**NASA DEVELOP National Program**

**2020 Spring Project Proposal**

**Massachusetts – Boston**

**Western Massachusetts Water Resources**

*Using Earth Observations to Assess Flood Events Resulting from North American Beaver Reintroduction to Inform Biodiversity and Infrastructure Management*

**Project Overview**

***Project Synopsis*:** Western Massachusetts communities have become increasingly impacted by beaver-induced flooding, affecting human infrastructure, wells, and septic systems. Given the many potential impacts of beavers and their dams on biological and environmental health as well as human infrastructure, understanding the spatial and temporal patterns in the distribution of beaver activity is of interest from both scientific and management perspectives. This project will create an interactive monitoring tool capable of identifying beaver-induced flooding events through characterization of the spectral-temporal response of beaver activities. Maps and time series will be created to help partners at the Massachusetts Audubon Society (Mass Audubon) manage and inform increasingly prevalent human-beaver conflicts. Earth observations used for these analyses include Landsat 5 TM, Landsat 7 ETM+, Landsat 8 OLI, and Sentinel-1 C-SAR. Overall, end products will help decision-makers assess potential environmental and human impacts of beaver dams, as well as explore further research options utilizing NASA EOs.

***Community Concern:*** After populations were decimated during the 1700s, North American beavers (*Castor canadensis*) are returning to the landscape of Western Massachusetts. These ecosystem engineers can rapidly alter the environment through the creation of dams, changing the extent and physical properties of waterbodies and landscapes. Flooding caused by these dams often affects human engineered infrastructure, such as roads, crops, homes, wells, and septic systems. Changes in aquatic biogeochemical cycling, water quality, and habitat availability also affect the conservation of many species targeted by organizations like the Mass Audubon. Given the wide range of potential impacts of beavers and beaver dams on environmental diversity and human infrastructure, understanding the spatial-temporal patterns in the distribution of beaver activity is of interest to both the scientific and management communities.

***Source of Project Idea:*** Dr. Valerie Pasquarella, Research Scientist and Assistant Director of the Center for Remote Sensing at Boston University, reached out to former MA Center Lead Zachary Bengtsson to see if DEVELOP would be interested in working on a project with her colleagues at Mass Audubon.

***National Application Area Addressed:*** Water Resources

***Study Location:*** Western Massachusetts

***Study Period:*** January 1985 – December 2019

***Advisors:*** Dr. Cedric Fichot (Boston University), Dr. Valerie Pasquarella (Boston University)

**Partner Overview**

***Partner Organization:***

|  |  |  |  |
| --- | --- | --- | --- |
| **Organization** | **POC (Name, Position/Title)** | **Partner Type** | **Boundary Org?** |
| **Massachusetts Audubon Society** | Joshua Rapp, Regional Scientist; Jeff Collins, Director of Conservation Science | End User | Yes |

***End User Overview***

***End User’s Current Decision-Making Process:***Mass Audubon is a non-profit organization focused on protecting and conserving Massachusetts’ natural landscape for the benefit of wildlife and people alike. The organization’s research, educational outreach, and advocacy efforts partner with academic institutions, local government organizations, camps, and more to stress the importance of conserving wildlife sanctuaries and living harmoniously with nature. The end user is familiar with spatial analysis; however remote sensing is not currently involved in their decision-making practices. Most environmental decision-making is completed using data collected directly from the field and information provided by academic or outside organizations, residents, or individual towns. Mass Audubon is in the process of informing the public of how to best respond to human-beaver conflicts, specifically responding to community concerns related to flood damage and monitoring. Currently, Mass Audubon’s beaver disturbance management procedures are not uniform across sites and vary on a case-by-case basis.

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

*Massachusetts Audubon Society* – The main partner POC, Joshua Rapp, has working knowledge of NASA Earth observations and GIS software. However, the organization as a whole does not currently use NASA EO data products for their research or decision-making. The end user POC detailed that the organization is excited to integrate a new methodology for acquiring sound scientific data to inform their future decision-making.

***Collaborator & Boundary Organization Overview***

***Dissemination by Boundary Organizations*:**

*Massachusetts Audubon Society* – Mass Audubon is one of the largest statewide providers of environmental education programming, with a broad network of partnerships and community outreach connections. These groups include local Massachusetts city and town government organizations, The Nature Conservancy, and other state organizations. Mass Audubon will share the results and tools of this project directly to cities or towns impacted by beaver flooding disturbances, as well as to their additional partnerships to communicate the practical applications of satellite remote sensing. Maps and results may also be disseminated to the public via their website or newsletter.

***Project Communication & Transition Overview***

***In-Term Communication Plan*:** The partner will meet with the MA DEVELOP team on a bi-weekly basis during the term. There is the possibility that one or more of these meetings will occur in-person due to the proximity of the Massachusetts – Boston Node to the partner’s offices. The main POC for all communications will be the Project Lead, with support from the Fellow, if necessary.

***Transition Plan*:** The hand-off to the end user will take place in week 10. Ideally, the hand-off will occur in-person, located at the Boston University Center for Remote Sensing. If an in-person hand-off is not possible, the event will take place remotely. The project team will present the term’s methods and findings, perform a tutorial of the Google Earth Engine tool, and answer questions. Maps and time series deliverables will be immediately delivered to partners for public dissemination and research integration. Code for the Google Earth Engine tool will be shared with the partner after it has completed the software release process.

**Earth Observations Overview**

***Earth Observations:***

|  |  |  |
| --- | --- | --- |
| **Platform & Sensor** | **Parameter** | **Use** |
| **Landsat 5 TM** | Surface Reflectance | Surface reflectance will be used to examine and map flooding events. |
| **Landsat 7 ETM+** | Surface Reflectance | Surface reflectance will be used to examine and map flooding events. |
| **Landsat 8 OLI** | Surface Reflectance | Surface reflectance will be used to examine and map flooding events, as well as provide a baseline comparison for years in which flooding events did not take place. |
| **Sentinel 1 C-SAR** | Land Cover | Sentinel-1 C-SAR data will be used to supplement Landsat data and map fluctuations in flooding events at an increased temporal and spatial resolution. |

***Ancillary Datasets:***

* iNaturalist Massachusetts beaver observations – integrate direct observations into the Google Earth Engine tool to distinguish between regular flooding and beaver-induced flooding

***Software & Scripting:***

* Google Earth Engine API – Data and timeseries analysis of Earth observation imagery
* Esri ArcGIS – Data processing, production of maps

**Decision Support Tool & End Product Overview**

***End Products:***

|  |  |  |  |
| --- | --- | --- | --- |
| **End Product** | **Partner Use** | **Datasets & Analyses** | **Software Release Category** |
| **Google Earth Engine Flood Detection Tool** | This will be a tool that will allow the partner to detect flooding events caused by North American beavers so that they may assess the potential negative impacts on infrastructure and changes to ecosystems of concern as a result of this natural species reintroduction. | Landsat 5 TM, Landsat 7 ETM+, Landsat 8 OLI, and Sentinel-1 C-SAR will be used to create a tool capable of identifying beaver-caused flooding events through characterization of the spectral-temporal response of beaver activity via Tasseled Cap transformations. The tool will include a toggle-able confirmed beaver location layer for each year of available data. | IV |
| **Flood Extent Time Series, Maps, and Animations** | These time series, maps, and animations will demonstrate the utility of the tool and how beavers have impacted Massachusetts ecosystems through time. | Landsat 5 TM, Landsat 7 ETM+, Landsat 8 OLI, and Sentinel-1 C-SAR will be used to create spatial and temporal records and identify patterns of potential beaver-created disturbance events at sites of interest. | N/A |

***End User Benefit*:** Mass Audubon is looking for products that will help them better monitor and manage the impacts of growing beaver populations. End products will allow them to detect potential beaver-related flooding events so that they may assess potential negative impacts to human infrastructure, water quality, and wetland ecosystems. A scalable mapping tool that identifies the spatial and temporal pattern of beaver impacts at the state scale will ultimately increase and unify understanding of Massachusetts’ beaver populations. Overall, the end user will use the provided products to increase public awareness in addressing human-wildlife conflicts and to explore further research options utilizing NASA EOs.

**Project Timeline & Previous Related Work**

***Project Timeline:*** 1 Term: 2020 Spring

***Related DEVELOP Work:***

2018 Summer (AL) – New Orleans Urban Development: Utilizing Earth Observations to Assist Groundwork New Orleans to Reduce Flood Vulnerability in New Orleans, Louisiana, Metropolitan Area

2017 Spring (MSFC) – Mississippi River Basin Disasters II: Automated Mapping of Flood Events in the Mississippi River Basin Utilizing NASA Earth Observations

2015 Fall (MCHD) – Utilizing NASA Earth Observations to Assess Current and Historic Wetland Extent along the Natchez Trace Parkway

**References:**

Deblinger, R. D., Field, R., Finn, J. T., & Loomis, D. K. (2004). A conceptual model of suburban wildlife management: a case study of beaver in Massachusetts. In *4th International Symposium on Urban Wildlife Conservation* (pp. 245-252).

Jonker, S. A., Muth, R. M., Organ, J. F., Zwick, R. R., & Siemer, W. F. (2006). Experiences with beaver damage and attitudes of Massachusetts residents toward beaver. *Wildlife Society Bulletin*, *34*(4), 1009-1021.

Pasquarella, V. J. (2016). A conceptual and methodological approach to characterize beaver-related wetland disturbance using Landsat time series. In Utilizing the Landsat spectral-temporal domain for improved mapping and monitoring of ecosystem state and dynamics (pp. 88 - 136). Doctoral dissertation, Boston University.

Rosell, F., Bozser, O., Collen, P., & Parker, H. (2005). Ecological impact of beavers Castor fiber and Castor canadensis and their ability to modify ecosystems. *Mammal Review*, *35*(3‐4), 248-276.