NORTHEAST-MIDWEST
STATE FORESTERS
ALLIANCE

URBAN FORE$TRY

ECONOMIC ANALYSIS

VERMONT

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FOREWORD

*Though predominantly a rural state, the trees in the heart of **Vermont** communities - our downtowns, village centers, and neighborhoods - provide a wide range of economic, environmental, and social benefits. Vermont's urban and community forests cool our streets, clean our water, conserve energy, enhance the retail experience, increase property values, defend against climate change, and so much more to enhance the quality of life for Vermont citizens. While urban forests only cover a small portion of Vermont's land base, 39% of Vermonters live in an urban forest, and many more regularly work in, play in and visit them. The management and maintenance of these vital trees – both on public lands and in private yards – contribute more than $193 million to our state and local economies by supporting over 2,200 jobs and other economic activities. Urban and community forests are our front line of defense to mitigate our footprint and offer a conservative estimate of $14.5 million in air pollution removal, avoided stormwater runoff, and carbon sequestration. These numbers begin to tell the story of the value and contribution of Vermont's urban and community forests and why they matter even in a rural forested state like Vermont.*

I am pleased to present Vermont's Urban Forestry Economic Analysis, the result of a regional study and state-by-state analysis that details the direct and indirect economic contributions of Vermont's urban forests for 2018. The information presented in this report represents a snapshot in time and demonstrates the value of urban and community forestry to our economy. It is my hope that it will increase awareness of the important positive role that urban forests play as a subset of Vermont's forest economy and encourage increased support for the growth and maintenance of trees in our state's urban areas. To learn more about and engage in urban and community forestry activities in Vermont, visit our Vermont Urban and Community Forestry program's website at vtcommunityforestry.org.

Michael Snyder
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NORTHEAST-MIDWEST
STATE FORESTERS
ALLIANCE
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I. EXECUTIVE SUMMARY

Urban forestry is a crucial sector of the green industry and continues to grow as a popular solution to both ecological and social issues in rapidly evolving urban landscapes. 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. This report features a comprehensive analysis of the estimated economic contribution of urban forestry to the state economy of Vermont. Economic contribution analyses, such as the one detailed in this report, are significant tools for communicating the greater monetary benefits of the urban forestry sector to policy makers and legislators.

THE OBJECTIVES OF THE PROJECT

1. Develop an input-output model to quantify the economic impact of the urban forest industry to the state economy.
2. Conduct economic impact analyses for the state.
3. Quantify financial impacts of the urban forest resource for the state using i-Tree Landscape derived environmental services and associated valuation estimate.
4. Develop and implement a framework and methodology to incorporate Urban Forest Inventory and Analysis data into i-Tree Landscape, piloting this work in Wisconsin.
5. Produce a report documenting methodology of analysis findings for the state detailing the financial contributions of the urban forest industry and resource.
6. Disseminate information developed for stakeholders and the public on the importance of the urban forest industry and resource.

Following rigorous discussion among project partners, the developed scope of urban forestry includes six different groups: private businesses, public (county and municipal governments), public (state agencies), higher education institutions, investor-owned utilities working in tree-line maintenance, and non-profit organizations. The project partners then created an electronic survey which was distributed to individual contacts associated with any of the six groups. The survey instrument for the private sector was primarily designed to separate urban forestry from broader green industries as well as to evaluate the current issues and opportunities related to urban forest businesses in the region, while the survey questions for the public sector focused on capturing the involvement of local and municipal governments and other public agencies in urban forestry. Next, we developed a complete profile of employment statistics associated with urban forestry businesses and activities for each group using the data obtained from primary surveys. The profile statistics were then input into the IMPLAN software, an input-output regional economic modeling system, to estimate economy-wide ripple effects in the state economy stemming from direct economic activities in urban forestry related industries.

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The individualized web-based survey had a final sample size of 30,336 emails across 24,880 businesses and agencies in the Northeast and Midwest United States. Response rates range from 3% (private businesses) to 59.5% (public state agencies), depending on the group surveyed. Out of the businesses surveyed, private landscaping and tree care followed by nursery and garden supply stores reported the highest number of employees on average, including full-time, part-time, and seasonal employees. Private landscaping and tree care providers also employ the largest percentage of workers in urban forestry (43%). Approximately a quarter of nursery and florist merchant wholesalers and nursery and tree production employees perform work in urban forestry-related activities. Less than 20% of the employees in the following business types perform work in urban forestry: nursery and garden supply stores; farm and garden equipment wholesalers; and landscape architectural services.

Results from the input-output modeling suggest that in 2018, urban forestry in Vermont directly contributed $128 million in industry output and $81 million in value-added by supporting about 1,780 full- and part-time jobs in various businesses and activities. Including direct, indirect, and induced effects, urban forestry in the state had a total contribution of $193.4 million in industry output to the state economy, employing more than 2,263 people with a payroll of about $80 million. The private sector, predominantly landscaping services, represents over 85% of the direct jobs and industry output in the study region. The public agencies (municipal and state agencies) collectively contributed about $2.6 million in total industry output by supporting approximately 36 jobs to the state economy. Similarly, higher education institutions and non-profit organizations had total job contributions of 3 and 106, respectively. We estimated that every dollar generated in urban forestry by the private sector contributed an additional $0.53 to the state economy. 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 Vermont.

Annual savings derived from urban forests were valued at $14.5 million across the 119 communities (incorporated and census designated places) in Vermont. This is a conservative estimate because it only incorporates three broad categories of ecosystem services: air pollution removal, avoided stormwater runoff and carbon sequestration. Community tree canopy, estimated to cover 38% of all incorporated and densely settled unincorporated communities, saved an estimated $3.3 million from the removal of air pollutants, $3.5 million from the reduction of stormwater and $7.7 million from the sequestration of carbon. These trees are critical pieces of community infrastructure that can be used to adapt to or mitigate environmental and social stressors.

II. GLOSSARY

Urban Forestry Defined In this study as the establishment, conservation, protection, and maintenance of trees in cities, suburbs, and other developed areas.

Carbon sequestration To capture and store atmospheric carbon dioxide.

Direct effects The expenditures or initial production changes associated with an industry or sector in the study area which are entered into the Input-Output analysis. These changes can be positive or negative and display how the study area's economy will respond.

Ecosystem services The benefits provided by ecosystems, such as wetlands filtering water or trees capturing air pollutants. Some of these services have financial implications.

Employee compensation Total payroll cost of an employee, inclusive of wages, salaries, payroll taxes, and benefits such as health insurance and retirement.

Employment The number of full-time, part-time, and seasonal jobs associated with a specific industry.

IMPLAN© Modeling software that performs Input-Output analysis. Its framework enables users to create regional economic models and multipliers for one or more counties or states in the USA. Version 3 of IMPLAN© accounts for commodity production and consumption for 536 industry sectors, 10 household income levels, taxes to local/state and federal governments, capital investment, imports/exports, transfer payments, and business inventories.

Indirect effects The economic impact of local industries purchasing goods and services from other industries along supply chains.

Induced effects The economic impact of household spending of labor income following deductions from taxes, savings, and income for commuting.

Industry Entities or businesses participating in similar types of economic activities.

Labor income The sum of employee compensation and proprietor income.

Multipliers The measure of an industry's connection to the economy of the study area in terms of purchases, payments of wages and taxes, and other transactions.

Municipality The Census definition of an incorporated place, which is a type of governmental unit, incorporated under state law as a city, town (except in New England, New York, and Wisconsin), borough (except in Alaska and New York), or village, generally to provide governmental services for a concentration of people within legally prescribed boundaries (U.S. Census Bureau, 2018).

North American Industry Classification System (NAICS) An industrial classification scheme established and utilized by countries in North America for grouping entities by similar production processes.

Output The value in dollars of production within a study area. It equates to the total of sales and net inventory change.

Proprietor income Production income of sole proprietorships, partnerships, and tax-exempt cooperatives.

Region or Regional Economy The geographic area of interest (i.e., one or more county or state) and its economic activity.

Sector The industries that make up the complete economy including businesses, households and institutions, and government. In the NAICS, sectors are one of the major areas of economic activity and are classified at the 2-digit level.

Social Accounting Matrix (SAM): SAMs capture all monetary market transaction, including what are called an economy's "ripple effects," during a study period by building upon Input-Out models to include transactions between industries and institutions, including those between institutions themselves.

Total effects: The sum of direct, indirect, and induced effects.

Value-added (or Gross Regional Product [GRP]): The total of labor income, other property income, and production and import taxes. It is also the difference between an industry's total output and the cost of its intermediate inputs. GRP equals the sum of value-added for all economic sectors within the study region.

III. INTRODUCTION

The green industry consists of the businesses and activities involved in the creation, distribution, and services associated with landscape design, garden supplies and equipment, and ornamental plants in urban and semi-urban settings. While academic literature defines green industry as it relates to the production of urban greening products (Hall et al., 2005; New Hampshire Landscape Association, 2021), some governments and private organizations interpret green industry as it pertains to environmentally sustainable economic growth (United Nations Industrial Development Organization [UNIDO], 2021; World Green Economy Council, 2021). Urban forestry is one important contributing sector of the green industry (Mcpherson et al., 2005) that was first documented in the literature at the end of the 19th century. More recently, urban forestry has evolved to embody a socio-economic approach to growing trees in urban landscapes (Konijnendijk et al., 2006b; Templeton & Goldman, 1996).

As such, urban forests provide essential ecosystem services to perpetually growing urban populations in the United States, making them an integral component of cities, municipalities, and communities. Urban forestry encompasses various tree management and maintenance activities on over 141 million acres of urban landscape in the United States (USDA Forest Service, 2021a). In addition to private businesses that perform urban forestry activities, governments, non-profit organizations, and utility sectors are also crucial providers of urban forestry related activities and contribute substantially to local and state economies.

Nonetheless, the lack of a standard definition and accounting methodology for estimating the economic and social benefits of urban forestry activities have restricted the successful planning and further expansion of the Urban and Community Forestry Program (National Urban and Community Forestry Advisory Council, 2015). Major barriers in managing urban forestry programs partially result from the lack of consistent definitions and terms. This deficient framework fosters challenges to estimating the extent, contributions, and impact of the urban forestry sector. For the purposes of this report, we define the urban forestry sector as all sectors that participate in urban tree management activities that contribute to urban forestry such as landscape management and architecture, nurseries and tree distributors, and equipment dealers.

Economic contribution analysis of the urban forestry sector aids to communicate the industry's monetary benefits in terms of dollar values and jobs to lawmakers. However, economic contributions analyses, similar to urban forestry terminology and related frameworks, have tended to vary in scope, data used, input-output methodology, and measures reported. In addition, while state-level and regional economic contribution analyses covering forest products industries have been common in the literature (Henderson et al., 2017; Joshi et al., 2017; Parajuli et al., 2018; Pelkki and Sherman, 2020), limited studies have focused on the urban forestry sector. This gap is due in part to the complexity of the urban forestry sector, but also by the historical economic and cultural significance of the forest product industry.

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The main purpose of this report is to estimate the economic contribution of the urban forestry sector in Vermont. First, we developed a standard definition of urban forestry that characterized the scope of the sectors building on the methodological approach of Hodges and Court (2019). We included all private, public, and non-profit businesses and organizations associated with urban forestry in the state of interest. The project partners then created an electronic survey which was distributed to individual contacts across the entire Northeast-Midwest study region. The survey instrument for the private sector was primarily designed to separate urban forestry from broader green industries, while the survey questions for the public sector focused on capturing the involvement of local and municipal governments and other public agencies in urban forestry related activities.

Following, we compiled the employment profile of all the related industries and agencies through the results from the online surveys and public sources. We used the Impact Analysis for Planning (IMPLAN) software, an input-output modeling program created by the U.S. government, to estimate the economic contribution of urban forestry to the state economy in terms of several economic and business metrics including jobs, labor income, value-added, and tax collections (IMPLAN, 2021). Lastly, we assessed the ecosystem benefits of Vermont communities using i-Tree Landscape.

IV. OBJECTIVES

This state-specific project is part of a broader analysis of urban forest industries in the Northeast and Midwest US (a 20-state region + Washington, D.C.) (F1).

THE OBJECTIVES OF THIS STATE-SPECIFIC PROJECT

1. Develop an input-output model to quantify the economic impact of the urban forest industry to the state economy.
2. Conduct economic impact analyses for the state.
3. Quantify financial impacts of the urban forest resource for the state using i-Tree Landscape derived environmental services and associated valuation estimate.
4. Develop and implement a framework and methodology to incorporate Urban Forest Inventory and Analysis data into i-Tree Landscape, piloting this work in Wisconsin.
5. Produce a report documenting methodology of analysis findings for the state detailing the financial contributions of the urban forest industry and resource.
6. Disseminate information developed for stakeholders and the public on the importance of the urban forest industry and resources.

F1 THE 21 STATES INVOLVED IN THE SURVEY

Connecticut	Michigan	Pennsylvania
Delaware	Minnesota	Rhode Island
Illinois	Missouri	**VERMONT**
Indiana	New Hampshire	Washington, D.C.
Iowa	New Jersey	West Virginia
Maine	New York	Wisconsin
Maryland	Ohio	

V. SCOPE OF URBAN FORESTRY

Since there are no well-defined industries specific to urban forestry and IMPLAN integrates urban forestry into broader green sectors, the first crucial step of economic contribution analysis was to delineate the scope of urban forest industries in the study region. First, a list of private industries as well as public agencies and non-profit organizations involved in urban forestry was developed based on an extensive review of available literature. The developed scope of urban forestry industries and activities was rigorously discussed with the representatives from each participating state, and other project partners from universities and agencies. Then, all the project team participants were surveyed to develop consensus on the following final list of urban forestry related industries and activities in both private and public sectors **(T1).**

The scope of urban forestry was discussed in all three webinars, with specific emphasis on sectors to be included in the second webinar. All team members who attended the webinar had ample opportunity to discuss their opinions on which sectors related to urban forestry should be included in the analysis. The consensus on the final list of urban forest industries in both private and public sectors was established by surveying all the project partners from participating states, institutions, and organizations.

The project 'Team' includes principal and co-principal investigators from several universities, WDNR staff, representatives from each participating state, project partners from the University of Wisconsin Stevens Point, Mid-State Technical College and the Tree Care Industry Association, and a USDA Forest Service representative. Other partners providing match for this project include: The Davey Institute, Indiana Arborist Association, Massachusetts State Urban Forestry Advisory Board, Michigan State University, Vermont Urban & Community Forestry Council, and Ohio Chapter International Society of Arboriculture.

T1 SCOPE OF URBAN FORESTRY IN NORTHEAST-MIDWEST STATES

PRIVATE INDUSTRIES

- **Landscaping services** (NAICS 561730)
- **Nursery and tree production** (NAICS 111421)
- **Nursery, garden, and farm supply stores** (NAICS 444220)
- **Farm and garden machinery and equipment merchant wholesalers** (NAICS 423820)
- **Nursery stock and florists' supplies merchant wholesalers** (NAICS 424930)
- **Landscape architectural services** (NAICS 541320)
- **Private (investor-owned) utility companies**

PUBLIC SECTORS

- **Municipalities**
- **Counties**
- **State agencies involved in urban forestry**

HIGHER EDUCATION INSTITUTIONS

NON-PROFIT ORGANIZATIONS

VI. METHODS

Six different groups across the 21-state region were surveyed: private businesses, public (county and municipal governments), public (state agencies), higher education institutions, investor-owned utilities working in tree-line maintenance, and non-profit organizations. The University of Wisconsin Survey Center (UWSC) sent the surveys out on September 29, 2020, and stopped accepting survey responses on November 4, 2020, after three reminder emails. The survey instrument for the private sector was primarily designed to separate urban forestry from broader green industries as well as to evaluate the current issues and opportunities related to urban forest businesses in the region. On the other hand, the survey questions for the public sector focused on capturing the involvement of local and municipal governments and other public agencies in urban forestry.

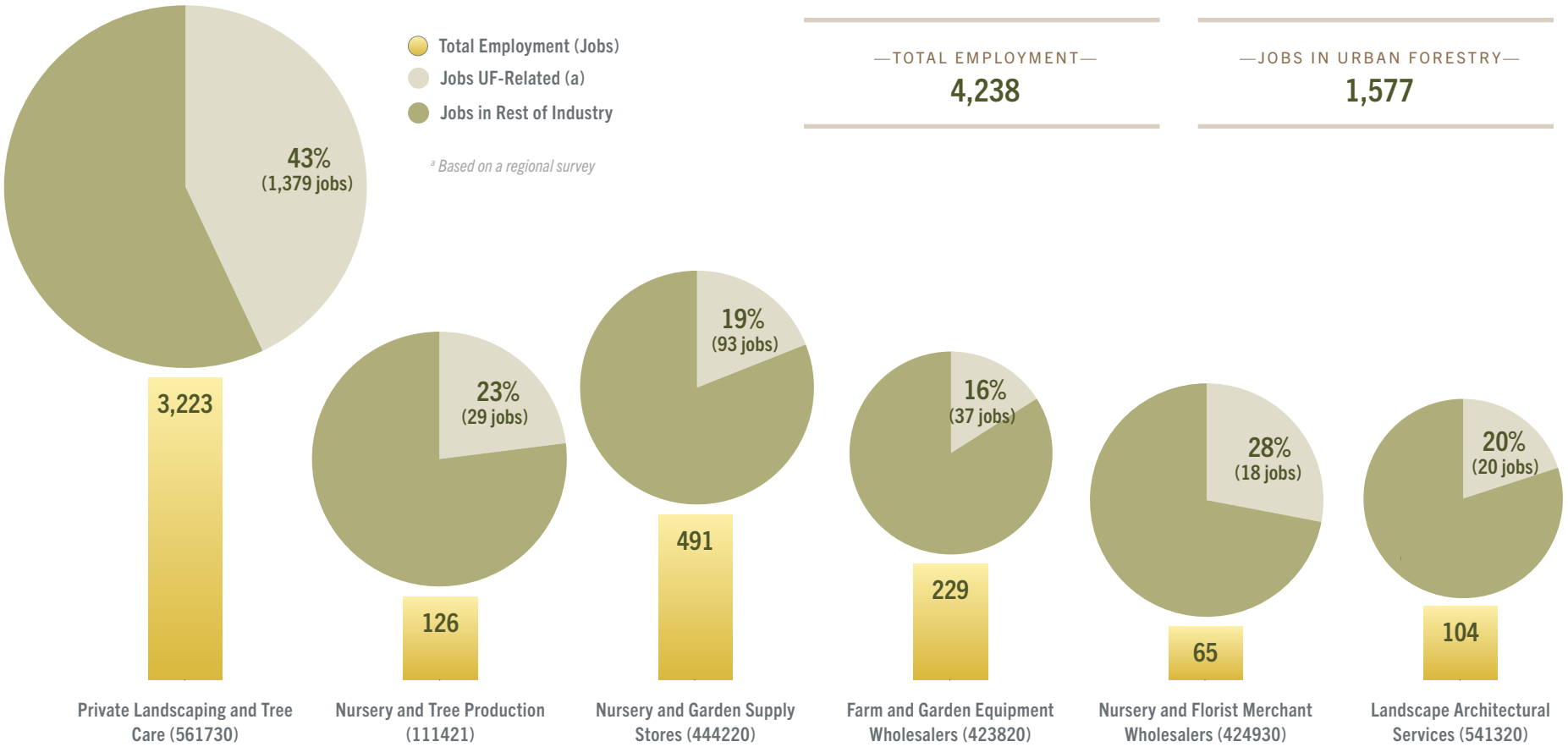
We then compiled a complete profile of sales and expenditures of economic activities related to establishment, care, and maintenance of urban forests utilizing publicly available sources in addition to the primary surveys to separate urban forestry activities from broader green industries. Also utilizing data from the primary surveys and publicly available sources, we developed a complete profile of employment statistics including job number and percentage of jobs in urban forestry associated with each group and sector, a key input in the IMPLAN modeling. For the private industries, the 2018 employment numbers in each North American Industry Classification System (NAICS) category were obtained from the Census of Employment and Wages (CEW) from the US Bureau of Labor Statistics (US BLS, 2021). Since CEW does not incorporate self-employed jobs and businesses with their own social insurance programs (IMPLAN Data Team, 2021), the 2017 IMPLAN data was utilized to compute self-employed jobs specifically in landscaping services (NAICS 561730) and Nursery and tree production businesses (NAICS 111421).

We specify the steps in our approach to the surveys and subsequent economic contribution analysis in more detail in the Urban Forestry Economic Analysis in the Northeast and Midwest Methodology Report. Also described in the Methodology Report, we quantified the estimated benefits from ecosystem services provided by urban trees using tools within i-Tree, a suite of software developed by the U.S. Forest Service that enables forestry analyses and benefit assessments (i-Tree, 2021). More specifically, this project used i-Tree Landscape to assess urban forest-derived ecosystem services across three broad categories: air quality, carbon storage and sequestration, and hydrology.

VII. EMPLOYMENT PROFILE

F2 AVERAGE EMPLOYMENT IN **PRIVATE BUSINESSES**

—TOTAL EMPLOYMENT—	—JOBS IN URBAN FORESTRY—
4,238	1,577



Out of the businesses surveyed, private landscaping and tree care followed by nursery and garden supply stores reported the highest number of employees on average, including full-time, part-time, and seasonal employees (**F2**). Private landscaping and tree care providers also employ the largest percentage of workers in urban forestry (43%). Approximately a quarter of nursery and florist merchant wholesalers and nursery and tree production employees perform work in urban forestry-related activities (Figure 2). Less than 20% of the employees in the following business types perform work in urban forestry: nursery and garden supply stores; farm and garden equipment wholesalers; and landscape architectural services.

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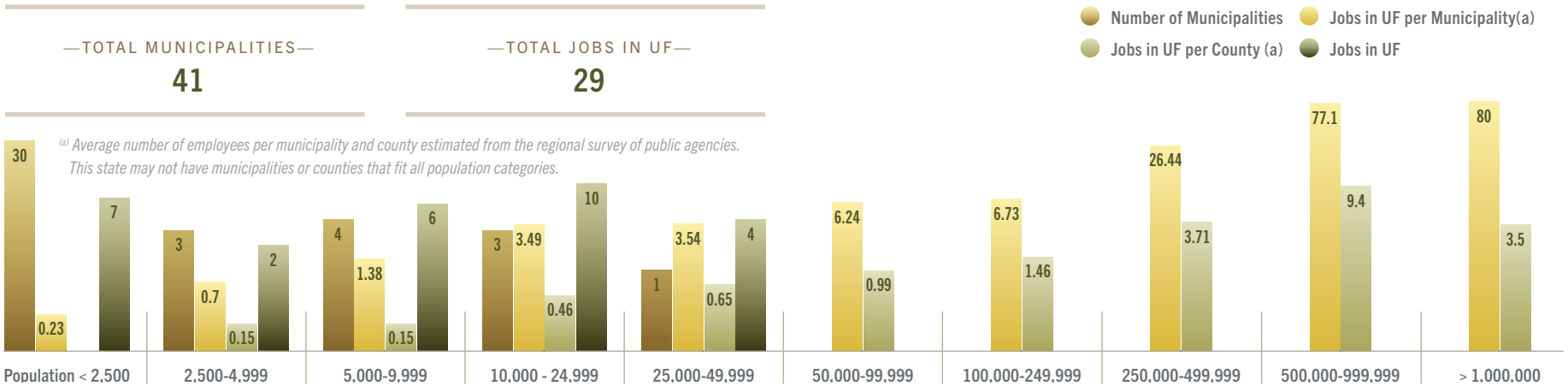
F3 URBAN FORESTRY JOBS IN **PUBLIC AGENCIES** IN VERMONT

—TOTAL MUNICIPALITIES—
41

—TOTAL JOBS IN UF—
29



(a) Average number of employees per municipality and county estimated from the regional survey of public agencies. This state may not have municipalities or counties that fit all population categories.

Since investor-owned private utility companies are also involved in tree line clearing and vegetation management in urban and suburban regions, their involvement in urban forestry in the study region is also included. As the regional survey did not produce meaningful statistics from these surveyed investor-owned utility (IOU) companies due to a very low response rate, the average expenditures of IOU companies in vegetation management are obtained from a similar study conducted by Arbor Day Foundation (P. Smith, Personal Communication). 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 $4.5 million per year. The total expenditures of IOUs in vegetation management are calculated by multiplying the number of IOUs in the study state by the average expenditures per company. Based on the total expenditures, the total number of urban forestry jobs (71) in Vermont supported by IOUs in landscaping and horticultural services (IMPLAN Industry 469) is imputed by using the IMPLAN model.

Similarly, total public employees involved in urban forestry are also estimated based on the population size of the jurisdiction that these agencies serve in the study region. The number of municipalities and counties in all 21 states by their population sizes are obtained from the Population Division of the U.S. Census Bureau (US Census Bureau, 2020). Then, the average numbers of employees in municipal and county estimated from our regional survey are used to estimate the total number of jobs in urban forestry employed by municipal governments **(F3)**. Vermont does not have a county government system, but in 2018, it is estimated that municipal governments in Vermont employed 29 people directly working in urban forestry activities. Moreover, the number of employees in state forestry or natural resources agencies directly involved in urban forestry is also included in the economic contribution analysis. According to the information collected from state representatives, in 2018, state agencies employed 3 positions in the study region.

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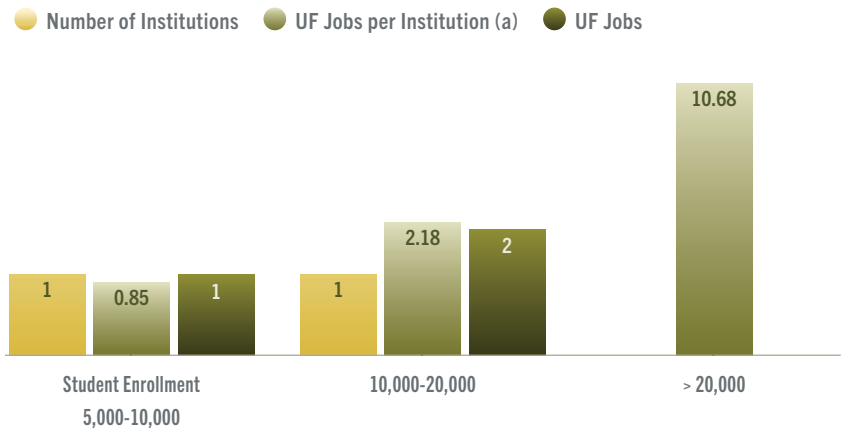
F4 URBAN FORESTRY JOBS IN **HIGHER ED INSTITUTIONS**

—TOTAL INSTITUTIONS—
2

—TOTAL UF JOBS—
3



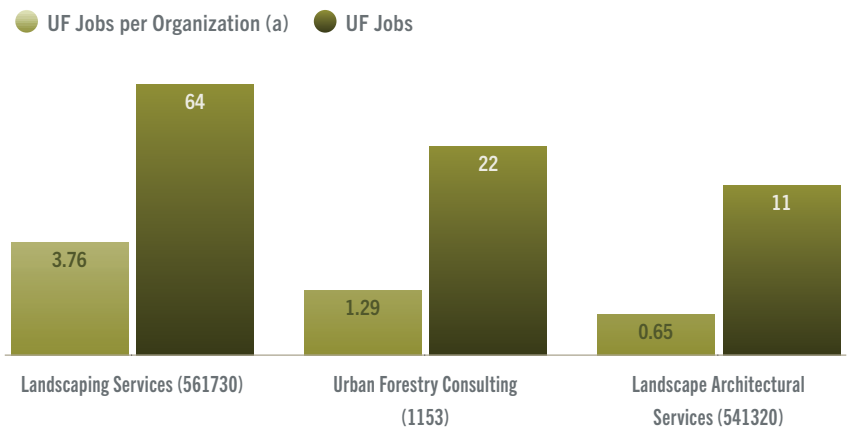
[a] *Based on a regional survey*

Similarly, the total jobs related to urban forestry supported by higher education institutions are estimated based on their student enrollment size. First, the total number of higher education institutions and student enrollments are collected from various publicly available sources in each state. The total urban forestry jobs in colleges and universities are estimated by multiplying the number of institutions by the average number of jobs per institution estimated from our regional survey of higher education institutions (**F4**). In 2018, there were 3 direct jobs from higher education institutions involved in urban forestry activities in the study region.

F5 URBAN FORESTRY JOBS IN **NON-PROFIT ORGANIZATIONS** (17 NPOS)

—UF JOBS PER ORGANIZATION—
5.70

—TOTAL UF JOBS—
97

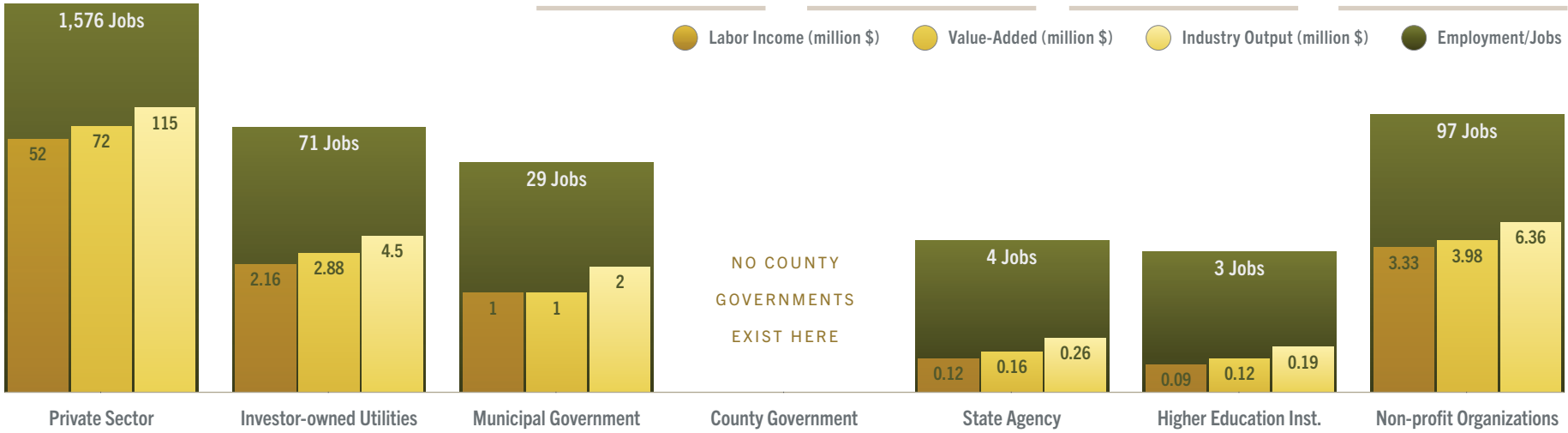


[a] *Based on a regional survey*

Further, this study also includes the total jobs related to urban forestry supported by non-profit organizations (NPOs) in the study region. The regional survey of NPOs reveals that on average, an NPO supports 3.76 jobs in landscaping services, 1.29 jobs in forestry consulting services, and 0.65 jobs in architectural services (**F5**). Urban forestry coordinators from the study states collected the names and contact information for the non-profits in their states. Collectively, it is estimated that in 2018, NPOs in Vermont supported 97 jobs directly working in urban forestry activities.

F6A **DIRECT EFFECT** ECONOMIC CONTRIBUTION OF URBAN FORESTRY IN VERMONT, 2018

TOTAL LABOR INCOME	TOTAL VALUE-ADDED	TOTAL INDUSTRY OUTPUT	TOTAL JOBS
$59 million	$81 million	$128 million	1,780



Figures 6A, 6B and 6C present the summary economic contribution results obtained from individual IMPLAN scenarios representing each sector of urban forestry in Vermont. Based on the input-output modeling, we estimated that in 2018, urban forestry in Vermont directly supported 1,780 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 2,263. In terms of labor income, urban forestry in this region collectively contributed about $59 million directly, and over $80 million including the multiplier effects throughout the state economy.

Similarly, in terms of value-added, which is equivalent to gross domestic product, urban forestry in Vermont contributed approximately $81 million to the state economy directly, and if we account for the indirect and induced effects, the total value-added contribution in 2018 was about $119 million **(F6B)**. In terms of industry output representing all economic activities, the direct and total contributions of urban forestry were approximately $128 million and $193.4 million, respectively. The overall SAM multiplier associated with employment was estimated to be 1.27, indicating that every job in urban forestry in these states resulted in another 0.27 jobs in other sectors of the economy **(F6C)**. Similarly, every dollar generated in urban forestry contributed an additional $0.51 in industry output to the rest of the regional economy.

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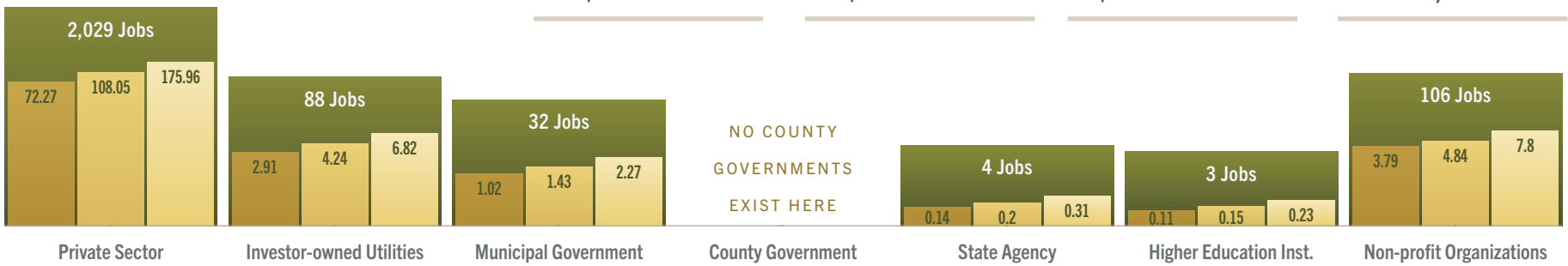
Labor Income (million $) | Value-Added (million $) | Industry Output (million $) | Employment/Jobs

F6B TOTAL EFFECT ECONOMIC CONTRIBUTION OF URBAN FORESTRY IN PENNSYLVANIA, 2018

TOTAL LABOR INCOME	TOTAL VALUE-ADDED	TOTAL INDUSTRY OUTPUT	TOTAL JOBS
$80 million	$119 million	$193.4 million	2,263



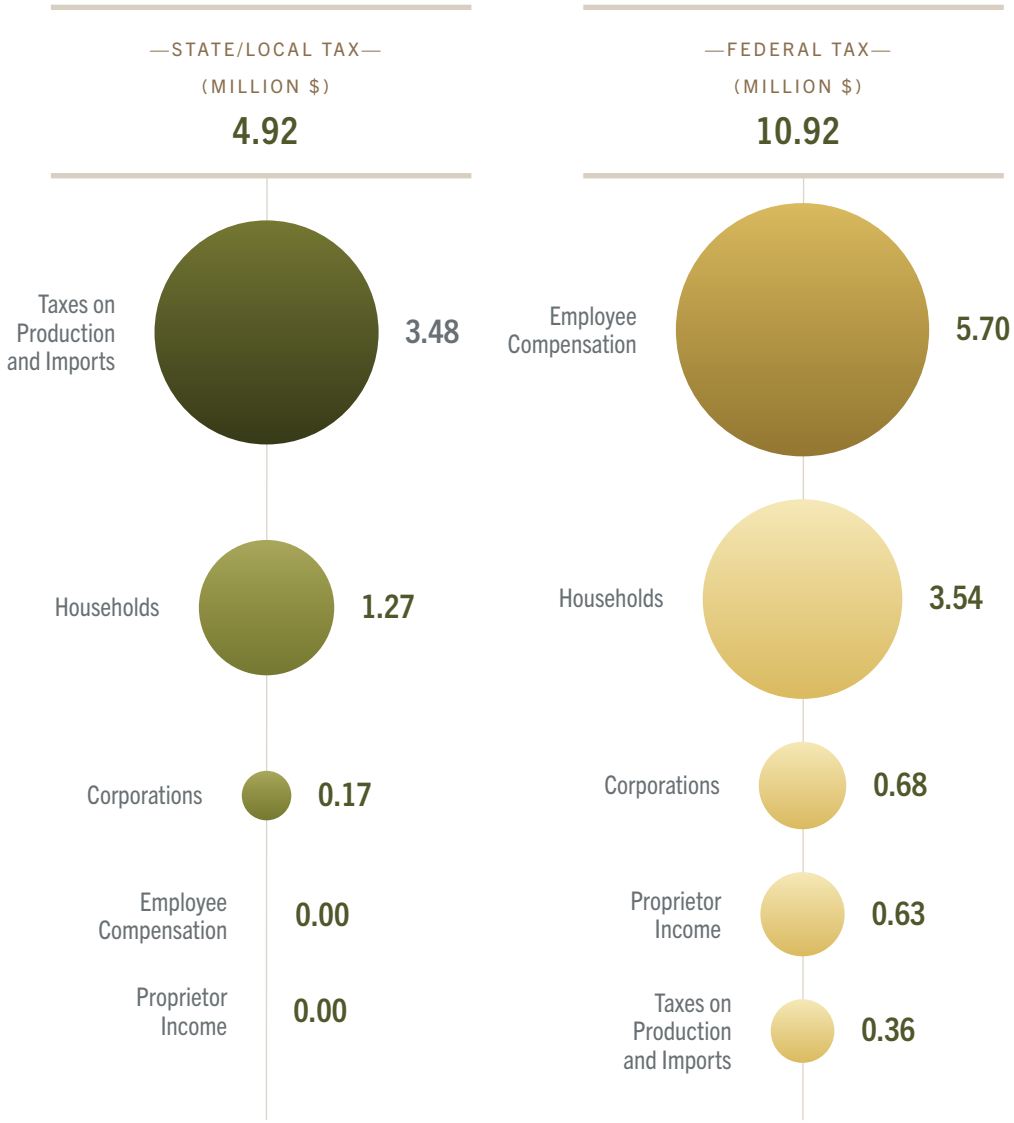
F6C SAM MULTIPLIER ECONOMIC CONTRIBUTION OF URBAN FORESTRY IN VERMONT, 2018

TOTAL LABOR INCOME	TOTAL VALUE-ADDED	TOTAL INDUSTRY OUTPUT	TOTAL JOBS
1.36	1.48	1.51	1.27

The economic contribution of urban forestry varies widely among the sectors. The private sector, predominantly landscaping services, represents over 85% of the direct jobs and industry output in the study region. The public agencies (municipal and state agencies) collectively contributed about $2.6 million in total industry output by supporting approximately 36 jobs to the state economy (**F6B**). Similarly, higher education institutions and non-profit organizations had total job contributions of 3 and 106, respectively. We estimated that the private sector had the highest SAM multiplier values in all metrics. The SAM value of 1.53 associated with the industry output of the private sector indicates that every dollar generated in urban forestry by the private sector contributed an additional $0.53 to the state economy.

Urban forestry in Vermont also had substantial contributions to the local or state and federal taxes **(F7)**. In 2018, urban forestry businesses and employees in the study region paid over $4.9 million in state and local taxes and about $10.9 million 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 93% of federal taxes collected directly from urban forestry businesses and employees in the region.

F7 DIRECT TAX CONTRIBUTION OF URBAN FORESTRY IN VERMONT, 2018



F8 PRESENTS THE TOP 10 INDUSTRIES AFFECTED BY JOBS IN URBAN FORESTRY IN VERMONT

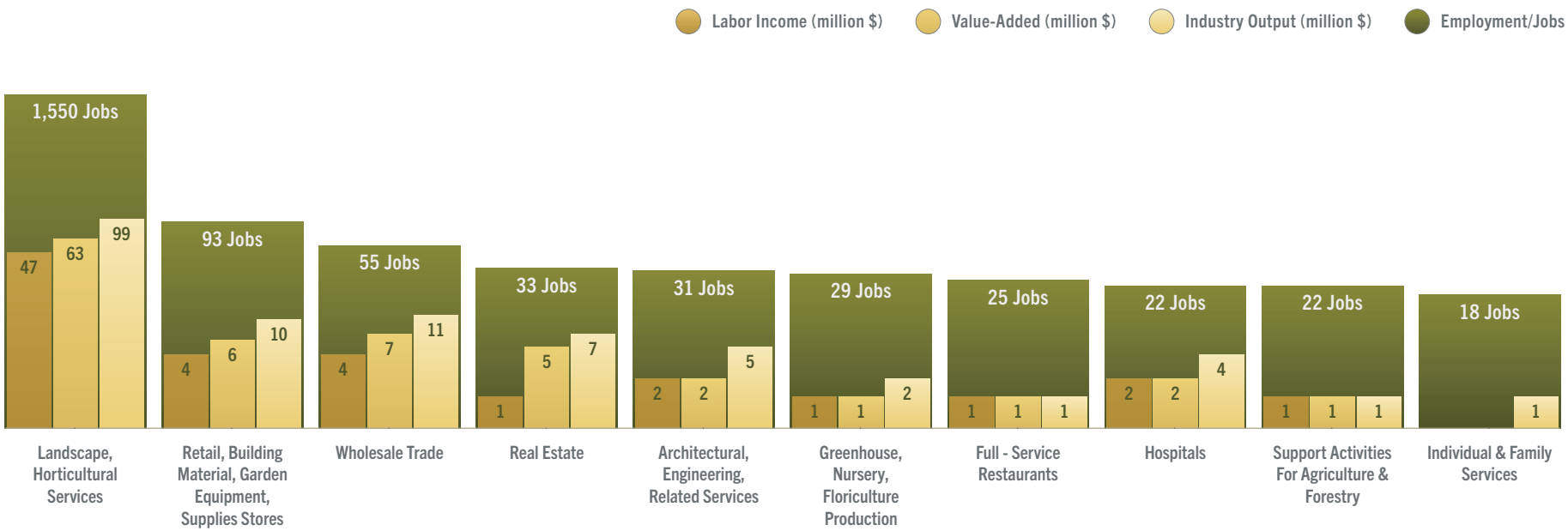


Figure 8 presents the top 10 industries in the state that have the highest employment contributions from urban forestry. A total of 1,550 jobs with an industrial output of about $98.9 million in landscape and horticultural services were contributed by the urban forestry in the study region. Urban forestry supported about 93 jobs in the retail sector, 55 jobs in the wholesale trade industry, and 33 jobs in real estate in the study region **(F8).** Through the induced effects, employees in urban forestry in the study region supported a number of jobs in architectural and engineering related services, greenhouse, nursery, and floriculture production, full-service restaurants, and hospitals, playing a vital role in the overall state economy.

Appendix A breaks down total economic contributions from urban forestry activities in the study by direct, indirect, and induced effects.

IX. ECOSYSTEM SERVICES

As a proxy for urban and community forests, this analysis uses the boundaries of Census places, a broad category encompassing both incorporated as well as densely settled unincorporated communities (U.S. Census Bureau, 2018). Of the 626,000 people who live in Vermont, 242,000 are in these places, accounting for 39% of the state's population.

Urban forests offer myriad ecosystem services to these places, from building community culture to improving mental and emotional health to offering food and habitat to wildlife. However, only some of these ecosystem services are quantifiable in economic terms on a large scale across the region. These include the removal of air pollutants, the reduction of stormwater and the storage and sequestration of carbon. i-Tree Landscape was used to tabulate these services.

It is estimated that trees cover 38% of the combined lands of Vermont communities, saving them $14.5 million a year across just those three broad categories of ecosystem services. This includes $3.3 million from the removal of air pollutants, $3.5 million from the reduction of stormwater and $7.7 million from the sequestration of carbon.

Six different air pollutants were analyzed within i-Tree Landscape: carbon monoxide (CO), nitrogen dioxide (NO_2), ozone (O_3), fine particulate matter ($PM_{2.5}$), particulate matter (PM_{10}) and sulfur dioxide (SO_2). Figure 9 identifies the weight removed, money saved and main emission sources for each of these pollutants. The figure also expresses urban forests' pollutant reduction capacity by the equivalent number of vehicles removed from roads. Monetary savings from air pollution removal are derived from pollutants' impacts on human health.

Trees also have an important role in intercepting and slowing rainwater, as well as preventing some of it from being funneled to grey stormwater infrastructure. In Vermont, trees are estimated to intercept 23.8 million m^3 of rainwater a year, ultimately preventing 1.5 million m^3 of it from reaching stormwater systems. To use a colloquial comparison, that is the equivalent of 390 Olympic size swimming pools (each 50m x 25m x 3m). The value of that avoided runoff is $3.5 million - calculated by the amount of water no longer needed to be managed by wastewater facilities. Additional hydrologic benefits of trees, such as erosion control or evapotranspiration helping to cool communities, are beyond this study.

Finally, urban forests are critical infrastructure for climate change mitigation. Across Vermont, these community trees store 2.6 million metric tons of carbon, the equivalent of 9.7 million metric tons of CO_2. This carbon storage is valued at $495.5 million. Each year, these forests sequester 41 thousand metric tons of carbon, or the equivalent of 150 thousand metric tons of CO_2. The annual sequestration of carbon in Vermont community forests is valued at $7.7 million. These monetary values are calculated using the current social costs of carbon within i-Tree Landscape.

Trees across the entire state, including rural areas, store 166.5 million metric tons of carbon, at a sequestration rate of 2.0 million metric tons a year. Thus, using i-Tree Landscape figures, urban and community forests store about 2% of the state's total carbon and sequester about 2% of the carbon a year. Some urban trees can also cool their surroundings or prevent sunlight or wind from penetrating a building. These processes could reduce emissions by avoiding emissions in the first place. However, estimates of avoided energy usage are not part of this study.

F9 OVERVIEW OF AIR POLLUTION REMOVAL BY TREES IN CENSUS PLACES IN VERMONT

—POLLUTANT AND MAIN SOURCES—		—TOTAL KILOGRAMS PER YEAR— (MILLION) 1.64 kg	—TOTAL DOLLARS SAVED PER YEAR— (MILLION $) 3.34	—VEHICLE REMOVAL EQUIVALENT—
CO	Automotive Vehicles	0.02	0.01	221
NO_2	Automotive Vehicles Power Plants	0.16	0.01	24,508
O_3	Created by Reactions between Nitrous Oxides (NOx) & Volatile Organic Compounds (VOCS)	1.15	0.93	
$PM_{2.5}$	Automotive Vehicles Power Plants; Wood-burning	0.05	1.93	53,355
PM_{10}	Power Plants; Construction; Agriculture	0.19	0.45	
SO_2	Power Plants; Other Industrial Processes	0.07	0	848,398

X. CONCLUSIONS

Urban forestry has received considerable attention in recent years, not only for trees' intrinsic and infrastructure values in urban and suburban landscapes, but also for the economic significance of various businesses and industries relying on urban forestry. However, estimating the economic contribution of urban forestry is somewhat challenging as it is quite difficult to separate the sector from broader green industries. As a result, estimation of the sector's economic contributions through input-output modeling requires additional effort to characterize industry portions specific to urban forestry. In this report, we outlined our approach to developing a standard methodology and model set-ups to capture urban forestry related businesses and activities exclusively. We then applied our approach to estimate the economic contributions of urban forestry in Vermont. To this end, our study makes an important methodological contribution and sets a milestone in urban forestry economic contribution analysis. We complemented this analysis with a conservative assessment of ecosystem services, allowing for a more holistic perspective on the economic impact of urban forests.

Results from our IMPLAN model suggest that the majority of the urban forestry-related employment opportunities are in the private sector, which collectively represents industries related to urban tree care and services, nursery and tree production, machinery supplies, and landscape architecture, among others. The results also indicate that landscaping and tree care services were the most dominant private sectors, contributing to more than 1,379 direct jobs in the study region. Interestingly, the magnitude of SAM multipliers in the private sector industries were higher than those associated with the public sectors, which reflects the diversified market channels of private industries and the subsequent magnified ripple effects in the rest of the economy (Henderson et al., 2017). While employment from urban forestry in the public sectors in the study region is minimal, our results suggest a meaningful contribution of this sector in large metro areas. Public sector investments in urban forestry have paid off through employment opportunities, ripple effects in other sectors of the economy, and ecosystem service-related benefits such as shade and health (Hardy et al., 2000; Donovan, 2017).

The framework and findings documented in this report also have important management and policy implications:

- Using stakeholder input and rigorous discussion as a foundation, we established an exhaustive scope of urban forestry, incorporating the involvements of private, public, non-profit, and higher education institutions in urban forestry.
- Our approach developed an input-output analysis framework for urban forestry with the use of a relatively novel application of the analysis-by-parts method and margins analysis for wholesalers and retailers. This approach is easily generalizable and can be used to estimate comparable results regardless of the study region.
- Our results could provide justification for enhancement of current programs or creation of new measures to support urban forest management.
- The comprehensive nature of this study leads to a complete picture of urban forestry contributions, including areas that require attention.

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- 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.
- The consideration of ecosystem services shows that urban forests save communities and society at-large substantial amounts of money, in addition to generating economic activity.

Response rates to the survey that varied widely among the target groups represent a potential caveat of this study. While 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), the response rate from private businesses (about 3%) was less than expected. The COVID-19 pandemic is one possible reason explaining lower survey responses from the private businesses. Nonetheless, the lower response rates 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.

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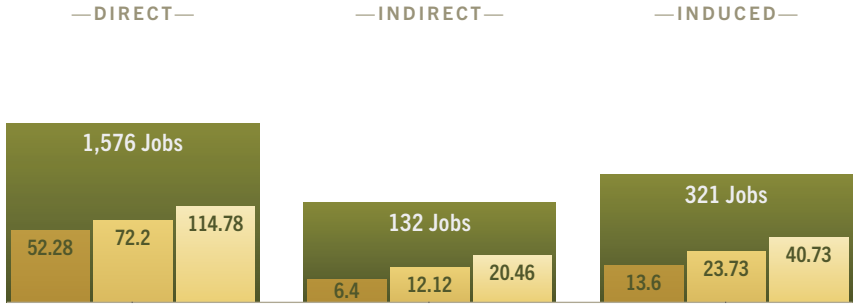
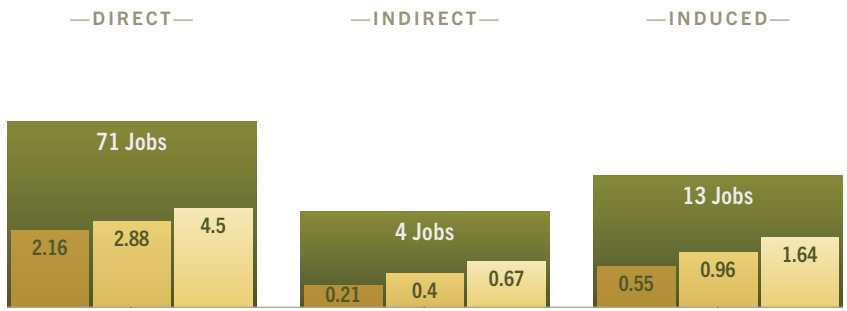
ECONOMIC CONTRIBUTIONS (DIRECT, INDIRECT, INDUCED, AND TOTAL) OF ALL SECTORS FEATURED IN THE STUDY

— PRIVATE —



Labor Income (million $)	Value-Added (million $)	Industry Output (million $)	Employment/Jobs
72.27	108.05	175.96	2,029

— INVESTOR-OWNED UTILITIES —

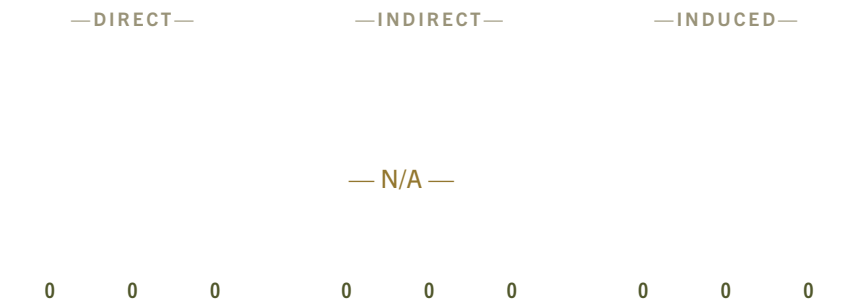


Labor Income (million $)	Value-Added (million $)	Industry Output (million $)	Employment/Jobs
2.91	4.24	6.82	88

— MUNICIPAL GOVERNMENT —

Labor Income (million $)	Value-Added (million $)	Industry Output (million $)	Employment/Jobs
1.02	1.43	2.27	32

— COUNTY GOVERNMENT —



Labor Income (million $)	Value-Added (million $)	Industry Output (million $)	Employment/Jobs

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ECONOMIC CONTRIBUTIONS (DIRECT, INDIRECT, INDUCED, AND TOTAL) OF ALL SECTORS FEATURED IN THE STUDY

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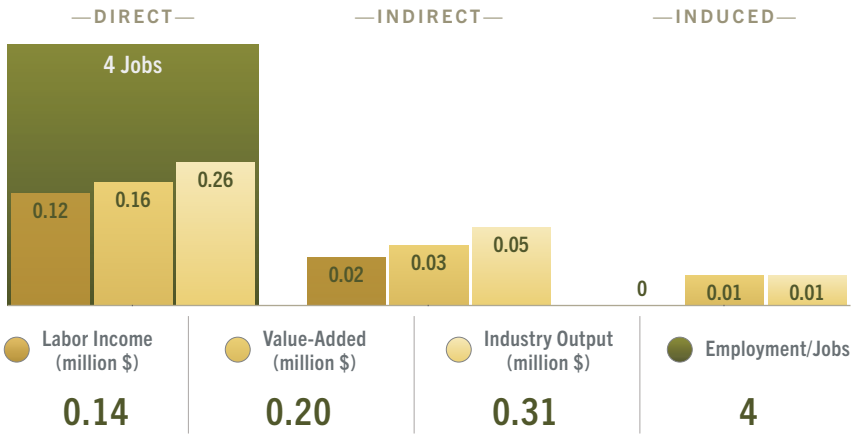

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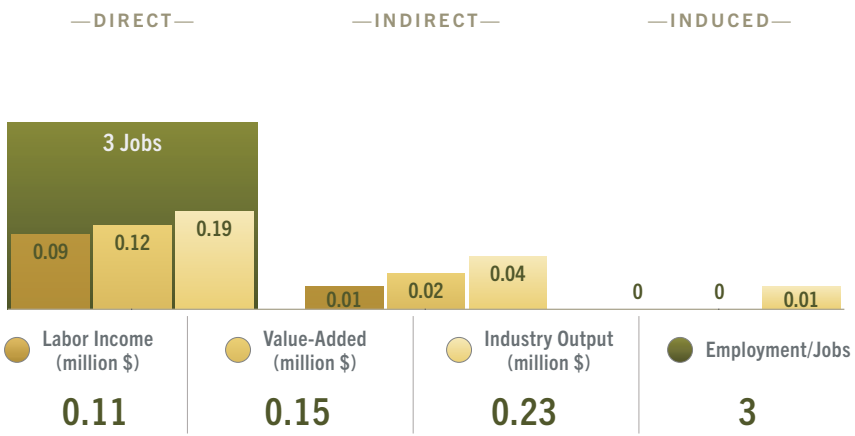
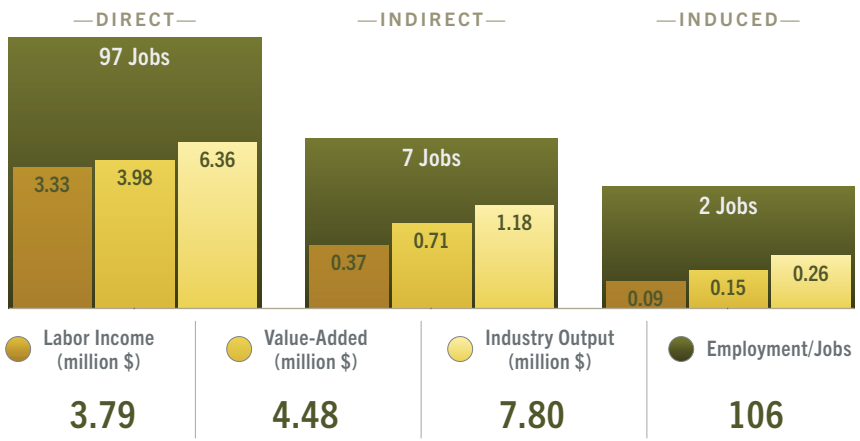


— NON-PROFIT —



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