The City of WORCESTER

Department of Public Works & Parks
Parks, Recreation & Cemetery Division
Forestry Operations
50 Officer Manny Familia Way, Worcester, MA 01605
P | 508-799-1190 F | 508-799-1293
Worcestertrees@worcesterma.gov

URBAN FORESTRY TREE COMMISSION MEETING

Wednesday February 28, 2024 – 6:00 P.M.

Parks, Recreation & Cemetery Administrative Office

Meeting Room A

50 Officer Manny Familia Way Worcester, MA 01605

Or

If you choose to use the Microsoft Teams platform:

1) Go to www.teams.com
2) Enter Meeting ID# 237 551 681 925
3) Enter password: nDV25o

If you choose to attend via phone:

1) Call 1-469-998-7682
2) Enter Meeting ID#: 974 788 764#

If technological problems interrupt the virtual meeting component, the meeting will continue in-person.

AGENDA

1. Call to Order

2. Attendance (Roll Call)

3. Acceptance of Minutes for the (Roll Call) – January 17, 2024

4. To request a reasonable accommodation or interpretation or submit written comments or questions in advance of the meeting, please contact the Parks, Recreation & Cemetery Division by email at Worcestertrees@worcesterma.gov. Please note that interpretation requests must be received no later than 48 hours in advance of the meeting. Para solicitar una interpretacion razonable, o enviar comentarios o preguntas por escrito por favor comuniquese con la oficina de la Division de Parques, Recreo & Cementerio por correo electronico a Worcestertrees@worcesterma.gov. Por favor note que las solicitudes de interpretacion deberan ser enviadas 48 horas antes de la reunion.

5. Public Participation – Pursuant to Chapter 20 of the Acts of 2021 and in order to ensure active, public engagement, the City of Worcester currently allows for both in person and remote participation at the Urban Forestry Tree Commission meetings. To partake in the "Public Participation" section of this meeting, you may join us directly within the 50 Officer Manny Familia Way Meeting Room A, follow the information above to join via the Teams application or dial the direct line as indicated. If you would like to raise your hand when in the meeting as a call-in user, you may dial *5.

6. Assistant Commissioners Report (See Report Topics Below)

7. Old Business

    - The second draft of the Urban Forestry Master Plan which can be found here: Trees in the City - Right Tree, Right Place | City of Worcester, MA (worcesterma.gov)
    - Request to discuss lessons learned https://www.boston.gov/departments/parks-and-recreation/urban-forest-plan
    - Request of Commissioner Winbourne to discuss Green School Yard Program
    - Request of Commissioner Winbourne to discuss Audubon Report on Solar
    - Request of Commissioner Winbourne for the Commission to set goals for the Commission

8. New Business

    Agenda items must be submitted (3) three business days before each Commission Meeting with subject line "Agenda Item" to worcestertrees@worcesterma.gov.

    - Review City Ordinances on Trees
        - Trees in the City - Right Tree, Right Place | City of Worcester, MA (worcesterma.gov)

9. Date of Next Meeting:
    - March 20, 2024
    - April 3, 2024 (Remove)
    - May 1, 2024
    - June 5, 2024

8. Meeting Adjourned (Roll Call)

The City of
WORCESTER
Department of Public Works & Parks

Department of Public Works & Parks
Parks, Recreation & Cemetery Division
50 Skyline Drive, Worcester, MA 01605
P | 508-799-1190 F | 508-799-1293
parks@worcesterma.gov

URBAN FORESTRY TREE COMMISSION MEETING MINUTES

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Parks, Recreation & Cemetery Administrative Office

Meeting Room A

50 Officer Manny Familia Way Worcester, MA 01605

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2) Enter Meeting ID# 251 040 578 709
3) Enter password: rtUHTL

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1) Call 1-469-998-7682
2) Enter Meeting ID#: 416 674 65#

If technological problems interrupt the virtual meeting component, the meeting will continue in-person.

AGENDA

1. Call to Order – Meeting was called to order at 6:25 PM

2. Attendance (Roll Call) –

   a. **Commissioners Present:**
      i. Alexander Elton
      ii. Robin Karoway-Waterhouse
      iii. Joy Winbourne
      iv. Kristin Wobbe (Virtual)

   b. **Administration Present:**
      i. Robert C. Antonelli, Jr. Assistant Commissioner
      ii. Brian Breveleri, Forestry Director
      iii. Milagros Pacheco, Staff Assistant III
      iv. Denis Tucker – Working Foreman

3. Acceptance of Minutes for the November 01, 2023. Commissioner Elton made a motion to accept the minutes. Second by Commissioner Karoway-Waterhouse. All were in favor. Motion was approved 4 – 0.
4. To request a reasonable accommodation or interpretation or submit written comments or questions in advance of the meeting, please contact the Parks,

Recreation & Cemetery Division by email at Worcestertrees@worcesterma.gov. Please note that interpretation requests must be received no later than 48 hours in advance of the meeting. Para solicitar una interpretacion razonable, o enviar comentarios o preguntas por escrito por favor comuniquese con la oficina de la Division de Parques, Recreo & Cementerio por correo electronico a Worcestertrees@worcesterma.gov. Por favor note que las solicitudes de interpretacion deberan ser enviadas 48 horas antes de la reunion.

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6. Assistant Commissioners Report (See Report Topics Below)

7. Old Business

    a. Request of Commissioner Winbourne for the Commission to set goals for the Commission

8. New Business

Agenda items must be submitted (3) three business days before each Commission Meeting with subject line "Agenda Item" to worcestertrees@worcesterma.gov.

a. The second draft of the Urban Forestry Master Plan which can be found here:
   Trees in the City - Right Tree, Right Place | City of Worcester, MA (worcesterma.gov)
b. Request to discuss lessons learned
   https://www.boston.gov/departments/parks-and-recreation/urban-forest-plan
c. Request of Commissioner Winbourne to discuss Green School Yard Program – Commissioner Winbourne made a motion to table this item until the following meeting. Second by Commissioner Elton. All were in favor. Motion was approved 4 – 0.
d. Request of Commissioner Winbourne to discuss Audubon Report on Solar – Tabled.
e. Request of Commissioner Karoway-Waterhouse for Forestry to report monthly data on removals & plantings including district, genus/species, reason for removal, or (if planting) was it by resident request. – See motion below.
f. Request of Commissioner Karoway-Waterhouse on the reason why Worcester does not have a fall planting and what would it take to start.
    i. Assistant Commissioner Antonelli explained that the reason there is no fall planting is because it doesn't give the trees enough time for the tree to survive.
g. Request of Commissioner Wobbe to advise if there is an effort to maintain our current canopy by removing invasives like oriental bittersweet
    i. Assistant Commissioner Antonelli said there is no proactive approach at this point for treating the invasive oriental bittersweet.

Commissioner Karoway-Waterhouse made the following motions:

a. Commissioner Karoway-Waterhouse made a motion to remove the phrase "to continue" from the first sentence of the Executive Summary on p. 5 of the 2nd draft of the Urban Forest Master Plan. The sentence should only reflect that "our vision is for the ... forest to be a model..." Second by Commissioner Winbourne. All were in favor. Motion was approved 4 – 0.
b. Commissioner Karoway-Waterhouse made a motion to request the Urban Forestry and Tree Commission recommend and request from the City Council a minimum of $500,000 in funding for the Forestry Dept. See pps. 76-7, 92-3 Master Plan. Second by Commissioner Elton. All were in favor. Motion was approved 4 – 0.
c. Commissioner Karoway-Waterhouse a motion that out of the aforementioned funds requested, that Forestry create three new positions: Second by Commissioner Winbourne. All were in favor. Motion was approved 4 – 0.
    i. another arborist position for the reasons outlined on p. 80 of the 2nd draft Master Plan
    ii. one Community Forester (in support of Master Plan recommendation #9) who can handle public education and outreach, facilitate community partnerships, and integrate with customer service, etc.
    iii. one forestry internship for reasons listed under 2.6 of p. 81 of the Master Plan
d. Commissioner Karoway-Waterhouse, in order to support increased tree plantings and a transition from reactive to proactive forestry practices, made a motion for the Urban Forestry Tree Commission to further study the prospect of a city-operated tree nursery to help address tree-sourcing shortages. Nursery should prioritize native species. UFTC should have recommendations within a time-period of about six months. Second by Commissioner Elton. All were in favor. Motion was approved 4 – 0.
e. Commissioner Karoway-Waterhouse in order to support increased tree plantings and a transition from reactive to proactive forestry practices, made a motion to support "Option 1" listed under "Tree Replacement Policy- Update" in the Assistant Commissioner's Report of the Agenda: Second by Commissioner Elton. All were in favor. Motion was approved 4 – 0.
    i. When a tree is removed, the City of Worcester will plant trees within the right of way that meets the Arbor Day Foundations "Right Tree, Right Place" protocols, Commonwealth of Massachusetts Urban & Community Forestry planting guidelines, ISA Planting standards, and ANSI A300 Part 6 tree planting and transplanting standards in all available locations without a request or agreement of the adjacent property owner.
f. Commissioner Karoway-Waterhouse made a motion to request that Forestry/the City of Worcester partner with organizations for new/young tree watering and pruning in contracts lasting a minimum of three years in order for partners to secure funding and staff where applicable. Second by Commissioner Elton. All were in favor. Motion was approved 4 – 0.
g. Commissioner Karoway-Waterhouse made a motion to request the UFTC explore the idea of a tree summit. Second by Commissioner Winbourne. All were in favor. Motion was approved 4 – 0.
h. Commissioner Karoway-Waterhouse made a motion to require that the Urban Forestry Master Plan be updated yearly with available data and re-assessed no more than ten years after its adoption. Second by Commissioner Elton. All were in favor. Motion was approved 4 – 0.
i. Commissioner Karoway-Waterhouse made a motion to require that the finished Master Plan be fully, professionally, and accurately translated into Spanish. Other languages on the recommendation of the city. Second by Commissioner Winbourne. All were in favor. Motion was approved 4 – 0.

Commissioner Winbourne made the following motions:

a. Commissioner Winbourne made a motion to create a subcommittee of rotating Worcester Urban Forestry Commission members to work with Davey Resource Group and Department of Parks & Recreation to finalize the urban forestry master plan. Second by Commissioner Karoway-Waterhouse. All were in favor. Motion was approved 4 – 0.
b. Commissioner Winbourne made a motion to change the goal for tree replacement ratio (as stated on p77 of the 2nd draft of the UFMP) of 1:1 to a minimum of 3:1. Second by Commissioner Karoway-Waterhouse. All were in favor. Motion was approved 4 – 0.

c. Commissioner Winbourne made a motion to create a Worcester Urban Forestry Research summits. The first, to occur in 2024, would bring together a panel of area expertise with the goal to examine existing datasets to help establish tree canopy goals, priorities, and strategies for the City of Worcester. Second by Commissioner Karoway-Waterhouse. All were in favor. Motion was approved 4 – 0.
d. Commissioner Winbourne made a motion for the Dept. of Parks and Recreation to create and present an annual progress report to the commission, and for that report to be used by the UFC to determine if the UFMP needs to be updated. Second by Commissioner Elton. All were in favor. Motion was approved 4 – 0.
e. Commissioner Winbourne made a motion to change the language throughout the plan whenever it points to the need for action being dependent upon conducting a comprehensive UTC assessment and replace this with action being dependent upon the recommendations made by the 2024 Worcester Forest Research Summit (WFRS). For example, while it is stated on p85 that "a lack of UTC should not keep Worcester from beginning to plant in high priority areas identified in other studies", there is no discussion of how planting priorities will be made in the meantime. To address this motion, I would suggest making current recommendation #7 appear before current recommendation #6. Modify current recommendation #7 to reflect the creation of a WFRS with Action #1 being the creation of the WFRS and Action 2 being the utilization of the results of the summit to create an annual tree planting and maintenance plan. Action #3 then being the creation of a comprehensive UTC and modification of plans based on that new knowledge. Second by Commissioner Karoway-Waterhouse. All were in favor. Motion was approved 4 – 0.

Commissioner Elton made the following motions:

a. Commissioner Elton made a motion to remove on pages 8, 40, and 49 of the Master Plan Worcester's urban forest valued at $123,000. Second by Commissioner Karoway-Waterhouse. All were in favor. Motion was approved 4 – 0.
b. Commissioner Elton made a motion to amend accurately on page 49, the report states, "The Worcester City Forester and a team of staff in DPW&P manage the street and parks trees through site plan and construction plan review for private and public projects." Second by Commissioner Karoway-Waterhouse. All were in favor. Motion was approved 4 – 0.
c. Commissioner Elton made a motion to review zoning ordinance at our next meeting about pages 64 and 72 of the master plan, mentioning establishing ordinances/regulations for tree planting requirements for development projects. Second by Commissioner Karoway-Waterhouse. All were in favor. Motion was approved 4 – 0.
d. Commissioner Elton made a motion to accurately spell the name of the New England Botanic Garden at Tower Hill on page 3 and twice on page 47. Second by Commissioner Karoway-Waterhouse. All were in favor. Motion was approved 4- 0.

Date of Next Meeting:

February 28, 2024
March 20, 2024
April 3, 2024
May 1, 2024
June 5, 2024

Meeting Adjourned (Roll Call)

ASSISTANT COMMISSIONER'S REPORT:

General:

Urban Forestry Master Plan Review

The second draft of the Urban Forestry Master Plan which can be found here:

Trees in the City - Right Tree, Right Place | City of Worcester, MA (worcesterma.gov)

- Worcester Regional Research Bureau Brief 23-14 "Worcester's Urban Forest Master Plan"

- Door Hanger - NA
- Tree Commission attending neighborhood meetings – Update
  - Neighborhood Response Team | City of Worcester, MA (worcesterma.gov)
- Tree replacement policy – Update
  - Commission to recommend a policy on Tree Planting & Replacement:
    - Option 1:

      The City of Worcester will plant trees within the right of way that meets the Arbor Day Foundation "Right Tree – Right Place" protocols, Commonwealth of Massachusetts Urban & Community Forestry planting guidelines, ISA Planting standards, and ANSI A300 Part 6 tree planting and transplanting standards in all available locations without a request or agreement of the adjacent property owner.
    - Option 2:

      The City of Worcester will plant trees within the right of way that meets the Arbor Day Foundation "Right Tree – Right Place" protocols Commonwealth of Massachusetts Urban & Community Forestry planting guidelines, ISA Planting standards, and ANSI A300 Part 6 tree planting and transplanting standards upon request or agreement of the adjacent property owner only.
- Neighborhood Based Urban Heat Risk Assessment - NA
- Worcester Now | Next online survey - NA
- Green Worcester Advisory Committee -NA
- Planting –
  - Spring 2024 Planting - NA
- Customer Service Update
  - Customer Service Contact Information 508-929-1300 &/or 311
- Street Resurfacing Opportunities & Challenges – NA
- Zoning Ordinance Discussion - NA
- Worcester Ordinance Relative to the Protection of Public Trees - NA
- Partnerships –
  - New England Botanical Garden @ Tower Hill - NA
- Grant Applications –
  - DCR Grant Program - NA
- Economic Development Initiatives –
  - NA
- Forestry Vandalism & Graffiti –
  - NA
- Donations –
  - NA
- Pests –
  - ALB (Asian Longhorned Beetle) - NA
  - EAB (Emerald Ash Borer) - NA
  - Spotted Lanternfly - NA
  - Elm Zigzag Sawfly – NA
- Forestry Operations –
  - Tree City USA – NA
  - Arbor Day –
    - April 26, 2024
    - April 27, 2024 – Festival

- Budget – Operational & Capital – NA
    - Parks, Recreation & Cemetery Division – NA
    - Capital Improvement Program – NA
    - City Five Point Financial Plan – NA
- Misc.
- Date of Next meeting – February 28, 2024

- Commissioner Winbourne made a motion to adjourn. Second by Commissioner Elton. All were in favor. Motion was approved 4 – 0. Meeting was adjourned at 6:43 PM.

- **A copy of this full meeting will be available to view and listen to at: www.worcesterma.gov/city-clerk/public-meetings/agendas-minutes**

Offered by Councilors Ricardo Arroyo and Liz Breadon, Lara, Bok, Coletta, Fernandes Anderson, Flaherty, Louijeune, Mejia, Murphy, Worrell and Flynn

CITY OF BOSTON
IN CITY COUNCIL

ORDINANCE ESTABLISHING PROTECTIONS FOR THE CITY OF BOSTON TREE CANOPY

WHEREAS: In September 2020, the City of Boston released a Tree Canopy Assessment, which analyzed tree cover changes in the City from 2014-2019 and evaluated which neighborhoods have ample tree cover and which areas have the most potential for increased tree cover; *and*

WHEREAS: Twenty-seven percent of Boston's land is covered by tree canopy, with higher concentrations in the neighborhoods of Hyde Park, Jamaica Plain, and West Roxbury; *and*

WHEREAS: While the report found that Boston's tree canopy remained relatively stable overall from 2014-2019, it also found that the southern and eastern neighborhoods have suffered the highest relative tree canopy losses especially in Hyde Park, Roslindale, Mattapan, and West Roxbury; *and*

WHEREAS: The 2020 Tree Canopy Assessment found that more tree canopy was lost on residential land than any other land use type; *and*

WHEREAS: Protecting urban tree canopy is an important way to mitigate detrimental environmental effects such as heat island effect, flooding, air pollution, and more; *and*

WHEREAS: The City of Boston experienced two heat waves in 2021, including a record high temperature of 100 degrees on June 30th, making it the hottest June in Boston's history; *and*

WHEREAS: In the City of Boston, neighborhoods that have high concentrations of Black Latinx, Asian, Indigenous, immigrant, and low-income communities are disproportionately impacted by negative environmental effects that affect their health and quality of life; *and*

WHEREAS: Residents in the City of Boston deserve to have a public, accessible, and transparent way to learn about changes to tree canopy in their neighborhoods; *and*

WHEREAS: Preserving existing tree canopy and planting new trees in areas where tree canopy is low or has been removed are the most effective ways to protect future tree canopy and build climate and environmental resiliency; **NOW**

Therefore be it ordained by the City Council of Boston as follows:

That the City of Boston Code, Ordinances be amended in ***Chapter VII*** by adding the following after *7-14*:

7-15: ESTABLISHING PROTECTIONS FOR THE CITY OF BOSTON TREE CANOPY

7-15.1 PURPOSE: The preservation of existing tree canopy and replenishment of depleted tree canopy is intended to prevent adverse climate effects such as heat island effect, flooding, air pollution, and more, as well as improve the quality of living for residents in the City of Boston.

7-15.2 APPLICABILITY: The terms and provisions of this ordinance shall apply to trees within the City of Boston that are located on city-owned property, private property, or in the public right of way.

7-15.3 DEFINITIONS:

Caliper means a measurement of the tree trunk diameter used when purchasing tree plantings measured at twelve inches (12") above the ground.

Capital Improvement Project means a major, non-recurring expenditure that generally meets all of the following criteria: M.G.L. c. 44, s. 7 and s. 8 permit the City to issue bonds to finance the expenditure, the expenditure is a facility or object or asset costing more than $50,000, and the expenditure will have a useful life of ten years or more for infrastructure, buildings, and parks.

City Tree means a tree located on property owned by the City of Boston, including Public Shade Trees, trees in City parks, and trees on the grounds of City buildings.

Diameter at Breast Height (DBH) means the diameter of a tree trunk measured in inches at a height of four and a half (4.5) feet above the ground. For multiple trunk trees, DBH is the aggregate diameter of the trunks.

Invasive Plant means a plant that is both a non-native and able to establish on many sites, grow quickly, and spread to the point of disrupting plant communities or ecosystems, including but not limited to the trees listed on the Massachusetts Prohibited Plant List.
Park Project means a project involving the renovation and maintenance of existing parks and City-owned open spaces and the development of new parks and open spaces within the City of Boston. City-owned open spaces include parks, community gardens, playgrounds, school yards, library lawns, cemeteries, public plazas, triangles, and squares.

Private Tree means a tree located on private property.

Public Shade Tree means a tree located in the public way, as defined in the Massachusetts General Laws (M.G.L.) c.87, section 5.

Removal means the intentional cutting down of any tree, including all other acts which cause actual or effective removal through damaging, poisoning, or other direct or indirect actions that result in the death of the tree. This includes, but is not limited to, excessive pruning.

Replacement Caliper means the replacement caliper for Significant Trees shall be at least equal to the DBH of the tree removed.

Significant Tree means any living tree that is not an Invasive Plant and is eight inches (8") or more in DBH.

7-15.4 TREE WARDEN: The Tree Warden shall be an employee of the City, appointed by the Mayor, subject to confirmation by the City Council, for a term of three years.

1. The Tree Warden shall be qualified for the role as defined in M.G.L. c. 41 s.106, and also according to the standards established and published by the Massachusetts Tree Wardens and Foresters Association.
2. The duties and responsibilities of the Tree Warden shall conform to M.G.L. c. 87 and shall include, but not be limited to, the following:
    a. Management of all trees within public rights-of-way and on City property. b. Granting or denying and attaching reasonable conditions to all permits required under this ordinance.
    c. Posting notices and holding public hearings for the Removal of Public Shade Trees and City Trees as required by this ordinance.
    d. Enforcement of this ordinance.

7-15.5 SENIOR URBAN FORESTRY AND LANDSCAPE PLANNER: The Senior Urban Forestry and Landscape Planner shall be an employee of the City, appointed by the Mayor.

1. The Senior Urban Forestry and Landscape Planner shall be a Certified Arborist by the Massachusetts Arborist's Association, the International Society of Arboriculture, or any successor of either organization.
2. The duties and responsibilities of the Senior Urban Forestry and Landscape Planner shall include, but not be limited to, the following:
    a. Seeking grants or other assistance concerning the preservation and maintenance of the City's tree canopy.
    b. Develop and publish policies, regulations, tree inventory, manuals, and other data and documents necessary to carry out the purposes and intent of this ordinance. c. Supervising the planting and care of City Trees to ensure that such planting and care meets these rules, regulations and standards.
    d. Assisting and working closely with the Tree Warden to help the Tree Warden fulfill their responsibilities.

7-15.6 URBAN FORESTRY COMMITTEE: The Urban Forestry Committee will be charged with advising with respect to the management and maintenance of all existing and new trees and shrubs on all public grounds and public ways of the City of Boston.

1. Urban Forestry Committee Membership:
    a. This Committee shall consist of the following members:
        i. The Senior Urban Forestry and Landscape Planner
        ii. The Tree Warden
        iii. Nine (9) members of the public, with at least one member demonstrating expertise in the field of urban forestry, at least one member demonstrating expertise in the field of landscape design, and two members shall be between the ages of fourteen and seventeen at the time of their appointment or re-appointment
    b. The Committee members will each serve a term of three years
    c. Committee members shall be selected by the Mayor and subject to confirmation by the Boston City Council.
2. The duties of the Urban Forestry Committee shall be as follow:
    a. Review planting policies for trees and shrubs on public grounds and public ways of the City of Boston, appraise the appropriateness of such plantings, their placement, and the type of maintenance necessary. The Urban Forestry Committee shall also review those planting proposals which it deems significant for trees and shrubs on public grounds and public ways of the City of Boston. b. Have the ability to comment during any City of Boston permitting review process. c. Elect to review issues related to the health, effective maintenance, and protection of existing trees and shrubs on public grounds and public ways of the City of Boston, recommend solutions to any problems identified with such plantings, update the tree inventory with detailed information, and support all public education and outreach by:
        i. Promoting knowledge and awareness of the benefits of trees in the City; ii. Developing and maintaining a website;

iii. Developing and maintaining a noteworthy tree program;
iv. Developing educational materials regarding best management practices for tree care;
v. Supporting City staff in establishing a volunteer adopt-a-tree program; vi. Supporting City staff during Arbor Day Celebrations; and
vii. Considering and recommending incentives for tree planting and maintenance.

d. Upon request of the applicant, this Committee shall consider and make recommendations to the Tree Warden on waivers for any required replantings or payments associated with the issuance of a Tree Permit.

e. Keep records of trees planted and removed within the City of Boston and may issue regular reports on the overall status of the City's urban canopy.

7-15.7 CRITERIA FOR REMOVAL OF PUBLIC SHADE TREES: A public hearing may not be initiated under M.G.L. c. 87 section 3 to remove a Public Shade Tree unless the Tree Warden finds in writing that there is a public health, safety, or welfare basis for removing the Public Shade Tree, including but not limited to hardship to a property owner, economic development, facilitating the development of affordable housing, pedestrian access enhancement, transportation improvement, or public project development. Nothing in this section shall be construed to prevent the cutting, trimming, or removal of trees in accordance with M.G.L. c. 87 section 5.

7-15.8 NOTICE REQUIREMENTS FOR REMOVAL OF PUBLIC SHADE TREES: In addition to notice under M.G.L. c. 87 s. 3 for Removal of a Public Shade Tree, notice shall be given by the City by electronic notification where feasible and first-class mail to all property owners located within 150 feet of the Public Shade Tree proposed to be removed at least 14 days before the public hearing. To the extent feasible, the City shall notify all residents within 150 feet of the Public Shade Tree proposed to be removed by flyering at least 14 days before the public hearing. Notice shall also be given by placing notice on the City website at least 14 days before the public hearing. In the event that a public hearing is initiated under M.G.L. c. 87 s. 3 at the request of anyone other than the City, the requesting party shall pay for all costs of mailing and advertising, such costs to be determined by the City Clerk. The City Clerk may waive the costs if the requesting party demonstrated to the City Clerk that payment of the fee would cause financial hardship. Guidelines for determining financial hardship shall be established by the City Clerk. Applications for financial hardship shall be provided by the City Clerk.

7-15.9 TREE REPLACEMENT FOR PUBLIC SHADE TREES: Any healthy Public Shade Tree removed at the request of a property owner or agent thereof must be replaced within one year from the date of Removal. These replacement trees must be located at or near the location from which the tree was removed, and in no case shall trees planted in a different neighborhood qualify as replacements. The replacement trees must conform to the standards for size, species, and planting established by the Senior Urban Forestry and Landscape Planner.

7-15.10 STREET TREE STABILIZATION FUND: There shall be established a tree fund

which shall be held in a separate identifiable account, and administered in accordance with applicable provisions of General Laws. Any payment required by this article shall be deposited in the Street Tree Fund and shall be used in accordance with this section.

1. Payment for planting replacement Public Shade Trees: Where a healthy Public Shade Tree is removed at the request of a property owner or agent thereof, solely for reasons of private financial gain or personal preference, the requesting party shall make a contribution to the Street Tree Fund in an amount sufficient to pay for replacement trees as described in Section 7-15.9. This amount will be calculated using the schedule of costs established by the Senior Urban Forestry and Landscape Planner.
2. Maintenance of the Street Tree Fund: The Street Tree Fund shall be maintained in a separate account in accordance with state law. All sums deposited into such Fund shall be used solely for the purpose of buying, planting, and maintaining trees in the City. The Senior Urban Forestry and Landscape Planner shall expend these funds for tree planting, transplanting, care, and other tree-related needs.

7-15.11 COMPLIANCE WITH STATE LAW: All Public Shade Tree hearings shall comply with the applicable requirements set forth in M.G.L. c. 87 s. 3.

7-15.12 CRITERIA FOR REMOVAL OF CITY TREES: This section shall apply exclusively to City Trees, as set forth in the Section 7-15.3. Nothing in this section shall be construed to apply to Public Shade Trees within the City of Boston, whose care, maintenance, trimming, planting, and Removal are governed by the Public Shade Tree Law, M.G.L. c. 87, and the City of Boston Code of Ordinances Chapter 7-4.7. The public notice and meeting requirements for Public Shade Trees shall remain in full force and effect and are entirely unaffected by the language of this section.

1. Cutting down or removal of trees: No person, including but not limited to City employees, the Tree Warden, and their deputies shall cut down or remove any tree on City-owned property without the Tree Warden first holding a public hearing.
    a. The Tree Warden, or their designee, shall post notice of the time and place of the public hearing in two or more public places in the City and upon the tree in question at least seven (7) days prior to the public hearing. This notice shall identify the size, type, and location of the trees to be cut down or Removed, and include a brief statement of the reason for the proposed action. Notice of this public hearing shall be sent to each City Councilor, all members of the Urban Forestry Committee, and published on the City website.
    b. No later than 48 hours prior to the cutting down or Removal of any City Tree, a notice on brightly colored paper will be placed upon the tree stating the anticipated date on which the action is expected to occur.
    c. Nothing in this section shall prohibit the Tree Warden, or their designee, from cutting down or Removing any tree which in their opinion is dead or dying or constitutes a threat to public health or safety.
2. Exceptions to the public notice and hearing requirements:

a. No public hearing shall be necessary prior to the Tree Warden, or their designee, curing down or removing trees measuring less than one and one-half inches (1½") in diameter one foot from the ground on City-owned property.

b. Public projects that fall under Park Projects and Capital Improvement Projects shall be exempt if their public process included all of the following:

i. All public meetings at which cutting down or Removal of trees is discussed were duly noticed and advertised including, but not limited to, notice sent to all member of the Urban Forestry Committee

ii. The public was provided reasonable opportunity to provide input regarding tree(s) to be cut down or removed.

iii. Reasonable notice was posted on or around any trees to be cut down or removed at least two (2) weeks prior to such action taking place.

7-15.13 REMOVAL OF PRIVATE TREES: No person may remove any Significant Tree from private property without first obtaining a Tree Permit from the Tree Warden.

1. Application for a Tree Permit:

a. Applications must be made in writing on forms specified by the Tree Warden. b. The Tree Warden, or their designee, will review applications for tree permits in accordance with the provisions of this article. The Tree Warden, or their designee, shall date stamp or otherwise record the date of filing of each application for a tree permit. The Tree Warden, or their designee, shall complete the review of each Tree Permit application no later than thirty (30) business days after the submission of a completed application. In the event that this review is not completed within the time required by this ordinance, and if the applicant did not request a waiver of fees or replanting, the permit shall be considered issued.

c. The application shall include a plan showing the location, species, and DBH of each tree on the property, and must indicate clearly which trees are to be Removed.

d. If replacement trees are to be planted, the plan shall indicate the planned location, species, and size of any replacement trees to be planted. In order to qualify as replacements, trees must be planted on the same or adjacent lot, and must conform to species and planting standards as defined by the Senior Urban Forestry and Landscape Planner. Trees planted in the adjacent right-of-way or otherwise located on public property shall not be considered suitable for consideration as replacement trees.

e. There shall be no fee or charge to submit an application for a tree permit.

2. Conditions for Granting a Tree Permit:

a. Removal of Significant Trees: If any Significant Trees are to be Removed, the plan must show planting of new trees equal to the total Replacement Caliper of those trees.

b. Payment instead of Replacement: Payment to the Street Tree Fund may be made in lieu of planting some or all of the Replacement Trees, according to a cost schedule established by the Senior Urban Forestry and Landscape Planner. Such

fees shall be based on the actual costs associated with purchasing, planting, and maintaining the City's Public Shade Trees. Payment must be made prior to issuance of the permit.

c. Request for Waiver: The application for a Tree Permit shall allow the applicant to request a waiver of the requirement for replanting or payment.

d. Hearing of Request for Waiver: The Tree Warden, or their designee, shall hear requests for such waivers within sixty (60) days of the date the application was received. This hearing may take place at a public meeting of the Urban Forestry Committee. The applicant shall have the opportunity to speak and to answer questions. The Committee may, at the request of the applicant, make a recommendation to approve or deny the waiver. Examples of reasons supporting a waiver include, but are not limited to: financial hardship associated with the care and upkeep of the trees; unreasonably high requirements for replacement or repayment; and ongoing or reasonably foreseen damage or risk from the trees. The Tree Warden shall consider such recommendation considering whether or not to grant the waiver. If the waiver is approved, a Tree Permit will be issued within ten (10) business days of the close of the hearing

e. Owner-Occupants: the owner-occupant of a lot containing a one, two, or three-family dwelling, who resides at the same property as demonstrated by issuance of, or good faith application for, a valid Residential Exemption shall at their request, be granted a waiver of the requirement for replanting or payment with no need for a hearing.

f. Departure of Owner-Occupant: If at any point during the 18 consecutive months following the issuance of a Tree Permit the owner no longer resides at that address, and if the requirements for replanting or payment were waived based on said owner-occupancy status as described above, then said waiver shall be revoked. In the case, the owner or, if the property has been sold, the new owner, shall be required to obtain a Tree Permit either for a replanting plan to make full payment within thirty (30) days of the fees that were waived.

3. Standards for Replacement Trees:

a. Replacement Trees must be planted within eighteen (18) months from the date the tree permit is issued, or prior to transfer of property ownership, whichever comes first.

b. Replacement trees must be of the same or similar species and size as described in the application for the Tree Permit, and must be planted according to standards established by the Senior Urban Forestry and Landscape Planner.

c. In the event that trees of the size and species that were described in the application for the Tree Permit cannot be obtained at the time of planting, multiple smaller replacement trees may be planted with the authorization of the Tree Warden.

d. If a replacement tree dies within eighteen (18) months from the date of planting, it must be replaced. The person planting the tree shall provide documentation as to the date of the planting and file the same with the Tree Warden within fifteen (15) days of the planting of said replacement tree.

4. Exceptions to the Tree Permit Requirement:
    a. Emergencies: If any tree shall be determined to be in a hazardous condition so as to immediately endanger the public health, safety, or welfare or cause an immediate disruption of public services and require immediate Removal without delay, verbal authorization may be given by the Tree Warden to remove such tree, and the tree may be removed without obtaining a written permit as otherwise required by this ordinance. The Tree Warden shall record in writing each such verbal authorization, and shall present these written notes at the next meeting of the Urban Forestry Committee.
    b. Waiver: The requirements of this article may be waived by the Tree Warden during the period of an emergency such as a hurricane, tornado, windstorm, flood, or similar threat to life and property.
5. Enforcement:
    a. If a Significant Tree is Removed without a Tree Permit, the property owner must apply for a Tree Permit within 30 days of the Removal. Each business day thereafter, until an application is filed, shall constitute a separate violation of this ordinance.
    b. Stop work order: Upon notice that trees are being removed without a Tree Permit, such work shall be immediately stopped by the Director of Inspectional Services or designee. The stop work order shall be in writing and shall be mailed to the owner of record of the property and posted at the front to the property in a conspicuous location, and if possible, given to the owner of the lot involved, or to the owner's agent, or to the person doing the work, and shall state the conditions under which work will be permitted to resume.
    c. Injunctive relief: Whenever there exists reasonable cause to believe that a person is violating any applicable provision of this article, the City may institute a civil action for a mandatory or prohibiting injunction in a court of competent jurisdiction ordering the defendant to correct the unlawful condition or to cease the unlawful use of the property.
6. Penalties:
    a. For each offense under this ordinance the person in violation shall be subject to a $100 fine.
    b. Failure to make payment of any fines may result in the revocation, suspension, or denial of any local license or permit, including renewals and transfers.
7. Safety of Life and Property: Nothing in this ordinance shall be construed to prevent a property owner from acting to Remove any Significant Tree, with written or oral authorization from the Tree Warden, that is an immediate and pressing health or safety hazard; that is dead or dying; or that is damaging existing structures or property; or could do so if it were to fall. In such cases, the Tree Warden may authorize immediate removal in writing or verbally, with written record to the Urban Forestry Committee as soon as practicable.

7-15.14 EFFECTIVE DATE: The provisions of this ordinance shall take effect 90 days after passage.

Filed in Council: January 9, 2023

Development Practices and Ordinances as Predictors of Canopy Coverage in Florida (United States) Communities

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Development Practices and Ordinances as Predictors of Canopy Coverage in Florida (United States) Cities

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Abstract: This study compared the management practices and ordinances enacted by 43 Florida (United States) communities to assess their potential impact on tree canopy coverage. Dot-based canopy analysis was used to assess community level canopy coverage. This information was paired with each community's responses to a 2014 survey of municipal forestry management practices in the United States. Canopy coverage ranged between 17.6% and 63.3% among the communities assessed, with average of 33.7%. Two factors were significant when attempting to predict canopy coverage. Housing density had a negative impact on tree canopy (P-value = 0.0116). In contrast, ordinance designating and protecting heritage or other trees of significance resulted in a 6.7% increase in canopy coverage (P-value = 0.0476). Results of this research provide base-level data regarding urban forest cover in a range of Florida communities. More importantly, this research suggests the heritage tree protections afforded to old or large-stature urban trees has a measurable impact on tree canopy retention.

Keywords: ecosystem services; environmental policy; heritage trees; tree ordinance; urban forest management; urban tree canopy

1. Introduction

Research has demonstrated that trees in urban environments provide a variety of ecosystem services (e.g., creation of habitats) and other benefits (e.g., increased quality of life) (Roy et al., 2012). Many of these benefits are associated with the healthy leaf area of a tree (Nowak & Greenfield, 2012), making urban tree canopy cover an important measurement for estimating overall urban forest benefits. Nowak et al. (1996) defines an urban tree canopy (UTC) as the proportion of area, when viewed from above, occupied by tree crowns. Environmental benefits derived from an UTC include ecosystem services such as improved air and water quality (Nowak et al., 2007) and energy use reduction (Akbari, 2002). Economic benefits range from increased property value (Pandit et al., 2013) to reduced heating and cooling costs (Pandit & Laband, 2010). Management of urban trees can be conducted with specific UTC cover goals in mind in order to maximize benefits (Nowak & Crane, 2000; Hill et al., 2010; McPherson et al., 2011; Hauer & Peterson, 2016).

In contrast to these benefits, urban trees have costs associated with their installation, care, and eventual removal which are shared between residents, businesses, and municipalities (e.g., planting, maintenance, or infrastructure repair) (Koeser et al., 2016; Vogt et al., 2015). Furthermore, urban trees are considered public assets in many municipalities, making an UTC subject to municipal tree management practices and ordinances (e.g., pruning cycles, planting initiatives, preservation ordinances, etc.) created by municipal staff and external groups (Hauer & Peterson, 2016). Land use ordinances and the degree to which they are enforced will impact the UTC (Elmendorf et al. 2003; Hill et al., 2010). For instance, a study of the UTC and associated management practices in the Atlanta Metropolitan Area showed that planning and zoning regulations aimed at UTC protection and quality growth were associated with an increase in canopy cover over ten years (Hill et al., 2010). Hill et al. (2010) also point out that UTC management actions should also extend to private trees, which can make up a large portion of the urban forest. In Tampa, Florida,

Landry and Pu (2010) found that tree canopy coverage was greater on private lots developed after the adoption of a 1974 tree protection ordinance compared to lots developed prior to the ordinance. However, regulations of private trees can cause political tensions. For example, a tree management bill was introduced to the Florida Senate in 2018 [Senate Bill (SB) 574: Tree and Vegetation Trimming and Removal] which, among other provisions, would roll back local governments' abilities to require permits for the trimming, pruning, removal, or harvesting of trees on private property in certain areas, and to require mitigation (i.e., replacement) of trees removed or harmed. This proposed bill concerned some individuals who were aware of the pattern of declining UTC across this United States (Nowak & Greenfield 2012).

A comprehensive understanding of a municipality's UTC can provide urban resource managers with baseline data to set goals, inform key stakeholders of the effects of certain management and development strategies, and subsequently improve various urban forest functions (Hill et al., 2010). In light of emerging research on management practices and the UTC, and legislation like the aforementioned Bill, we were motivated to investigate the effects Florida municipal management actions have on local UTC and how different municipalities compare. The objectives of this study were to 1. use dot-based spatial analysis to estimate canopy cover in Florida municipalities, and to 2. investigate the relationships between canopy cover and variables related to municipal development, tree management practices, and tree-related municipal ordinances gathered from a survey of municipal forestry managers.

2. Materials and methods

2.1. Study area

The study area consisted of 43 Florida (United States) communities who had returned a comprehensive survey on urban forest management (Hauer and Peterson, 2016). Locations of these communities are shown in Fig. 1.

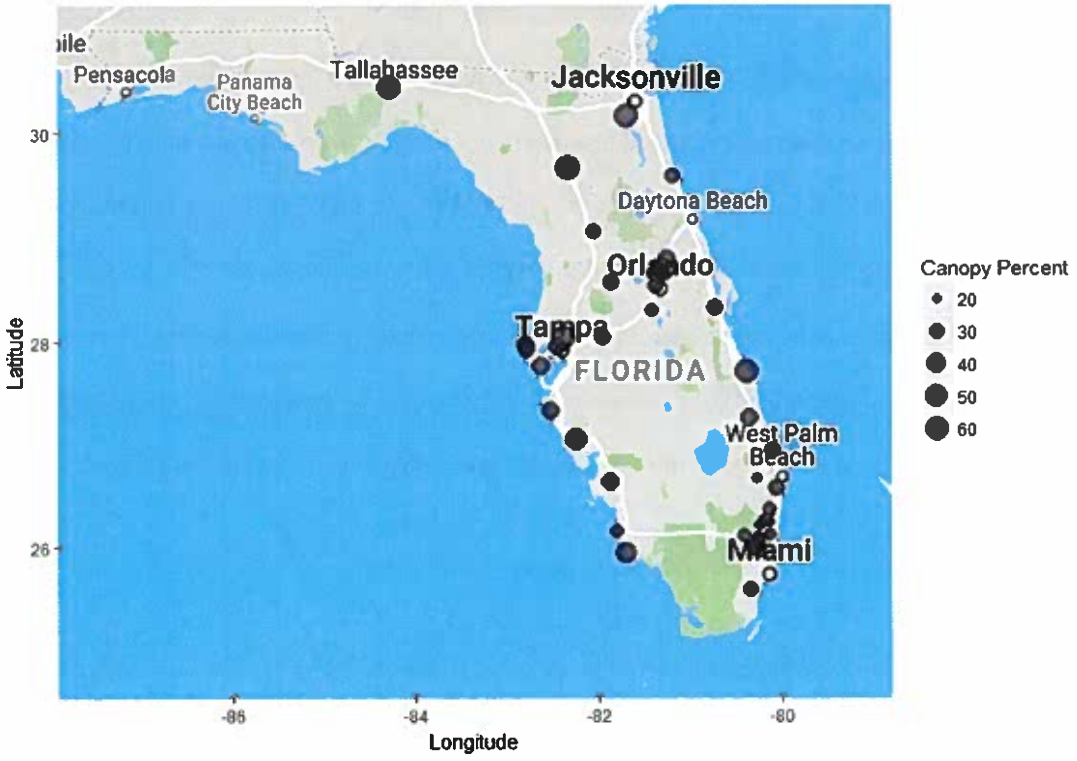

Figure 1. Locations of the 43 Florida (United States) communities included in this assessment of canopy coverage. The sizes of the points are scaled to reflect relative differences in canopy coverage.

2.2. Survey methodology

The predictor variables used to model percent canopy coverage were derived in part from the results of a 2014 survey of municipal forestry management practices in the United States (Hauer and Peterson, 2016). The comprehensive, 109-question survey was sent to a stratified sample of 1727 communities in all fifty states, of which 87 were sent to Florida communities. All communities with populations over 50,000 received the survey and a random sample was taken for cities with populations between 25,000 and 49,999 (50%) and between 2,500 and 24,999 (10%). More detailed information regarding the generation of the mailing list is available by referencing Koeser et al. (2016). The survey was approved through the [redacted] Institutional Review Board (IRB) prior to study recruitment.

Following the approach outlined by Dillman et al. (2014), all communities on our mailing list received a pre-notice followed by a printed copy of the survey (i.e., with a cover letter). Non-respondents were also sent a reminder postcard, followed by a second printed survey (i.e., with a cover letter). A final email reminder was sent to any remaining non-respondents.

A second round of surveying was conducted using a truncated, 53-question survey in an attempt to reach communities that did not complete the larger set of questions. This shortened questionnaire (with cover letter) was sent non-respondents to the long-form version. A single email reminder was sent to non-respondents of the truncated survey. In addition to the communities that responded to the survey in 2014, the authors reached out to the urban foresters from Fort Lauderdale, Naples, Pompano Beach, and Temple Terrace. The authors knew these individuals personally through their local professional society (though knew little of their respective programs) and used this connection to increase the sample size for the canopy analysis. Interviews occurred July of 2018. These four individuals referenced records from 2014 to answer the survey questions relevant to our canopy analysis.

2.3. Dot-based canopy analysis

The aerial imagery assessed in this study was accessed from the National Agricultural Imagery Program (NAIP; USDA, 2018). Specifically, imagery from 2015 was used to coincide with the timeframe of the survey mentioned above. Spatial resolution for the 2015 NAIP imagery was 1 m. A random point sampling method was conducted following the 'i-Tree Canopy' user guidelines (https://canopy.itreetools.org/) and Nowak and Greenfield (2012), which suggests the collection of 500-1,000 random survey points per community. In an effort to increase measurement confidence, we adopted the larger, 1,000 point sample size within this suggested range. Boundaries for each community assessed were provided by the American Community Survey (ACS; United States Census Bureau, 2015).

A geographic information system (ArcGIS 10; ESRI, Redlands, CA, United States) was used to import NAIP aerial imagery and generate the random points (at an average minimum distance of 5 meters). Urban tree canopy was assessed as either tree or non-tree. Each city was assessed at least two interpreters. Points where the interpreters disagreed were discarded prior to analysis, thus minimizing photointerpreter bias. Canopy percentage, agreement between/among interpreters, standard error (SE), and 95% confidence intervals were (Parmehr et al., 2016).

$$SE = \sqrt{p(1-p/N}$$

Where p = number of tree points (n)/the total number of sample points (N)

$$95\%\, CI = UTC \pm SE \times 1.96$$

2.4. Data analysis

A multiple linear regression model was fit using community-wide percent canopy coverage as the dependent variable of interest. This analysis was conducted using the lm() function in R (R Core Team, 2016). Initially, a maximal model was fit using the explanatory variables listed in Table 1.

113 **Table 1. Initial set of variables assessed in modelling canopy coverage in Florida (United States)**
114 **communities. Mean/counts include data from the survey and data acquired from other sources**
115 **(U.S. Census Bureau, 2018; various municipal ordinance websites).**
116

Variable	Definition	Mean (Std. Dev.) or Count
Canopy coverage[z]	Response variable, percent (%) of city covered by tree canopy	34.4% (11.7%)
Housing density[y]	Housing units per square kilometer	520.4 (294.6)
Median home value[y]	Median value of resident-owned housing units	$221,482 ($155,976)
House percent since 2010[y]	Percent of total housing units constructed after 2010	0.6% (0.6%)
House percent since 2000[y]	Percent of total housing units constructed after 2000	20.3% (14.1%)
House percent since 1990[y]	Percent of total housing units constructed after 1990	37.5% (18.7%)
Maintains Rights-of-ways (ROW)[x]	Who is responsible for maintaining trees in rights-of-way (e.g., street trees between sidewalk and curb/ alley trees)	Community - 23 Homeowner - 7 Joint ownership - 7 Other - 1
ISA Certified Arborist - yes[x]	Community employs at least one ISA Certified Arborist credential holder	Yes - 31 No - 9
Four year degree - yes[x]	Community employs at least one person with a four year degree related to tree care	Yes - 19 No - 21
Tree board - yes[x]	Community has a government-authorized board to help develop/administer tree management policy	Yes - 28 No - 11
Tree preservation ordinance[xw]	Community has an ordinance requiring the preservation of trees during development	Yes - 32 No - 8
Removal permit ordinacne[xw]	Community has an ordinance restricting tree cutting on private property	Yes - 23 No - 18
Heritage tree ordinance[xw]	Community identified and preserves heritage/significant trees	Yes - 26 No - 15

Tree inventory - yes[x]	Community has a record of public trees within its jurisdiction	Yes - 25 No - 14
Canopy goal - yes[x]	Community has a goal for enhancing or maintaining % tree canopy coverage	Developing - 2 Yes - 14 No - 20

[z]Source: Dot-based canopy analysis
[y]Source: U.S. Census Bureau (2018)
[x]Source: Hauer and Peterson (2016)
[w]Source: Municipal websites

As missing data prevented the use of a stepwise deleting function, the regsubsets() function from the *leaps* package (Lumley and Miller, 2017) was used to run and plot (by R^2 value) the 20 best subsets of our predictor variables. This plot (Fig 1.) was used to identify which variables were most commonly associated with models having higher predictive power. A second, reduced model with housing density, house percent since 2010, maintains ROW, ISA Certified Arborist, tree board, and ordinance: heritage trees was run and non-significant explanatory variables were removed one-at-a-time based on P-value (highest first). Each reduced model was compared against its preceding model using the anova() function in R (R core team, 2016) to determine if there was a significant difference in fit between the two iterations (Crawley, 2013). All determinations of statistical significance were made at an $\alpha=0.05$ level of Type 1 error. Diagnostic plots were referenced to confirm no underlying assumptions associated with the analysis were violated.

135 ## 3. Results
136
137 ### 3.1. Survey results for Florida cities
138
139 Overall, 667 communities responded to either the initial survey (n=513) or the truncated survey (n=154)
140 for a total response rate of 38.6% in all 50 states. In Florida, 39 of the 87 communities surveyed
141 responded leading to a statewide response rate of 44.8%, higher than that of the total survey population.
142 The initial survey, combined with the four additional communities from this study, resulting in a 49.4%
143 response rate. The survey results provided information on different aspects of urban forest management,
144 including the community, staff, management practices, and inventorying activities. When asked who is
145 legally responsible for trees in rights-of-way, 61% said the community was solely responsible. Over
146 three-quarters of the respondents said they had at least one ISA Certified Arborist on the staff, and about
147 half said they had at least one employee with a four-year degree. Over two-thirds of the responding
148 communities reporting having a government-organized tree board, over three-quarters had tree
149 preservation ordinances in place, and over half had ordinances that protect heritage or significant trees.
150 About half of the respondents said they had permit requirements that restrict tree cutting on private
151 property. A majority said they had a tree inventory, but only a third of those respondents said the
152 inventory was up-to-date. Finally, less than half of the communities said they had canopy cover goals.

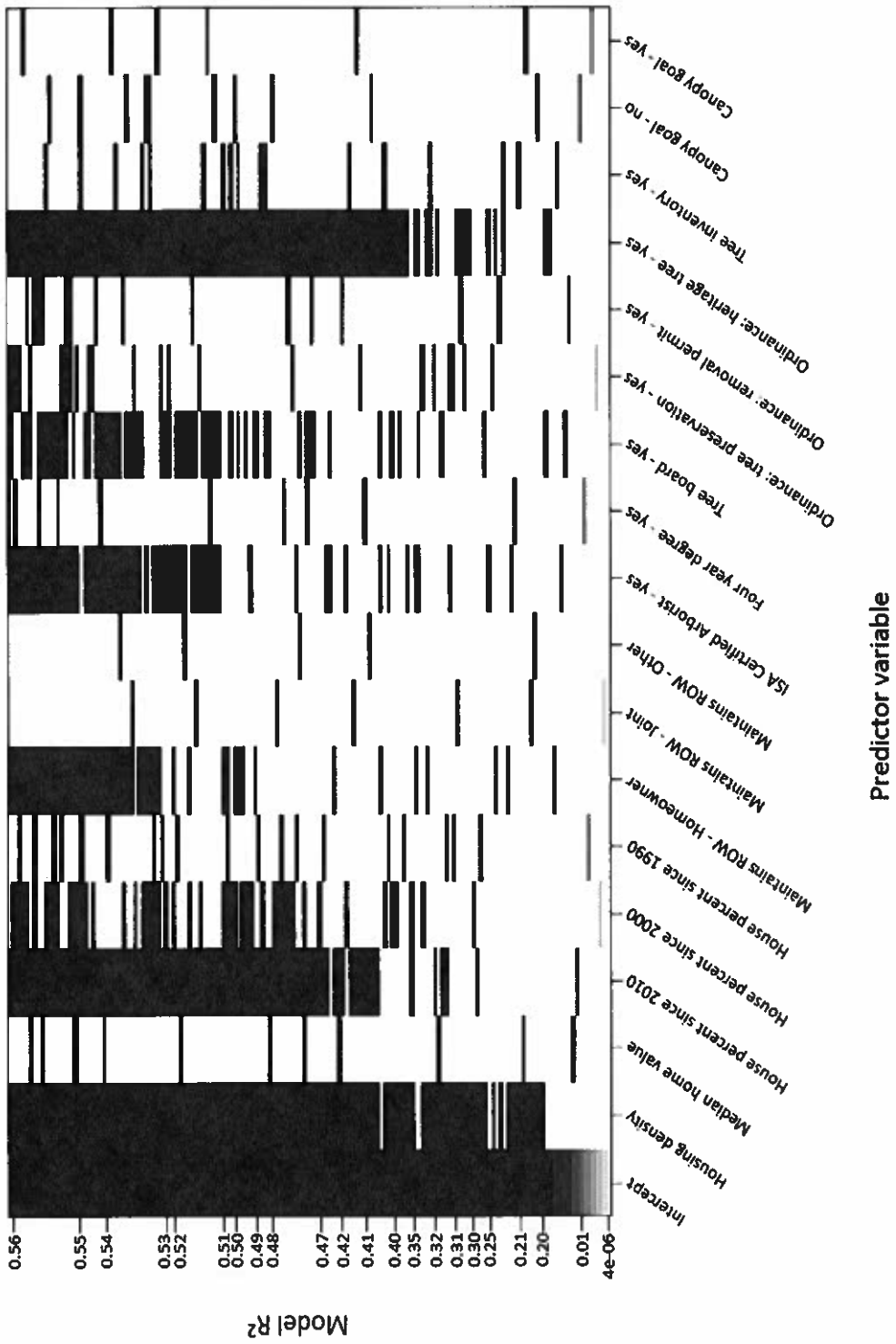

Figure 2. Coefficient of determination (R^2) values for the various combinations of predictor variables selected for initial testing. Variables most commonly associated with the highest predictive power were selected for initial model simplification. Figure generated using the leaps package in R (Lumley and Miller, 2017).

158 ### 3.2. Canopy coverage in Florida cities
159

160 Canopy coverage ranged from 17.6% in Deerfield Beach to 63.3% in Gainesville Florida (Table 2).

161 Average canopy coverage for the 43 assessed communities was 33.7% (±1.5%). Agreement among our

162 interpreters ranged from 94.9% to 99.5%. Average agreement for the 43 cities was 97% (Table 2).

163

164 **Table 2. Population, percent canopy coverage, standard error, 95% confidence intervals, number of**
165 **interpreters, and percent agreement associated with the dot-based canopy analysis of 43 Florida**
166 **(United States) communities.**
167

Community Name	2014 Population	Canopy Coverage (%)	SE (%)	95% CI Lower (%)	95% CI Upper (%)	Interpreters	Agreement (%)
Gainesville	124,354	63.3	1.5	60.4	66.2	2	99.3
Tallahassee	181,376	58.7	1.6	55.6	61.8	2	99.0
Indian River Shores	4,070	57.9	1.6	54.8	61.0	2	99.4
Temple Terrace	25,495	55.6	1.6	52.5	58.7	2	98.8
Orange Park	8,412	55.0	1.6	51.9	58.1	2	97.8
Winter Springs	33,282	54.4	1.6	51.3	57.5	2	96.1
North Port	57,357	51.5	1.6	48.4	54.6	2	98.7
Marco Island	16,413	48.5	1.6	45.4	51.6	2	98.2
Altamonte Springs	42,215	40.2	1.6	37.1	43.3	2	97.2
Clearwater	107,685	37.2	1.6	34.1	40.3	3	95.6
St. Petersburg	244,769	36.9	1.5	34.0	39.8	2	97.5
Fort Myers	62,298	36.1	1.5	33.2	39.0	3	97.4
Port St. Lucie	164,603	36.1	1.5	33.2	39.0	2	97.7
Sarasota	51,917	35.8	1.5	32.9	38.7	2	97.6
Tampa	335,709	35.7	1.5	32.8	38.6	2	98.4
Sanford	53,570	35.1	1.5	32.2	38.0	2	99.1
Casselberry	26,241	34.7	1.5	31.8	37.6	3	97.2
Jupiter	55,156	34.4	1.5	31.5	37.3	2	98.4
Largo	77,648	34.2	1.5	31.3	37.1	2	97.5
Lakeland	97,422	34.0	1.5	31.1	36.9	2	97.4
Rockledge	24,926	32.9	1.5	30.0	35.8	2	98.1
Hypoluxo	2,588	32.2	1.5	29.3	35.1	2	97.4
Groveland	8,729	32.1	1.5	29.2	35.0	2	96.7
Cutler Bay	40,286	30.1	1.5	27.2	33.0	3	96.2
Cooper City	28,547	29.8	1.5	26.9	32.7	2	96.9

Palm Coast	75,180	29.7	1.5	26.8	32.6	2	98.8
Belleview	4,492	29.4	1.5	26.5	32.3	3	98.5
Orlando	238,300	29.4	1.4	26.7	32.1	2	99.3
Miramar	122,041	28.1	1.4	25.4	30.8	2	99.3
Pembroke Pines	154,750	28	1.4	25.3	30.7	2	96.8
Coconut Creek	52,909	26.9	1.4	24.2	29.6	3	94.9
Kissimmee	59,682	26.3	1.4	23.6	29.0	2	98.4
Boca Raton	84,392	26.2	1.4	23.5	28.9	3	95.5
Weston	65,333	25.6	1.4	22.9	28.3	2	97.7
Naples	20,913	25.3	1.4	22.6	28.0	2	98.0
Davie	91,992	25.1	1.4	22.4	27.8	3	97.3
Fort Lauderdale	175,599	24.5	1.4	21.8	27.2	2	99.5
North Lauderdale	41,023	22.6	1.3	20.1	25.1	2	96.8
Wellington	56,508	21.6	1.3	19.1	24.1	2	96.9
Pompano Beach	105,851	20.6	1.3	18.1	23.1	2	98.9
Tamarac	60,427	20.4	1.3	17.9	22.9	2	97.4
Miami Gardens	107,167	19.4	1.3	16.9	21.9	2	99.4
Deerfield Beach	75,018	17.6	1.2	15.2	20.0	3	98.8

3.3. Predictors of canopy coverage

In conducting the model simplification process, two significant predictors of canopy coverage beyond the intercept term were significant. The first significant predictor was *housing density* ($P<0.0116$) which had a negative relationship with canopy coverage (Table 3). A 1.1% decrease in UTC would occur for each 500 housing units per km^2 compared to a situation with no housing units. The second predictor in our model was having a *heritage tree ordinance* ($P<0.0476$). For this variable, having some form of heritage or significant tree designation was associated with a 6.7% increase in canopy coverage (Table 3). *Housing density* and *heritage tree ordinance* accounted for approximately a quarter of the variability seen with regard to community canopy coverage (adjusted $R^2 = 0.24$).

183 **Table 3. Final model and regression results in predicting canopy coverage for 43 Florida (United**
184 **States) communities with a range of urban forest management strategies and ordinances.**

Variable	Coefficient	Standard Error	*P* value	95% CI Lower	95% CI Upper
Intercept	37.2696	4.1194	<0.0001	28.9303	45.6089
Housing density	-0.0021	0.0008	0.0116	-0.0038	-0.0005
Heritage tree ordinance	6.7207	3.2827	0.0476	0.0751	13.3664

185

186 **4. Discussion**

187

188 **4.1. Survey results for Florida cities**

189 The information gleaned from this study creates a picture of urban forest management in Florida. Most
190 surveyed communities had tree inventories, despite this very few had tree canopy goals. This might be
191 due in part to the fact that most UTC typically falls on private property, complicating a municipality's
192 ability to maintain a specific amount of canopy cover (Miller at al., 2015). However, many respondents
193 said they had measures in place (i.e., permit requirements) for cutting trees on private property.
194 Additionally, a majority of the Florida communities had tree preservation and heritage tree ordinances
195 protecting their public and (in some instances) private trees. Preservation ordinances that protect trees
196 during development activities can be significant management practices in rapidly-urbanizing areas such as
197 Florida. This is also true of heritage tree preservation ordinances, which protect trees with large stem
198 diameters. These significantly-sized trees would likely have greater canopy areas that provide more
199 benefits and ecosystem services than smaller trees of the same species (Maco and McPherson, 2003;
200 Leibowitz, 2012). Extra attention should be paid to these large trees when examining UTC and creating
201 canopy goals.

202 **4.2. Canopy coverage in Florida cities**
203

204 Dot-based canopy assessment is a proven, albeit somewhat labor-intensive, method of conducting land
205 classification (Walton et al., 2008; Jackson et al. 2010). In urban forestry research, dot-based
206 interpretation is often considered that standard to compare against other manual or more automated
207 approaches for identifying canopy coverage (Nowak and Greenfield, 2010; Nowak and Greenfield, 2012;
208 Parmehr et al., 2016). In testing the repeatability of dot-based canopy assessment, Jackson et al (2010),
209 compared canopy classifications for five locations (e.g., Georgia, Kansas, Michigan, Oregon, and Utah)
210 across the United States. The authors had two to five assessors interpret a total 208 plots (with 105 dots
211 per plot) and reported how many plots from each location met a 90% threshold for agreement. With over
212 70% meeting or surpassing this threshold for all but the Georgia location (which had an errant
213 interpreter), the authors concluded that the method offered a high level of agreement (Jackson et al.,
214 2010). In comparison, 100% of the cities assessed by our interpreters met or surpassed the 90% agreement
215 threshold used by Jackson et al. (2010; Table 2) using the same imagery source, (National Agriculture
216 Imagery Program or NAIP).
217

218 Canopy coverage for the Florida communities included in this study ranged from 17.6% in Deerfield
219 Beach to 63.3% in Gainesville. The latter value for percent canopy coverage is among the highest
220 reported in the literature. In looking at 29 Chicago-area communities, Iverson and Cook (2000) estimated
221 62.7% canopy coverage in North Barrington, Illinois, United States. Heynen and Lindsey (2003) observed
222 a maximum canopy coverage of 55.7% in their assessment of 60 central Indiana communities. At 55%
223 canopy coverage, Nowak et al (1996) identified Baton Rouge, Louisiana as the most treed city in their
224 aggregation of 68 canopy analyses conducted in the United States.
225

226 Several of the communities assessed for this study had previous assessments of canopy coverage to draw
227 on for comparison. In 2016, one year after our referenced imagery, researchers estimated Tampa had a

228 total canopy coverage of 32.3% (Landry et al., 2018). In comparing 95% confidence intervals, the lower
229 bound for our study's estimate of canopy coverage (32.8%) overlapped with the upper bound for the
230 estimate (33.7%) calculated by Landry et al. (2018). Even greater overlap was noted with canopy
231 coverage estimates calculated by the City of Fort Lauderdale. The urban forester for this community
232 related that he had estimated canopy coverage in 2018 at 25.9% with a 95% confidence interval between
233 23.2 and 28.6 (Mark Williams, personal communication; Table 2). Despite differences in methodology,
234 canopy estimates from Orlando's 2012 i-Tree Eco analysis (31.4 %; Epke et al., 2012) also fell within our
235 95% confidence intervals (Table 2).
236
237 Our canopy estimates were less consistent with past estimates when looking at our two most treed
238 communities - Gainesville and Tallahassee. Using 2013 imagery, Ucer et al. (2016) compared two
239 different sampling techniques for estimating canopy coverage in Tallahassee. While both methods tested
240 garnered similar results in their study (44.5% to 49.1% depending on imagery source), their results were
241 well below our canopy estimate of 58.7% (Table 2). That said, our estimates did align with a 55% canopy
242 coverage estimate obtained by the City of Tallahassee as part of efforts to develop an Urban Forest
243 Master Plan (City of Tallahassee, 2018). Similarly, our estimate of tree canopy coverage in Gainesville
244 (63.3%) was higher than independent estimates (54%) derived from the same 2015 imagery (Andreu et
245 al., 2017). That noted, our estimate was in line with historic estimates of canopy coverage (59% to 67%)
246 for the community calculated by Szantoi et al. (2008).
247
248 **4.3. Predictors of canopy coverage**
249
250 While our two-variable reduced model may appear somewhat simplistic compared to other attempts at
251 predicting canopy coverage (Hill et al., 2010; Landry and Pu, 2010; Kendal et al., 2012; Conway and
252 Bourne, 2013), it is appropriate for our sample size of 43 communities and likely avoids the generation of
253 misleading coefficients, *P*-values, and coefficient of determination values associated with overfitting

(Minitab Blog Editor, 2015). The negative relationship between housing density and canopy coverage is both intuitive and in line with findings from past research (Iverson and Cook, 2000; Conway and Bourne, 2013). The importance of housing density also supports the "population density" explanation of tree canopy distribution (i.e., that people displace trees; Locke et al, 2016). In plotting canopy coverage values by location (Fig. 1), the relationship is particularly noticeable in the densely populated, Southeastern portion of the state (e.g., Palm Beach, Broward, and Miami-Dade counties).

More interesting with regard to our original research questions is the significance of having heritage tree designations and protections. A 6.7% increase in canopy coverage represents anywhere from 10.5% to 38.1% of the total canopy coverage depending on the community investigated (Table 2). While the other ordinances noted in our survey did not remain in our reduced model as predictors of canopy coverage, their absence cannot be taken as evidence that they are not effective. For example, nearly every city surveyed had ordinances in place requiring the planting of trees for new developments (n=39) and new parking lots (n=39). As such these were not used as predictors for canopy coverage in any of our models.

Of the tree ordinance types used to predict canopy coverage (i.e., *tree preservation ordinance, removal permit ordinance;* and *heritage tree ordinance*), only *heritage tree ordinance* was significant (Table 3). However, 92.3% of the cities that reported having protections enacted for heritage trees also reported having ordinances regarding the preservation of existing trees during development. Similarly, 69.2% of cities with heritage tree designations also had ordinances restricting tree cutting on private property. As such it is not clear if heritage tree protections alone are responsible for the measured increase in canopy. The increase in canopy may ultimately be the combined impact of all the ordinances in addition to any special protections communities afford for their large stature trees.

That noted, *heritage tree ordinance* did play a role in many of the models with the highest predictive ability derived from our initial set or variable (Fig. 2). Its statistical significance could reflect the stricter

protections afforded to trees of noteworthy stature or historical notoriety. Large stature trees in both forest and urban environments are the genetic and environmental lottery winners of the plant world - defying odds that weeded out hundreds, if not thousands, of peer trees over the decades (i.e., other trees that did not reach maturity). While this is the case even in hospitable locales, urban sites can be especially challenging as the conditions (e.g., adequate space, native soils, protection from neighboring trees) which allowed heritage trees to grow to their fullest potential may no longer exist in a post-development environment. Despite their relative rareness, large stature trees provide a disproportionate amount of environmental and economic benefit. Benefits like shading, air pollution capture, stormwater control, and carbon sequestration are all tied to tree size and canopy area. Factoring in growth and attrition rates, it could take decades, dozens of replacement trees, or both to mitigate the loss associated with a single large stature heritage tree.

While tree preservation ordinances and removal permits are intended, in part, to reduce canopy loss, neither *tree preservation ordinance* nor *removal permit ordinance* made it into our final reduced model (Table 3). With regard to tree preservation ordinances, there could be several reasons we did not see a relationship with canopy coverage (beyond the overlap in ordinances noted above). Tree preservation ordinances do allow the removal of trees to permit the development of a forested site. To offset these removals, new trees can be planted elsewhere on the property or in the community. Alternatively, developers are often given the option of paying into a tree mitigation fund if they prefer or if suitable planting sites are not available. Depending on how the number of replacement trees is calculated, it could take several decades to regain the canopy lost to development. Additionally, if mitigation funds are not actively spent to replant trees within a community, the canopy linked to these funds is essentially lost without replacement. Even with an active replanting program, transplant losses, vandalism, and other stressors that afflict younger trees could limit canopy replacement efforts - especially if adequate early care is not provided.

306 Research by Landry and Pu (2010) in the Tampa Bay area suggests that protections for trees of a certain
307 size regardless of ownership (public or private) can lead to higher canopy area. However, tree removal
308 permits on private land are a potentially contentious issue which residents may see as being at odds with
309 their individual property rights (Conway and Lue, 2018). In contrast to the findings of Landry and Pu
310 (2010), our data did not indicate private tree protections had any influence on canopy coverage when
311 assessment was expanded beyond the City of Tampa, Temple Terrace, and the surrounding county.
312 Effective private tree protection depends on enforcement and public knowledge of permitting
313 requirements - both of which may could vary by community (Conway and Lue, 2018). Moreover,
314 enforcement occurs only after a tree has been cut down and often only after a member of the public has
315 reported the removal (Conway and Lue, 2018). Finally, permitting generally does not restrict the removal
316 of trees for development or to reduce tree risk, which likely account for the majority of tree removals
317 (even unpermitted).
318
319 **4.4. Policy implications**
320
321 As noted, urban canopy coverage directly affects many ecological and economic benefits. However,
322 maintaining, protecting, and expanding urban tree canopy requires an investment of resources by
323 communities. Moreover, trees, buildings, and urban infrastructure all compete for limited space -
324 potentially putting canopy goals at odds with development efforts. Ultimately, it is up to community
325 leaders and their constituents to decide where this balance best fits their needs and values.
326
327 That noted, this work provides evidence that at least some protection measures currently used in Florida
328 communities are associated with increases in urban tree canopy. For those questioning the validity of
329 current ordinances, the data provided for this work hopefully alleviates some of the concerns that existing
330 regulations are not serving their intended function. Additional work looking at the impacts of urban forest
331 management over time is the next logical step in this line of inquiry. Additionally, the impacts of urban

forest management efforts on storm resiliency (specifically canopy loss) would be a very relevant question for hurricane-prone areas like Florida.

5. Conclusion

Many of the ecosystem services urban tree managers calculate when assessing the value of their urban forest are directly linked to canopy coverage. Large trees contribute more canopy than smaller-sized trees, but must compete with other aspects of urban infrastructure for above and belowground space. This can lead to conflict, tree injury, and even tree death if care is not taken during the development and redevelopment of sites.

Communities enact ordinances to reduce damage to trees given development efforts and restrict the removal of healthy, stable trees as a public good. These efforts can be somewhat controversial, especially when they interfere with private property owner rights. Regardless of one's opinion on this matter, there appears to be some measurable benefit associated with some tree protection ordinances. In particular, we observed a significant increase in canopy associated with communities that designated and protected heritage trees. These findings add much needed empirical evidence to a debate which is playing out in the study area and beyond.

Authors' contributions

[redacted]

Conflicts of interest

The authors declare no conflict of interest

References

1. Akbari, H. (2002). Shade trees reduce building energy use and CO_2 emissions from power plants. *Environmental Pollution*, 116, Supplement 1, S119-S126. https://doi.org/10.1016/S0269-7491(01)00264-0.

2. Andreu, M. G., Fox, D., Landry S., Northrop, R., & Hament, C. (2017). Urban Forest Ecological Analysis. Report to the City of Gainesville, March 2017. City of Gainesville, Florida.

3. City of Tallahassee. Urban Forest Master Plan (2018). http://www.talgov.com/place/pln-urbanforestry.aspx Accessed 28 August 2018.

4. Conway, T.M. & Bourne, K.S. (2013). A comparison of neighborhood characteristics related to canopy cover, stem density, and species richness in an urban forest. *Landscape and Urban Planning*, 113,10-18.

5. Elmendorf, W. F., Cotrone, V. J., & Mullen, J. T. (2003). Trends in urban forestry practices, programs, and sustainability: Contrasting a pennsylvania, U.S., study. *Journal of Arboriculture*, *29*, 237-247.

6. Ekpe, E.K., Becker, E., Lab, J., Hinkle, R. & Escobedo, F. 2012. Orlando, Florida's Urban and Community Forests and their Ecosystem Services. *EDIS Factsheet FOR290* (10 pp.). Gainesville Florida: Institute of Food and Agricultural Science, University of Florida.

7. Hauer R. J. & Peterson W. D. 2016. Municipal Tree Care and Management in the
8. United States: A 2014 Urban & Community Forestry Census of Tree Activities. Special Publication 16-1, College of Natural Resources, University of Wisconsin – Stevens Point. 71 pp.

9. Heynen, N.C. & Lindsey, G. (2003). Correlates of urban forest canopy cover: Implications for local public works. *Public Works Management & Policy*, 8, 33-47.

10. Hill, E., Dorfman, J.H., & Kramer, E. (2010). Evaluation the impact of government land use policies on tree canopy coverage. *Land Use Policy*, 27, 407-414.

11. Iverson, L.R. & Cook, E.A. (2000). Urban forest cover of the Chicago region and its relation to house density and income. *Urban Ecosystems*, 4, 105-124.

12. Jackson, T.A., Moisen, G.G., Patterson, P.L. & Tipton, J. (2010). Repeatability in photo-interpretation of tree canopy cover and its effect on predictive mapping. Paper at the 2010 Join Meeting of the Forest Inventory and Analysis (FIA) Symposium and the Southern Mensurationists, Knoxville, TN.

13. Kendal, D., Williams, N.S.G., & Williams, K.J.H. (2012). Drivers of diversity and tree cover in gardens, parks, and streetscapes in an Australian city. *Urban Forestry & Urban Greening*, 11, 257-265.

14. Koeser, A.K., Vogt, J.M., Hauer, R.J., Northrop, R.J., & Peterson, W. (2016). The Cost of Not Maintaining Trees: Findings and Recommendations from an International Symposium and Summit. *Arboriculture & Urban Forestry*, 42, 377-388.

15. Landry S., Koeser, A., Northrop, R., McLean, D., Donovan, G., Andreu, M. & Hilbert, D. (2018). City of Tampa Tree Canopy and Urban Forest Analysis 2016. Tampa, FL: City of Tampa, Florida

16. Landry, S.M. & Pu, R. (2010). The impact of land development regulation on residential tree cover: An empirical evaluation using high-resolution IKONOS imagery. *Landscape and Urban Planning*, 94, 94-104.

17. Leibowitz, R. (2012). Urban tree growth and longevity: An international meeting and research symposium white paper. *Arboriculture & Urban Forestry,* 38, 237-241.

18. Locke, D.H., Landry, S.M., Grove, J.M., & Chowdhury, R.R. (2016). What's scale got to do with it? Models for urban tree canopy. *Journal of Urban Ecology* 2,16pp.

19. Lumley, T & Miller, A. (2017). Leaps: Regression Subset Selection. URL https://CRAN.Rproject.org/package=leaps.

20. Maco, S.E. & McPherson, E.G. (2003). A practical approach to assessing structure, function, and value of street tree populations in small communities. Journal of Arboriculture 29,84-97.
21. McPherson, E.G., Simpson, J.R., Xiao, Q., and Wu, C. (2011). Million trees Los Angeles canopy cover benefit assessment. *Landscape and Urban Planning*, 99(1), 40-50.

22. Miller, R.W., Hauer, R,J., & Werner, L.P. (2015). *Urban Forestry Planning and Managing Urban Greenspaces (3rd Edition).* Waveland Press. Long Grove, IL.

23. Minitab Blog Editor. The Danger of Overfitting Regression Models. (2015). http://blog.minitab.com/blog/adventures-in-statistics-2/the-danger-of-overfitting-regression-models Accessed 28 August 2018.

24. Nowak, D.J., & Crane, D.E. (2000). The Urban Forest Effects (UFORE) Model: Quantifying urban forest structure and functions. In Integrated tools for natural resources inventories in the 21st century, ed. M. Hansenand T. Burk. USDA Forest Service General Technical Report NC-212. St. Paul, MN: U.S. Department of Agriculture, 714–720.

25. Nowak, D.J. & Greenfield, E.J. (2010). Evaluating the national land cover database tree canopy and impervious cover estimates across the conterminous United States: A comparison with photo-interpreted estimates. *Environmental Management*, 46, 378-390.

26. Nowak, D.J. & Greenfield, E.J. (2012). Tree and impervious cover in the United States. *Landscape and Urban Planning*. 107, 21-30.

27. Nowak, D.J., Rowntree, R.A. McPherson, E.G., Sisinni, S.M., Kerkmann, E.R., & Stevens, J.C. (1996). Measuring and analyzing urban tree cover. *Landscape and Urban Planning*, 36, 49-57.

28. Nowak, D.J., Wang, J. & Endreny, T. (2007). Environmental and Economic Benefits of Preserving Forests Within Urban Areas: Air and Water Quality. CH. 4, USDA, U.S. Forest Service.

29. Pandit, R. & Laband, D.N. (2010). Energy savings from tree shade. *Ecological Economics*, 69, 1324-1329.

30. Pandit, R., Polyakov, M., Tapsuwan, S., & Moran, T. (2013). The effect of street trees on property value in Perth, Western Australia. *Landscape and Urban Planning*. 110, 134-142.

31. Parmehr, E.G., Amati, M., Taylor, E.J., & Livesley, S.J. (2016). Estimation of urban tree canopy using random point sampling and remote sensing methods. *Urban Forestry & Urban Greening*. 20, 160-171.

32. R Core Team. R: A language and environment for statistical computing. (2016). https://www.R-project.org/. Accessed 28 August 2018.

33. Roy, S., Byrne, J., & Pickering, C. (2012). A systematic quantitative review of urban tree benefits, costs, and assessment methods across cities in different climatic zones. *Urban Forestry & Urban Greening*. 11, 351-363.

34. Szantoi, Z., Escobedo, F., Dobbs, C., & Smith, S. (2008). Rapid methods for estimating and monitoring tree cover change in Florida urban forests: The role of hurricanes and urbanization. In P. Bettinger, K. Merry, S. Fei, J. Drake, N. Nibbelink, and J. Hepinstall (Eds.), *Proceedings of the 6th Southern Forestry and Natural Resources GIS Conference*. (pp. 281-304). Athens, GA: Warnell School of Forestry and Natural Resources, University of Georgia.

35. Ucar, Z., Bettinger, P. Merry, K. Siry, J. & Bowker, J.M. (2016). A comparison of two sampling approaches for assessing the urban forest canopy cover from aerial photography. *Urban Forestry & Urban Greening*. 16, 221-230.

36. United States Department of Agriculture (USDA). National Agriculture Imagery Program (2018). https://www.fsa.usda.gov/programs-and-services/aerial-photography/imagery-programs/naip-imagery/ Accessed 28 August 2018.

37. Vogt J.M., Hauer R.J., & Fischer B.C. (2015). The Costs of Maintaining and Not Maintaining the Urban Forest: A Review of the Urban Forestry and Arboriculture Literature. *Arboriculture & Urban Forestry,* 41, 293-323.

38. Walton, J.T., Nowak, D.J., & Greenfield, E.J. (2008). Assessing urban forest canopy cover using airborne or satellite imagery. *Arboriculture & Urban Forestry,* 34, 334-340.

Appendix A:

Select Survey Questions and Summary of Responses

Municipal Tree Care and Management in Florida: *A 2014 Urban & Community Forestry Census of Tree Activities*. The survey was conducted for several municipalities (n=87) in the State of Florida. In looking at the returned survey results, questions with 7 or more non-responses (16.3%) were not considered for inclusion in the regression model.

Section I – Community and Staff
Section II -- Budget
Section III -- Tree Management Profile
Section IV -- Volunteers/Partnerships
Section V -- Contractors
Section VI -- Inventory
Section VII -- Operations Profile
Section VIII -- Assistance Programs

Section I -- Community and Staff

Did your community conduct any kind of shade tree/urban & community forestry activities in 2014?

Yes
No
Don't know

Who in your community is primarily (legally) responsible for maintaining trees in municipal rights-of-way, for example street trees between sidewalk and curb or alley trees?

Municipality responsible
Abutting property owner responsible
Jointly responsible (municipality and abutting owner)
Other (*please specify:* _____)

Does someone in your community (i.e., employee, volunteer, consultant, etc.) oversee the care of municipal street trees, park trees or other public trees?

Yes
No
Don't Know

How many years has your community had a person responsible for the management of trees?

_____ Number of Years

What training and/or credentials are collectively held by the staff responsible for tree activities and/or management of trees?

No specific training or workshops	Yes	No
In-house and/or on-the-job-training	Yes	No
Attend tree care/management workshops	Yes	No
ISA Certified Arborist	Yes	No
ISA Certified Municipal Specialist	Yes	No
Two year degree	Yes	No
Four year degree	Yes	No
Graduate degree	Yes	No

How many public employees, including managers, are involved with the municipal tree management program?

_____ # of Total Employees

_____ # of Full Time Equivalents (2080 hour base year)

Section II -- Budget

What is the total municipal budget (excluding school budget) for 2014? (Please include entire amount for all governmental functions, activities, etc.)

_____ $ Total 2014 Municipal Budget

What is the total annual budget of your municipality funded tree care activities and management from all municipal sources? (Include all tree activity expenses; include personnel, overhead, equipment, supplies, tree care and contract payments.)

_____ $ Total 2014 Tree Budget

Is your budget adequate to meet current needs as defined in your work plan or your identified annual urban forestry budget needs? (This includes planting, maintenance, removal, inventory, education, etc.)

Yes
No → If no, _____% below identified need

What percent of the total tree management budget from all sources is used for the following activities?

Tree Removal _____

Section III -- Tree Management Profile

Does your community have a government-authorized tree board, parks board, city department, commission, or similar group that helps develop and/or administer tree management policy?

Yes
No

Does your municipality have one or more municipal ordinances that pertain to trees?

Yes
No
Developing

What topics do your community tree ordinances include?

Requires tree planting in new developments	Yes
Requires tree planting around new parking lots	Yes
Requires preservation of trees during development	Yes
Restricts tree cutting on private property	Yes
Identifies preservation of heritage or significant trees	Yes

Does your community have a written strategic plan for urban forestry, tree management, open space, green infrastructure, or land use management that includes trees?

Yes
No
Don't Know

Section IV -- Volunteers/ Partnerships

Does your community work with partners and/or volunteers (individuals or groups not paid for providing services) for tree planting, tree care, or other tree activities on public property?

Yes
No

Section V-- Contractors

Does your community use paid contractors for any of your tree care activities?

Yes
No

Section VI -- Inventory

Does your community have a tree inventory? (An inventory is any record of public trees in your community.)

Yes
No

What is the state of your tree inventory? (current = up to date) (CHECK ONE CHOICE)

Current (reflects tree population)
Developing (in process of making current)
Not current (missing tree population information)

Does your municipality have a tree canopy goal? (check one)

Yes
No → (PLEASE GO TO QUESTION 18, PAGE 18)
Developing → (PLEASE GO TO QUESTION 18, PAGE 18)

What is the total number of publicly owned trees in your community?

_____ # of Publicly Owned Trees

Section VII -- Operations Profile

Please fill in the number of trees by tree care activity on all municipal properties in 2014 in the appropriate column. (Please enter 0 if no activity type was performed last year.)

# of Trees removed_____

# of Trees planted_____

What percent of tree care (pruning, pest control, etc.) is done on a systematic (regularly scheduled) cycle and what percent on demand as reactive (complaints, hazardous situations, crisis, post storm etc.)? (Total = 100%)

_____ % Systematic (Scheduled)

_____% Reactive (on Demand)

Does your community conduct any of the following urban activities? (Check yes or no for each activity)

Provide technical assistance (information) for tree maintenance on private property?

Yes
No

Provide financial assistance for specific insect or diseased tree removal on private property?

Yes
No

Does your community regularly conduct tree risk management (hazard tree identification)?

Yes
No

Does your community have a written tree risk management policy?

Yes
No

Does your community have an emergency response system which includes trees?

Yes
No

Section VIII -- Assistance Programs

Do municipal staff provide educational presentations to city residents in regard to tree care?

Yes
No

Is your community currently a Tree City USA?

Yes
No

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Chapter 21

PARKS, RECREATION AND CULTURE, PUBLIC GROUNDS AND TREES*

ARTICLE I.
IN GENERAL

Sec. 21-1. Parks, recreation and culture commissioner—Designation; duties generally; compensation.

(a) The office of commissioner of parks, recreation and culture, and the department of parks, recreation and culture are established. The commissioner shall be an officer of the city and the provisions of the law for the appointment and removal of heads of departments shall be applicable to such office. He shall have under his immediate control and direction such assistants and employees as may from time to time be duly authorized. The commissioner shall consult with the Director of the history museum regarding the manner of maintenance, care and management of the burial grounds. He shall receive for his services such salary as shall be fixed by the mayor and city council.

(b) The parks, recreation and culture commissioner shall have charge of maintenance, care and management of playgrounds and all recreation lands, except to the extent conferred upon the Parks and Recreation Commission, pursuant to Chapter 426 of the Acts of 1982 and G.L. c. 45. He shall have and exercise the power conferred by G. L. c. 45, sec. 14, except that of taking by eminent domain. He shall also be responsible for the control and supervision of the parks, recreation and culture department. The commissioner also shall have charge of the maintenance, care and management of burial grounds and the grounds about public buildings and the maintenance of lands under the jurisdiction and control of the conservation commission. The commissioner shall consult with the conservation commission regarding the manner of maintaining lands under the commission's jurisdiction.

(c) The parks, recreation and culture commissioner shall also be designated as the local superintendent of insect pest control pursuant to the G.L. c. 132, sec. 13. He shall perform the duties of tree warden and have the care and control of all public shade trees and the planting, trimming and cutting thereof. He shall make and keep an itemized account with vouchers, showing the definite amounts expended for the purposes named in the General Laws for the suppression of insects. He shall, under the direction of the mayor, cause notices as required by the statutes to be sent to owners of parcels of land infested with such insects. He shall make lists of the amounts expended on spraying as provided by law, containing the names of the owners of estates, the locations thereof and the amounts expended thereon. (Rev. Ords. 1973, § 2-125, § 19-39; Ord. No. 90, 10-6-75; Ord. No. 190, 12-20-76; Ord. No. 220, 6-7-77; Ord. No. 233, 8-15-77; Ord. No. 317, 2-20-79; Ord. No. R- 267, 10-18-82; Ord. No. T-318, 12-6-93; Ord. No. V-289, 3-20-00; Ord. No. B-53, 03-02-20)

State law references—Office of tree warden, G.L. c. 41, § 1; statements of expenditures of local superintendents of pest control, G.L. c. 132, § 15

*__Cross references__ – Cultural affairs committee, Ch. 2, Art. VI, Div. 3
State law reference—Parks and playgrounds generally, G.L. c. 45

Sec. 21-2. Same—Authority over school property.

(a) The parks, recreation and culture commissioner shall have charge of the management, care and maintenance of the city's school yards and school grounds. No layout of a school yard or school ground shall be made by the parks, recreation and culture commissioner until the plan and design of the same has received the written approval of the school committee.

(b) Control of the use of school yards and school grounds shall be entirely within the jurisdiction of the school committee which shall determine the persons entitled to use the grounds and how the same shall be used. The school committee may, however, during vacation periods of the school, turn over the control of the use of designated school yards and school grounds to the parks, recreation and culture commissioner and it may turn over the control of the use of any designated portion of such ground during the school year to the parks, recreation and culture commissioner. The release of jurisdiction provided for in this section shall only be accomplished if and when the parks, recreation and culture commissioner in writing applies for and the school committee in writing authorizes the same. In the event of such turning over of jurisdiction, the adjoining school building and the equipment of the school department shall only be used under such regulations as to use as the school committee makes. (Rev. Ords. 1973, § 2-270; Ord. No. 190, 12-20-76; Ord. No. 220, 6-6-77; Ord. No. R-267, 10-18-82; Ord. No. B-53, 03-02-20)

Cross reference-Newton community education program, Ch. 2, Art. VI, Div. 2

Sec. 21-3. Operation of vehicles.

No person, unless by permission of the commissioner of public works or, on parks and playgrounds, of the parks, recreation and culture commissioner, shall operate a motor vehicle in or upon parks or other public grounds except upon the driveways thereof. (Rev. Ords. 1973, § 19-102; Ord. No. 90, 10-6-75; Ord. No. B-53, 03-02-20)

Sec. 21-4. Selling goods and wares; amusement tents, booths, etc.

No person, except by permission of the commissioner of public works, or, on parks and playgrounds, of the parks, recreation and culture commissioner, shall expose for sale or sell any goods, wares or merchandise in or upon any park or other public grounds, nor erect or maintain a booth, stand, tent or apparatus of any kind for the purpose of amusement or show in any park or on public grounds. (Rev. Ords. 1973, § 19-103; Ord. No. 90, 10-6-75; Ord. No. B-53, 03-02-20)

Cross reference—Licensing and permits generally, Ch. 17

Sec. 21-5. Nuisances generally.

No person shall commit a nuisance in parks or on other public grounds. (Rev. Ords. 1973, § 19-104; Ord. No. 90, 10-6-75)

Sec. 21-6. Playing games, etc.

No person, except by the permission of the commissioner of public works, or, on parks and playgrounds, of the parks, recreation and culture commissioner, shall engage in a game of ball, football, baseball or other athletic sports in or upon any park or public grounds, except upon such portions thereof as may be set apart for such purposes. (Rev. Ords. 1973, § 19-105; Ord. No. B-53, 03-02-20)

Sec. 21-7. Throwing missiles.

No person shall throw a stone, snowball or other missile in or upon any park or public playground. (Rev. Ords. 1973, § 19-106; Ord. No. 90, 10-6-75)

Sec. 21-8. Damaging property.

No person shall pull up, break, cut or deface any of the seats, fences or railings upon or around any park or other public grounds, nor deface any monument or statue in any park or on public grounds. (Rev. Ords. 1973, § 19-107)

Sec. 21-9. Climbing, posting bills on trees.

No person shall climb a tree in any park or upon other public grounds, nor post a bill, nor place a sign upon or around any tree in any park or upon other public grounds of the city. (Rev. Ords. 1973, § 19-108)

Sec. 21-10. Digging, carrying dirt, etc.

No person, except by permission of the commissioner of public works, or, on parks and playgrounds, of the parks, recreation and culture commissioner, and for some public use, shall dig or carry away any sward, gravel, sand, turf or earth from, nor place or deposit or cause to be placed or deposited any stones, sand, gravel or other substance upon, any park, playground or other public grounds. (Rev. Ords. 1973, § 19-109; Ord. No. 90, 10-6-75; Ord. No. B-53, 03-02-20)

Sec. 21-11. Damaging flowers.

No person shall walk, stand, sit or lie down in or upon, or pull a flower or plant out of a flower bed, in any park or upon public grounds. (Rev. Ords. 1973, § 19-110)

Sec. 21-12. Walking on grass.

No person shall stand, walk or lie upon the grass in any park or upon public grounds where such walking, standing or lying has been prohibited, and notice of such prohibition is given to the public by legible notices placed in or upon such park or public grounds. (Rev. Ords. 1973, § 19-111)

Sec. 21-13. City-owned burial grounds.

No further burials are to be permitted in that portion of the City-owned burial ground located on Centre Street, said portion being bounded on the west side by Centre Street and Loring Park, on the south side by Cotton Street, on the east by the land of the Franciscan Sisters, and on the north by a driveway, as more specifically shown on a plan entitled "Plan of Centre Street Cemetery, January 1901; Amended 1918", on file in the engineering division of the department of public works. (Ord. No. R-251, 6-21-82; Ord. No. V-289, 3-20-00)

Sec. 21-14. Spraying for insects.

(a) The commissioner of parks, recreation and culture may, at the request of owners of private property in the city, spray trees and shrubs thereon for the purpose of destroying or suppressing insects or pests and preventing or controlling the spread of Dutch Elm Disease. The commissioner of parks, recreation and culture may establish rules and regulations governing such spraying, including the time and manner of making requests and payments therefor.

(b) There shall be charged for each such spraying an amount determined by the size of the lot upon which such spraying is done according to the following table:

Size of lot (square feet)	
Amount under 7,500	$ 5.00
7,500 to 9,999	7.50
10,000 to 14,999	10.00
15,000 to 19,999	12.50
20,000 to 24,999	15.00
25,000 and over	the cost of labor and materials employed for the purpose as estimated by the commissioner.

(c) The amount to be charged shall in each case be paid to the parks, recreation and culture commissioner before the spraying is done. (Rev. Ord. 1973, § 2-129, § 19-44; Ord. No. 90, 10-6-75; Ord. No. R-267, 10-18-82; Ord. No. B-53, 03-02-20)

Sec. 21-15. Parks, recreation and culture department; functions generally.

The parks, recreation and culture department shall be responsible for planning, scheduling, organizing and supervising programs for designated city groups and citizens. Under direction of the parks, recreation and culture commissioner, it shall provide supervision and patrol activities at swimming ponds, swimming pools, skating areas, playgrounds and all other recreation areas; it shall also conduct all senior citizens recreation programs. (Rev. Ord. 1973, § 2-271; Ord. No. 190, 12-20-76; Ord. No. R-287, 1-19-83; Ord. No. B-53, 03-02-20)

Secs. 21-16—21-45. Reserved.

ARTICLE II.
PARKS AND RECREATION COMMISSION

Sec. 21-46. Composition; appointment of members; vacancies; chairman.

(a) There shall be a parks and recreation commission comprised of eight (8) voting members together with the parks, recreation and culture commissioner who shall serve, ex officio, as a non-voting member of the parks and recreation commission. One resident from each ward of the city shall be appointed as permanent members by the mayor with the approval of the city council. Four (4) alternate members selected at large shall also be appointed by the mayor with the approval of the city council.

(b) Appointments by the mayor shall strive to balance the concerns of parks and open space preservation with the concerns of recreation.

(c)(i) Permanent members of the parks and recreation commission shall be appointed for a term of three (3) years.

(ii) Four (4) alternate members shall be appointed by the mayor following the effective date of passage of this ordinance. The initial terms of three (3) of the alternate members shall be shortened as follows to stagger expiration of their terms: one member shall be appointed for one (1) year; two members shall be

appointed for two (2) years; one member shall be appointed for three (3) years. All alternate member appointments subsequent to the initial appointments shall be for a term of three (3) years.

(iii) Both permanent and alternate members shall continue to serve after expiration of their terms until their successors shall be duly appointed and qualified. Vacancies in the offices of either permanent or alternate members shall be filled in the same manner as the original appointment for any unexpired term.

(d) The permanent members shall elect one member to act as chair. In the event that a permanent member is absent or unable to act for any reason, the chair shall designate an alternate member to act. (Rev. Ords. 1973, §2-267; Ord. No. R-287, 1-19-83; Ord. No. T-317, 12-6-93; Ord. No. B-53, 03-02-20)

Editor's note—As amended in 1970, this section provided for the members of the former recreation commission whose terms had not expired to serve until December 31, 1970, as well as for the mayor to appoint additional members to serve until December 31, 1970. The section also provided for appointment of members, commencing January 1, 1971, for staggered terms of one, two (2) and three (3) years.

Cross references—Commissions generally, Ch. 2, Art. VII; regulations governing appointment to and service on commissions and committees, § 2-8

State law reference—Recreation commission for city of Newton, c. 631, Acts of 1969

Sec. 21-47. Powers and duties.

The parks and recreation commission shall advise the mayor and city council in relation to matters pertaining to sports, recreation, parks, open space and preservation of scenic beauty and shall render decisions concerning parks, recreation and culture programs and the use of lands under its jurisdiction in accordance with written guidelines or policies. The guidelines or policies established by the parks and recreation commission shall preserve and enhance access to parks, recreation and culture opportunities for Newton citizens. The parks and recreation commission shall also advise the mayor and city council as to the amount of money to be spent annually by the department of parks, recreation and culture. Pursuant to Chapter 426 of the Acts of 1982, the parks and recreation commission shall have all the rights, powers, duties and obligations of a park commission as set forth in Chapter 45 of the General Laws, and shall exercise the powers of eminent domain conferred by Sections 2 and 14 of Chapter 45 of the General Laws.

Pursuant to Section 2 of Chapter 87 of the General Laws, the commission may delegate its powers as tree warden under Section 5 of Chapter 45 to the parks, recreation and culture commissioner. (Rev. Ords. 1973, § 2-268; Ord. No. 190, 12-20-76; Ord. No. R-287, 1-19-83; Ord. No. T-317, 12-6-93; Ord. No. B-53, 03-02-20)

Secs. 21-48. —21-59. Reserved.

ARTICLE III.
TREES

DIVISION 1. URBAN TREE COMMISSION

Sec. 21-60. Establishment and purpose.

There is hereby established the urban tree commission to advise and assist the tree warden in carrying out his duties and responsibilities. The purpose of the urban tree commission shall be to advise the tree warden, the mayor, the city council and the general public on all matters concerning public trees, including but not limited to, the selection of trees for planting, planting and pruning of trees, the treatment of disease, and the preservation and regular maintenance of trees. (Ord. No. V-71, 3-4-96)

Cross reference—Tree warden, Ch. 21, Art. I, § 21-1

Sec. 21-61. Powers and duties.

(a) The commission shall issue a city tree maintenance manual which shall set forth the standards for planting and maintaining all public shade trees in the city and which shall also set forth the general policies in regard to those trees. The commission shall regularly revise and distribute the tree maintenance manual and review the implementation of the practices and policies it enunciates.

(b) The commission shall annually review the needs of various geographical areas of the city for the planting and replacement of trees and shall recommend priorities based on the annual review to the tree warden and superintendent of urban forestry or such other municipal officials as may hereafter be assigned the duties of tree warden and superintendent of urban forestry.

(c) Whenever a hearing is required to be held in regard to cutting down or removal of a tree, the commission may offer written recommendation(s) to the tree warden.

(d) Whenever the tree warden prepares an impact statement on the effect of any construction project on existing trees or the ability to plant trees in that area in the future, the tree commission may submit its advice as part of a submission to appropriate city agencies and/or to the city council for its review of the project. (Ord. No. V-71, 3-4-96)

Sec. 21-62. Composition and organization.

(a) The commission shall consist of twelve (12) voting members who shall serve for three year terms in accordance with Section 2-8 of these Revised Ordinances. Ten (10) members shall be appointed by the mayor in accordance with Section 3-3 of the Charter. The commissioner of parks, recreation and culture, in his capacity as tree warden, or such other municipal official as may hereafter be assigned the duties of tree warden, shall serve, ex officio, as the eleventh voting member. The superintendent of urban forestry, or such other municipal official as may hereafter be assigned the duties of superintendent of urban forestry, shall serve, ex officio, as the twelfth voting member. Three (3) of the initial appointees shall serve for a term of one year; three (3) of the initial appointees shall serve for a term of two years; and four (4) of the initial appointees shall serve for a term of three years.

(b) Members of the commission, so far as practicable, shall be selected so as to provide representation of citizens with expertise or interest in the preservation and care of trees. Consistent with this requirement, whenever a vacancy occurs on the commission, the commission shall offer a list of prospective members for the mayor's consideration in making appointments.

In making the initial appointees to the urban tree commission, the city council requests that the mayor consider any active members of the urban tree task force who wish to be appointed, it being the will of the city council that the urban tree commission be established as the successor to the urban tree task force. The city council also requests that the mayor also consider appointing any such members of the urban tree task force to the longest terms of office available prior to appointing persons who are not currently serving on the urban tree task force. (Ord. No. V-71, 3-4-96; Ord. No. B-53, 03-02-20)

Secs. 21-63. —21-69. Reserved.

Sec. 21-70. Volunteer work on city property.

(a) Improvements to and maintenance of real property owned or controlled by the City of Newton may be carried out by volunteer workers in accordance with a permit issued by the head of the department having care, custody or control of such real property, or his designee. Every such permit shall state the location, scope and

nature of the project and any other limitations and requirements which, in the opinion of the department head, are necessary in order to carry out the city's policies for the use of such real property.

(b) Whenever such a permit has been issued, the head of the department shall provide city personnel who shall act as supervisors of the volunteer work on the improvement project. All persons serving as volunteer workers shall follow all instructions of and act under the supervision of the city personnel supervising such work.

(c) Volunteer workers who work on improvement and maintenance projects in accordance with such a permit shall be deemed to be "public employees" within the meaning of section one of chapter 258 of the Massachusetts General Laws for the purpose of third party claims; provided that any such claim arises as a result of the project described in the applicable permit.

(d) In order to facilitate the protection provided to volunteer workers pursuant to subsection (c), the head of the department shall keep a record of the names and addresses of every volunteer worker who works at the site of each such project; and every such volunteer worker shall provide his/her name and address for inclusion in such record. (Ord. No. V-96, 11-18-96)

Sec. 21-71. Reserved.

DIVISION 2. REGULATION OF PUBLIC TREES

Sec. 21-72. Public Tree Regulation

(a) Purpose

The purpose of this ordinance is to promote a diverse, healthy and sustainable urban forest in order to provide for the general welfare of Newton's citizens. A healthy urban forest improves the quality of air and water, controls erosion, moderates air temperature, absorbs carbon, reduces noise, enhances appearance and increases property values. Public trees also define public spaces and create civic identity. This ordinance sets out measures to protect trees located on city property and on public rights of way from construction and other preventable damage; to establish conditions for long-term preservation and expansion of the urban forest; to extend the protections afforded by the Tree Preservation Ordinance to city-owned trees and supplement Chapter 87 of the Massachusetts General Laws.

(b) Definitions

Aggregate diameter: The combined diameter of a multiple trunk tree measured at breast height.

Building: The term "building" shall be as defined in section 30-1.

Caliper: The measure of a newly installed tree and is determined in the following manner - Caliper measurement of the trunk shall be taken six inches above the ground up to and including four-inch caliper size. If the caliper at six inches above the ground exceeds four inches, the caliper should be measured at twelve inches above the ground.

Certified arborist: An arborist certified by the Massachusetts Arborists Association, or any successor organization.

Diameter breast height (DBH): The diameter of the trunk of a tree 4½ feet above the existing grade at the base of the tree.

Drip line: A vertical line running through the outermost portion of the crown of a tree and extending to the ground.

Person: Any person, firm, partnership, association, corporation, company or organization of any kind including, but not limited to, the person removing a public tree or public shade tree.

Pruning standards: Standards for pruning as defined in the City of Newton Tree Management Manual, 1995 and any future amendments or revisions to the same.

Public tree: Any tree having a diameter of eight inches (8") DBH or larger or having an aggregate diameter of fifteen inches (15") DBH or larger and which is located on land owned by the city of Newton.

Public Shade Tree: Any tree within the city that fits the definition of public shade tree under G.L. Ch. 87

Remove (including removing and removal): The cutting down of any public tree or public shade tree and all other acts which cause the actual removal or the effective removal through damaging, poisoning or other direct or indirect actions resulting in the death of a public tree, including, but not limited to, excessive or improper pruning.

Tree Manual: The City of Newton Tree Management Manual, 1995, and any future amendments and revisions to the same. (Ord. No. V-275, 12-6-99)

Tree warden: The commissioner of parks, recreation and culture or his designee.

(c) *Applicability*: The terms and provisions of this article shall be administered by the tree warden and shall apply to any public shade tree as defined in G.L. Ch. 87 and to any public tree located on land owned and managed by the city of Newton, with the exception of the land under the auspices of the conservation commission.

(d) *Permit*: No person other than the tree warden shall remove, prune, or alter a public tree or public shade tree located on land subject to the provisions of this article without first obtaining a tree permit from the tree warden. Applications shall be made in writing on forms specified by the tree warden.

(e) *Activities requiring a Tree Permit*: A tree permit issued by the tree warden is required prior to any of the following activities:

(1) Any exterior work that requires the removal of a public tree;

(2) Any construction on city property within the dripline of a public tree;

(3) Removal of a public shade tree. This requirement is in addition to the requirements of G.L. Ch. 87 pertaining to removal of a public shade tree;

(4) Construction within that portion of the dripline of a public shade tree that is located over the public right of way;

(5) Pruning or treatment for the benefit of the health, safety, or overall well-being of a public shade tree and/or public tree, as deemed appropriate by the tree warden, by anyone other than the tree warden or his designee as provided in G.L. Ch. 87;

(6) Planting of a tree in the public right of way or on city property by anyone other than the tree warden or his designee as outlined under G.L. Ch. 87;

(7) Pruning or altering of a public shade tree and/or public tree for the purposes of overhead utility line clearance;

(8) Affixing or hanging anything from a public shade tree or public tree.

(f) *Permit application; fee*: An application for a tree permit shall be submitted to the tree warden. Such application shall be on a form prescribed by the tree warden and shall include any materials or information required by the tree warden based on the nature of the activity for which application is made. The application for a tree permit shall be accompanied by an administrative fee of $150.00. Such fee shall be waived if the applicant is a city department, agency, commission or other public instrumentality of the city or if the tree warden determines in writing that the proposed activity will benefit the health of the tree or the wellbeing of the public.

(g) *Review of permit applications*: The tree warden shall review applications for tree permits in accordance with the provisions of this article and with any rules or regulations promulgated hereunder. The tree warden shall date stamp or otherwise record the date of filing of each application for a tree permit. The tree warden shall complete the review of each tree permit application no later than ten (10) business days after the submission of a completed application to the tree warden except in the case of a request to remove a public shade tree which shall be subject to the procedures set forth in G.L. Ch. 87.

(h) *Conditions*: The tree warden may condition issuance of a tree permit upon such measures as he deems necessary to protect existing public trees or public shade trees. Such conditions shall be in writing. The tree warden shall make a determination that the prescribed protected measures have been adequately provided before site disturbance related to the permitted activity may begin.

(i) *Construction*: Except as provided in a tree permit, construction activities on city-owned property and public right of ways under the drip line of a public tree or public shade tree are prohibited. Prohibited construction activities include, but are not limited to, trenching or grading, storage of materials or equipment, passage of heavy equipment within the drip line and spillage of chemicals or other materials, which are damaging to trees.

(j) *Suspension or revocation*: The tree warden may suspend or revoke a tree permit at any time upon written notice to the permit holder that the permit holder has failed to comply with any provisions of this section, or with any rules or regulations promulgated hereunder, or with conditions of the permit. Written notice shall be sent by certified mail, return receipt requested, or by hand delivery and shall provide an opportunity for the permit holder to correct the noncompliance and apply for a renewal of the tree permit upon compliance, where practicable. The suspension or revocation of a tree permit in accordance with this subsection shall not affect the validity of a building permit issued in reliance upon the issuance of such tree permit nor shall such suspension or revocation be cause for withholding the issuance of a certificate of occupancy.

(k) *Public Tree Removal*: The tree warden shall notify the urban tree commission upon receipt of an application to cut down or remove a public tree, and no public tree shall be removed pursuant to a permit until five (5) days after its issuance unless such removal of the tree(s) is necessary based on a determination by the tree warden that at least one of the following conditions are met:

(1) The public tree is interfering with existing structure, utilities, streets, sidewalks or proposed necessary improvements, and there is no alternative to removal;

(2) The public tree is dead, diseased, injured, in danger of falling, dangerously close to existing structures, is causing disruption of public utility service, is causing drainage or passage problems upon rights of way, or poses a threat to pedestrian or vehicular safety.

(3) The removal of the public tree is necessary and desirable in order to enhance or benefit the health or condition of other trees on the same site as certified to the tree warden by a certified arborist.

(l) *Appeal*: Any person aggrieved by a decision of the tree warden may file an appeal with the mayor or his designee. Said appeal must be in writing and must be received by the mayor or his designee within five (5) business days of issuance of the tree warden's decision. Upon receipt of such appeal, the mayor or his designee shall provide a copy to the clerk of the city council and to each councilor for the ward in which the trees are located. The mayor or his designee shall make a final decision on the matter within thirty (30) days from the date of receipt of the appeal request. The mayor or his designee shall include in the decision the rationale there for. Upon issuance of the final decision, the mayor or his designee shall provide a copy to the clerk of the city council and to each ward councilor for the ward in which the trees are located. There shall be no further appeal of the matter decided by the mayor or his designee. No public trees shall be removed while an appeal is pending.

(m) *Permit length*: Any permit issued by the tree warden shall be valid for sixty (60) days from issuance. Length may be extended by tree warden following written request by the applicant. The tree warden may grant the extension for any length of time as he deems necessary and appropriate.

(n) *Emergencies*: A public tree or public shade tree may be removed without first obtaining a written permit as otherwise required by this section only if the tree warden determines that the condition of the public tree or public shade tree is hazardous and immediately endangers the public health, safety or welfare or causes an immediate disruption of public services such that immediate removal is required. If such determination is made, the tree warden may remove the tree or provide oral authorization for its removal, utilizing such professional criteria and technical assistance as he deems necessary. The tree warden shall memorialize in writing each such oral authorization to remove a hazardous tree and keep a record of same.

(o) *Waiver*: The requirements of this section may be waived by the tree warden during the period of an emergency such as a tornado, windstorm, flood or other act of God.

(p) *Tree replacement:* The tree warden may require that replacement of a removed public tree or public shade tree in the manner required in section 21-85 of these ordinances and in any rule or regulation or the tree warden

(q) *Payment in lieu of planting replacement tree(s)*: In lieu of planting a replacement tree as provided in section (p) above, a person who has been granted a tree permit may make a contribution to the tree replacement fund as established in section 21-86 in an amount equal to the cost to replace the tree in accordance with the provisions of section 21-85, which cost shall be determined by the tree warden who shall maintain on file the city's current tree planting costs.

(r) *Rules and regulations:* The tree warden is authorized to promulgate reasonable rules and regulations to implement administration and enforcement of this section

(s) *Enforcement*: The commissioner of parks, recreation and culture, in his capacity as tree warden, or such other municipal official as may hereafter be assigned the duties of tree warden, shall be authorized to enforce the provisions of this section. The tree warden shall provide written notice to the offender of the specific violation and provide a reasonable time for compliance. Such notice shall be sent by certified mail, return receipt requested, or by hand delivery. Thereafter, the tree warden may impose the fines described in (t) below.

(t) *Penalties:* Violations of any portion of this section, including violations of any regulation promulgated hereunder, or failure to comply with conditions of a permit, or failure to replace any removed tree as required by the tree warden, or failure to pay the required amount into the tree replacement fund shall be punishable by a fine of three hundred dollars ($300.00) for each day during which the violation continues. Nothing herein shall be construed to require the city to make a payment for violation of this section; however the city agency that caused

the violation shall be responsible for the costs of replacement or repair of the tree(s) which were damaged or removed.

(u) *Severability*: The provisions of this article are severable. If any section, provision, or portion of this article is determined to be invalid by a court of competent jurisdiction, then the remaining provisions of this article shall continue to be valid.

(v) *Conflict of laws*: Nothing herein is intended to conflict with the General Laws, Chapter 87 and to the extent that any provision hereof conflicts with said Chapter 87, such provision shall not be valid. Nothing herein is intended to conflict with existing special permit procedures as provided in section 30-24 and to the extent that any provision hereof conflicts with said special permit procedures, such provision shall not be valid. Nothing herein is intended to conflict with any state law regulating public utilities and to the extent that any provision hereof conflicts with state law, such provision shall not be valid. (Ord. No. Z-80, 02-22-11; Rev. Ord. 2007, § 20-72; Ord. No. B-53, 03-02-20)

Secs. 21-73. —21-79. Reserved.

DIVISION 3. TREE PRESERVATION

Sec. 21-80 Findings, intent, and purpose.

The city council has determined that many trees are being lost without replacement incident to demolition of existing buildings in order to construct new buildings and lot clearing in connection with the construction of new buildings on previously undeveloped land. The city council has further determined that trees have been lost, severely damaged or disfigured through excessive or improper pruning or other than natural causes. The result is a net loss of the tree population in the city. The city council has further determined that the city has insufficient legal vehicles to assure that such development adequately preserves, protects and provides for replacement of trees.

The preservation of the private tree canopy and the planting of replacement trees is intended to enhance the quality of life and the environment of the city; to preserve the character of the wooded and natural areas; to reduce energy consumption; to protect air quality; to baffle noise; to preserve and enhance habitat for wildlife; to reduce topsoil erosion and storm water runoff; to protect and increase property values; and to enhance the overall appearance of the city. (Ord. No. A-38, 05-05-14)

Sec. 21-81. Definitions.

The following words, terms and phrases, when used in this article, shall have the meanings ascribed to them in this section, except where the context clearly indicates a different meaning:

Aggregate diameter: The combined diameter of a multiple trunk tree measured at breast height.

Building: The term "building" shall be as defined in section 30-1.

Certified arborist: An arborist certified by the Massachusetts Arborists Association or International Society of Arboriculture, or any successor organization.

Diameter breast height (DBH): The diameter of the trunk of a tree 4½ feet above the existing grade at the base of the tree.

Drip line: A vertical line running through the outermost portion of the crown of a tree and extending to the ground.

Exempt lot: A lot which meets all of the following criteria:

(1) The lot is occupied and used primarily as a dwelling for up to four families at the time any protected tree(s) are removed.

(2) The lot owner at the time of protected tree removal has owned the lot continuously for a minimum of ninety (90) days prior to the removal of any protected tree(s).

(3) The existing structure on the lot remains occupied as a dwelling with a person or persons living in it for eighteen consecutive months from the date any protected tree(s) are removed.

(4) The lot remains owned by the same person for eighteen consecutive months from the date any protected tree(s) are removed.

Exterior work permit: A permit or approval which is required in order to perform work on a vacant lot or to the exterior of a building on a lot, including, but not limited to the following: a building permit; a review of an alteration of contour of land if required pursuant to section 30-5(c)(1); curb cut and street opening permits; an order of conditions; certificates of appropriateness, nonapplicability, or hardship; a demolition permit pursuant to section 22-44; site plan approval pursuant to section 30-23; subdivision approval; a special permit pursuant to section 30-24; a comprehensive permit.

Occupied Lot: A lot containing a legally constructed, permanent structure, used primarily as a dwelling that is currently being legally occupied and lived in and used as a residence by a person or persons. The dwelling must have a functioning, legally permitted, permanent water service, permanent sanitary service, and permanent electrical service.

Person: Any person, firm, partnership, association, corporation, company or organization of any kind including, but not limited to, the person removing a protected tree as well as the owner of the real property from which the tree is removed. The definition of "person" shall not include the City of Newton.

Protected tree: Any tree having a diameter of eight inches (8") DBH or larger or having an aggregate diameter of fifteen inches (15") DBH or larger and which is located on land subject to the provisions of section 21-82.

Pruning standards: Standards for pruning as defined in the City of Newton Tree Management Manual, 1995 and any future amendments or revisions to the same.

Remove (including removing and removal): The cutting down of any protected tree and all other acts which cause the actual removal or the effective removal through damaging, poisoning or other direct or indirect actions resulting in the death of a protected tree, including, but not limited to, excessive or improper pruning.

Tree Manual: The City of Newton Tree Management Manual, 1995, and any future amendments and revisions to the same. (Ord. No. V-275, 12-6-99)

Tree Warden: The commissioner of parks, recreation and culture or his designee. (Rev. Ord. 2007, § 20-31; Ord. No. A-38, 05-05-14; Ord. No. B-53, 03-02-20)

Sec. 21-82. Applicability, permit or certificate of exemption required.

(a) *Applicability*: The terms and provisions of this article shall apply to any protected tree located on land within the city not owned by the city, the commonwealth, or any independent authority of the commonwealth, or by the federal government except protected tree(s) located on an exempt lot pursuant to paragraphs (c) and (d) below.

(b) *Permit, certificate of exemption*: No person shall remove a protected tree on a non-exempt lot located on land subject to the provisions of this article, or commence legally permitted exterior work on any lot without first obtaining a tree permit or a certificate of exemption from the tree warden. Applications shall be made in writing on forms specified by the tree warden.

(c) *Exempt lot, certificate of exemption:* The owner of an exempt lot shall not be required to apply for a tree permit, provided however, that an owner of an exempt lot who seeks an exterior work permit must certify to the tree warden on form(s) provided by the tree warden, that as of the date on the form(s) the lot qualifies as an exempt lot and will remain an exempt lot for eighteen months following tree removal. There shall be no fee for filing a certificate of exemption.

(1) The tree warden shall determine whether a property is an occupied lot for the purposes of establishing exempt lot status. The property owner shall, if requested by the tree warden provide proof of ownership as well as a written statement confirming ownership and that a person or persons are living in the property.

(2) If lot ownership changes during the eighteen consecutive months following the removal of any protected tree(s) on an exempt lot, the new owner must apply for a tree permit and shall be required to replace any protected tree(s) that were removed. If, however, a change of ownership occurs on a lot for which an extension of exempt lot status for non-occupancy during construction has been issued within the eighteen months prior to the change in ownership, the person issued such extension shall apply for a tree permit and shall be required to replace any protected tree(s) that were removed.

(d) *Extension of exempted lot status*: If at any point during the eighteen consecutive months following the removal of any protected tree(s) the property is no longer an occupied lot, the current owner of the lot must apply for a tree permit. If the non-occupancy is due to legally permitted construction, the tree warden may grant an extension of exempt lot status for the duration of the construction, provided:

(1) The owner intends to own the lot for eighteen consecutive months from the date a certificate of occupancy is issued for the construction for which the extension was issued; and

(2) The property remains an occupied lot for eighteen consecutive months from the date a certificate of occupancy is issued for the construction for which the extension was issued.

(3) Upon request of an applicant for exempt lot status extension, the tree warden may also waive the requirement that the lot be continuously owned by the same owner for ninety (90) days prior to protected tree removal provided the owner intends to own the lot for twenty-one months from the date a certificate of occupancy is issued for the construction for which the extension is granted..

(4) If at any time during the applicable eighteen or twenty-one month period the lot ownership changes or the lot is not occupied, the tree warden shall revoke the tree permit and exempt lot status extension. The person issued the extension shall file a new tree permit application and shall replace any protected trees that were removed.

(5) Any person issued an extension of exempt lot status must report to the tree warden any change of ownership and any change of occupancy status within fifteen (15) days of the change if that change takes

place during the applicable eighteen (18) month or twenty-one (21) month period following the date the certificate of occupancy issued. (Ord. No. A-38, 05-05-14)

Sec. 21-83. Permit application.

(a) *Contents, fee*: An application for a tree permit shall be submitted to the tree warden. The application for a tree permit shall be accompanied by a fee in the amount of one hundred fifty dollars ($150.00) and shall include, but not be limited to, the following:

(1) The shape and dimensions of the parcel of real property to be developed, together with the existing and proposed locations of structures and improvements, if any;

(2) A tree plan showing the location, type and size of each protected tree indicating which protected tree(s) are to be removed, and the location, type and size of replacement trees;

(3) The proposed relocation of any existing protected tree with a statement prepared by a certified arborist explaining how each such protected tree is to be relocated and maintained;

(4) The location of existing and proposed underground or overhead utility services, existing and proposed roadways, bikeways, walkways and parking areas;

(5) Any proposed grade changes which might adversely affect or endanger any protected tree with a statement prepared by a certified arborist explaining how each such protected tree shall be protected and maintained;

(6) The proposed method of protecting the remaining protected trees during the course of the construction.

(b) *Review of permit applications*: The tree warden shall review applications for tree permits in accordance with the provisions of this article. The tree warden shall date stamp or otherwise record the date of filing of each application for a tree permit. The tree warden shall complete the review of each tree permit application no later than ten (10) business days after the submission of a completed application to the tree warden and shall report to the commissioner of inspectional services within ten (10) business days of a request with respect to any tree permit application submitted in connection with a building permit as to whether said tree permit has been granted or denied. If no such report is received by the commissioner within the above-stated time period, he shall accept an application for a building permit without receipt of such report.

(c) *Standards for grant or denial*: No tree permit shall be issued unless one of the following conditions exists:

(1) The protected tree will be relocated or replaced on site.

(2) The protected tree will be replaced by payment in lieu of planting replacement trees as outlined in section 21-86.

(3) The protected tree is interfering with existing structures, utilities, streets, sidewalks or other existing improvements

(4) The protected tree is dead, diseased, injured, in danger of falling, dangerously close to existing structures, is causing disruption of public utility service, is causing drainage or passage problems upon rights-of-way, or poses a threat to pedestrian or vehicular safety.

(5) The removal of the protected tree is necessary and desirable in order to enhance or benefit the health or condition of other trees on the same site as certified to the tree warden by a certified arborist.

(6) No protected tree(s) are to be removed from the site and appropriate tree protection measures will be in place where necessary as determined by the tree warden.

(d) *Conditions*: Upon the issuance of a tree permit, the tree warden may prescribe in writing such protective measures for existing protected trees as he deems necessary. Before site disturbance may begin, the tree warden may make a determination that the prescribed protective measures have been adequately provided.

(e) *Construction*: Except as provided in a tree permit, construction activities under the drip line of a protected tree are prohibited. Activities include, but are not limited to, trenching or grading, storage of materials or equipment, passage of heavy equipment within the drip line and spillage of chemicals or other materials, which are damaging to trees.

(f) *Suspension or revocation*: A tree permit may be suspended or revoked at any time by the tree warden upon written notice to the permit holder that the permit holder has failed to comply with either this article or the conditions of the permit. The written notice shall be sent by certified or registered mail, return receipt requested, or by hand delivery and shall provide an opportunity for the permit holder to correct the noncompliance and apply for a renewal of the tree permit upon compliance, where practicable. The suspension or revocation of a tree permit in accordance with this subsection shall not affect the validity of a building permit issued in reliance upon the issuance (granting) of such tree permit nor shall such suspension or revocation be cause for withholding the issuance of a certificate of occupancy.

(g) *Appeal:* Any person aggrieved by a decision of the tree warden may file an appeal with the mayor or his designee. Said appeal must be in writing and must be received by the mayor or his designee within five (5) business days of issuance of the tree warden's decision. Upon receipt of such appeal, the mayor or his designee shall provide a copy to the clerk of the city council and to each councilor for the ward in which the trees are located. The mayor or his designee shall make a final decision on the matter within thirty (30) days from the date of receipt of the appeal. The mayor or his designee shall include in the decision the rationale therefor. Upon issuance of the final decision, the mayor or his designee shall provide a copy to the clerk of the city council and to each ward councilor for the ward in which the trees are located. There shall be no further appeal of the matter decided by the mayor or his designee. No protected trees shall be removed while an appeal is pending. (Ord. No. V-275, 12-6-99; Ord. No. X-202, 04-03-06; Rev. Ord. 2007, § 20-33; Ord. No. A-38, 05-05-14)

Sec. 21-84. Activities not requiring a permit.

(a) *Pruning*: A permit is not required for the pruning of protected trees. However, in order to prevent excessive pruning and topping of trees and to prevent pruning that will be hazardous to the health and natural appearance of the tree, compliance with approved pruning standards is required, and failure to meet these standards is a violation of this article. The tree warden shall maintain on file at all times a copy of the current edition the Tree Manual and shall make copies of the Tree Manual available for the cost of reproduction upon request.

(b) *Emergencies*: If any protected tree shall be determined to be in a hazardous condition so as to immediately endanger the public health, safety or welfare or cause an immediate disruption of public services and require immediate removal without delay, oral authorization may be given by the tree warden to remove such tree, utilizing such professional criteria and technical assistance as he deems necessary, and the protected tree may be removed without obtaining a written permit as otherwise required by this article. The tree warden shall memorialize in writing each such oral authorization to remove a tree and keep a record of the same.

(c) *Waiver*: The requirements of this article may be waived by the tree warden during the period of an emergency such as a tornado, windstorm, flood or other act of God. (Ord. No. V-275, 12-6-99; Rev. Ord. 2007, § 20-34; Ord. No. A-38, 05-05-14)

Sec. 21-85. Tree replacement.

(a)Required: A protected tree shall be replaced in the manner provided in subsection (b) hereof in each instance in which a protected tree was removed from land subject to the provisions of section 21-82 without a tree permit.

(b) *Standards*: A person who has removed a protected tree and is required to replace such tree pursuant to subsection (a) hereof or as a condition of granting a tree permit in accordance with section 21-83, shall replace such tree within eighteen (18) months, or prior to transfer of property ownership whichever comes first from the date the tree permit is issued and in accordance with the following standards:

(1) A replacement tree shall be of the same or similar species or such other species as deemed advisable by the tree warden in accordance with the Tree Manual and shall have the same or equivalent size as measured in DBH inches as that of the protected tree that has been removed.

(2) In the event that a tree of the same or equivalent size as measured in DBH inches cannot be planted, then multiple smaller replacement trees may be planted provided that, wherever practicable, as determined by the tree warden, the total DBH of the replacement trees shall, when added together, equal the total DBH of the protected tree that has been removed. The tree warden may specify that replacement trees be of a minimum caliper when consistent with current accepted practice as stated in the Tree Manual.

(3) A replacement tree shall be required to survive for a minimum of eighteen (18) months from the date it is planted. The person planting the tree shall provide documentation as to the date of planting and file the same with the tree warden within fifteen (15) days of the planting of said replacement tree.

(4) A replacement tree shall be planted on the same lot from which the tree was removed.. (Ord. No. V-275, 12-6-99; Rev. Ord. 2007, § 20-35, Ord. No. A-38, 05-05-14)

Sec. 21-86. Tree replacement fund.

(a) *Established*: There is hereby established a tree replacement fund which shall be held in a separate identifiable account and administered in accordance with applicable provisions of the General Laws. Any payments into the tree replacement fund required by this article shall be deposited in the tree replacement fund and shall be used in accordance with subsection (c) hereof.

(b) *Payment in lieu of planting replacement tree(s)*: In lieu of planting a replacement tree as provided in section 21-85, a person who has been granted a tree permit may make a contribution to a tree replacement fund in an amount equal to the cost to replace the tree in accordance with the provisions of section 21-85, which cost shall be determined by the tree warden based on the City's current cost to purchase and install trees.

(c) *Maintenance of tree replacement fund*: The tree replacement fund shall be maintained in a separate account in accordance with state law. All sums deposited into such fund shall be used solely for the purpose of buying, planting and maintaining trees in the city. (Ord. No. V-275, 12-6-99; Rev. Ord. 2007, § 20-36; Ord. No. A-38, 05-05-14)

Sec. 21-87. Rule and regulations.

The tree warden is authorized to promulgate reasonable rules and regulations to implement administration of sections 21-80 through 21-90. (Ord. No. A-38, 05-05-14)

Sec. 21-88. Enforcement.

(a) Notice of violation: Any person who violates any of the provisions of this article shall be notified by the tree warden of the specific violation by certified mail, return receipt requested, or by hand delivery. The notice shall set forth the nature of the violation and a reasonable time period within which compliance must be had. The tree warden shall send notice of violation of section 21-86), which notice shall include the date by which trees were to be replaced or payment was to be made for purposes of computing the "per day" violation fine, as provided in section 21-89.

(b) *Stop work order*:

(1) Upon notice from the tree warden that work on any protected tree, or lot on which a protected tree is located, is being performed contrary to the provisions of this article, such work shall be immediately stopped. The stop work order shall be in writing and shall be given to the owner of the property involved, or to the owner's agent, or to the person doing the work; and shall state the conditions under which work will be permitted to resume.

(2) The tree warden is also authorized to request the agency which has granted an exterior work permit to order, to the extent permissible by law, that the owner cease any activity pursuant to the exterior work permit that might affect such protected tree while a stop work order is pending.

(3) Any person who shall continue any work in or about the protected tree or lot on which a protected tree is located after having been served with a stop work order, except such work as that person is directed to perform to remove a violation or unsafe condition, shall be liable to a fine of not more than three hundred dollars ($300.00) for each such violation. Each day during which a violation exists shall constitute a separate offense.

(c) *Injunctive relief*:

(1) Whenever there exists reasonable cause to believe that a person is violating this article or any standards adopted pursuant to this article or any term, condition or provision of an approved tree permit, the city may, either before or after the institution of any other action or proceeding authorized by this article, institute a civil action in the name of the city for a mandatory or prohibitory injunction and an order of abatement demanding the defendant to correct the unlawful condition upon or cease the unlawful use of the property.

(2) Upon determination of a court that an alleged violation is occurring, it shall enter such order or judgment as is necessary to abate the violation. The institution of an action for injunctive relief under this subsection shall not relieve any party to such proceedings from any civil penalty prescribed for violation of this article. (Ord. No. V-275, 12-6-99; Rev. Ord. 2007, § 20-37; Ord. No. A-38, 05-05-14)

Sec. 21-89. Penalties.

(a) *Removal without a permit*: Each instance in which a protected tree is removed without a permit shall constitute a violation of this article which shall be subject to a fine in the amount of three hundred dollars ($300.00).

(b) *Failure to replace trees or make payment*: Each failure to replace a tree or make a payment into the tree replacement fund shall constitute a separate violation of this article which shall be subject to a fine in the amount of three hundred dollars ($300.00). Each day such violation continues shall constitute a separate offense.

(c) *Failure to comply with a condition contained in a tree permit or stop work order:* Each instance where there is a failure to comply with a condition contained in a tree permit or stop work order shall constitute a violation of this article which shall be subject to a fine in the amount of three hundred dollars ($300.00). Each day such violation continues shall constitute a separate offense.

(d) *City trees*: Nothing herein shall be construed to require the city to make a payment into the tree replacement fund for any tree(s) which it removes. (Ord. No. V-275, 12-6-99; Rev. Ord. 2007, § 20-38; Ord. No. A-38, 05-05-14)

Sec. 21-90. Severability, effect on other laws.

(a) *Severability*: The provisions of this article are severable. If any section, provision, or portion of this article is determined to be invalid by a court of competent jurisdiction, then the remaining provisions of this article shall continue to be valid.

(b) *Conflict of laws*: This article shall not apply to any public shade tree as that term is defined by the General Laws, Chapter 87 or any amendments thereto. Nothing herein is intended to conflict with the General Laws, Chapter 87 and to the extent that any provision hereof conflicts with said Chapter 87, such provision shall not be valid. Nothing herein is intended to conflict with existing special permit procedures as provided in section 30-24 and to the extent that any provision hereof conflicts with said special permit procedures, such provision shall not be valid. (Ord. No. V-275, 12-6-99; Rev. Ord. 2007, § 20-39; Ord, No. A-38, 05-05-14)

CITY OF PROVIDENCE
ZONING ORDINANCE

CHAPTER 2014-39 NO. 513

ADOPTED NOVEMBER 24, 2014

EFFECTIVE DECEMBER 24, 2014

CONTAINS AMENDMENTS UP TO AND INCLUDING ORDINANCE 2020-14, NO. 119, APPROVED APRIL 6, 2020

ARTICLE 15. TREES AND LANDSCAPING

1500 LANDSCAPING REQUIRED

A. Development activity that meets any of the criteria described below triggers conformance with this Article:

1. At a minimum, full conformance is required for the entire development or area within the limits of disturbance, whichever is less.

2. If land within limits of disturbance equals more than 50% of the area of the lot or lots being developed, the entire development shall fully conform to the requirements of this Article.

3. Full conformance is required when new principal buildings are constructed in the R-1A, R-1, R-2, R-3, and RP Districts.

No development or tree cutting may result in a loss of trees and landscaping below what is required by this Article.

1501 LANDSCAPE PLAN

A. Content of Landscape Plan

1. The location and dimensions of all existing and proposed structures, property lines, easements, parking lots and drives, rights-of-way, refuse disposal and recycling areas, pedestrian and bicycle paths, fences, mechanical equipment, overhead utility wires, and drainage facilities.

2. The location, quantity, size, name, and condition, both botanical and common, of all existing trees and shrubs on-site, indicating trees and shrubs to be retained and removed.

3. The location, quantity, size, and name, both botanical and common, of all proposed plant material.

4. The existing and proposed grading of the site indicating contours at one foot intervals. Proposed berming shall also be indicated using one foot contour intervals.

5. Elevations of all proposed fences, walls, stairs, and retaining walls.

B. Enforcement of Landscape Plan

1. No certificate of occupancy shall be issued until all the requirements of this Article and the landscape plan have been fulfilled.

2. If weather prohibits the installation of landscaping at the time a certificate of occupancy is applied for, a temporary certificate of occupancy may be issued for a six-month period.

1502 LANDSCAPE DESIGN STANDARDS

A. Selection of Plant Materials

All plant materials shall be of good quality and meet American Association of Nurserymen (AAN) standards for minimum acceptable form, quality, and size for species selected, and capable to withstand the seasonal temperature variations of Rhode Island, as well as the individual site microclimate. The use of species native or naturalized to Rhode Island is encouraged. Size and density

of plant material, both at the time of planting and at maturity, are additional criteria that shall be considered when selecting plant material. Where appropriate, the use of drought and salt tolerant plant material is preferred.

B. Installation of Plant Materials

All landscape materials shall be installed in accordance with the current planting procedures established by the AAN. All plant materials shall be free of disease and installed so that soil of sufficient volume, composition, and nutrient balance are available to sustain healthy growth. Installation of plant materials during the appropriate growing season is encouraged.

C. Minimum Planting Sizes

1. Shade trees shall have a minimum trunk size of two inches in tree caliper at planting.

2. Evergreens trees shall have a minimum height of six feet at planting.

3. Single stem ornamental trees shall have a minimum trunk size of two inches in tree caliper at planting. Multiple stem ornamental trees shall have a minimum height of eight feet at planting.

4. Large deciduous and evergreen shrubs shall have minimum height of three feet at installation. Small deciduous and evergreen shrubs shall have a minimum height of 18 inches at installation. Large shrubs are those shrubs that reach five or more feet in height at maturity. Small shrubs are those shrubs that may grow up to five feet in height if left unmaintained, but are generally maintained at heights of 18 to 30 inches.

D. Species Diversity

Diversity is required in plant material for visual interest and to reduce the risk of losing a large population of plants due to disease.

E. Maintenance

1. Landscape material depicted on approved landscape plans is considered a required site element in the same manner as structures, parking, lighting, and other improvements. As such, the property owner is responsible for the maintenance, repair, and replacement of all landscape material, fences, walls, steps, retaining walls, and similar landscape elements.

2. All landscape material shall be maintained in good condition, present a healthy, neat, and orderly appearance, and kept free of refuse and debris. Any dead, unhealthy, or missing plants shall be replaced within 60 days.

F. Tree Protection During Development

1. During development, all precautions shall be undertaken to prevent construction damage to existing trees, as described in the City Tree Ordinance of the Providence Code of Ordinances. Protection includes prevention of injury to the trunk, branches, and root systems.

2. No person may create a trench through the root system of an existing tree, expose the roots to the air overnight without a method for maintaining moisture, change the soil grade within the dripline of the tree, or cause soil compaction with the use of vehicles, machinery, or other method. The root systems of trees on adjacent lots shall also be protected.

1503 ON-SITE LANDSCAPING AND REQUIRED TREES

A. General Requirements

1. All portions of a lot not covered by structures or paved surfaces shall be landscaped with trees, shrubbery, grass, live groundcover, and other plantings. The landscape design may also include the use of stone, mulch beds, or other pervious landscaping materials (this excludes pervious pavement).

2. All existing plantings that are maintained on a site may be counted toward any required on-site landscaping.

3. Nothing in this section prohibits tree pruning to promote the health of a tree or for public safety purposes.

B. Significant Tree Preservation

1. A significant tree is any tree that measures 32 inches or more in diameter at four and one-half feet above the ground. No significant tree may be removed without the permission of the City Forester.

2. Any person wishing to remove a significant tree shall file a request with the City Forester. In order to grant permission to remove a significant tree, the City Forester shall make one or more of the following findings within 30 days of receipt of the request:

   a. The tree is in poor health or diseased with an expected life span less than two years.

   b. The removal of the tree is unavoidable because the tree poses a danger to property or human health, safety, and welfare.

   c. The tree prevents the property owner from developing the property in conformance with this ordinance, and there are no alternatives to removal of the tree. In this case, the City Forester shall not approve removal of the tree until a permit for new construction has been approved.

3. Any person who removes a significant tree without prior permission from the City Forester or causes the death of a significant tree through negligent construction practices or other means, as determined by the City Forester, is subject to a one-time fine equivalent to the value of the tree. The tree value is established using the Trunk Formula Method set forth in the latest edition of "Guide for Plant Appraisal," authored by the Council of Tree and Landscape Appraisers, or the maximum fine allowed by Rhode Island General Laws, whichever is greater. Fines will be held by the Parks Department for forestry-related uses as determined by the City Forester.

C. Required Tree Canopy

1. Required Tree Canopy Percentage

Sufficient trees shall be retained and/or planted on a lot so that the square footage of vegetative canopy of such trees, when mature, equals a certain percentage of the square footage of the lot. This required percentage is established by district as follows:

a. All residential districts, and the PS, OS, and CD Districts: 30% of the square footage of the lot

b. I-1 and I-2 Districts: 30% of the square footage of the lot

c. D-1 District: 15% of the lot area not occupied by a structure

d. All other districts: 15% of the square footage of the lot

2. Calculation of Tree Canopy Coverage

The total canopy coverage for a lot is the sum of the canopy, at maturity, of the individual trees located on the lot. The square footage of canopy cover varies according to tree species. The City Forester maintains a list of trees species and the expected size of the canopy for each species, at maturity, when planted. Trees are classified as small, medium, or large and the canopy coverage credit for each classification is as follows:

a. Large: 1,000sf

b. Medium: 700sf

c. Small: 300sf

3. **Tree Retention Bonus**

Additional credit for canopy coverage may be granted for the retention of healthy trees of appropriate species and in the proper location, subject to the approval of the City Forester. The following thresholds and associated coverage bonus is as follows:

a. Tree diameter at four and one-half feet above the ground is between 10 and 19 inches: 300sf of canopy coverage credit

b. Tree diameter at four and one-half feet above the ground is 20 inches or greater: 700sf of canopy coverage credit

4. **Street Tree Accommodation**

Existing or planned street trees located in the public right-of-way directly adjacent to the lot line may be counted toward the canopy coverage for the lot.

5. **Landscaping for Multiple Lots**

For developments that encompass more than one lot, the percentage is calculated for the total canopy for the total area of all of the lots. For developments that span multiple blocks, the percentage required is calculated separately for each contiguous area of the development within a block.

6. **Off-Site Planting Permission**

Where existing conditions or other provisions of this Ordinance make it impracticable to meet the canopy coverage requirement on or adjacent to the site, the applicant shall plant sufficient trees to make up the shortfall in public rights-of-way within one-quarter mile of the lot, with the location to be determined by the City Forester.

1504 PARKING LOT PERIMETER LANDSCAPE STRIP

A perimeter landscape strip is required for all parking lots that abut a public right-of-way, excluding curb cuts, and shall be established along the edge of the parking lot that abuts such public right-of-way to screen the parking lot. The landscape treatment shall run the full length of the parking lot perimeter along the right-of-way. The landscape strip shall be improved as follows: (Figure 15-1)

A. The perimeter parking lot landscape strip shall be a minimum of five feet in depth. There shall be a minimum linear distance of six inches between wheels stops or curbs and the landscape strip to accommodate vehicle bumper overhang, which is not included in the minimum five foot calculation.

B. One shade tree shall be planted for every 25 feet of landscape strip length, spaced linearly.

C. The landscape strip shall also be planted over a minimum of 60% of its length with shrubs, perennials, native grasses, and other planting types that provide screening of a minimum of three feet in height.

D. Alternatively, a low fence or pedestrian wall a minimum of three feet to a maximum of four feet in height may be used instead of such plantings. Where feasible, plant materials shall be installed between the sidewalk and the wall to provide a softening effect on the fence or wall.

E. Where existing conditions or other provisions of this Ordinance make it impracticable to meet the perimeter landscape strip requirements, the City Forester may approve a modification to the width or location of the perimeter landscape strip, or the spacing or number of trees in the perimeter landscape strip, so long as there is no net loss of planted area or number of trees required.

F. The use of stormwater management techniques such as rain gardens and bioswales is encouraged in landscape strips. Landscaped areas should be designed for the absorption of stormwater.

FIGURE 15-1

1505 INTERIOR PARKING LOT LANDSCAPING

All parking lots consisting of 20,000 gross square feet or more require interior parking lot landscaping as described in this section. When the calculation of interior parking lot landscaping requirements results in a fraction, said fraction is rounded up. (Figure 15-2)

A. One parking lot island shall be provided between every ten parking spaces. As part of the landscape plan approval, parking lot island locations may be varied based on specific site requirements or design scheme, but the total number of islands shall be no less than the amount required of one island for every ten spaces.

B. In addition to parking lot islands, additional landscape areas shall be provided within the interior of parking lots. The minimum total landscape area of a parking lot, including parking lot islands, shall be 10% of the total parking lot area. Parking lot perimeter landscaping is excluded from the calculation of total parking lot area.

C. All rows of parking spaces shall terminate in a parking lot island or landscaped area.

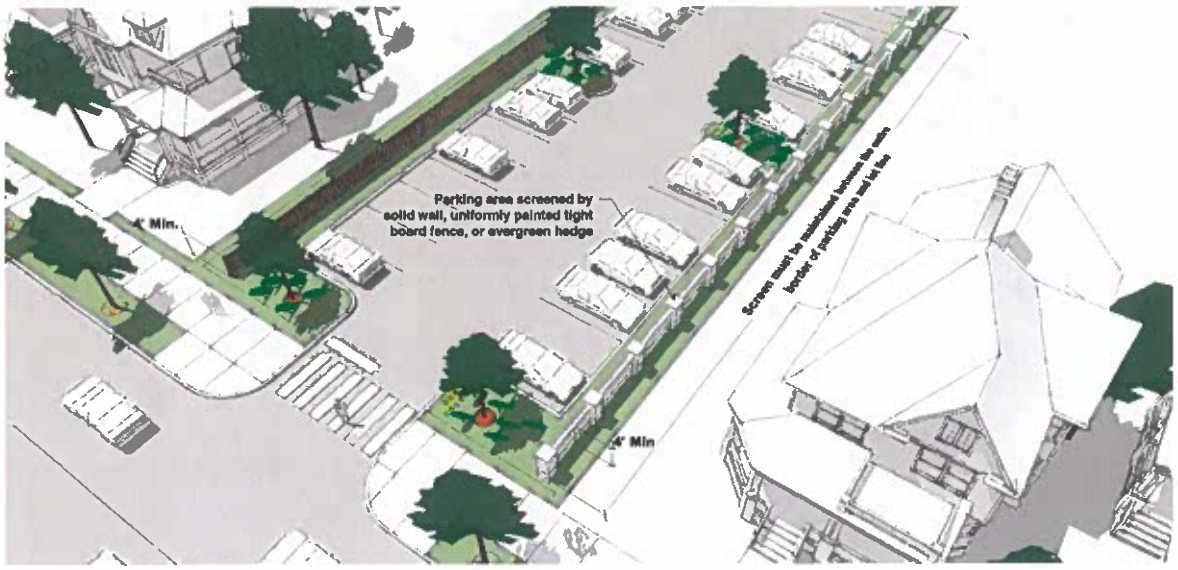
D. Parking lot islands shall be the same dimension as the parking stall at a minimum. Double rows of parking shall provide parking lot islands that are the same dimension as the double row.

E. A minimum of one shade tree shall be provided for every parking lot island or landscape area. If a parking lot island extends the width of a double row, then two shade trees are required..

F. The use of stormwater management techniques such as rain gardens and bioswales is encouraged in landscaped areas. Parking lot islands and landscaped areas should be designed for the absorption of stormwater.

G. Where existing conditions or other provisions of this Ordinance make it impracticable to meet the interior parking lot landscaping requirements, the City Forester may approve a modification to the requirements so long as there is no net loss of planted area or number of trees required.

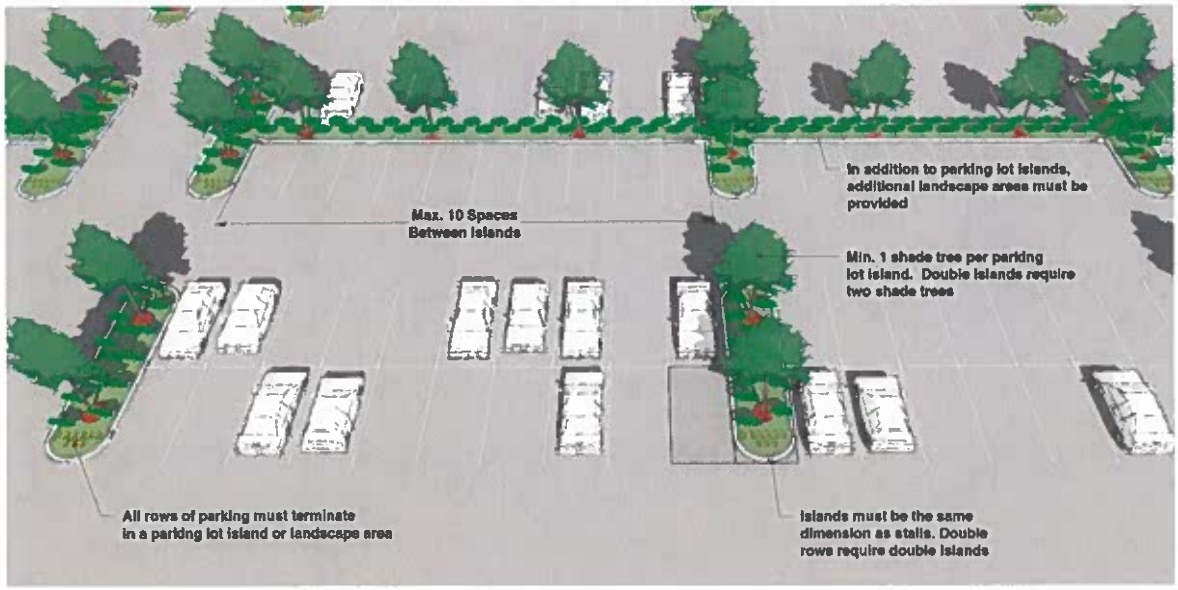
FIGURE 15-2



1506 SCREENING OF PARKING LOTS FROM RESIDENTIAL DISTRICTS

Where a parking area in any district abuts a lot in a residential district, the parking area shall be screened by a solid wall, a uniformly painted tight board fence, or a hedge of compact evergreens or other suitable plantings. Such screen shall be at least four feet in height, and erected and maintained between the entire border of such parking area and the property in the residential district. (Figure 15-3)

FIGURE 15-3



1507 WATERBODY VEGETATIVE BUFFERS

A. Unless otherwise specified by the Rhode Island Coastal Resources Management Program Special Area Management Plan, a vegetated buffer a minimum of 25 feet in width is required adjacent to the entire length of any water body. This buffer area is measured from the water's edge or the inland edge of a coastal shoreline feature for tidal waterbodies, as defined by the Rhode Island Coastal Resources Management Program.

B. This buffer shall include trees and plant material that filter stormwater runoff and help to improve the quality of the water body.

C. No parking or structures are permitted within this buffer. However, paving for a walking path, bicycle path, or access to docks, piers, or beaches may be included within this buffer.

Briefing Sheet 5: Tree Replacement and Conservation Ordinances 08/12/2020

§ 15.2-961. Tree replacement of trees during development process in certain localities.

§ 15.2-961.1 Conservation of trees during land development process in localities belonging to a nonattainment area for air quality standards.

Background

A **tree replacement ordinance** sets maximum tree canopy coverage by zoning classes. It is designed to provide for tree canopy during the development process, through conservation and/or replacement. Some localities offer bonus credits for protecting existing mature trees on site to meet tree cover standards.

Benefits:

- In urban areas, it can prevent canopy loss or maintain canopy cover over the long-term for the locality.
- It requires developers to mitigate losses to the urban tree canopy, while giving them some flexibility to achieve a locality's urban tree canopy cover standards. For example, through the use of a Tree Bank (see separate briefing sheet on this topic).

Challenges:

- The law is narrow in scope and prevents a locality from setting more progressive canopy standards to counter development impacts.
- Localities are restricted to a 20-year timeline for developers to achieve canopy cover requirements (with a few exceptions).
- Depending on the locality, mature trees can be sacrificed on site, as long as new tree plantings create the required canopy within the window of time.
- In Virginia, conditions and stipulations of state zoning laws and locally implemented zoning ordinances allow for building conditions that are in direct conflict with the conservation of trees, such as building set-back distances, lot coverages, or uses that allow for deviations and exemptions.

Current Policy

§ 15.2-961. Tree replacement of trees during development process in certain localities.

The following excerpts are included to highlight limitations of the existing law. For a full review of the code please click on the hyperlink above.

A. Any locality with a population density of at least 75 persons per square mile or any locality within the Chesapeake Bay watershed may adopt an ordinance providing for the planting and replacement of trees during the development process pursuant to the provisions of this section. Population density shall be based upon the latest population estimates of the Weldon Cooper Center for Public Service at UVA.

B. The ordinance shall require that the site plan for any subdivision or development include the planting or replacement of trees on the site to the extent that, at 20 years, minimum tree canopies or covers will be provided in areas to be designated in the ordinance, as follows:
1. Ten percent tree canopy for a site zoned business, commercial, or industrial;
2. Ten percent tree canopy for a residential site zoned 20 or more units per acre;
3. Fifteen percent tree canopy for a residential site zoned more than 10 but less than 20 units per acre; and
4. Twenty percent tree canopy for a residential site zoned 10 units or less per acre.

J. In no event shall any local tree replacement or planting ordinance adopted pursuant to this section exceed the requirements set forth herein.

§ 15.2-961.1 Conservation of trees during land development process in localities belonging to a nonattainment area for air quality standards.

This briefing sheet and analysis were funded by the Virginia Department of Forestry (VA DOF) under a contract to the Green Infrastructure Center Inc. The opinions in this briefing do not necessarily reflect the values, opinions, or policy positions of VA DOF.

B. Any locality within Planning District 8 that meets the population density criteria of subsection A of § 15.2-961 and is classified as an eight-hour nonattainment area for ozone under the federal Clean Air Act and Amendments of 1990, in effect as of July 1, 2008, may adopt an ordinance providing for the conservation of trees during the land development process pursuant to the provisions of this section. In no event shall any local tree conservation ordinance adopted pursuant to this section also impose the tree replacement provisions of § 15.2-961.

C.
3. Fifteen percent tree canopy for a residential site zoned more than eight but less than 20 units per acre;
4. Twenty percent tree canopy for a residential site zoned more than four but not more than eight units per acre;
5. Twenty-five percent tree canopy for a residential site zoned more than two but not more than four units per acre; and
6. Thirty percent tree canopy for a residential site zoned two or fewer units per acre.

In meeting these percentages, (i) the ordinance shall first emphasize the preservation of existing tree canopy where that canopy meets local standards for health and structural condition, and where it is feasible to do so within the framework of design standards and densities allowed by the local zoning and other development ordinances; and (ii) second, where it is not feasible in whole or in part for any of the justifications listed in subsection E to preserve existing canopy in the required percentages listed above, the ordinance shall provide for the planting of new trees to meet the required percentages.

D. Except as provided in subsection E, the percentage of the site covered by tree canopy at the time of plan submission shall equate to the minimum portion of the requirements identified in subsection C that shall be provided through tree preservation. This portion of the canopy requirements shall be identified as the "tree preservation target" and shall be included in site plan calculations or narratives demonstrating how the overall requirements of subsection C have been met.

E. The ordinance shall provide deviations, in whole or in part, from the tree preservation target defined in subsection D under the following conditions:

1. Meeting the preservation target would prevent the development of uses and densities otherwise allowed by the locality's zoning or development ordinance.
2. The predevelopment condition of vegetation does not meet the locality's standards for health and structural condition.
3. Construction activities could be reasonably expected to impact existing trees to the extent that they would not likely survive in a healthy and structurally sound manner. This includes activities that would cause direct physical damage to the trees, including root systems, or cause environmental changes that could result in or predispose the trees to structural and health problems.

Limitations: This code is limited to only jurisdictions within the Chesapeake Bay Watershed and/or jurisdictions with a population density of more than 75 people per square mile according to the latest U.S. Census. Localities are capped at the minimum covers unless they are located within the Planning District 8 in which case they can enact higher standards for tree cover and conservation in certain zones. This limits the ability of localities to take proactive measures at protecting tree canopy in their jurisdictions and setting higher standards.

Practice

Falls Church, VA. Generally, meets the desired goal of 20% canopy over 10 years. Canopy cover was not significantly different from 20% at the time of redevelopment (after trees were removed for construction) indicating that 20% threshold is probably too low. Prior to redevelopment, Falls Church's mean canopy cover was 52% and lots generally had large mature trees. When canopy cover is compared using other metrics, such as basal area, canopy cover as a metric was shown to ignore the importance and loss of large trees.

This briefing sheet and analysis were funded by the Virginia Department of Forestry (VA DOF) under a contract to the Green Infrastructure Center Inc. The opinions in this briefing do not necessarily reflect the values, opinions, or policy positions of VA DOF.

Alpharetta, GA – Has minimum tree density requirements based on basal area per acre.
Section 3.2.7
A. All sites within the City other than 'For-Sale' residential lots shall maintain or achieve a Minimum Tree Density of 130 inches per acre. The owner shall be subject to the minimum tree density requirement set forth in this paragraph, but the owner shall base the density calculations on the net site area excluding the acreage required for Buffers and infrastructure improvements (roads, utility lines, detention ponds, etc.). In no event shall a parking lot be considered an infrastructure improvement.
B. All 'For-Sale' residential lots in the City shall maintain a minimum tree density of 130 inches per acre or provide a calculation as described in the Guidance Document that shows the lot meets or exceeds a 30% canopy coverage based upon trees growing within the property lines. For new construction or new plantings this calculation may be based upon the mature spread of the newly planted trees at 20 years after planting.

In total, 18 communities throughout Virginia adopted code 15.2-961, examples are: City of Alexandria, Albemarle County, Arlington County, City of Charlottesville, Chesapeake City, City of Manassas, City of Portsmouth, City of Suffolk, and City of Waynesboro. These localities fall within the parameters of the law. Further study is necessary to understand how effective this ordinance is at reducing canopy loss across jurisdictions.

Example of Virginia localities that have adopted the tree conservation (§ 15.2-961.1) are: Fairfax County. Fredericksburg pursued expanding this bill to include other jurisdictions with no success.

2020 General Assembly Legislation

Proposes to amend 15.2-961.1

HB 1624 - Conservation of trees during land development process. Authorizes any locality to adopt an ordinance providing for either the conservation of or the planting and replacement of trees during the land development process. Currently, only a locality within Planning District 8 with a population density of 75 persons per square mile and which is classified as an eight-hour nonattainment area for ozone under the federal Clean Air Act and Amendments of 1990, in effect as of July 1, 2008, may adopt such an ordinance for the conservation of trees.
Status: 01/31/20 House: Continued to 2021 in Counties, Cities and Towns by voice vote.

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Evaluating Urban Canopy Cover Before and After Housing Redevelopment in Falls Church, Virginia, USA

By David C. Chojnacky, Emily K. Smith-McKenna, Laura Y. Johnson, John A. McGee, and Cindy C. Chojnacky

Abstract. Local governments have created regulations aimed to maintain and increase valuable urban tree cover. The City of Falls Church, Virginia, USA, requires each residential redevelopment to retain or plant enough trees for 20% canopy cover within ten years. To assess whether this goal is being met, we studied 21 Falls Church residential lots redeveloped between 1994 and 2011 where existing houses had been replaced with larger ones. Initial tree inventories and measurements prior to redevelopment were recorded in redevelopment plans. We remeasured preserved and planted trees in a ground survey and modeled tree canopy growth from a periodic tree diameter growth model linked to a model relating tree and crown diameters. Geospatial analysis was used to calculate nonoverlapping canopy cover within lots from crown diameter measurements and/or model predictions. We found that the City of Falls Church generally met its 20% canopy cover goal, but that the canopy cover metric alone is insufficient to fully describe urban forest recovery. Although canopy cover might recover rapidly from planting many small trees, recovery to the larger tree sizes that maximize ecosystem services can take much longer. Our modeling of lot-scale growth from field measurements showed the potential to manage forests using traditional diameter-based forest metrics that would relate results to canopy cover when needed. These forest stand metrics—based on basal area and trees per hectare—can account for tree size changes masked by the canopy cover metric.

Keywords. Basal Area; GIS Buffer; GIS Dissolve; Municipal Tree Ordinance; Municipal Tree Policy; Quadratic Mean Diameter; Urban Forestry.

INTRODUCTION

Trees in cities provide essential environmental and economic services; these include reducing runoff, giving shade, enhancing aesthetics, harboring wildlife, and storing carbon (McPherson et al. 1997; Nowak and Crane 2002; Nowak et al. 2006). The overall vulnerability of urban forests, which are complex social-ecological systems, may be influenced by a variety of interrelated biophysical, built, and human components (Steenberg et al. 2017). Increased urban development typically results in increased impervious cover and decreased tree cover (Nowak and Greenfield 2012). Similarly, city expansion into surrounding forests fragments and reduces those forests and the services they provide; commuting and driving also increase, and attendant air pollution, road construction, and traffic congestion are exacerbated (Miller et al. 2015). One way to revitalize urban areas without clearing new land is to replace old houses with new ones. However, the long-term effects of redevelopment on the patchwork urban forest—such as the time needed for preserved and planted trees to restore the canopy cover that was present prior to construction—are only beginning to be studied (Berland 2012; Steenberg et al. 2018).

Local governments have created regulations that aim to maintain and increase the level of tree cover in cities (Hauer and Peterson 2015). Some cities have quite ambitious goals (Locke et al. 2017, Table 1). This produces a need to evaluate that tree cover (Bernhardt and Swiecki 1991; Abbey 1998; Zhang et al. 2009; Nguyen et al. 2017). Remote sensing techniques are frequently used for "top-down" assessments of urban canopy cover to address broad concerns, such as overall percent cover and changes over time, or to identify large areas of impervious

surfaces (Berland 2012; McGee et al. 2012; Alonzo et al. 2016; Song et al. 2016; Locke et al. 2017). Complementary field-sampled "bottom-up" studies, while providing specifics about tree species, age, and condition, typically sample and assess limited areas because field measurements are costly and it is difficult to obtain access to generally private urban forest properties (Wiseman and McGee 2010; Alonzo et al. 2016). Therefore, few studies have addressed the effects of specific policies on urban tree cover based on detailed field measurements (Landry and Pu 2010; Roman et al. 2014).

Increased new housing construction within the area of northern Virginia near Washington, D.C., USA, generally follows the approach of replacing old houses rather than expanding urban boundaries. In Falls Church, Virginia, redevelopment is escalating, with existing houses being replaced by larger ones (City of Falls Church 2005), and most of the city forest is on private property (Walker 2015). An *i-Tree* ecosystem analysis (*i-Tree* 2017) based on a randomized field sample of public and private plots recently completed for Falls Church estimated 35% canopy cover overall (Wiseman and King 2012); a similar study evaluated street trees (Wiseman and Bartens 2012). However, neither of these assessments provided the kind of information necessary to evaluate, at the plot level, the city's existing policies that regulate canopy cover on private land.

Municipal management of trees is done less often on private property than on public lands (Conway and Urbani 2007), and can be difficult (Conway 2016), particularly in states with strong private property rights. However, in Falls Church the residential

Table 1. Lot-scale summary of urban forest data for trees on 21 lots in Falls Church, Virginia. Nonoverlapping canopy cover (cover), basal area (ba), trees per hectare (tph), quadratic mean diameter (qmd), and total above/belowground carbon (C) were calculated for inventory Time0 (including trees slated for removal as well as all others on the lot), Time1 (trees preserved and newly planted at time of redevelopment), and Time2 (field inventory 1–18 years after redevelopment). The variable *period* is the number of years between Time1 and Time2 inventories; Time0 was generally one year less than Time1.

Lot	Lot area (m^2)	Period (yr)	% Canopy cover			Basal area (m^2/ha)			Trees per hectare			Quadratic mean diameter (cm)			Total carbon (Mg/ha)		
			$Cover_0$	$Cover_1$	$Cover_2$	Ba_0	Ba_1	Ba_2	Tph_0	Tph_1	Tph_2	Qmd_0	Qmd_1	Qmd_2	C_0	C_1	C_2
1	1,551	11	53	7	22	18.7	1.8	5.8	109.6	96.7	96.7	47	16	28	36.6	2.4	8.1
2	855	1	80	28	29	19.9	8.0	8.5	175.5	128.7	128.7	38	28	29	24.8	7.5	7.9
3	1,213	10	35	32	41	11.1	9.7	13.1	49.5	65.9	65.9	53	43	50	18.0	16.3	22.8
4	1,540	8	49	0	28	22.0	0.1	4.0	58.4	279.2	279.2	69	3	14	46.3	0	4.1
5	1,707	9	56	48	63	13.2	11.6	17.8	210.9	246.0	246.0	28	25	30	33.2	30.7	42.8
6	1,176	6	82	50	56	50.1	32.4	36.8	221.2	144.6	144.6	54	53	57	77.2	50.9	58.6
7	687	7	64	64	75	14.9	15.0	17.1	14.6	58.2	58.2	114	57	61	15.6	15.6	18.0
8	639	8	80	0	7	31.2	0	0.8	140.8	46.9	46.9	53	3	15	28.6	0	0.4
9	970	15	41	0	51	6.9	0.1	7.9	41.2	185.5	185.5	46	3	23	7.7	0	7.3
10	855	11	28	0	29	10.4	0.1	2.7	140.4	105.3	105.3	31	3	18	8.4	0	1.8
11	584	6	3	2	13	1.0	0.7	2.5	119.9	308.4	308.4	10	5	10	0.2	0.1	0.7
12	1,091	14	51	43	58	16.1	12.6	17.8	229.2	412.5	412.5	30	20	23	18.8	14.7	21.6
13	1,297	3	85	30	33	31.4	5.2	6.0	316.1	84.8	84.8	36	28	30	51.1	8.8	10.0
14	582	11	55	5	26	11.3	0.6	3.7	86.0	171.9	171.9	41	7	17	8.6	0.2	2.0
15	994	12	44	30	51	13.8	9.6	19.0	110.6	231.3	231.3	40	23	32	17.1	10.3	21.5
16	972	14	8	0	6	2.7	0.1	0.7	92.6	185.2	185.2	19	3	7	2.2	0	0.4
17	1,100	5	44	36	43	19.4	14.8	19.9	181.8	163.7	163.7	37	34	39	26.3	19.8	28.0
18	1,439	9	19	1	13	4.2	0.3	1.5	62.5	111.2	111.2	29	6	13	6.0	0.2	1.5
19	790	13	62	5	35	16.7	1.0	6.8	101.3	113.9	113.9	46	10	27	18.9	0.9	6.7
20	1,229	18	80	15	59	31.9	4.6	18.4	366.1	268.5	268.5	33	15	30	54.8	4.4	22.6
21	1,008	1	77	11	14	24.1	3.3	3.7	267.8	89.3	89.3	34	22	23	33.3	3.9	4.1
Min	582	1	3	0	6	1	0	1	15	47	47	10	3	7	0	0	0
Max	1,707	18	85	64	75	50	32	37	366	413	413	114	57	61	77	51	59
Mean	1,061	9	52	19	36	18	6	10	147	167	167	42	19	27	25	9	14
SD	325	5	24	20	20	12	8	9	94	95	95	21	17	15	20	13	15

redevelopment process provides a private property management opportunity for the city government and allowed us to examine and assess the efficacy of one tree cover ordinance (cited in City of Falls Church 2008) as it applied to individual lots. According to the ordinance, landowners are required to retain or plant enough trees for 20% canopy cover on their property in 10 years. The ordinance is implemented through a site-specific redevelopment plan for each lot that must be approved by the city arborist and other city officials. Each carefully crafted plan is a legal document that addresses the architecture, drainage, sewer, utilities, and landscape of a proposed residential redevelopment and includes a tree inventory: a list of trees, by species, to be preserved, cut, and planted; diameter of those to be preserved and cut; and generally a sketch of tree locations on the lot's architectural map(s). The city arborist has two years beginning at redevelopment to enforce the plan; after two years, the homeowners—like any other homeowners—can do anything they wish to property landscaping and trees. Key to enforcement is knowing how long it takes various tree arrangements to reach 20% cover, but implementation guidelines provided by the city (City of Falls Church 2008; see especially pp. 6–9), partially based on nursery industry standards for open-grown tree species, lack documented scientific supporting information. Therefore, the Falls Church city arborist asked us to compare redevelopment plans to a current inventory to determine if tree arrangements approved under current guidelines are achieving the 20% goal and to develop a more scientific basis for projecting percent tree cover for future development.

Our study focused on comparing Falls Church redevelopment plans to current tree inventories on sampled lots where existing houses had been replaced by larger ones. The study objectives were to (1) determine if City of Falls Church urban forest management guidelines result in 20% canopy cover on a lot within 10 years after residential redevelopment, as mandated by ordinance, and (2) develop a lot-scale model framework for canopy growth projection after redevelopment using data from preserved and planted trees as input. We also explored the more traditional forestry metrics of basal area and quadratic mean diameter as complements to the canopy cover metric, because measurements and calculations for these metrics are simple and they appear to have potential for use in urban forestry (Kershaw et al. 2017).

METHODS

Study Area

The City of Falls Church is located within the Piedmont forest vegetation zone (Farrell and Ware 1991). Prior to development, white oak (*Quercus alba*) was probably the most abundant species, followed by other oaks, hickory (*Carya* spp.), tulip poplar (*Liriodendron tulipifera*), black gum (*Nyssa sylvatica*), and red maple (*Acer rubrum*); the latter three would have been more abundant on poorer acidic soils. Recovering Piedmont forests on about 100 plots in the surrounding counties are currently sampled by the Forest Inventory and Analysis Program (FIA 2015). These plots are mostly nonindustrial private ownerships, with some local, state, and federal government ownerships; none are managed for timber. The FIA-sampled forest plots are dominated by *Quercus* (mostly white oak), *Pinus* (mostly Virginia pine, *P. virginiana*), *Acer* (mostly red maple), *Carya* (mostly mockernut, *C. tomentosa*, and pignut hickory, *C. glabra*) and tulip poplar.

Although a complete inventory of public and private trees in Falls Church is lacking, a 2003 street tree inventory (on file with the City of Falls Church) shows the dominant genera are *Acer* (mostly red maple), *Quercus* (mostly red oak, *Q. rubra*, and willow oak, *Q. phellos*), *Cornus* (dogwood), and *Prunus* (cherry).

Sampling Overview

Two inventory datasets were compared: initial measurements from redevelopment plans and current remeasurements. Because redevelopment included the entire lot, we used the entire lot as the sample unit (i.e., basis of per-area statistics). Two types of lot-scale metrics were calculated and compared: a canopy cover metric and traditional forest stand metrics based on basal area and trees per hectare. These metrics were used for assessing canopy cover after redevelopment and to develop a framework for predicting canopy cover growth.

Twenty-one residential lots were selected from a list of more than 300 properties redeveloped in the City of Falls Church since 1994 (Figure 1). Random sampling was done within 6 classes that were defined by construction date to more heavily select lots with older construction dates and thus obtain more long-term growth data. Construction occurred between 1994 and 2011. Data from the initial redevelopment

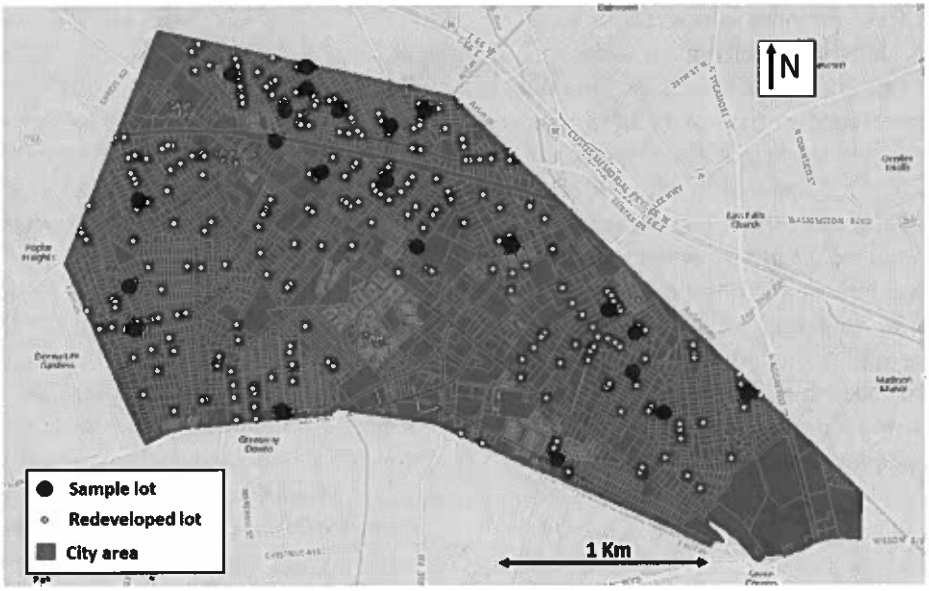

Figure 1. Map of Falls Church, Virginia, showing locations of 21 lots sampled for study (large black dots) among about 300 recent redevelopments. Falls Church is 5.3 square kilometers (2.1 square miles).

plan inventory and our field inventory up to 18 years after redevelopment were separated into three time periods: Time0, just before redevelopment; Time1, just after redevelopment; and Time2, the time of our field inventory. Time0 and Time1 separated the historical data (i.e., the data from redevelopment plans) into two categories for analysis. Time0 was the initial inventory of all trees identified on the plan and measured prior to redevelopment, both trees slated for removal and all others on the lot at that time. The Time1 inventory included trees preserved and those newly planted during redevelopment but omitted trees that had been removed during that process. Time1 was assumed to be 1 year after Time0, but Time1 was adjusted to the year the house was built if it was built later than a year after Time0 (determined from city records). All trees on the sample lots were remeasured in a ground survey at Time2 in 2012, 2013, or 2014.

Time0 and Time1 Inventory Data

For initial Time0 and Time1 inventories, redevelopment plans provided diameter (dbh), species, and rough location data from maps; if those trees were still present at Time2, their location was more precisely measured. We identified trees planted after redevelopment from redevelopment plans, but supplemented and verified these identifications with Time2 field observations, because plans were not necessarily adhered to for all lots. Precision of tree diameter measurements on plans was not identified, but trees appeared to have been measured or estimated to the nearest 2.5 to 5 cm (1 to 2 inches). Measurements of all preserved trees at Time1 were assumed to be the same as for Time0, and newly planted trees were assumed to have a dbh (diameter at breast height, 1.3 m aboveground) of 2.5 cm (1 inch) and a crown area of zero. Redevelopment plans omitted crown measurements, which had to be modeled for initial Time0 and Time1 inventories as described below.

Time2 Inventory Data

Field measurements at Time2 included tree species; diameter to the nearest 0.25 cm (0.1 inch); crown diameter (two roughly perpendicular measurements to the nearest 0.3 m [1 foot]); and geographic coordinates of each tree, measured perpendicular from the two closest lot boundaries for manual transfer onto lot boundaries in a geographic information system (GIS) environment. All diameters were measured at dbh except for some multiple-stemmed species that

branched profusely at dbh; in those cases, diameters were measured at ground line just above the root collar (drc) and adjusted to dbh as described below.

All nonoverlapping crown cover and all per-hectare calculations were based on GIS base maps for lot areas using scanned copies of original architectural redevelopment plans on file with the City of Falls Church. Because the city right-of-way was not always labeled clearly on redevelopment plans, calculated lot areas differed slightly (maximum about ± 8%) from those supplied by city property tax records; for consistency, our calculated lot area was used.

Diameter was measured at dbh for single-stemmed trees but was calculated as

$$\left(\sqrt{\sum_{i=1}^{n} d_i^2}\right)$$

for multiple-stemmed trees from individual-stem diameters (d_i)(Batcheler 1985). Because all analyses were done at dbh, a drc-to-dbh conversion model was needed for 56 trees (on 14 lots) only measured at drc (Chojnacky and Rogers 1999); the genera of these trees were *Acer*, *Amelanchier*, *Cercis*, *Lagerstroemia*, *Magnolia*, *Taxus*, *Picea*, *Prunus*, and *Ulmus*. This need was anticipated; subsamples for all tree sizes and species were measured at both drc and dbh. A model was constructed from data from 163 subsampled trees from the needed genera (dbh = -0.8399 + 0.8244 drc + 1.7648 I_L + 1.0336 I_P; *where* diameters in cm, I_L = 1 for *Lagerstroemia*, 0 *otherwise*; I_P = 1 for *Prunus*, 0 *otherwise*; (R^2-statistic = 0.93; data limit dbh < 40 cm).

Crown area at Time2 was computed as a circle by using crown diameter calculated as the geometric mean of crown diameter (c_1, c_2) measurements $\left(\sqrt{(c_1)(c_2)}\right)$.

Crown Modeling

Crown diameter was modeled for 217 cut and 125 preserved trees in initial Time0 and Time1 inventories because redevelopment plans lacked crown diameter measurements. A separate crown diameter (crndia) model was developed from Time2 inventory data for each of the 21 lots, which averaged approximately 25 trees per lot (lncrndia = β_0 + $\beta_1 ln$dbh + $\beta_0 I_{eh} \beta_0 I_c$; *where* I_{eh} and I_c are indicator [0,1] variables for evergreen hardwood and conifer species respectively; R^2-statistics = 0.80–0.99, median = 0.94). To avoid illogical extrapolations when all Time2 inventory trees for a given lot were considerably smaller than initial inventory cut trees (as was the case for 10 lots), a few large trees from neighboring lots that matched the species in question were included in the estimation.

Calculations of crown diameter worked well in later analysis after including a modification, motivated by some cases where calculated canopy growth for preserved trees was negative (particularly when the interval between Time1 and Time2 was less than 10 years). The modification used an adjustment ratio based on regression residuals from the crown diameter model. For each preserved tree, actual measured crown diameter at Time2 was divided by a model estimate of crown diameter at Time2; the Time1 model-estimate of crown diameter was then multiplied by this ratio. If the Time2 ratio was less than one, then the model predicted high, and the ratio multiplication reduced the Time1 estimate; similarly if the ratio was greater than one, the model predicted low, and Time1 crown diameter was adjusted upward by the ratio. The ratios ranged from 0.4 to 1.9, but most (25th to 75th percentiles) ranged from 0.91 to 1.12.

Canopy Cover Calculations

We calculated nonoverlapping canopy cover on each lot from individual geographically located tree crown areas using a series of ArcMap™ geoprocessing tools—*Buffer*, *Dissolve*, *Union*, and *Clip* (i.e., within a lot boundary, half the area of overlap from the union of circles corresponding to the crowns was excluded). The total nonoverlapping cover within a lot was divided by the total lot area (total area of open space and nonoverlapping canopy) with no exclusions for the house footprint and expressed as percent canopy cover.

Cover from trees spreading into neighbor lots was excluded, as was cover from neighbors' trees or street trees extending into the sampled lot; this was consistent with the canopy cover definition used by the City of Falls Church and appeared reasonable. A paired *t*-test using data from 3 of our 21 sampled lots showed no significant difference between nonoverlapping cover from within-lot trees that extended over a neighbor's lot and that from neighbor trees that extended into the sampled lot. Only 3 lots were analyzed because comparison was limited to lots where all neighbor trees extending into a sampled lot had both measured field data and geolocated coordinates; these were difficult to obtain because access permission was required from all surrounding neighbors while in the field.

Calculations of Other Metrics

Also calculated for each lot were basal area (ba, sum of cross section area of trees at dbh in m^2 divided by lot area in hectares), trees per hectare (tph), and quadratic mean diameter for an estimate of average tree size (qmd = $[200\sqrt{ba/(\pi \cdot tph)}]$, in cm)(Curtis and Marshall 2000; Kershaw et al. 2017). In addition, carbon (assumed to be 50% of biomass) was calculated (Chojnacky et al. 2014) for interpreting results. These metrics were developed for traditional forestry, so caution should be exercised when using them in urban forests in ways beyond the scope of this study; for example, modifications might be needed in our use of the entire lot (including impervious surfaces) as the basis for calculations.

Analysis

The preliminary calculations above and statistical analyses were conducted using SAS/STAT® software version 9.4 (SAS Institute Inc., Cary, North Carolina, USA) and spatial analysis was done with ArcMap™ software version 10.3.1 (Esri, Redlands, California, USA). SAS/Graph® was used to create statistical graphics. Statistical testing assumed a significance level of 0.05. Because each lot was considered a sample unit, tree data were summed to per-hectare lot-scale for analysis (Table 1).

Objective 1: Lot-scale Canopy Cover Assessment

An estimate of canopy cover 10 years after redevelopment for each lot was obtained by assuming a general canopy growth curve as a function of time since redevelopment (period, or years, between Time1 and Time2), "indexed" to growth on each specific lot: *ln*c-growth = $ß_0 + ß_1 ln$period + $ß_0$index, *where*: c-growth = $cover_2 - cover_1$, period = years since redevelopment, index = c-growth / period, *ln* = natural log (Table 1). This canopy growth curve was first fit to data (*ln*c-growth = -0.5633 + 0.9898 × *ln*period + 0.5833 × index; R^2-statistic = 0.98, n = 21). Then 10-year adjusted data were obtained by solving the equation for 10 years after redevelopment (*ln*period = *ln*10 = 2.3026). Cover at year 10 for each lot was then calculated by adding canopy cover at redevelopment ($cover_1$) to the 10-year growth prediction from the equation. We hypothesized that this calculated canopy cover at year 10 would be greater than 20%; a one-sided t-test was used to test this hypothesis ($H_0 = 20$, $H_A > 20$).

After statistical testing was conducted, statistical graphics were created to help interpret the entire sample distribution: canopy cover was easily compared to other metrics, and the graphs provided the perspective of "years since redevelopment" for each lot or inventory period.

Objective 2: Lot-scale Model Development

Modeling was done in two parts with per-hectare scale data (Table 1): (1) canopy cover predictions were developed from basal area (Mitchell and Popovich 1997), and (2) average basal area growth was estimated so that canopy growth could be projected.

The correlation between nonoverlapping canopy cover at Time2 and basal area at Time2 was the basis for modeling canopy cover predictions from basal area, but the model also included quadratic mean diameter (qmd) at Time2 and an indicator variable to separate growth rates for planted trees from those for preserved trees. The model was fit using robust regression (regression modification where effects of outliers minimized; SAS Institute Inc. 2016).

To model basal area growth, we defined *average annual* growth as the difference between Time1 and Time2 basal area divided by years between Time1 and Time2 (or period in Table 1). We separated data into four major categories—planted and preserved trees within deciduous and evergreen (hardwood and conifer) classes—to group basal area for these categories into similar ranges. A model was then fit to each category to estimate an average annual basal area growth rate from Time1 basal area. Robust regression and log transformations were used to estimate parameters; regression was aimed at prediction only, so our primary interest was evaluating the model with respect to data fit rather than other regression diagnostics.

The following were computed from Table 2 equations in order to examine the overall statistical fit of data modeling:

1. Average annual basal area growth (bag) of each lot was estimated from equations for the respective categories ($\widehat{bag}_{dpr}$, $\widehat{bag}_{epr}$, $\widehat{bag}_{dpl}$, $\widehat{bag}_{epl}$, for deciduous preserved, evergreen preserved, deciduous planted, and evergreen planted, respectively).
2. Basal area at Time2 was estimated from basal area growth model results multiplied by the period between Time1 and Time2 in years (1 to 18) and added to Time1 basal area (for example, $(\widehat{ba}_{dpr2} = [\widehat{bag}_{dpr} \cdot \text{period}] + \widehat{ba}_{dpr1})$.

Table 2. Model parameters for projecting canopy cover from basal area (ba) growth. Modeling was done in two parts: (1) canopy cover predictions were developed from basal area, and (2) average basal area growth was estimated so that canopy growth could be projected.

Component variable	$ß_0$	$ß_1$	$ß_2$	$ß_3$	n	R^2
Canopy cover (%)	0.9796	0.7221	0.4353	-0.9319	21	0.81
Ba growth (m^2/ha/yr):						
Deciduous preserved (bag_{dpr})	-1.9221	0.3582			14	0.48
Evergreen preserved (bag_{epr})	-2.3942	0.6830			11	0.31
Deciduous planted (bag_{dp})	1.4720	1.0697			21	0.55
Evergreen planted (bag_{ep})	-0.5290	0.7915			17	0.41

Where:

cover = $Exp[\beta_0+\beta_1 lnba+\beta_2 lnqmd+\beta_3 l]$; ba = basal area ($m^2$/ha);

qmd = quadratic mean diameter (cm); l=1 for preserved, 0 planted

$bag_{dpr} = Exp[\beta_0+\beta_1 lnba_{dpr}]$; ba_{dpr} = deciduous preserved basal area (m^2/ha)

$bag_{epr} = Exp[\beta_0+\beta_1 lnba_{epr}]$; ba_{epr} = evergreen preserved basal area (m^2/ha)

$bag_{dpl} = Exp[\beta_0+\beta_1 lnba_{dpl}]$; ba_{dpl} = deciduous planted basal area (m^2/ha)

$bag_{epl} = Exp[\beta_0+\beta_1 lnba_{epl}]$; ba_{epl} = evergreen planted basal area (m^2/ha)

3. Basal area at Time2 was summed for deciduous and evergreen trees for preserved and planted tree classes (for example, $\widehat{ba}_{pr2} = \widehat{ba}_{dpr2} + ba_{epr2}$).
4. Quadratic mean diameter at Time2 was calculated for preserved and planted trees ($\widehat{qmd}_{pr2}$, $\widehat{qmd}_{pl2}$, respectively) from the above basal area estimates and trees per hectare for each lot.
5. Finally, canopy cover was estimated at Time2 for each lot (from Table 2 cover equation) by using the above calculations of basal area and quadratic mean diameter as Time2 predictor variables.

We then compared canopy cover predictions to actual data for Time2 (actual minus predicted in a residual graph).

RESULTS

Objective 1: Lot-Scale Canopy Cover Assessment

Statistical Testing

Canopy cover was significantly larger than 20% ten years after redevelopment (one-sided *t*-test; $H_0 = 20$, $H_A > 20$; mean = 37%, *P*-value = 0.0002). However, the canopy cover at redevelopment Time1 ($crown_1$) of preserved and planted trees was not significantly different from 20% (one-sided *t*-test; $H_0 = 20$, $H_A < 20$; mean = 19%, *P*-value = 0.4450); in other words, since the mean lot cover was near 20% from preserved trees at redevelopment Time1, it was not surprising cover exceeded 20% after 10 years.

Statistical Graphics

A statistical graph (Figure 2) shows lot details for the three inventory periods compared to the ordinance objective of 20% canopy cover after 10 years. Canopy cover prior to redevelopment was as high as 85% (mean 52%, sampling error 21% of mean at 95% confidence); only 3 lots had cover below 20%. Although the mean canopy cover at Time1 ($cover_1$), time of redevelopment, was 19% (46% sampling error; not significantly different from 20% as shown above), about half the lots were cut back to nearly 10% cover or less while the other half retained approximately 30% cover or more.

Ten of the 21 lots sampled were remeasured at least 10 years after redevelopment and only one had canopy cover at Time2 below 20% (Figure 2; mean 36% with 24% sampling error). Eleven lots were remeasured less than 10 years after redevelopment; only 4 of these had cover less than 20% and most of those appeared likely to meet the 20% goal. However, only 8 of 21 lots showed canopy cover at Time2 greater than that prior to redevelopment, and these were primarily lots where canopy cover had not been severely reduced or that had had more than 10 years to recover. In sum, graphical results suggested further examination of the data might be worthwhile.

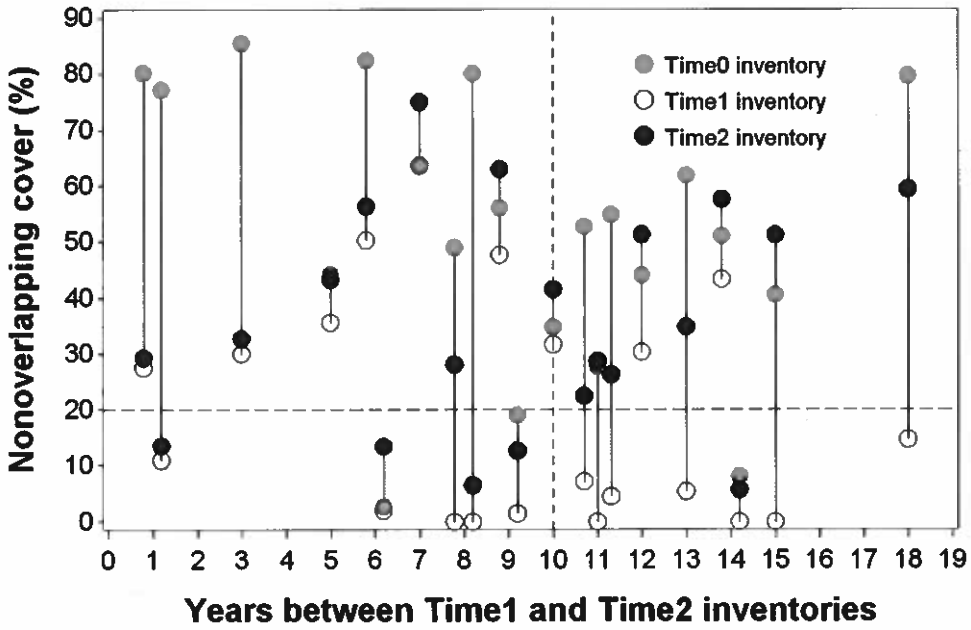

Figure 2. Canopy cover over time for 21 redeveloped lots in Falls Church, Virginia. Each vertical line connects nonoverlapping cover at Time0, the period prior to redevelopment, including trees slated for removal as well as all others on the lot; Time1, trees preserved and newly planted at the time of redevelopment; and Time2, field inventory showing canopy 1 to 18 years after redevelopment. Distance between Time0 and Time1 represents amount of canopy removed at time of redevelopment; distance between Time1 and Time2 illustrates canopy recovery over time. Dashed lines show threshold for judging whether cover at Time2 exceeds 20% (horizontal line) within 10 years (vertical line) after redevelopment (Time1). Only one lot (at 14 years) does not meet this standard and two others (at 8 and 9 years) may not quite meet it; the remaining 18 lots have or likely will exceed 20% canopy cover after 10 years.

Other Forestry Metrics

Because canopy cover does not distinguish among tree dimensions (i.e., dbh, height) to account for a given cover, we wondered if recovery of urban forests could be viewed through the conventional forestry metrics that we calculated: basal area (ba), trees per hectare (tph), and quadratic mean diameter (qmd).

Canopy cover data in Figure 3 were sorted from least to greatest decrease in cover from Time0 to Time2 and compared to similarly sorted data for ba and qmd metrics (Figure 3). Recovered basal area exceeded initial basal area on 8 of 21 lots (Figure 3B), the same number as for canopy cover (Figure 3A), but rankings differed; quadratic mean diameter, a metric of average tree size, showed only 4 of 21 lots where average tree size exceeded predevelopment tree size (Figure 3C). Only two lots (5 and 11) showed recovery exceeding predevelopment conditions for all three metrics.

Overall, Figure 3 is useful for comparing lots where a metric's Time2 value exceeded that prior to redevelopment (left of threshold) to lots not yet back to predevelopment conditions (right of threshold) and for comparing individual lots among metrics. For example, lot 7 recovery looks good from cover and basal area perspectives, but panel C reveals that when large trees are removed (i.e., qmd is greatly reduced), it takes a long time for the lot to recover that initial status. On the other hand, lot 6 recovery is relatively poor from cover and basal area perspectives but quite good in terms of preserving large trees.

Finally, basal area and canopy cover display similar patterns in Figure 3. We compared the difference between Time0 and Time2 for basal area with that for canopy cover for each lot; Pearson correlation (r = 0.918) showed close correspondence between metrics.

Objective 2: Lot-Scale Model Development

We developed a growth projection methodology for estimating future tree status that is potentially useful to urban foresters seeking to mitigate redevelopment

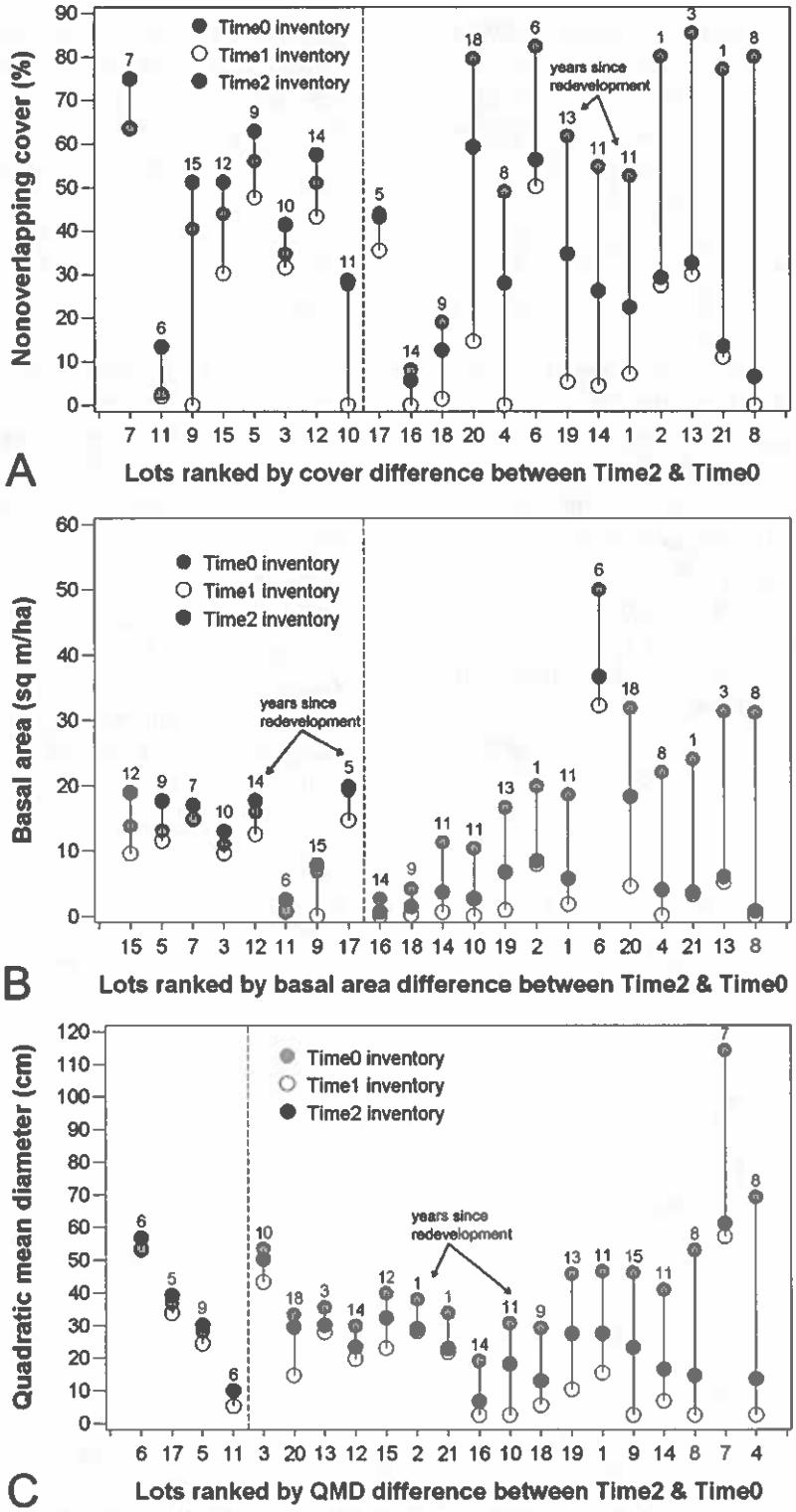

Figure 3. Comparison of 3 metrics for evaluating conditions prior to and after redevelopment for trees on 21 lots in Falls Church, Virginia. Time0 included trees slated for removal as well as all others on the lot; Time1, trees preserved and newly planted at time of redevelopment; and Time2, field inventory 1 to 18 years after redevelopment. Numbers on x-axis are lot numbers and sorted from least to greatest decrease in a metric between Time0 and Time2; in lots to the left of the dashed vertical lines (threshold), the Time2 metric has recovered and exceeds that prior to redevelopment (Time0). Panels show (A) percent nonoverlapping canopy cover, (B) basal area, and (C) quadratic mean diameter.

effects. The two-part framework described above provided a 10-year projection of canopy cover from basal area that addressed the efficacy of the city ordinance. A simplifying assumption included was that basal area growth was constant for respective planted and preserved trees over about 10 years.

The canopy cover prediction model (part 1) included 4 significant parameters (Table 2) fit from robust regression. Four average basal area growth models (part 2) were fit with robust regression; data for deciduous trees fit better than those for evergreens (Table 2).

When examining overall statistical fit of the model (by combining parts 1 and 2), the comparison of canopy cover predictions to actual data for Time2 showed more or less unbiased predictions, but the variation was large; about half the projections were more than 25% different from cover at Time2 (Figure 4). The model should be adequate for unbiased results at least for short-term projections of about 10 years in Falls Church. But we strongly caution against long-term projections, because basal-area growth of planted trees was modeled very simply and does not account for expected slower growth as trees mature. More data would have been needed to link modeled growth of planted trees to that of preserved trees in smooth transition once planted trees reached 15 to 20 years of age. Also, the model is only for growth and does not account for mortality.

We also compared modeled canopy growth of planted trees (from Time1 data) for 10 years to City of Falls Church 10-year projections of individual species crown area. The city has been using crude crown area growth tables to judge canopy cover after 10 years for planted trees (City of Falls Church 2008; pp. 6–9). The city projections were tallied ignoring any crown overlap and compared to our modeled projections. Regression showed nearly 1-to-1 correspondence (slope = 1.06 and R^2-statistic = 0.89) with a slight 2% difference (intercept = 2.3); city values were the lower (Figure 5).

DISCUSSION

We found that the City of Falls Church generally meets its desired goal of 20% canopy cover 10 years after redevelopment using current urban forest management practices, that other metrics can help more fully inform urban forest management, and that

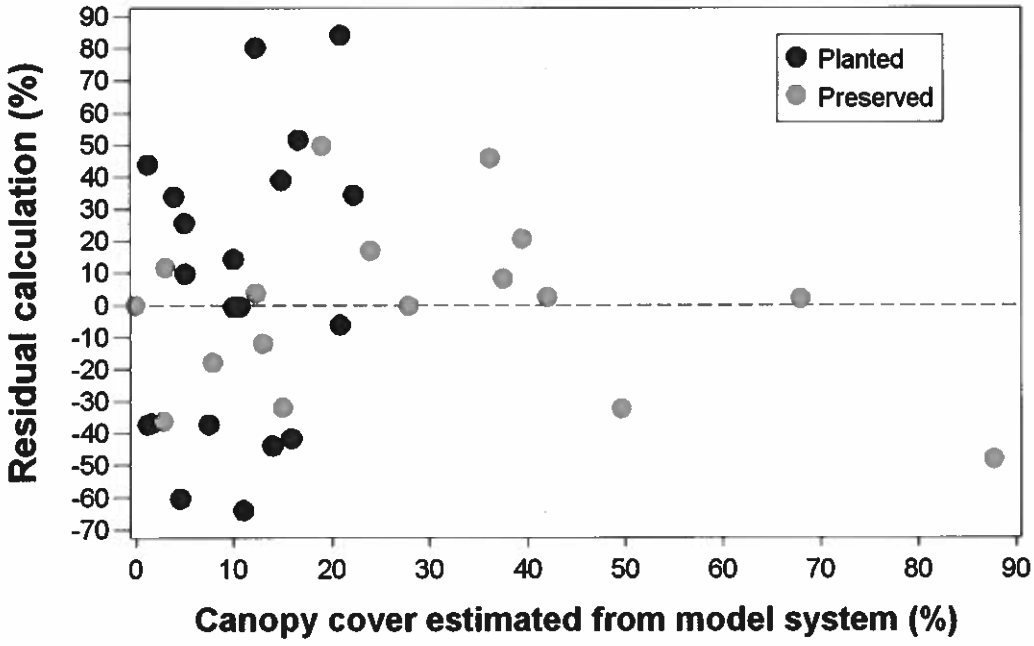

Figure 4. Canopy cover on 21 lots in Falls Church, Virginia, at Time1 (trees preserved and newly planted at time of redevelopment) was projected to Time2 (1 to 18 years after redevelopment) with a model (Table 2) and compared to actual canopy cover measured at Time2. The y-axis represents Time2 measured cover minus predicted cover divided by the average of the two covers, with the result expressed in percent. Note that negative residual differences indicate canopy cover was *overpredicted* by the model. One lot outside the range of the figure was omitted: planted cover at Time2 was 0.15% but predicted at 2.6%—over 100% overprediction.

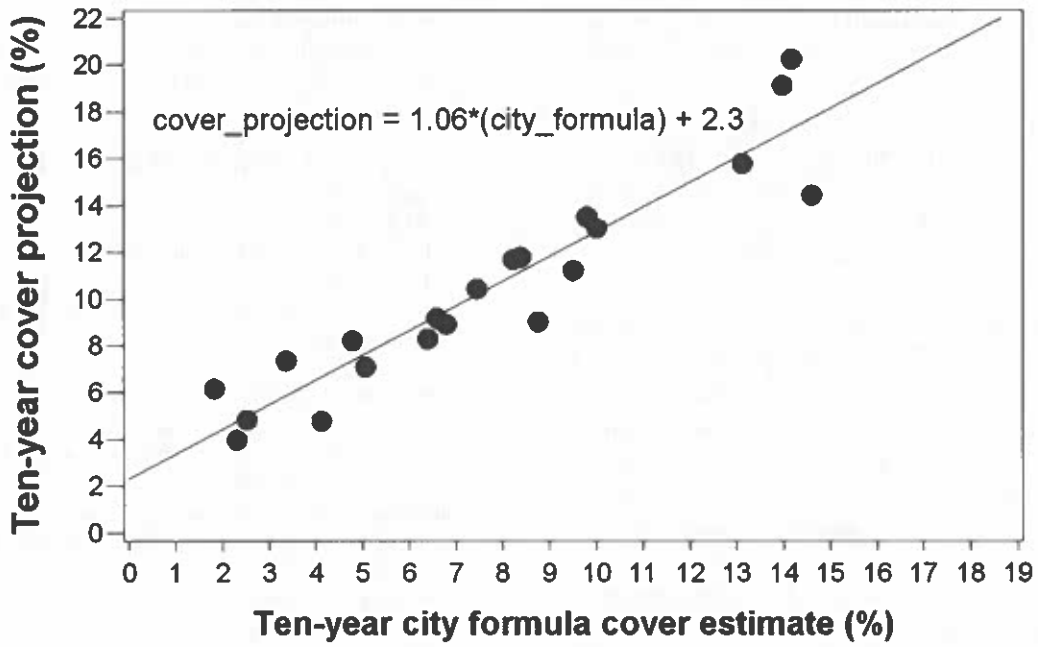

Figure 5. Comparison of canopy cover projected (cover_projection) by the model system in this study to predicted planted tree cover from City of Falls Church, Virginia, formula (city_formula). The city tables projected canopy areas of individual species listed in cover project groups from 2 to 16 m² in 10 years. The model predicted canopy cover on 21 lots for 10 years in Falls Church for trees newly planted at time of redevelopment (Time1).

modeling lot-scale growth from simple field measurements also shows potential for use in urban forest evaluations.

Meeting the formal 20% canopy cover requirement may fall short of the overall municipal goal of preserving and maintaining urban forests. Canopy cover was not significantly different from 20% at the time of redevelopment (after trees were removed for construction), indicating that the 20% threshold is probably too low for a compliance standard, at least for this community. Prior to redevelopment (Time0), Falls Church mean canopy cover was 52%, and lots generally had large majestic trees; canopy cover, when compared to other metrics, was shown to ignore the importance and loss of large trees. Strict reliance upon a formal rule such as "20% cover in 10 years" fits the spirit of other progressive-sounding but ineffective urban forestry practices found by Hill et al. (2010). They suggested municipalities move beyond just having a formal tree ordinance, a tree commission or board, an arborist, and so forth; instead, the key municipal entities need to interact and engage with actual results of urban forest management. Our study's findings illustrate one need to evaluate policy results: the canopy cover metric alone seems insufficient to fully describe urban forest recovery.

Canopy cover is an appealing metric because it is easily understood by the public, developers, and planners, and relatively easy to measure from aerial photographs or remote sensing data. However, it is not easy to measure in the field (Richardson and Moskal 2014), and accounting for overlap is not simple; our study required complex GIS calculations of nonoverlapping canopy cover from crown diameters measured for all trees in each lot. Furthermore, canopy cover is only two-dimensional and does not distinguish between cover of small and large trees.

On the other hand, basal area and quadratic mean diameter (qmd) are metrics that are easily calculated from only tree diameter measurements and that can be used to monitor and manage trees for the larger sizes (large dbh, tall height, and wide crown) that maximize benefits to urban forest environmental services (McPherson et al. 2006; Alliance for Community Trees 2011; Ko et al. 2015). For example, in our study the qmd metric showed that although canopy cover might recover rapidly (from planting many small trees), recovery to average tree size prior to

development can take much longer; for only 4 of 21 lots did average tree size exceed predevelopment tree size.

Modeling cover as a function of basal area is a promising strategy. Through our modeling effort, we showed the potential to manage urban forests "on the ground" using traditional forestry metrics based on dbh measurement, and yet still relate results to canopy cover when needed for code ordinances or common understanding. Our growth model corroborated the current City of Falls Church practice of basing new tree planting upon 10-year tree-scale canopy cover. Data from the 21 lots sampled were insufficient to fully develop a canopy growth projection system for widespread use, particularly for growth projections exceeding 10 years; the time-consuming task of securing access to private residential yards hampers collection of adequate data for studies such as this (Roman et al. 2014; Nguyen et al. 2017). Nevertheless, results were promising, and we feel strongly that arborists and urban foresters should use every opportunity to start measuring urban forest tree diameters accurately and on an area basis (e.g., lot area or smaller plot size where appropriate) in anticipation of more widespread use of basal area and quadratic mean diameter metrics—in other words, basal–area–based management. These professionals should take the lead in ensuring that measurements are accurate and precise (to nearest 0.50 cm or 0.1 inch), regardless of immediate needs or contract specifications, so that solid management data will be available.

As practitioners know, urban forestry affects the lives and health of the majority of the world population; most of us now live in cities (United Nations 2014). It is also a relatively new field (Miller et al. 2015). Our initial findings show that urban forestry research needs are great, as are the opportunities to improve practices in the field and support the forests in our communities. Because we found no similar residential urban forest inventory studies, we used a simple sampling scheme and borrowed heavily from conventional forest inventory techniques. Perhaps others can now improve upon our work to strengthen scientific foundations for municipal forest inventories and monitoring of residential city property. We applaud the National Urban and Community Forestry Advisory Council for recognizing the need for more urban forestry research (NUCFAC 2015). We think that tree ordinances and other community practices aimed to improve urban forests need to be backed by solid science in order to attain maximum effectiveness and avoid becoming mere quick fixes.

LITERATURE CITED

Alonzo, M., J.P. McFadden, D.J. Nowak, and D.A. Roberts. 2016. Mapping urban forest structure and function using hyperspectralimagery and lidar data. *Urban Forestry & Urban Greening* 17: 135-147.

Abbey, B. 1998. *U.S. Landscape Ordinances: An Annotated Reference Handbook, 1st Edition*. Wiley, Hoboken, New Jersey, USA. 456 pp.

Alliance for Community Trees. 2011. Benefits of Trees and Urban Forests: A Research List. Accessed March 2016. <http://www1.cityoflompoc.com/PublicWorks/UrbanForestry/benefits_of_trees.pdf>

Batcheler, C.L. 1985. Note on measurement of woody plant diameter distributions. *New Zealand Journal of Ecology* 8: 129-132.

Berland, A. 2012. Long-term urbanization effects on tree canopy cover along an urban–rural gradient. *Urban Ecosystems* 15: 721-738.

Bernhardt, E.A., and T.J. Swiecki. 1991. Guidelines for Developing and Evaluating Tree Ordinances. Urban Forestry Program, California Department of Forestry and Fire Protection, Sacramento, California, USA. 76 pp.

Chojnacky, D.C., and P. Rogers. 1999. Converting tree diameter measured at root collar to diameter at breast height. *Western Journal of Applied Forestry* 14(1): 14-16.

Chojnacky, D.C., J.C. Jenkins, and L.S. Heath. 2014. Updated generalized biomass equations for North American tree species. *Forestry* 87: 129-151.

City of Falls Church. 2005. Comprehensive Plan. Accessed March 2017. <http://www.fallschurchva.gov/412/Comprehensive-Plan>

City of Falls Church. 2008. Tree Preservation and Replacement Guide for Development and/or Redevelopment on Single Family Residential Lots. Accessed July 2016. <http://www.fallschurchva.gov/documentcenter/view/157>

Conway, T.M. 2016. Tending their urban forest: Residents' motivations for tree planting and removal. *Urban Forestry & Urban Greening* 17: 23-32.

Conway, T.M., and L. Urbani. 2007. Variations in municipal urban forestry policies: A case study of Toronto, Canada. *Urban Forestry & Urban Greening* 6: 181-192.

Curtis, R.O., and D.D. Marshall. 2000. Technical note: Why quadratic mean diameter? *Western Journal of Applied Forestry* 15(3): 137-139.

Farrell, J.D., and S. Ware. 1991. Edaphic factors and forest vegetation in the Piedmont of Virginia. *Bulletin of the Torrey Botanical Club* 118(2): 161-169.

Forest Inventory and Analysis Program. 2015. FIA Data Mart: Download Files, U.S. Department of Agriculture, Forest Service. FIADB5.1.6 Accessed April 2015. <http://apps.fs.fed.us/fiadb-downloads/datamart.html>

Hauer, R., and W. Peterson. 2015. Municipal tree care and management in the United States. In: *Conference Proceedings of the International Society of Arboriculture 91st Annual Conference*

& Trade Show. Orlando, Florida, 9–12 August 2015. International Society of Arboriculture, Champaign, Illinois, USA.

Hill, E., J.H. Dorfman, and E. Kramer. 2010. Evaluating the impact of government land use policies on tree canopy coverage. *Land Use Policy* 27: 407-414.

i-Tree. 2017. *i-Tree* eco user's manual, version 6.0. Accessed February 2017. <https://www.itreetools .org/resources/manuals/Ecov6_ManualsGuides/Ecov6_UsersManual.pdf>

Kershaw, J.A., M.J. Ducey, T.W. Beers, and B. Husch. 2017. *Forest Mensuration, 5th Edition*. John Wiley & Sons, Inc., Hoboken, New Jersey, USA. 632 pp.

Ko, Y., J.H. Lee, E.G. McPherson, and L.A. Roman. 2015. Long-term monitoring of Sacramento Shade program trees: Tree survival, growth and energy-saving performance. *Landscape and Urban Planning* 143: 183-191.

Landry, S., and R. Pu. 2010. The impact of land development regulation on residential tree cover: An empirical evaluation using high-resolution IKONOS imagery. *Landscape and Urban Planning* 94: 94-104.

Locke, D.H., M. Romolini, M. Galvin, J.P.M. O'Neil-Dunne, and E.G. Strauss. 2017. Tree canopy change in coastal Los Angeles, 2009–2014. *Cities and the Environment* 10(2): Article 3.

McGee, J.A., III, S.D. Day, R.H. Wynne, and M.B. White. 2012. Using geospatial tools to assess the urban tree canopy: Decision support for local governments. *Journal of Forestry* 110: 275-286.

McPherson, E.G., D. Nowak, G. Heisler, S. Grimmond, C. Souch, R. Grant, and R. Rowntree. 1997. Quantifying urban forest structure, function, and value: The Chicago Urban Forest Climate Project. *Urban Ecosystems* 1(1): 49-61.

McPherson, E.G., J.R. Simpson, P.J. Peper, S.L. Gardner, K.E. Vargas, S.E. Maco, and Q. Xiao. 2006. Coastal Plain community tree guide: Benefits, costs, and strategic planting. U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station. Accessed March 2016. <http://www.fs.fed.us/psw/programs/uesd/uep/products/2/cufr_679_gtr201 _coastal_tree_guide.pdf>

Miller, R.W., R.J. Hauer, and L.P. Werner. 2015. *Urban Forestry: Planning and Managing Urban Greenspaces, 3rd Edition*. Waveland Press, Inc., Long Grove, Illinois, USA. 560 pp.

Mitchell, J.E., and S.J. Popovich. 1997. Effectiveness of basal area for estimating canopy cover of ponderosa pine. *Forest Ecology and Management* 95: 45-51.

National Urban and Community Forestry Advisory Council. 2015. Ten-year urban forestry action plan: 2016–2026. Accessed November 2018. <https://urbanforestplan.org/wp-content/uploads/2015/11/FinalActionPlan_Complete_11_17_15.pdf>

Nguyen, V.D., L.A. Roman, D.H. Locke, S.K. Mincey, J.R. Sanders, E.S. Fichman, M. Duran-Mitchell, and S.L. Tobing. 2017. Branching out to residential lands: Missions and strategies of five tree distribution programs in the U.S. *Urban Forestry & Urban Greening* 22: 24-35.

Nowak, D.J., and D.E. Crane. 2002. Carbon storage and sequestration by urban trees in the USA. *Environmental Pollution* 116: 381-389.

Nowak, D.J., D.E. Crane, and J.C. Stevens. 2006. Air pollution removal by urban trees and shrubs in the United States. *Urban Forestry & Urban Greening* 4: 115-123.

Nowak, D.J., and E.J. Greenfield. 2012. Tree and impervious cover change in U.S. cities. *Urban Forest & Urban Greening* 11: 21-30.

Richardson, J.J., and L.M. Moskal. 2014. Uncertainty in urban forest canopy assessment: Lessons from Seattle, WA, USA. *Urban Forestry & Urban Greening* 13: 152-157.

Roman, L.A., J.J. Battles, and J.R. McBride. 2014. Determinants of establishment survival for residential trees in Sacramento County, CA. *Landscape and Urban Planning* 129: 22-31.

SAS Institute Inc. 2016. SAS/STAT® Knowledge Base/Documentation. Accessed March 2016. <http://support.sas.com/documentation/onlinedoc/stat/>

Song, Y., J. Imanishi, T. Sasaki, K. Ioki, and Y. Morimoto. 2016. Estimation of broad-leaved canopy growth in the urban forested area using multi-temporal airborne LiDAR datasets. *Urban Forestry & Urban Greening* 16: 142-149.

Steenberg, J.W.N., A.A. Millward, D.J. Nowak, and P.J. Robinson. 2017. A conceptual framework of urban forest ecosystem vulnerability. *Environmental Reviews* 25: 115-126.

Steenberg, J.W.N., P.J. Robinson, and A.A. Millward. 2018. The influence of building renovation and rental housing on urban trees. *Journal of Environmental Planning and Management* 61(3): 553-567.

United Nations. 2014. World Urbanization Prospects: The 2014 Revision, Highlights. United Nations, Department of Economic and Social Affairs, Population Division. ST/ESA/SER.A/352. Accessed April 2016. <http://esa.un.org/unpd/wup/Publications/Files/WUP2014-Highlights.pdf>

Walker, C.S. 2015. Designing an urban forest inventory system for a small municipality: A case study of Falls Church, Virginia. M.F. thesis, Virginia Polytechnic Institute and State University, Blacksburg, Virginia, USA. 43 pp.

Wiseman, E., and J. Bartens. 2012. Street Tree Assessment Report: Falls Church, Virginia. Virginia Tech Department of Forest Resources and Environmental Conservation, Blacksburg, Virginia, USA. Accessed March 2017. <http://urbanforestry.frec.vt.edu/STREETS/reports /FallsChurchReport.pdf>

Wiseman, E., and J. King. 2012. *i-Tree* Ecosystem Analysis, Falls Church: Urban Forest Effects and Values February 2012. Virginia Tech Department of Forest Resources and Environmental Conservation, Blacksburg, Virginia, USA. Accessed March 2017. <http://urbanforestry.frec.vt.edu/documents/eco/fallsch_eco.pdf>

Wiseman, E., and J. McGee. 2010. Taking stock: Assessing urban forests to inform policy and management. *Virginia Forests Magazine* 65(4): 4-7.

Zhang, Y., B. Zheng, B. Allen, N. Letson, and J.L. Sibley. 2009. Tree ordinances as public policy and participation tools: Development in Alabama. *Arboriculture & Urban Forestry* 35(3): 165-171.

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Conflicts of Interest:
The authors reported no conflicts of interest.

Résumé. Les administrations locales ont émis des dispositions réglementaires destinées à maintenir et à accroître le précieux couvert forestier urbain. La ville de Falls Church, Virginie, USA, requiert, au moment de tout redéveloppement résidentiel, de maintenir ou de planter suffisamment d'arbres afin d'obtenir un couvert arborescent de 20% au terme des dix années suivantes. Afin de déterminer si cet objectif est atteint, 21 lots résidentiels de Falls Church, redéveloppés entre 1994 et 2011 aux fins du remplacement de maisons existantes par des maisons plus grandes, furent étudiés. Les données initiales d'inventaire et de mesures des arbres préalablement au redéveloppement avaient été enregistrées sur les plans proposés pour ce redéveloppement. Un relevé de terrain permit de remesurer les arbres préservés ainsi que ceux plantés depuis et nous modélisâmes la croissance du couvert des arbres à partir d'un modèle périodique de croissance du diamètre des arbres et d'un autre modèle associant le diamètre du tronc à celui de la cime. Une analyse géospatiale fut utilisée afin de calculer le couvert arborescent non chevauchant à l'intérieur des lots à partir des mesures de diamètre de la cime et/ou des prédictions du modèle. Nous constatâmes que la ville de Falls Church rencontrait généralement son objectif de 20% du couvert arborescent, mais que la seule donnée du couvert forestier était insuffisante pour décrire complètement le rétablissement de la forêt urbaine. Bien que le couvert arborescent puisse récupérer rapidement suite à la plantation de plusieurs petits arbres, le rendement attendu d'arbres de grande dimension maximisant les services écosystémiques nécessitait beaucoup plus de temps. Notre modélisation de la croissance à l'échelle des lots suite aux relevés de terrain démontra le potentiel de gérer les forêts en utilisant les données traditionnelles basées sur le diamètre mais dont les résultats pouvaient être corrélés lorsque le couvert forestier était recherché. Ces données sur les peuplements forestiers, basées sur les surfaces terrières et le nombre d'arbres par hectare, pouvaient être pris en compte pour les modifications des dimensions non-visibles des arbres au-moment de la mesure du couvert arborescent.

Zusammenfassung. Lokale Verwaltungen haben Regelwerke entwickelt, die wertvollen urbanen Baumbestand erhalten und vergrößern. Die Stadt Falls Church, Virginia, USA, fordert bei jeder Neuentwicklung von Siedlungsräumen entweder genug Bäume zu pflanzen oder zu erhalten, um innerhalb von 10 Jahren eine Bedeckung von 20 % zu erzielen. Für die Untersuchung, ob dieses Ziel erreicht wird, studierten wir 21 Siedlungsbereiche in Falls Church, die zwischen 19994 und 2011 neu gestaltet wurden, wo die existierenden Häuser durch größere ersetzt wurden. Erste Baumkataster und Messungen vor der Umgestaltung wurden in die Entwicklungspläne aufgenommen. In einer Bodenerfassung wurden die erhaltenen und gepflanzten Bäume neu vermessen und das Kronenwachstum von einem periodischen Baumdurchmesserwachstumsmodell beispielhaft übernommen und mit einem Modell zur Beziehung zwischen Baum und Kronendurchmesser verbunden. Eine räumliche Analyse wurde verwandt, um die nicht überlappenden Kronenbedeckungen innerhalb der Siedlungsbereiche aus den Kronendurchmessermessungen und/oder den Modellvorhersagen zu kalkulieren. Wir fanden heraus, dass die Stadt Falls Church generell ihr Ziel von 20 % erreicht, aber dass die Kronenbedeckung allein nicht ausreicht, um die Erholung der urbanen Forste zu beschreiben. Obwohl sich die Kronenbedeckung durch die Pflanzung kleinerer Bäume schnell erholen könnte, wird das Heranwachsen zu großen Baumgrößen, die die ökologischen Leistungen maximieren, viel länger dauern. Unser Modell von flächenbezogenem Wachstum aus Feldmessungen zeigte das Potential zur Verwaltung von Waldflächen unter der Verwendung traditioneller auf Durchmesser basierender Forstmesswerte, die die Ergebnisse zur Kronenbedeckung wenn erforderlich

relativieren würden. Diese Forstmesswerte—basierend auf basaler Fläche und Baum pro Hektar können für die Baumgrößenveränderungen in Bezug zur Kronenbedeckung hinzugezogen werden.

Resumen. Los gobiernos locales han creado regulaciones destinadas a mantener y aumentar la valiosa cubierta de árboles urbanos. La ciudad de Falls Church, Virginia, EE. UU., requiere que cada remodelación residencial retenga o plante suficientes árboles para una cobertura del dosel en un plazo de diez años. Para evaluar si se ha cumplido este objetivo, estudiamos 21 lotes residenciales de Falls Church reconstruidos entre 1994 y 2011, donde las casas existentes habían sido reemplazadas por otras más grandes. Los inventarios y mediciones iniciales de los árboles antes de la reurbanización se registraron en los planes de reurbanización. Volvimos a medir los árboles preservados y plantados en un estudio de suelo y modelamos el crecimiento de la copa de los árboles a partir de un modelo de crecimiento periódico del diámetro del árbol vinculado a un modelo que relaciona los diámetros de los árboles y las copas. El análisis geoespacial se usó para calcular la cobertura del dosel sin solapamiento dentro de los lotes a partir de mediciones del diámetro de la corona y / o predicciones del modelo. Descubrimos que la ciudad de Falls Church generalmente cumplió con su objetivo de cobertura del dosel del 20%, pero que la métrica de la cubierta del dosel por sí sola es insuficiente para describir completamente la recuperación del bosque urbano. Aunque la cubierta del dosel puede recuperarse rápidamente a partir de la plantación de muchos árboles pequeños, la recuperación a los árboles más grandes que maximizan los servicios del ecosistema puede llevar mucho más tiempo. Nuestro modelo de crecimiento a escala de lote a partir de mediciones de campo mostró el potencial para gestionar los bosques utilizando métricas forestales tradicionales basadas en el diámetro que relacionarían los resultados con la cubierta del dosel cuando sea necesario. Estas métricas de masas forestales, basadas en el área basal y los árboles por hectárea, pueden dar cuenta de los cambios en el tamaño de los árboles enmascarados por la métrica de la cubierta del dosel.

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Protecting the urban forest: Variations in standards and sustainability dimensions of municipal tree preservation ordinances

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ABSTRACT

Trees help create sustainable urban systems by providing important functions aligned with the three dimensions of sustainability, i.e., environment, economy, and society. Yet urban forest loss remains a problem in expanding metropolitan regions. To accrue urban forest services, municipalities have enacted tree preservation ordinances (TPO) to regulate tree removal. These ordinances describe not only how cities manage their urban forests but also what urban forest services they value. The goals of this research are to locate cities with TPOs in Texas, compare the scope and intent of these ordinances, and assess the extent to which they reference the sustainability dimensions of urban forest services. We documented the parameters, extent, and conditions of tree protection found in TPOs via descriptive statistics and examined their statements of purpose for references to urban forest services through a quantitative content analysis (QCA). We found 60 municipalities possess TPOs, and most are in rapidly growing metropolitan areas. Our results indicate variations occur in their scope and intent. The majority of TPOs protect trees on private property but many also contain exemptions that potentially limit their effectiveness. Over half of TPOs contained a statement of purpose with references to one or more of the sustainability dimensions of urban forest services. Communities across metropolitan areas place more emphasis on the environment and society dimensions of sustainability. Overall, our results suggest that more communities should enact TPOs with less exemptions, and the sustainability dimensions of urban forests should be explored with equal vigor and stated more clearly so that all stakeholders are equipped with a better argument of not only why to write TPOs but why to enforce them.

1. Introduction

Trees play a vital role in creating sustainable urban systems through several important services aligned with the three primary dimensions of sustainability, i.e., environment, economy, and society (Hirokawa, 2011). Protecting and enhancing the urban forest has become a key component in achieving municipal sustainability objectives (Duinker et al., 2015). Despite their importance to urban systems and municipal sustainability goals, urban processes often result in the loss of urban trees (Nowak and Walton, 2005). Estimates suggest that 4 million trees each year in the United States are lost to new urban development (Nowak and Greenfield, 2012). Natural hazards, such as drought (Holopainen et al., 2006) and hurricanes (Burley et al., 2008; Thompson et al., 2011), also contribute to urban tree loss. Additionally, urban tree loss has been linked to neighborhood-scale socioeconomic characteristics (Lavy and Hagelman, 2017), risk perceptions (Conway, 2016), and individual preferences (Kirkpatrick et al., 2013).

To reduce tree loss from urban development and to accrue urban tree services, municipalities have deployed a variety of urban forestry programs and regulations. Federal funding has allowed for the proliferation of state-oriented urban and community forestry programs (Hauer et al., 2008; Hauer and Johnson, 2008). State and federal assistance along with private donations and nonprofit funding have provided support for local efforts to grow and maintain urban forests. Existing research has focused on outcomes of these efforts, including education and outreach programs (Poland and McCullough, 2006), planting programs (Locke and Grove, 2016; Perkins et al., 2004), and management planning (Ordóñez and Duinker, 2013). Some cities have also adopted more broadly focused, aggressive planting programs (Pincetl et al., 2012). Others have produced tree inventories and assessments using community mapping (Hawthorne et al., 2015). The outcomes of these programs, however, varies. Previous research has indicated that a lack of community or political support often impedes the implementation and expansion of urban forestry programs in cities

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(Elmendorf et al., 2003; Schroeder et al., 2003; Driscoll et al., 2015; Carmichael and McDonough, 2018).

To further protect and enhance urban greenspace, municipalities also use public policy instruments to guide the management of urban growth and the preservation of urban trees (Bengston et al., 2004). Various types of municipal tree ordinances play an important role in the management of urban forests (Miller, 2007). They provide legal frameworks for the protection and preservation of public and/or private trees by regulating tree removal. Recent studies have addressed the effectiveness of municipal tree ordinances (Hill et al., 2010; Landry and Pu, 2010; Sung, 2012) but have also shown that urban forestry policies vary in terms of their structure, enforcement, and community character (Dickerson et al., 2001; Conway and Urbani, 2007; Lavy and Hagelman, 2017). While evidence points toward the overall efficacy of tree ordinances, a systematic evaluation of their content is an important step in understanding how communities not only protect trees but view and prioritize their benefits. Further insight into these dimensions of urban forest regulation promises to inform both research and management practices related to building sustainable urban systems. The purpose of this research is to document and compare the scope and intent of municipal tree preservation ordinances within the state of Texas in order to illustrate how cities manage and protect their urban forests and how they interpret and value urban forest services within a sustainability framework.

2. Municipal tree ordinances

Cities have enacted several regulatory mechanisms to manage and preserve trees. Urban forest regulations give municipalities the authority to enforce minimum standards concerning removal, mitigation, protection, and planting of trees on public and/or private land (Bernhardt and Swiecki, 2001; Bardon et al., 2001). Urban forest regulations fall into one of four categories: 1) street tree ordinances; 2) tree protection or preservation ordinances; 3) buffer or view ordinances; and 4) landscape ordinances. Street tree ordinances regulate trees within public properties and right-of-ways. Tree preservation ordinances commonly regulate trees on private properties. Buffer ordinances typically serve to protect view sheds of private properties. Landscape ordinances customarily establish tree-planting requirements for new developments. While each type of tree ordinance varies in its intent and scope, the tree preservation (or protection) ordinance's (TPO) primary objective is to preserve and protect trees for the collective benefit of the urban environment by requiring landowners to receive permission from local municipal authorities before removing trees of a certain size and/or species. Tree preservation ordinances contain a variety of key standards for protecting and preserving urban trees. For example, the scope of a typical TPO includes the following information: 1) the parameters of protection (e.g., the size and species of protected trees), 2) the extent of protection (e.g., types of property subject to regulation), and 3) the conditions of protection (e.g., mitigation requirements and enforcement measures). Many TPOs also contain statements of purpose describing the community's intent behind the ordinance.

Research has found TPOs to be an effective tool for preserving urban trees but also indicates that the design of a community's tree ordinance is of consequence in assessing its regulatory success (Gatrell and Jensen, 2002; Galenieks, 2017). Tree preservation ordinances enacted in Tampa, Florida, and Atlanta, Georgia, are credited with an increase in urban forest canopy cover (Hill et al., 2010; Landry and Pu, 2010). In central Texas, an increase in tree height has been linked to TPOs (Sung, 2012). The efficacy of urban forest regulations, however, has been shown to vary across both urban scale and community demographics (Conway and Urbani, 2007; Zhang et al., 2009). For example, site exemptions from tree ordinances have been linked to decreased canopy cover in Florida (Gatrell and Jensen, 2002). Research conducted in Austin, Texas, found most protected tree removal requests were granted (Lavy and Hagelman, 2017). In a survey of Illinois cities, communities with higher income levels and educational attainment were more apt to adopt tree protection measures (Dickerson et al., 2001). Even with an existing tree ordinance, research has shown canopy cover tends to be greater in majority white residential areas compared to more racially diverse neighborhoods (Landry and Pu, 2010). Less, however, is known about the specific statutory requirements found in TPOs, the stated intent of them, and how their content may contribute to the variations reported in the literature.

Given the perceived importance of TPOs in protecting the urban forest and creating sustainable urban systems, we analyze the content of TPOs promulgated by Texas municipalities. In doing so, we add to the growing body of scholarly work that examines urban forest policies by providing a detailed account of the regulatory requirements contained in TPOs as well as their stated intent. Specifically, we document, summarize, and compare TPO regulatory requirements, and we test one method for quantifying the stated intent of TPOs and visualize those values on a standardized data display tool reflecting the relative dimensions of TPOs across the three common sustainability realms of environment, economy, and society (von Hauff and Wilderer, 2008; McDonough and Braungart, 2002). This study offers a more nuanced understanding of the policies that protect trees, the differences observed in their statutory language, and the urban forest services that communities prioritize. Therefore, this research answers two primary questions: how does the scope and intent of municipal TPOs vary by municipality and by region, and to what extent do municipalities with TPOs address the sustainability dimensions of urban forest services?

3. Materials and methods

3.1. Site and situation

Texas is located in the American South and is bordered by four U.S. states—New Mexico, Oklahoma, Arkansas, and Louisiana—and Mexico. Texas is the second most-populated state (26 million) in the United States (U.S. Census Bureau, 2014) and has experienced rapid population growth over the past few decades. Population growth in Texas has spurred new development in many Texas cities and redevelopment within city centers. It regularly hosts four of the top 20 fastest growing large urban areas in the United States with a population greater than one million, including Austin, San Antonio, Dallas-Fort Worth, and Houston (U.S. Census Bureau, 2012).

Climate varies across the state. East Texas is subtropical humid with hot, humid summers and cool, dry winters, and the western portion of Texas is semiarid steppe, possessing hot, dry summers and mild, warm winters. Precipitation across the state is variable, ranging from an annual average of 1,397 mm in the east to less than 381 mm in the west (TWDB, 2012). Moreover, the state is prone to drought. The Texas Forest Service estimates extreme drought conditions in 2011 claimed 5.6 million urban trees (TFS, 2012a) and another 300 million rural trees (TFS, 2012b). In recent years, several Texas cities, large and small, have implemented protective measures, including TPOs, to preserve valuable environmental resources under pressure from rapid urbanization, redevelopment, and recent climate shifts.

3.2. Data and analysis

We obtained data for this study from Texas municipal TPOs. We acquired an initial list of municipalities with TPOs from the Texas Chapter of the International Society for Arboriculture (International Society of Arboriculture Texas Chapter (ISAT), 2012). We then verified, augmented, and updated the list through Internet searches and by referencing MuniCode (a municipal code database) to create a comprehensive list of municipalities with TPOs and used ArcMap Version 10.1 (2019) to map them (ESRI, 2015). Next, we downloaded TPOs from the municipalities' websites and systematically extracted the standards and

statements of purpose from each. Analysis for this portion of the study consisted of descriptive statistics to provide a generalized view of municipal and regional trends in urban forest management. Specifically, we documented and summarized key components of TPOs related to the parameters, extent, and conditions of tree protections and drew comparisons between metropolitan statistical areas (MSAs). We combined the Austin-Round Rock and San Antonio-New Braunfels MSAs into one group because of their proximity and because together they anchor the rapidly expanding central Texas Interstate-35 corridor.

In order to illustrate the sustainability dimensions of urban forest services valued by cities with TPOs, we conducted a quantitative content analysis (QCA) on the text contained in TPO statements of purpose. Quantitative content analysis is "a research technique for the systematic, objective, and quantitative description of the manifest content of communication" (Berelson, 1952, 18). In QCA, text serves as the data source, and portions of the text are coded into categories of interest, counted, and recorded (Krippendorff, 2013). Specifically, we identified and counted phrases from the statements of purpose that most reflected one of the three sustainability dimensions of urban forest services. As such, we coded three categories of interest: 1) society, 2) economy, and 3) environment. Due to synergistic interaction among the sustainability dimensions of urban forest services (i.e., their ability to transcend categories), for each phrase identified we coded it to the most obvious category of interest implied by the phrase or surrounding text. For example, phrases such as "provide ecological habitat for songbirds" and "reduce the erosive effects of rainfall" were coded as environmental services. Phrases such as "protect property values" and "increase tax revenues" were coded as economic benefits. Phrases such as preservation for "education and enjoyment of future generations" and "to promote health and quality of life" were coded as societal benefits. From here, we calculated trends in references by MSA and identified which services were given more importance and which were marginalized.

Finally, we illustrated the relative importance each TPO places on the sustainability dimensions of urban forest services using a ternary diagram. The ternary plot is a useful diagram to represent the interdependence and interconnectedness between three variables. Most recently, ternary plots have been used to assess, guide, and visualize sustainability efforts in urban planning (Campbell, 1996), industrial ecology (von Hauff and Wilderer, 2008), industrial and product design (McDonough and Braungart, 2002), and economic development (Xu et al., 2006). For this part of the study, we plotted the proportion of references to the sustainability dimensions of urban forest services for each TPO using JMP® Version 11 (2019). The resulting diagram highlights the extent to which a TPO's statement of purpose provides more emphasis to any one of the sustainability dimensions of urban forest services, while allowing for a visual analysis of the spatial relationships among sustainability dimensions across all TPOs.

4. Results

We found 60 municipalities in Texas possessed a TPO at the time of analysis. Of these, 34 included a statement of purpose section. Most cities with TPOs cluster near the fastest growing metropolitan statistical areas (MSA) in Texas—Dallas-Fort Worth-Arlington, Austin-Round Rock, San Antonio-New Braunfels, and Houston-The Woodlands-Sugar Land (Fig. 1). The Dallas-Fort Worth-Arlington MSA contains 28 cities with TPOs. The combined MSAs of Austin-Round Rock and San Antonio-New Braunfels contain 14 cities with TPOs. The Houston-The Woodlands-Sugar Land MSA contains 12 cities with TPOs. The remaining six cities with TPOs fall outside of these large (one million plus) metropolitan areas. The following sections explore trends in the parameters, extent, and conditions of protection found in municipal TPOs (Table 1).

4.1. Parameters of protection

Tree preservation ordinances typically stipulate at what size a tree becomes protected under the ordinance. Tree size is most often determined by diameter at breast height (DBH). This tree measure is expressed by the diameter in inches of the trunk at 4.5 feet above natural grade. In their respective cities, all ordinances indicate protected species and size. Yet, protected species, protected size, and how size is determined varies by municipality and region. Protected trees range in size from 1.5 to 23 in. DBH. The Dallas-Fort Worth-Arlington MSA protects trees at the smallest size on average (6.04 in. DBH) with little variation (Table 1). The combined Austin and San Antonio MSAs, the Houston-The Woodlands-Sugar Land MSA, and remaining cities protect trees closer to 10 in. DBH with more variation across cities. Some cities use other measures in addition to DBH. A Dallas area TPO considers evergreen trees that are 8 feet in height or taller protected trees. Similarly, a Houston area TPO protects trees that are 1/3 their mature height. Other cities also designate protected trees based on their potential maximum growth. For example, a San Antonio area TPO designates small tree species as protected trees at the size of 5 in. DBH.

Many ordinances also designate a secondary classification of protected trees, which is larger than the minimum size of a protected tree (n = 28). Trees that fall under this secondary designation generally are referred to as heritage trees, and typically, the rules and regulations for removing them are more stringent than for protected trees. Variations also occur in this category, and most heritage classifications are based on tree species. The combined Austin and San Antonio MSAs possess the largest amount of TPOs with heritage tree classifications (93 percent), whereas only a third of TPOs in the other areas designate heritage tree protection. Heritage tree size ranges from 14 to 42 in. DBH, depending on tree species. The average heritage tree size is similar across cities in the major metropolitan areas.

Finally, some TPOs identify which species of trees are considered protected or heritage trees. Protected tree species lists often include native tree species with aesthetic value and long lifespans and exclude native and non-native invasive tree species. In Austin, all tree species are protected, but only certain tree species are considered protected with a heritage tree designation. Similarly, some ordinances possess two lists of protected trees: one for large tree species and one for small tree species. Other ordinances base tree protection on regional biogeography of tree species, whereas others list unprotected tree species.

4.2. Extent of protection

The extent of protection varies depending on property type, land development status, size, and land-use zoning designations (Table 1). Only one TPO (in the Houston-The Woodlands-Sugar Land MSA) does not protect trees on private property; however, protection on public property varies. Twenty-four TPOs specifically state the ordinance pertains to all protected trees on public lands. Tree protection on public property is greatest in the Dallas-Fort Worth-Arlington MSA. All TPOs, except Houston's ordinance, protect trees on undeveloped land, but only a tenth of ordinances protect trees on developed land. In addition, the regulations for six ordinances apply only to properties of a stipulated size. For example, ordinance regulations for two municipalities do not apply to parcels less than or equal to one acre, and three others exempt parcels less than or equal to two or three acres. Another TPO exempts parcels less than 15,000 square feet. Finally, land-use designations also inform protected tree status. Twenty-nine ordinances exempt one or more zoning districts from its regulations based on permitted land uses (Table 1). Exemptions include owner-occupied single-family (n = 25) and multi-family (n = 11) residential lots. Ordinances in the Dallas-Fort Worth-Arlington MSA contain the majority of TPOs with land use exemptions compared to TPOs in other areas. Moreover, of the sixty ordinances analyzed, only six cities – all in the Austin and San Antonio MSAs – protect trees in their extraterritorial jurisdictions

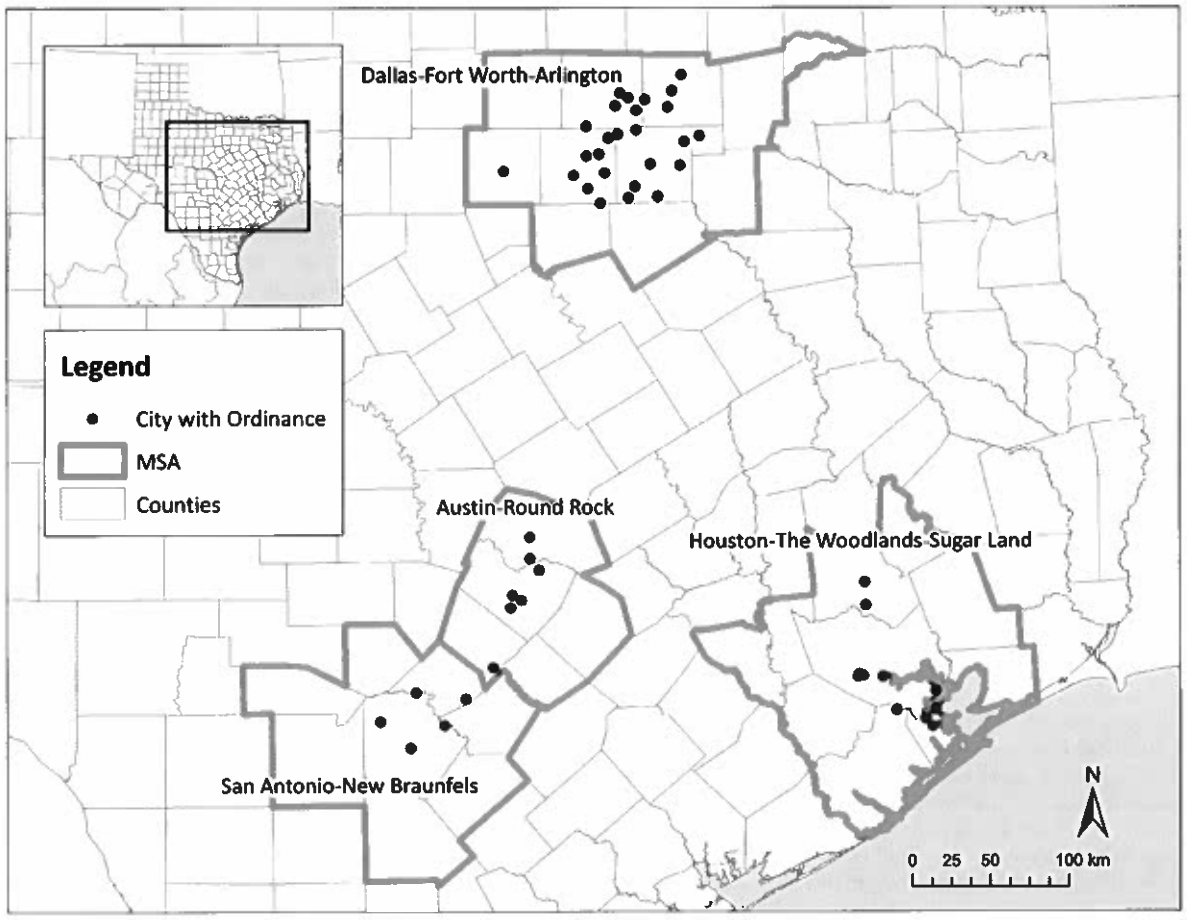

Fig. 1. Location of municipalities with TPOs in major Texas MSAs.

Table 1
Protections of TPOs grouped by MSAs.

TPO Protections		*Austin-Round Rock and San Antonio-New Braunfels MSAs (n = 14)*	*Dallas-Fort Worth-Arlington MSA (n = 28)*	*Houston-The Woodlands-Sugar Land MSA (n = 12)*	*Others (n = 6)*
		Mean (Standard deviation)			
Tree Size	Protected Tree	9.92 in (5.28)	6.04 in (2.11)	10.73 in (6.09)	9.4 in (6.31)
	Heritage Tree	23.36 in (3.17)	24.75 in (14.77)	22.5 in (2.38)	19 in (.)
		Frequency (%) of ordinances with protection			
Parameters of Protection	Protected Tree	14 (100)	28 (100)	12 (100)	6 (100)
	Heritage Tree	13 (93)	9 (32)	4 (33)	2 (33)
	Tree Species List	8 (57)	19 (68)	3 (25)	4 (67)
Extent of Protection	Private Property	14 (100)	28 (100)	11 (92)	6 (100)
	Public Property	4 (29)	14 (50)	3 (25)	3 (50)
	Developed Property	6 (43)	6 (21)	8 (67)	2 (33)
	Undeveloped Property	14 (100)	28 (100)	11 (92)	6 (100)
	Land-Use Exemptions	5 (36)	18 (64)	4 (33)	2 (33)
	Extraterritorial Jurisdiction	6 (43)	0 (.)	0 (.)	0 (.)
Conditions of Protection	Permit Required	14 (100)	26 (93)	9 (75)	4 (67)
	Mitigation	13 (93)	28 (100)	12 (100)	3 (50)
	Enforcement	11 (79)	24 (86)	11 (92)	4 (67)

(ETJ).

4.3. Conditions of protection

While the purpose of each TPO is the preservation of protected and/or heritage trees, the ordinances also allow for the removal of protected trees and stipulate the process and circumstances under which landowners may remove a protected tree. In order to remove a protected tree, 53 ordinances require the property owner to apply for removal and be in possession of a tree removal permit. During a site visit, the city arborist or urban forester determines whether to grant a permit for the removal of a protected tree based on certain criteria, such as tree health, whether the tree prevents reasonable access or use of a property or poses a risk to property or people. The process for removing a heritage tree typically is more stringent and involves either the issuance of a variance to the ordinance or the approval of a city council or equivalent city body. Other municipalities either do not specify a process for removing heritage trees or allow the removal of heritage trees based on meeting the minimum mitigation requirements.

If protected and heritage tree removal is approved, most municipalities outline rules for mitigating its loss (n = 56; Table 1). These mitigation requirements also vary in form and function. Mitigation is accomplished through replacement, fees, credits, or a combination of these, and the use of these mechanisms varies from one municipality to the next. Replacement regulations stipulate the type and size of tree that must be planted if a protected tree is removed. Fee schedules detail the amount that must be paid for each diameter inch of tree removed. Credit systems assign points to each protected tree that is preserved and subtract points for each protected tree that is removed. Negative credit totals require mitigation through replacement or fee payment. Over half of the ordinances stipulate that removed protected trees must be replaced by trees from a list of preferred trees and be equal to, or in some instances, greater than the amount of DBH inches removed from a property (n = 34), and mitigation requirements for the removal of heritage trees are typically greater.

The last condition considers enforcement action for violations of tree preservation ordinances. All municipalities surveyed identify who has the authority to enforce their ordinance regulations, which ranges from the city manager to the urban or municipal forester or arborist, whereas only nine ordinances detail the civil and criminal punishments and the fines imposed for violating the ordinance. Fines range from $500 to $2000 USD per violation. Current state policy caps fines at $2000 USD.

4.4. Sustainability dimensions of urban forest services

Of the 60 Texas municipalities with TPOs, 34 contained a statement of purpose section and referenced at least one of the three sustainability dimensions of urban forest services (Table 2). Across all TPOs, we found more references (48.6 percent) to the environmental dimension of sustainability, than the society (36.1 percent) and economy (15.3 percent) dimensions. Tree preservation ordinances from the Dallas-Fort Worth-Arlington MSA referenced environmental services (50.7 percent) more than the society (27.2 percent) and economy (22.1 percent)

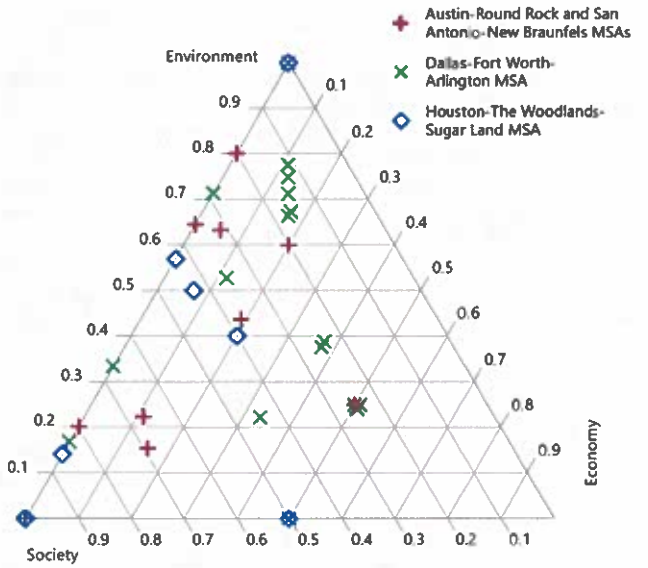

Fig. 2. Ternary diagram of the three sustainability dimensions of urban forest services mentioned in municipal TPOs by MSA (n = 34). Each vertex is representative of one of the three sustainability dimensions of urban forest services.

dimensions of sustainability. Tree preservation ordinances from the Austin and San Antonio MSAs referenced environmental services (46.9 percent) slightly more than social benefits (42.7 percent), whereas TPOs from the Houston area referenced social benefits (47.9 percent) slightly more than environmental services (45.8 percent). Tree preservation ordinances from both the Houston area and the Austin and San Antonio region included minimal references to economic services (6.3 percent and 10.4 percent, respectively).

The results of our visualization analysis show that communities across MSAs place more emphasis on urban forest services related to the environment and society dimensions of sustainability (Fig. 2). The majority of TPOs (n = 14) give preference to the environmental values of trees. Nine TPOs prioritize social benefits, and four TPOs give preference to economic services. The remaining TPOs either prioritize environment and social services (n = 3) or economic and social services (n = 2). Two TPOs provide parity among the environment, economy, and society sustainability dimensions. Values expressed in TPOs of the Austin and San Antonio regions as well as the Houston-The Woodlands-Sugar Land MSA display greater variation, whereas values contained in the Dallas-Fort Worth-Arlington MSA cluster together.

5. Discussion

Municipal tree preservation ordinances are an important component of urban forest management efforts. The details contained within TPOs provide insight into how communities not only maintain urban forest structure and function but also value trees' social, economic, and environmental services. This study documented cities with TPOs and

Table 2
References to the three sustainability dimensions of urban forest services in TPOs.

Sustainability dimension	Austin-Round Rock and San Antonio-New Braunfels MSAs (n = 10)	Dallas-Fort Worth-Arlington MSA (n = 17)	Houston-The Woodlands-Sugar Land MSA (n = 7)	Total (n = 34)
	Frequency (%) of references			
Environment	45 (46.9)	69 (50.7)	22 (45.8)	136 (48.6)
Society	41 (42.7)	37 (27.2)	23 (47.9)	101 (36.1)
Economy	10 (10.4)	30 (22.1)	3 (6.3)	43 (15.3)
Total	96 (100)	136 (100)	48 (100)	280 (100)

examined the key components of these ordinances to understand which Texas municipalities are protecting urban forests, how they are protecting them, and how they interpret and value urban forest services with a particular emphasis on sustainability. We found 60 cities possess TPOs and several similarities and regional variations in these policies.

Nearly all municipalities with TPOs cluster in and around some of the fastest growing metropolitan areas of Texas. This finding suggests that tree preservation is being undertaken in areas where it is needed. Yet, coverage remains sparse. Cities with TPOs in the three MSAs makeup around 10 percent of the total number of cities within these areas (54 cities with versus 508 without TPOs). Moreover, other fast-growing areas of the state, such as the McAllen-Edinburg-Mission MSA in the Rio Grande Valley, contain an abundance of municipalities that do not possess TPOs. The relative dearth of TPOs across metropolitan regions may indicate a lack of community or political support for tree policies found elsewhere (Driscoll et al., 2015). At the state level, private-property rights are consistently defended. Therefore, low numbers of cities with TPOs might reflect reticence of homeowners to fully support tree policies (Conway and Bang, 2014; Kirkpatrick et al., 2013). Without TPOs or similar policies, many of Texas's urban areas remain vulnerable to unregulated urban deforestation and possible reductions in the many economic, social, and environmental benefits of urban forests. Future research should explore the characteristics of municipalities with TPOs in more detail and examine how they compare with cities that do not possess tree ordinances.

5.1. Parameters, extent, and conditions of protection

While growing the coverage of TPOs is important to achieving sustainable urban systems, the parameters, extent, and conditions of protection are equally important. Evaluation of these elements show diverse yet subtle approaches to regulatory tree preservation. Regionally, protected tree DBH emerges as a unique component of TPOs. Differences among ordinance DBH at the region scale reflect not only biogeography and native species patterns in each site but also prescribed statutory objectives that vary across communities and jurisdictions. This pattern may also reflect a diffusion process within metropolitan areas, where TPOs spread from municipality to municipality. This could explain why a majority of TPOs in the Dallas-Fort Worth-Arlington MSA define protected tree size at or near 6 in. DBH (Table 1), as well as why the values prioritized in each TPO are similar (Fig. 2). These municipalities may have used a neighboring city's ordinance as a template when creating their own ordinance. Thus, protected tree DBH, other regulatory language, and the urban forest services expressed in their TPOs possibly spread or diffused from one city to the next within this region. This reflects similar diffusion patterns found in other urban forest management strategies, including tree planting programs (Pincetl et al., 2012). The spread of TPO content presents opportunities and challenges. While diffusion of TPOs from one municipality to the next extends tree protection across urban space, the reproduction of their content may reflect a one-size-fits-all approach that limits their effectiveness due to population, cultural, or socioeconomic differences. It may also indicate a top-down management approach that lacks input, awareness, and support from residents and other interested stakeholders (Carmichael and McDonough, 2018).

Tree preservation ordinances in the Houston-The Woodlands-Sugarland, Austin-Round Rock, and San Antonio-New Braunfels MSAs do not follow this trend. Some ordinances in the Austin and San Antonio areas have undergone multiple iterations since their passage or were the result of lengthy participatory negotiation processes among multiple stakeholders. For example, Austin passed its tree preservation ordinance in 1983 and amended it in 2010 with heavy input from the community (American Forests, 2012). San Antonio passed its ordinance in 1997 and amended it in 2003, 2006, 2009, and again in 2010 (San Antonio, 2018). With these amendments, both cities sought to strengthen their respective ordinances. Also in the Austin-Round Rock MSA, the city of Round Rock's ordinance underwent a lengthy comment period that included community participation, as well as input from key stakeholders, including developers, realtors, and environmentalists (Findell, 2017). This may explain the variation in protected tree DBH and the differences observed in the stated intent of TPOs within the Austin-Round Rock and San Antonio-New Braunfels MSAs compared to the Dallas-Fort Worth-Arlington MSA.

Tree preservation ordinances exist to regulate tree loss; however, many ordinances provide several exemptions that potentially limit their effectiveness in protecting the urban forest. First, private property harbors most urban trees (McPherson, 1998). Yet, many TPOs provide exemptions for private property owners. Almost half exempt either single-family residential or owner-occupied single-family land uses from TPO regulations, and only a third of the regulations pertain to trees on developed land (Table 1). While research has found a relationship between TPOs and increased canopy cover (Landry and Pu, 2010) or tree height (Sung, 2012), the interplay between developed and private property exemptions suggests that Texas TPOs might limit the removal of trees from undeveloped forested lands during urbanization but fail to protect the existing urban forest structure. Thus, the exemptions for developed and private property may impact city-wide canopy cover (Gatrell and Jensen, 2002). Moreover, protection may be further compounded by trends in the number of permitted tree removals. In Austin, for example, permitted tree removals greatly exceed denied requests (Lavy and Hagelman, 2017). Second, few municipalities protect trees in their ETJs, potentially easing growth-related restrictions in these areas and pushing urban developments into forested lands without tree removal regulations. These exceptions obviously weaken an ordinance's ability to preserve and protect trees, and taken together, established urban forests and forested land within and beyond a city's normal jurisdictional boundaries, in many cases, may be diminishing even under existing protection ordinances. The extent to which exemptions found in Texas TPOs impacts city-wide canopy cover and forest structure, however, is unknown and warrants further research.

5.2. Sustainability dimensions of urban forest services

Urban forestry initiatives arise for a variety of reasons, including economic development, environmental services, climate mitigation, aesthetic improvements, and human-health related goals, that align with municipal sustainability objectives (Hirokawa, 2011). The intent of TPOs provide evidence for how municipalities understand and value urban forest services and by extension the three sustainability dimensions. In its text, each ordinance describes the collective benefits trees provide to urban areas; however, each is somewhat modified to suit the preservation and development goals of their individual communities. We used a ternary diagram to visualize the three interconnected and interdependent sustainability dimensions of urban forest services present in TPOs. We departed from other more normative measures by taking qualitative data and using it to create a quantitative visualization that assesses the extent to which community members and policymakers reference the three sustainability dimensions provided by urban forests and which ones are given prominence in municipal policy.

The findings show the texts of the TPOs across the state of Texas are skewed towards the environment leg and society base of the sustainability triangle (Fig. 2). We expected to observe greater parity between references to the three sustainability dimensions of urban forest services within the texts of the TPOs, especially given the well-articulated values of trees as described in the literature and the increasing role their services play in urban sustainability objectives. At the very least, we expected TPOs would be skewed towards the right leg of the triangle with more importance placed on environmental and economic benefits at the sacrifice of social benefits. Several factors possibly explain the relative preference for environmental and social values over economic benefits within the texts of Texas municipal TPOs.

First, many TPOs are passed specifically as urban environmental policies. Urban environmental policies are generally enacted to regulate a real or perceived environmental ill. Then, it makes sense that a greater number of TPOs reference environmental values of urban trees. The more environmental values listed within a TPO legitimates its labeling as an urban environmental policy. In other words, it adds credence to the policy with environmental stakeholders. Second, historical trends in urban forestry research and by extension empirical investigations on the benefits of urban trees have tended to neglect the social functions of trees and attended in more and greater detail to the examination of environmental benefits and economic values associated with urban trees (Tyrväinen et al., 2005; Roy et al., 2012). Thus, preference for environmental values may reflect the attention municipalities and non-profit organizations, supported by historical urban forest research trends, give to the environmental benefits of trees (Silvera Seamans, 2013). The finding that social values outweigh economic benefits of trees is less straightforward.

Second, environmental policies are often championed by environmental groups and often contested by landowners. Therefore, when we look at environmental policy from the stakeholders' perspectives, we would assume that the economic benefits of trees would appeal to landowners. For example, in the case of TPOs, research has shown that trees increase the dollar value of properties (Anderson and Cordell, 1988; Nicholls and Crompton, 2005). While there are costs associated with tree preservation during development, the potential return for preservation should be greater. Given the potential for economic benefits to equalize some of the perceived difficulties for preserving trees, we expected to observe more references to economic values of urban trees. Yet only seven out of the 34 TPOs evaluated in this study reference economic values more than 30 percent. This finding might underscore the community-led process of policy formation at the municipal level and reflect a collective understanding of the larger societal benefits of trees at the exclusions of benefits accrued mostly to individual property owners, such as property value increases attributed to trees. This aligns with research that indicates residents find social values of trees more appealing than their economic and environmental benefits (Peckham et al., 2013). Our findings suggest that preferences for social benefits carry over when formulating tree policies.

Finally, efforts have been undertaken to assess whether cities, nation-states, and corporations are practicing sustainable development, and many governmental institutions, and private and non-profit entities have developed tools to assess whether their initiatives are truly sustainable. Sustainability indicators often measure a host of purely quantifiable indicators. Many sustainability initiatives, programs, and policies, however, are the product of back and forth negotiations between interested stakeholders, including the city, interested citizen groups, landowners, developers, industry, commercial entities, and others, and should reflect the overall intentions of municipal-wide interest groups around sustainability objectives. Yet, this may not the be the case in all circumstances. The results of the QCA plotted on a ternary diagram provide a simple yet effective method for decision makers and residents to assess the extent to which community intent reflects the sustainability dimensions of urban forest services. Future research should include visualizations of different types of sustainability initiatives, programs, and policies (e.g., water, housing, transportation) to verify the technique and include more complex examinations of universal sustainable development goals.

6. Conclusions

The results of this research illustrate the subtle differences that can be observed in the regulatory objectives and language of tree preservation ordinances and provides a mechanism to compare community intent across municipalities. Differences and similarities in the parameters, extent, and conditions of tree protection describe where and how municipalities protect their urban forests as well as the exemptions that weaken tree preservation. Additionally, the statements of purpose contained in TPOs reflect a strong community commitment to the environmental and social dimensions of sustainability. However, when taken together, the values articulated within TPOs may serve as platitudes for regulations hindered by exemptions. More research is needed to ascertain which TPOs are most effective at preserving the urban forest. Additionally, further analysis that encompasses a range of municipal characteristics is needed to explain the many factors that give rise to the passage of TPOs. In addition, comparison of socioeconomic characteristics between cities with TPOs to those without can be used to extrapolate the relative importance of each variable to the existence of TPOs. Case studies should also be undertaken to understand why communities supported the passage of TPOs, including who participated and whose ideas prevailed.

The findings should be of interest to urban forest researchers and policymakers. Municipalities have seen a rapid proliferation of progressive regulations at the metropolitan scale in Texas; however, TPOs in Texas have been written in such a way that economic services of urban trees are often neglected, the social benefits are somewhat nebulous, and environmental services are strongly articulated. If sustainability is the end goal, the initial intent of sustainability policies should articulate in an equitable manner each of the three sustainability dimensions of urban forest services. Favoring one dimension over the others or neglecting one altogether could potentially undermine the policy's wider intent and support. Thus, in order to stand the test of time all sustainability dimensions should be explored with equal vigor and stated more clearly so that all stakeholders—residents, landowners, land developers, city managers, and policymakers—are equipped with a better argument of not only why to write them but why to enforce them.

References

American Forests, 2012. Urban Forests Case Studies: Challenges, Potential and Success in a Dozen Cities. Scott Steen, Washington, D. C.

Anderson, L.M., Cordell, H.K., 1988. Influence of trees on residential property values in Athens, Georgia (U.S.A.): A survey based on actual sales prices. Landsc. Urban Plan. 15 (1-2), 153–164.

Bardon, R.E., Megalos, M.A., Graul, A.L., Miller, K.T., 2001. Developing successful tree ordinances. North Carolina Cooperative Extension, Raleigh, NC.

Bengston, D.N., Fletcher, J.O., Nelson, K.C., 2004. Public policies for managing urban growth and protecting open space: policy instruments and lessons learned in the United States. Landsc. Urban Plan. 69 (2-3), 271–286.

Berelson, B., 1952. Content analysis in communication research. Free Press, Glencoe, IL.

Bernhardt, E.A., Swiecki, T.J., 2001. Guidelines for Developing and Evaluating Tree Ordinances. International Society of Arboriculture, Champaign, IL. Available from https://www.isa-arbor.com/education/resources/educ_TreeOrdinanceGuidelines.pdf (accessed 17 December 2018).

Burley, S., Robinson, S.L., Lundholm, J.T., 2008. Post-hurricane vegetation recovery in an urban forest. Landsc. Urban Plan. 85 (2), 111–122.

Campbell, S., 1996. Green cities, growing cities, just cities?: urban planning and the contradictions of sustainable development. J. Am. Plan. Assoc. 62 (3), 296–312.

Carmichael, C.E., McDonough, M.H., 2018. The trouble with trees? Social and political dynamics of street tree planting efforts in Detroit, Michigan, USA. Urban For. Urban Green. 31, 221–229.

Conway, T.M., 2016. Tending their urban forest: residents' motivations for tree planting and removal. Urban For. Urban Green. 17, 23–32.

Conway, T.M., Bang, E., 2014. Willing partners? Residential support for municipal urban forestry policies. Urban For. Urban Green. 13 (2), 234–243.

Conway, T.M., Urbani, L., 2007. Variations in municipal urban forestry policies: a case study of Toronto, Canada. Urban For. Urban Green. 6 (3), 181–192.

Dickerson, S.D., Groninger, J.W., Mangun, J.C., 2001. Influences of community characteristics on municipal tree ordinances in Illinois, US. J. Arboric. 27 (6), 318–325.

Driscoll, A.N., Ries, P.D., Tilt, J.H., Ganio, L.M., 2015. Needs and barriers to expanding urban forestry programs: an assessment of community officials and program managers in the Portland-vancouver metropolitan region. Urban For. Urban Green. 14 (1), 48–55.

Duinker, P., Ordóñez, C., Steenberg, J., Miller, K., Toni, S., Nitoslawski, S., 2015. Trees in Canadian cities: indispensable life form for urban sustainability. Sustainability 7 (6), 7379–7396.

Elmendorf, W.F., Cotrone, V.J., Mullen, J.T., 2003. Trends in urban forestry practices, programs, and sustainability: contrasting a Pennsylvania, US, study. Arboric. Urban For. 29 (4), 237.

ArcMap Version 10.1, 2019. ArcMap Version 10.1. Environmental Systems Research Institute, Redlands, CA.

Findell, E., 2017. Gov. Abbott eyes repeal of local tree ordinances. Austin American Statesman. . 19 June 2017. Available from https://www.statesman.com/news/local/gov-abbott-eyes-repeal-local-tree-ordinances/v1F1H76V6LI95TnSEmDHmI/ (accessed 16 December 2018).
Galenieks, A., 2017. Importance of urban street tree policies: a Comparison of neighbouring Southern California cities. Urban For. Urban Green. 22, 105–110.
Gatrell, J.D., Jensen, R.R., 2002. Growth through greening: developing and assessing alternative economic development programmes. Appl. Geogr. 22 (4), 331–350.
Hauer, R.J., Casey, C.J., Miller, R.W., 2008. Advancement in state government involvement in urban and community forestry in the 50 United States: changes in program status from 1986 to 2002. Arboric. Urban For. 34 (1), 5.
Hauer, R.J., Johnson, G.R., 2008. State urban and community forestry program funding, technical assistance, and financial assistance within the 50 United States. Arboric. Urban For. 34 (5), 280–289.
Hawthorne, T.L., Elmore, V., Strong, A., Bennett-Martin, P., Finnie, J., Parkman, J., Harris, T., Singh, J., Edwards, L., Reed, J., 2015. Mapping non-native invasive species and accessibility in an urban forest: a case study of participatory mapping and citizen science in Atlanta, Georgia. Appl. Geogr. 56, 187–198.
Hill, E., Dorfman, J.H., Kramer, E., 2010. Evaluating the impact of government land use policies on tree canopy coverage. Land Use Policy 27 (2), 407–414.
Hirokawa, K.H., 2011. Sustainability and the urban forest: an ecosystem services perspective. Nat. Resour. J. 51 (2), 233–259.
Holopainen, M., Leino, O., Kämäri, H., Talvitie, M., 2006. Drought damage in the park forests of the city of Helsinki. Urban For. Urban Green. 4 (2), 75–83.
International Society of Arboriculture Texas Chapter (ISAT), 2012. Some Texas Municipal Tree Ordinances. Available from http://www.isatexas.com/Members/Municipal/TX_Tree_Ordinances.htm (accessed 3 December 2017).
JMP®, Version 11. SAS Institute Inc., Cary, NC, 1989–2019.
Kirkpatrick, J.B., Davison, A., Daniels, G.D., 2013. Sinners, scapegoats or fashion victims? Understanding the deaths of trees in the green city. Geoforum 48, 165–176.
Krippendorff, K., 2013. Content analysis: an introduction to its methodology, third edition. Sage, Los Angeles.
Landry, S., Pu, R., 2010. The impact of land development regulation on residential tree cover: an empirical evaluation using high-resolution IKONOS imagery. Landsc. Urban Plan. 94 (2), 94–104.
Lavy, B.L., Hagelman, R.R., 2017. Spatial and temporal patterns associated with permitted tree removal in Austin, Texas, 2002–2011. The Professional Geographer 69 (4), 539–552.
Locke, D.H., Grove, J.M., 2016. Doing the hard work where it's easiest? Examining the relationships between urban greening programs and social and ecological characteristics. Appl. Spat. Anal. Policy 9 (1), 77–96.
McDonough, W., Braungart, M., 2002. Design for the triple top line: new tools for sustainable commerce. Corp. Environ. Strategy 9 (3), 251–258.
McPherson, E.G., 1998. Structure and sustainability of Sacramento's urban forest. J. Arboric. 24, 174–190.
Miller, R.W., 2007. Urban Forestry: Planning and Managing Urban Green Spaces, second edition. Waveland Press, Inc., Long Grove, IL.
Nicholls, S., Crompton, J.L., 2005. The impact of greenways on property values: evidence from Austin, Texas. J. Leis. Res. 37 (3), 321–341.
Nowak, D.J., Greenfield, E.J., 2012. Tree and impervious cover change in U.S. cities. Urban For. Urban Green. 11 (1), 21–30.
Nowak, D.J., Walton, J.T., 2005. Projected urban growth (2000–2050) and its estimated impact on the US forest resource. J. For. 103 (8), 383–389.
Ordóñez, C., Duinker, P.N., 2013. An analysis of urban forest management plans in Canada: implications for urban forest management. Landsc. Urban Plan. 116, 36–47.
Peckham, S.C., Duinker, P.N., Ordóñez, C., 2013. Urban forest values in Canada: views of citizens in Calgary and Halifax. Urban For. Urban Green. 12 (2), 154–162.
Perkins, H.A., Heynen, N., Wilson, J., 2004. Inequitable access to urban reforestation: the impact of urban political economy on housing tenure and urban forests. Cities 21 (4), 291–299.
Pincetl, S., Gillespie, T., Pataki, D.E., Saatchi, S., Saphores, J.-D., 2012. Urban tree planting programs, function or fashion? Los Angeles and urban tree planting campaigns. GeoJournal 78 (3), 475–493.
Poland, T.M., McCullough, D.G., 2006. Emerald ash borer: invasion of the urban forest and the threat to North America's ash resource. J. For. 104 (3), 118–124.
Roy, S., Byrne, J., Pickering, C., 2012. A systematic quantitative review of urban tree benefits, costs, and assessment methods across cities in different climatic zones. Urban For. Urban Green. 11 (4), 351–363.
San Antonio, 2018. City of. n.d. Tree Ordinance Spreadsheet. Available from. https://docsonline.sanantonio.gov/FileUploads/dsd/TreeOrdinanceSpreadsheet.pdf.
Schroeder, H.W., Green, T.L., Howe, T.J., 2003. Community tree programs in Illinois, US: A statewide survey and assessment. J. Arboric. 29 (4), 218–225.
Silvera Seamans, G., 2013. Mainstreaming the environmental benefits of street trees. Urban For. Urban Green. 12 (1), 2–11.
Sung, C.Y., 2012. Evaluating the efficacy of a local tree protection policy using LiDAR remote sensing data. Landsc. Urban Plan. 104 (1), 19–25.
Texas A&M Forest Service (TFS), 2012a. Drought takes toll on urban forest, millions of shade trees dead. Texas A&M Forest Service.
Texas A&M Forest Service (TFS), 2012b. Texas A&M Forest Service survey shows 301 million trees killed by drought. Texas A&M Forest Service.
Thompson, B.K., Escobedo, F.J., Staudhammer, C.L., Matyas, C.J., Qiu, Y., 2011. Modeling hurricane-caused urban forest debris in Houston, Texas. Landsc. Urban Plan. 101 (3), 286–297.
Texas Water Development Board (TWDB), 2012. Water for Texas: State Water Plan. Texas Water Development Board, Austin, TX.
Tyrväinen, L., Pauleit, S., Seeland, K., de Vries, S., 2005. Benefits and uses of urban forests and trees. In: Konijnendijk, C., Nilsson, K., Randrup, T., Schipperijn, J. (Eds.), Urban Forests and Trees. Springer, Berlin, Heidelberg.
U.S. Census Bureau, 2012. Census Estimates Show New Patterns of Growth Nationwide. Available from http://www.census.gov/newsroom/releases/archives/population/cb12-55.html (accessed 3 December 2013).
U.S. Census Bureau, 2014. Texas: State and County QuickFacts. Available from http://quickfacts.census.gov/qfd/states/48000.html (accessed 6 January 14).
von Hauff, M., Wilderer, P.A., 2008. Industrial ecology: engineered representation of sustainability. Sustain. Sci. 3 (1), 103–115.
Xu, F.-L., Zhao, S.-S., Dawson, R.W., Hao, J.-Y., Zhang, Y., Tao, S., 2006. A triangle model for evaluating the sustainability status and trends of economic development. Ecol. Modell. 195 (3-4), 327–337.
Zhang, Y., Zheng, B., Allen, B., Letson, N., Sibley, J.L., 2009. Tree ordinances as public policy and participation tools: development in Alabama. Journal of Arboric. 35 (3), 165–171.

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Article

Trends in Vegetation Ordinances across the Southern United States

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Abstract: Vegetation regulations or ordinances are the local laws that govern the policies surrounding urban trees and landscape management. The complexity of urban areas, within the mosaic of private and public vegetation, necessitates regulation to manage the numerous benefits of urban vegetation. As urban populations continue to increase, regulations governing vegetation become increasingly common. This article presents an analysis of the language and provisions of vegetation regulations within communities across the southern United States by using data from the Municode, a public database of ordinances, and employing a content analysis. Findings demonstrate both similarities and variations in ordinance language and content while identifying limitations such as unclear ordinance provisions, lack of essential ordinance provisions, duplications, and section contradictions. Overall, findings suggest a need to improve ordinance design, content, and language clarity therein, so they can have a more positive impact on community green infrastructure. Findings are useful for urban foresters, arborists, planners, and elected officials in efforts to develop or revise codes.

Keywords: ordinance; tree law; U.S. south; urban forest; arboriculture; planning

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1. Introduction

Urban forests are an integral part of the urban ecosystem as they provide numerous benefits and services including mitigation of the urban heat island effect, air and water purification, noise level reduction, and carbon sequestration [1,2]. These benefits decrease as urban expansion increases. The southeast United States (U.S.) has the second highest (7.5%) amount of urbanized area after the northeast U.S. (9.7%) [2], demonstrating a strong possibility of increasing these percentages in the future [3]. This could be further accelerated since the population of urban areas is expected to increase by 85% (or 439 million) by 2025 [4]. As population growth leads to expansion of the urban environment, urban tree canopy growth typically diminishes [5]. The impact of urban development pressures over time, motivated communities to use various tools to achieve and maintain sound, healthy, and well-managed forests.

The establishment, management, and protection of vegetation on urban landscapes is shaped by public and private property owners' decisions as well as regulations established by municipal authorities [6]. Local laws and regulations governing the policies surrounding urban trees and landscape management are known as vegetation ordinances. The success of these ordinances depends on several factors, including sociodemographic and cultural characteristics of the community, ordinance enforcement, and community leadership that supports urban forest conservation [6]. Many guidelines to developing ordinances exist, often from state forestry commissions and tree councils. In addition, local governments have employed guidelines written by Grey [7], Fazio [8], Abbey [9], Bernhardt and Swiecki [10], and Burgess et al. [11] as frameworks for developing ordinances. Weber [12] stated all communities differ, among other things, by soils and climatic conditions, cultural traditions,

political and economic climates, and legal frameworks. Such varying biophysical and social factors are essential to address when developing ordinances to achieve desired impacts.

Several previous work has focused on frequencies of the existence of tree ordinances and provisions (e.g., [13–15]. A few studies (e.g., [16] and a report by Head [17]) paid attention to the intricacies of tree ordinance language, clauses, and specific provisions. Most of these findings are, however, at the state level. Furthermore, research must not only assess tree ordinances, but also a variety of regulations that fall under the umbrella term of "vegetation ordinances" that includes vegetation, trees, plants, landscapes, grass, weeds, and shrubs. This more inclusive approach provides a broader analysis of regulation of green infrastructure than focusing on "trees" alone. Therefore, this study for the first time aimed to provide an overview of existing vegetation ordinances across the southern United States. Specifically, we examined the language, provisions, and organization of vegetation ordinances within communities across the southern United States. A detailed and systematic analysis of ordinance helps in understanding communities' priorities and scopes [18]. In addition, the study of language and provisions of vegetation ordinances helps in examining whether these ordinances are interpreted and understood clearly in terms of contributing towards community and urban tree management. This study adds to the body of work addressing municipal ordinances, which are critical aspects of urban forest governance, by empirically observing and describing the differences and similarities. Findings will help local policy makers identify strengths and weaknesses of their ordinances to improve ordinance design, implementation, and enforcement practices.

2. Materials and Methods

2.1. Study Area

The study was conducted across eight states of the International Society of Arboriculture Southern Chapter (ISASC), including Alabama (AL), Arkansas (AR), Georgia (GA; as of 2021, the state of Georgia contained two ISA chapters, namely the Southern Chapter and the Georgia Arborist Association), Louisiana (LA), Mississippi (MS), North Carolina (NC), South Carolina (SC), and Tennessee (TN) (Figure 1).

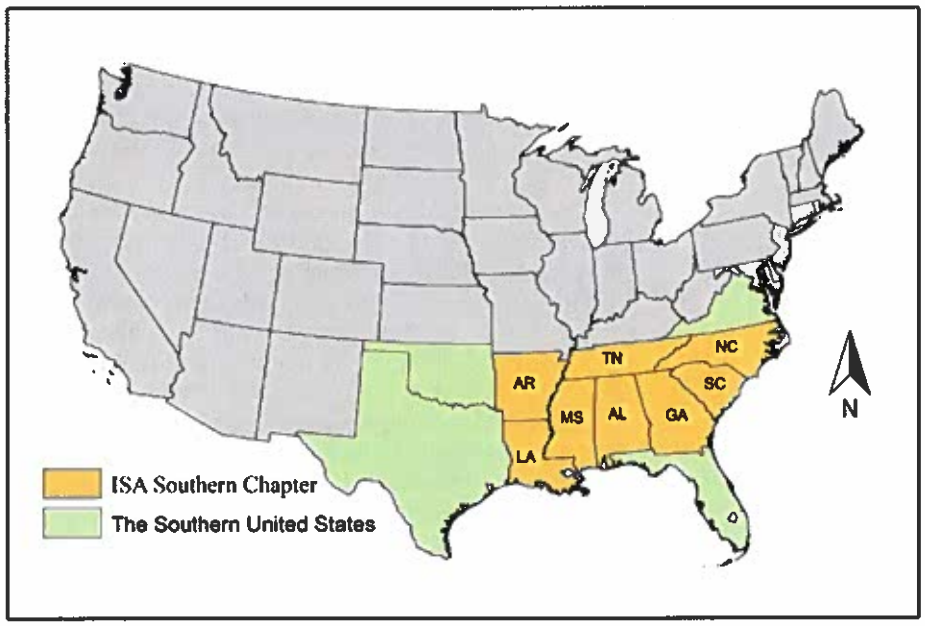

Figure 1. Location of the International Society of Arboriculture Southern Chapter (ISA-SC) in the map of the United States.

2.2. Sample Selection

We collected data from Municode (www.municode.com), an online platform that publishes local codification of municipal legislation for every state. Since communities must pay a membership fee to have their codes posted to Municode for free public access, not all community ordinances are available on Municode. We focused only on the municipal level of government; therefore, we excluded county and parish ordinances as well as communities which were not incorporated places as listed in the U.S. Census. In total, 678 communities in Municode satisfied the sampling criteria. To create a manageable sample size for qualitative data analysis, we set sampling intensity to 10% of communities listed in Municode for each state (Table 1). Though numbers of samples were sufficient for five states (AL, GA, LA, NC, and SC), 10% sampling intensity yielded less than four samples for AR, MS, and TN. Therefore, the least sample size of five states (i.e., eight from SC) was set as a minimum threshold for AR, MS, and TN (Table 1). Given the minimum threshold, we sampled 83 out of the 678 communities.

Table 1. Total number of communities represented in Municode and the corresponding adjusted sample size selected by state.

States	Communities Listed in Municode	10% Sample Size	Adjusted Sample Size
Georgia	214	21.4	21
North Carolina	119	11.9	12
Louisiana	93	9.3	9
Alabama	90	9.0	9
South Carolina	84	8.4	8
Mississippi *	37	3.7	8
Arkansas *	24	2.4	8
Tennessee *	17	1.7	8
Total	678		83

* States with a minimum threshold of eight communities.

We next selected communities based on population size to ensure a reflection of large, medium, and small communities. Reflecting Kuhns et al. [13], we created three population categories of residents: (1) less than 10,000, (2) 10,000 to 50,000, and (3) more than 50,000. The number of sample communities to each population stratum was allocated by multiplying the proportion of communities in that stratum with the total number of samples for each state (Table 2). Finally, we used the Microsoft Excel RAND function to randomly select communities for each population category.

Table 2. Final sample size by state and population stratum.

States	Small (<10,000)	Medium (10,000–50,000)	Large (>50,000)	Total Number of Communities in Each State
Georgia	14	6	1	21
North Carolina	7	4	1	12
Alabama	4	4	1	9
Louisiana	6	2	1	9
Arkansas	1	4	3	8
Mississippi	1	6	1	8
South Carolina	5	2	1	8
Tennessee	1	4	3	8
Total	39	32	12	83

2.3. Data Collection and Analysis

We collected data in the years 2019–2020 and involved two phases. First, we identified ordinance chapters addressing vegetation, including trees, in each municipal code. Second,

we involved querying the entire code using words such as vegetation, trees, plants, landscapes, grass, weeds, and shrubs to identify vegetation and tree regulations that lacked specific standalone chapters but were presented under other chapters and sections. We used qualitative content analysis and NVivo (QSR International 2017) software to observe differences and similarities among ordinances. Content analysis is a research method used for interpreting text-based information with a systematic procedure of coding and identifying themes or patterns [19]. Widely used in the social sciences, it is a fundamental tool for examining collected government documents [20]. Following Berg and Lune [21], we formulated codes based on identification and analysis of keywords, sentences, phrases, and purposes of ordinance sections. Codes were then constructed into themes and sub-themes of data. We sorted these themes and sub-themes based on similar phrases, patterns, relationships, and commonalities or disparities. Data representing these themes are presented as quotes in the results.

3. Results and Discussions

3.1. Organization of Ordinances

The proper organization of vegetation ordinances in Municode aids in quick and easy access of existing laws to local policymakers and stakeholders. In this study, we found large variation in the location of vegetation ordinances in Municode. Some vegetation ordinances were in the body of codes while others were in the codes' appendices. For example, one (medium) community included two sections and one article within an appendix. One section was entitled *37-14—Landscape and Tree Protection* under the article *XXXVII.— EASTERN SHORE PARK OVERLAY DISTRICT GENERAL PROVISIONS*. Another section was entitled *39-14—Landscape and Tree Protection* under the article *XXXIX.—JUBILEE RETAIL DISTRICT OVERLAY*. In addition to the aforementioned articles, the code included a stand-alone article: *ARTICLE XIX.—LANDSCAPE STANDARDS AND TREE PROTECTION*. Similarly, other vegetation ordinances were located within multiple chapters within the body of the code. For example, one (large) community addressed two vegetation articles under the two chapters of *Landscaping and Tree Protection* and *Parks, Recreation, and Cultural Affairs*. Another (small) community mentioned its three vegetation articles within three separate chapters: (1) *Street, Sidewalks, and Public Places*, (2) *Environment*, and (3) *Zoning*. By contrast, most communities addressed vegetation ordinances within a single chapter, but not necessarily a chapter devoted solely to vegetation. For example, commonly found single chapters were under the topics of *Environment; Streets, Sidewalks, and Public Places; Trees; Buildings and Building Regulations; Nuisance; Parks and Recreation; Boards, Commissions, and Committees; Administration; Landscaping;* and *Zoning*. In some cases, communities lacked standalone vegetation ordinances, but regulations related to vegetation were found scattered in multiple sections of the code. For instance, one (small) community addressed vegetation regulations in two sections of the code: (1) *Sec. 109-229.—Street Trees* and (2) *Sec. 49.—Trees in Public Places*.

The unsystematic placement of vegetation ordinances in Municode is an important finding, consistent with Zhang et al. [15]. The presence of vegetation ordinances in an appendix section demonstrates the poor understanding of code placement in the ordinance because an appendix, by definition, is supplementary information. Ordinances related to vegetation could be organized under the broad chapter titles of "vegetation" or "environment" in the code section of Municode.

3.2. Variations in Terminology and Lack of Clarity in Ordinance Language

The language and words used plays an important role in the formation of any policy. They provide the basis for interpreting the meaning of laws and provisions stated. Despite this knowledge, the meaning of words used in legal documents are not always apparent [22]. In this study, we identified ambiguous language in tree topping and tree removal provisions of vegetation ordinances. While a number of ordinances stated, "tree topping of all public trees is prohibited", one (medium community) ordinance addressed tree topping provisions

as "the practice of topping a tree for growth control is prohibited" leading to the idea that topping was acceptable for some objectives (e.g., minimize risk of failure or reduce tree height). Growth controls are the key words that lead to ambiguity in the clause and are open to subjective interpretation. Regarding tree removal, one (medium community) ordinance indicated, "If the tree is removed from the city's right-of-way, easement, or servitude, an appropriate species of tree shall be replaced if space is available (. . .)". The provision would be clearer if it were to specify tree replacement with the appropriately sized tree at maturity based on the available space. Ordinances like this may not achieve the overall goals of ordinances as it lacks the basic standards for performance [10]. In addition, unspecific ordinance provisions (e.g., appropriate species) may not be enforceable. The existence of such ambiguity or vagueness in ordinances could refer to various reasons. For example, Jakes et al. [23] found policy makers write ambiguous language intentionally to provide flexibility to implementers, while Matland [24] stated conflict between policy makers leads to compromise and thereafter ambiguousness in policy.

By comparison, other tree topping and pruning practice provisions included encouraging verbiage. In one example regarding tree topping, an (medium community) ordinance stated, "The practice of tree topping is strongly discouraged on all public trees and as a tree care practice for private trees". In another example regarding pruning practices, an (medium community) ordinance wrote, "The city shall make every effort possible to prune public trees as necessary to encourage healthy form and resistance to breakage". In these instances, both "strongly discouraged", and "every effort" reflects encouraging verbiage in one way, and signals communities' concerns regarding negative consequences of tree topping (e.g., disfigures the tree, excessive crown removal limits the food-making capacity of tree-leading to tree starvation, rapid growth of weak limbs and branches, vulnerable to insects and decay, and in some cases leading to tree death) and advantages of pruning practices (e.g., promotes plant health, fruit production, and growth control; provides good appearance and adds value to the adjacent property), respectively, while on the other hand, these provisions are subjective.

Language involving ordinance enforcement was a common limitation with a few exceptions. In very limited ordinances with enforcement clauses, the person and/or department responsible for enforcing the article varied. For example, some ordinances indicated director of public works, city departments, mayor, planning department director, and urban environment officer as their enforcement officers, while others noted city building and neighborhood services department; city building and zoning department; city arborist, department of community's services, and city park commission. However, in one extreme case, an (medium community) ordinance gave the authority of right-of-way (ROW) tree pruning decisions on private property to the police: "The city shall have the right to prune any tree or shrub on private property (. . .). The discretion to prune such trees or shrubs is vested in the chief of police". Most municipal tree care programs-maintained trees in the ROW, but the authority lies with someone more familiar with tree management or infrastructure maintenance than the chief of police. This shows that some municipal ordinances provide numerous authorities to enforce tree management tasks (e.g., tree pruning) while some are much more restrictive [25].

Clear, specific, and measurable ordinance objectives are important so provisions can be assessed after a period of enactment; however, such characteristics were fairly uncommon in the sample. For example, one (large) community stated the purpose of the ordinance was "To establish and maintain the maximum sustainable amount of tree cover on public and private lands in the city". In another (small) community, the overall purpose of the ordinance was "To promote tree conservation, the increase of tree canopy, and the protection of existing trees in the city". These clauses, and other clauses that detail tree benefits in the objectives, would be more appropriate for an urban forest master plan than an ordinance. As local laws, ordinances should not manage the urban forest, but regulate behaviors that impact vegetation. The purpose clause of many communities appropriately stated

that the ordinance was adopted to provide requirements for planting, preservation, and maintenance of trees and vegetation on public and private lands.

3.3. Unique Provisions Identified in Ordinances

A minority of communities' ordinances contained provisions not commonly present across the region. These provisions were unique in the sense that they focused on urban and community tree management in terms of training and education ($n = 3$), public input ($n = 1$), guides used for tree board meetings ($n = 1$), enforcement provision ($n = 1$), and electronic record keeping of trees ($n = 1$). We selected seven provisions to illustrate in this article. For example, some ordinances included a code of ethics as well as planning commission training for tree board members. These provisions may have referenced industry-accepted standards or guidelines. In addition, while most communities focused on several requirements that an individual should possess prior to serving as a tree board member, some communities emphasized professional credentials tree board members should fulfill following appointment to the board. One (small) community ordinance stated: "Each member must complete one hour of (...). the Code of Governmental Ethics per calendar year as per R.S. 42:1170 and each member must complete the planning commission training within one year of appointment (...)". Providing additional knowledge and training to tree board members even after the appointment help succeed the urban forestry programs [26]. Many ordinances addressed state licensing, professional credentials, insurance, and bonding. However, only some communities specified expectations regarding professional qualifications, such as completing educational training. For example, as stated by one (medium community) ordinance:

"Each applicant shall attend educational training on basic tree science and the proper techniques of tree pruning; and/or shall demonstrate sufficient knowledge of basic tree science and the proper techniques of tree pruning (...). Requirements to procure a business permit (...) shall include attendance at, and completion of, an arborist training program approved by the city, with subject matter being related to cutting, pruning, trimming, removing, spraying, or otherwise treating trees".

Notably, some ordinances (medium and large communities) stated a specific objective of educating residents regarding trees benefits. As stated, the ordinance aims "To encourage public education about trees and their value to the community". This is an illustration of communities using ordinances as a means to educate public. Likewise, related to public input was another uncommon finding concerned with residents' rights regarding tree care. In many sampled communities, all rights regarding public tree care and management were given solely to municipal departments. One (medium) community ordinance specifically encouraged the public to look after public and private trees. The ordinance stated: "(...) All city employees and the general public have the right and are encouraged to report any trees within the city limits that are in need to be protected, maintained, or removed to the designated city authority (...)". This is an example of an ordinance integrating public participation into the code of law. Such provision should be emphasized in many ordinances because ordinances integrating public participation are more successful in achieving its objectives [15].

Another rare provision was the introduction of Robert's Rules of Order to be employed in tree board meetings. Robert's Rules of Order are a widely used guide in the U.S. for governing meetings and making group decisions [27]. With one (large community) exception, ordinances did not mention the procedure to be follow in tree board meetings, which can result in confusion and inefficiencies. The exception stated, "The tree board shall adopt Roberts Rules of Order as its rules of procedure and shall keep records of the applications and the actions, which shall be a public record".

One (large community) ordinance stated a very exceptional provision regarding its enforcement. While the majority of sample ordinances lacked enforcement provisions, this ordinance included the provision of designating alternative personnel to work as an enforcement officer under the absence of the main designated personnel. As stated by

that ordinance: "The UEO [Urban Environment Officer] shall cause the provisions of this chapter to be enforced. In the UEO's absence, these duties shall be the responsibility of a qualified alternate designated by the City Manager". This community gave the impression of strong concern for enforcing the article. Ordinances with enforcement officers specify ways of monitoring compliance with laws. In addition, the objective of many ordinances—to promote the health, safety, and welfare of community citizens—can be achieved through the proper development and enforcement of ordinances [9].

A final unique provision was the requirement of electronic record keeping of all trees maintained, planted, and removed within the community. As stated by one (medium) community: "Maintenance records: The day after this ordinance is adopted, the designated city authority shall start and maintain electronic records of all trees that are maintained within the city limits. Records shall include the following minimum information: Species, location, name of person that planted the tree, date tree was planted". "Removal records: The day after this ordinance is adopted, the designated city authority shall start and maintain electronic records of all trees that are removed within the city limits (...). Species, location, name of person that removed the tree, date tree was removed". "Planting records: The day after this ordinance is adopted, the designated city authority shall start and maintain electronic records of all trees that are planted within the city limits (...). Species, location, name of person that planted the tree, date tree was planted". In some cases, the record keeping requirement was found in regulations dealing with tree fund/account finances (in lieu of contribution funds) and tree board meetings; however, electronic record keeping of all trees maintained, removed, and planted in the community was only found in a minority of ordinances. Provisions like this could exist as a reflection of a community that plans for future needs and could provide a good evaluation of various components of urban forest management. This is because the good record keeping of all trees in the community assists in recognizing poor practices that require improvement and good practices that needs to be sustained. It aids in identifying appropriate plant species for an area and monitors changes in the tree population. In addition, the electronic record keeping prevents accidental damage of tree information through natural calamities, theft, and rodents.

3.4. Loopholes in the Existing Ordinances

Duplication was commonly found among all sampled ordinances. Evidence of duplication included line-by-line and word-by-word duplication, duplication of clauses with only slight additions, deletions, or changes to some key words and phrases, paraphrasing and/or writing different section headings but duplicating the associated provisions, and replicating the same provisions within the same article. Duplication occurred in new ordinances as well as revisions of established ordinances. Unsurprisingly, duplication was higher among communities within the same state rather than across the states. For example, two communities within one state had the same language for the goal of the ordinance: "(...) to promote and protect the public health, safety, and general welfare of citizens and visitors by providing for the development of a community forestry plan to address the planning, maintenance, and removal of public trees within the city in order to promote the benefits of our community forest resources". These communities were characterized by small and medium-sized populations, respectively.

In another case, communities of two neighboring states closely duplicated eight sections of vegetation ordinances between two communities across the states. Sections included: spacing of street trees, distance from curb and sidewalks, distance from street corners and fireplugs, proximity to utilities, public tree care, pruning corner clearance, interference with city, and review or appeal. For example, a (medium) community in State A indicated,

> "*Sec. 24-78.—Distance from curb and sidewalk*: The distance trees may be planted from curbs or curb lines and sidewalks will be in accordance with the three (3) species size classes listed in section 24-77, and no trees may be planted

> closer to any curb or sidewalk than the following: Small trees, two (2) feet; medium trees, three (3) feet; and large trees, four (4) feet."

This can be compared with a (small) community in State B:

> "*Sec. 78-35.—Distance from curb and sidewalk*: The distance trees may be planted from curbs or curb lines and sidewalks will be in accordance with the tree species size classes listed in section 78-33, and no trees may be planted closer to any curb or sidewalk than the following: small trees, two feet; medium trees, three feet; and large trees, four feet."

Language between these two examples is similar, except the word, "three" and "tree" and the way spacing distances are written. Duplication such as illustrated here is not necessarily a bad thing, as long as the unique contexts and needs of each community are taken into account, and the ordinance is not simply a nominal policy instrument. Such existence of duplication in vegetation ordinances could be due to the similarity in geographical, social and cultural characteristics among communities across the south.

Several decades ago, Weber [12] and Profous [28] suggested that municipal tree ordinances were rarely copied. Nevertheless, Head [17] found that many communities in Georgia used Fulton County's (where most of Atlanta is located) tree ordinance as a template, possibly without fully considering how social and physical differences necessitate unique code. Our findings also demonstrate a substantial amount of duplication, suggesting that over time, possibly due to increasing urbanization, communities rushed to develop ordinances leading to problems with their design.

Some ordinances included the same text under different heading titles within the ordinances. In some cases, the content of the text did not reflect the title. For example, the text "Nothing in this article shall be deemed to impose any liability upon the city, its officers or employees, nor to relieve the owner of any private property from the duty to keep any tree, shrub, or plant upon any street area on his property or under his control in such condition as to prevent it from constituting a hazard or an impediment to travel or vision upon any street, park, pleasure ground, boulevard, alley or public place within the city" was placed under both "*Liability*" and "*Scope of Article*". It seems the "*Liability*" section would be a better fit than "*Scope of Article*". These sections were characterized in ordinances from two medium-sized communities.

Among the several themes that we classify as loopholes were sections within the same ordinance directly contradicting themselves. For instance, one (small community) ordinance stated that the scope of an article was limited to private property, i.e., "*Sec. 27-21.—Scope*: The provisions of this article shall apply to Oaks, Magnolia, Cypress, Sycamore and Cedar trees within the city limits of the City of (. . .), on all privately-owned property". However, the same ordinance also included one section that dealt with public trees, i.e., "*Sec. 27-26.—Trees on public property*: All trees of any kind, regardless of size, located on public property belonging unto the (. . .) shall not be removed, cut down nor destroyed except upon action of the city manager (. . .)". Since the section "scope" in ordinances refers to the jurisdiction covered by the provisions in the article, the scope of the ordinance presented in the example was up to the trees owned on private property, but the article also included a provision for public trees, contradicting the scope of the article. Ordinances with such contradicting sections may struggle to achieve their goals or never accomplish them.

Finally, a few ordinances were not codified. Codification refers to collection and organization of regulations into a logical and systematic pattern [29]. One (small) community placed its updated ordinance on the Municode home page under the title "*Adopted Ordinances Not Yet Codified*" rather than in the appropriate code section. Under the said title, it was written as "This code of ordinances is up to date as indicated by the banner text above. Municipal codes may have received additional legislation, but it has not been posted for interim display and is not currently scheduled to be codified. Ordinance No. 24, Adopted 11/6/18. AN ORDINANCE AMENDING ORDINANCE NO. 24 REGULATING THE CUTTING AND REMOVAL OF TREES (. . .)". At the time of this study, the posting

was already more than a year old and still lacked codification. The lack of codification hinders the accessibility of ordinances for both authorities and the public. In addition, such inaccessibility could fail in determining policies that are contradictory, identical, and equivocal.

4. Conclusions

We reviewed vegetation ordinances of 83 communities across eight states of the southeastern U.S. Many of these communities referenced model ordinances, often developed by state forestry agencies and urban forest councils. These model ordinances provided a good starting point for designing a code that reflects the unique social and landscape contexts of each community [30]. Some vegetation ordinances were well-written, included distinct provisions that supported unique community needs, and well-organized in Municode, while others lacked important components and contained loopholes and ambiguities. Poorly written ordinances can be difficult to implement and may not yield desired outcomes [31].

The effectiveness of an ordinance depends on the presence or absence of key elements. For example, Bernhardt and Swiecki [10] mentioned five essential elements that should be included in ordinances to be considered as effective ordinances: clearly stated goals, the designation of responsibility, setting of basic performance standards, flexibility, and enforcement standards. Some of these components were rarely mentioned in our sample of ordinances. Many community ordinances stated very general goals (e.g., "to provide regulation or established standards for the planting, maintenance, and removal of trees, shrubs, and other plants within the city"). The goal of an ordinance should be the basis for interpreting its success [10]. Enforcement standards was another common issue (also see [17,32]. Public engagement and severability were also not commonly addressed, despite being recommended by most guidelines (e.g., [11]).

Unsurprisingly, the presence of vegetation ordinances in Municode depended upon community population size. Compared with their larger counterparts, communities with smaller populations were more likely to not have vegetation ordinances in Municode. Similar findings were observed by other studies [13,14,17,33,34]. This may be associated with fewer resources—particularly for urban forest policy—related to perceptions of low marginal return for such programs in small communities [33,35]. However, the systematic and proper placement of ordinances is essential for all communities regardless of size for the effective implementation of regulation.

Our findings showed the need for simplification of many ordinances to make them more understandable, actionable, and sustainable. For instance, the presence of minor errors in ordinances (e.g., typographical errors) illustrate the lack of careful reading of the ordinance before its adoption. As well, the quality of ordinances depended more upon its scope rather than the length and complexity of ordinances. For example, some vegetation ordinances included provisions for all vegetation types such as trees, shrubs, plants, and weeds, while few ordinances included provisions for weeds only. In such communities, management of weeds could be the major priority, but in the long term, a community should focus on holistic management of all vegetation types.

Findings of this study can help to overcome the issues that occur in many ordinances (e.g., inconsistencies, redundancies, and duplications). Local policymakers and municipal authorities can use the findings to make informed policy decisions for creating new ordinances and guide communities in the process of updating and revising ordinances. Cooperative Extension Services can disseminate these findings to educate stakeholders, such as local policy makers, municipal departments, and tree boards, which can mitigate possible weaknesses that might occur while developing effective enforcement mechanisms.

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References

1. Bolund, P.; Hunhammar, S. Ecosystem Services in Urban Areas. *Ecol. Econ.* **1999**, *29*, 293–301. [CrossRef]
2. Nowak, D.J. *Assessing Urban Forest Effects and Values: New York City's Urban Forest*; US Department of Agriculture, Forest Service, Northern Research Station: New York, NY, USA, 2007; Volume 9.
3. Nowak, D.J.; Walton, J.T. Projected Urban Growth (2000–2050) and Its Estimated Impact on the US Forest Resource. *J. For.* **2005**, *103*, 383–389.
4. Department of Economic and Social Affairs United Nations Secretariat. World Population Prospects: The 2012 Revision. In *Population Division*; Department of Economic and Social Affairs United Nations Secretariat: New York, NY, USA, 2013; Volume 18.
5. Zhu, P.; Zhang, Y. Demand for Urban Forests in United States Cities. *Landsc. Urban Plan.* **2008**, *84*, 293–300. [CrossRef]
6. Miller, R.W.; Hauer, R.J.; Werner, L.P. *Urban Forestry: Planning and Managing Urban Greenspaces*; Waveland Press: Long Grove, IL, USA, 2015, ISBN 1478629495.
7. Grey, G.W. *Comprehensive Management: The Urban Forest*; John Wiley & Sons: New York, NY, USA, 1996.
8. Fazio, J.R.; Date, N. Tree Protection Ordinances. *Tree City USA Bull.* **1997**, *31*.
9. Abbey, B. *US Landscape Ordinances: An Annotated Reference Handbook*; John Wiley & Sons: New York, NY, USA, 1998, ISBN 0471292761.
10. Swiecki, T.J.; Bernhardt, E.A. *Guidelines for Developing and Evaluating Tree Ordinances*; International Society of Arboriculture: Atlanta, GA, USA, 2001.
11. Burgess, J.; Reisch, S.; Dolliver, S.; Macie, E.; Forester, R.U. *Tree Ordinance Development Guidebook*; Georgia Forestry Commission: Atlanta, GA, USA, 2005.
12. Weber, C.C. *Developing a Successful Urban Tree Ordinance*; International Society of Arboriculture: Atlanta, GA, USA, 1982.
13. Kuhns, M.R.; Lee, B.; Reiter, D.K. Characteristics of Urban Forestry Programs in Utah, US. *J. Arboric.* **2005**, *31*, 285–295.
14. Stevenson, T.R.; Gerhold, H.D.; Elmendorf, W.F. Attitudes of Municipal Officials toward Street Tree Programs in Pennsylvania, US. *Arboric. Urban For.* **2008**, *34*, 144–151. [CrossRef]
15. Zhang, Y.; Zheng, B.; Allen, B.; Letson, N.; Sibley, J.L. Tree Ordinances as Public Policy and Participation Tools: Development in Alabama. *J. Arboric.* **2009**, *35*, 165. [CrossRef]
16. Gutman, R.; Landry, J. An Analysis of Tree Ordinances: The Example of New Jersey. *J. Arboric.* **1977**, *3*, 191–197. [CrossRef]
17. Head, C. *Georgia's Tree Ordinances: Results of the Survey of Community Tree Regulation in Georgia*; The Georgia Urban Forest Council: Atlanta, GA, USA, 2006.
18. Lavy, B.L.; Hagelman, R.R., III. Protecting the Urban Forest: Variations in Standards and Sustainability Dimensions of Municipal Tree Preservation Ordinances. *Urban For. Urban Green.* **2019**, *44*, 126394. [CrossRef]
19. Hsieh, H.-F.; Shannon, S.E. Three Approaches to Qualitative Content Analysis. *Qual. Health Res.* **2005**, *15*, 1277–1288. [CrossRef]
20. Huang, X.; Zhao, D.; Brown, C.G.; Wu, Y.; Waldron, S.A. Environmental Issues and Policy Priorities in China: A Content Analysis of Government Documents. *China Int. J.* **2010**, *8*, 220–246. [CrossRef]
21. Berg, B.L.; Lune, H. Chapter 11: An Introduction to Content Analysis. *Qual. Res. Methods Soc. Sci.* **2007**, *238*, 267.
22. Schane, S. Ambiguity and Misunderstanding in the Law. *T. Jefferson Law Rev.* **2002**, *25*, 167–182.
23. Jakes, P.J.; Nelson, K.C.; Enzler, S.A.; Burns, S.; Cheng, A.S.; Sturtevant, V.; Williams, D.R.; Bujak, A.; Brummel, R.F.; Grayzeck-Souter, S. Community Wildfire Protection Planning: Is the Healthy Forests Restoration Act's Vagueness Genius? *Int. J. Wildl. Fire* **2011**, *20*, 350–363. [CrossRef]
24. Matland, R.E. Synthesizing the Implementation Literature: The Ambiguity-Conflict Model of Policy Implementation. *J. Public Adm. Res. Theory* **1995**, *5*, 145–174.
25. Duerksen, C.J.; Richman, S. *Tree Conservation Ordinances: Land-Use Regulations Go Green*; Planning and Advisory Services Report; USDA Forest Services: New York, NY, USA, 1993.
26. Elmendorf, W.F.; Cotrone, V.J.; Mullen, J.T. Trends in Urban Forestry Practices, Programs, and Sustainability: Contrasting a Pennsylvannia, US, Study. *J. Arboric.* **2003**, *29*, 237–248. [CrossRef]
27. Henry, M., III; Honemann, D.H.; Balch, T.J. *Robert's Rules of Order Newly Revised*; Da Capo Press: Massachusetts, MA, USA, 2011; ISBN 0306820218.
28. Profous, G.V. Trees and Urban Forestry in Beijing, China. *J. Arboric.* **1992**, *18*, 145–154. [CrossRef]
29. Bergel, J.L. Principal Features and Methods of Codification. *LA Law Rev.* **1988**, *48*, 1073.
30. American Public Work Association. *Urban Forestry Best Management Practices for Public Works Managers: Urban Forest Management Plan*; APWA, The Georgia Urban Forest Council: Atlanta, GA, USA, 2006.
31. Engebretson, J.M.; Nelson, K.C.; Larson, K.L.; Andrade, R.; Wheeler, M.M.; Lerman, S.B.; Locke, D.H.; Trammell, T.L.E.; Groffman, P.M. Ambiguity and Clarity in Residential Yard Ordinances across Metropolitan Areas in the United States. *J. Urban Aff.* **2021**, 1–18. [CrossRef]

32. Coughlin, R.E.; Mendes, D.C.; Strong, A.L. Local Programs in the United States for Preventing the Destruction of Trees on Private Land. *Landsc. Urban Plan.* **1988**, *15*, 165–171. [CrossRef]
33. Kenney, W.A.; Idziak, C. The State of Canada's Municipal Forests–1996 to 1998. *For. Chron.* **2000**, *76*, 231–234. [CrossRef]
34. Schroeder, H.W.; Green, T.L.; Howe, T.J. Community Tree Programs in Illinois, US: A Statewide Survey and Assessment. *J. Arboric.* **2003**, *29*, 218–224.
35. Conway, T.M.; Urbani, L. Variations in Municipal Urban Forestry Policies: A Case Study of Toronto, Canada. *Urban For. Urban Green* **2007**, *6*, 181–192. [CrossRef]

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Article

Trends in Vegetation Ordinances across the Southern United States

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Abstract: Vegetation regulations or ordinances are the local laws that govern the policies surrounding urban trees and landscape management. The complexity of urban areas, within the mosaic of private and public vegetation, necessitates regulation to manage the numerous benefits of urban vegetation. As urban populations continue to increase, regulations governing vegetation become increasingly common. This article presents an analysis of the language and provisions of vegetation regulations within communities across the southern United States by using data from the Municode, a public database of ordinances, and employing a content analysis. Findings demonstrate both similarities and variations in ordinance language and content while identifying limitations such as unclear ordinance provisions, lack of essential ordinance provisions, duplications, and section contradictions. Overall, findings suggest a need to improve ordinance design, content, and language clarity therein, so they can have a more positive impact on community green infrastructure. Findings are useful for urban foresters, arborists, planners, and elected officials in efforts to develop or revise codes.

Keywords: ordinance; tree law; U.S. south; urban forest; arboriculture; planning

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1. Introduction

Urban forests are an integral part of the urban ecosystem as they provide numerous benefits and services including mitigation of the urban heat island effect, air and water purification, noise level reduction, and carbon sequestration [1,2]. These benefits decrease as urban expansion increases. The southeast United States (U.S.) has the second highest (7.5%) amount of urbanized area after the northeast U.S. (9.7%) [2], demonstrating a strong possibility of increasing these percentages in the future [3]. This could be further accelerated since the population of urban areas is expected to increase by 85% (or 439 million) by 2025 [4]. As population growth leads to expansion of the urban environment, urban tree canopy growth typically diminishes [5]. The impact of urban development pressures over time, motivated communities to use various tools to achieve and maintain sound, healthy, and well-managed forests.

The establishment, management, and protection of vegetation on urban landscapes is shaped by public and private property owners' decisions as well as regulations established by municipal authorities [6]. Local laws and regulations governing the policies surrounding urban trees and landscape management are known as vegetation ordinances. The success of these ordinances depends on several factors, including sociodemographic and cultural characteristics of the community, ordinance enforcement, and community leadership that supports urban forest conservation [6]. Many guidelines to developing ordinances exist, often from state forestry commissions and tree councils. In addition, local governments have employed guidelines written by Grey [7], Fazio [8], Abbey [9], Bernhardt and Swiecki [10], and Burgess et al. [11] as frameworks for developing ordinances. Weber [12] stated all communities differ, among other things, by soils and climatic conditions, cultural traditions,

political and economic climates, and legal frameworks. Such varying biophysical and social factors are essential to address when developing ordinances to achieve desired impacts.

Several previous work has focused on frequencies of the existence of tree ordinances and provisions (e.g., [13–15]. A few studies (e.g., [16] and a report by Head [17]) paid attention to the intricacies of tree ordinance language, clauses, and specific provisions. Most of these findings are, however, at the state level. Furthermore, research must not only assess tree ordinances, but also a variety of regulations that fall under the umbrella term of "vegetation ordinances" that includes vegetation, trees, plants, landscapes, grass, weeds, and shrubs. This more inclusive approach provides a broader analysis of regulation of green infrastructure than focusing on "trees" alone. Therefore, this study for the first time aimed to provide an overview of existing vegetation ordinances across the southern United States. Specifically, we examined the language, provisions, and organization of vegetation ordinances within communities across the southern United States. A detailed and systematic analysis of ordinance helps in understanding communities' priorities and scopes [18]. In addition, the study of language and provisions of vegetation ordinances helps in examining whether these ordinances are interpreted and understood clearly in terms of contributing towards community and urban tree management. This study adds to the body of work addressing municipal ordinances, which are critical aspects of urban forest governance, by empirically observing and describing the differences and similarities. Findings will help local policy makers identify strengths and weaknesses of their ordinances to improve ordinance design, implementation, and enforcement practices.

2. Materials and Methods

2.1. Study Area

The study was conducted across eight states of the International Society of Arboriculture Southern Chapter (ISASC), including Alabama (AL), Arkansas (AR), Georgia (GA; as of 2021, the state of Georgia contained two ISA chapters, namely the Southern Chapter and the Georgia Arborist Association), Louisiana (LA), Mississippi (MS), North Carolina (NC), South Carolina (SC), and Tennessee (TN) (Figure 1).

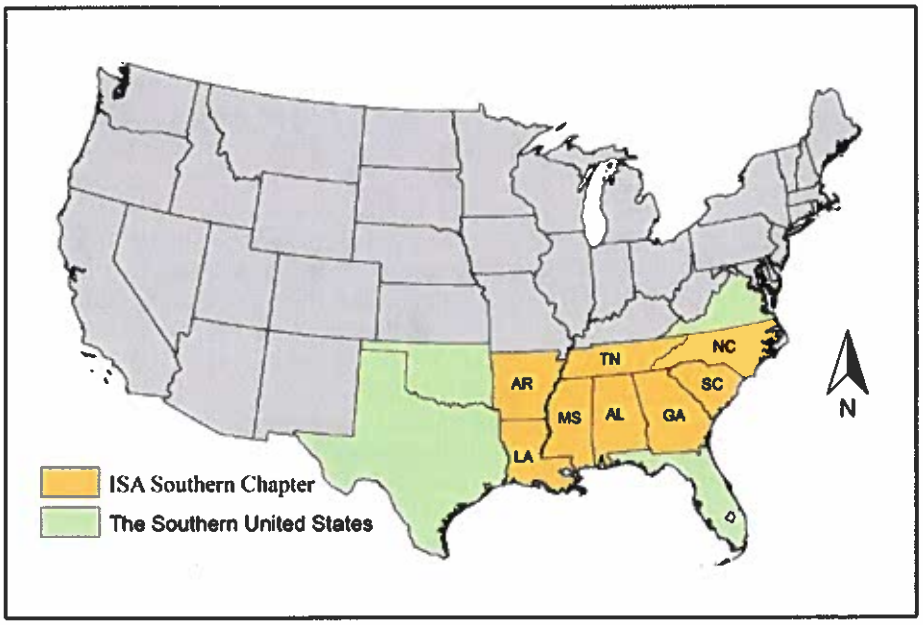

Figure 1. Location of the International Society of Arboriculture Southern Chapter (ISA-SC) in the map of the United States.

2.2. Sample Selection

We collected data from Municode (www.municode.com), an online platform that publishes local codification of municipal legislation for every state. Since communities must pay a membership fee to have their codes posted to Municode for free public access, not all community ordinances are available on Municode. We focused only on the municipal level of government; therefore, we excluded county and parish ordinances as well as communities which were not incorporated places as listed in the U.S. Census. In total, 678 communities in Municode satisfied the sampling criteria. To create a manageable sample size for qualitative data analysis, we set sampling intensity to 10% of communities listed in Municode for each state (Table 1). Though numbers of samples were sufficient for five states (AL, GA, LA, NC, and SC), 10% sampling intensity yielded less than four samples for AR, MS, and TN. Therefore, the least sample size of five states (i.e., eight from SC) was set as a minimum threshold for AR, MS, and TN (Table 1). Given the minimum threshold, we sampled 83 out of the 678 communities.

Table 1. Total number of communities represented in Municode and the corresponding adjusted sample size selected by state.

States	Communities Listed in Municode	10% Sample Size	Adjusted Sample Size
Georgia	214	21.4	21
North Carolina	119	11.9	12
Louisiana	93	9.3	9
Alabama	90	9.0	9
South Carolina	84	8.4	8
Mississippi *	37	3.7	8
Arkansas *	24	2.4	8
Tennessee *	17	1.7	8
Total	678		83

* States with a minimum threshold of eight communities.

We next selected communities based on population size to ensure a reflection of large, medium, and small communities. Reflecting Kuhns et al. [13], we created three population categories of residents: (1) less than 10,000, (2) 10,000 to 50,000, and (3) more than 50,000. The number of sample communities to each population stratum was allocated by multiplying the proportion of communities in that stratum with the total number of samples for each state (Table 2). Finally, we used the Microsoft Excel RAND function to randomly select communities for each population category.

Table 2. Final sample size by state and population stratum.

States	Small (<10,000)	Medium (10,000–50,000)	Large (>50,000)	Total Number of Communities in Each State
Georgia	14	6	1	21
North Carolina	7	4	1	12
Alabama	4	4	1	9
Louisiana	6	2	1	9
Arkansas	1	4	3	8
Mississippi	1	6	1	8
South Carolina	5	2	1	8
Tennessee	1	4	3	8
Total	39	32	12	83

2.3. Data Collection and Analysis

We collected data in the years 2019–2020 and involved two phases. First, we identified ordinance chapters addressing vegetation, including trees, in each municipal code. Second,

we involved querying the entire code using words such as vegetation, trees, plants, landscapes, grass, weeds, and shrubs to identify vegetation and tree regulations that lacked specific standalone chapters but were presented under other chapters and sections. We used qualitative content analysis and NVivo (QSR International 2017) software to observe differences and similarities among ordinances. Content analysis is a research method used for interpreting text-based information with a systematic procedure of coding and identifying themes or patterns [19]. Widely used in the social sciences, it is a fundamental tool for examining collected government documents [20]. Following Berg and Lune [21], we formulated codes based on identification and analysis of keywords, sentences, phrases, and purposes of ordinance sections. Codes were then constructed into themes and sub-themes of data. We sorted these themes and sub-themes based on similar phrases, patterns, relationships, and commonalities or disparities. Data representing these themes are presented as quotes in the results.

3. Results and Discussions

3.1. Organization of Ordinances

The proper organization of vegetation ordinances in Municode aids in quick and easy access of existing laws to local policymakers and stakeholders. In this study, we found large variation in the location of vegetation ordinances in Municode. Some vegetation ordinances were in the body of codes while others were in the codes' appendices. For example, one (medium) community included two sections and one article within an appendix. One section was entitled *37-14—Landscape and Tree Protection* under the article *XXXVII.— EASTERN SHORE PARK OVERLAY DISTRICT GENERAL PROVISIONS*. Another section was entitled *39-14—Landscape and Tree Protection* under the article *XXXIX.—JUBILEE RETAIL DISTRICT OVERLAY*. In addition to the aforementioned articles, the code included a stand-alone article: *ARTICLE XIX.—LANDSCAPE STANDARDS AND TREE PROTECTION*. Similarly, other vegetation ordinances were located within multiple chapters within the body of the code. For example, one (large) community addressed two vegetation articles under the two chapters of *Landscaping and Tree Protection* and *Parks, Recreation, and Cultural Affairs*. Another (small) community mentioned its three vegetation articles within three separate chapters: (1) *Street, Sidewalks, and Public Places*, (2) *Environment*, and (3) *Zoning*. By contrast, most communities addressed vegetation ordinances within a single chapter, but not necessarily a chapter devoted solely to vegetation. For example, commonly found single chapters were under the topics of *Environment*; *Streets, Sidewalks, and Public Places*; *Trees*; *Buildings and Building Regulations*; *Nuisance*; *Parks and Recreation*; *Boards, Commissions, and Committees*; *Administration*; *Landscaping*; and *Zoning*. In some cases, communities lacked standalone vegetation ordinances, but regulations related to vegetation were found scattered in multiple sections of the code. For instance, one (small) community addressed vegetation regulations in two sections of the code: (1) *Sec. 109-229.—Street Trees* and (2) *Sec. 49.—Trees in Public Places*.

The unsystematic placement of vegetation ordinances in Municode is an important finding, consistent with Zhang et al. [15]. The presence of vegetation ordinances in an appendix section demonstrates the poor understanding of code placement in the ordinance because an appendix, by definition, is supplementary information. Ordinances related to vegetation could be organized under the broad chapter titles of "vegetation" or "environment" in the code section of Municode.

3.2. Variations in Terminology and Lack of Clarity in Ordinance Language

The language and words used plays an important role in the formation of any policy. They provide the basis for interpreting the meaning of laws and provisions stated. Despite this knowledge, the meaning of words used in legal documents are not always apparent [22]. In this study, we identified ambiguous language in tree topping and tree removal provisions of vegetation ordinances. While a number of ordinances stated, "tree topping of all public trees is prohibited", one (medium community) ordinance addressed tree topping provisions

as "the practice of topping a tree for growth control is prohibited" leading to the idea that topping was acceptable for some objectives (e.g., minimize risk of failure or reduce tree height). Growth controls are the key words that lead to ambiguity in the clause and are open to subjective interpretation. Regarding tree removal, one (medium community) ordinance indicated, "If the tree is removed from the city's right-of-way, easement, or servitude, an appropriate species of tree shall be replaced if space is available (...)". The provision would be clearer if it were to specify tree replacement with the appropriately sized tree at maturity based on the available space. Ordinances like this may not achieve the overall goals of ordinances as it lacks the basic standards for performance [10]. In addition, unspecific ordinance provisions (e.g., appropriate species) may not be enforceable. The existence of such ambiguity or vagueness in ordinances could refer to various reasons. For example, Jakes et al. [23] found policy makers write ambiguous language intentionally to provide flexibility to implementers, while Matland [24] stated conflict between policy makers leads to compromise and thereafter ambiguousness in policy.

By comparison, other tree topping and pruning practice provisions included encouraging verbiage. In one example regarding tree topping, an (medium community) ordinance stated, "The practice of tree topping is strongly discouraged on all public trees and as a tree care practice for private trees". In another example regarding pruning practices, an (medium community) ordinance wrote, "The city shall make every effort possible to prune public trees as necessary to encourage healthy form and resistance to breakage". In these instances, both "strongly discouraged", and "every effort" reflects encouraging verbiage in one way, and signals communities' concerns regarding negative consequences of tree topping (e.g., disfigures the tree, excessive crown removal limits the food-making capacity of tree-leading to tree starvation, rapid growth of weak limbs and branches, vulnerable to insects and decay, and in some cases leading to tree death) and advantages of pruning practices (e.g., promotes plant health, fruit production, and growth control; provides good appearance and adds value to the adjacent property), respectively, while on the other hand, these provisions are subjective.

Language involving ordinance enforcement was a common limitation with a few exceptions. In very limited ordinances with enforcement clauses, the person and/or department responsible for enforcing the article varied. For example, some ordinances indicated director of public works, city departments, mayor, planning department director, and urban environment officer as their enforcement officers, while others noted city building and neighborhood services department; city building and zoning department; city arborist, department of community's services, and city park commission. However, in one extreme case, an (medium community) ordinance gave the authority of right-of-way (ROW) tree pruning decisions on private property to the police: "The city shall have the right to prune any tree or shrub on private property (...). The discretion to prune such trees or shrubs is vested in the chief of police". Most municipal tree care programs-maintained trees in the ROW, but the authority lies with someone more familiar with tree management or infrastructure maintenance than the chief of police. This shows that some municipal ordinances provide numerous authorities to enforce tree management tasks (e.g., tree pruning) while some are much more restrictive [25].

Clear, specific, and measurable ordinance objectives are important so provisions can be assessed after a period of enactment; however, such characteristics were fairly uncommon in the sample. For example, one (large) community stated the purpose of the ordinance was "To establish and maintain the maximum sustainable amount of tree cover on public and private lands in the city". In another (small) community, the overall purpose of the ordinance was "To promote tree conservation, the increase of tree canopy, and the protection of existing trees in the city". These clauses, and other clauses that detail tree benefits in the objectives, would be more appropriate for an urban forest master plan than an ordinance. As local laws, ordinances should not manage the urban forest, but regulate behaviors that impact vegetation. The purpose clause of many communities appropriately stated

that the ordinance was adopted to provide requirements for planting, preservation, and maintenance of trees and vegetation on public and private lands.

3.3. Unique Provisions Identified in Ordinances

A minority of communities' ordinances contained provisions not commonly present across the region. These provisions were unique in the sense that they focused on urban and community tree management in terms of training and education ($n = 3$), public input ($n = 1$), guides used for tree board meetings ($n = 1$), enforcement provision ($n = 1$), and electronic record keeping of trees ($n = 1$). We selected seven provisions to illustrate in this article. For example, some ordinances included a code of ethics as well as planning commission training for tree board members. These provisions may have referenced industry-accepted standards or guidelines. In addition, while most communities focused on several requirements that an individual should possess prior to serving as a tree board member, some communities emphasized professional credentials tree board members should fulfill following appointment to the board. One (small) community ordinance stated: "Each member must complete one hour of (. . .). the Code of Governmental Ethics per calendar year as per R.S. 42:1170 and each member must complete the planning commission training within one year of appointment (. . .)". Providing additional knowledge and training to tree board members even after the appointment help succeed the urban forestry programs [26]. Many ordinances addressed state licensing, professional credentials, insurance, and bonding. However, only some communities specified expectations regarding professional qualifications, such as completing educational training. For example, as stated by one (medium community) ordinance:

"Each applicant shall attend educational training on basic tree science and the proper techniques of tree pruning; and/or shall demonstrate sufficient knowledge of basic tree science and the proper techniques of tree pruning (. . .). Requirements to procure a business permit (. . .) shall include attendance at, and completion of, an arborist training program approved by the city, with subject matter being related to cutting, pruning, trimming, removing, spraying, or otherwise treating trees".

Notably, some ordinances (medium and large communities) stated a specific objective of educating residents regarding trees benefits. As stated, the ordinance aims "To encourage public education about trees and their value to the community". This is an illustration of communities using ordinances as a means to educate public. Likewise, related to public input was another uncommon finding concerned with residents' rights regarding tree care. In many sampled communities, all rights regarding public tree care and management were given solely to municipal departments. One (medium) community ordinance specifically encouraged the public to look after public and private trees. The ordinance stated: "(. . .) All city employees and the general public have the right and are encouraged to report any trees within the city limits that are in need to be protected, maintained, or removed to the designated city authority (. . .)". This is an example of an ordinance integrating public participation into the code of law. Such provision should be emphasized in many ordinances because ordinances integrating public participation are more successful in achieving its objectives [15].

Another rare provision was the introduction of Robert's Rules of Order to be employed in tree board meetings. Robert's Rules of Order are a widely used guide in the U.S. for governing meetings and making group decisions [27]. With one (large community) exception, ordinances did not mention the procedure to be follow in tree board meetings, which can result in confusion and inefficiencies. The exception stated, "The tree board shall adopt Roberts Rules of Order as its rules of procedure and shall keep records of the applications and the actions, which shall be a public record".

One (large community) ordinance stated a very exceptional provision regarding its enforcement. While the majority of sample ordinances lacked enforcement provisions, this ordinance included the provision of designating alternative personnel to work as an enforcement officer under the absence of the main designated personnel. As stated by

that ordinance: "The UEO [Urban Environment Officer] shall cause the provisions of this chapter to be enforced. In the UEO's absence, these duties shall be the responsibility of a qualified alternate designated by the City Manager". This community gave the impression of strong concern for enforcing the article. Ordinances with enforcement officers specify ways of monitoring compliance with laws. In addition, the objective of many ordinances—to promote the health, safety, and welfare of community citizens—can be achieved through the proper development and enforcement of ordinances [9].

A final unique provision was the requirement of electronic record keeping of all trees maintained, planted, and removed within the community. As stated by one (medium) community: "Maintenance records: The day after this ordinance is adopted, the designated city authority shall start and maintain electronic records of all trees that are maintained within the city limits. Records shall include the following minimum information: Species, location, name of person that planted the tree, date tree was planted". "Removal records: The day after this ordinance is adopted, the designated city authority shall start and maintain electronic records of all trees that are removed within the city limits (...). Species, location, name of person that removed the tree, date tree was removed". "Planting records: The day after this ordinance is adopted, the designated city authority shall start and maintain electronic records of all trees that are planted within the city limits (...). Species, location, name of person that planted the tree, date tree was planted". In some cases, the record keeping requirement was found in regulations dealing with tree fund/account finances (in lieu of contribution funds) and tree board meetings; however, electronic record keeping of all trees maintained, removed, and planted in the community was only found in a minority of ordinances. Provisions like this could exist as a reflection of a community that plans for future needs and could provide a good evaluation of various components of urban forest management. This is because the good record keeping of all trees in the community assists in recognizing poor practices that require improvement and good practices that needs to be sustained. It aids in identifying appropriate plant species for an area and monitors changes in the tree population. In addition, the electronic record keeping prevents accidental damage of tree information through natural calamities, theft, and rodents.

3.4. Loopholes in the Existing Ordinances

Duplication was commonly found among all sampled ordinances. Evidence of duplication included line-by-line and word-by-word duplication, duplication of clauses with only slight additions, deletions, or changes to some key words and phrases, paraphrasing and/or writing different section headings but duplicating the associated provisions, and replicating the same provisions within the same article. Duplication occurred in new ordinances as well as revisions of established ordinances. Unsurprisingly, duplication was higher among communities within the same state rather than across the states. For example, two communities within one state had the same language for the goal of the ordinance: "(...) to promote and protect the public health, safety, and general welfare of citizens and visitors by providing for the development of a community forestry plan to address the planning, maintenance, and removal of public trees within the city in order to promote the benefits of our community forest resources". These communities were characterized by small and medium-sized populations, respectively.

In another case, communities of two neighboring states closely duplicated eight sections of vegetation ordinances between two communities across the states. Sections included: spacing of street trees, distance from curb and sidewalks, distance from street corners and fireplugs, proximity to utilities, public tree care, pruning corner clearance, interference with city, and review or appeal. For example, a (medium) community in State A indicated,

> "*Sec. 24-78.—Distance from curb and sidewalk*: The distance trees may be planted from curbs or curb lines and sidewalks will be in accordance with the three (3) species size classes listed in section 24-77, and no trees may be planted

> closer to any curb or sidewalk than the following: Small trees, two (2) feet; medium trees, three (3) feet; and large trees, four (4) feet."

This can be compared with a (small) community in State B:

> "*Sec. 78-35.—Distance from curb and sidewalk*: The distance trees may be planted from curbs or curb lines and sidewalks will be in accordance with the tree species size classes listed in section 78-33, and no trees may be planted closer to any curb or sidewalk than the following: small trees, two feet; medium trees, three feet; and large trees, four feet."

Language between these two examples is similar, except the word, "three" and "tree" and the way spacing distances are written. Duplication such as illustrated here is not necessarily a bad thing, as long as the unique contexts and needs of each community are taken into account, and the ordinance is not simply a nominal policy instrument. Such existence of duplication in vegetation ordinances could be due to the similarity in geographical, social and cultural characteristics among communities across the south.

Several decades ago, Weber [12] and Profous [28] suggested that municipal tree ordinances were rarely copied. Nevertheless, Head [17] found that many communities in Georgia used Fulton County's (where most of Atlanta is located) tree ordinance as a template, possibly without fully considering how social and physical differences necessitate unique code. Our findings also demonstrate a substantial amount of duplication, suggesting that over time, possibly due to increasing urbanization, communities rushed to develop ordinances leading to problems with their design.

Some ordinances included the same text under different heading titles within the ordinances. In some cases, the content of the text did not reflect the title. For example, the text "Nothing in this article shall be deemed to impose any liability upon the city, its officers or employees, nor to relieve the owner of any private property from the duty to keep any tree, shrub, or plant upon any street area on his property or under his control in such condition as to prevent it from constituting a hazard or an impediment to travel or vision upon any street, park, pleasure ground, boulevard, alley or public place within the city" was placed under both "*Liability*" and "*Scope of Article*". It seems the "*Liability*" section would be a better fit than "*Scope of Article*". These sections were characterized in ordinances from two medium-sized communities.

Among the several themes that we classify as loopholes were sections within the same ordinance directly contradicting themselves. For instance, one (small community) ordinance stated that the scope of an article was limited to private property, i.e., "*Sec. 27-21.—Scope*: The provisions of this article shall apply to Oaks, Magnolia, Cypress, Sycamore and Cedar trees within the city limits of the City of (. . .), on all privately-owned property". However, the same ordinance also included one section that dealt with public trees, i.e., "*Sec. 27-26.—Trees on public property*: All trees of any kind, regardless of size, located on public property belonging unto the (. . .) shall not be removed, cut down nor destroyed except upon action of the city manager (. . .)". Since the section "scope" in ordinances refers to the jurisdiction covered by the provisions in the article, the scope of the ordinance presented in the example was up to the trees owned on private property, but the article also included a provision for public trees, contradicting the scope of the article. Ordinances with such contradicting sections may struggle to achieve their goals or never accomplish them.

Finally, a few ordinances were not codified. Codification refers to collection and organization of regulations into a logical and systematic pattern [29]. One (small) community placed its updated ordinance on the Municode home page under the title "*Adopted Ordinances Not Yet Codified*" rather than in the appropriate code section. Under the said title, it was written as "This code of ordinances is up to date as indicated by the banner text above. Municipal codes may have received additional legislation, but it has not been posted for interim display and is not currently scheduled to be codified. Ordinance No. 24, Adopted 11/6/18. AN ORDINANCE AMENDING ORDINANCE NO. 24 REGULATING THE CUTTING AND REMOVAL OF TREES (. . .)". At the time of this study, the posting

was already more than a year old and still lacked codification. The lack of codification hinders the accessibility of ordinances for both authorities and the public. In addition, such inaccessibility could fail in determining policies that are contradictory, identical, and equivocal.

4. Conclusions

We reviewed vegetation ordinances of 83 communities across eight states of the southeastern U.S. Many of these communities referenced model ordinances, often developed by state forestry agencies and urban forest councils. These model ordinances provided a good starting point for designing a code that reflects the unique social and landscape contexts of each community [30]. Some vegetation ordinances were well-written, included distinct provisions that supported unique community needs, and well-organized in Municode, while others lacked important components and contained loopholes and ambiguities. Poorly written ordinances can be difficult to implement and may not yield desired outcomes [31].

The effectiveness of an ordinance depends on the presence or absence of key elements. For example, Bernhardt and Swiecki [10] mentioned five essential elements that should be included in ordinances to be considered as effective ordinances: clearly stated goals, the designation of responsibility, setting of basic performance standards, flexibility, and enforcement standards. Some of these components were rarely mentioned in our sample of ordinances. Many community ordinances stated very general goals (e.g., "to provide regulation or established standards for the planting, maintenance, and removal of trees, shrubs, and other plants within the city"). The goal of an ordinance should be the basis for interpreting its success [10]. Enforcement standards was another common issue (also see [17,32]. Public engagement and severability were also not commonly addressed, despite being recommended by most guidelines (e.g., [11]).

Unsurprisingly, the presence of vegetation ordinances in Municode depended upon community population size. Compared with their larger counterparts, communities with smaller populations were more likely to not have vegetation ordinances in Municode. Similar findings were observed by other studies [13,14,17,33,34]. This may be associated with fewer resources—particularly for urban forest policy—related to perceptions of low marginal return for such programs in small communities [33,35]. However, the systematic and proper placement of ordinances is essential for all communities regardless of size for the effective implementation of regulation.

Our findings showed the need for simplification of many ordinances to make them more understandable, actionable, and sustainable. For instance, the presence of minor errors in ordinances (e.g., typographical errors) illustrate the lack of careful reading of the ordinance before its adoption. As well, the quality of ordinances depended more upon its scope rather than the length and complexity of ordinances. For example, some vegetation ordinances included provisions for all vegetation types such as trees, shrubs, plants, and weeds, while few ordinances included provisions for weeds only. In such communities, management of weeds could be the major priority, but in the long term, a community should focus on holistic management of all vegetation types.

Findings of this study can help to overcome the issues that occur in many ordinances (e.g., inconsistencies, redundancies, and duplications). Local policymakers and municipal authorities can use the findings to make informed policy decisions for creating new ordinances and guide communities in the process of updating and revising ordinances. Cooperative Extension Services can disseminate these findings to educate stakeholders, such as local policy makers, municipal departments, and tree boards, which can mitigate possible weaknesses that might occur while developing effective enforcement mechanisms.

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References

1. Bolund, P.; Hunhammar, S. Ecosystem Services in Urban Areas. *Ecol. Econ.* **1999**, *29*, 293–301. [CrossRef]
2. Nowak, D.J. *Assessing Urban Forest Effects and Values: New York City's Urban Forest*; US Department of Agriculture, Forest Service, Northern Research Station: New York, NY, USA, 2007; Volume 9.
3. Nowak, D.J.; Walton, J.T. Projected Urban Growth (2000–2050) and Its Estimated Impact on the US Forest Resource. *J. For.* **2005**, *103*, 383–389.
4. Department of Economic and Social Affairs United Nations Secretariat. World Population Prospects: The 2012 Revision. In *Population Division*; Department of Economic and Social Affairs United Nations Secretariat: New York, NY, USA, 2013; Volume 18.
5. Zhu, P.; Zhang, Y. Demand for Urban Forests in United States Cities. *Landsc. Urban Plan.* **2008**, *84*, 293–300. [CrossRef]
6. Miller, R.W.; Hauer, R.J.; Werner, L.P. *Urban Forestry: Planning and Managing Urban Greenspaces*; Waveland Press: Long Grove, IL, USA, 2015, ISBN 1478629495.
7. Grey, G.W. *Comprehensive Management: The Urban Forest*; John Wiley & Sons: New York, NY, USA, 1996.
8. Fazio, J.R.; Date, N. Tree Protection Ordinances. *Tree City USA Bull.* **1997**, *31*.
9. Abbey, B. *US Landscape Ordinances: An Annotated Reference Handbook*; John Wiley & Sons: New York, NY, USA, 1998, ISBN 0471292761.
10. Swiecki, T.J.; Bernhardt, E.A. *Guidelines for Developing and Evaluating Tree Ordinances*; International Society of Arboriculture: Atlanta, GA, USA, 2001.
11. Burgess, J.; Reisch, S.; Dolliver, S.; Macie, E.; Forester, R.U. *Tree Ordinance Development Guidebook*; Georgia Forestry Commission: Atlanta, GA, USA, 2005.
12. Weber, C.C. *Developing a Successful Urban Tree Ordinance*; International Society of Arboriculture: Atlanta, GA, USA, 1982.
13. Kuhns, M.R.; Lee, B.; Reiter, D.K. Characteristics of Urban Forestry Programs in Utah, US. *J. Arboric.* **2005**, *31*, 285–295.
14. Stevenson, T.R.; Gerhold, H.D.; Elmendorf, W.F. Attitudes of Municipal Officials toward Street Tree Programs in Pennsylvania, US. *Arboric. Urban For.* **2008**, *34*, 144–151. [CrossRef]
15. Zhang, Y.; Zheng, B.; Allen, B.; Letson, N.; Sibley, J.L. Tree Ordinances as Public Policy and Participation Tools: Development in Alabama. *J. Arboric.* **2009**, *35*, 165. [CrossRef]
16. Gutman, R.; Landry, J. An Analysis of Tree Ordinances: The Example of New Jersey. *J. Arboric.* **1977**, *3*, 191–197. [CrossRef]
17. Head, C. *Georgia's Tree Ordinances: Results of the Survey of Community Tree Regulation in Georgia*; The Georgia Urban Forest Council: Atlanta, GA, USA, 2006.
18. Lavy, B.L.; Hagelman, R.R., III. Protecting the Urban Forest: Variations in Standards and Sustainability Dimensions of Municipal Tree Preservation Ordinances. *Urban For. Urban Green.* **2019**, *44*, 126394. [CrossRef]
19. Hsieh, H.-F.; Shannon, S.E. Three Approaches to Qualitative Content Analysis. *Qual. Health Res.* **2005**, *15*, 1277–1288. [CrossRef]
20. Huang, X.; Zhao, D.; Brown, C.G.; Wu, Y.; Waldron, S.A. Environmental Issues and Policy Priorities in China: A Content Analysis of Government Documents. *China Int. J.* **2010**, *8*, 220–246. [CrossRef]
21. Berg, B.L.; Lune, H. Chapter 11: An Introduction to Content Analysis. *Qual. Res. Methods Soc. Sci.* **2007**, *238*, 267.
22. Schane, S. Ambiguity and Misunderstanding in the Law. *T. Jefferson Law Rev.* **2002**, *25*, 167–182.
23. Jakes, P.J.; Nelson, K.C.; Enzler, S.A.; Burns, S.; Cheng, A.S.; Sturtevant, V.; Williams, D.R.; Bujak, A.; Brummel, R.F.; Grayzeck-Souter, S. Community Wildfire Protection Planning: Is the Healthy Forests Restoration Act's Vagueness Genius? *Int. J. Wildl. Fire* **2011**, *20*, 350–363. [CrossRef]
24. Matland, R.E. Synthesizing the Implementation Literature: The Ambiguity-Conflict Model of Policy Implementation. *J. Public Adm. Res. Theory* **1995**, *5*, 145–174.
25. Duerksen, C.J.; Richman, S. *Tree Conservation Ordinances: Land-Use Regulations Go Green*; Planning and Advisory Services Report; USDA Forest Services: New York, NY, USA, 1993.
26. Elmendorf, W.F.; Cotrone, V.J.; Mullen, J.T. Trends in Urban Forestry Practices, Programs, and Sustainability: Contrasting a Pennsylvannia, US, Study. *J. Arboric.* **2003**, *29*, 237–248. [CrossRef]
27. Henry, M., III; Honemann, D.H.; Balch, T.J. *Robert's Rules of Order Newly Revised*; Da Capo Press: Massachusetts, MA, USA, 2011; ISBN 0306820218.
28. Profous, G.V. Trees and Urban Forestry in Beijing, China. *J. Arboric.* **1992**, *18*, 145–154. [CrossRef]
29. Bergel, J.L. Principal Features and Methods of Codification. *LA Law Rev.* **1988**, *48*, 1073.
30. American Public Work Association. *Urban Forestry Best Management Practices for Public Works Managers: Urban Forest Management Plan*; APWA, The Georgia Urban Forest Council: Atlanta, GA, USA, 2006.
31. Engebretson, J.M.; Nelson, K.C.; Larson, K.L.; Andrade, R.; Wheeler, M.M.; Lerman, S.B.; Locke, D.H.; Trammell, T.L.E.; Groffman, P.M. Ambiguity and Clarity in Residential Yard Ordinances across Metropolitan Areas in the United States. *J. Urban Aff.* **2021**, 1–18. [CrossRef]

32. Coughlin, R.E.; Mendes, D.C.; Strong, A.L. Local Programs in the United States for Preventing the Destruction of Trees on Private Land. *Landsc. Urban Plan.* **1988**, *15*, 165–171. [CrossRef]
33. Kenney, W.A.; Idziak, C. The State of Canada's Municipal Forests–1996 to 1998. *For. Chron.* **2000**, *76*, 231–234. [CrossRef]
34. Schroeder, H.W.; Green, T.L.; Howe, T.J. Community Tree Programs in Illinois, US: A Statewide Survey and Assessment. *J. Arboric.* **2003**, *29*, 218–224.
35. Conway, T.M.; Urbani, L. Variations in Municipal Urban Forestry Policies: A Case Study of Toronto, Canada. *Urban For. Urban Green* **2007**, *6*, 181–192. [CrossRef]

The City of WORCESTER

Department of Public Works & Parks
Parks, Recreation & Cemetery Division
Forestry Operations
50 Officer Manny Familia Way, Worcester, MA 01605
P | 508-799-1190 **F** | 508-799-1293
Worcestertrees@worcesterma.gov

ASSISTANT COMMISSIONER'S REPORT:

1. General:

- Urban Forestry Master Plan Review
  - The second draft of the Urban Forestry Master Plan which can be found here: Trees in the City - Right Tree, Right Place | City of Worcester, MA (worcesterma.gov)
- Door Hanger - NA
- Tree Commission attending neighborhood meetings – Update
  - Neighborhood Response Team | City of Worcester, MA (worcesterma.gov)
- Tree replacement policy – NA
- Neighborhood Based Urban Heat Risk Assessment - NA
- Worcester Now | Next online survey - NA
- Green Worcester Advisory Committee -NA
- Planting –
  - Spring 2024 Planting - NA
- Customer Service Update
  - Customer Service Contact Information 508-929-1300 &/or 311
- Street Resurfacing Opportunities & Challenges – NA
- Zoning Ordinance Discussion - NA
- Worcester Ordinance Relative to the Protection of Public Trees - NA
- Partnerships –
  - New England Botanical Garden @ Tower Hill - NA
- Grant Applications –
  - DCR Grant Program - NA
- Economic Development Initiatives –
  - NA
- Forestry Vandalism & Graffiti –
  - NA
- Donations –
  - NA
- Pests –
  - ALB (Asian Longhorned Beetle) - NA
  - EAB (Emerald Ash Borer) - NA
  - Spotted Lanternfly - NA
  - Elm Zigzag Sawfly – NA
- Forestry Operations –
  - Tree City USA – NA
  - Arbor Day –
    - April 26, 2024
    - April 27, 2024 – Festival
- Budget – Operational & Capital – NA
  - Parks, Recreation & Cemetery Division – NA
  - Capital Improvement Program – NA
  - City Five Point Financial Plan – NA
- Misc.

URBAN FORESTRY TREE COMMISSION MEETING

Wednesday February 28, 2024 – 6:00 P.M.

Parks, Recreation & Cemetery Administrative Office

Meeting Room A

50 Officer Manny Familia Way Worcester, MA 01605

Or

Virtual with Teams

ASSISTANT COMMISSIONER'S REPORT

GENERAL