenance activities in over 141 million acres of urban landscape in the United States (USDA Forest Service, 2021a). In addition to private commercial arboriculture and other businesses, municipal and county governments, non-profit organizations, and utility sectors are also key providers of urban forestry related activities contributing substantially to local and state economies. For the purposes of this research, we define urban forestry as the establishment, conservation, protection, and maintenance of trees in cities, suburbs, and other developed areas. We refer to all sectors involved in urban tree management as the urban forestry sector, including activities that contribute to urban forestry such as landscape management, landscape architecture, nurseries and tree distributors, and equipment dealers.

Over the past several decades, there has been increased interest in maintaining and improving trees and forest resources in urban and surrounding areas. In 1990, lawmakers amended the Cooperative Forestry Assistance Act to expand authorities of the USDA Forest

* Corresponding author.
E-mail addresses: rparaju@ncsu.edu (R. Parajuli), sjchizma@ncsu.edu (S. Chizmar), mahoy@ncsu.edu (M. Hoy), omkar.joshi@okstate.edu (O. Joshi), jason.gordon@uga.edu (J. Gordon), mehmood.9@osu.edu (S. Mehmood), jeh149@msstate.edu (J.E. Henderson), poudelj@michigan.gov (J. Poudel), olivia.witthun@wisconsin.gov (O. Witthun), laura.buntrock@wisconsin.gov (L. Buntrock).

https://doi.org/10.1016/j.ufug.2022.127490
Received 20 August 2021; Received in revised form 12 January 2022; Accepted 24 January 2022
Available online 26 January 2022

Service's Urban and Community Forestry Program (USDA Forest Service, 2021b). Since then, urban forestry has evolved into a complex field composed of diverse stakeholders, businesses, and communities. However, lack of a standard accounting framework for estimating the scale and economic and social benefits of urban forestry efforts has hindered the successful planning and further expansion of urban and community forestry programs across the nation (National Urban and Community Forestry Advisory Council, 2015). Major obstacles in managing urban forestry programs are in part due to the different terminology or lack of consistent definitions, which create challenges for estimating the size, contributions, and impact of the industries that support and manage urban forests and related activities.

Economic contribution analysis of the urban forestry industry helps communicate to policy makers the industry's monetary benefits in terms of dollar values and jobs. Since 1978, Impact Analysis for Planning (IMPLAN) has been used to model economic impacts of resource outputs on local communities. The software program is commonly used to quantify indirect effects and induced effects based on an input-output modeling of a production function. Although originally developed by the U.S. government to understand economic contributions of the forest products industry, IMPLAN is currently a fee-based private enterprise (IMPLAN, 2021). Over the last twenty years, economic contributions analyses have tended to differ in scope, data used, input-output methodology, and measures reported. Further, while state-level and regional economic contribution analyses covering forest products industry are common (Henderson et al., 2017; Joshi et al., 2017; Parajuli et al., 2018; Pelkki and Sherman, 2020), limited studies have focused on the urban forestry context. This gap is partly explained by the historical economic and cultural importance of the forest product industry, but also by the complexity of the urban forest sector which is not easily segregated from broader green industry contributors in urban places.

While numerous studies estimated economic contributions of the green industry within distinct regions across the United States, only a few studies have specifically examined the urban forestry economic contributions by separating the urban forestry portion from broader green industry sectors (Table 1). Most of the private green industry sectors are well defined by IMPLAN and the North American Industry Classification System (NAICS), so it is relatively easy to conduct economic contribution analysis of the overall green industry. Hall et al. (2006) first estimated the national-level economic impacts of the green industry in the United States using the IMPLAN data in 2002, and continued updating this analysis periodically (Hall and Dickson, 2011; Hodges et al., 2015; Hall et al., 2020). Hall et al. (2020) estimated that in 2018, the green industry in the United States had a total economic contribution of $348 billion in industry output, which supported over 2.3 billion jobs within the broader national economy. Palma and Hall (2015) and Gale (2021) also estimated the economic contributions of the green industry to the Texas and Utah economies, respectively.

Templeton and Goldman (1996) were the first to estimate economic impacts of urban forestry activities in California, which was later updated with new datasets and methodology in Templeton et al. (2011). Based on the extensive data collected from primary and secondary sources to account for involvements of households, commercial businesses, and utilities, Templeton et al. (2011) estimated that in 2009, urban forestry in California contributed over $3.5 billion economic output by supporting about 58,770 full- and part-time jobs (Table 1). Similarly, other studies in economic contributions of urban forestry in the state economy include Hodges and Court (2019) in Florida, Tian and Stottlemyer (2019) in Texas, and Georgia Forestry Commission (Georgia Tech, 2021) in Georgia (Table 1). Of note, these studies are widely varied in terms of defining the scope of urban forest industries, data sources, and the analysis methodology of input-output analysis. Further, except Templeton and Goldman (1996), all other studies are non-peer reviewed reports.

The limited and inconsistent efforts in economic contribution analysis of urban forestry are due primarily to two reasons: (a) there are currently no established IMPLAN or NAICS sectors that correspond specifically to urban forestry and (b) there is no standard framework of the urban forestry sector so that it can be segregated easily from broader green industries. Since IMPLAN does not have a defined industry sector specific to urban forestry, the economic activity of urban forestry can be represented by parts into multiple industries within the broader IMPLAN green industry sectors. IMPLAN integrates urban forestry related private businesses into the broader green industries, and public sector involvement is not well distinguished in the industry classification system. Hence, the previous studies in urban forestry economic analysis either overlooked the public sector involvement (e.g., Georgia Tech, 2021) or relied on dated secondary information to estimate private sectors' contributions (Tian and Stottlemyer, 2019). Further, Templeton et al. (2011) incorporated both private and public sectors in their analysis, but their methodological framework is almost impossible to replicate in other states as they utilized data sources only found in California.

In contrast, Hodges and Court (2019)'s methodological approach in identifying the scope of urban forest industries in Florida, as well as the input-output analysis, are replicable, relatively inclusive, and up-to-date. By surveying the related private businesses, Hodges and Court (2019) separated the urban forestry portion from the green industry, and utilized a national survey of municipal tree care and management (Hauer and Peterson, 2016) to estimate the public sector involvement in urban forestry in Florida. However, their approach still excluded various segments of urban and community forestry including proprietary jobs in urban forestry specifically in landscaping and tree care services, other public agencies except city governments, non-profit organizations, and higher education institutions. Their IMPLAN analysis approach is also not clear as to whether they accounted for margin analysis for wholesalers and retailers, and the public sector's economic contribution using the analysis-by-parts method.

The main purpose of this study was to estimate the economic contribution of urban forestry in the Northeastern and Midwest states of the United States. First, we developed a definition of urban forestry that characterized the scope of the sectors in this region. We incorporated all private, public, and non-profit businesses and organizations related to

Table 1
Previous studies on economic impact and contribution analysis of urban forestry in various states in the U.S. This is not an exhaustive list.

Region	Year(s)	Title	Author(s)	Results
California	1990s	Estimating Economic Activity and Impacts of Urban Forestry in California with Multiple Data Sources form the Early 1990s	Templeton and Goldman (1996)	57,200 jobs $3.384 billion in output $1.86 billion in wages
California	2009	Impacts of Urban Forestry on California's Economy in 2009	Templeton et al. (2011)	58,769 jobs $3.53 billion in output $3.26 billion in wages
Florida	2017	Economic Contributions of Urban Forestry in Florida in 2017	Hodges and Court (2019)	80,808 total job $8.4 billion in output $3.4 billion in wages
Texas	2017	Economic Impact of Urban Forests in Texas	Tian and Stottlemyer (2019)	43,430 job $2.5 billion in output $1.3 billion in wages
Georgia	2019	2019 Economic Benefits of the Forest Industry in Georgia	Georgia Tech (2021)	48,244 jobs $4.8 billion in output $2.03 billion in wages

urban forestry in the region. We then compiled the employment profile of all the related industries and agencies through online surveys and public sources. We used the IMPLAN software to estimate the economic contribution of urban forestry to the regional economy in terms of several economic and business metrics including jobs, labor income, value added, and tax collections. Building on Hodges and Court (2019)'s methodological approach, we developed an extensive scope of urban forestry sectors and industries by incorporating the involvements of private, public, higher education institutions, private utility companies, and non-profit organizations.

Further, we employed a standard method of economic contribution analysis (Parajuli et al., 2018) along with the margins analysis for wholesalers and retailers in the private sector, and the analysis-by-parts approach for public sectors' contribution analyses. We have explained all the methodological steps with well-defined data sources. Our methodology can be applied in similar economic contribution analyses of urban and community forestry industries, regardless of the size and scope of the study area. These estimated regional economic contribution numbers are crucial to highlight the economic significance of the urban forestry businesses and agencies as well as to educate the general public, economic development professionals, and legislatures about the importance of urban and community forestry in the local and regional economies. Moreover, this study serves as a baseline for future studies to track trends in the performance of urban forestry in terms of economic contributions in line with the anticipated future economic patterns and compares to the economic contribution of green industries for the region.

2. Methods and materials

2.1. Scope of urban forestry industries and activities in Northeastern and Midwest States

The first crucial step of economic contribution analysis was to delineate the scope of urban forest industries and activities in the study region. The study region covers 20 Northeastern and Midwest states and Washington D.C. (Fig. 1). This region aligns with the US Forest Service's Region 9, and these states work together for the multi-state US Forest Service funding via Landscape Scale Restoration grants. Additionally, these 20 states and Washington D.C. comprise the Northeast-Midwest State Foresters Alliance. Based on extensive review of available literature and close examination of the structure of green industries, we developed a list of private industries as well as public agencies and non-profit organizations involved in urban forestry (Table 2). The developed scope of urban forestry industries and activities was discussed with state agency urban forestry employees from each participating state and other stakeholders followed by a survey of the same members to provide their quantitative input. These activities resulted in the following final list of urban forestry related industries and activities in both private and public sectors.

2.2. Surveys

Once the scope of urban forestry related industries and activities in the study region was finalized, we employed regional online surveys to

Table 2
Scope of urban forestry related industries and activities in Northeastern and Midwest states.

Various sectoral groups
1. Private industries
· Nursery and tree production (NAICS 111421)
· Farm and garden machinery and equipment merchant wholesalers (NAICS 423820)
· Nursery stock and florists' supplies merchant wholesalers (NAICS 424930)
· Nursery, garden, and farm supply stores (NAICS 444220)
· Landscape architectural services (NAICS 541320)
· Landscaping services (NAICS 561730)
2. Private (investor-owned) utility companies
3. Public sectors
· Cities
· Counties
· State agencies involved in urban forestry
4. Higher education institutions
5. Non-profit organizations

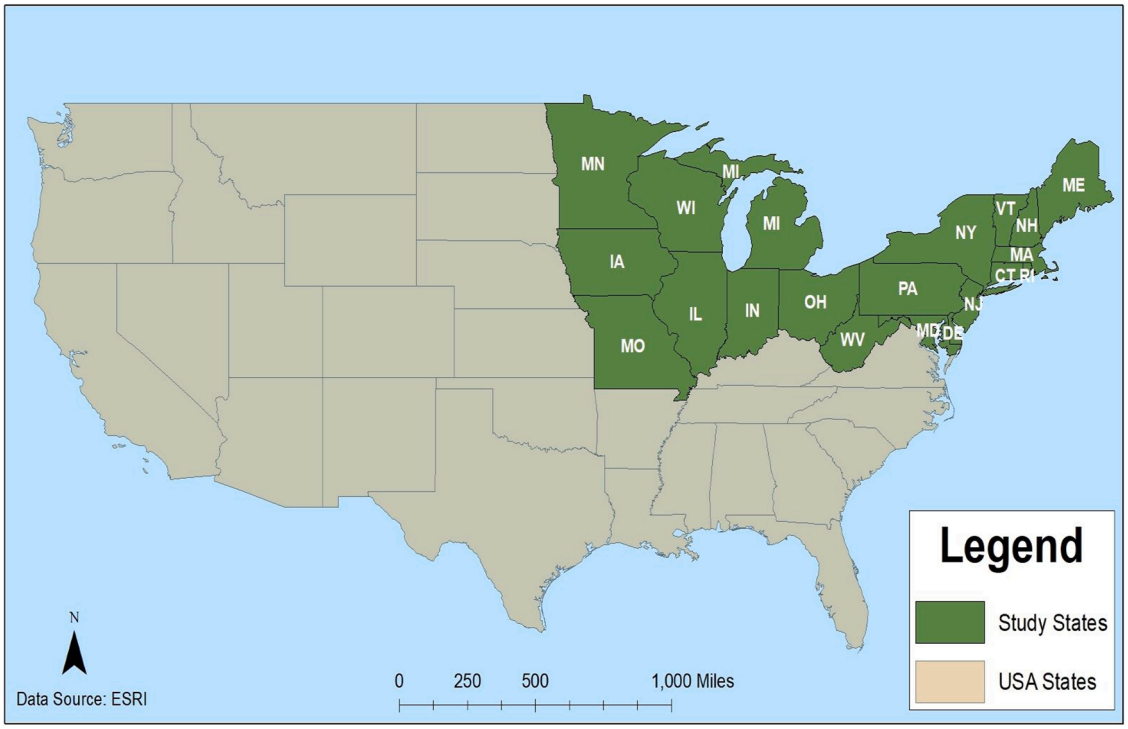


Fig. 1. Map depicting the 20 states and Washington D.C. from the Northeastern and Midwest region included in the study.

Table 3
Survey samples and responses.

Group Surveyed	Contacted	Opted out	Non-contact	Survey Responses, including partial completes	Adjusted response rate
Private Businesses	21,922	636	20,719	630	3.0%
Public (County & Municipal Government) agencies	2,157	38	1,711	408	19.3%
State Agencies	21	–	–	21	100%
Higher Education Institutions	252	3	183	66	26.5%
Investor-Owned utility company	172	4	158	10	6%
Non-Profit Organizations	335	3	250	82	24.7%

separate contributions specific to urban forestry industries from the broader green industries and to quantify contributions of the urban forestry activities in public and non-profit agencies. The survey instruments were primarily focused to estimate the number of employees in all private companies and public agencies involved in urban forestry businesses and activities in 2018. The survey instruments were approved with exemption by North Carolina State University Institutional Review Board. As a part of this broader project, the University of Wisconsin Survey Center (UWSC) was separately contracted by the Wisconsin Department of Natural Resources to administer these surveys in the 20 states and Washington D.C. The UWSC employed regional online Qualtrics surveys with an emailed recruitment invitation. Email contacts of private businesses involved in the green industry were purchased from Exact Data, which compiles the contact information of businesses by their NAICS codes. We worked with state agency urban forestry employees to collect emails associated with public agencies and other groups in all study states. Dillman et al. (2014)'s approach was applied in survey administration: the initial email invitation with a Qualtrics link was followed by three email reminders with no incentives. Table 3 provides a breakdown of sample sizes and responses received based on each group surveyed.

2.3. Employment in urban forestry

Using the data obtained from primary surveys, we developed a complete profile of employment statistics associated with urban forestry businesses and activities for each group, which was a key input in IMPLAN modeling. For the private industries, we obtained 2018 employment numbers in each NAICS category from the Quarterly Census of Employment and Wages (QCEW), US Bureau of Labor Statistics (US BLS, 2021). Since QCEW does not incorporate self-employed jobs and the businesses with their social insurance programs (IMPLAN Data Team, 2021), we utilized the 2017 IMPLAN data to compute proprietary jobs specifically in landscaping services (NAICS 561,730) and nursery and tree production businesses (NAICS 111421). IMPLAN augments proprietary jobs to the QCEW employment statistics using the Regional Economic Accounts (REA) data from the Bureau of Economic Analysis (IMPLAN Data Team, 2021). We estimated the proportions of self-employed jobs to the QCEW reported statistics for the IMPLAN industries 6, 449, and 469 in 2017, and used those proportions to estimate total jobs in their respective industries in 2018 (Table 4). Next, we used the average percentage of jobs involved in urban forestry obtained from our survey of the private sector to estimate the total number of urban forestry jobs in each private green industry business in the study region. The estimated average urban forestry portions in the green industry jobs are comparable to Hodges and Court (2019)'s similar survey in Florida. We estimated that there were 237,455 jobs in urban forestry in 2018, directly supported by private businesses involved in green industries (Table 4).

Since investor-owned private utility companies are also involved in tree line clearing and vegetation management in urban and suburban regions, we included their involvement in urban forestry in the study region. Our regional survey did not produce meaningful statistics from these surveyed investor-owned utility (IOU) companies, as we were able to collect only four usable responses from IOUs. For this information, we relied on a recent study of urban forestry economic analysis at a national scale conducted by Thompson et al. (2021). According to their survey of IOUs participating in Tree Line USA, the average per company in-house expenses of IOU companies in vegetation management in our study region was $2.25 million per year. We estimated the total expenditures of IOUs in vegetation management by multiplying the number of IOUs in the study states by the average expenditures per company. Based on the total expenditures, we imputed the total number of urban forestry jobs (5991) in the study region supported by IOUs in landscaping and horticultural services (IMPLAN Industry 469) by using the state-level IMPLAN models.

We estimated total public employees involved in urban forestry based on the population size of the jurisdiction that these agencies served in the study region. We obtained the number of cities and counties in all 20 states and Washington D.C. by their population sizes from the U.S. Census Bureau, Population Division (US Census Bureau, 2020). We used the average numbers of employees in a city and county estimated from our regional survey to estimate the total number of jobs in urban forestry employed by city and county governments (Table 5). For the cities with population less than 250,000, the estimated average jobs in urban forestry per city are consistently smaller than Hodges and Court (2019)'s estimates in Florida as well as national averages reported by Hauer and Peterson (2016). Our job estimates for the cities with population ranging from 250,000–1 million are larger than the numbers reported by Hauer and Peterson (2016). Altogether we estimated that in 2018, county and city governments in these states employed 11,673 people directly working in urban forestry activities. Moreover, we also collected the number of employees in state forestry or natural resources

Table 4
Urban forestry jobs in the private sector.

Industry type (NAICS code)	IMPLAN Industry, 2017	Total jobs in 2018	Percentage jobs in urban forestry (%)[a]	Jobs in urban forestry (UF)
Nursery and tree production (111421)	6	33,850	23.33	7,897
Farm and garden machinery and equipment merchant wholesalers (423820)	399	40,569	16.00	6,491
Nursery stock and florists' supplies merchant wholesalers (424930)	399	14,995	28.44	4,265
Nursery, garden, and farm supply stores (444220)	395	49,264	18.97	9,345
Landscape architectural services (541320)	449	12,341	19.56	2,414
Landscaping services (561730)	469	483,970	42.78	207,042
Total				237,455

[a] Estimated from the private sector survey.

agencies directly involved in urban forestry. According to the information collected from state representatives, in 2018, state agencies employed 263 full-time, part-time, and seasonal positions in the study region.

Similarly, we estimated the total jobs related to urban forestry supported by higher education institutions based on their student enrollment size. We first collected the total number of higher education institutions and student enrollments from various publicly available sources in each state. We estimated the total urban forestry jobs in colleges and universities by multiplying the number of institutions by the average number of jobs per institution estimated from our regional survey of higher education institutions (Table 6). In 2018, there were 1231 direct jobs from higher education institutions involved in urban forestry activities in the study region. Of note, these jobs include full-time, part-time, and seasonal employees recruited by the institutions to work on various urban forestry related activities. Besides university faculty positions, maintenance staff such as facilities and building maintenance personnel, arborists, and landscape and groundkeepers fully or partially involved in urban forestry were incorporated.

We also estimated the total jobs related to urban forestry supported by non-profit organizations (NPOs) in the study region. We estimated from our regional survey of NPOs that on average, a NPO supports 3.76 jobs in landscaping services, 1.29 jobs in forestry consulting services, and 0.65 jobs in architectural services (Table 7). State agency urban forestry employees from the study states collected the names and contact information for the non-profits in their states. Collectively, we estimated that in 2018, NPOs in the 20 states and Washington D.C. supported 1938 jobs directly working in urban forestry activities.

2.4. Economic contribution analysis

Economic contributions are usually evaluated in terms of several business and economic metrics such as employment, labor income, value-added, industry output, and local, state, and federal tax collections. We used the IMPLAN software, an input-output regional economic modeling system, to estimate economy-wide ripple effects in the regional economy stemming from direct economic activities in urban forestry related industries. We aggregated state-level IMPLAN models from these states to develop a regional input-output model with a trade flows specification and social accounts for households. In terms of an economic contribution method, we employed Method 1 for multi-sector contribution analysis explained in Parajuli et al. (2018). We normalized commodity production coefficients to one and zeroed out local use ratios for the directly related IMPLAN industries to account for the contribution analysis in the existing industries in the aggregate regional economy.

Table 5
Urban forestry jobs in public agencies.

Population	Number of cities	Number of counties	Jobs in UF per city[a]	Jobs in UF per county[a]	Jobs in UF
<2,500	6,080	2	0.23		1,420
2,500-4,999	1,033	476	0.70	0.15	794
5,000-9,999	815	507	1.38	0.15	1,195
10,000-24,999	746	558	3.49	0.46	2,861
25,000-49,999	316	427	3.54	0.65	1,398
50,000-99,999	164	258	6.24	0.99	1,277
100,000-249,999	41	189	6.73	1.46	563
250,000-499,999	13	83	26.44	3.71	651
500,000-999,999[b]	7	54	77.10	9.40	1,125
>1,000,000[c]	3	16	80.00	3.50	399
Total					11,673

[a] Average number of employees per city and county estimated from the regional survey of public agencies.
[b] 155 additional employees from Milwakee, WI were added.
[c] 183 additional employees from Chicago, IL were added.

Table 6
Urban forestry jobs in higher education institutions.

Student enrollments	Number of institutions	Jobs in UF per institution	Jobs in urban forestry (UF)
5,000—10,000	191	0.85	162
10,000—20,000	123	2.18	268
>20,000	75	10.68	801
Total	389		1,231

Table 7
Urban forestry jobs in non-profit organizations: 340 organizations in the study region.

NPO's involvement	Jobs in UF per organization	Jobs in urban forestry (UF)
Landscaping services (561730)	3.76	1,278
Urban forestry consulting (1153)	1.29	439
Landscape architectural services (541320)	0.65	221
Total	5.70	1,938

In the regional IMPLAN model, the employment statistics from Tables 4–7 were entered to set up events and activities in respective IMPLAN industry sectors. For instance, urban forestry jobs in landscaping services, nursery and tree production, and landscape architectural services supported by the private sector were entered in IMPLAN sectors 469, 6, and 449, respectively. The industry sectors involved in retail and wholesale businesses (IMPLAN 395 and 399) were adjusted using the margins analysis (Clouse, 2021). Jobs supported by investor-owned private utility companies were entered in IMPLAN industry 469 corresponding to their main effort in landscaping and tree line clearing businesses.

Modeling the contribution of government enterprises and public universities is quite complicated in IMPLAN, as the IMPLAN industry sectors representing employment and payroll of government employees do not consist of intermediate expenditures attributed to them directly (Clouse, 2021). Since we have developed a complete employment profile of these local and state governments, higher education institutions, and non-profit organizations, we applied the analysis-by-part (ABP) method for the labor income spending pattern for all these public agencies and non-profit organizations. The spending patterns of these government payroll jobs should be linked with private industries. As public agencies and organizations are mostly involved in arboriculture, tree planting, and management, their contributions are lined up well with IMPLAN industry 469. Hence, to model public sector's economic contribution, we first imputed expenditure values from the jobs profile in IMPLAN sector 469, and then using those expenditure values, we employed the labor income ABP procedure to estimate indirect and induced effects in IMPLAN sector 469 by the public agencies (Lucas, 2019; B. Barlow personal communication). We applied this procedure to estimate the economic contribution of the involvement of counties, cities, state agencies, higher education institutions, and non-profit organizations in urban forestry. Moreover, we have estimated social accounting matrix (SAM) multipliers of each economic metric, which are the ratios of total effects to the direct effects. SAM multipliers explain the extent to which an industry contributes to the wider local economy through purchases, payments of wages and taxes, and other transactions related to household expenditures.

3. Results

Table 8 presents the summary economic contribution results obtained from individual IMPLAN scenarios representing each sector of urban forestry in the 20 states and Washington D.C. Based on the input-output modeling, we estimated that in 2018, urban forestry in the Northeastern and Midwest states directly supported 258,550 full- and

part-time jobs in various businesses and activities. The total job contribution of urban forestry including the direct, indirect, and induced employment was 357,215. In terms of labor income, urban forestry in this region collectively contributed about $10.4 billion directly, and over $16 billion including the multiplier effects throughout the regional economy.

Similarly, in terms of value-added, which is equivalent to gross domestic product, urban forestry in the study region contributed approximately $13.5 billion to the regional economy directly, and if we account for the indirect and induced effects, the total value-added contribution in 2018 was about $23.4 billion (Table 8). In terms of industry output representing all economic activities, the direct and total contributions of the regional urban forestry were approximately $17.6 billion and $34.7 billion, respectively. The overall SAM multiplier associated with employment was estimated to be 1.38, indicating that every job in urban forestry in these states resulted in another 0.38 jobs in other sectors of the economy. Similarly, every dollar generated in urban forestry contributed an additional 97 cents in industry output to the rest of the regional economy.

The economic contribution of urban forestry varies widely among the sectors. The private sector, predominantly landscaping services, represents about 92 % of the direct jobs and industry output in the study region. The public agencies (city, county, and state agencies) collectively contributed about $1.2 billion in total industry output by supporting approximately 13,800 jobs to the regional economy (Table 8). Similarly, higher education institutions and non-profit organizations had total job contributions of 1430 and 2270, respectively. We estimated that the private sector had the highest SAM multiplier values in all metrics. The SAM value of 2.00 associated with the industry output of the private sector indicates that every dollar generated in urban forestry by the private sector contributed an additional $1.00 to the regional economy.

Urban forestry in the study region also had substantial contributions to the local or state and federal taxes (Table 9). In 2018, urban forestry businesses and employees in the study region paid over $988.68 million in state and local taxes and about $2.1 billion in federal taxes. Most of the state and local taxes were collected on production and imports of goods, followed by household taxes. Employee compensation and households were the major categories contributing to about 90 % of federal taxes collected directly from urban forestry businesses and employees in the region.

Table 10 presents the top 10 industries in the region that have the highest employment contributions from urban forestry. A total of 227,478 jobs with an industrial output of about $15.7 billion in landscape and horticultural services were contributed by the urban forestry in the study region. Urban forestry supported over 10,750 jobs in greenhouse, nursery, and floriculture production, about 9345 jobs in the wholesale trade industry, and about 7900 jobs in the retail sector in the study region (Table 10). Through the induced effects, employees in urban forestry in the study region supported a number of jobs in real estate, full-service and limited-service restaurants, and hospitals, playing a vital role in the overall regional economy.

Because the private sector represents over 92 % of the urban forestry industries in the region, we also explored the economic contribution of each industry within the private sector. Table 11 presents economic contributions of the private urban forestry industries in the study region. Among the six major business types, landscaping and tree care services (NAICS 561,730) represent about 85 % of the total contribution from the private sector in terms of all business metrics. Over 207,000 direct full- and part-time jobs were supported by private landscaping and tree care services in various aspects of urban trees management, plantation, and arboriculture services. Retailers and wholesalers involved in equipment and supplies needed in urban forestry also contributed over $872 million in industry output directly by supporting over 20,000 direct jobs in the region. The numbers were even higher when we accounted for indirect and induced effects in the regional economy stemming from direct employment and value-added services in urban forestry. In aggregate (direct, indirect, and induced effects), the private industries involved in urban forestry contributed over $32 billion in industry output and about $22 billion in value-added by employing over 331,400 people in the

Table 8
Economic contribution of urban forestry in Northeastern and Midwest States, 2018.

Sector	Employment (jobs)	Labor Income (million $)	Value-Added (million $)	Industry Output (million $)
Direct Effect				
Private sector	237,454	9,756	12,505	16,167
Investor-owned utilities	5,991	223	275	413
City government	9,591	357	440	661
County government	2,082	78	96	144
State agency	263	10	12	18
Higher education institutions	1,231	46	56	85
Non-profit organization	1,938	88	97	145
Total	**258,550**	**10,377**	**13,481**	**17,632**
Total Effect				
Private sector	331,446	14,957	21,897	32,359
Investor-owned utilities	8,205	350	498	800
City government	11,141	459	618	971
County government	2,418	100	134	211
State agency	305	13	17	27
Higher education institutions	1,430	59	79	125
Non-profit organization	2,270	109	132	205
Total	**357,215**	**16,046**	**23,376**	**34,696**
SAM Multiplier				
Private sector	1.40	1.56	1.75	2.00
Investor-owned utilities	1.37	1.57	1.81	1.94
City government	1.16	1.29	1.41	1.47
County government	1.16	1.29	1.41	1.47
State agency	1.16	1.28	1.40	1.47
Higher education institutions	1.16	1.29	1.41	1.47
Non-profit organization	1.17	1.24	1.36	1.41
Total	**1.38**	**1.55**	**1.73**	**1.97**

Economic contributions, based on multi-industry contribution analysis, are reported in 2018 dollars.

Table 9
Direct tax contribution of urban forestry in Northeastern and Midwest States, 2018.

Category	State/Local tax (million $)	Federal tax (million $)
Employee compensation	11	962
Proprietor income	0	82
Taxes on production and imports	637	67
Households	311	866
Corporations	30	109
Total	989	2,086

Table 10
Top 10 industries affected by jobs in urban forestry in the Northeastern and Midwest region.

Description (IMPLAN industry)	Employment (jobs)	Labor income (million $)	Value added (million $)	Output (million $)
Landscape and horticultural services (469)	227,478	8,471	10,435	15,679
Greenhouse, nursery, and floriculture production (6)	10,756	979	1,816	513
Wholesale trade (395)	9,345	408	623	359
Retail - Building material and garden equipment and supplies stores (399)	7,897	239	340	615
Real estate (440)	5,841	177	946	1,266
Full-service restaurants (501)	4,450	114	128	234
Hospitals (482)	4,264	348	395	715
Limited-service restaurants (502)	3,717	79	198	338
Employment services (464)	2,925	128	190	250
Architectural, engineering, and related services (449)	2,635	261	249	447

Northeastern and Midwest region.

In order to explore the state-specific economic contribution analysis of urban forestry, we also estimated the state-level IMPLAN models for all 20 states and Washington D.C. separately. Table 12 reports the economic contribution analysis of urban forestry by state. Among the states included in the regional analysis, the top five states in terms of the total jobs and industry output are Illinois, New York, Pennsylvania, Ohio, and New Jersey, all of which had over 33,000 jobs supported by urban forestry in their respective state economy. Other notable states with employment contributions exceeding over 22,000 jobs include Michigan and Massachusetts. States with over 15,000 jobs supported by urban forestry in 2018 are Maryland, Indiana, Wisconsin, Missouri, and Minnesota. Other state-specific business metrics in both direct and total contributions are presented in Table 12.

Table 11
Economic contributions of private urban forestry industries in the region.

Industries	Employment (jobs)	Labor Income (million $)	Value Added (million $)	Industry Output (million $)
Direct Effect				
Nursery and tree production	7,897	239	340	615
Farm and garden machinery and equipment merchant wholesalers	6,491	591	1,096	310
Nursery stock and florists' supplies merchant wholesalers	4,265	388	720	204
Nursery, garden and farm supply retailers	9,345	408	623	359
Landscape architectural services	2,414	239	228	409
Landscaping and tree care services	207,042	7,710	9,497	14,270
Total	**237,454**	**9,576**	**12,505**	**16,167**
Total Effect				
Nursery and tree production	10,156	369	566	1,020
Farm and garden machinery and equipment merchant wholesalers	11,264	856	1,548	1,072
Nursery stock and florists' supplies merchant wholesalers	7,401	563	1,017	705
Nursery, garden and farm supply retailers	13,339	632	1,014	1,014
Landscape architectural services	5,748	432	535	916
Landscaping and tree care services	283,538	12,105	17,218	27,631
Total	**331,446**	**14,957**	**21,897**	**32,359**

4. Discussion and conclusions

With rapidly growing urban populations, urban forestry has received considerable attention in recent years not only for trees' intrinsic values in urban and suburban landscapes but also for the economic significance of various businesses and industries relying on urban forestry. Estimating the economic contribution of urban forestry is somewhat challenging, as there are many broader industries that are tangentially related to urban trees and their management. As such, additional efforts are required to develop input-output models that characterize industry portions specific to urban forestry from other related sectors. Urban forestry relies on a large number of industry actors and a broad interpretation of the related industries resulting in higher estimates of the contribution of urban forestry to regional economies; however, such broad definitions also result in substantial overlap with other green jobs-reporting metrics and could result in confusion and double-counting. By developing a standard methodology and model set-ups to capture urban forestry related businesses and activities exclusively, we estimated the economic contributions of urban forestry in the Northeastern and Midwest states. Our approach attempted to establish a standard framework for estimating economic contribution analysis of urban forestry in any defined scale of regional economy. Therefore, study results are valuable to urban and municipal foresters, Extension professionals, public service leadership, and other policymakers to gauge the size and overall trend of economic contribution of businesses, industries, and organizations involved in urban forestry. To this end, our study makes an important methodological contribution and sets a milestone in urban forestry economic contribution analysis.

IMPLAN results suggest that most of the urban forestry-related employment opportunities are in the private sector, which collectively represents industries related to urban tree cares and services, nursery and tree production, machinery supplies, and landscape architecture, among others. These results also suggest that landscaping and tree care services were the most dominant private sectors contributing to more than 237,400 direct jobs in the region. These results are consistent with other studies (e.g., Hall et al., 2006; Palma and Hall, 2015; Hodges and Court, 2019), which also reported the significant economic contributions of landscaping services nationally and in state-specific analyses. Hall et al. (2020) reported that the landscaping industry represented approximately 63 % of total jobs among private green industries in the United States. Interestingly, the magnitude of SAM multipliers in the private sector industries were relatively higher compared to public sectors reflecting their diversified market channels, which indicates magnified ripple effects in the rest of the economy (Henderson et al., 2017).

Urban foresters and other professionals working in municipal and county governments are heavily involved in tree planting, care, and

Table 12
Summary of urban forestry economic contributions by states in 2018.

State	Employment (jobs)	Labor Income (million $)	Value Added (million $)	Industry Output (million $)
	Direct effects			
CT	9,271	421	533	770
DC*	475	21	23	37
DE	3,038	117	143	219
IA	6,267	237	344	553
IL	25,348	1,072	1,436	2,150
IN	12,829	455	591	942
MA	17,355	789	937	1,375
MD	15,391	607	793	1,189
ME	3,954	117	159	258
MI	20,442	751	954	1,507
MN	11,050	462	618	955
MO	11,945	395	530	880
NH	3,890	156	192	291
NJ	20,579	1,025	1,347	1,894
NY	26,611	1,161	1,528	2,233
OH	24,717	913	1,215	1,855
PA	25,246	984	1,223	1,882
RI	2,656	104	130	197
VT	1,780	59	81	128
WI	12,517	479	623	966
WV	3,194	109	141	222
	Total effects**			
CT	11,994	591	819	1,222
DC*	539	26	31	49
DE	3,815	156	221	342
IA	8,352	327	511	844
IL	34,830	1,601	2,373	3,699
IN	16,818	648	925	1,530
MA	22,937	1,136	1,505	2,289
MD	19,739	844	1,224	1,886
ME	5,056	164	245	410
MI	27,442	1,086	1,540	2,533
MN	15,262	690	1,004	1,624
MO	16,008	582	856	1,459
NH	5,094	219	300	468
NJ	27,691	1,454	2,074	3,078
NY	33,913	1,638	2,377	3,515
OH	33,214	1,315	1,950	3,126
PA	33,811	1,452	2,017	3,211
RI	3,471	144	204	317
VT	2,263	80	119	193
WI	16,725	672	973	1,572
WV	3,986	142	200	326

* DC is not a formal state but for our modeling purpose we ran Washington D. C. as a separate economy.

** Total effects from the individual state-level numbers do not sum to the total regional results because of the leakage effects.

management of more than 140 million acres of urban forests in the United States (American Forests, 2021). Although public sector employment from urban forestry in this region is minimal, results suggest a meaningful contribution of this sector in large metro areas. In other words, apart from the shade, health, and other ecosystem service-related benefits obtained from urban forests (Hardy et al., 2000; Donovan, 2017), public sector investments in urban forestry have paid off through employment opportunities and ripple effects in other sectors of the economy.

Since sales taxes and property taxes are the largest sources of general revenue for local governments (Gordon et al., 2016), larger cities have more revenue bases and higher operating budgets. However, findings from the primary survey of cities and counties suggest that there was no substantial difference between public sector urban forestry jobs between small- and medium-sized cities (Table 5). These findings suggest that urban forestry programs receive a lower priority in the budgets and programs of small- and medium-sized cities. By contrast, a few large cities such as Milwaukee and Chicago employ a significant number of people in urban forestry. Since local government responsibilities vary between the states and the counties (Carlee, 2021; Gordon et al., 2016), these results were not surprising.

Our study results suggest important management and policy implications. While the economic contribution analysis framework for the traditional forestry sector has long been established and results have been used in budget appropriations, attracting investments, and policy advocacy (Joshi et al., 2017; Henderson et al., 2017; Parajuli et al., 2018), limited efforts have been made to develop a similar comprehensive framework for identifying the scope and economic contributions of urban forestry. In particular, without well-defined urban forestry industries within the IMPLAN modeling setup, an across-the-board urban forestry framework has not been established. Using stakeholder input and rigorous discussion as a foundation, we developed an exhaustive scope of urban forest industries incorporating the involvements of private, public, non-profit, and higher education institutions in urban forestry. With the use of a relatively novel application of the analysis-by-parts method and margins analysis for wholesalers and retailers, our study has developed an input-output analysis framework for urban forestry, which can be used to generate comparable results regardless of the study region.

In addition to improving public awareness, our results are useful to policymakers at local, state, and federal levels. The results could provide justification for enhancement of existing programs or creation of new measures to support urban forest management. Furthermore, the comprehensive nature of this study leads to a complete picture of urban forestry contributions, including areas that need attention. For example, counties, municipalities, and public institutions vary widely in terms of their resource allocations and expenditures related to urban forestry. Results from this study could be used to develop targeted technical and financial assistance to jurisdictions that require capacity building. Private sector urban forestry industries could also use the results to highlight their importance while communicating with the public and policymakers. Since natural area forests in urban areas in the United States have been reportedly decreasing in recent years with a primary issue of lower public awareness (Pregitzer et al., 2021), the estimated business metrics from urban forestry could play a pivotal role in educating policymakers, stakeholders, and the public about the economic vitality of urban forestry in the local economies.

Response rates for our survey varied widely among the target groups. For example, response rates from the public sector, higher education institutions, and non-profit organizations were relatively higher compared to other studies based on web-based surveys (e.g., Sinclair et al., 2012). However, the response rate from private businesses (about 3%) was less than expected. The ongoing COVID-19 Pandemic could be one of the main reasons of lower survey responses from the private businesses. Of importance, survey responses were only used to solicit employment profiles of urban forestry industries and the total responses ($n = 630$) far exceeded the required samples to meet the 5% ($n = 384$) margin of error (Dillman et al., 2014). Similarly, the paired two-sample T-test between the first 10 % and the last 10 % responses of the private sector survey indicates that non-response bias might not be a major issue. We compared the full-time employment and total sales in dollars of the early versus late responders, and the T-statistics for both variables were statistically insignificant. Nonetheless, the lower responses are consistent with the finding that web-based surveys may be more effective for the groups with smaller population sizes (Sinclair et al., 2012). To this end, we suggest that future studies adopt the mixed-mode approach utilizing both paper-based and web-based platforms.

Conflict of interest

Authors declare that there is no conflict of interests regarding the publication of this paper in Urban Forestry & Urban Greening.

Declaration of Competing Interest

Authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements

This research is funded by the Wisconsin Department of Natural Resources as a part of the US Forest Service Landscape Scale Restoration Grant (Agency reference number: RFP 19-173-20). We would like to acknowledge urban forestry coordinators from all the study states for their assistance in survey administration and for providing inputs in various stages of this study. Similarly, we would like to thank two anonymous reviewers and associate editor for their constructive comments and suggestions on the earlier version of the manuscript. All remaining errors belong to us.

References

American Forests, 2021. Urban Forestry and the Role of Tree Equity. Retrieved August 18, 2021 from. American Forests. https://www.americanforests.org/our-work/urban-forestry/.

Carlee, R., 2021. Budgeting for Local Governments in the United States: Deciding Who Gets What, How Much, and Who Pays? Retrieved August 18, 2021 from BPA Studies. https://www.bpastudies.org/bpastudies/article/view/73/151.

Clouse, C., 2021. Margins and Deflators. IMPLAN. Retrieved August 18, 2021 from. https://implanhelp.zendesk.com/hc/en-us/articles/115009506007-Margins-Deflators.

Dillman, D.A., Smyth, J.D., Christian, L.M., 2014. Internet, Phone, Mail, and Mixed-mode Surveys: the Tailored Design Method. John Wiley & Sons, Inc, Hoboken, NJ. Print.

Donovan, G.H., 2017. Including public-health benefits of trees in urban-forestry decision making. Urban For. Urban Green. 22, 120–123. https://doi.org/10.1016/j.ufug.2017.02.010.

Gale, L., 2021. Performance and Contributions of the Green Industry to Utah's Economy [All Graduate Plan B and Other Reports]. Retrieved August 18, 2021 from. https://digitalcommons.usu.edu/cgi/viewcontent.cgi?article=2582&context=gradreports.

Georgia Tech, 2021. 2019 Economic Benefits of the Forest Industry in Georgia. Retrieved August 18, 2021 from. Enterprise Innovation Institute, Georgia Institute of Technology, Atlanta, GA, pp. 1–34. https://gatrees.org/wp-content/uploads/2021/01/2019-Forestry-Impact-Report-WEB.pdf.

Gordon, T., Auxier, R., Iselin, J., 2016. Assessing Fiscal Capacities of States [Research Report]. Retrieved August 18, 2021 from. Urban Institute, Washington, DC. http://www.urban.org/sites/default/files/publication/78431/2000646-Assessing-Fiscal-Capacities-of-States-A-Representative-Revenue-System%E2%80%93Representative-Expenditure-System-Approach-Fiscal-Year-2012.pdf.

Hall, C.R., Dickson, M.W., 2011. Economic, environmental, and Health/Well-Being benefits associated with green industry products and services: a review. J. Environ. Hortic. 29 (2), 96–103. Retrieved August 18, 2021 from. http://meridian.allenpress.com/jeh/article-pdf/29/2/96/1757256/0738-2898-29_2_96.pdf.

Hall, C.R., Hodges, A.W., Haydu, J.J., 2006. Economic impacts of the green industry in the United States. HortTechnology 16 (35437). https://doi.org/10.21273/HORTTECH.16.2.0345.

Hall, C.R., Hodges, A.W., Khachatryan, H., Palma, M.A., 2020. Economic contributions of the green industry in the United States in 2018. J. Environ. Hortic. 38 (3), 73–79. Retrieved August 18, 2021 from. http://meridian.allenpress.com/jeh/article-pdf/38/3/73/2593064/i0738-2898-38-3-73.pdf.

Hardy, J., Behe, B.K., Barton, S.S., Page, T.J., Schutzki, R.E., Muzii, K., et al., 2000. Consumers preferences for plant size, type of plant material and design sophistication in residential landscaping. J. Environ. Hortic. 18 (4), 224–230. https://doi.org/10.24266/0738-2898-18.4.224.

Hauer, R.J., Peterson, W.D., 2016. Municipal Tree Care and Management in the United States: A 2014 Urban & Community Forestry Census of Tree Activities [Special Publication 16-1]. Retrieved August 18, 2021 from. University of Wisconsin College of Natural Resources, Stevens Point, WI, pp. 1–71. https://www.uwsp.edu/cnr/Documents/MTCUS%20-%20Forestry/Municipal%202014%20Final%20Report.pdf.

Henderson, J.E., Joshi, O., Tanger, S., Boby, L., Hubbard, W., Pelkki, M., et al., 2017. Standard procedures and methods for economic impact and contribution analysis in the forest products sector. J. For. 115 (2), 112–116. https://doi.org/10.5849/jof.16-041.

Hodges, A.W., Court, C.D., 2019. Economic Contributions of Urban Forestry in Florida in 2017. Retrieved August 18, 2021 from. Florida Department of Agriculture and Consumer Services-Florida Forest Service. https://fred.ifas.ufl.edu/DEStudio/html/EconomicImpactAnalysis/EconomicContributionsFloridaUrbanForestry.pdf.

Hodges, A.W., Hall, C.R., Palma, M.A., Khachatryan, H., 2015. Economic contributions of the green industry in the United States in 2013. Journal of Horticulture Science and Technology 25 (6), 805–814. https://doi.org/10.21273/HORTTECH.25.6.805.

IMPLAN, 2021. IMPLAN. Retrieved August 18, 2021 from. https://www.implan.com/.

IMPLAN Data Team, 2021. CEW Data Details. Retrieved August 18, 2021 from. https://support.implan.com/hc/en-us/articles/115009679608-CEW-FAQ.

Joshi, O., Henderson, J.E., Tanger, S.M., Boby, L.A., Pelkki, M.H., Taylor, E.L., 2017. A synopsis of methodological variations in economic contribution analyses for forestry and forest-related industries in the US South. J. For. 115 (2), 80–85. https://doi.org/10.5849/jof.16-044.

Lucas, M., 2019. IMPLAN Pro: Providing Analysis-by-Parts With a Comparison of Event Types. Retrieved August 18, 2021 from. IMPLAN. https://support.implan.com/hc/en-us/articles/115009542287-Case-Study-Analysis-By-Parts.

National Urban and Community Forestry Advisory Council, 2015. Ten-Year Urban Forestry Action Plan: 2016-2026. Retrieved August 18, 2021 from. University of Virginia Institute for Environmental Negotiation. https://urbanforestplan.org/wp-content/uploads/2015/11/FinalActionPlan_Complete_11_17_15.pdf.

Palma, M.A., Hall, C.R., 2015. Economic Contributions of the Green Industry to the Texas Economy. Retrieved August 18, 2021 from. http://greenindustryresearch.org.

Parajuli, R., Henderson, J.E., Tanger, S., Joshi, O., Dahal, R., 2018. Economic contribution analysis of the forest-product industry: a comparison of the two methods for multisector contribution analysis using IMPLAN. J. For. 116 (6), 513–519. https://doi.org/10.1093/jofore/fvy047.

Pelkki, M., Sherman, G., 2020. Forestry's economic contribution in the United States, 2016. For. Prod. J. 70 (1), 28–38. https://doi.org/10.13073/FPJ-D-19-00037.

Pregitzer, C.C., Charlop-Powers, S., Bradford, M.A., 2021. Natural area forests in US cities: opportunities and challenges. J. For. 119 (2), 141–151. https://doi.org/10.1093/jofore/fvaa055.

Sinclair, M., O'Toole, J., Malawaraarachchi, M., Leder, K., 2012. Comparison of response rates and cost-effectiveness for a community-based survey: postal, internet and telephone modes with generic or personalised recruitment approaches. BMC Med. Res. Methodol. 12 (1), 1–8. https://doi.org/10.1186/1471-2288-12-132.

Templeton, S.R., Goldman, G., 1996. Estimating Economic Activity and impacts of urban forestry in California with multiple data sources from early 1990s. J. Arboriculture. 22 (3), 131–143. Retrieved August 18, 2021 from. http://www.actrees.org/files/Research/templeton_economics.pdf.

Templeton, S.R., Campbell, W., Henry, M., Lowdermilk, J., 2011. Impacts of Urban Forestry on California's economy in 2009 [Unpublished Report Submitted to Mary Klass-schultz, Fire and Resources Assessment Program. California Department of Forestry and Fire Protection]., pp. 1–32

Thompson, E., Herian, M., Rosenbaum, D., 2021. The Economic Footprint and Quality-of-life Benefits of Urban Forestry in the United States. Prepared for the Arbor Day Foundation. Retrieved Jan 11, 2022 from. https://www.arborday.org/urban-forestry-economic/downloads/complete-report-findings.pdf.

Tian, N., Stottlemyer, A., 2019. Economic Impact of Urban Forests in Texas. Retrieved August 18, 2021 from. Texas A&M Forest Service, College Station, TX. https://tfsweb.tamu.edu/uploadedFiles/TFSMain/Data_and_Analysis/Forest_Economics_and_Resource_Analysis/Contact_Us(1)/Urban%20Economic%20Impact%20Report.pdf.

US BLS, 2021. Quarterly Census of Employment and Wages: Various Years. Retrieved August 18, 2021 from. U.S. Bureau of Labor Statistics. https://www.bls.gov/cew/.

US Census Bureau, 2020. Annual Estimates of the Resident Populations. Population Division. Retrieved August 18, 2021 from. U.S. Census Bureau. https://www.census.gov/topics/population.html.

USDA Forest Service, 2021a. Urban Forests: What Are Urban Forests? Retrieved August 18, 2021 from. https://www.fs.usda.gov/managing-land/urban-forests.

USDA Forest Service, 2021b. National Urban and Community Forestry Advisory Council. Retrieved August 18, 2021 from. https://www.fs.usda.gov/managing-land/urban-forests/ucf/nucfac.