**NASA DEVELOP National Program**

**Arizona - Tempe**

*Project Summary – Spring 2018*

**Ajax Urban Development**

*Utilizing NASA Earth Observations to Assess Urban Forestry as an Adaptation Strategy for Extreme Heat in Ajax, ON, Canada*

**VPS Title:** Keeping Trees Happy and Healthy: Urban Forestry in a Changing Canadian Climate

**Project Team**

***Project Team*:**

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***Advisors & Mentors*:**

Dr. David Hondula (Arizona State University)

Dr. Qunshan Zhao (Arizona State University)

**Project Overview**

***Project Synopsis*:** Urban forestry is a primary heat mitigation strategy for many municipalities. The town of Ajax, Ontario is seeking to improve its urban forestry management strategies to expand the ecosystem services provided to residents and ensure the resiliency of its forests. This project assessed the spatial distribution of urban green infrastructure, compared it with patterns in social vulnerability indicators, and quantified the influence of climatic variables on tree stress. A case study analysis at the neighborhood scale examined the influence of tree species, tree placement, and tree orientation on thermal comfort. The results will be used to guide urban forestry management.

***Abstract*:**

The town of Ajax, Ontario received a report from Specialists in Energy, Nuclear and Environmental Sciences (SENES) Consultants detailing the likely changes in local weather patterns for 2040-2049. The climate model predicts an increase in the frequency and intensity of monthly rainfall, a decrease in annual snowfall, and an increase in average annual temperature of approximately 4 °C. The Town of Ajax, Operations & Environmental Services aims to take early action to mitigate the potential impacts of these changes, such as increased tree fatalities and extreme temperature. In particular, tree fatalities due to increased stress, disease, and infestation are of special concern because trees are an important resource for ameliorating extreme temperatures via shading and evapotranspiration. To create a model for how tree stress varied in conjunction with climate variables, Landsat 5, Landsat 8, and high-resolution imagery from 2000 to 2016 were used to estimate the tree canopy coverage and land cover classes. Combined with meteorological data, these classifications were used to examine the relationship between tree stress and climate variables such as temperature and precipitation. To supplement these results, the group used an ENVI-MET model simulation to perform a case study that determined the optimal tree placement and orientation in a vulnerable residential area within the city. These results will provide city planners with tools needed to plan for the predicted increase in extreme heat events and mitigation of the effects on the community.

**Keywords:**

Remote sensing, PlanetScope, urban forestry, tree health, social vulnerability, Landsat 8, ENVI-MET

***National Application Area Addressed:*** Urban Development

***Study Location:*** Ajax, ON, Canada

***Study Period:*** January 2000 – December 2017; Forecasting to January 2040 – January 2049

***Community Concern:***

* Recent extreme weather events have impacted the health of Ajax’s urban forest, leading to a reduction in overall tree coverage.
* Maintaining the health of Ajax’s urban forest is essential since forests are effective infrastructural adaptations that can provide reprieve from extreme heat.
* A recent study, which modeled past and future climate, indicated that the Ajax area can expect an increase in daily average, maximum, and minimum temperatures, an increase of monthly rainfall, and an increase in the intensity and frequency of weather events.
* Future climate conditions could challenge the ability of Ajax and surrounding municipalities to maintain or grow tree coverage to build community resilience to extreme heat.

***Project Objectives:***

* Determine Ajax’s town hall tree health when impacted by extreme heat, drought, and extreme weather events that SENES Consultants projected for 2040 - 2049
* Discover where Ajax residents are most vulnerable to extreme heat
* Create a new land use and land cover classification for the town of Ajax, Ontario
* Identify arrangements of trees that will help to mitigate the vulnerability and risks associated with extreme heat via simulation at the backyard scale

**Partner Overview**

***Partner Organizations:***

|  |  |  |  |
| --- | --- | --- | --- |
| **Organization** | **POC (Name, Position/Title)** | **Partner Type** | **Boundary Org?** |
| **Town of Ajax, Operations & Environmental Services** | Jade Schofield, Environmental Sustainability Coordinator | End User | No |
| **Great Lakes and St. Lawrence Cities Initiative** | Andrea Paine, Program and Administrative Assistant | Collaborator | No |
| **Arizona State University, Urban Climate Research Center** | Dr. David Sailor, Director | Collaborator | No |

***Decision Making Practices & Policies***:

Currently, Ajax’s Operations and Environmental Services decision making relies on a US Forest Services tree inventory that contains data for public land only. Although Ajax is comprised of both public and private land, trees existing in private land have not been recorded in detail, and thus are not used in the current decision-making process. The town created a Climate Adaptation Plan which identifies and addresses specific challenges that the town expects to face. This plan includes strategies for mitigating and protecting against the impact of extreme heat. For example, it offers strategies for protecting outside workers, increasing social and building resilience against severe weather, protecting electrical structures, and reducing urban flooding hazards.

***Project Benefit to End User***:

The outcomes of this project will inform Ajax’s Operations and Environmental Services by supplementing the Climate Adaptation Plan which identifies the work needed to ensure that communities can adapt to effects of changing weather patterns. The end products produced this term will allow end users to identify preferable areas for future increases in urban tree cover. The end products will also provide tools for municipal foresters, policy planners, and utility operators to prioritize best management practices in maintaining a resilient socio-ecological system. Additionally, the end products will allow the end users to be more effective in implementing tree cover to ameliorate extreme heat in vulnerable communities.

**Earth Observations & End Products Overview**

***Earth Observations:***

|  |  |  |
| --- | --- | --- |
| **Platform & Sensor** | **Parameter** | **Use** |
| **Landsat 8 OLI** | Surface reflectance/radiance | This dataset was used to calculate vegetation indices and land surface temperature. |
| **Landsat 5 TIRS** | Surface reflectance/radiance | This dataset was used to calculate vegetation indices and land surface temperature. |

***Ancillary Datasets:***

SENES Consultants Future Climate Parameters Dataset – A dataset of past and future climate variables (i.e. air temperature, rainfall, wind speed, etc.) used to predict tree health for 2040 - 2049

USDA, Forest Service Urban Forest Effects Model (UFORE) – The Urban Forest Effects Model dataset contains tree location and species for the City of Toronto and surrounding towns, including the town of Ajax

Canadian Census Program Census of Population – Sociodemographic variables like age, income, ethnicity, and immigration status used to identify areas of Ajax vulnerable to extreme heat

Planet PlanetScope – High resolution imagery used for more detailed land cover classification and mapping of the current urban forest

DayMet Version 3 – Estimated gridded meteorological data from point weather station observations, including temperature and precipitation data from 2000-2016 for the Ajax area used as predictor variables when assessing tree health

***Modeling:***

ENVI - MET (Dr. Qunshan Zhao, Science Advisor) – Simulates microclimate environment when choosing the best arrangement of trees within properties

***Software & Scripting:***

Esri ArcGIS Pro – Object-based land cover classification

Esri ArcMap – Map generation

Google Earth Engine – Raster data processing

R – Data manipulation and analysis

***End Products:***

|  |  |  |  |
| --- | --- | --- | --- |
| **End Product** | **Earth Observations Used** | **Partner Benefit & Use** | **Software Release Category** |
| **2017 Land Use Land Cover Map** | PlanetScope | This will allow partners to identify changes in Ajax’s landcover since the last land cover land usage map was created in 2010. | N/A |
| **Predicted Tree Health for 2040 -2049** | Landsat 5 TM and Landsat 8 OLI | Partners can use future estimates of tree health in the town hall area when planning to support future tree growth. | N/A |
| **Heat Vulnerability Assessment** | Landsat 8 OLI | This will allow partners to identify communities in Ajax that are vulnerable to extreme heat reside. | N/A |
| **Tree Health Time Series 2000 - 2016** | Landsat 5 TM and Landsat 8 OLI | Partners will use the tree health time series to identify areas throughout Ajax where trees should be planted to reduce the impact of extreme temperatures on vulnerable communities. | N/A |
| **Tree Canopy Changes 2000 - 2017** | Landsat 5 TM and Landsat 8 OLI | This will allow partners to identify changes in Ajax’s tree canopy. | N/A |

**Project Handoff Package**

**Transition Plan:**

The team will present their results and end products to partners and other interested parties through a web video conference. In June 2018, team members will also present results and methodology in Ajax at the Great Lakes & St. Lawrence Cities Annual Conference to a contingency of mayors and decision makers from the US and Canada. The processed datasets, end products, and supporting documentation will be sent to partners through NASA Large File Transfer. At this time, software release will not be required.

**Team POC:** Huntington Keith, hwkeith@asu.edu

**Partner POC**: Jade Schofield, jade.schofield@ajax.ca

**Handoff Package:**

* Map package: Land Use Land Cover classifications for Ajax, ON from 2000 - 2017 (raster data set), Tree Canopy Changes for Ajax, ON from 2000 - 2017 (raster data set), and Tree Health Time Series for Ajax from 2000 - 2016 (raster data set)
* Presentation detailing where trees within Ajax are currently at risk, recommendations on spatial arrangements of trees within the microclimate scale, and a forecast for Ajax’s town hall tree health during 2040 - 2049 (including PowerPoint, ENVI - MET simulation animation, and poster)
* Technical Paper

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