PI: Shawn Landry, Ph.D.	**Department:** Geosciences
Institution: University of South Florida	**Agency:** National Science Foundation

Project Summary

Overview:

Hurricane Irma resulted in extensive wind and water damage across Florida. Damage to trees and the urban forest was also widespread, with uprooted and downed trees reported; as well as severe defoliation and limb loss. Preliminary data from the storm, however, suggests a spatial heterogeneity in the damage, even when considering differences in wind speed, with patterns related to landscape context, species composition, and community socioeconomic factors. Urban forests provide a wide variety of ecosystem services, including decreased pollution, flood risk and climate mitigation, and carbon sequestration. Moreover, they are an ideal system to study disturbance impacts as a proxy for future climate conditions. While destructive, hurricane Irma offers an opportunity to increase our knowledge about the response of trees and urban forests to hurricane disturbance. Understanding the resistance and resilience of urban forests to disturbance is essential to increasing our knowledge about how ecosystems will respond to changing climate regimes (e.g., increased storm frequency) into the future. The goal of this proposed research is to understand how windstorm-caused tree failure relates to urban forest structure, and socio-ecological context. We hypothesize that storm damage will be lower in areas with higher tree density and native tree cover, and higher in areas with indicators of lower socioeconomic status. The severity and scale of this storm will allow us to test these hypotheses across a range of urban forest conditions and increase our knowledge about disturbance impacts, an area which is poorly understood.

Intellectual merit:

This project will make a strong contribution to our understanding of the relationship between tree damage, and urban and forest structural context, particularly in the southeastern US. This research will also provide us with the opportunity to directly evaluate urban tree canopy responses to hurricanes, and relate changes in canopy cover to biophysical and social characteristics. Our findings and predictions will directly address larger-scale questions about how urban forest ecosystems are altered in the face of increased disturbance and future climate scenarios. This project will build on existing measurements made by our research group, utilizing our previously measured (most recently in the months prior to the storm) forest inventory data in Tampa, Gainesville, and Orange County, Florida. The combination of field measurements and remotely sensed data will also allow us to draw inferences about the relationships between socioeconomic factors (e.g., income and education), forest structural factors (e.g., tree density, canopy cover and species diversity) with tree failure. The project will also improve our ability to estimate the overall consequences of hurricanes to urban forests, allowing policy makers to make better decisions to manage the ecosystem services of this important resource in the face of increased disturbance. On a global scale increases in disturbance, such as hurricanes and tropical storms, are expected to increase in frequency and intensity in the future, making this work essential to improve our understanding of how extreme weather events alter forested systems.

Broader Impacts:

This project will advance understanding of forests to disturbance in general, with an emphasis on the urban forests of central Florida following extensive hurricane damage. The importance of this study centers on the fact that alterations in climate will lead to higher frequencies of hurricanes across the globe. Moreover, Florida and many coastal forest areas continue to urbanize as populations shift in the US. This study will give the scientific community and city managers a foundational understanding of how urban forests respond to hurricanes, and provide an initial vulnerability assessment of the effects of extreme weather on urban forests. Moreover, the project presents an opportunity for graduate student training in collaborative research, and for intensive research opportunities for undergraduate students and technicians. Educational outreach will be accomplished through presentations and workshops to urban planners and tree care professionals. Finally, the data from this project will be incorporated into student projects in modeling, forestry, and remote sensing courses taught by the PIs.

I. Introduction

On September 10, 2017, Hurricane Irma made landfall in Florida, buffeting much of the state with heavy rains and tropical storm- to hurricane-force winds. This wind and rain worked together to inundate coastal structures and overturn or otherwise damage trees and infrastructure further inland. While the strongest winds were sustained in southwest Florida and the Florida Keys, Irma maintained intensity as it passed over a large portion of the state. Hillsborough County, which includes the city of Tampa, recorded wind gusts over 146 kph and several rivers rose above flood stage (NCDC 2017). While winds generally weakened inland and as the storm passed northward, heavy rainfall and flooding caused extensive property damage in Orlando and elsewhere. Though less publicized, damage to Florida's urban forest was widespread with uprooted and downed trees, as well as severe defoliation and limb loss (Figure 1).

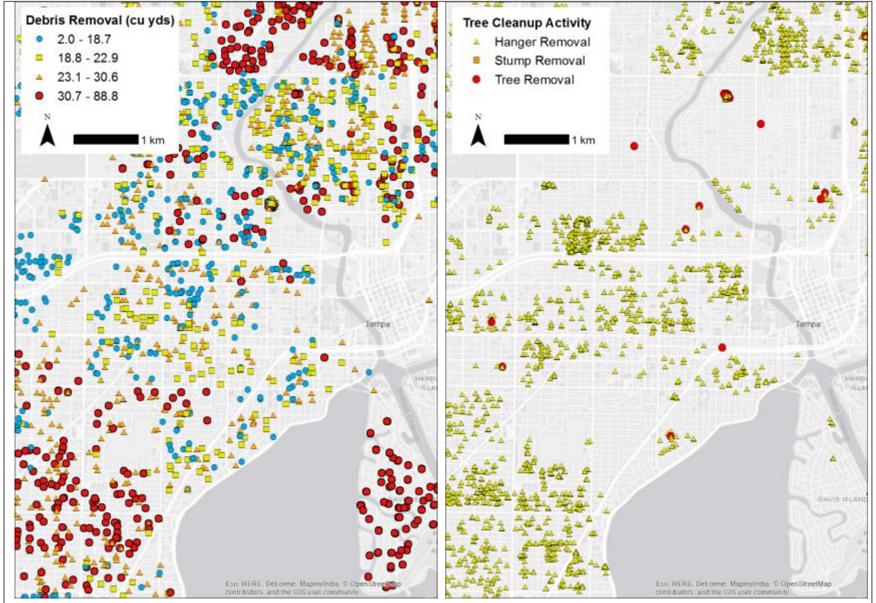

Figure 1. Post-storm woody and vegetation debris removal (quartile groups) and tree cleanup activity in central Tampa.

Urban forests are increasingly recognized for their essential ecosystem services, including decreasing air, water, and noise pollution, mitigating flood risk, and providing recreational areas (Escobedo et al, 2011; Roy et al 2012). Urban trees also provide climate change mitigation services including carbon sequestration and reduction of the urban heat island effect (Kleerekoper et al 2012). In an effort to assess their urban forest resource and value their ecosystem services, cities (including many in Florida) have conducted sample-based inventories designed to integrate with models such as the USDA Forest Service's i-Tree Eco (Nowak et al 2008). Moreover, urban forests have been recognized as ideal systems in which to study future climate, as they are subject to more extreme conditions than those of neighboring natural areas (Carrerio and Tripler 2005). Understanding the resilience of urban forests, interpreted as their ability to absorb disturbance while retaining function, structure, and feedbacks (Walker et al 2004) has important implications in socio-ecological systems, in terms of urban sustainability, but also for increasing knowledge about how forest ecosystems will respond to changing climate, as hurricanes and tropical storms are expected to increase in frequency and intensity in the future.

While destructive, hurricane Irma and its aftermath offer an opportunity to study the response of urban forests to hurricane disturbance. Our team is ideally positioned to examine the synergistic effect of wind, landscape configuration, and socio-economic context on tree failure, using our existing pre-storm urban forest data from three urbanized areas (Tampa, Gainesville, and Orange County) along a gradient of storm intensity. The severity and scale of this storm will allow us to increase our knowledge about how disturbance impacts urban systems, an area which is poorly understood (Grimm et al 2017). Considering the complexity of urban systems, this work will specifically recognize the biophysical and social drivers, mechanism, impact, and response to this intense disturbance (following Grimm et al 2017). We request RAPID funds to capitalize on this opportunity, assessing post storm damage before the next hurricane season potentially overwrites the living record from Irma. ***The primary objective of this proposed RAPID project is to understand how tree failure relates to urban forest structure, topography, and socioeconomic variables in large-scale storms like Hurricane Irma.***

Prior to Hurricane Irma, the three study sites had high levels of tree cover and diversity (Table 1). For example, tree cover in Tampa was in the top quartile in a study of 20 US cities (Nowak and Greenfield 2012), and tree cover was similar in Orange County and higher in Gainesville (47%; Table 1). Compared to urban areas in other regions, all three study sites have high species diversity, in part due to the long growing season and abundance of non-native species (Escobedo et al 2009; Landry et al 2013). However, the three sites do differ in terms of species composition; Gainesville's and Orange County's urban forests more closely reflect that of the natural forest communities (Blood et al 2016) when compared to Tampa, which includes more novel and emerging communities including many non-native species.

Table 1. Summary of urban forest structure and composition in the three proposed study locations.

Pre-storm characteristics	Tampa, FL	Gainesville, FL	Orange County, FL
Tree cover	32%	47%	30%
Tree density (trees ha^{-1})	309	440	217
# tree species	112	173	94
% native FL species	70%	94%	53%
% trees < 6" DBH	70%	60%	70%
% good/excellent condition	83%	80%	63%
# plots	201	177	279

DBH=diameter at breast height; Sources: Andrew et al 2017, Landry et al *In press*; Givens and Marcus 2017, Landry and Yu 2017.

Cleanup efforts suggest Hurricane Irma has altered urban forest structure and function through reductions in leaf area and removal of woody biomass. In Tampa, at least 127,625 m^3 of vegetation and woody debris were removed by contractors (Tampa 2017). Preliminary data suggest that damage from the storm varied within the city (see Fig. 1), with patterns associated with storm intensity, landscape context, and community socioeconomic factors. This damage is reflective of both the immediate response (e.g., clearing roads and reconnecting utilities), as well as more gradual recovery tied to community-level decisions regarding the removal of damaged trees and replanting of vacated planting spaces —a pattern we expect to see in all three sites.

Proposed research:

Our group is uniquely qualified to study the effects of Hurricane Irma on urban forest ecosystems given our existing datasets and continued involvement in urban forest projects in the southeastern US. Our team has been monitoring permanent plots in the Tampa Bay watershed for 12 years, using these data to answer basic and applied research questions including assessments of tree failure characteristics in this urban ecosystem (Koeser et al 2016). Fortuitously these plots were re-inventoried in the months leading up to Hurricane Irma. Moreover, our team members have conducted inventories using identical measurement protocols in the city of Gainesville (initially measured in 2005; Lawrence et al 2012) and Orange County (which includes the city of Orlando, initially measured in 2009; Horn et al 2015), with the latest data recorded during the same period as the Tampa assessment. The timeliness and completeness of these pre-storm data is a huge asset to this project and represents a significant investment of resources by the team.

While pre-storm data were collected with uniform measurement protocols, the strength of Hurricane Irma varied greatly between and within the three sites. Hurricanes produce highly variable winds, but Tampa recorded hurricane force winds (69-80 mph sustained winds), and Gainesville and Orange County strong tropical storm winds (40 and 59 mph sustained winds, respectively; Daniel Noah, National Weather Service, pers. comm., Feb. 28, 2018). This range of conditions with regard to storm intensity, paired with forest composition, will provide great insight into the resilience of urban forests when faced with disturbance events like hurricanes.

We will utilize these existing field data, pre-and post-storm remotely sensed images, post-storm field-based damage assessments, and sociodemographic census data to assess urban forest resilience and resistance—in the sense of the effort required to change this system (Walker et al 2004)—as it relates to tree, landscape, and socioeconomic factors. The post-storm field data we will collect is invaluable when assessing small-scale effects such as tree removal and species replacement. This will be coupled with traditional remote sensing and aerial interpretation methods to assess the protection offered by surrounding trees (if any) and to up-scale canopy loss estimates to the larger city and county areas assessed. In Tampa, we will also use our 2016 high-resolution tree and land cover classification data, together with 2017 LiDAR data, to assess the role of urban forest vertical structure (both trees and neighboring buildings).

II. Urban forest structural characteristics in response to water and wind

Hypothesis 1: Storm damage will be lower in areas with higher tree density and with higher native tree cover and diversity.

Hurricanes have both short- and long-term impacts on urban forests, resulting from the immediate "pulse" disturbance interacting with the human-driven response to the disturbance (Stanturf et al 2007*)*. Storm damage results in tree removal and replacement in managed lands and natural succession in less developed portions of the urban forest. Beyond this reactive response, storms can lead to alterations to public and private vegetation management, as well as, changes in zoning and land development regulations. This affects the trajectory of urban forest development, driving structure and function of the urban forests and ultimately the ecosystem services derived from those forests (Roman et al *In Press*). However, these impacts are not uniform across urban areas, even when storm conditions are similar. Tree resistance to damage and the forest's ability to absorb that damage, are intimately related to ecological factors. For example, tree density, species composition, and position in the landscape can have mitigating effects in terms of tree damage, as certain species may be more windfirm (Duryea et al 2007) and nearby trees and structures may affect local wind patterns and speeds (Staudhammer et al 2009). Moreover, resilience and resistance have been tied to traits of the dominant plant species, indicating a connection to the functional diversity of the forest (Diaz and Cabido 2001).

We will test hypotheses that relate tree density and native tree diversity with storm damage by assessing trees post-storm (via field re-inventory) and comparing them with plot-level, pre-storm canopy coverage (including a buffer areas surrounding the plot) derived from aerial imagery. These site factors will be combined with tree- (e.g., species, size, condition, etc.) and storm-related factors (e.g., wind intensity, rain intensity, years since last storm event, etc.) to predict whole and partial tree failure. Tree diversity will be assessed at both a plot-level, as well as at the neighborhood and landuse level (see Statistical Analysis section). As the structure of the urban forest is influenced by the built environmental within it, we will also use high-resolution aerial imagery and LiDAR (available for Tampa) to see if building height and proximity increases the predictive power of tree failure models.

Hypothesis 2: Areas with lower income will have greater relative rates of tree damage compared to higher income areas.

While the ecological factors noted in the first hypothesis are likely important determinants of tree response to wind, socio-economic factors may play an equally great role in determining tree resistance and resilience to storm damage, reflecting differences in participation and investments in tree planting and maintenance programs. Furthermore, in cities where trees and tree canopy are disproportionately distributed in favor of neighborhoods with a higher socioeconomic status (e.g., Landry and Chakraborty 2009, Locke et al 2016), pulse disturbances, such as hurricanes can exacerbate environmental inequity related to tree cover, maintenance, and replanting efforts, and are closely related to issues of environmental justice.

There is a gap in understanding of the relationship between neighborhood socioeconomic characteristics and tree damage and associated impacts. Related studies suggest disproportionate impacts, with differences in tree planting and maintenance related to socioeconomic status. Locke and Grove (2016) found higher participation in tree planting programs within affluent neighborhoods of Baltimore, MD and Washington, DC when compared to lower income areas. In a local survey of Tampa residents, Landry (2013) found a positive correlation between measures of socioeconomic status (e.g., property value and educational achievement) and reported tree trimming maintenance activity by homeowners. Similarly, Escobedo et al (2006) found evidence that public expenditure for urban forest management increased in areas with a higher socioeconomic status in Santiago, Chile. While the impact of this increased maintenance and care is not fully known, Vogt et al (2015) and Elmes et al (2018) provide some evidence of higher tree survival rates in areas associated with measures of higher income and socioeconomic status. Additionally researchers have been able to predict current levels of vegetation cover using historic socioeconomic data (Boone et al 2010, Grove et al 2014) — suggesting a legacy of the differences in how past residents may have planted or managed trees.

We hypothesize that (even when controlling for pre-storm canopy coverage and the other factors mentioned above) urban trees in low-income areas will have higher levels of damage given reduced pre-storm condition and higher levels of whole tree removal. We will test this hypothesis utilizing Census American Community Survey (ACS) block group data, existing pre-storm remotely sensed canopy cover and existing post-storm assessments of debris and new field-based tree damage, linked with storm data.

III. Methods

III.a. Field observations.

In 2017, members of our team inventoried urban trees and characterized landuse/cover in 200 permanent 0.04 ha plots (first established in 2006) in Tampa and 177 permanent plots in Gainesville. Additionally, Orange County (which contains the city of Orlando) completed an inventory with 279 permanent plots. In all locations, plots were selected to meet the requirements of the USDA Forest Service’s i-Tree Eco model and included data on the location, species, size, and condition of the trees present. To focus our efforts on urbanized areas, we will exclude plots previously classified as water and/or natural areas in the Tampa data, and revisit a random selection of 100 plots (each) in Gainesville in Orlando. This will enable us to gauge the impacts of Hurricane Irma on urban trees and obtain sampling coverage of existing patterns in local-scale tree coverage and socioeconomic conditions. Trees and plots will be relocated using GPS and proximity to permanent landmarks. Once relocated, they will be visually inspected to identify damaged, and recently pruned trees. Missing trees/stumps will be noted as well. Removed and damaged trees will be noted and compared to municipal maintenance and storm response records. No data will be collected on fully intact trees as they were thoroughly inventoried within the last year (e.g., species, location, size, condition, etc.).

III.b. Pre-and post-storm tree canopy measurements

Pre-storm imagery will be used to ensure a range of canopy densities are represented in the 100 plots re-inventoried in Gainesville and Orange County (selected using sample stratification).

For all study areas, pre- and post-storm tree canopy estimates in buffer areas surrounding tree plots will be measured using a point-based photo-interpretation with available aerial imagery. We will use the random point-based sampling approach (e.g., Nowak and Greenfield 2012), a robust method which has been found to be insensitive to minor differences in aerial image quality and resolution (Ucar et al 2016). In Tampa, very high resolution LiDAR (20 returns/m^2) collected February 2017 will be processed using QT Modeler to derive first-return height above ground, and merged with 2016 tree cover classification (0.3 m resolution) to provide additional tree and building height information for analysis of landscape context.

III.c. Socio-economic data

Indicators of socioeconomic status (e.g., income, education level; Locke et al 2016) in areas surrounding tree plots, debris removal and hazardous tree cleanup will be extracted from Census 5-year ACS block group data. Geographic information systems (GIS) data for Census block groups will be combined with plot location, tree canopy and landscape measures, land use and other relevant GIS data for analysis using appropriate software (e.g., ArcGIS 10.5, ArcGIS Pro), or extraction of data for analysis within separate statistical software (e.g., R).

III.d Data analysis

Hypotheses will be tested using statistical methods that explicitly recognize the spatially explicit nature of these data. We will utilize mixed modeling techniques with spatial autocorrelation structures to test effects of various forest structure and storm intensity variables on damage and debris measurements. Where spatial correlation structures cannot be adequately modeled, we will investigate Geographically Weighted Regression (Fotheringham et al 1998), spatial regression, or multi-level modeling as appropriate (Landry and Chakraborty 2009, Locke et al 2016). While tree diversity could be assessed using estimates of species richness at the plot-level, we will use a more robust approach, utilizing data subsets at a neighborhood and/or landuse level. We will assess overall species richness, as well as native species composition as inputs in models of damage at this level.

III. Broader Impacts

This project will make important contributions to the field of urban ecology while having broader implications for tree risk assessment and hurricane preparation and response. In an urbanizing world where storms are becoming more frequent and intense, this study will give the scientific community a foundational understanding of how urban ecosystems respond to hurricanes, and provide an initial vulnerability assessment of the effects of extreme weather on urban forests. Currently, risk assessment protocols used in urban forest management instruct the assessor to consider both the climate of area and any protective factors associated with a site's micro-climate. This research will ultimately help provide guidance where none currently exists.

The project also presents intensive research opportunities for graduate and undergraduate students and technicians. Educational outreach will be accomplished through presentations and workshops to urban forest stakeholders at professional meetings locally (e.g., Trees Florida, Florida Urban Forestry Institute) and internationally (e.g., International Society of Arboriculture). Finally, the data from this project will be incorporated into student projects, PI-taught course materials, industry risk assessment BMPS, and a USDA Forest Service failure prediction tool for urban forest practitioners. Better knowledge of hurricane impacts should impact our ecological understanding, as well as promote policies and practices to build more resilient and resistant urban forests.

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Budget Justification

The budget request for this project is a total of $32,894 for this project.

A. Senior Personnel (Salaries and Wages)

The budget requests 1 month summer salary for Co-PI Landry of [redacted]. Landry will be responsible for oversight of project timeline, budget, and deliverables associated with the University of South Florida efforts; coordinating with project team members from U. Alabama and U. Florida; and oversight of all personal and work efforts from U. South Florida. Landry will lead the data collection and analysis associated with GIS (geographic information systems), including: acquisition of Census American Community Survey data, i-Tree plot location, remote sensing data, and other spatial data from all study areas; spatial analysis of tree damage and canopy loss; processing of LiDAR data to derive tree canopy height; and management of dot-based quantification of tree canopy. Landry will assist all collaborators with GIS data management and spatial analysis, including the selection of i-Tree sampling plots based on spatial dimensions (e.g., Census and Landsat).

B. Other Personnel (Salaries and Wages)

Part-time support for an existing graduate student with expertise in remote sensing is requested for this project. The probable student, Qiuyan Yu, is an advisee of Co-PI Landry in the School of Geosciences, University of South Florida. Part-time (20 hours/wk) summer hourly wage support is requested to conduct the dot-based photo-interpretation analysis of pre- and post-Irma tree canopy cover. Part-time (10 hours/wk) fall 2018 hourly wage support is requested to process LiDAR data to extract tree height, and compile spatial variables for data analysis by project team members. Requested salary is commensurate with GA pay rate for graduate students at USF. A total of $11,187 student salary is requested.

C. Fringe Benefits

Fringe benefits are calculated at 18.80% on faculty summer salaries and wages for all faculty participants. Graduate Student hourly wage positions receive fringe benefits at the rate of 1.75% for the summer position. Since the fall hourly position coincides with an existing graduate assistantship position, the fringe for the hourly position is only 0.3%. Total fringe of $1,899 is requested.

D. Equipment

No capital equipment is requested. All equipment is available at the University of South Florida for successful completion of the project.

E. Travel

E.l. Domestic Travel

No travel is requested. The PI and doctoral student will use other sources of funding to attend and present research results at the Association of American Geographers annual meeting, and other relevant conferences..

E.2. International Travel

No International travel funds are requested for the PIs or senior personnel for this project.

F. Participant Support Costs

None.

G. Other Direct Costs

G.1 Materials and Supplies. None.

G.2. Computers Services and Software. None.

G.3. Other. None. Tuition for existing graduate student is already provided by the School of Geosciences, University of South Florida.

H. Indirect Costs

Indirect costs are calculated as 49.5% of modified total direct costs and equate to $10,891.

Facilities, Equipment, and Other Resources

Facilities, equipment and resources are available from the University of South Florida (USF) in the research institute directed by Co-PI Landry, the Water Institute in the School of Geosciences.

Water Institute (WI), School of Geosciences

The Water Institute is a USF research institute affiliated with the USF College of Arts and Sciences, School of Geosciences. Dr. Shawn Landry and five professional staff joined the Water Institute in 2014 after more than a decade leading the Florida Center for Community Design and Research at USF. The Water Institute provides innovative and sustainable solutions to complex water-related problems (waterinstitute.usf.edu). As part of his assignment in his home department, Geosciences, Landry is also very engaged in urban forest research.

Office facilities of the Water Institute are equipped with standard desktop computing, internet, telephone, printing, and other office resources. The WI has an 8-desk student office space equipped with computing resources and software that is available for use by the graduate students of this project. Conference room facilities to accommodate meetings of the project team are also available for use by the project. The WI has the hardware and software resources needed for the development and management of the proposed data management portal and tools. The geospatial analytical software application ESRI ArcGIS and remote sensing application ENVI are available to all project staff through site licensing agreements at USF. Licenses for additional geospatial (e.g., GWR, GeoDa), remote sensing (e.g. Erdas IMAGINE, Trimble eCognition) and LiDAR (e.g., Quick Terrain Modeler) software tools are available to the staff of the WI. Computing resources available at the WI include high-availability online GIS, spatial database and web application infrastructure, high-powered 64-bit workstations designed for GIS and remote sensing data processing, and professional information technology staff trained to manage these infrastructures.

File server and web server technology are used to support projects such as WaterAtlas.org, Water-CAT.org, PlantAtlas.org, tampatreemap.org, and others. All servers that will support the data management plan are housed in a virtual server farm managed by the USF Information Technology department. Virtual servers are supported by nightly backups to an off-site facility, a diesel generator to ensure continuous power, multiple T3 and other internet connections, and a trained staff who manage these resources. The server farm was tested during the 2004 Florida hurricane season when the WaterAtlas.org remained online to provide local emergency management agencies with access to near-realtime hydrologic and meteorological sensor data.

The Water Institute also owns a Ford F150 vehicle that is available for travel to field locations, if needed.

Data Management Plan

I. Types of Data

The research team is committed to compliance with NSF policies on the preservation, dissemination, and sharing of research data. The data inputs and outputs are detailed in the table below. Relevant software include R, SAS, and SPSS for statistical analysis, ArcGIS for spatial analysis, QT Modeler for LiDAR data processing, and i-Tree ECO for field plot data management. In general, the products of the research will include conference presentations, peer-reviewed publications, and presentations to urban forest managers.

Data Inputs	Data Outputs
Tree attributes collected at sampled field plots in Tampa, Gainesville and Orange County.	Statistical data analysis, results, and reports. Field plot data included in i-Tree ECO database submitted to the iTreetools.org data repository.
Pre- and post-storm estimates of tree canopy cover in buffers surrounding sampled field plots.	Statistical data analysis, results, and reports.
Pre-storm very high resolution tree canopy cover data for Tampa, with height above ground of tree canopy and building elements (i.e., normalized digital surface model). Available Census and other ancillary spatial data.	Statistical data analysis and results. Spatial data (other than Census) will be made available as data layers in an Open Data repository of the USF Water Institute (directed by co-PI Landry) at http://waterinstitute.usf.edu/data-and-maps.

II. Data and Metadata Standards and Dissemination Methods

Metadata will be documented using the Ecological Metadata Language standard (EML) using the open-source software package Morpho (https://knb.ecoinformatics.org/#tools/morpho). Metadata will include the basic descriptors of the whole data set (e.g., title, originator); the research activities (site locations and descriptions, experimental design and methods, names of variables, catalog of samples, etc.); data set status (latest update and verification, proprietary rights and accessibility, etc.); and data structure (file sizes and formats). Researchers will document metadata for each new data set developed in the study, and publish the metadata on the Knowledge Network for Biocomplexity repository. For example, Shawn Landry. 2015. Tree Canopy Cover Data, Tampa, FL USA, 2006. Knowledge Network for Biocomplexity. shawnlandry.3.2. (https://knb.ecoinformatics.org/#view/shawnlandry.3.2). Tree canopy and other related spatial (i.e., GIS) data layers will also be incorporated into the USF Water Institute (directed by co-PI Landry) Open Data repository at http://waterinstitute.usf.edu/data-and-maps.

III. Policies for Access and Sharing and Provisions for Appropriate Protection/Privacy

Data Sharing Policy

Data to be shared include input and output data, and spatial analysis, results, and maps and KNB repository of metadata. The data will be shared at the end of the project and the restrictions will require approval from the project team. Journal, conference, and/or thesis and doctoral dissertation publications (if generated) will by shared in PDF format upon publication with no restrictions.

Privacy. There are no privacy concerns with the data collected as part of this study. No data related to human subjects will be collected, other than the publicly available sociodemographic datasets provided by the Census American Community Survey.

Data Citation Policy. Data should be cited using the standard APA citation style when used by others.

IV. Policies and Provisions for Re-use, Re-distribution

The majority of data will be made publicly available, either as soon as available in the case of existing datasets or after publication in order to temporarily protect intellectual property. All pre-storm i-Tree ECO data has already been submitted to the i-Tree website and according to the data sharing agreement within the i-Tree ECO software the data are already publicly available (http://www.itreetools.org/). Metadata of all new datasets will be made publicly available through the KNB. The purpose of open sharing of data is for the re-use and re-distribution and production of derivatives (with appropriate citation of our publications and databases) by the scientific community and other NGO and government agencies.

V. Resources and Facilities for Data Storage, Preservation and Archiving

For long-term storage, researchers have institutional file storage systems with replication/backup and redundancy. Systems are on scheduled backup cycles and include back-up generator in case of power outages.