**NASA DEVELOP National Program**

**Fall 2015 Project Proposal**

**Mobile County Health Department**

**Coastal Texas Water Resources II**

Utilizing NASA Earth Observations to Assess Estuary Health and Enhance Management of Water Resources in Coastal Texas through Land Cover and Precipitation Mapping

**Objective:**

To conduct a land cover classification and precipitation analysis of Laguna Madre in Padre Island National Seashore to analyze the suspected correlation between the changes in mesquite trees cover the area and changes in salinity of the lagoon.

**Community Concern:**

Laguna Madre of Padre Island National Seashore is a hypersaline estuary (salinity is higher than the adjacent marine environment). There is compelling historical evidence dating from pre-European settlement of the region that the Laguna Madre was not always hypersaline, thus the original ecosystem of the lagoon was dramatically altered at some point in time. A National Park Service hydrologist hypothesizes that this is in part due to the increase of mesquite trees in the area, which have replaced local grasses. The trees have long taproots that extract large quantities of groundwater that previously reached the Laguna Madre via groundwater discharge, thus decreasing salinity. Artesian wells once common upslope of the Laguna Madre have ceased to flow over the past decades, likely matched by a decrease of groundwater discharge into the estuary. This situation poses an interesting management challenge. The mesquite tree, the suspected culprit of the changing hydrology, is also a native plant. Furthermore, the increased tree coverage has occurred on privately-owned, undeveloped land around the lagoon. This concern presents the complexities of managing native plants, and the interconnectivity between private and public land management.

**Partner Organizations:**

National Park Service (End-user, POC: Joe Meiman, Hydrologist)

Contact with the partner began in October 2014 via email and teleconferences. Communication has been with Joe Meiman, a hydrologist for several national parks in the southern US. While the intent of the initial email was to gauge interest in project ideas, Joe responded back with a clear project idea of testing the hypothesis that the increase in mesquite trees in the area surrounding Laguna Madre in the Padre Island National Seashore was decreasing groundwater flow into the lagoon and causing the increase in salinity of the estuary. Throughout the first term of the project, communication occurred weekly though emails, teleconferences, videoconferences. The partner will also attend the AESAS closeout event in DC. Due to the distance between the team and the partner, the transition of support tools will likely be sent through email with a video conference presentation and discussion of results, if the partner is unable to attend a local closeout event. The results of this project are meant to provide insight into this situation and lay the basis for future management plans.

**Letters of Support:** National Park Service, Joe Meiman, Hydrologist

**Decision Making Process:**

As part of the Padre Island National Seashore, a portion of the Laguna Madre falls under federal land management. The water quality (e.g. temperature, pH levels, turbidity, salinity, etc.) and nutrient levels of the lagoon are currently monitored with *in situ* data collection. According to our partner, the park has some lidar data processed by the USGS in Tampa to monitor coastal morphology and vegetation. This data is from 2005-2008 from the Texas Natural Resources Information System and would be available to the team. Currently, the relationship between the mesquite trees, groundwater, and the lagoon is not studied in a systematic manner. Furthermore, as the mesquite trees are primarily on private land, the proposed analysis would serve as a foundation for decision-making in regards to how the national park worked with its partners in Texas for land management purposes. According to Meiman, “This project will serve to lay the data foundation to determine if connections exist between changes in natural land over and estuarine ecology. If eventually found to have merit, profound changes in land cover management could positively affect both agriculture and ecology.”

**Earth Observations:**

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| **Platform** | **Sensor** | **Geophysical Parameter** |
| **Landsat 8** | OLI | Land cover |
| **Landsat 7** | ETM+ | Land cover, thermal bands |
| **Landsat 5** | TM | Land cover, thermal bands |
| **GRACE** | ACC/SCA/KBR | Root Zone Soil Moisture Content |

**NASA Earth Observations Highlighted:**

A key component of this analysis is change over time (in groundwater, in the mesquite tree population, and in the salinity of the lagoon). Landsat 5, 7, and 8 data will provide insights into the changes in coverage of the mesquite trees in the area extending over a thirty year period. In addition, these data will also be utilized to create vegetation indices, such as the Normalized Difference Infrared Index (NDVI) and the Soil-Adjusted Vegetation Index (SAVI), as well as to conduct thermal mapping of the lagoon. The vegetation indices will assist in highlighting the difference between the mesquite trees, which, with their long taproots are able to obtain deeper groundwater, and the other, more shallow-rooted vegetation, with more limited access to groundwater. The thermal mapping will be analyzed to determine if fresh groundwater is being discharged through the bottom of the shallow (<1m) estuary, as in the winter months, as this will provide the highest contrast between the warmer, lighter, fresh groundwater and the cooler, dense saline water of the estuary. In addition, GRACE derived Root Zone Soil Moisture data, processed during the first term of the project, will be analyzed with PRISM precipitation data for potential correlations. The PRISM data will be utilized to provide a finer resolution than the TRMM monthly accumulated data used in the first term of the project.

**Ancillary Datasets:**

* *In situ* and historic water temperature and salinity data
* USGS – National Land Cover Dataset (NLCD)
* USDA NRCS – Geologic formations and soil data
* PRISM Climate Group – Precipitation data

**Models:**

TerrSet Land Change Modeler for ArcGIS/IDRIS Land Change Modeler (POC: Dr. James Toledano, Clark Labs)

**Decision Support Tools & Analyses:**

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| **Proposed End Products** | **Decision to be Impacted** | **Current Partner Tool/Method** |
| LULC Map Time Series | Whether changes in land management are needed if increase in mesquite trees correlates with decrease in groundwater and increase in estuary salinity | NPS Inventory and Monitoring Network annual vegetative monitoring within park boundaries |
| Mesquite Tree Extent Prediction Maps | Whether changes in land management are needed if increase in mesquite trees correlates with decrease in groundwater and increase in estuary salinity and tree expansion is predicted | NPS Inventory and Monitoring Network annual vegetative monitoring within park boundaries |
| Vegetation Indices Maps | Whether changes in land management are needed if increase in mesquite trees correlates with decrease in groundwater as indicated by vegetation water stress levels | NPS Inventory and Monitoring Network annual vegetative monitoring within park boundaries |
| Precipitation Analysis | Whether changes in land management are needed if increase in mesquite trees correlates with decrease in groundwater and increase in estuary salinity (and not only/primarily precipitation) | None |
| Soil Type by Mesquite Tree Occurrence Map | Whether soil type can be identified as a factor in mesquite tree location and can be used as a predictor of tree occurrence to be considered in land management decisions | NPS Inventory and Monitoring Network annual vegetative monitoring within park boundaries |
| Thermal Map of Lagoon | Whether changes in groundwater inflow to lagoon can be identified and need to be addressed through changes in land management practices | Water quality *in situ* measurements |

*LULC Map Time Series* – Landsat 7 ETM+ and Landsat 5 TM data will be used to create LULC maps specifically focused on mapping the extent of mesquite trees in the area extending the time series begun during the first term.

Mesquite Tree Extent Prediction Maps – Landsat 5 TM, Landsat 7 ETM+, and Landsat 8 OLI data will be used to create LULC maps to input into the Land Change Modeler, to create a predictive map of mesquite tree expansion,

Vegetation Indices Maps – Landsat 7 ETM+ and Landsat 5 TM data will be used to create maps of several vegetation indices (e.g. Normalized Difference Infrared Index (NDII), Moisture Stress Index (MSI), Enhanced Vegetation Index (EVI), and Soil-Adjusted Vegetation Index (SAVI)) illustrating plant productivity and water stress to correlate with the mesquite trees mapped in the LULC time series.

Precipitation Analysis – PRISM precipitation data will be analyzed with GRACE derived Root Zone Soil Moisture Content data processed during the first project term to identify potential correlations between the two.

Soil Type by Mesquite Tree Occurrence Map – USDA soil type data will be combined with the LULCs created from Landsat 5, 7, and 8 data to find possible correlations between soil type and tree occurrence.

*Thermal Maps of Lagoon* – Landsat 5 TM, and 7 ETM+ data will be analyzed to extend the thermal map time series produced during the first term and will be used to identify cooler areas indicative of cooler groundwater entering the lagoon.

**Project Details:**

**National Application Area(s) Addressed:** Water Resources

**Source of Project Idea:** Joe Meiman, NPS expressed interest a project using NASA Earth observations to study one of the parks he manages as a hydrologist near Corpus Christi, Texas. He had a fairly well-developed project idea and hypothesis already and through a teleconference worked with the DEVELOP Mobile team to define this project.

**Study Location:** Padre Island National Seashore, Texas

**Period being Studied:** January 1987 to January 2015

**Advisor(s):** Joe Spruce (NASA Stennis Space Center), James “Doc” Smoot (NASA Stennis Space Center)

**Participants Requested:** 2

**Project Timeline:** 2 Terms: 2015 Summer (Start) to 2015 Fall (Completion)

**Multi-Term Objectives:**

* **Term 1** – Briefly, what are the specific goals/objectives (or were the accomplishments) for the first term of this project, and how do they set the stage for subsequent terms. Include details related to partner interaction. During the first term, the team created four Land Use Land Cover maps spanning 2000-2015 with Normalized Difference Infrared Index maps for comparison. Thermal maps were created to look for thermal anomalies from warmer groundwater inflow to the cooler lagoon. Root zone soil moisture content and precipitation were analyzed for correlation and as variables influencing groundwater inflow. Partner interaction was sustained throughout the term and included numerous teleconferences, emails, videoconferences, data sharing, and attendance at the AESAS closeout.
* **Term 2 (Proposed Term)** – The first term served to validate the methodology of the LULC mapping of mesquite trees, thermal mapping of the lagoon, and utility of the NDII. This term will serve to expand the study period by twenty years to identify broader trends in the mesquite tree expansion, as well as refocus the study area to consider the predominant geologic formation in the area, the Beaumont Formation. Continuing with the NDIIs and precipitation analyses, and the inclusion of soil data will aid in identifying additional variables in the mesquite tree growth and its effects on the ecosystem. With the challenge of groundwater data availability, adding a geologic aspect to the project will aid in assessing related variables. With the partner’s level of engagement and relatively close proximity, a handoff will likely occur either at the term closeout event or through video conferencing.

**Previous Related DEVELOP Work:**

Padre Island Ecological Forecasting: Utilizing NASA EOS, European Remote-Sensing Satellites 1 and 2 (ERS-1&2), and Environmental Satellite (ENVISAT) to Create a Methodology for Monitoring Marine Debris Dispersal to Coastal Areas by Examining the Gulf of Mexico Loop Current and Associated Circulation Patterns - Summer 2011 (Stennis Space Center)

**Software & Scripting Requested:**

* ArcGIS – Raster analysis of Landsat 5, 7 and 8 and auxiliary data, map creation
* dnnpy - scripts for converting Landsat imagery to TOA reflectance and surface temperature with Python
* ERDAS IMAGINE – land classification of Landsat imagery
* TerrSet - land modeling and forecasting of mesquite tree expansion

**Notes:** Throughout the first term, our partner showed his enthusiasm and dedication to this project and the team, and has shown no indication that the partnership will do anything but strengthen over the course of a second term. In addition, the two projects proposed by MCHD both partner with the National Park Service. Joe Meiman knows our new proposed fall partners at the Natchez Trace Parkway and has indicated he would be willing to assist with that project as well. With these partners, and similar scopes, the two projects will complement each other and enable the two teams to collaborate and be mutually supportive.

While there are several proposed end products, the mesquite tree predictive and soil type maps are an extension of the LULC maps to be created, and thus will primarily make use of the data processing and analysis from those maps. In addition, the NDII will also utilize the Landsat data needed to be processed for the LULCs.