**NASA DEVELOP National Program**

**2018 Spring Project Proposal**

**Arizona – Tempe**

**Ajax Urban Development**

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

**Project Overview**

***Project Synopsis*:**

The Town of Ajax, Ontario has identified risks and vulnerabilities facing the community associated with climate hazards such as extreme heat. In the coming years, one of the major threats identified is the potential for transition of the natural landscape as temperatures increase. This project will estimate the impact of projected warming on the health of Ajax’s urban forest. It will also estimate the impact of local-scale climate variations on tree canopy and speciation through the application of Landsat 8 and Sentinel-2. The assessment of current urban forest will be overlaid with projected climate variables to identify areas where existing or alternative species would be most likely to thrive. The project will also examine geographic patterns in urban tree coverage, high temperatures, and social vulnerability. This study will enable Ajax to prioritize action items to be included in the proposed Community Climate Adaptation Plan.

***Community Concern:***

Recent extreme weather events including a 2013 ice storm, 2016 drought, and 2017 flooding have impacted the health of Ajax’s urban forest and led to a reduction in overall tree coverage. Urban greening, including increasing tree canopy coverage are effective infrastructural adaptations to the health impacts of heat. Through shading and evapotranspiration, trees can provide an effective reprieve from extreme heat. A recent study conducted by SENES consultants and the city of Toronto modeled past and future climate for the entire Durham region. This study indicated that the Town of Ajax is expected to experience increase in the number of days above 30 °C, the potential for increased flooding events, and more destructive storms. This conditions could challenge the ability of Ajax and surrounding municipalities to maintain or grow tree coverage to build community resilience to extreme heat.

***Source of Project Idea:***

This project idea was requested through contacts with the Town of Ajax and the Great Lakes St. Lawrence Cities Initiative. After the initial request, conversations between the partners and the DEVELOP National Program Office resulted in a refinement of the idea.

***National Application Areas Addressed:*** Urban Development, Health & Air Quality

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

***Study Period:*** January 2010 – January 2016; January 2040 – January 2049

***Advisors:*** Dr. David Hondula (Arizona State University), Dr. Qunshan Zhao (Arizona State University)

**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** | Simon Belisle, Program Manager | Collaborator | Yes |
| **Arizona State University, Urban Climate Research Center** | Dr. David Sailor, Director | Collaborator | No |

***End-User Overview***

***End User’s Current Decision-Making Process:***

Through the Operations & Environmental Services, the Town of Ajax promotes sustainable practices and increases community resilience to heat and other climate hazards in multiple ways. One such way is the development of a Climate Adaptation Plan which identifies specific challenges the town is expected to face and outlines solutions to improving community well-being.

***End User’s Capacity to Use NASA Earth Observations:***

*Town of Ajax, Operations & Environmental Services* – The town has used NASA Earth observation data derived products to estimate the urban heat island as a planning tool to identify land features. This project will build upon the partner’s current capacity and will provide them further knowledge and use of Earth observations using spatial modeling to prioritize action needed to reduce the impacts of extreme temperatures.

***Collaborator & Boundary Organization Overview***

***Collaborator Support:***

*Great Lakes and St. Lawrence Cities Initiative* – Collaborators with GLSLCI have helped connect the team with end users associated with the Town of Ajax. They will be featuring the project’s results and methodology at their annual conference in June 2018.

*Arizona State University, Urban Climate Research Center* – The Urban Climate Research Center will provide scientific advising and software resources specific to urban heat island issues.

***Dissemination by Boundary Organizations*:**

*Great Lakes and St. Lawrence Cities Initiative (GLSLCI)* – The GLSLCI is a coalition of 131 US and Canadian mayors and local officials who work together to promote sustainable use of the Great Lakes and St. Lawrence River. This includes addressing issues relating to the urban heat island. The GLSLCI will facilitate DEVELOP presenting this project to all the mayors in the region at their annual meeting. Additionally, the project will be a highlight their discussions with other cities and communities interested in addressing similar issues.

***Project Communication & Transition Overview***

***In-Term Communication Plan*:** The Arizona – Tempe Center Lead will establish regular meetings with the partners prior to the start of the term. The POC will be the team lead throughout the duration of the term.

***Transition Plan*:** The team will present their results and end products to our partners and other interested parties through a web video conference. There will also be an opportunity in June 2018 to 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.

**Earth Observations Overview**

***Earth Observations:***

|  |  |  |
| --- | --- | --- |
| **Platform & Sensor** | **Parameters** | **Use** |
| **Landsat 8 OLI** | Top-of-atmosphere reflectance/radiance | This dataset will be used to calculate vegetation indices and land surface temperature. |
| **Landsat 5 TIRS** | Top-of-atmosphere reflectance/radiance | This dataset will be used to calculate vegetation indices and land surface temperature. |
| **Sentinel-2 MSI** | Top-of-atmosphere reflectance | This dataset will be used to create a land cover classification for the town of Ajax. |

***Ancillary Datasets:***

SENES Consultants Future Climate Parameters Dataset – A dataset of past and future gridded climate variables (i.e. air temperature, rainfall, wind speed, etc.) that will be used to identify suitable areas for sustainable tree growth.

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 Census of Population – Various sociodemographic variables like age, income, ethnicity, and immigration status will be collected and used to identify areas of Ajax vulnerable to extreme heat.

***Software & Scripting:***

Esri ArcGIS – Object Based Land Cover Classification, Map Generation

Google Earth Engine – Raster Data Processing

Python – Data Manipulation and Analysis

ERDAS IMAGINE – Land Cover Classification

R – Data Manipulation and Analysis

**Decision Support Tool & End Product Overview**

***End Products:***

|  |  |  |  |
| --- | --- | --- | --- |
| **End Products** | **Partner Use** | **Datasets & Analyses** | **Software Release Category** |
| **Urban Tree Assessment** | Partners will be able to identify the location of urban tree canopy associated with key tree species. | An object based land cover classification completed with Sentinel-2 data and potentially high resolution aerial imagery. | N/A |
| **Tree Health Regression** | Partners will able to identify where different climate and build environment variables significantly influence tree health | Tree data provided by partners with the Town of Ajax and output from the Urban Tree Assessment will be regressed against climate predictors from SENSES Future Climate Parameters Dataset and built environment characteristics from Sentinel-2 land cover classification and infrastructure data provided by the partners with the Town of Ajax. A global regression will be conducted and if possible a local regression will be conducted. | N/A |
| **Tree Suitability Assessment** | Partners can use future estimates of climate variables (i.e. extreme temperature and precipitation) to identify areas throughout Ajax that can and cannot support future tree growth. | Data from Landsat 8 and Sentinel-2 will be combined with the SENES Consultants Future Climate Parameters Dataset provided by partners with the town of Ajax. | N/A |
| **Urban Heat Index** | Partners will use this index to identify where the hottest and coolest locations are throughout the town. | Land surface temperatures will be calculated from Landsat 5 and Landsat 8 then aggregated into an index depicting hotter and cooler locations throughout the town | N/A |
| **Heat Vulnerability Assessment** | This will allow partners to identify areas throughout Ajax where communities vulnerable to extreme heat may reside. This product will be combined with the Tree Growth Suitability Assessment to identify areas were tree growth could help those most vulnerable to extreme heat. | This product will utilize the socioeconomic data gathered from the Canadian Census to produce a social vulnerability index, which will be combined with the Urban Heat Index producing the final Extreme Heat Vulnerability Assessment. | N/A |
| **Tree Placement Optimization** | This end product will allow partners to better identify how and where trees should be planted to reduce the impact of extreme temperatures on vulnerable communities. | This product will combine the resulting Tree Suitability Assessment and Heat Vulnerability Assessment to identify areas for tree placement in high vulnerability portions of the town of Ajax. | N/A |

***End-User Benefit*:**

The outcomes of this project will inform the town’s Climate Adaptation Plan which identifies the work needed to ensure that communities can adapt to effects of changing weather patterns. The end products produced in this term will allow the end-users to identify areas that will be suitable for future increases in urban tree cover. This would allow for municipal foresters, policy planners, and utility operators to prioritize best management practices to maintain a resilient socioecological 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.

**Project Timeline & Previous Related Work**

***Project Timeline:*** 1 Term: 2018 Spring

***Related DEVELOP Work:***

Summer 2017 (AZ) – Las Cruces Health & Air Quality: Assessing Urban Heat as it Relates to Social Vulnerability and Land Use Changes in Las Cruces, New Mexico

**Notes & References:**

***Notes*:** Anything else you deem relevant and that supports the proposal.

***References:***

Durham Region (2016). *Towards Resilience: Durham Community Climate Adaptation Plan 2016*

SENES Consultants (2014). *Durham Region’s Future Climates (2040 – 2049) SUMMARY.*

Cutter, S. L., Boruff, B. J., & Shirley, W. L. (2003). Social Vulnerability to Environmental Hazards\*. *Social Science Quarterly, 84*(2), 242–261. <https://doi.org/10.1111/1540-6237.8402002>

Harlan, S., Declet-Barreto, J., Stefanov, W., & Petitti, D. (2013). Neighborhood Effects on Heat Deaths:

Social and Environmental Predictors of Vulnerability in Maricopa County, Arizona. *Environmental Health Perspectives, 121*(2), 197–204. <https://doi.org/10.1289/ehp.1104625>

Harlan, S. L., Brazel, A. J., Prashad, L., Stefanov, W. L., & Larsen, L. (2006). Neighborhood microclimates

and vulnerability to heat stress. *Social Science & Medicine, 63*(11), 2847–2863. <https://doi.org/10.1016/j.socscimed.2006.07.030>

Reid, C., O’Neill, M., Gronlund, C., Brines, S., Brown, D., Diez-Roux, A., & Schwartz, J. (2009). Mapping

Community Determinants of Heat Vulnerability. *Environmental Health Perspectives, 117*(11), 1730-1736. <https://doi.org/10.1289/ehp.0900683>

Uejio, C. K., Wilhelmi, O. V., Golden, J. S., Mills, D. M., Gulino, S. P., & Samenow, J. P. (2011). Intra-urban

societal vulnerability to extreme heat: The role of heat exposure and the built environment, socioeconomics, and neighborhood stability. *Health & Place, 17*(2), 498–507. https://doi.org/10.1016/j.healthplace.2010.12.005

Turner II, B. L. (2016). Land system architecture for urban sustainability: new directions for land system

science illustrated by application to the urban heat island problem. *Journal of Land Use Science*, *11*(6), 689-697

Wilhelmi, O. V., & Hayden, M. H. (2010). Connecting people and place: a new framework for reducing urban

vulnerability to extreme heat. *Environmental Research Letters, 5*(1), 14021. <https://doi.org/10.1088/1748-9326/5/1/014021>

Zhao, Q., Wentz, E. A., & Murray, A. T. (2017). Tree shade coverage optimization in an urban residential environment. *Building and Environment*, *115*, 269–280. <https://doi.org/10.1016/j.buildenv.2017.01.036>

Zhao, Q., & Wentz, E. A. (2016). A MODIS/ASTER Airborne Simulator (MASTER) Imagery for Urban Heat Island Research. *Data*, *1*(1). https://doi.org/10.3390/data1010007