

BID COVER

Procurement Division
(352) 334-5021(main)

Issue Date: May 26, 2023

REQUEST FOR PROPOSAL: #PWDA-230046-DH
Ecological Analysis and Tree Inventory

PRE-PROPOSAL MEETING: ☒ Non-Mandatory ☐ Mandatory ☐ N/A ☐ Includes Site Visit

DATE: June 8, 2023 **TIME:** 9:00 am

LOCATION: Smokey Bear Park (2300 NE 15th St Gainesville, FL 32609)

QUESTION SUBMITTAL DUE DATE: June 15, 2023 @ 5:00 pm

All meetings and submittal deadlines are Eastern Time (ET).

DUE DATE FOR UPLOADING PROPOSAL: June 22, 2023 @ 3:00pm

SUMMARY OF SCOPE OF WORK: The purpose of this project will be to complete an ecological analysis of the City of Gainesville's (CITY) urban forest, public and private; complete a detailed tree inventory of all City of Gainesville owned trees, and to estimate change in the overall canopy coverage in Gainesville from 1995 -2023.

For questions relating to this solicitation, contact: Diane Holder, holderds@gainesvillefl.gov

Bidder is not in arrears to City upon any debt, fee, tax or contract: ☐ Bidder is NOT in arrears ☐ Bidder IS in arrears
Bidder is not a defaulter, as surety or otherwise, upon any obligation to City: ☐ Bidder is NOT in default ☐ Bidder IS in default

Bidders who receive this bid from sources other than City of Gainesville Procurement Division or DemandStar.com MUST contact the Procurement Division prior to the due date to ensure any addenda are received in order to submit a responsible and responsive offer. Uploading an incomplete document may deem the offer non-responsive, causing rejection.

ADDENDA ACKNOWLEDGMENT: Prior to submitting my offer, I have verified that all addenda issued to date are considered as part of my offer: Addenda received (list all) # _____

Legal Name of Bidder: _____

DBA: _____

Authorized Representative Name/Title: _____

E-mail Address: _____ FEIN: _____

Street Address: _____

Mailing Address (if different): _____

Telephone: (_____) _____ Fax: (_____) _____

By signing this form, I acknowledge I have read and understand, and my business complies with all General Conditions and requirements set forth herein; and,

☐ Proposal is in full compliance with the Specifications.

☐ Proposal is in full compliance with the Specifications except as specifically stated and attached hereto.

SIGNATURE OF AUTHORIZED REPRESENTATIVE: _____

SIGNER'S PRINTED NAME: _____ **DATE:** _____

This page must be completed and uploaded to DemandStar.com with your Submittal.

PART 1 – REQUEST FOR PROPOSAL INFORMATION

Thank you for your interest in working with the City of Gainesville.

Pertinent information and required documents regarding this bid as part of a responsive offer are listed below:

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NOTE: The terms “bidder” and “proposer” are used interchangeably throughout this document.

1.1 DISTRIBUTION OF INFORMATION

The City posts and distributes information pertaining to its procurement solicitations on DemandStar (www.demandstar.com). The City has transitioned from accepting hard (paper) copy submittals to accepting submittals through “E-Bidding” on DemandStar.com. In order to submit a bid response to this solicitation the bidder must be registered with DemandStar.

It is the responsibility of the vendor to monitor DemandStar. Properly registered vendors can expect to receive automatic notification of solicitations for bids and proposals, by participating purchasing entities. Bidder’s failure to retrieve available, required procurement information from DemandStar and include the appropriate documentation and information in solicitation responses may result in disqualification.

1.2 PRE-PROPOSAL MEETING/QUESTIONS/CLARIFICATIONS AND BID OPENING

If scheduled (refer to Bid Cover Page), attending a pre-proposal meeting is strongly recommended as the project’s scope of work, procedures, and specifications will be discussed at this time. It is the only time during the bid process that bidders may ask questions directly of the end user.

NOTE: For a bidder’s attendance of a mandatory pre-proposal meeting to count, the bidder must sign-in before the Procurement Specialist calls the end of that meeting. If the bidder is not signed in by that time, they will be disqualified from bidding on the project. If the mandatory pre-proposal meeting also includes a required site visit, then bidder must sign in, both at the pre-proposal meeting, and again at the end of the site visit, in order to have their attendance count and not be disqualified from submitting a proposal.

NOTE: Failure to attend a mandatory pre-proposal meeting will result in disqualification of your proposal.

If special accommodations are needed in order to attend a pre-proposal meeting or a bid opening, please contact the Procurement Division at least 72 hours in advance.

All questions that occur outside of the pre-proposal meeting must be submitted to Procurement only, and must be received by the date indicated on the Bid Cover Page to be considered. Technical and/or specification questions will not be answered over the phone; they must be submitted by email directed to the Procurement Specialist conducting the solicitation (refer to Bid Cover Page). All questions will be answered via Addendum which will be posted on DemandStar.com for vendor access. All addenda must be acknowledged by the bidder on the Bid Cover Page.

All meetings and submittal deadlines are Eastern Time (ET).

1.3 RFP TIME TABLE

The anticipated schedule for the RFP and contract approval is as follows:

RFP available for distribution	May 26 2023
[Non-Mandatory] Pre-Proposal Meeting	June 8, 2023
Deadline for receipt of questions	June 15, 2023
Deadline for uploading of proposals	June 22, 2023 (3:00 p.m. local time)
Evaluation/Selection process	Week of June 26, 2023
Oral presentations, if conducted	Week of July 10, 2023
Projected award date	August 3, 2023
Projected contract start date	TBD

All dates are subject to change. Bidders will be notified via Addendum posted in DemandStar.com in event of any schedule change.

1.4 PROHIBITION OF LOBBYING

To ensure fair consideration, consistent and accurate dissemination of information for all bidders, the City prohibits communication to or with any department, employee, or agent evaluating or considering proposals during the submission process, except as authorized by the Procurement Division representative. **Additionally, the City prohibits communication initiated by a bidder to any city official or employee evaluating or considering the proposals (up to and including the City Commissioners) before the time an award decision has been made.** Any communication between bidder and the City required to obtain information or clarification for preparing a bid or to enable a proper, accurate evaluation of a proposal will be handled solely through the Procurement Division staff. **Any communications initiated between the bidder and the City outside these parameters may be grounds for disqualifying the offending bidder from consideration for award of the proposal and/or any future proposal.**

1.5 CONE OF SILENCE

During the Cone of Silence (formerly called Blackout period) as defined in the next paragraph, except as pursuant to an authorized appeal, no person may lobby (as defined in section 1.4) on behalf of a competing party in a particular procurement process, City officials or employees except the Procurement designated staff contact in the Procurement division. Violation of this provision shall result in disqualification of the party on whose behalf the lobbying occurred.

The Cone of Silence is the period between the issue date of the RFP, which allows for immediate submittals to the City of Gainesville Procurement Division for the Request for Proposal and the time the City Officials and Employee awards the contract.

1.6 DETERMINATION OF RESPONSIBILITY OF BIDDERS

The specific qualifications of bidders for this specific Request for Proposal are included in Part 3, 3.1, d) Qualifications. Bidder must also demonstrate that it is responsible as defined in the City of Gainesville's [Financial Services Procedures Manual](#), Section 41-522, as may be amended.

As a part of the proposal evaluation process, City reserves the right to conduct a background investigation of bidder, including a record check by the Gainesville Police Department if the qualifications require it. Bidder's submission of a proposal constitutes acknowledgment of the process and consent to such investigation.

No contract will be awarded to any proposer who is in arrears to City upon any debt, fee, tax or contract, or who is a defaulter, as surety or otherwise, upon any obligation to City, or who is otherwise determined to be not responsible by City pursuant to Section 41-522, [Financial Services Procedures Manual](#), following:

These criteria consider the bidder's capability to perform:

- a) The ability of the bidder to successfully carry out a proposed contract.
- b) Past performance (including reference check), experience, business and financial capabilities, skills, technical organization, legal eligibility and reliability.
- c) Current litigation pending between the bidder and the City.
- d) Bidder has paid all debts owed to the City.
- e) Bidder possesses all required licenses.

If it is determined that the bidder is not responsible, City will notify bidder of its finding, including evidence used, and allow bidder the opportunity to come into compliance within three (3) business days of notification.

Successful Bidder must either update or complete City's vendor application, pay business tax (if applicable), and register with the State of Florida (if required by law).

1.7 RESPONSIVENESS OF PROPOSAL

Each proposal will be reviewed to determine if the proposal is responsive to the submission requirements outlined in the RFP. A responsive proposal is one which follows the requirements of the RFP, includes all required documentation, is submitted in the format outlined in the RFP, is of timely submission (via upload to DemandStar.com), and has the appropriate signatures as required on each document. Failure to comply with these requirements may deem the proposal non-responsive (see Section 41-444 of the [Financial Services Procedures Manual](#)).

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PART 2 – PROJECT OVERVIEW

2.1 GENERAL DESCRIPTION

It is the intent of the City of Gainesville to obtain proposals to complete an ecological analysis of the City of Gainesville's (CITY) urban forest, public and private; complete a detailed tree inventory of all City of Gainesville owned trees, and to estimate change in the overall canopy coverage in Gainesville from 1995 -2023.

2.2 PROJECT SPECIFICATIONS

This Analysis is authorized by the City of Gainesville's Land Development Code, Section 30-8.7, C.2

ECOLOGICAL ANALYSIS

The purpose of this project will be to complete an ecological analysis of the City of Gainesville's (CITY) urban forest, public and private; complete a detailed tree inventory of all City of Gainesville owned trees, and to estimate change in the overall canopy coverage in Gainesville from 1995 -2023. The results of this analysis will be compared to a similar analysis completed in 2016 by Dr. Michael Andreu - UF School of Forest Resources and Conservation, Rob Northrop – University of Florida Extension, Dr. Shawn Landry – University of South Florida, Dr. Wayne Zipperer- USDA Forest Service, and Dr. David Fox - UF School of Forest Resources and Conservation. The project area will be the boundary of the City of Gainesville that comprises approximately 161 square kilometers (62 mi²), and approximately 400 miles of City owned and/or maintained roads.

This project will include mapping of the urban forest utilizing remote sensing technologies (Landsat imagery and NAIP aerial photography; bidder may propose different imagery methods) to analyze the tree canopy coverage, utilize field sampling technologies to quantify the structure of the urban forest, a detailed and thorough tree inventory of City owned urban trees, and use scientifically proven modeling techniques to evaluate the benefits of the urban forest within the City.

TREE INVENTORY

The City of Gainesville seeks a comprehensive tree inventory of all City-owned street trees, on rights-of-ways (ROW's), and in urbanized sections of City parks. Trees owned by the City in forested and conservation lands are not to be included in the Inventory. Distinguishing characteristics to identify an urbanized section of a City park would be the presence of buildings, parking lots, domestic grass turf, or manmade ground cover of some type. . Trees should be inventoried if they are within 100' of these aforementioned distinguishing characteristics.

The inventory shall consist of data taken for each tree 8" in diameter and larger. Data shall be recorded on "TreePlotter" software, and include the following:

Picture Latitude-Longitude Species

Diameter at Breast Height Estimated Height (Range of Values)

Estimated Crown Spread (Range of Values)

Condition (Excellent, Good, Fair, Poor; including specific Condition of Concern) Risk Rating (Level 1 Assessment)

Available Planting Locations should also be geo-located and tallied.

TIMEFRAME:

This Inventory is projected to be carried out over a three-year timeframe, due to the estimated number of trees subject to the Inventory. This estimated number is 38,500 trees; 25,000 total street trees, and 13,500 total urban park trees. **Important:** This is an estimate only and not a guarantee. Those bidding are encouraged to carry out their own due diligence regarding an estimated number of trees subject to this inventory.

INFORMATION DESIRED

The information gained through this inventory of urban trees will help the City accomplish the following goals:

1. Estimate the citywide percent of the tree canopy using 2022 aerial imagery, and create maps showing 1995-2023 tree canopy change.
2. Assess the urban forest overall health, diversity, and size distribution by species and land- use.
3. Determine estimated diversity and invasive species (tree) composition based on the results of field sampling efforts.
4. Estimate the economic benefits provided by the current canopy as calculated by the Urban Forest Effects (UFORE) model.
5. Compare the current economic benefits to the previously reported benefits (2016 Ecological Analysis).
6. Build public support for the City urban forestry programs by making citizens aware of the results of this inventory.
7. Promote better tree care of ROW and City Park trees, since the City will have data on each tree for which it is responsible.
8. Assist in determining tree planting locations available for the Urban Forestry Division to install new trees.

SCOPE OF SERVICES

The project will be conducted according to the following scope of services:

Task 1.0 Project Planning

The project will involve significant collaboration between the winning proposer and the City of Gainesville which will make up the project team. One of the primary goals of this first phase of the project will be to conduct background research regarding inventory methods and to collect materials (e.g. GIS data and imagery) needed to complete the project. The project team will meet to review project details including specific research questions the City may have, review field sampling techniques, discuss access issues to field locations, imagery, GIS data requirements, and TreePlotter data requirements. The results of this project planning task will guide the overall project. However, the collaborative and dynamic nature of the project will continue as part of each individual task mentioned below; the project team may refine or add any desired analyses or techniques as required or based on available budget.

Task 2.0 Analysis of Tree Canopy using Remote Sensing Techniques

The purpose of this task will be to utilize remote sensing techniques using Landsat and NAIP imagery (bidder may propose different imagery methods) in order to analyze the citywide urban forest. Through the acquisition and analysis of imagery, the winning bidder will characterize the urban forest canopy coverage in 1995, 2005, 2016, 2023, and report on changes over these time periods across the CITY. Since Landsat imagery is known to underestimate tree canopy cover, the winning bidder will also use very-high resolution aerial imagery to develop accurate estimates of citywide tree canopy cover. A dot-based sampling approach will be used, if using NAIP aerial photographic imagery from 2005 and the soon to be released 2023 imagery to quantify citywide tree canopy cover and change with a 90% or greater confidence interval. The combination of the moderate-resolution mapping and the accurate citywide estimate will show the pattern of tree cover distribution across the city and canopy change loss/gain at the neighborhood level, and provide very accurate estimates of citywide change. Image analysis results will be converted to GIS data format and provided to the CITY. Future work efforts, with additional funding, could utilize the very-high resolution aerial imagery to develop detailed land cover maps for exploration of tree cover and change at the resolution of the property parcel. All analysis results will be included within the final report (Task 5)

Task 3.0 Field Work and I-Tree ECO Analysis

The winning proposer will be the lead partner on the field sampling of the urban forest. During the spring of 2023 the winning proposer will establish a minimum of 150 permanent field plots (and not to exceed 200 plots) in the City of Gainesville. A stratified random sampling approach will be used to distribute these plots across land use categories agreed upon by the project team.

Land use categories will be derived from existing land use/land cover GIS data sets.

Plot data will be collected using the methodology prescribed for the UFO RE models (henceforth called i-Tree ECO) developed by the USDA Forest Service and modified by the project team for use in Florida. This methodology will include the establishment of 1/10th acre circular permanent plots and all measurements will occur within the plot area. As these plots may fall in both public and privately owned lands, the CITY will provide access to publicly owned lands and help contact landowners to gain permission to access private property.

The following is an outline of the data to be collected on each permanent plot:

1. Individual plot data collected, at a minimum, will include:

- A. Plot ID number
- B. Latitude and longitude
- C. Land use/land cover from CITY provided GIS data
- D. Actual land use/cover
- E. % Tree cover/plot
- F. Individual tree data
 - 1. Tree id#
 - 2. Species
 - 3. DBH (>1 inch)
 - 4. Total height
 - 5. Height to crown base
 - 6. Crown width
 - 7. Crown condition class
 - 8. % Canopy missing/% dieback
 - 9. Direction/distance to residential building (need for energy conservation only)
- G. % Shrub cover
- H. % Ground cover

2. Plot locations will be recorded using Global Positioning Systems (GPS) receivers and range finders.

3. Quality assurance will be conducted to ensure accurate field sampling results. Quality assurance procedures used in data collection will be documented and sent along with the field data. Checks will be made during training of new employees, and on randomly selected audited plots after they are completed. The number of errors detected will determine the frequency of inspections.

4. In 2006, approximately 95 sample plots were established by Drs. Escobedo and Zipperer. In 2011 these plots were resampled by this team, but they were only able to relocate and/or access approximately 65 of those original plots. The 2016 Ecological Analysis provided data on 177 plots. Ideally these plots would be revisited during the 2022-2023 sampling effort to provide long term data about individual tree growth and vegetation change over time. Where feasible (assuming access permission is given and plot center can be identified) the winning bidder will attempt to re-measure those plots and account for them in the stratification of the field plots.

The winning bidder will process the collected field data using i-Tree ECO modeling software. The output of the models will provide information related to the physical structure and health of the urban forest as well as some of the economic benefits trees provide in the urban environment. An analysis of the model output will be included in the final report (Task 5).

Task 4.0 Tree Inventory

A comprehensive inventory of all CITY-owned trees on street ROW's and urbanized areas of CITY parks, as described above. Timeframe is expected to cover three years, but can be accomplished sooner if finalized prior to three years.

Task 5.0 Final Report

The project team will produce a final report that outlines the data collection methodology and results from data analysis. Proposed analysis results will focus on the percentage canopy cover by land use/cover, general forest health, urban forest structure, and a summary of urban forest benefits provided to the citizens of Gainesville at the time of inventory. Street tree and Park tree inventory will be summarized by totals and individual categories, plus provided within the TreePlotter software. Methodology and results from the remote sensing task will be included in the final report as will electronic copies of GIS data sets developed and derived during the study. The final report will be provided in PDF format and GIS data layers created during the project will be provided with appropriate metadata in an ArcGIS compatible format for distribution to the CITY. Finally, the project team will present results to the CITY Commission, CITY administrator's office, Public Works Department, and two additional presentations to be determined by the CITY.

Analysis to be provided in the final report at minimum are as follows:

- Citywide tree canopy temporal change from 1995 - 2023
- Tree cover maps and summarized data by neighborhood and land use/cover
- Tree species diversity summarized by land use/cover
- Density of trees by land use/cover category
- Tree species/size distribution
- Tree, shrub and ground cover estimates by land use/cover category
- Leaf area by tree species and land use/cover category
- Relative health of trees by land use/cover category
- Residential energy savings and CO2 emissions avoided
- Estimated air pollution removal by trees including carbon monoxide (CO), nitrogen dioxide (NO2), ground level ozone (O3), particulate matter (PM10), and sulfur dioxide (SO2)
- Carbon dioxide (CO2) storage and annual sequestration amounts by tree species, size class and land use/cover category
- Estimated compensatory (i.e. replacement) value of the trees in Gainesville

CITY ASSISTANCE

The CITY will provide digital GIS data (boundaries, zoning, parcels and streets, ROW) for use in creating base map for remote sensing and field data analysis.

The City will provide access to the TreePlotter software for inventory data collection.

The CITY will provide the winning bidder right of entry to CITY property for a mutually agreeable time period.

The CITY will notify residents and concerned CITY employees, such as park employees and public safety officials, as to the nature of this project and the presence of the project team in the neighborhoods.

Once sample plot locations have been generated using GIS, the CITY will contact landowners and attempt to gain permission for the data collection teams to access private lands. Data collection teams can follow up and make appointments with landowners as necessary for property access and plot measurement.

CITY Project Manager

Dave Conser City Arborist
City of Gainesville, Public Works, Operations – Urban Forestry Division
405 NW 39th Ave, Gainesville, Florida, 32609
ConserDS@cityofgainesville.org

TIME FRAME

The duration of this project will begin upon execution of the contract and end September 1, 2026.

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PART 3 – PRICE PROPOSAL

3.1 PROJECT COSTS AND DELIVERABLES

Total cost is based on completion of all project tasks and deliverables stated above (TASKS 1- 5).

Budget will cover: labor, field equipment (including computer tablets for data collection), computer for data input and analysis, vehicle mileage, printing and postage, purchase of imagery.

1. TOTAL COST FOR ECOLOGICAL ANALYSIS:- \$_____

2. COST FOR TASK 4 TREE INVENTORY - \$_____ per tree cost
(Total cost will be based on an estimated 38,500 number of trees-25,000 total street trees and 13,500 total urban park trees)

Award will be based on total cost of 1 and 2.

NOTE: If travel is involved in the execution of an awarded contract for this solicitation, should any air travel be required the City's travel policy allows for Coach air travel only. All other travel will be billed in accordance with the Federal General Services Administration rates which can be found at: <https://www.gsa.gov/travel/plan-book/per-diem-rates>. In addition, long distance phone calls, printing, and other administrative costs may be billed at cost only -no mark-up. Evidence of these expenditures will be submitted when invoicing the City. Travel and administrative costs should be identified in the Price Proposal.

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PART 4 – HOW TO SUBMIT A PROPOSAL

Instructions to bidders: Proposals must contain each of the documents listed below; each fully completed and signed, as required. Required signatures for proposal forms may be applied using electronic signature software (i.e., DocuSign, Adobe Sign, etc.). Proposals submitted which do not include the following items may be deemed non-responsive and may not be considered for contract award.

4.1 FORMAT OF PROPOSAL

a) Table of Contents

The table of contents should outline in sequential order the major areas of the proposal, and all pages of the proposal, including the enclosures, must be clearly and consecutively numbered and correspond to the table of contents.

b) Technical Proposals

The technical proposal is a narrative which addresses the scope of work, the proposed approach to the work, the schedule of the work, and any other information called for by the RFP which the bidder deems relevant.

c) Price Proposal

The price proposal is a presentation of the bidder's total offering price including the estimated cost for providing each component of the required goods or services.

Bidders should indicate the dollar amount which will be attributed to each sub-contractor, if any.

If a prescribed format for the price proposal is appended, bidders must use it; otherwise, bidders may use formats of their choice.

d) Qualifications

The response to the minimum qualification requirements should address each of the qualifications set out in the section below. Bidders must provide documentation which demonstrates their ability to satisfy all of the minimum qualification requirements. Bidders who do not meet the minimum qualification requirements or who fail to provide supporting documentation will not be further considered. If a prescribed format, or required documentation for the response to minimum qualification requirements is stated below, bidders must use said format and supply said documentation.

- Must have at least one (1) Certified Arborist on staff. (Certified by the International Society of Arboriculture)

4.2 CONTENT OF PROPOSAL

Required Documents:

The following documents are required to be included in the bidder's submission:

- RFP Cover Page
- Address each Minimum Qualification
- Provide a Statement of all Qualifications that will communicate the capabilities of the proposer to successfully complete the project
- Pricing Proposal
- Drug-Free Workplace Form
- Bidder Verification Form
- References Form
- Bidder's W-9
- Copy of any applicable, current licenses and/or certification required by City/County/State
- Exceptions to the RFP (refer to Part 4, 4.5 Exception to the RFP)
- Copy of Certification of Arborist

4.3 PROPOSAL SUBMISSION INSTRUCTIONS

The bid response, containing all required documents, with authorized signatures, must be received by 3:00 p.m. on the due date indicated on the Bid Cover Page for this project. The bidder's complete pdf response must be uploaded into DemandStar.com prior to the 3:00 p.m. deadline. This platform will not accept late submittals.

Upload bid response as a pdf formatted document only, unless the solicitation states otherwise. The pdf document should be titled with bidder's name, bid number, and, if the response is submitted in parts, include "Part # of x".

On occasion, the City will request proposals present pricing separately from the main proposal. If separate pricing is requested, upload a separate document that indicates Pricing as its content.

Modifications to or withdrawal of a bidder's submittal can be made up to the deadline date. Modifications and withdrawals must be documented in DemandStar.com in order to be recognized by the City. Any bid not withdrawn will constitute an irrevocable offer, for a period of one hundred twenty (120) days, to provide the City adequate time to award the Contract for the services specified in this solicitation.

Both the response and the price proposal, if required to be submitted as a separate document, must be signed by an officer of the business who is legally authorized to enter into a contractual relationship in the name of the bidder. An authorized representative who is not an officer may sign the proposal, but must attach a corporate resolution granting authorization to the representative to execute on behalf of the business.

The submittal of a response by a bidder will be considered by the City as constituting an offer by the bidder to perform the required services at the stated fees.

4.4 DISCLOSURE AND CONFIDENTIALITY

Florida's Public Records Law, Chapter 119, Florida Statutes, includes numerous exemptions to the general requirement to disclose information to the public in response to a public record's request. Exemptions are found in various provisions of the Florida Statutes, including but not limited to Section 119.071, Florida Statutes (General exemptions from inspection or copying of public records), and Section 119.0713, Florida Statutes (Local government agency exemptions from inspection or copying of public records). Section 815.045, Florida Statutes (Trade secret information), provides that trade secret information as defined in Section 812.081, Florida Statutes (Trade secrets; theft, embezzlement; unlawful copying; definitions; penalty) is confidential and exempt from disclosure because it is a felony to disclose such records. The Parties understand and agree that Florida's Public Records Law is very broad and that documents claimed by a Party to be confidential and exempt from public disclosure pursuant to the Public Records Law may in fact not be deemed such by a court of law. Accordingly, the following provisions shall apply:

- (i) Identifying Trade Secret or Otherwise Confidential and Exempt Information. For any records or portions thereof that bidder claims to be Trade Secret or otherwise confidential and exempt from public disclosure under the Public Records Law, bidder shall:
 - a. Specifically identify the records or specific portions thereof that are confidential and exempt and reference the particular Florida Statute that grants such status. Provide one redacted copy of the record and one copy of the record with the confidential and exempt information highlighted as outlined in 1 and 2 on the following page. Bidder shall take care to redact only the confidential and exempt information within a record.
 - b. Provide an affidavit or similar type of evidence that describes and supports the basis for Contractor's claim that the information is confidential and exempt from public disclosure.
- (ii) Request for Trade Secret or Otherwise Confidential and Exempt Information.
 - a. In the event City receives a public records request for a record with information labeled by bidder as Trade Secret or otherwise as confidential and exempt, City will provide the public record requester with the redacted copy of the record and will notify bidder of the public records request.
 - b. However and notwithstanding the above, in the event that City in its sole discretion finds no basis for bidder's claim that certain information is Trade Secret or otherwise confidential and exempt under Florida's Public Records Law, then City shall notify bidder in writing of such conclusion and provide bidder a reasonable amount of time to file for declaratory action requesting a court of law to deem the requested information as Trade Secret or otherwise as confidential and exempt under Florida's Public Records Law. If bidder fails to file for declaratory action within the reasonable amount of time provided, then City will disclose the information requested.
 - c. If a public records lawsuit is filed against CITY requesting public disclosure of the information labeled by bidder as Trade Secret or otherwise as confidential and exempt, CITY shall notify bidder and bidder shall intervene in the lawsuit to defend the nondisclosure of such information under Florida's Public Records Law.

- d. Bidder hereby indemnifies and holds CITY, its officers and employees harmless from any and all liabilities, damages, losses, and costs of any kind and nature, including but not limited to attorney's fees, that arise from or are in any way connected with bidder's claim that any information it provided to CITY is Trade Secret or otherwise confidential and exempt from public disclosure under Florida's Public Records Law.

How to Designate Trade Secret or Otherwise Confidential and Exempt Information

If a bidder believes that its response contains trade secret or otherwise confidential and exempt information (as defined by Florida or Federal law) and should be withheld from disclosure to the public, in such cases the bidder must provide a redacted copy of the proposal for public access.

- Redacted means that the confidential/proprietary information in the proposal has been obscured so that it cannot be read.
 - Unredacted means that the entire document, including the confidential/proprietary information, has not be obscured and is visible for the evaluation team to use in their evaluation process.
1. Upload a pdf version response of the complete UNREDACTED proposal. Include "UNREDACTED, CONFIDENTIAL" in document title. This is the version that will be used by the evaluators when they are reviewing your proposal. It is essential that the items that will be redacted are highlighted in yellow to prevent the evaluation team from discussing these items after the award. The first page of the document for the **unredacted** document should provide a general description of the information bidder has designated as confidential and/or exempt, and provide a reference to the appropriate Florida or Federal statute supporting the confidential and/or exempt classification.
 2. Upload a pdf version response of the REDACTED copy of the proposal. Include "REDACTED" in the document title. This copy will be used to support any public records requests that may arise from this solicitation.

How the City will Handle Material Identified as Trade Secret or Otherwise Confidential and Exempt Information

The City's evaluators will be provided with the complete unredacted proposal, including any trade secret or otherwise confidential and exempt information. The City evaluators will maintain the confidentiality of the information through the evaluation process, including any recorded evaluation team meetings.

In the event a public record request is made to view the information which bidder claims is confidential and/or exempt, the City will notify the bidder and give the bidder a reasonable opportunity (generally 2 business days) to institute appropriate legal action to prevent the disclosure of the information claimed as confidential and/or exempt.

All public records submitted to the City, including those claimed as confidential and/or exempt, will be retained by the City and will not be returned to a bidder at the conclusion of the bidding process.

4.5 EXCEPTION TO THE RFP

Bidders may take exceptions to any of the terms of this RFP unless the RFP specifically states where exceptions may not be taken. Should a bidder take exception where none is permitted, the proposal will be rejected as non-responsive. All exceptions taken must be specific, and the bidder must indicate clearly what alternative is being offered to allow the City a meaningful opportunity to evaluate and rank proposals.

Where exceptions are permitted, the City shall determine the acceptability of the proposed exceptions and the proposals will be evaluated based on the proposals as submitted. The City, after completing evaluations, may accept or reject the exceptions. Where exceptions are rejected, the City may request that the bidder furnish the services or goods described herein, or negotiate an acceptable alternative.

4.6 ONLY ONE BID

Only one bid from any individual, firm, corporation, organization or agency under the same or different name shall be considered. Should it appear to the City that any bidder has a financial interest in more than one submission under this bid, all bids in which such bidder has a financial interest will be rejected. A subcontractor is permitted to appear in more than one submittal for the same bid, as long as the subcontractor is not a lead bidder in any of the submittals. The City considers a financial interest to include, but not be limited, to joint ventures and, partnerships.

4.7 FULLY INFORMED BIDDER

A bidder is expected to fully inform itself as to the requirements of the Specifications and Contract terms and conditions; failure to do so will be at its own risk. A bidder shall not expect to secure relief on the plea of error.

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PART 5 – EVALUATION PROCESS

5.1 EVALUATION CRITERIA

a) Selection and Evaluation Criteria

Proposals will be evaluated in accordance with the procedures described in the City's, [Professional Services Evaluation Handbook](#).

The proposals will be evaluated using the following process: Qualifications Evaluation, Written Proposal Evaluation and/or Presentation/Interview Evaluation, and Other Factors as deemed appropriate. The City shall consider the ability of the firm's professional personnel, willingness to meet time and budget requirements, workload, location, past performance, volume of previous work with the City, and location. The Evaluation process provides a structured means for consideration of all these areas.

b) Technical Qualifications Evaluation

The Technical Qualifications Evaluation will assess each responding firm's ability based on experience and qualifications of key team members, the firm's capability of meeting time and budget requirements, and the firm's record with regard to this type of work, particularly in the City of Gainesville or in the State of Florida. This stage does not involve review and evaluation of a proposal addressing the project scope of work. Consideration will be given to the firm's current workload, financial stability, and the location where the majority of the technical work will be produced. The City will not be impressed with excessive amounts of boilerplate, excessive numbers of resumes, excessive length of resumes, excessive numbers of photographs, work that distant offices have performed, or work not involving personnel to be assigned to the proposed project.

c) Written Proposal Evaluation

The Written Proposal Evaluation will assess the firm's understanding of the project and the proposed approach to be undertaken as addressed in a written proposal. The evaluation process will assess how effectively the requirements of the scope of services have been addressed. The written proposal should identify a project manager and other key members of the project/service team. It should relate the capabilities of the project/service team to the requirements of the scope of services.

d) Presentation/Interview Evaluation

The Proposal Presentation/Interview Evaluation is based on an oral presentation that addresses both the technical qualifications of the firm and the approach to the project. Importance is given to the firm's understanding of the project scope of work, the placement of emphasis on various work tasks, and the response to questions. The evaluation process will assess the project manager's capability and understanding of the project and his/her ability to communicate ideas. The role of key members of the project/service team should be established based on the scope of services and the firm's approach to the project/service. The role of any subcontracted firm in the proposal should be clearly identified. Unique experience and exceptional qualifications may be considered with emphasis on understanding of the project/service, particularly "why it is to be done" as well as "what is to be done". The City of Gainesville will not be impressed with excessive boilerplate, excessive participation by "business development" personnel, and the use of "professional" presenters who will not be involved in the project or future presentations.

e) Other factors

The Other Factors to be considered, based upon the specific project (but not limited to), are those items, such as Small or Service-Disabled Veteran Business and/or Local Preference. Fee proposals, when requested and deemed appropriate, are also to be considered in the evaluation process, where the request for such fees is in accordance with the City's Procurement Policies and Procedures.

PART 6 – SELECTION PROCESS

The bidder(s) will be selected from the qualified, responsive and responsible bidders submitting responses to this Request for Proposal. The selection process will be as follows:

1. Evaluators consisting of City staff will review the proposals. The evaluation process provides a structured means for consideration of all proposals.
2. Upon review and evaluation, the City may request oral presentations from the top ranked bidders. During the oral presentations, the bidders shall further detail their qualifications, approach to the project and ability to furnish the required services. These presentations shall be made at no cost to the City. Bidders selected for further presentations should provide one (1) electronic copy of materials presented in PDF format on a USB Flash drive.
3. The final ranking of bidders will be in accordance with the procedures described in the City's [Professional Services Evaluation Handbook](#).
4. If required, the final ranking of bidders will be presented to the City Commission. The City Commission will be requested to approve the recommended ranking and authorize negotiation and execution of the contract beginning with the top ranked bidder.
5. Provided that the City Commission approves the ranking and an award, the City will negotiate a contract with the top ranked bidder. Should the City be unable to negotiate a satisfactory contract with the top ranked bidder, negotiations will be terminated with that bidder and negotiations will be initiated with the second most qualified bidder, and so on until a satisfactory contract is negotiated.

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PART 7 – AWARD

7.1 TIE BIDS

Whenever two or more bids which are equal with respect to price, quality and service are received, preference shall be given in the following order: (1) Bidders submitting the attached Drug-Free Workplace form with their bid/proposal certifying they have a drug free workplace in accordance with Section 287.087, Florida Statutes; (2) Bidders located within the City of Gainesville, if not subject to the Local Preference Ordinance; (3) Bidders located within Alachua County; (4) Bidders located within the State of Florida; and (5) coin toss.

7.2 DRUG-FREE WORKPLACE

Preference shall be given to submitters providing a certification with their qualifications certifying they have a drug-free workplace whenever two or more bids which are equal with respect to price, quality, and service are received in accordance with Section 287.087, Florida Statutes. The attached form should be filled out and returned with the qualifications in order to qualify for this preference.

7.3 CONTRACT TERMS AND CONDITIONS

The City may award a contract on the basis of initial offers received, without discussions. A sample contract is attached to the bid. Therefore, each initial offer should contain the bidder's best terms from a cost or price and technical standpoint and any changes to the sample contract.

The City reserves the right to enter into contract negotiations with the selected bidder regarding the terms and conditions of the contract and technical terms. Price will not be negotiated. If the City and the selected bidder cannot negotiate a successful contract, the City may terminate said negotiations and begin negotiations with the next selected bidder. This process will continue until a contract has been executed or all bidders have been rejected. No bidder shall have any rights against the City arising from such negotiations.

7.4 CONTRACT AWARD

The award(s), if any, shall be made to the bidder(s) whose proposal(s) shall be deemed by the City to be in the best interest of the City. The decision of the City of whether to make the award(s) and which proposal is in the best interest of the City shall be final.

7.5 CONTRACT

The Contract to be entered into will designate the successful bidder as the City's Contractor. The terms and conditions in the Sample Contract, Part 9, shall be applicable and binding. The successful bidder will be required to execute an agreement with the City in substantially the same format as found in Part 9.

7.6 BID PROTEST

Participants in this solicitation may protest the RFP specifications or award in accordance with Section 41-580 of the [Financial Services Procedures Manual](#).

7.7 RFP POSTPONEMENT/CANCELLATION/WAIVER OF IRREGULARITIES

The City may, at its sole and absolute discretion, reject any and all, or parts of any and all, proposals; re-advertise this RFP; postpone or cancel, at any time, this RFP process; or waive any irregularities in this RFP or in the proposals received as a result of this RFP. See Section 41-444 [Financial Services Procedures Manual](#).

PART 8 – GENERAL INFORMATION

8.1 REIMBURSABLES

If travel is involved in the execution of an awarded contract for this solicitation, should any air travel be required the City's travel policy allows for Coach air travel only. All other travel will be billed in accordance with the Federal General Services Administration rates which can be found at: <https://www.gsa.gov/travel/plan-book/per-diem-rates>. In addition, long distance phone calls, printing, and other administrative costs may be billed at cost only -no mark-up. Evidence of these expenditures will be submitted when invoicing the City. Travel and administrative costs should be identified in the Price Proposal.

8.2 LOCAL PREFERENCE

In bidding of, or letting contracts for procurement of, supplies, materials, equipment and services, as described in the purchasing policies, the city commission, or other purchasing authority, may give a preference to local businesses in making such purchase or awarding such contract in an amount not to exceed five percent of the local business' total bid price, and in any event the cost differential should not exceed \$25,000.00. Total bid price shall include not only the base bid price but also all alterations to that base bid price resulting from alternates which were both part of the bid and actually purchased and awarded by the City Commission or other authority. In the case of requests for proposals, letter of interest, best evaluated bids, qualifications or other solicitations and competitive negotiation and selection in which objective factors are used to evaluate the responses. Local Businesses are assigned five (5) percent of the total points of the total evaluation points.

Local business means the vendor has a valid business tax receipt, issued by the City of Gainesville at least six months prior to bid or proposal opening date, to do business in said locality that authorizes the business to provide the goods, services, or construction to be purchased, and a physical business address located within the limits of said locality, in an area zoned for the conduct of such business, from which the vendor operates or performs business on a day-to-day basis. Post office boxes are not verifiable and shall not be used for the purpose of establishing said physical address. In order to be eligible for local preference, in the Bid or RFP evaluation, the vendor must provide a copy of the business tax receipt and Zoning Compliance Permit. For more information on City's Local Preference Policy: [Municipal Code Article X Local Preference Policy](#).

8.3 SMALL AND SERVICE-DISABLED VETERAN BUSINESS PARTICIPATION

Small or Service-Disabled Veteran's Business Enterprise Definition: A Small Business or a Service-Disabled Veteran's Business, which is duly licensed and authorized to engage in business and maintains a permanent principal place of operation with full time personnel within Alachua, Bradford, Columbia, Gilchrist, Levy, Putnam, or Union County and possess a current City business tax receipt as required, and is so certified by the Small and Service-Disabled Veteran's Business Program Coordinator.

It is the policy of the City of Gainesville that small and service-disabled veteran businesses as defined in the Small and Service-Disabled Veteran Business Program, have the maximum practical opportunity to participate in contracting opportunities provided by the City. In keeping with this policy, each bidder is asked to state whether it will utilize small and service-disabled veteran businesses that are eligible for assistance to perform work on the project(s) being advertised.

For bidders not yet certified by the City, a small and service-disabled veteran application may be accessed via the [Diversity Business Management System](#) website. To be considered as a certified small and/or service-disabled veteran business, a bidder must have a current certificate at the time of the solicitation submittal due date. For more information on certified small and service-disabled veteran businesses, please visit the [Office of Equity and Inclusion](#) website.

8.4 LIVING WAGE REQUIREMENTS

Living Wage requirements, Ordinance 020663, as amended in Ordinance 030168, and in [Ordinance 180999](#), and as shown on the City's web page, applies to contracts solicited by the City after midnight on March 31, 2021.

Section 2-619. – Living Wage Requirements.

- (a) The following are requirements of each service contractor/subcontractor:
- (1) A service contract or/subcontractor shall pay a living wage to each of its covered employees during the time they are providing the covered services.
 - (2) A copy of the living wage rate shall be posted by the service contractor/subcontractor in a prominent place where it can easily be seen by the covered employees and shall be supplied to any covered employee upon request.

- (3) Each service contractor shall make all of its service subcontractors aware of the requirements of this division and shall include the contract provisions listed in the **Sample Contract** under the *Living Wage* paragraph in each of its service subcontracts to ensure compliance with this article. The city shall not be deemed a necessary or indispensable party in any litigation between the service contractor and a subcontractor.
- (4) A service contractor/subcontractor shall not discharge, reduce the compensation of, or otherwise retaliate against any covered employee for filing a complaint, participating in any proceedings or otherwise asserting the requirement to pay a living wage under this division. A covered employee who claims their employer has not paid them a living wage as required by this division may file a written complaint with the city.
- (5) Each service contractor/subcontractor shall produce payroll records, and any other requested documentation to the city as necessary for the city to audit or investigate compliance with or a reported violation of this division.

The adjusted Living Wage for this contract will be \$15.00 per hour (Living Wage with Health Benefits) or \$17.25 per hour if Health Benefits are not offered. The living wage for this contract will increase annually on the anniversary date of the contract at the City's prevailing living wage rate, which is updated October 1 each year.

8.5 TAXES, CHARGES AND FEES

The bidder agrees that any applicable Federal, State and Local sales and use taxes, which are to be paid by City of Gainesville, are included in the stated bid prices. Since the City of Gainesville is often exempt from taxes for equipment, materials and services, it is the responsibility of the Contractor to determine whether sales taxes are applicable. The Contractor is liable for any applicable taxes which are not included in the stated bid prices.

8.6 COSTS INCURRED BY BIDDERS

All expenses involved with the preparation and submission of proposals to the City, or any work performed in connection therewith shall be borne by the bidder(s). No payment will be made for any responses received, nor for any other effort required of or made by the bidder(s) prior to commencement of work as defined by a contract approved by the City Commission (if so required).

8.7 RULES; REGULATIONS; LICENSING REQUIREMENT

The bidder shall comply with all laws, ordinances and regulations applicable to the services contemplated herein, including those applicable to conflict of interest and collusion. Bidders are presumed to be familiar with all Federal, State and local laws, ordinances, codes and regulations that may in any way affect the services offered.

8.8 RECORDS/AUDIT

Contractor shall maintain records sufficient to document their completion of the scope of services established by this Contract. These records shall be subject at all reasonable time to review, inspect, copy and audit by persons duly authorized by the City. These records shall be kept for a minimum of three (3) years after completion of the Contract. Records which relate to any litigation, appeals or settlements of claims arising from performance under this Order shall be made available until a final disposition has been made of such litigation, appeals, or claims.

8.9 DEBARMENT, SUSPENSION, OTHERWISE EXCLUDED

By submitting this proposal, bidder agrees that it:

- Is not presently debarred, suspended, proposed for debarment, declared ineligible, or voluntarily excluded from covered transactions by any Federal department or agency;
- Has not within a three-year period preceding this proposal been convicted of or had a civil judgment rendered against it for commission of fraud or a criminal offense in connection with obtaining, attempting to obtain, or performing a public (Federal, State, or local) transaction or contract under a public transaction; violation of Federal or State antitrust statutes or commission of embezzlement, theft, forgery, bribery, falsification, or destruction of records, making false statements or receiving stolen property;
- Is not presently indicted for or otherwise criminally or civilly charged by a governmental entity (Federal, State, or local) with commission or any of the offenses enumerated in paragraph (2) of this certification; and
- Has not within a three-year period preceding this application/proposal had one or more public transactions (Federal, State, or local) terminated for cause or default.

8.10 PUBLIC ENTITY CRIME INFORMATION STATEMENT

Section 287.133 (2)(a), Florida Statutes, contains the following provisions: “A person or affiliate who has been placed on the convicted vendor list following a conviction for public entity crime may not submit a bid on a contract to provide any goods or services to a public entity, may not submit a bid on a contract with a public entity for the construction or repair of a public building or public work, may not submit bids on leases of real property to a public entity, may not be awarded or perform work as a contractor, supplier, subcontractor, or consultant under a contract with any public entity, and may not transact business with any public entity, in excess of the threshold amount provided in Section 287.017, for CATEGORY TWO for a period of 36 months from the date of being placed on the convicted vendor list.”

8.11 INVESTIGATION OF ALLEGED WRONGDOINGS, LITIGATION/ SETTLEMENTS/FINES/PENALTIES

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8.12 NON-DISCRIMINATION POLICY AND COMMERCIAL NON-DISCRIMINATION REQUIREMENT

As a condition of entering into this agreement, the company represents and warrants that it will comply with Title VI and Title VII of the Civil Rights Act of 1964 and all other federal, state or local laws prohibiting discrimination. The company shall not discriminate on the basis of race, color, religion, gender, national origin, marital status, sexual orientation, age, disability or gender identity, or other unlawful forms of discrimination in the solicitation, selection, hiring, commercial treatment of subcontractors, vendors, suppliers or commercial customers, nor shall the company retaliate against any person for reporting instances of such discrimination.

The City reserves the right to investigate any claims of illegal discrimination by the Contractor and in the event a finding of discrimination is made and upon written notification thereof, the Contractor shall take all necessary steps to cure and rectify such action to the reasonable satisfaction of the City. The company understands and agrees that a violation of this clause shall be considered a material breach of this agreement and may result in termination of this agreement, disqualification of the company from participating in City contracts, or other sanctions. This clause is not enforceable by or for the benefit of, and creates no obligation to, any third party.

For more information on this policy and requirement, please visit the [Office of Equity and Inclusion](#).

8.13 USE OF RFP REPLY IDEAS

The City has the right to use any or all information presented in any response to the RFP, whether amended or not, except as prohibited by law. Selection or rejection of the submittal does not affect this right.

8.14 E-VERIFY REQUIREMENT

Section 448.095, Florida Statute states the statute shall be construed in a manner so as to be fully consistent with any applicable federal laws or regulations. The Contractor shall (1) utilize the U.S. Department of Homeland Security’s E-Verify system to verify the employment eligibility of all new employees hired by the Contractor during the term of the Contract; and (2) shall expressly require any subcontractors performing work or providing services pursuant to the Contract to likewise utilize the U.S. Department of Homeland Security’s E-Verify system to verify the employment eligibility of all new employees hired by the subcontractor during the contract term. Alternatively, Contractor shall provide proof that one of the exceptions to the E-Verify federal contractor rule applies.

8.15 INTERNATIONAL PROPOSER REQUIREMENTS

The City is unable to send ACH payments to international banks. Therefore, ACH payments will only be made to U.S.A. banks. Additionally, the international company must be from a country that has a tax treaty with the U.S.A. International proposers must agree to these requirements and provide proof of same should they receive an award recommendation.

8.16 SPECIALITY FUNDING, IF APPLICABLE INTENTIONALLY LEFT BLANK

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PART 9 – SAMPLE CONTRACT

THIS CONTRACT ("Contract"), entered into on the ____ day of _____, 20__ between the CITY OF GAINESVILLE, a Florida municipal corporation, ("City"), and _____, ("Contractor"), , taken together, shall be known as "Parties".

WHEREAS, clauses that briefly describe project and history of project (if applicable)

NOW, THEREFORE, in consideration of the foregoing premises and the mutual covenants contained herein, the Parties agree as follows:

1. EFFECTIVE DATE AND TERM OF CONTRACT.

The term of the Contract shall be effective on **insert date** and shall expire **September 30, 2026**, unless otherwise terminated pursuant to this Contract. The Contract may be extended, upon mutual agreement of the Parties.

2. SCOPE OF SERVICES.

Complete an ecological analysis of the City of Gainesville's (CITY) urban forest, public and private; complete a detailed tree inventory of all City of Gainesville owned trees, and to estimate change in the overall canopy coverage in Gainesville from 1995-2023, as more specifically described in the Specifications.

3. CONTRACT DOCUMENTS.

A. The Contract consists of the following documents, whether attached to this Contract or incorporated by reference (collectively the 'Contract Documents'):

- i. Contract;
- ii. Addenda to Bid Documents (*attach and identify by title, number and date*);
- iii. Bid Documents (*attach and identify by title, number and date*); and
- iv. Contractor's response to Bid documents (*attach and identify by title, number and date*).

B. The Contract Documents constitute the entire contract between the City and Contractor. In the event of conflict or inconsistency between the Contract Documents, the order of precedence for interpretation shall be the order in which the Contract Documents are listed above. Conflict or inconsistency within a particular contract document shall be resolved by having the more specific reference to the matter prevail.

4. DELIVERY SCHEDULE: (*to be included for goods*)

The delivery schedule is hereby defined as the period which will elapse between receipt of a purchase order and the arrival of the materials or equipment at the designated point of delivery. Meeting specified delivery schedules is of the essence of this Contract and is a significant part of the performance of the Contract. Failure to meet such schedules may result in Termination of the Contract as described in Paragraph 10 of this Contract.

A DELIVERY LOCATION:

All materials or equipment shall be bid F.O.B. Gainesville, Florida.

B. DELAY

Notwithstanding the delivery schedule, the City shall have the right to delay the delivery for up to three months as necessary or desirable and such delay shall not be deemed a breach of contract, but the delivery schedule shall be extended for a period equivalent to the time lost by reason of the City's delay.

If the project for which the delivery is required is stopped or delayed for more than three months, either in whole or in substantial part, and either the City or Contractor elects to terminate the Contract because of such delay, if such stoppage or delay is due to actions taken by the City within its control, Contractor's sole remedy under the Contract shall be reimbursement for costs reasonably expended in preparation for or in performance of the work to the date of termination.

[OR]

4. TIME FOR PERFORMANCE *(To be included for services, if needed)*

The Parties agree that time is of the essence for the Scope of Services. Contractor shall complete the work on or before [date].

[OR]

4. PARAGRAPH INTENTIONALLY OMITTED.

[In some contracts, there is no need to put a provision in for completion. For instance, if you have hired a janitorial service on an annual contract, there would not be a need to have a time of performance or completion date]

5. COMPENSATION/PAYMENT.

City will pay Contractor in an amount of (\$amount bid if lump sum or budget amount if annual agreement) for the term of the contract. Payment shall be based upon completion of each Task 1, 2, 3, and 5. For Task 4 payment will be made at 25%, 50%, 75% and 100% completion. For Task 5 a completed report for the Ecological Analysis; and a completed report for the Inventory must be provided. *(describe whether City is paying on an hourly basis, or for a percentage of work completed, amount of material delivered or some other measurement).*

City shall make payments in accordance with the Local Government Prompt Payment Act, Sections 218.70, et. seq. Florida Statutes. Contractor will be paid electronically as an electronic funds transfer (EFT).

6. INDEMNIFICATION.

Contractor shall indemnify the City, its officials, agents and employees, and hold it harmless from suits, actions, damages, liability, expenses, losses and costs, including, but not limited to reasonable attorney's fees in connection with loss of life, bodily or personal injury, or property damage arising from or occasioned by any act or omission or negligence or intentional wrongdoing on the part of the Contractor and other persons employed or utilized by the Contractor.

[OR]

6. INDEMNIFICATION. *(To be included for Professional Design Services, if needed)*

In accordance with Florida Statute 725.08, "The design professional shall indemnify and hold harmless the agency, and its officers and employees, from liabilities, damages, losses, and costs, including, but not limited to, reasonable attorneys' fees, to the extent caused by the negligence, recklessness, or intentionally wrongful conduct of the design professional and other persons employed or utilized by the design professional in the performance of the contract."

7. ANTI-DISCRIMINATION.

CONTRACTOR shall not discriminate on the basis of race, color, religion, gender, national origin, marital status, sexual orientation, age, disability or gender identity, or other unlawful forms of discrimination in the performance of this Contract. CONTRACTOR understands and agrees that a violation of this clause shall be considered a material breach of this Contract and may result in termination of the Contract. This clause is not enforceable by or for the benefit of, and creates no obligation to, any third party.

8. INSURANCE. *(Check with risk for amount if Professional Liability is applicable)*

A. During the term of this Contract, Contractor shall maintain insurance as follows:

Workers' Compensation insurance	providing coverage in compliance with Florida Statutes
---------------------------------	--

Professional Liability insurance

[\$contact risk] per occurrence combined
single limit for bodily injury and property
damage

Public Liability insurance
(other than automobile) consisting of
broad form comprehensive general liability
insurance including contractual coverage

\$1,000,000 per occurrence combined single
limit for bodily injury and property damage

Automobile Liability insurance

\$500,000 per occurrence combined single
limit for bodily injury and property damage

B. Prior to the effective date of this Contract, Contractor shall provide to City a certificate of insurance certifying such insurance and naming City as additional insured and that City will be notified in writing at least thirty (30) days before any such insurance is canceled or materially changed.

C. Insurance must be written by a company licensed to do business in the State of Florida and satisfactory to City.

9. SOVEREIGN IMMUNITY.

Nothing in the Contract Documents shall be interpreted as a waiver of the City's sovereign immunity as granted under Section 768.28, Florida Statutes.

10. LIVING WAGE.

The definitions, terms and conditions of the city's living wage requirements set forth in Division 2 of Article IX of Chapter 2 of the City's Code of Ordinances shall apply to this agreement. These requirements include that the service contractor/subcontractor: shall pay a living wage to each covered employee during the term of this agreement, including any extension(s) to this agreement; shall maintain records sufficient to demonstrate compliance with the living wage requirements; shall not discharge, reduce the compensation of, or otherwise retaliate against any covered employee for filing a complaint, participating in any proceedings or otherwise asserting the requirement to pay a living wage; shall cooperate with any city audit or investigation concerning compliance with or a reported violation of the living wage requirements, including providing all requested documentation. Failure to comply with the City's living wage requirements shall be a material breach of this agreement, enforceable by the city through all rights and remedies at law and equity.

11. TERMINATION.

A. If the Contractor fails to observe or perform in accordance with the Contract Document (a "Default"), then the City, after providing at least ten (10) days written notice to the Contractor of the Default and the City's intent to terminate if such Default continues unremedied during the ten (10) day period, may terminate this Contract without prejudice to any other rights or remedies the City may have under this Contract and Florida law.

B. This Contract may be terminated by the City, without cause, upon thirty (30) days written notice to the Contractor. In the event this Contract is so terminated, the Contractor shall be compensated for services rendered through the effective date of the termination.

12. MULTI-YEAR CONTRACT.

The obligations of the City as to any funding required pursuant to this Contract shall be limited to an obligation in any given year to budget and appropriate from legally available funds, after monies for essential City services have been budgeted and appropriated, sufficient monies for the funding that is required during that year. Notwithstanding the foregoing, the City shall not be prohibited from pledging any legally available non-ad valorem revenues for any obligations heretofore or hereafter incurred, which pledge shall be prior and superior to any obligation of the City pursuant to this Contract.

13. INDEPENDENT CONTRACTOR.

Contractor shall be considered an independent contractor and as such shall not be entitled to any right or benefit to which City employees are or may be entitled to by reason of employment. Except as specifically noted in the Contract Documents, Contractor shall be solely responsible for the means, method, techniques, sequences, and procedures utilized by the Contractor for the full performance of the Contract Documents.

14. INTELLECTUAL PROPERTY AND WORK PRODUCT.

A. Ownership and Publication of Materials. All reports, information, data, and other materials prepared by the Contractor pursuant to the Contract Documents, except those separately identified in the Scope of Services or in other written agreements between the Parties, are owned by the City. The City has the exclusive and unrestricted authority to release, publish or otherwise use, in whole or in part, information contained therein and relating thereto. No material produced in whole or in part under the Contract Documents may be copyrighted or patented in the United States or in any other country without prior written approval of the City.

B. Intellectual Property. Contractor warrants that it owns or has rights to use all intellectual property used for the scope of each project, including patent rights, copyrights, or other intellectual property rights, except with respect to designs, processes or products of a particular manufacturer expressly required by the City [or process or product is an infringement of a patent, copyright or other intellectual property, the Contractor shall promptly give City [and Professional if applicable] written notice of the infringement.

15. RECORDS AND RIGHT-TO-AUDIT.

Contractor shall maintain records sufficient to document completion of the scope of services established by the Contract Documents. These records shall be subject at all reasonable time to review, inspect, copy and audit by persons duly authorized by the City. These records shall be kept for a minimum of three (3) years after termination of the Contract. Records that relate to any litigation, appeals or settlements of claims arising from performance under this Contract shall be made available until a final disposition has been made of such litigation, appeals, or claims

16. CONTRACTOR'S ASSURANCES.

Contractor warrants that the goods and services supplied to the City pursuant to this Contract shall at all times fully conform to the specifications set forth in the Invitation to Bid and be of the highest quality. In the event the City, in the City's sole discretion, determines that any product or services supplied pursuant to this Contract is defective or does not conform to the specifications set forth in the Invitation to Bid, the City reserves the right unilaterally to cancel an order or cancel this Contract upon written notice [and an opportunity to cure if applicable] to the Contractor, and reduce commensurately any amount of money due the Contractor.

17. WARRANTY.

[are there specific warranties requested in the bid? If so, list them here or reference them here]

18. PUBLIC RECORDS.

Florida has a very broad public records law and certain records of a contractor may be considered public records. Accordingly, by entering into an agreement with the City, contractor must:

1. Keep and maintain public records required by the public agency to perform the service.
2. Upon request from the public agency's custodian of public records, provide the public agency with a copy of the requested records or allow the records to be inspected or copied within a reasonable time at a cost that does not exceed the cost provided in this chapter or as otherwise provided by law.
3. Ensure that public records that are exempt or confidential and exempt from public records disclosure requirements are not disclosed except as authorized by law for the duration of the contract term and following completion of the contract if the contractor does not transfer the records to the public agency.
4. Upon completion of the contract, transfer, at no cost, to the public agency all public records in possession of the contractor or keep and maintain public records required by the public agency to perform the service. If the contractor transfers all public records to the public agency upon completion of the contract, the contractor shall destroy any duplicate public records that are exempt or confidential and exempt from public records disclosure requirements. If the contractor keeps and maintains public

records upon completion of the contract, the contractor shall meet all applicable requirements for retaining public records. All records stored electronically must be provided to the public agency, upon request from the public agency's custodian of public records, in a format that is compatible with the information technology systems of the public agency.

IF THE CONTRACTOR HAS QUESTIONS REGARDING THE APPLICATION OF CHAPTER 119, FLORIDA STATUTES, TO THE CONTRACTOR'S DUTY TO PROVIDE PUBLIC RECORDS RELATING TO THIS CONTRACT, CONTACT THE CUSTODIAN OF PUBLIC RECORDS AT (telephone number, e-mail address, and mailing address).

19. DISPUTE RESOLUTION

Except as otherwise provided in this Contract, any dispute concerning a question of fact or of interpretation of a requirement of the Contract which is not disposed of by mutual consent between the parties shall be decided by the City Manager or designee, who shall reduce the decision to writing and furnish a copy thereof to the parties. In connection with any dispute proceeding under this clause each party shall be afforded an opportunity to be heard and to offer evidence in support of its version of the facts and interpretation of the Contract. The City Manager or designee shall make such explanation as may be necessary to complete, explain or make definite the provisions of this Contract and the findings and conclusions shall be final and binding on both parties. Pending the final decisions of a dispute hereunder, Contractor shall proceed diligently with its performance of the Contract in accordance with the preliminary directions of the City Manager or designee.

20. FORCE MAJEURE (not needed if paragraph 4 is blank)

If the performance of the Contract is delayed by fire, lightning, earthquake, cyclone, or other such cause completely beyond the control of either the City or the Contractor, then the time for completion of the Contract shall be extended for a period equivalent to the time lost by reason of any of the aforesaid causes.

[OR]

20. PARAGRAPH INTENTIONALLY OMITTED

21. APPLICABLE LAW AND VENUE.

This Contract shall be governed by and construed in accordance with the laws of the State of Florida, notwithstanding any Florida conflict of law provision to the contrary. In the event of any legal action under this Contract, venue shall be in Alachua County, Florida.

22. DEFAULT AND REMEDIES.

The non-breaching party shall have available all remedies at law.

23. NOTICES.

Any notices from either party to the other party must be in writing and sent by certified mail, return requested, overnight courier service or delivered in person with receipt to the following:

CITY:

City of Gainesville
Insert Department Name
Attn:
Insert Address

CONTRACTOR:

Insert Contractor's Information

24. SEVERABILITY.

If any provision of this Contract is declared void by a court of law, all other provisions will remain in full force and effect.

25. INTEGRATION/MERGER.

This Contract, together with the attached bid documents, contains the entire contract and understanding of the Parties regarding the matters set forth herein and supersedes all previous negotiations, discussions, and understandings, whether oral or written, regarding such matters. The Parties acknowledge that they have not relied on any promise, inducement, representation, or other statement made in connection with this agreement that is not expressly contained in this Contract. The terms of this Contract are contractual and not merely recital.

26. MODIFICATION AND WAIVER.

The provisions of this Contract may only be modified or waived in writing signed by all the Parties. No course of dealing shall be deemed a waiver of rights or a modification of this Contract. The failure of any party to exercise any right in this contract shall not be considered a waiver of such right. No waiver of a provision of the Contract shall apply to any other portion of the Contract. A waiver on one occasion shall not be deemed to be a waiver on other occasions.

27. CAPTIONS AND SECTION HEADINGS.

Captions and section headings used herein are for convenience only and shall not be used in construing this Contract.

28. ASSIGNMENT OF INTEREST.

Neither party will assign or transfer any interest in the Contract without prior written consent of the other party.

29. SUCCESSORS AND ASSIGNS.

The Parties each bind the other and their respective successors and assigns in all respects to all the terms, conditions, covenants, and provisions of this Contract.

30. THIRD PARTY BENEFICIARIES.

This Contract does not create any relationship with, or any rights in favor of, any third party.

31. CONSTRUCTION.

This Contract shall not be construed more strictly against one party than against the other merely by virtue of the fact that it may have been prepared by one of the Parties. It is recognized that both Parties have substantially contributed to the preparation of this Contract.

32. EXHIBITS.

All exhibits attached to this Contract are incorporated into and made part of this Contract by reference.

IN WITNESS WHEREOF, the Parties hereto have executed this Agreement, or caused to be executed by their duly authorized officials, on the day and year first written above.

NAME OF COMPANY:

CITY OF GAINESVILLE:

Signature: _____

Signature: _____

Print Name: _____

Print Name: _____

Title: _____

Title: _____

Date: _____

Date: _____

APPROVED AS TO FORM AND LEGALITY

City Attorney

PART 10 – EXHIBITS

The following documents/forms are included in this section:

- Drug-Free Workplace Form
- Bidder Verification Form
- Reference Form

DRUG-FREE WORKPLACE FORM

The undersigned bidder in accordance with Florida Statute 287.087 hereby certifies that

does:

(Name of Bidder)

1. Publish a statement notifying employees that the unlawful manufacture, distribution, dispensing, possession, or use of a controlled substance is prohibited in the workplace and specifying the actions that will be taken against employees for violations of such prohibition.
2. Inform employees about the dangers of drug abuse in the workplace, the business's policy of maintaining a drug-free workplace, any available drug counseling, rehabilitation, and employee assistance programs, and the penalties that may be imposed upon employees for the drug abuse violations.
3. Give each employee engaged in providing the commodities or contractual services that are under bid a copy of the statement specified in subsection (1).
4. In the statement specified in subsection (1), notify the employees that, as a condition of working on the commodities or contractual services that are under bid, the employee will abide by the terms of the statement and will notify the employer of any conviction of, or plea of guilty or nolo contendere to, any violation of Chapter 893 or of any controlled substance law of the United States or any state, for a violation occurring in the workplace no later than five (5) days after such conviction.
5. Impose a sanction on, or require the satisfactory participation in a drug abuse assistance or rehabilitation program if such is available in the employee's community, by any employee who is so convicted.
6. Make a good faith effort to continue to maintain a drug-free workplace through implementation of this section.

As the person authorized to sign the statement, I certify that this bidder complies fully with the above requirements.

Bidder's Signature

Date

In the event of a tie bid, bidders with a Drug Free Workplace Program will be given preference. To be considered for the preference, this document must be completed and uploaded to DemandStar.com with your Submittal.

BIDDER VERIFICATION FORM

LOCAL PREFERENCE (Check one)

Local Preference requested: ☐ YES ☐ NO

A copy of your ***Business Tax Receipt*** must be included in your submission if you are requesting Local Preference:

QUALIFIED SMALL BUSINESS AND/OR SERVICE DISABLED VETERAN BUSINESS STATUS (Check one)

Is your business qualified, in accordance with the City of Gainesville's Small Business Procurement Program, as a local Small Business? ☐ YES ☐ NO

Is your business qualified, in accordance with the City of Gainesville's Small Business Procurement Program, as a local Service-Disabled Veteran Business? ☐ YES ☐ NO

REGISTERED TO DO BUSINESS IN THE STATE OF FLORIDA

Is Bidder registered with Florida Department of State's, Division of Corporations, to do business in the State of Florida?

☐ YES ☐ NO (refer to Part 1, 1.6, last paragraph)

If the answer is "YES", provide a copy of SunBiz registration or SunBiz Document Number (# _____)

If the answer is "NO", please state reason why: _____

Bidder's Name

Printed Name/Title of Authorized Representative

Signature of Authorized Representative

Date

REFERENCE FORM

Name of Bidder: _____

Provide information for three references of similar scope performed within the past 3 years. You may include photos or other pertinent information.

#1 Year(s) services provided (i.e. 1/2015 to 12/2018): _____

Company Name: _____
Address: _____
City, State Zip: _____
Contact Name: _____
Phone Number: _____ Fax Number: _____
Email Address (if available): _____

#2 Year(s) services provided (i.e. 1/2015 to 12/2018): _____

Company Name: _____
Address: _____
City, State Zip: _____
Contact Name: _____
Phone Number: _____ Fax Number: _____
Email Address (if available): _____

#3 Year(s) services provided (i.e. 1/2015 to 12/2018): _____

Company Name: _____
Address: _____
City, State Zip: _____
Contact Name: _____
Phone Number: _____ Fax Number: _____
Email Address (if available): _____

PART 11 – NO BID SURVEY

GENERAL GOVERNMENT PROCUREMENT DIVISION SURVEY BID INFORMATION

RFP #: PWDA-230046-DH

DUE DATE: June 22, 2023
@ 3:00 pm

PROPOSAL TITLE: Ecological Analysis and Tree Inventory

IF YOU DO NOT BID

If you choose to not bid, please complete this form, and either upload it into DemandStar.com or email to the procurement specialist. Your responses will assist the City in developing future solicitations, your responses will remain anonymous and will be aggregated into a spreadsheet for analysis purposes only.

Check the appropriate responses and provide additional information that may help the City develop future solicitations.

1. _____ The solicitation time-frame was too short
2. _____ My company did not learn of this solicitation until it was too late to develop a response
3. _____ My company's work load did not allow time to develop a submittal
4. _____ If awarded, my company's work load could not support this project
5. _____ Specifications were not clear
6. _____ My company does not handle this type of work
7. _____ My company does not submit responses to Municipalities
8. _____ Have experienced delays in payments from Government agencies in the past
9. _____ Is there anything the City could have done differently in the solicitation package to prompt your company to submit a proposal?
Explain: _____
10. _____ If the City were to rebid this solicitation, would your company be interested in responding?
11. _____ Please provide any additional information regarding this solicitation that may help us develop our next steps in fulfilling the City's needs for this project.

Bidder Name: _____

Address: _____

Is your company a certified City of Gainesville small business? ☐ YES ☐ NO

Is your company a certified City of Gainesville service-disabled veteran business? ☐ YES ☐ NO

**City of
Gainesville
Urban Forest
Ecological
Analysis
2016**



City of Gainesville Urban Forest Ecological Analysis 2016

Final Report to the City of Gainesville
March 2017

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Special Thanks

Joe Wolf, Gainesville Regional Utilities
Geoff Parks, City of Gainesville PRCA
Landowners and residents of Gainesville

Citation for this report:

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

Photos by Caroline Hament and David Fox

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Executive Summary

Economic Values:

- Compensatory value: \$1.4 billion.
- Total savings from urban forest benefits: \$24.4 million/year.
- Residential heating and cooling savings: \$7.7 million/year.
- Avoided air pollution abatement value: \$2.7 million/year.
- Public health savings: \$2.66 million/year.
- Carbon sequestration: 44,200 tons of carbon per year (\$5.88 million/year).
- Carbon storage: 746,000 tons of carbon (\$99.2 million).
- Avoided stormwater costs: \$3.8 million/year.

Ecological Structure:

- Number of trees*: 7.2 million.
- Tree canopy cover: 47%.
- Number of species identified: 173 (97 in tree stratum; 153 in shrub stratum).
- Loblolly pine, slash pine, laurel oak, water oak, and red maple make up over half of Gainesville's urban forest.
- Over 94% of tree species identified are native to Florida.
- Average density: 178 trees per acre.
- 60% of trees in Gainesville are less than 6 inches in diameter.
- 80% of trees are in excellent or good condition, 11% in fair health, and 9% in poor condition or dead.
- 30% of the city is covered by shrubs.
- 24% of the City is covered by impervious surfaces; 23% is covered by maintained grass.

*Trees in this study are woody stems ≥ 1 " diameter at breast height (DBH).



Ecological Assessment



This ecological assessment provides a detailed look into some of the economic and ecological values of the City of Gainesville's urban forest. The outcomes from this study can serve as the basis for:

- enhancing the understanding of the urban forest's values
- improving urban forest policies
- urban forest planning and management
- providing empirical data for the inclusion of trees within environmental regulations

During spring to early fall of 2016, one hundred and seventy-seven plots were sampled and analyzed to quantify the vegetation structure, functions, and values of the urban forest in Gainesville. This report documents the methods used and a discussion of results from these analyses.

Methods

In order to capture a representative sample of the urban forest across broad land use categories, a systematic random sampling design was used to achieve a geographic distribution of inventory plots throughout the city. Using geographic information system (GIS) tools, a hexagonal grid was projected onto a map of the city; each full hexagon represented approximately 200 acres (Figure 1). One sample point was randomly located within each hexagon. The latitude and longitude was acquired from the GIS for each point to aid in plot establishment and data collection. 177 plots were randomly sampled (Table 1). GIS land use and tax parcel data were acquired from the City (Appendix A). Broad land use categories were generalized from these spatial data sets (Table 1 and Figure 2).

With this systematic sampling, the percentage of plots that fall into each land use was similar to the percent of Gainesville in each land use (Table 1). A comparatively small area of the City has an agricultural land use (pasture and wholesale nursery), and no sample plots fell in these areas (Figure 2). Over one-quarter of Gainesville is covered by forestland, about half of which is composed of pine plantations along the northern City boundary. The large *Industrial* area in the NW corner of the City includes lands surrounding the Deerhaven power plant while the large *Transportation* area in the eastern part of the City is the Gainesville Regional Airport (Figure 2). The land use that occupies the most acreage in the city is Residential (29%) (Table 1).

Data collection in the 177 plots began May 9 and ended October 21, 2016. Using the latitude and longitude values from the GIS, a fixed radius 1/10th acre ($r = 37.2$ ft) sample area was established at each plot center location. Plot center was documented with distances and directions to reference objects, which can be used to facilitate future plot reestablishment.

Three vertical strata of the urban forest were quantified at every sample plot: tree, shrub, and ground cover (Table 2). The tree stratum includes woody stems greater than or equal to 1 inch in diameter at breast height (DBH), measured 4.5 feet from the

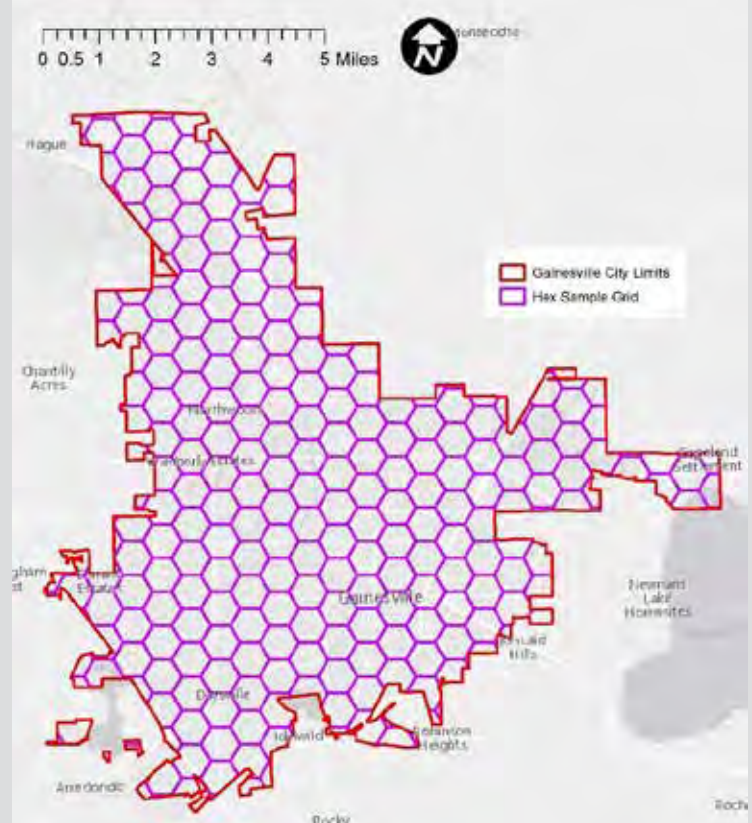


Figure 1. Study area map with sample grid overlay.

Land Use	Area (acres)	Percent of City	Number of Plots
Residential	11,792	28.9	48
Forested	11,098	27.2	35
Transportation	6,218	15.3	29
Public/Institutional	3,972	9.7	24
Industrial	2,973	7.3	13
Commercial	2,828	6.9	19
Open Space/Park	1,719	4.2	9
Agriculture	141	0.3	0
Gainesville	40,740	100	177

Table 1. Generalized land uses in the City of Gainesville, FL with number of sample plots per strata.

ground. The shrub stratum is made up of woody plants at least 1 foot tall but with stems less than 1 inch DBH. The ground cover stratum consists of woody or herbaceous vegetation less than 1 foot tall. Data was collected following the plot sampling protocol referenced in the 2017 i-Tree User's Manual (v6), Phase III found at www.itreetools.org.

Data collected also included the following:

- Percent cover of each stratum
- Identification of tree and shrub plant species
- Tree DBH
- Tree height
- Tree crown measurements
- Crown condition assessments
- Proximity of trees to buildings
- Tree crown light exposure index

Data was analyzed by the i-Tree Eco software tool (v6), formerly known as UFORE (Urban Forest Effects Model) (Nowak, Stevens, Sisinni, & Luley, 2002), which was created by the U.S. Forest Service. This tool is widely used throughout the U.S., Canada, Australia, and the U.K. Models within i-Tree Eco quantify the structure and following values of the urban forest:

- Compensatory value
- Residential heating and cooling savings
- Avoided air pollution abatement value
- Public health savings
- Carbon sequestration value
- Carbon storage value
- Avoided stormwater costs

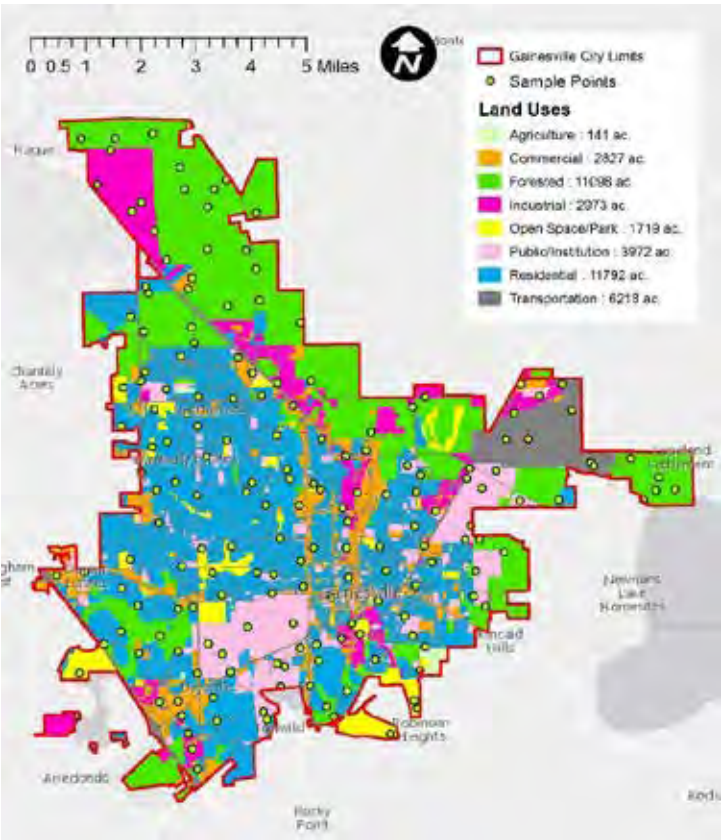
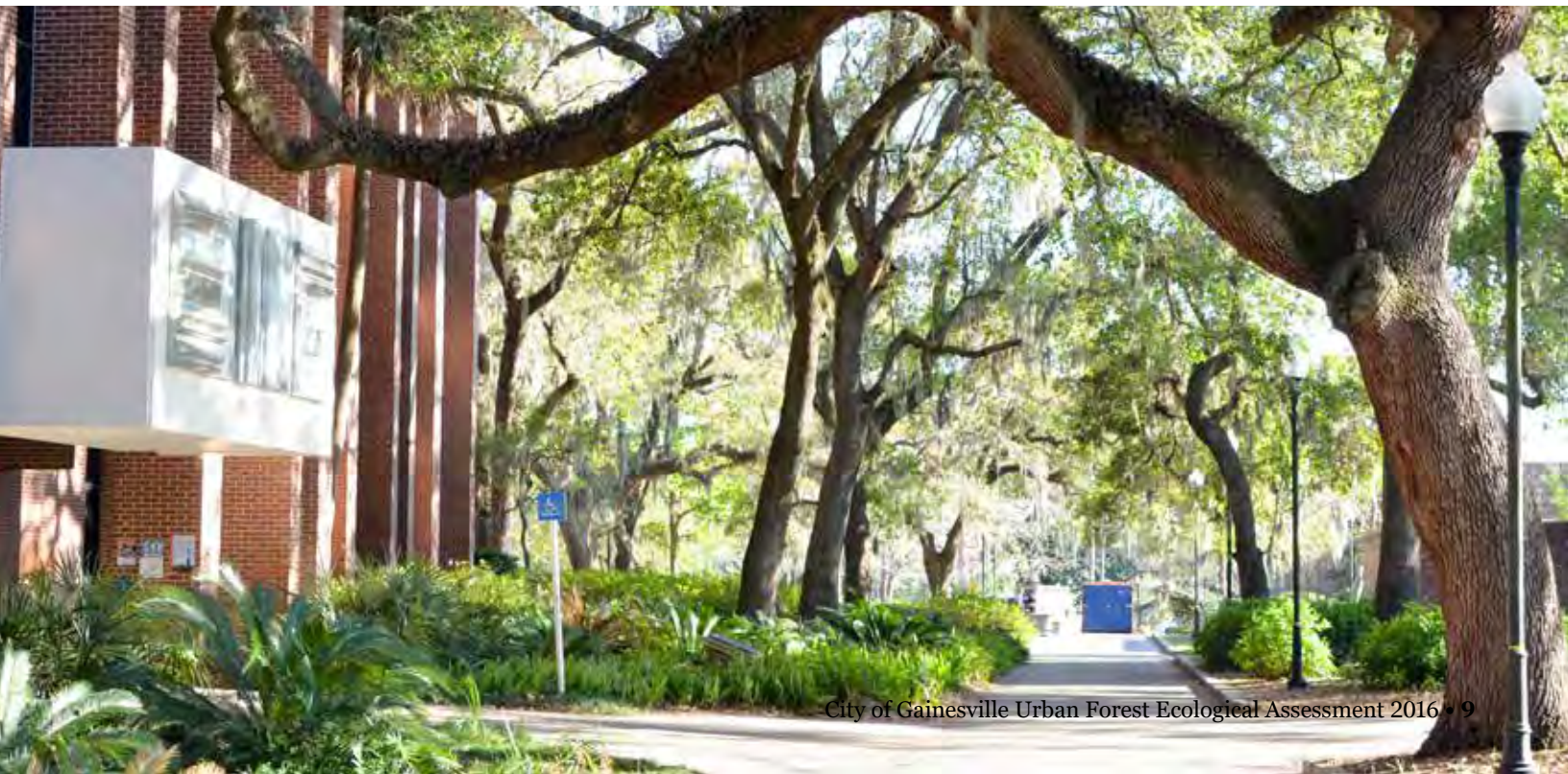


Figure 2. Generalized land use map of Gainesville, FL including sample plot locations.

Strata	Description
Tree	Woody stems ≥1" DBH
Shrub	Woody plants ≥1ft height; <1" DBH
Ground Cover	Woody or herbaceous vegetation <1ft height

Table 2. Description of each vertical stratum of the urban forest included in the i-Tree Eco sampling methodology.



Results



Gainesville is located in temperate north Florida. Many of the plant species found in Gainesville are specific to this climate zone (Plant Hardiness Zone 9a: average annual extreme minimum temperatures between 20-25° F) and are not found further south in the sub-tropical regions of the state. Typical forest types in this region include mixed pine and mixed hardwood uplands and cypress/gum wetlands. Remnants of these forest types were found within the city limits. Southern pine timber production is also common in northern Florida, and the City of Gainesville contains some active production forests.

Diversity

For the purpose of this study, species diversity is the number of species present. Diversity can be used as an indicator for vulnerability or resilience to natural disturbances such as insect and disease outbreaks. In this study, 173 species were identified in the City of Gainesville. Of these, 97 species were identified in the tree stratum (woody stems ≥ 1 " DBH) and 153 species in the shrub stratum (woody plants ≥ 1 ft height; < 1 " DBH) (Appendix B). The land use category with the greatest diversity is *Residential* (70 species), as homeowners typically plant a broader suite of tree species than may be found in other urban areas. The land use category with the lowest number of species is *Industrial* (21 species). By comparison, 42 tree species were identified in the *Forested* land use (Figure 3).

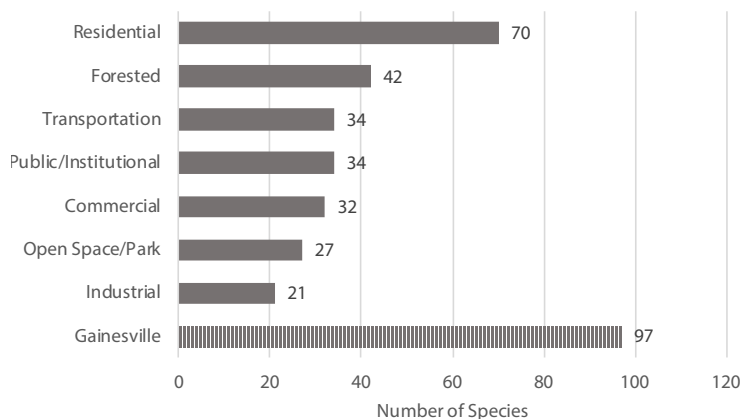


Figure 3. Comparison of the number of tree species by land use designation.



Tree Population

There are an estimated 7.2 million trees in the City of Gainesville, comprised of 97 species. The 10 most common tree species, representing 70% of the population are loblolly pine (*Pinus taeda*), slash pine (*Pinus elliot-tii*), laurel oak (*Quercus laurifolia*), water oak (*Quercus nigra*), red maple (*Acer rubrum*), Carolina laurel cherry (*Prunus caroliniana*), sweetgum (*Liquidambar styraci-flua*), wax myrtle (*Morella cerifera*), swamp tupelo (*Nys-sa biflora*), and sugarberry (*Celtis laevigata*) (Figures 4 and 5). All of these species are common in natural plant communities, described by the Florida Natural Areas Inventory (FNAI), found in this geographical region. Loblolly and slash pines represent 28% of the trees in this inventory due to the large acreage of pine plantations within the City. Relative to other cities in Florida, it is notable that Gainesville’s urban forest is not dominated by any invasive tree species.

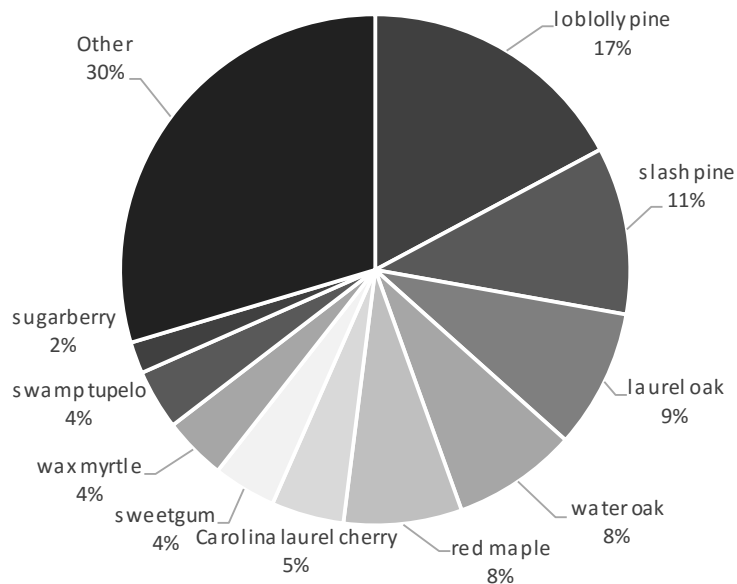


Figure 4. Top ten tree species as a percentage of the total tree population in Gainesville, FL.



Figure 5. Top ten tree species in the City of Gainesville.





Carolina Laurel Cherry
Prunus caroliniana



Sweetgum
Liquidambar styraciflua



Wax Myrtle
Morella cerifera



Swamp Tupelo
Nyssa biflora



Sugarberry
Celtis laevigata

Native and Non-Native Tree Species

Of the 97 tree species identified in the City, 65 are native to Florida, meaning they were found in Florida prior to European colonization in the 16th century. The remaining 32 species are non-native, meaning they were introduced outside of their native range. Of these non-native species, six were listed by the Florida Exotic Pest Plant Council (FLEPPC, 2016) as invasive (Table 3). Invasive species are those that spread into and dominate an area, and they negatively affect ecological functions of the forest. Five of these are considered Category I (CAT I) invasive species, which is a subset of the FLEPPC list indicating those species which have caused severe documented ecological damage.

Although other invasive species were found in the shrub and ground cover strata, the i-Tree sampling scheme does not capture the cover of these species.

Species	Common Name	Percent of Tree Population	Percent Leaf Area	Number of Plots Present
<i>Albizia julibrissin</i> *	Mimosa	0.14	0.16	3
<i>Broussonetia papyrifera</i>	Paper mulberry	0.24	0.06	1
<i>Cinnamomum camphora</i> *	Camphor tree	0.91	1.05	9
<i>Ligustrum lucidum</i> *	Glossy privet	0.19	0.14	4
<i>Syzygium cumini</i> *	Jambolan plum	0.02	<0.01	1
<i>Triadica sebifera</i> *	Chinese tallow	0.16	0.06	5

Table 3. Invasive tree species found in the City of Gainesville as defined by FLEPPC.

*CAT I Invasive Species

Forest Structure

Forest structure is the distribution of vegetation both horizontally and vertically. The following sections review physical attributes of the forest that were measured and calculated to determine forest structure: tree density, diameter distribution, forest health, urban forest cover, and leaf area. These metrics were ultimately used to quantify the ecological functions of Gainesville's urban forest.



Tree Density

Tree density is the number of trees per acre (TPA). The highest TPA is found in the *Forested* land use, where loblolly and slash pine are often planted at densities between 500 and 700 TPA. The *Residential* land use, which represents the most acreage in the city (Table 1) and has the highest number of species (Figure 3), has far fewer TPA. The lowest TPA is found on *Commercial* and *Transportation* lands (Figure 6), which make up 22% of the City.

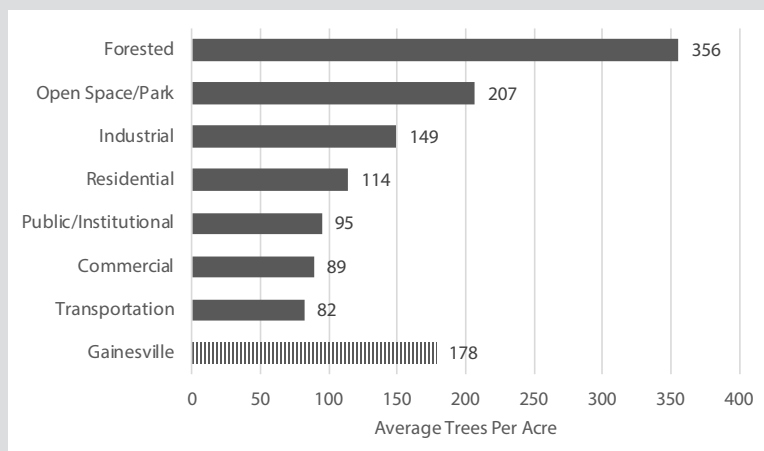


Figure 6. Comparison of average trees per acre (TPA) for each land use designation in Gainesville, FL.

Diameter Distribution of Trees

The diameter distribution of live trees in Gainesville is skewed toward smaller diameter classes (Figure 7). However, species within each class grow at different rates and have different maximum size potentials. For example, wax myrtle (*Morella cerifera*), which makes up 10% of the 1-3" diameter class (Table 4), grows quickly, but has a small maximum diameter and is short-lived. Loblolly pine (*Pinus taeda*), however, grows quickly, but has a large maximum diameter and is longer-lived. By comparison, live oak (*Quercus virginiana*), which makes up 25% of the largest diameter class (Table 4), grows relatively slowly, has the potential to get large, and is very long-lived. Only four of the 97 species identified in the City make up the largest diameter class (>30"), and 3 of the 4 are not present in the species that make up the majority of the smallest diameter class (Table 4).

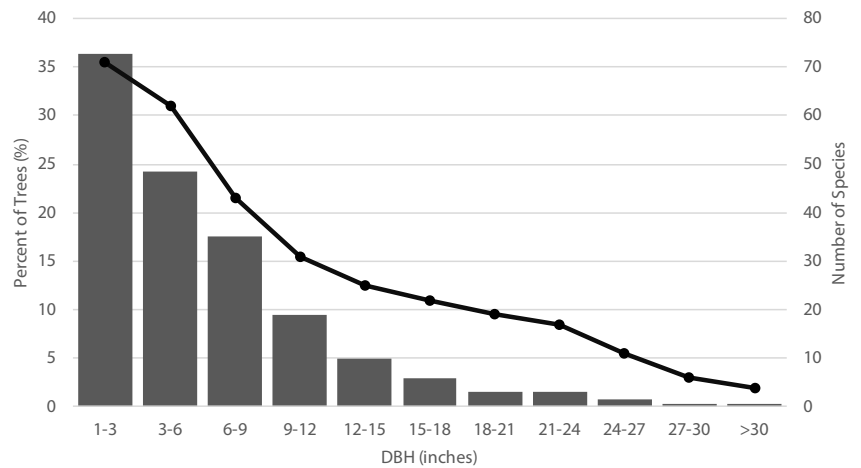


Figure 7. Comparison of diameter (DBH) distribution by diameter class (columns) with the number of species present in each diameter class (line).

Species	Percent of 1-3" DBH class	Species	Percent of >30" DBH class
Laurel oak	12%	Bald cypress	41%
Red maple	11%	Live oak	25%
Water oak	10%	Swamp tupelo	23%
Wax myrtle	10%	Sugarberry	11%
Carolina laurel cherry	9%	—	—
Loblolly pine	5%	—	—
Sweetgum	3%	—	—
Sugarberry	3%	—	—
Elderberry	2%	—	—
Dahoon	2%	—	—

Table 4. Ten species make up 68% of the 1-3" diameter class in Gainesville's urban forest. Four species make up the largest diameter class (>30").

Forest Health

The 2016 analysis indicates that approximately 80% of the trees are considered to be in excellent or good health, 11% are in fair health, and the remaining 9% are in poor condition or lower. Tree health was evaluated by land use. The i-Tree methodology to determine estimates of tree health is based on canopy condition assessments. These estimates of health do not reflect structural integrity. The highest percentage of healthy trees (defined as excellent and good categories) in Gainesville are those in *Public/Institutional* (85%), *Industrial* (81%), and *Forested* (81%) land uses (Figure 8). Approximately 71-81% of trees in *Commercial*, *Transportation*, and *Residential* land uses were in excellent or good health. A greater percentage of trees in *Commercial* areas were in fair condition (15%) than those in *Transportation* and *Residential* areas (8% and 11%). The lowest percentage of healthy trees occurs on *Open Space/Park* lands and the highest percentage of unhealthy or recorded dead trees fell on *Transportation*.

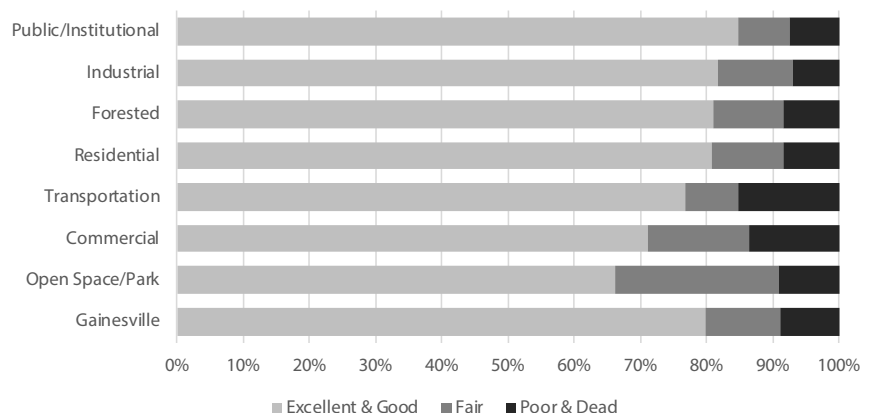


Figure 8. Condition of trees in Gainesville by land use designation.

Cover of Urban Forest Strata

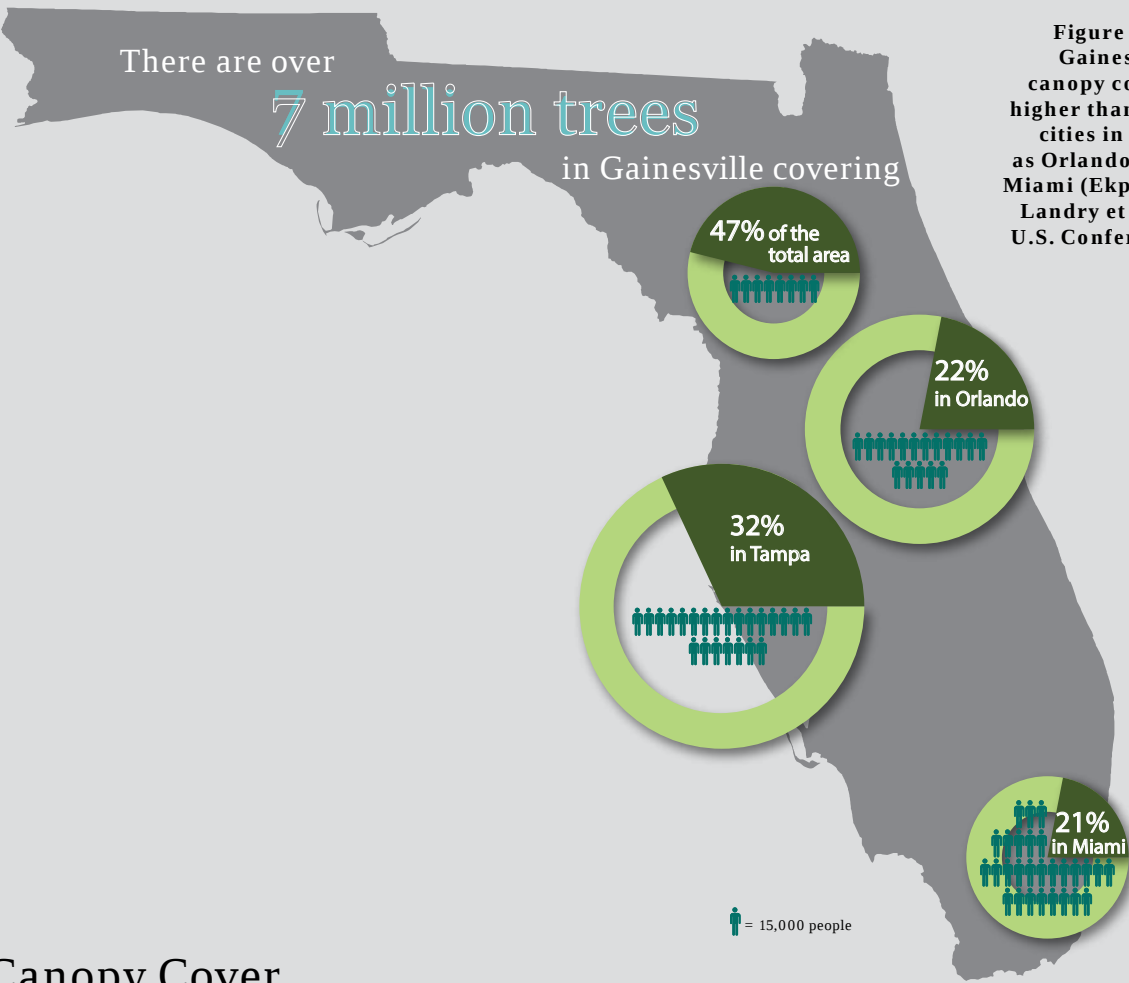


Figure 9. The City of Gainesville has 47% canopy cover, which is higher than other major cities in Florida, such as Orlando, Tampa, and Miami (Ekpe et al., 2012, Landry et al., 2011, and U.S. Conference of Mayors, 2008).

Tree Canopy Cover

Tree canopy cover is used to quantify the amount of land area under and around trees. Sometimes thought of as the “footprint” of the urban forest, ecologically, canopy cover influences microclimate (e.g. shade in parking lots and homes) as well as the interception of rainfall (stormwater flow) and air pollution abatement (Leff, 2016).

Based on Eco sample plot data collected, the estimated average tree canopy cover of Gainesville is 47% (Figure 9), but it is spatially variable across land uses (Figure 10). Tree cover is greatest in *Forested* areas (71%) and lowest in *Industrial* areas (25%). The *Residential* (44%) and *Open Space/Park* (44%) land uses were nearly at the Gainesville average (Figure 10) and together represent 33% of the City (Table 1).

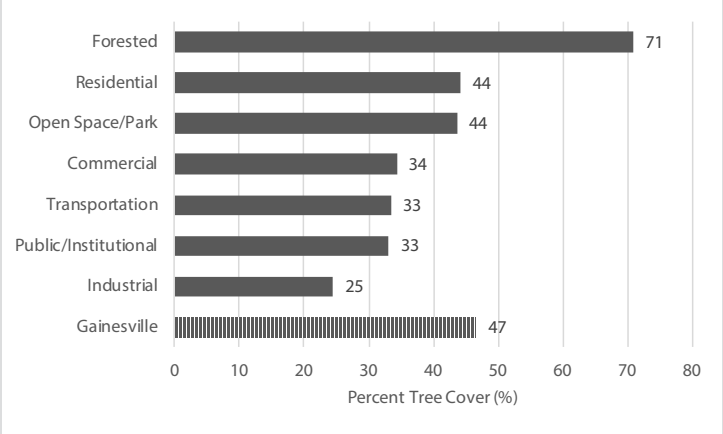


Figure 10. Percent tree cover by land use in the City of Gainesville.

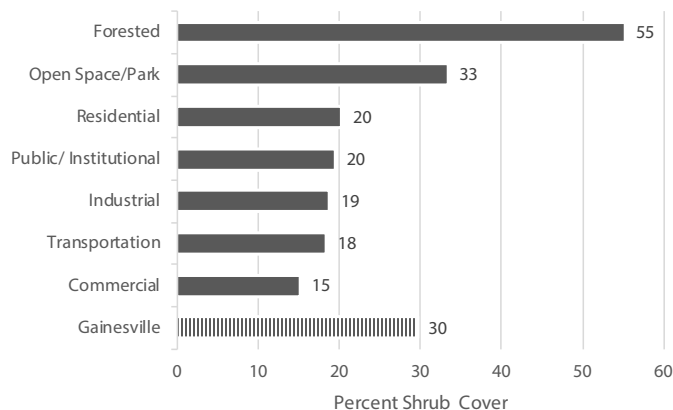


Figure 11. Percent shrub cover by land use designation in the City of Gainesville.

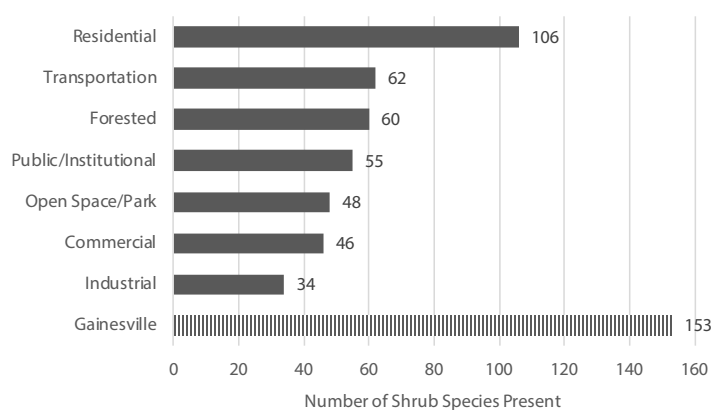


Figure 12. Number of shrub species present in each land use designation.

Shrub Cover

Shrub cover is often overlooked and undervalued as a component of the urban forest. Like tree cover, it is an estimate of the amount of area in the urban forest covered by the shrub stratum (comprised of woody plants at least 1 foot in height and less than 1 inch DBH). The shrub stratum provides additional leaf area and some of the same benefits as trees. Because the tree and shrub layers are in overlapping strata their cover estimates are not additive.

In Gainesville approximately 30% of the city is covered with shrubs (Figure 11), comprised of 153 species (Figure 12). The *Forested* land use has the greatest shrub cover (55%) and is comprised of 60 species. By comparison, the *Residential* land use has much less cover (20%), but has the highest number of species present (106 species).





Leaf Area

Leaf area (LA) is a three-dimensional measure of the total green leaf surface area on a tree or shrub. This differs from canopy cover, a two-dimensional measure, because it is calculated for each tree and shrub regardless of canopy position or overlap.

Leaf area is used in quantifying pollution removal and avoided runoff, as leaves are responsible for wind, solar, and water interception. The i-Tree Eco model calculates leaf area of individual species using regression equations and takes into consideration tree condition.

The tree species with the greatest LA in Gainesville were loblolly pine (20%) and slash pine (15%), which were also the most dominant tree species in the urban forest based on the number of trees (Table 5). However, not all species followed this pattern. Live oak represented only 1% of the total tree population, yet 4% of the LA. Many of the species that make up majority of the City’s LA are common in forested wet-land plant communities described by FNAI.

Since leaf area is a crucial factor in quantifying the benefits of the urban forest, leaf area by land use was also considered. The land use with the highest percentage of the City’s LA was *Forested* (44%) (Figure 13). The *Residential* land use, which takes up the greatest percentage of the City, had 26% of the City’s LA. *Industrial*, *Open Space/Park*, and *Commercial* areas had the smallest proportion of the City’s LA (3%, 4%, and 5%), but also account for the smallest portion of Gainesville’s total acreage (Figure 13).

Species	Leaf Area (%)
Loblolly pine	20%
Slash pine	15%
Water oak	8%
Laurel oak	7%
Red maple	6%
Sweetgum	5%
Live oak	4%
Bald cypress	4%
Swamp tupelo	3%
Sugarberry	3%

Table 5. Species with the most leaf area (LA) in Gainesville.

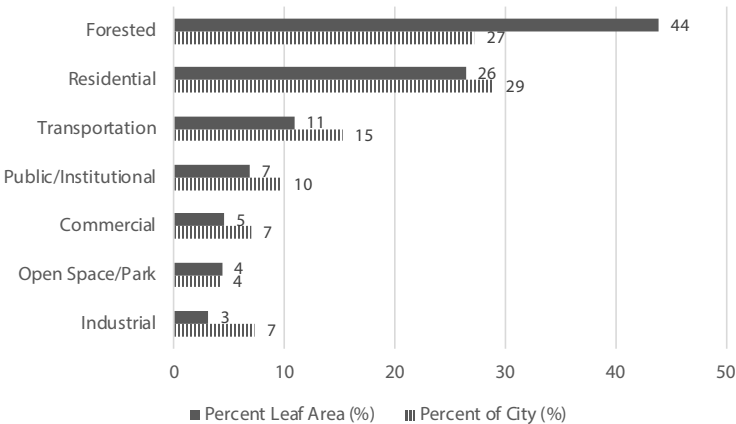


Figure 13. Distribution of leaf area by land use and the percentage of the City represented by each land use.

Ground Cover

The groundcover stratum is made up of the surfaces covering the ground including herbaceous and woody vegetation less than 1 foot tall. Ground cover is divided into two broad categories: impervious (e.g. roads, rooftops, and sidewalks) and pervious (e.g. lawns, gravel driveways, mulched beds, and ponds) surfaces. The groundcover type likely determines whether rainfall will seep into the ground or be diverted as stormwater runoff.

Urbanization tends to increase the amount of impervious surface area in a city. In Gainesville, 23% percent of the ground cover in the city is impervious (Figures 14 and 15). The land use areas with the greatest amount of impervious surfaces are *Commercial* (66%), *Residential* (38%), and *Transportation* (32%) (Figure 14).

The land use categories with the greatest amount of pervious ground cover are *Forested* (99%) and *Open Space/Park* (97%) (Figure 14). Pervious surfaces were divided into seven categories (maintained grass, unmaintained grass, duff/mulch, herbs, bare soil, water, and rock) as each have different hydrological impacts (Figure 15). Much of the pervious surfaces in Gainesville are classified as maintained grasses or lawns (23%). In Florida approximately "one-third of the freshwater use is for municipal use, half of which is used to water lawns (Cervone, 2003)." The land uses with the highest percentage of maintained grass are *Transportation* (36%), *Public/Institutional* (34%), and *Residential* (34%) (Figure 14).

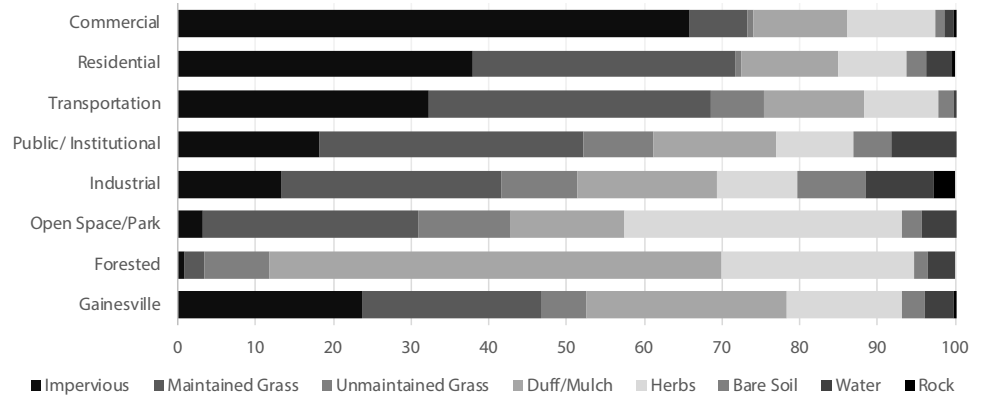


Figure 14. Proportional distribution of ground covers by land use in Gainesville.

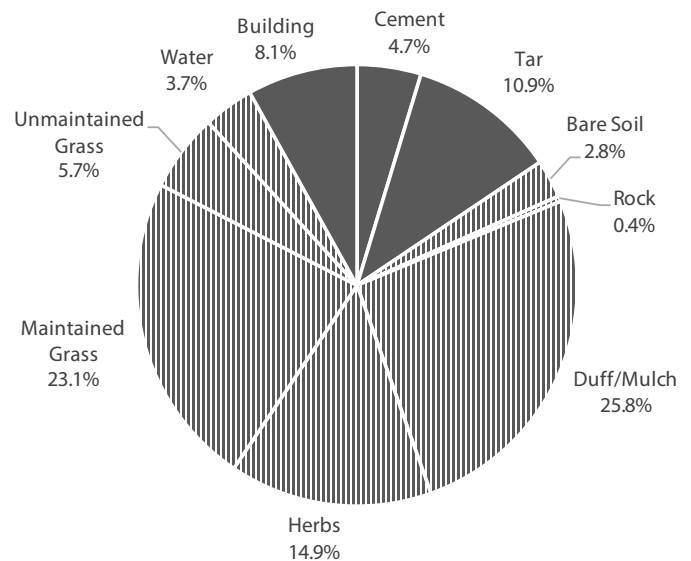


Figure 15. Distribution of ground cover types by percent in Gainesville.



Tree Cover Change

Independent of the i-Tree Eco plot-based analysis, an additional tree canopy analysis for the City of Gainesville was completed using remote sensing techniques. Landsat imagery and high-resolution aerial photography (NAIP) were used to examine tree canopy cover over the nineteen year period between 1996 and 2015 (see Appendix C for study methods). Landsat images are considered ‘moderate resolution’ having a 30-meter pixel size while the NAIP images are ‘high resolution’ having 1-meter pixels. While Landsat imagery was available for the entire study period, NAIP photography was only available between 2006 and 2015.

Landsat analysis results indicate a decrease in Gainesville tree canopy cover between 1996 and 2015. There was an overall net loss in tree canopy between 1996 and 2006 followed by a net gain from 2006 to 2015 (Table 6). The net gain was also indicated by the NAIP photography analysis. The distribution of canopy change from 1996 to 2015, from 1996 to 2006 and from 2006 to 2015 is shown in Figures 16, 17, and 18 respectively. Canopy gains and losses can be found throughout the City, and large concentrated areas of change can also be seen. From 1996 to 2006 large blocks of land in the northern portion of the city experienced losses and then showed canopy gains from 2006 to 2015. Much of this portion of the City is covered by production pine forests so the gains and losses can likely be attributed to timber harvest followed by reforestation activity.

Imagery Source	1996	2006	2015
Landsat	58%	46%	47%
NAIP	-	50%	54%

Table 6. Tree canopy cover by year for Gainesville measured using remote sensing.

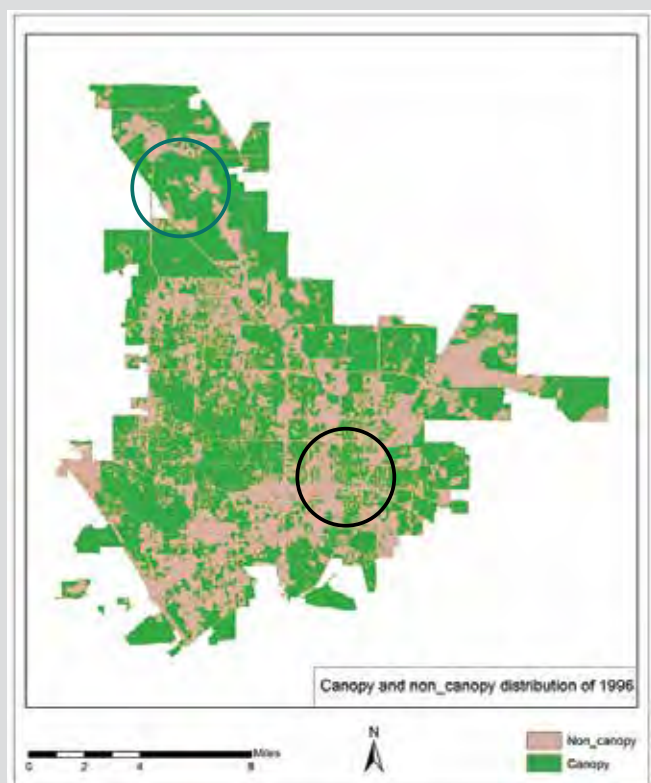


Figure 16. Canopy and non-canopy distribution of 1996 in the City of Gainesville.

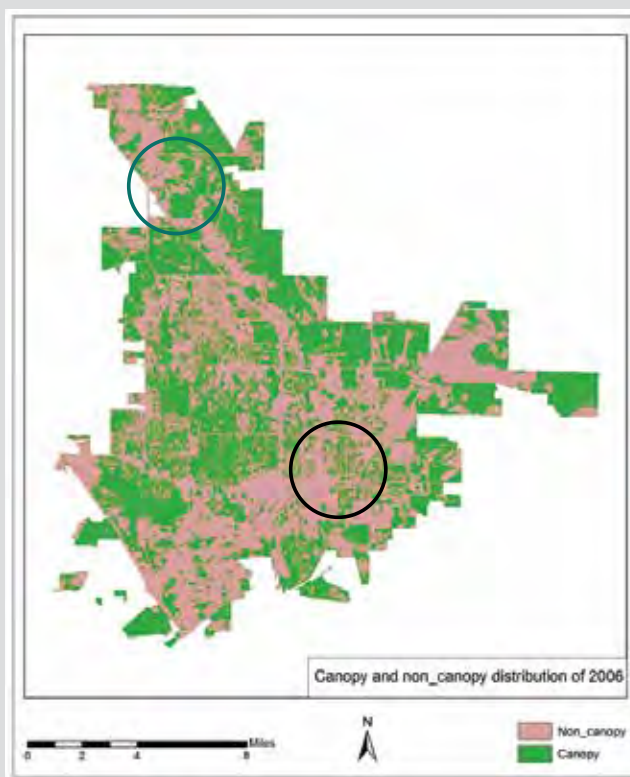
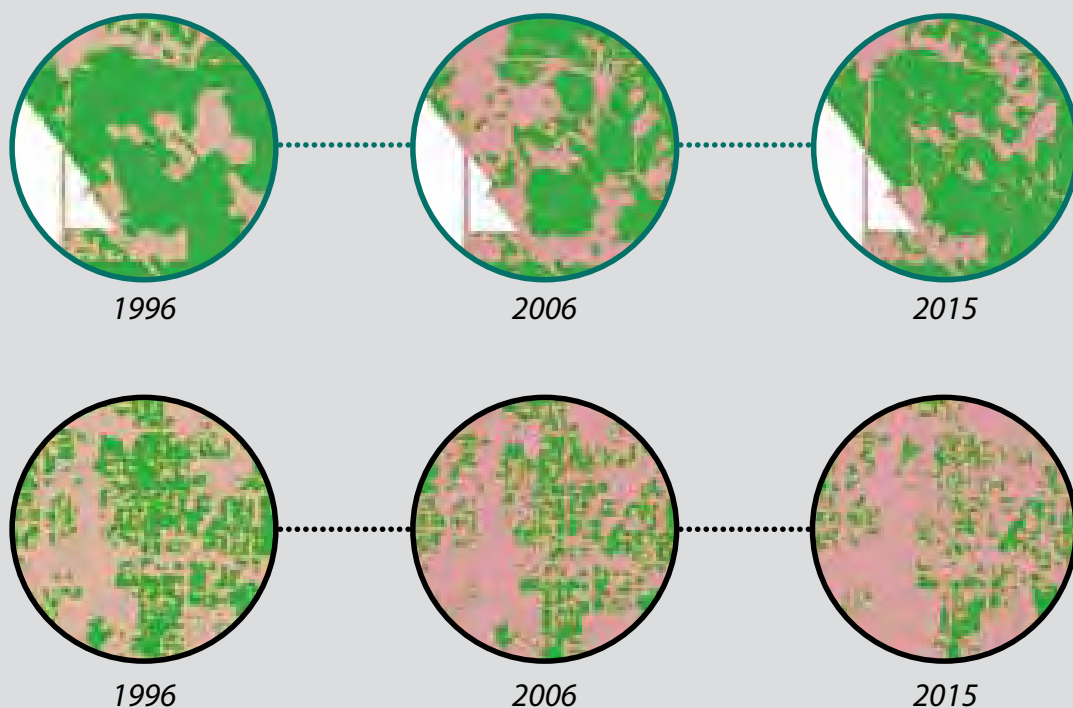


Figure 17. Canopy and non-canopy distribution of 2006 in the City of Gainesville.



Changes to Gainesville's canopy occurred between 1996 and 2015 (Figures 16, 17, 18). In some areas (top), canopy was lost then gained, likely due to timber harvest followed by reforestation. In other areas of the city (bottom), canopy has been lost over time without gains.

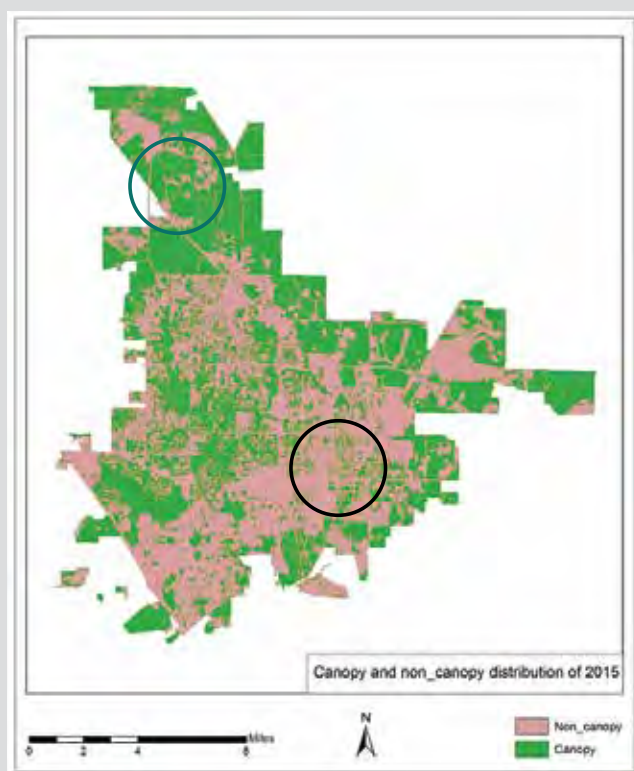


Figure 18. Canopy and non-canopy distribution of 2015 in the City of Gainesville.

The Value of Gainesville’s Urban Forest

The i-Tree Eco model uses the urban forest structure metrics discussed in the previous section to quantify and value the benefits of the urban forest. These benefits are considered ecosystem services because of their beneficial effects on the health and well-being of humans (Escobedo, Kroeger, and Wagner, 2011). These ecosystem services and their values (summarized in Table 7) are discussed in the following sections.

\$24.4 million/year + \$1.4 billion
Ecosystem Services Compensatory Value

Ecosystem Service	Annual Value (million \$)
Tree shading energy savings	7.7
Avoided carbon emissions	1.7
Air pollution capture	2.7
Avoided health care costs	2.7
Avoided stormwater runoff costs	3.8
Carbon sequestration	5.9
Total Annual Urban Forest Benefits	24.4

Table 7. Summary of ecosystem services and annual values of Gainesville’s urban forest.

In addition to its annual values, the urban forest has an overall estimated value referred to as its compensatory value. This value considers tree size, species, condition, and location. The compensatory value is an estimate of the cost to replace all trees in the city if they were removed (e.g. deliberately or due to a storm).

The compensatory value of trees in Gainesville’s urban forest is over \$1.4 billion dollars. This value was calculated by the ECO model using the industry standard methodology developed by the Council of Tree and Landscape Appraisers.

Energy Conservation

Trees can reduce the need to heat or cool a building. This reduction in energy use saves consumers money, reduces the amount of carbon emitted into the atmosphere by power plants, and decreases the demand for non-renewable fossil fuels, which is a global concern.

Trees that were 20 feet tall and less than 60 feet from a residential building that was 3 stories tall or less were considered to have an influence on energy consumption (increase or decrease) (McPherson & Simpson, 1999). Trees and residential buildings that met these criteria were located, identified, measured (height and crown area), and mapped on all inventory plots. The i-Tree Eco model estimated energy conservation utilizing the average amount of energy consumed by residential buildings in Gainesville (McPherson and Simpson 1999).

By reducing the amount of energy needed to heat or cool a building, trees also reduce the amount of carbon that would be released into the atmosphere during the production of electricity through burning of fossil fuels. Avoided carbon emissions were estimated based on modeled energy conservation due to tree shading. Energy savings were calculated using Florida state wide averages of \$116.15/MWH and \$17.30/MBtu. The carbon avoided value is based on \$133.05 per ton.

Gainesville’s urban forest resulted in an estimated reduction of residential energy use for cooling of 58,770 MWhs valued at \$6.8 million dollars. The estimated reduction of carbon emissions due to reduced energy production by power plants was 12,900 tons with an associated value of about \$1.7 million. In 2016, trees saved Gainesville residents an estimated \$7.7 million dollars in total heating and cooling costs (Table 8).

Type	Heating	Cooling	Total	Price (\$)	Value (\$)
Natural Gas (MBTU)	38,130	0	38,130	\$17.30	\$659,600
Electricity (MWH)	1,570	58,770	60,340	\$116.15	\$7,008,400
Carbon Avoided (ton)	910	11,980	12,890	\$133.05	\$1,715,000

Table 8. Annual energy savings from residential trees.





Public Health: Air Pollution Removal

Air pollution in cities causes deleterious health impacts for residents. Some of the most serious air pollutants in urban environments are carbon monoxide (CO), nitrogen dioxide (NO₂), ground-level ozone (O₃), fine particulate matter (PM_{2.5}), and sulfur dioxide (SO₂). Carbon monoxide is a toxic gas that enters the atmosphere through the combustion of fossil fuels (e.g. vehicles and power plants). Nitrogen dioxide is a respiratory irritant, and it is an ingredient in the formation of ground-level ozone (O₃; smog). Smog is created in the presence of sunlight, when NO₂ and other volatile organic compounds react with one another. This reaction rate increases as temperatures increase. Trees can play a vital role in lowering temperatures in urban areas, reducing the rate of ground-level ozone formation (Nowak & Dwyer, 2007).

Particulate matter less than 2.5 micrometers (PM_{2.5}) consists of suspended microscopic droplets (liquid or solid) that are small enough to be inhaled. PM_{2.5} is associated with serious respiratory issues when it penetrates into the lungs. Trees improve air quality by intercepting PM_{2.5} on their leaves. They remove carbon monoxide (CO), nitrogen dioxide (NO₂), ozone (O₃), and sulfur dioxide (SO₂) from the atmosphere through uptake via their leaf stomata.

The i-Tree Eco model estimated that Gainesville's trees and shrubs remove 846 tons of pollution per year with a value of \$2.67 million dollars (Table 9). The model calculates the amount of pollution eliminated from the atmosphere based on 2016 Environmental Protection Agency (EPA) air pollution and weather monitors in Gainesville and assumes pollution reduction does not happen during rain events. Value estimates for CO and PM_{2.5} were calculated with guidelines suggested by Murray, Marsh, & Bradford (1994) and Ottinger, Wooley, Robinson, Hodas, & Babb (1990). Value estimates for O₃, SO₂, and NO₂ were calculated based on the EPA Benefits Mapping and Analysis Program (BenMAP) model (EPA, 2012).

Pollutant	Removal (short ton)	Value (\$)
O ₃	692	\$1,310,010
NO ₂	102	\$22,930
SO ₂	26	\$2,090
PM _{2.5}	22	\$1,324,400
CO	4	\$6,176
Total	846	\$2,665,600

Table 9. Annual pollution removal by the trees and shrubs in Gainesville.

	NO ₂	O ₃	PM _{2.5}	SO ₂
Tree	\$15,310	\$861,200	\$979,900	\$1,360
Shrub	\$7,620	\$448,820	\$344,500	\$730
Subtotal	\$22,930	\$1,310,010	\$1,324,400	\$2,090
Total	\$2,659,430			

Table 10. Estimated annual economic benefits of reduced health impacts from airborne pollutant reduction by trees and shrubs in the city of Gainesville (BenMAP).

The BenMAP model estimates the reduction in health impacts and the associated economic benefits derived from changes in air quality. Pollutant reduction estimates from i-Tree were used by the BenMAP model to produce estimates of potential savings in health care costs (e.g. reduced incidence of respiratory illness and related hospital visits or days lost from work/school). Gainesville's urban forest reduces air pollution levels resulting in an estimated \$2.66 million savings on airborne pollutant related health care costs (Table 10).

Avoided Runoff

Trees influence urban hydrology by improving water quality through the interception of pollution and reduction of stormwater flows. One study found that for each 5% increase in tree cover, stormwater flow is reduced by 2% (Coder, 1996). This analysis includes the savings in stormwater control costs associated with the estimated interception of precipitation by the trees of Gainesville’s forest. In 2016, it is estimated that rainfall interception from trees in the Gainesville urban forest saved the City \$3.8 million in stormwater control costs (Table 12).

Loblolly pines represent 18% of the overall estimated population and account for one fifth (20%) of the total estimated rainfall interception and savings in stormwater control costs (Figure 18). The top ten species having the greatest estimated leaf area accounts for 75% of all estimated interception and savings.

The land use with the greatest avoided runoff value is *Forested* (\$1.7 million/year). The second greatest value is in *Residential* areas (\$1.0 million/year), which occupies 29% of the city (Table 11).

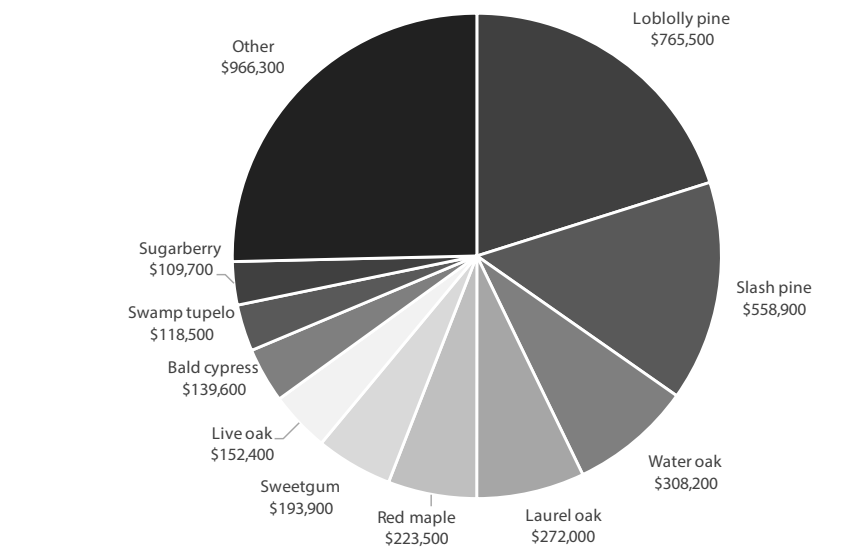


Figure 19. Savings in avoided runoff costs by species.

Strata	Avoided Runoff (mil ft³/yr)	Avoided Runoff Value (\$/yr)	Percent of City (%)
Forested	25	\$1,670,700	27.2
Residential	15	\$1,006,700	28.9
Transportation	6	\$415,900	15.3
Public / Institutional	4	\$259,600	9.7
Commercial	3	\$172,700	6.9
Open Space / Park	2	\$165,600	4.2
Industrial	2	\$117,400	7.3
Gainesville	57	\$3,808,500	100

Table 11. Avoided runoff and associated savings in each land use designation in the City with the percent acreage of each land use.



Carbon Sequestration

Carbon dioxide (CO₂) is a greenhouse gas that contributes to climate change. During the process of photosynthesis, trees incorporate atmospheric carbon into the tissue in their new growth which is then considered to be sequestered or locked up for the life of the tree or plant part (leaves, branches, trunk, or roots) (Abdollahi, Ning, & Appeaning, 2000). Carbon sequestration rates vary by species, but healthier and more vigorous trees tend to sequester carbon at higher rates than unhealthy trees. The urban forest of Gainesville is a carbon sink, meaning it stores more carbon than it releases. Net carbon sequestration is the amount of carbon sequestered minus the estimated amount of carbon emitted as dead trees decay. The Eco model estimated that in 2016 Gainesville's urban forest sequestered or removed 44,200 gross tons of carbon from the atmosphere, valued at \$5.88 million.

The rate of carbon sequestration by an individual tree is a function of the tree size, species, and condition. The tree species with the highest rate of carbon sequestration in Gainesville is loblolly pine, which is also the species that stores the greatest amount of carbon (Figure 20).

The carbon sequestered annually by Gainesville's urban forest is equivalent to...

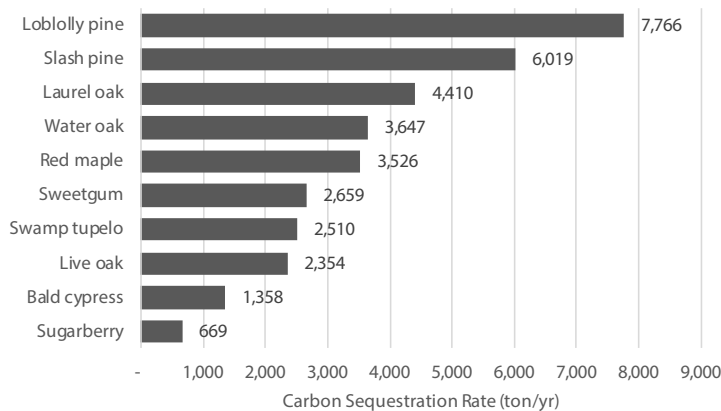
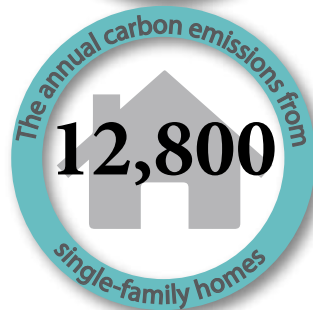
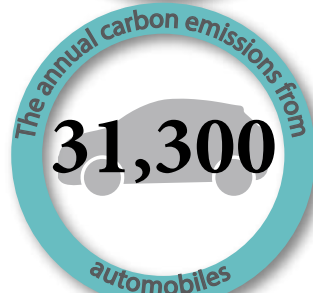


Figure 20. Carbon sequestration rates in Gainesville by species.





Carbon Storage

The amount of stored carbon in a tree fluctuates as it grows (increases), dies (ceases), or decays (decreases). To calculate current carbon storage, biomass for each tree was calculated using equations from the literature and measured tree data. Tree dry-weight biomass was converted to stored carbon by multiplying by 0.5. The total amount of carbon stored by the trees of Gainesville's urban forest is estimated to be 746,000 tons valued at \$99.2 million. In Gainesville 27% of the stored carbon is in loblolly pines and slash pines combined. An additional 18% of carbon is stored in live oak and laurel oak combined (Figure 21).

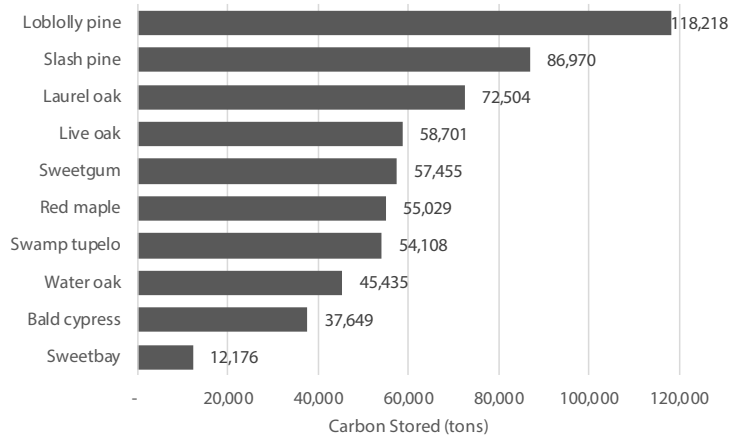


Figure 21. Carbon stored in Gainesville by species.

The land use storing the most carbon is *Forested* (44%), which represents 27% of the City (Table 12). The *Residential* land use represents 29% of the City, and it stores 25% of the carbon. The land use storing the least carbon is *Industrial* (3%), which represents 7% of the City.

Strata	Carbon Storage (tons)	Carbon Storage (%)	Percent of City (%)
Forested	331,400	44.4	27.2
Residential	184,200	24.7	28.9
Transportation	99,500	13.3	15.3
Public / Institutional	48,100	6.4	9.7
Commercial	34,000	4.6	6.9
Open Space / Park	27,700	3.7	4.2
Industrial	21,000	2.8	7.3
Gainesville	745,800	100	100

Table 12. Carbon storage by land use designation and percent acreage.



Appendices

Appendix A: Land Use

Land use categories were defined for use as strata by the i-Tree Eco model based on land uses and zoning provided by the City in geographic information (GIS) files. Classification of all parcels within the City was done according to the following Eco land use definitions:

ECO Land Use	Description
Agriculture	Pastures, row crops, or wholesale nurseries
Commercial	Retail and professional business uses
Forested	Upland and wetland forests, both natural and planted
Industrial	Industrial uses including municipal water, waste, and power facilities
Open Space / Park	Park and recreational lands, cemeteries, golf courses
Public / Institutional	Government offices, hospitals, schools, churches, & other municipal facilities
Residential	All forms of housing
Transportation	Roads, railroads, and airports

Certain City land use codes directly translated to Eco land uses while others did not. In the table below, blank Eco land uses indicate that more than one classification could have been applied to the City land use, depending on the specific parcel. Some individual parcels were manually classified using GIS layers and aerial photography to aid in the classification decision.

ECO LAND USE	City LANDUSE DESCR	LANDUSE CODE
Agriculture	Acrg Not Znd Ag	9900
Transportation	Airport	2000
Commercial	Auto Sales	2700
Industrial	Bottler	4500
Commercial	Bowling Alley	3400
Public/Institutional	Churches	7100
Commercial	Clb/Ldg/Un Hall	7700
Public/Institutional	College-Wtr Mgt Dist	8400
Residential	Common Area	900
Residential	Condominium	400
	County Vacant/Xfeatures	8010
Public/Institutional	County-Sch Brd Vacant/Xf	8011
	Cty Inc Nonmuni	8600
	Cultural	7900
Commercial	Dept Store	1300
	Federal	8800
	Federal Vacant/Xfeatures	8040
Commercial	Financial	2300
Commercial	Florist	3000
Commercial	Food Processing	4600
Open Space/Park	Forest/Pk/Rec-Wtr Mgt Dst	8200
Open Space/Park	Golf Course	3800
Agriculture	Grzgsoil Class2	6100
Industrial	Heavy Mfg	4200
Public/Institutional	Hospital	8500
Commercial	Insurance	2400

ECO LAND USE	City LANDUSE DESCR	LANDUSE CODE
Industrial	Light Mfg	4100
Industrial	Lumber Yd/Mill	4300
Residential	MFR <10 Units	800
Industrial	Min Processing	4700
Industrial	Ming/Pet/GasInd	9200
Residential	Misc. Residence	700
Residential	Mobile Home	200
Open Space/Park	Mort/Cemetary	7600
Commercial	Motel	3900
Residential	Multifamily	300
	Municipal	8900
	Municipal Vacant/Xfeature	8050
Commercial	Night Clubs	3300
Public/Institutional	Nursing Home	7400
Commercial	Off Multistory	1800
Commercial	Office 1 Story	1700
Commercial	Open Storage	4900
Agriculture	Orn/Misc Agri	6900
Commercial	Orphng/Non-Prof	7500
	Other Public Vac/Xfeature	8090
Open Space/Park	Outdr Rec/Pk Ld	9700
Commercial	Pkg Lot (Comm)	2800
Commercial	Post Office	1701
Commercial	Prof Offices	1900
Public/Institutional	Prv Hospital	7300
Public/Institutional	Prv Schl/Coll	7200
Public/Institutional	Pub Cty School	8300
Transportation	Railroad Owned-Local Assd	9110
Commercial	Rest, Drive-in	2200
Commercial	Restaurant	2100
Residential	Retirement	600
Transportation	Right-Of-Way	9400
Residential	Sani/ Rest Home	7800
Commercial	Serv Stations	2600
Commercial	Service Shops	2500
Industrial	Sewg/Waste Land	9600
Commercial	Sh Ctr Cmmtiy	1600
Commercial	Sh Ctr Nbhd	1601
Commercial	Sh Ctr Regional	1500
Residential	Single Family	100
	State Of Fla - TIITF	8701
	State(Not TIITF)Vac/Xf	8020
	State(TIITF) Vacant/Xf	8030
	State-Not TIITF	8700
Commercial	Store/Off/Res	1200

ECO LAND USE	City LANDUSE DESCR	LANDUSE CODE
Commercial	Stores	1100
Commercial	Supermarket	1400
Commercial	Theater	3200
Forested	Tmbr Not Clssfd	5900
Forested	Tmbr Si 80-89	5500
Forested	Tmbr Si 90+	5400
Commercial	Tourist Attraction	3500
Industrial	Utility	9100
	Vacant	0
	Vacant Comm	1000
	Vacant Industrial	4000
	Vacant Institutional	7000
Industrial	Wareh/Dist Term	4800
Forested	Water Mgt Dist Vac/Xfeat	8000
Industrial	Wholesaler	2900

Appendix B: Ecological Assessment Species Level Results

Tree species identified in Gainesville's urban forest:

a Tree, Shrub strata

b Native, Exotic (non-native), and Invasive status

*Category I Invasive Species

Species	Common Name	T, S ^a	% Tree	N, E, I ^b
<i>Abelia chinensis</i>	Abelia	S	-	E
<i>Acca sellowiana</i>	Feijoa	S	-	E
<i>Acer floridanum</i>	Florida maple	T, S	0.1%	N
<i>Acer negundo</i>	Boxelder	T, S	0.7%	N
<i>Acer rubrum</i>	Red maple	T, S	7.5%	N
<i>Acoelorrhaphe wrightii</i>	Paurotis palm	T, S	<0.1%	N
<i>Aesculus pavia</i>	Red buckeye	T, S	<0.1%	N
<i>Albizia julibrissin</i>	Mimosa	T, S	0.1%	E, I*
<i>Aralia spinosa</i>	Devils walking stick	T, S	0.1%	N
<i>Ardisia crenata</i>	Coral ardisia	S	-	E, I*
<i>Asimina angustifolia</i>	Slimleaf pawpaw	S	-	N
<i>Asimina parviflora</i>	Smallflower pawpaw	S	-	N
<i>Asimina reticulata</i>	Netted pawpaw	S	-	N
<i>Asimina triloba</i>	Common pawpaw	S	-	N
<i>Baccharis halimifolia</i>	Saltbush	T, S	<0.1%	N
<i>Bambusa spp.</i>	Bamboo	S	-	E
<i>Betula nigra</i>	River birch	T	<0.1%	N
<i>Bismarckia nobilis</i>	Bismarck palm	T	<0.1%	E
<i>Broussonetia papyrifera</i>	Paper mulberry	T, S	0.2%	E, I
<i>Bumelia spp.</i>	Bumelia	T, S	<0.1%	N
<i>Bumelia lanuginosa</i>	Chittamwood	S	-	N
<i>Butia capitata</i>	Jelly palm	T, S	<0.1%	E
<i>Buxus microphyllus</i>	Boxwood	S	-	E
<i>Cajanus spp.</i>	Pigeon pea	S	-	E
<i>Callicarpa americana</i>	American beautyberry	S	-	N
<i>Camellia japonica</i>	Camellia	T, S	0.1%	E
<i>Camellia sasanqua</i>	Sasanqua camellia	S	-	E
<i>Carpinus caroliniana</i>	American hornbeam	T, S	0.9%	N
<i>Carya glabra</i>	Pignut hickory	T, S	0.3%	N
<i>Carya illinoensis</i>	Pecan	T, S	0.9%	N
<i>Carya tomentosa</i>	Mockernut hickory	T, S	<0.1%	N
<i>Celtis laevigata</i>	Sugarberry	T, S	2.0%	N
<i>Cephalanthus occidentalis</i>	Button bush	T, S	0.3%	N
<i>Cercis canadensis</i>	Eastern redbud	T, S	0.2%	N
<i>Chamaerops humilis</i>	European fan palm	S	-	E
<i>Chionanthus virginicus</i>	Fringe tree	T, S	<0.1%	N
<i>Cinnamomum camphora</i>	Camphor tree	T, S	0.9%	E, I*

Species	Common Name	T, S^a	% Tree	N, E, I^b
<i>Citrus spp.</i>	Citrus	T, S	<0.1%	E
<i>Citrus aurantium</i>	Sour orange	S	-	E
<i>Citrus limon</i>	Lemon	S	-	E
<i>Clerodendrum spp.</i>	Glorybower	S	-	E
<i>Cornus florida</i>	Flowering dogwood	T, S	0.1%	N
<i>Cornus foemina</i>	Swamp dogwood	T, S	0.1%	N
<i>Crataegus spp.</i>	Hawthorn	T, S	<0.1%	N
<i>Crataegus marshallii</i>	Parsley hawthorn	T, S	0.2%	N
<i>Cycas revoluta</i>	Sago palm	S	-	E
<i>Cyrilla racemiflora</i>	Swamp titi	S	-	N
<i>Diospyros spp.</i>	Persimmon	S	-	E
<i>Diospyros virginiana</i>	Common persimmon	T, S	<0.1%	N
<i>Duranta erecta</i>	Golden dewdrop	S	-	E
<i>Dyopsis lutescens</i>	Areca palm	S	-	E
<i>Elaeagnus pungens</i>	Thorny elaeagnus	S	-	E, I
<i>Eriobotrya japonica</i>	Loquat tree	T, S	<0.1%	E
<i>Euonymus americanus</i>	American strawberry bush	S	-	N
<i>Ficus carica</i>	Common fig	S	-	E
<i>Ficus pumila</i>	Climbing fig	S	-	E
<i>Fraxinus americana</i>	White ash	T	0.5%	N
<i>Fraxinus pennsylvanica</i>	Green ash	T, S	0.7%	N
<i>Gardenia jasminoides</i>	Cape jasmine	S	-	E
<i>Gaylussacia dumosa</i>	Dwarf huckleberry	S	-	N
<i>Gaylussacia frondosa</i>	Blue huckleberry	S	-	N
<i>Gordonia lasianthus</i>	Loblolly bay	T, S	0.7%	N
<i>Hamelia patens</i>	Firebush	S	-	N
<i>Hibiscus rosa-sinensis</i>	Chinese hibiscus	S	-	E
<i>Hypericum spp.</i>	St. John's wort	S	-	N
<i>Ilex cassine</i>	Dahoon	T, S	1.7%	N
<i>Ilex cornuta</i>	Chinese holly	S	-	E
<i>Ilex glabra</i>	Gallberry	S	-	N
<i>Ilex myrtifolia</i>	Myrtle dahoon	T	<0.1%	N
<i>Ilex opaca</i>	American holly	T, S	<0.1%	N
<i>Ilex x attenuata</i> 'Savannah'	Savannah holly	T	<0.1%	N
<i>Ilex vomitoria</i>	Yaupon holly	T, S	0.4%	N
<i>Ilex x attenuata</i> 'Fosteri'	Foster's holly	S	-	N
<i>Illicium parviflorum</i>	Yellow anise	S	-	N
<i>Itea virginica</i>	Virginia sweetspire	S	-	N
<i>Ixora coccinea</i>	Ixora	S	-	E
<i>Juniperus spp.</i>	Juniper	S	-	E
<i>Juniperus chinensis</i>	Chinese juniper	S	-	E
<i>Juniperus chinensis</i> 'Torulosa'	Hollywood juniper	T	<0.1%	E
<i>Juniperus conferta</i> 'Blue Pacific'	Shore juniper	S	-	E
<i>Juniperus virginiana</i>	Eastern red cedar	T, S	0.3%	N

Species	Common Name	T, S^a	% Tree	N, E, I^b
<i>Koelreuteria paniculata</i>	Golden rain tree	T, S	<0.1%	E, I
<i>Lagerstroemia indica</i>	Crape myrtle	T, S	0.7%	E
<i>Lantana camara</i>	Lantana	S	-	E, I*
<i>Ligustrum japonicum</i>	Ligustro	T, S	0.2%	E
<i>Ligustrum lucidum</i>	Glossy privet	T, S	0.2%	E, I*
<i>Liquidambar styraciflua</i>	Sweetgum	T, S	4.0%	N
<i>Loropetalum chinense</i>	Chinese fringe flower	S	-	E
<i>Lyonia ferruginea</i>	Rusty lyonia	T, S	<0.1%	N
<i>Lyonia lucida</i>	Fetterbush	T, S	0.4%	E
<i>Magnolia grandiflora</i>	Southern magnolia	T, S	1.2%	N
<i>Magnolia virginiana</i>	Sweetbay	T, S	0.8%	N
<i>Magnolia x soulangeana</i>	Saucer magnolia	T	<0.1%	E
<i>Manihot</i> spp.	Manihot	S	-	E
<i>Morella cerifera</i>	Wax myrtle	T, S	4.0%	N
<i>Moringa oleifera</i>	Horseradish tree	T, S	<0.1%	E
<i>Morus rubra</i>	Red mulberry	T	0.3%	N
<i>Musa</i> spp.	Banana	S	-	E
<i>Nandina domestica</i>	Heavenly bamboo	S	-	E, I*
<i>Nyssa biflora</i>	Swamp tupelo	T, S	3.8%	N
<i>Osmanthus fragrans</i>	Tea olive	S	-	E
<i>Ostrya virginiana</i>	Eastern hophornbeam	T, S	0.9%	N
<i>Persea americana</i>	Avocado	T	<0.1%	E
<i>Persea borbonia</i>	Redbay	T, S	1.0%	N
<i>Persea palustris</i>	Swamp bay	T, S	0.1%	N
<i>Photinia × fraseri</i>	Fraser photinia	S	-	E
<i>Pinus elliotii</i>	Slash pine	T, S	10.6%	N
<i>Pinus glabra</i>	Spruce pine	T, S	0.2%	N
<i>Pinus palustris</i>	Longleaf pine	T, S	0.6%	N
<i>Pinus taeda</i>	Loblolly pine	T, S	17.2%	N
<i>Pittosporum tobira</i>	Pittosporum	S	-	E
<i>Platanus occidentalis</i>	Sycamore	T	0.1%	N
<i>Platycladus orientalis</i>	Arborvitae	T, S	<0.1%	E
<i>Podocarpus macrophyllus</i>	Podocarpus	T, S	0.1%	E
<i>Populus deltoides</i>	Eastern cottonwood	T	<0.1%	N
<i>Prunus</i> spp.	Plum	S	-	N
<i>Prunus angustifolia</i>	Chickasaw plum	T, S	<0.1%	N
<i>Prunus caroliniana</i>	Carolina laurel cherry	T, S	4.6%	N
<i>Prunus persica</i>	Peach	S	-	E
<i>Prunus serotina</i>	Black cherry	T, S	0.7%	N
<i>Prunus umbellata</i>	Flatwoods plum	T, S	0.3%	N
<i>Prunus virginiana</i>	Common chokecherry	S	-	E
<i>Punica granatum</i>	Pomegranate	S	-	E
<i>Pyrus</i> spp.	Pear	S	-	E
<i>Pyrus calleryana</i> 'bradford'	Bradford pear	T	0.1%	E

Species	Common Name	T, S ^a	% Tree	N, E, I ^b
<i>Quercus alba</i>	White oak	T	<0.1%	N
<i>Quercus austrina</i>	Bluff oak	T	<0.1%	N
<i>Quercus falcata</i>	Southern red oak	T	<0.1%	N
<i>Quercus geminata</i>	Sand live oak	T, S	<0.1%	N
<i>Quercus hemisphaerica</i>	Darlington oak	T, S	0.5%	N
<i>Quercus laurifolia</i>	Laurel oak	T, S	8.8%	N
<i>Quercus michauxii</i>	Swamp chestnut oak	T, S	0.3%	N
<i>Quercus nigra</i>	Water oak	T, S	7.9%	N
<i>Quercus shumardii</i>	Shumard oak	T	0.1%	N
<i>Quercus virginiana</i>	Live oak	T, S	0.8%	N
<i>Rhaphiolepis indica</i>	Indian hawthorn	S	-	E
<i>Rhapidophyllum hystrix</i>	Needle palm	S	-	N
<i>Rhapis excelsa</i>	Lady palm	T, S	0.1%	E
<i>Rhododendron xobtusum</i>	Kurume azalea	S	-	E
<i>Rhododendron canescens</i>	Pinxter azalea	S	-	N
<i>Rhododendron simsii</i>	Indian azalea	S	-	E
<i>Rhus copallinum</i>	Winged sumac	S	-	N
<i>Rosa spp.</i>	Rose	S	-	E
<i>Rubus spp.</i>	Blackberry	S	-	N
<i>Sabal minor</i>	Dwarf palmetto	S	-	N
<i>Sabal palmetto</i>	Cabbage palm	T, S	0.6%	N
<i>Salix caroliniana</i>	Carolina willow	S	-	N
<i>Sambucus canadensis</i>	Elderberry	T, S	0.9%	N
<i>Senna bicapsularis</i>	Butterfly bush	S	-	E
<i>Serenoa repens</i>	Saw palmetto	S	-	N
<i>Spiraea spp.</i>	Spiraea	S	-	E
<i>Syzygium cumini</i>	Jambolan plum	T, S	<0.1%	E, I*
<i>Taxodium ascendens</i>	Pond cypress	T	1.0%	N
<i>Taxodium distichum</i>	Bald cypress	T, S	1.8%	N
<i>Ternstroemia gymanthera</i>	Cleyera	S	-	E
<i>Tilia americana</i>	American basswood	T, S	0.2%	N
<i>Trachycarpus fortunei</i>	Windmill palm	T	<0.1%	E
<i>Triadica sebifera</i>	Chinese tallow	T, S	0.2%	E, I*
<i>Ulmus alata</i>	Winged elm	T, S	0.5%	N
<i>Ulmus americana</i>	American elm	T, S	0.2%	N
<i>Ulmus parvifolia</i>	Chinese elm	T	<0.1%	E
<i>Vaccinium arboreum</i>	Sparkleberry	S	-	N
<i>Vaccinium corymbosum</i>	Highbush blueberry	S	-	N
<i>Vaccinium myrsinites</i>	Shiny blueberry	S	-	N
<i>Vaccinium stamineum</i>	Deerberry	T, S	0.2%	N
<i>Viburnum suspensum</i>	Sandankwa viburnum	S	-	E
<i>Viburnum dentatum</i>	Arrowwood	S	-	N
<i>Viburnum obovatum</i>	Small-leaf arrowwood	T, S	<0.1%	N
<i>Viburnum odoratissimum</i>	Sweet viburnum	T, S	0.2%	E

Species	Common Name	T, S^a	% Tree	N, E, I^b
<i>Viburnum rufidulum</i>	Rusty blackhaw	T, S	0.1%	N
<i>Yucca aloifolia</i>	Spanish bayonet	S	-	N
<i>Zanthoxylum americanum</i>	Hercules' club	S	-	N
<i>Ziziphus mauritiana</i>	Indian jujube	S	-	E

Appendix C: Gainesville Tree Canopy Assessment Using Remote Sensing Methods

Authors: Shawn Landry and Qiuyan Yu, University of South Florida

Introduction

The purpose of this project was to utilize relatively low-cost remote sensing methods to quantify tree canopy coverage and change in Gainesville. Through the acquisition and analysis of moderate-resolution Landsat imagery, urban forest canopy coverage was mapped for 1996, 2006 and 2015 and also reported as canopy change over these time periods. The original intent was to use 1995, 2005 and 2015 time periods, but cloud-free Landsat imagery was unavailable for the 1995 and 2006 (see below). Since Landsat imagery is known to underestimate tree canopy cover, very-high resolution aerial imagery from the National Agriculture Imagery Program (NAIP) was utilized with a dot-based method to develop accurate estimates citywide tree canopy cover for 2016 and 2015. Future work efforts, with additional funding, could utilize the very-high resolution aerial imagery to develop detailed land cover maps for exploration of tree cover and change at the resolution of the property parcel.

Accurate Estimate of Citywide Tree Canopy Cover

Citywide tree canopy in the City of Gainesville was accurately estimated using a dot-based sampling approach with NAIP aerial photographic imagery from 2006 and 2015 (Figure 1). This approach to estimate citywide tree canopy cover followed the “dot-based” estimation methods described by David Nowak and colleagues from the U.S. Forest Service (Nowak et al. 1996, Nowak and Greenfield 2012). The dot-based approach has been shown to be a very accurate and consistent method of characterizing canopy cover and change (Landry et al. 2013). A total of 1500 dots were randomly placed within the Gainesville boundary. At each location, a dot was photo-interpreted as “canopy” or “not canopy” by a trained photo-interpreter using 2006 NAIP and separately with 2015 NAIP. A subsample of 500 dots were independently classified a second time as a method to test the verification error. Dots located within the tree canopy were classified as canopy, while dots located on other vegetation or other surfaces were classified as no canopy.

	2006 NAIP	2015 NAIP
Canopy	748 (49.9% +/- 1.3%)	808 (53.9% +/- 1.3%)
Non-Canopy	752 (50.1%)	692 (46.1%)
Total	1500	1500

Table 1. Count of canopy and non-canopy of both 2006 and 2015.

In 2006, 748 out of 1500 dots were classified as canopy, while 808 out of 1500 dots were canopy in 2015 (Table 1). The standard error is 1.3% for both 2006 and 2015 dot methods. Citywide tree canopy coverage was thus 49.9% +/- 1.3% (48.6 – 51.2%) in 2006 and 53.9% +/- 1.3% (52.6 – 55.2%) in 2015. These results suggest a small increase in tree canopy cover within the City of Gainesville between 2006 and 2015.

Moderate Resolution Tree Cover Mapping

Measurements of tree canopy cover over time can provide an indicator of the geographic distribution of urban forest benefits within different areas of the city and how it has changed over time. The use of moderate-resolution satellite imagery such as Landsat have been shown to underestimate urban tree canopy cover (i.e., 30 meter pixels compared to 1 meter pixels for the NAIP imagery). However, the use of Landsat provides a consistent long-term measurement of change for several decades prior to the availability of high-resolution mapping techniques.

Landsat Data download

Landsat data were acquired from United States Geological Survey (<http://earthexplorer.usgs.gov/>) for 5/6/1996, 5/2/2006 and 5/11/2015 as shown in Figure 2. Although the original intent was to focus on 1995 and 2005, Landsat scenes acquired in summer of 1995 and 2005 were covered by clouds over the study area as shown in the Appendix.

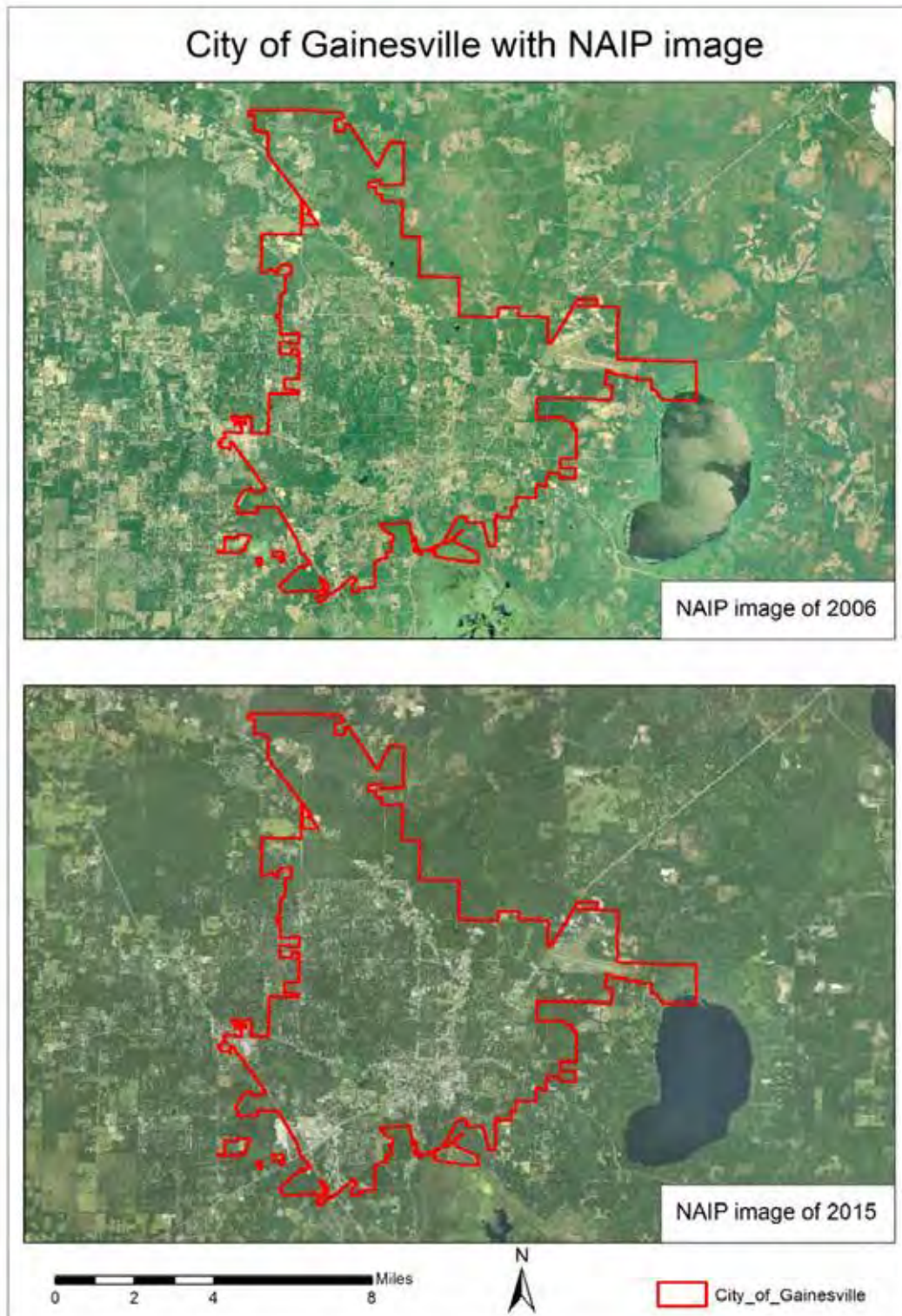


Figure 1. City of Gainesville with NAIP images.

Landsat image processing

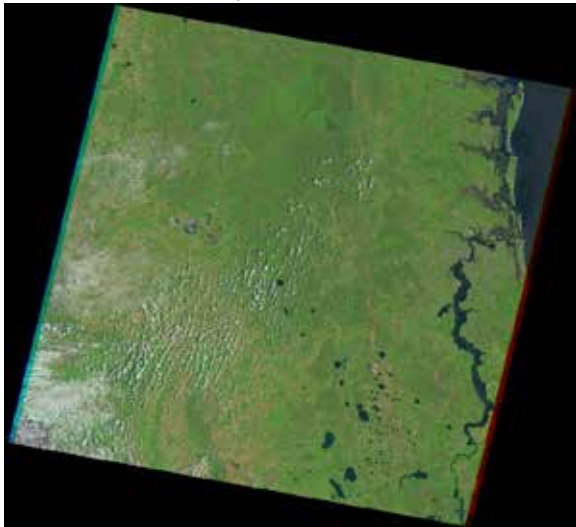
Image processing followed standard accepted remote sensing techniques and utilized ENVI software. Calibration is to calibrate original DN to radiance, reflectance or brightness temperature. Top of atmospheric reflectance and surface reflectance were achieved using ENVI 5.2 classic and ENVI 4.8. ToA (top of atmosphere) Reflectance used ENVI 5.2 classic > Basic Tools > Preprocessing > Calibration Utilities > Landsat Calibration, select Reflectance. Surface Reflectance used the FLAASH model in ENVI 4.8.

Normalization was used to minimize the differences caused by atmospheric or solar conditions between images so that the tree canopy mapping method would be consistent through time (1996, 2006 and 2015). The data of 2006 was employed as the standard image, based on which other two images (1996, 2015) were normalized. Linear model is generated for each band with corresponding band of 2006. The general model is as shown in in Equation 1:

$$y = x + b \quad (1)$$

where y is band reflectance of 2006, and x stands for corresponding band reflectance of 1996 or 2015. The linear models of normalization for each band based on the image of 2006 are as shown in Table 2. The R squares are higher than 75%, except band 2 of Landsat image of 2015 with R square 74.89%, pretty close to 75%. Therefore, all the regression models are acceptable.

5/6/1996 - Path 17, Row 39 - Landsat 5



5/2/2006 - Path 17, Row 39 - Landsat 5



5/11/2015 - Path 17, Row 39 - Landsat 8



Figure 2. Natural color preview images of Landsat TM data used.

		2006_B1	2006_B2	2006_B3	2006_B4	2006_B5	2006_B7
1996	a	1.0539	1.1205	1.0471	0.97	0.9227	0.9328
	b	-80.955	-91.335	-63.242	-100.18	66.302	82.921
	R ²	0.966	0.9516	0.9294	0.9705	0.9776	0.9765
2015	a	0.6439	0.7459	0.7622	0.8081	0.8215	0.8808
	b	214.43	217.66	184.37	186.99	50.946	137.04
	R ²	0.7872	0.7489	0.822	0.9325	0.9746	0.8808

Table 2. Linear models of normalization for each band, image of 2006 as standard image.

Tree Canopy Classification Using Decision tree

To achieve the amount and distribution of canopy and non-canopy from Landsat image, decision tree with biophysical composition index (BCI) and normalized difference vegetation index (NDVI) was applied to classify canopy and no-canopy from Landsat images. The decision tree classifier is generated using Landsat image of 2006 based on the verification data from NAIP image (Canopy and Non_canopy), then it is tested using image of 2015, lastly, it is applied to extract canopy from image of 1996. Decision tree classification is popular in remote seeing community to classify land cover types. It is defined as a classification procedure that recursively partitions a data set into smaller subdivisions on the basis of a set of tests defined at each branch in the tree (Friedl and Brodley 1997). BCI is a quantitative spectral indicator designed for characterizing major urban land cover compositions following Ridd's conceptual vegetation–impervious surface–soil (V–I–S) triangle model. It could be derived with the help of the normalized Tasseled Cap (TC) spectral, as shown in Eqs 2-5. TC transformation for Landsat data, which could transform spectral reflectance to brightness, greenness and wetness (the first three components), is able to highlight relevant vegetation variance (Healey, Cohen et al. 2005). The combination of BCI and NDVI is able to reduce within-class variation and enhance between-class variation among various urban compositions. This method was successfully used to extract endmembers of urban land cover types in urban areas of Franklin County, Ohio (Deng and Wu 2013).

$$BCI = \frac{(H + L)/2 - V}{(H + L)/2 + V} \quad (2)$$

$$H = \frac{TC1 - TC1_{min}}{TC1_{max} - TC1_{min}} \quad (3)$$

$$V = \frac{TC2 - TC2_{min}}{TC2_{max} - TC2_{min}} \quad (4)$$

$$L = \frac{TC3 - TC3_{min}}{TC3_{max} - 3} \quad (5)$$

where H, V, and L are the normalized TC components 1, 2 and 3, indicating “high albedo material”, “vegetation”, and “low albedo material”, respectively; TC_i (i = 1, 2, 3) are the first three original TC spectra; TC_{imax} and TC_{imin} are the maximum and minimum values of the ith TC component, respectively.

The extraction rule for canopy and non_canopy from decision tree applied for 2006 and 2015 is achieved using decision tree classification in Rstudio programming software. According to the decision rule (Figure 3), pixels with NDVI equal and larger than 0.7286 or pixels with NDVI larger than 0.6617 and BCI larger than -0.2913 were considered as canopy, otherwise as non_canopy. Confusion matrices were computed to compare the pixels classified using Landsat to the 1500 dots classified from NAIP images, as shown in Table 3-4. Of the 1500 Landsat pixels that correspond with the NAIP dots, 77.94% of the 2006 pixels classified as canopy were correctly classified, while 86.04% of pixels classified as non-canopy were correctly classified. In 2015, 75.53% of canopy pixels and 83.82% of non-canopy pixels were correctly classified.

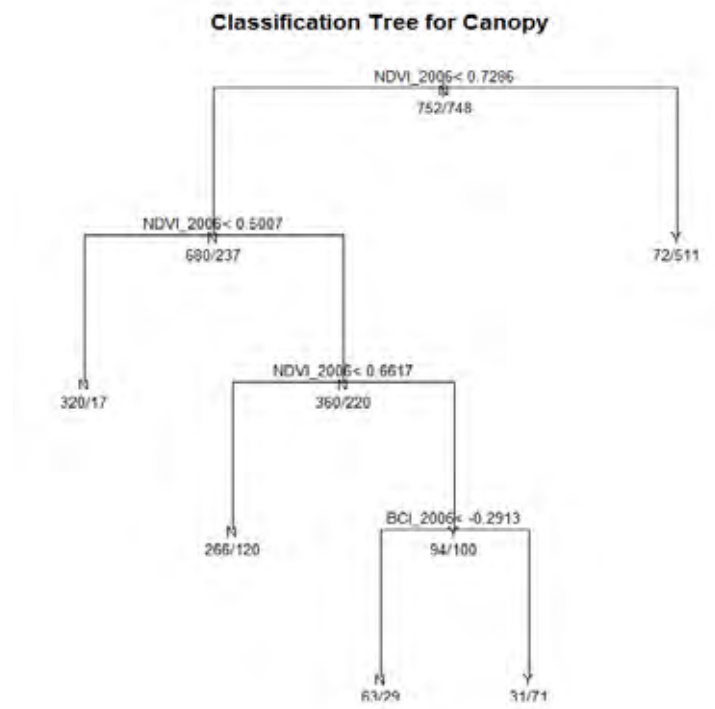


Figure 3. Decision tree rule for 2006

n=1500		True 2006			True 2015		
Class		Canopy	Non_canopy	Total	Canopy	Non_canopy	Total
Predicted Using Landsat	Canopy	583	105	688	565	112	677
	Non_canopy	165	647	812	243	580	823
	Total	748	752	1500	808	692	1500

Table 3. Classification confusion matrix on pixel.

n=1500		True 2006 (Percent)			True 2015 (Percent)		
Class		Canopy	Non-Canopy	Total	Canopy	Non_canopy	Total
Predict-ed using Landsat (Percent)	Canopy	77.94	14.04	45.87	75.53	14.97	45.13
	Non-canopy	22.06	86.04	54.13	30.07	83.82	54.87
	Total	100	100	100	100	100	100

Table 4. Classification confusion matrix on percent.

Tree Cover Results

The decision tree classifier was applied to whole study area (City of Gainesville) for 1996, 2006 and 2015. The distribution of canopy and non-canopy in 1996, 2006 and 2015 is shown in Figure 4-6. The amount of canopy from 1996 to 2006 was decreased and then increased a small portion from 2006 to 2015 (Table 5). Total area in the City of Gainesville as of 2016 is approximately 165 Km². Because of the lower accuracy of Landsat-based results, all numbers are rounded to the nearest percent or nearest square kilometer.

	Landsat 1996	Landsat 2006	Landsat 2015
Canopy (%)	58 % (96 Km ²)	46 % (76 Km ²)	47 % (78 Km ²)
Non-canopy (%)	42 % (69 Km ²)	54 % (89 Km ²)	53 % (87 Km ²)

Table 5. Classification result from Landsat images for the City of Gainesville using decision tree.

The results of the Landsat classification results, as expected, show less canopy than the dot-based analysis that used the higher resolution NAIP imagery. Results for the 2006 NAIP showed 49.9% +/- 1.3% canopy, compared to 46% canopy estimated from 2006 Landsat; and 53.9% +/- 1.3% canopy from the 2015 NAIP compared to 47% canopy estimated from 2015 Landsat. A comparison of the image resolution as shown in Figure 4 illustrated how Landsat results underestimate tree canopy within highly heterogeneous areas of the City. As previously discussed, despite the underestimation of canopy from the Landsat images, the temporal trend results are valuable. A full land cover classification from the NAIP imagery would be necessary to estimate canopy with greater accuracy for individual neighborhoods in the City.

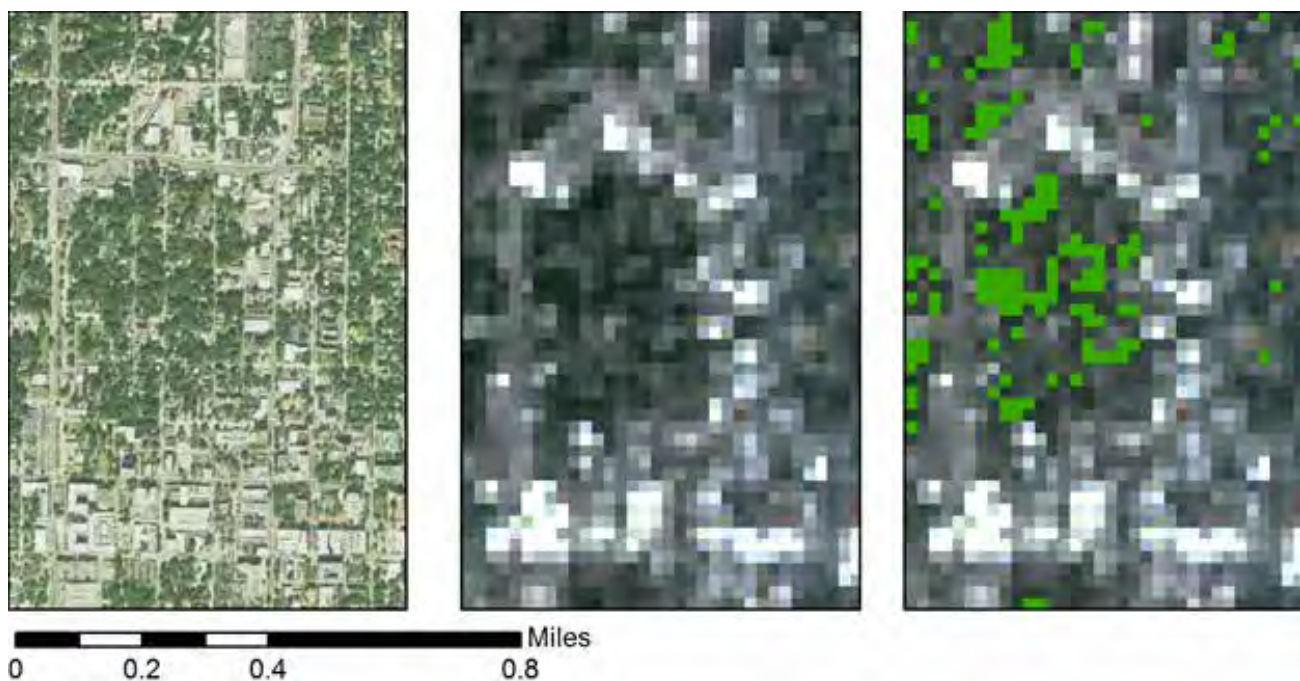


Figure 4. 2015 NAIP imagery (left), 2015 Landsat (middle) and mapped canopy from Landsat.

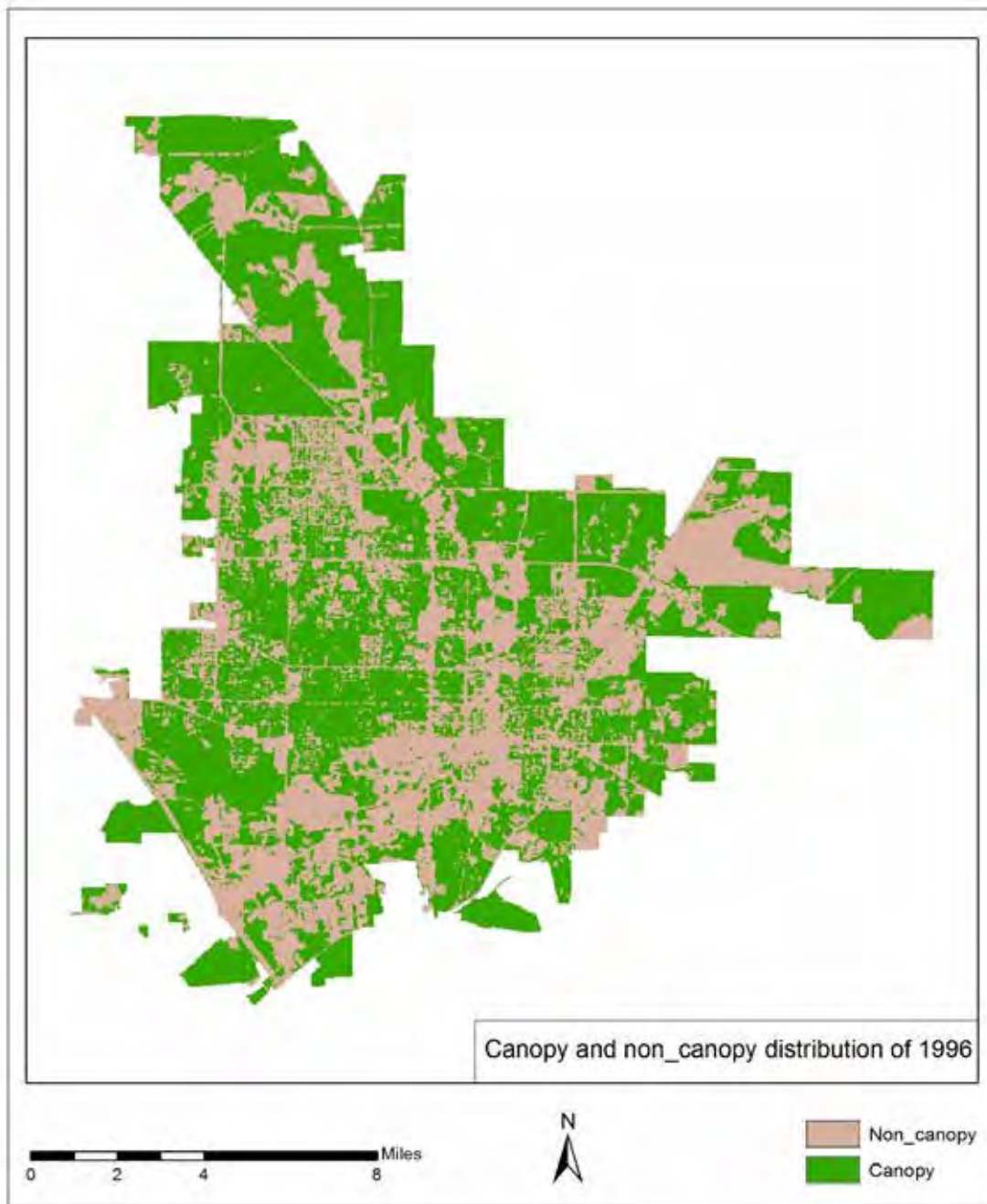


Figure 5. Canopy and non-canopy distribution of 1996 in the City of Gainesville.

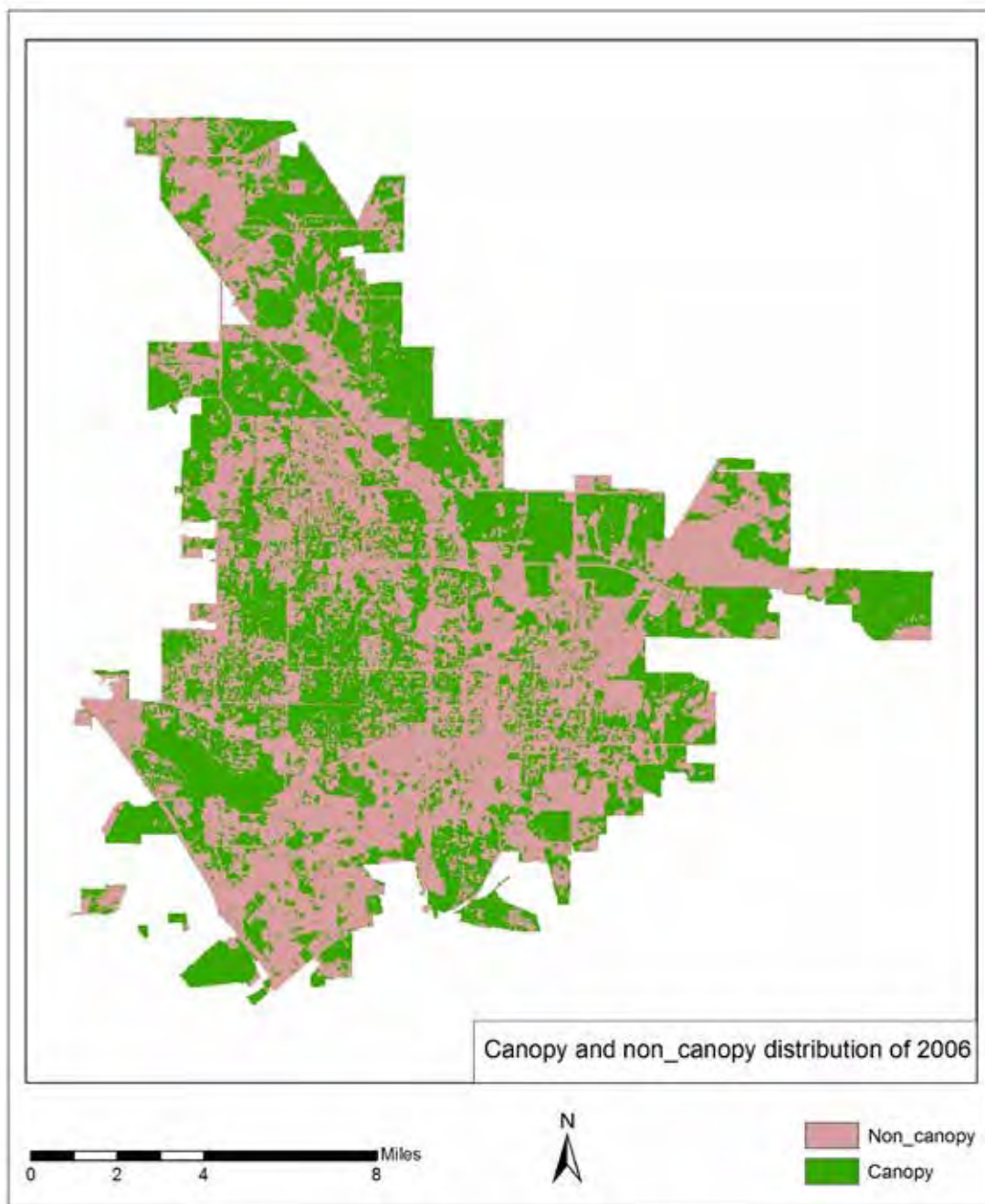


Figure 6. Canopy and non-canopy distribution of 2006 in the City of Gainesville.

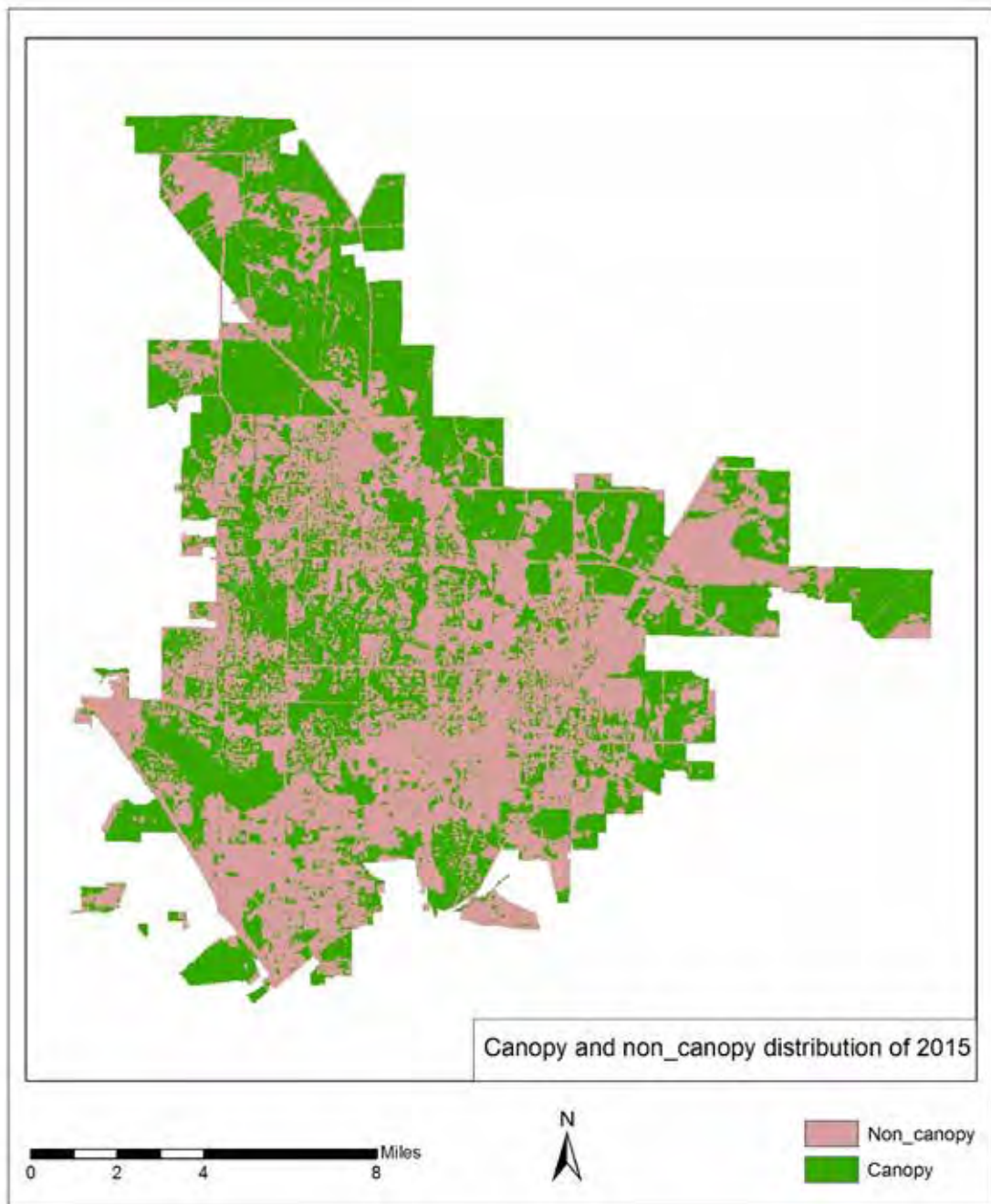


Figure 7. Canopy and non-canopy distribution of 2015 in the City of Gainesville.

Tree Cover Change

The canopy in the City of Gainesville decreased from 1996 to 2015. There was an overall net loss in tree canopy from 1996 to 2006, and then a net gain in tree canopy from 2006 to 2015 (Table 6). The distribution of canopy change from 1996 to 2015, from 1996-2015 and from 2006 to 2015 is shown in Figures 7, 8 and 9, respectively.

	Canopy gain km2(%)	Canopy loss km2(%)	No change km2(%)
1996 to 2015	8 (5%)	25 (15%)	132 (80%)
1996 to 2006	8 (5%)	27 (16%)	130 (79%)
2006 to 2015	15 (9%)	13 (8%)	137 (83%)

Table 6. Canopy change in the City of Gainesville.

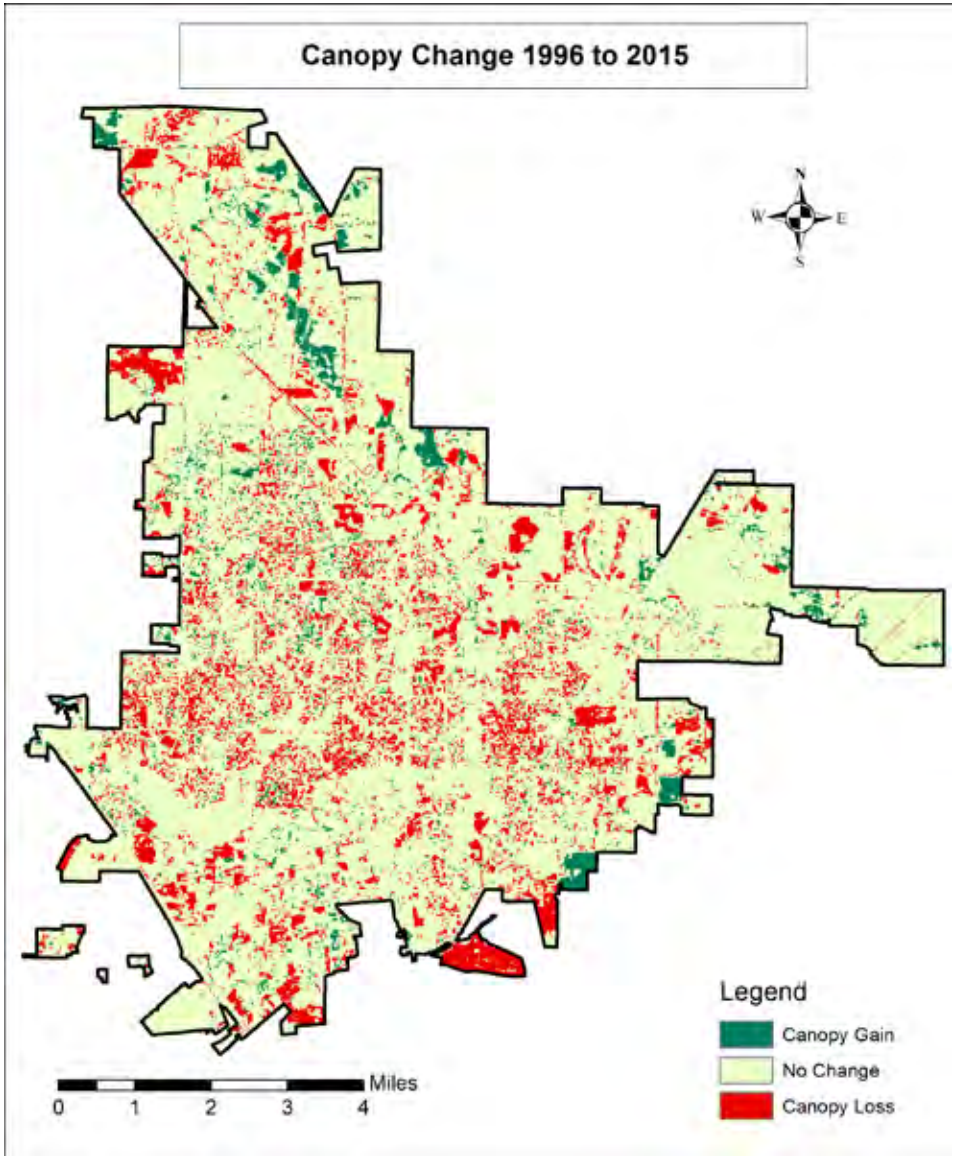


Figure 8. Canopy change distribution from 1996 to 2015 in the City of Gainesville.

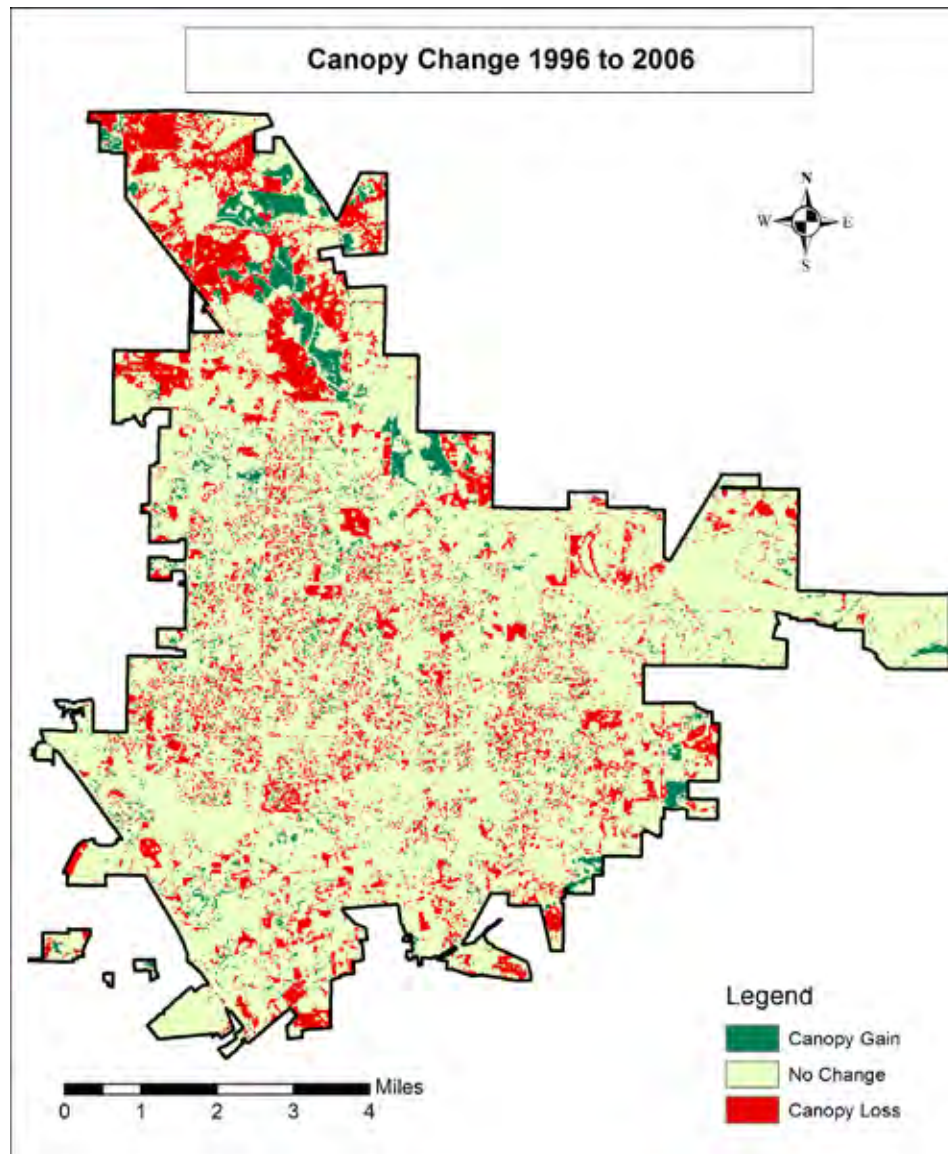


Figure 9. Canopy change distribution from 1996 to 2006 in the City of Gainesville.

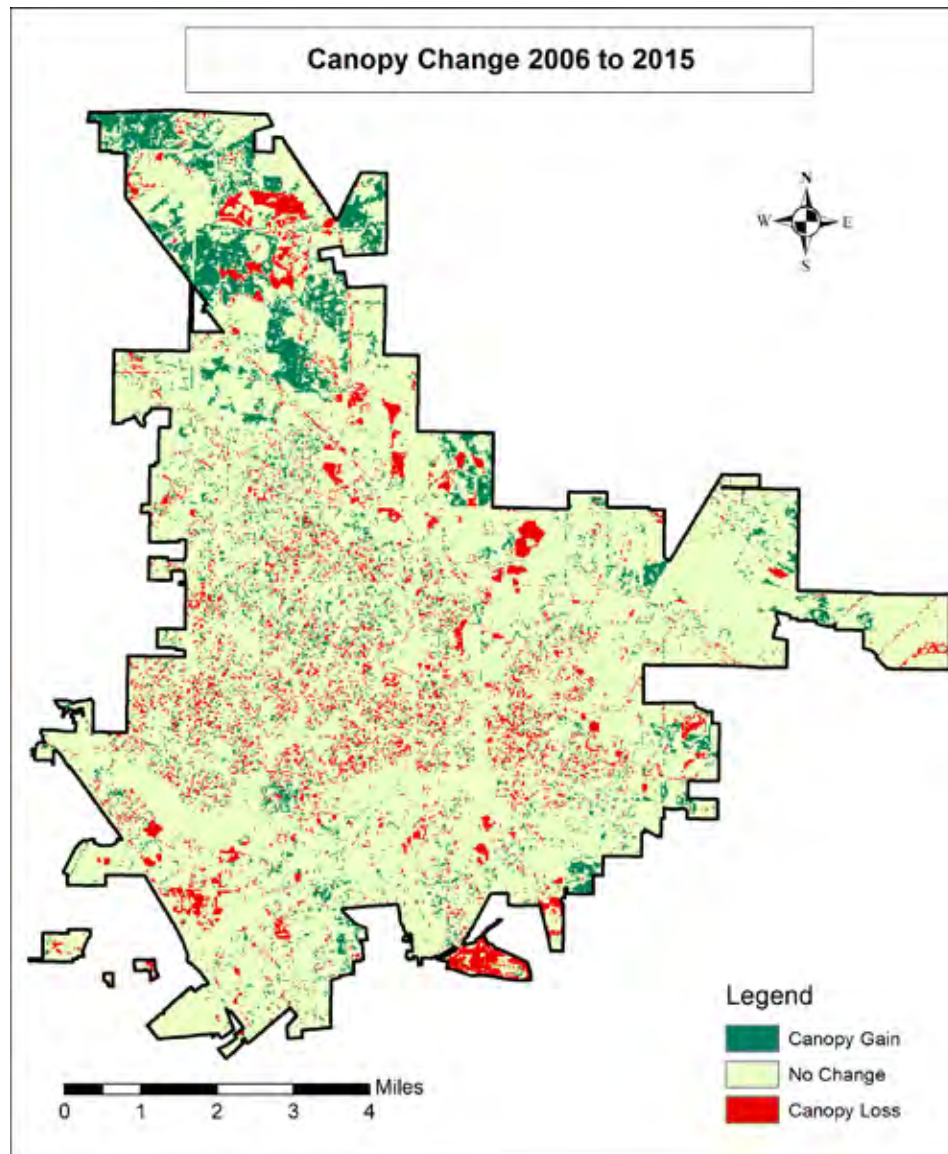
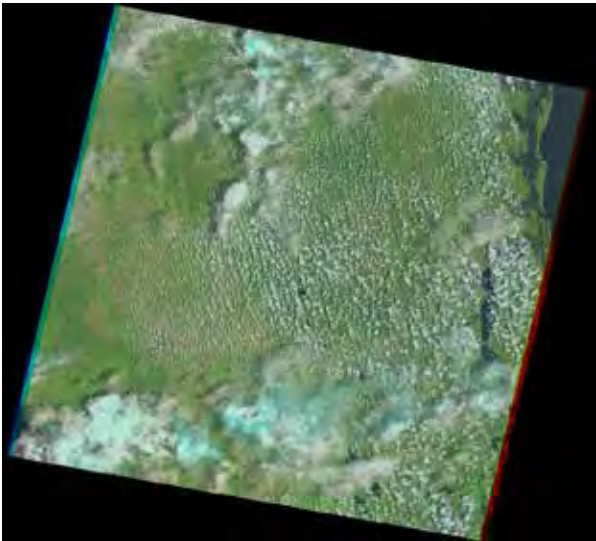


Figure 10. Canopy change distribution from 2006 to 2015 in the City of Gainesville.

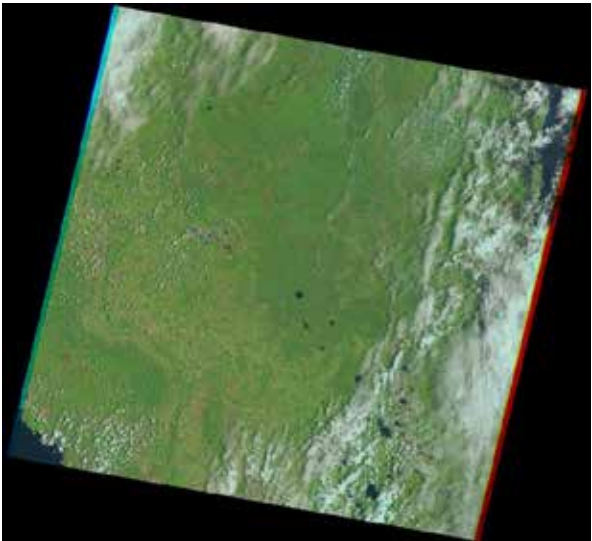
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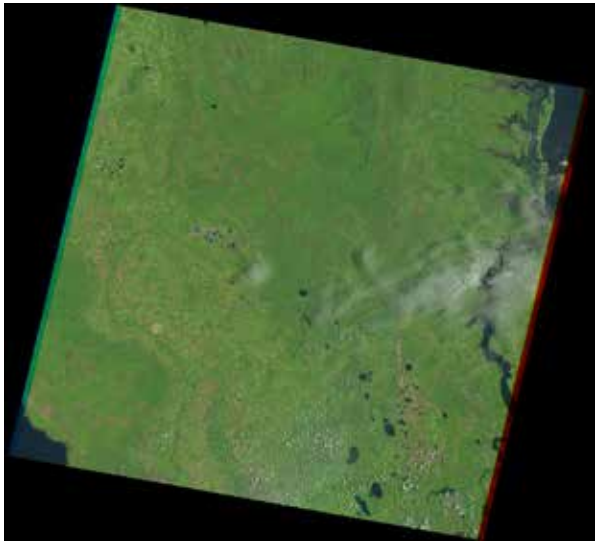
Remote Sensing Analysis Appendix: Landsat images with cloud cover in 1995 and 2005



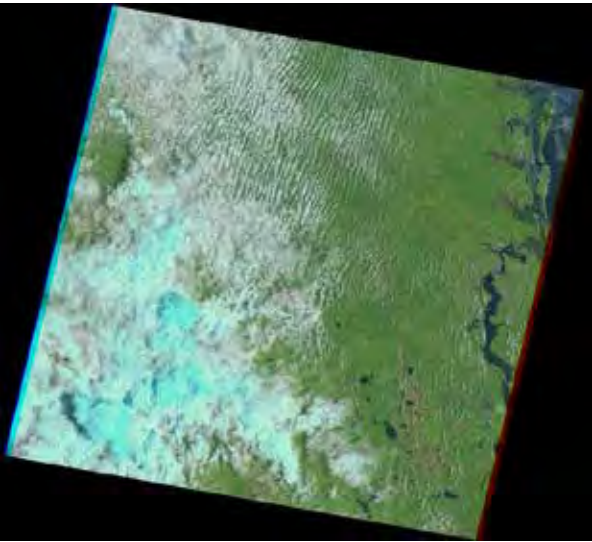
5/4/1995



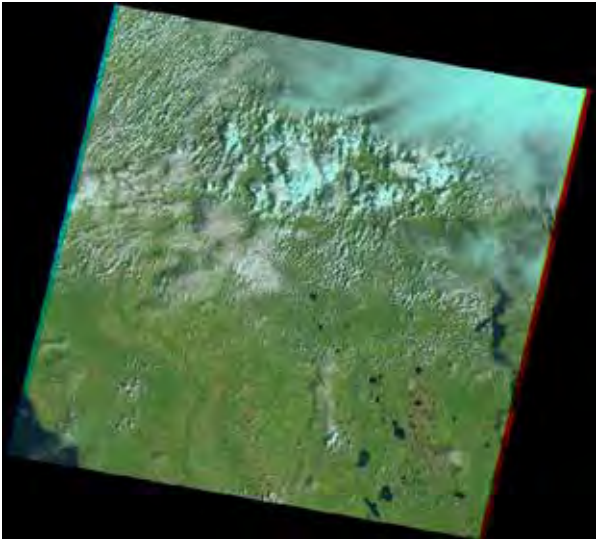
6/21/1995



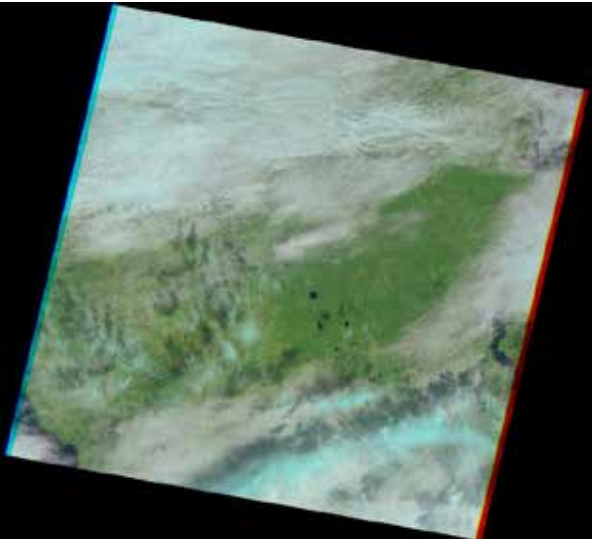
7/7/1995



8/8/1995

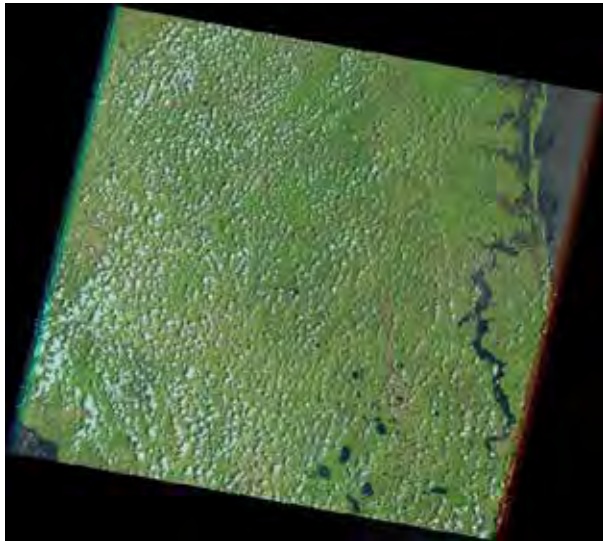


9/9/1995

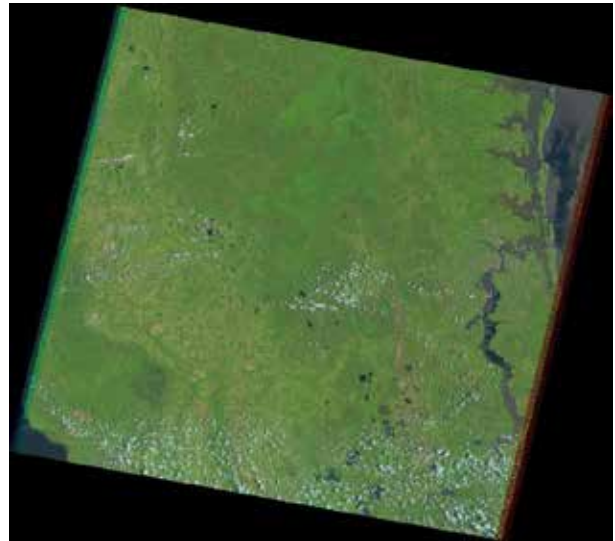


9/25/1995

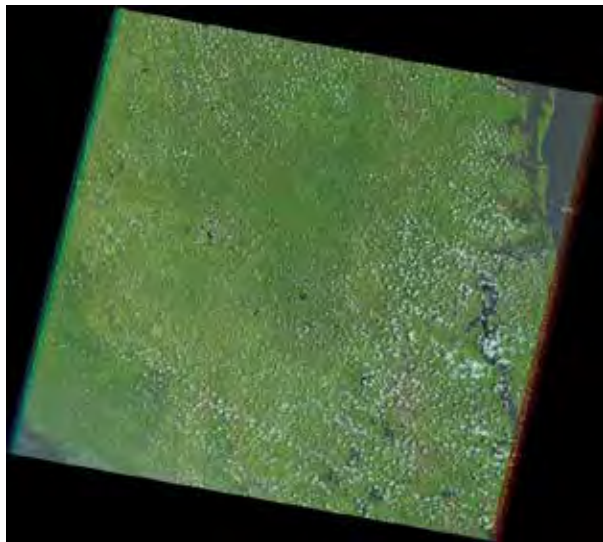
Figure 1. Landsat TM data acquired in summer of 1995 covered by clouds.



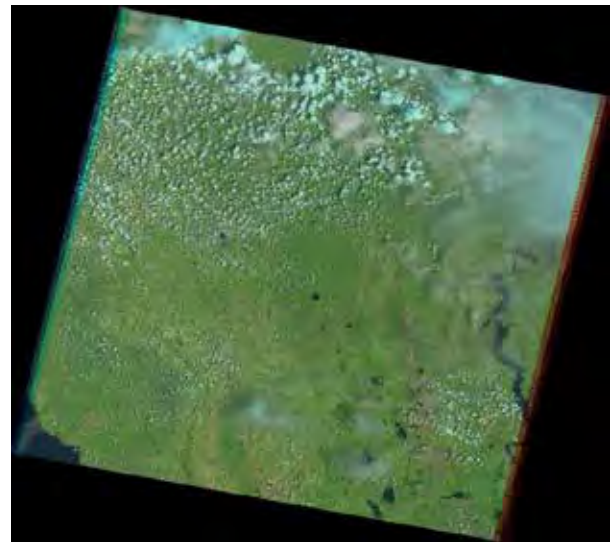
5/15/2005



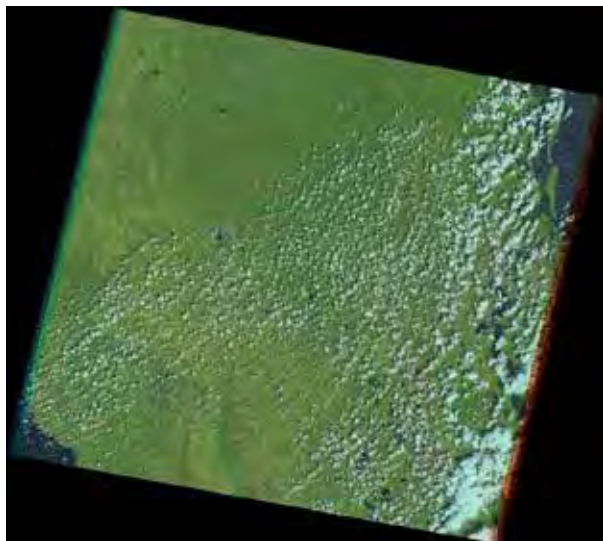
6/16/2005



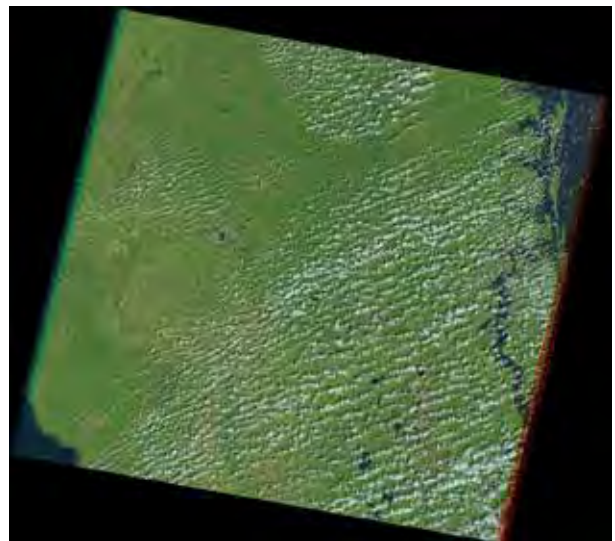
7/18/2005



8/19/2005



9/4/2005



9/20/2005

Figure 2. Landsat TM data acquired in summer of 2005 covered by clouds.

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