**NASA DEVELOP National Program**

**2019 Summer Project Proposal**

**Massachusetts – Boston**

**Southern Maine Health & Air Quality**

*Examining Tick-Borne Illness Risk by Evaluating Land Cover and Tick Habitat Suitability in Southern Maine*

**Project Overview**

***Project Synopsis*:** This project will work with the Maine Medical Center Research Institute (MMCRI), Lyme & Vector-Borne Disease Laboratory and Bigelow Laboratory for Ocean Sciences to examine the relationship between tick-borne illness, land cover type, and remotely sensed environmental parameters. Data from Landsat 8 OLI, Terra MODIS, Aqua AIRS and MODIS, and GPM IMERG will be used to create maps and data layers of land cover, vegetation, temperature, precipitation, and humidity measurements. The team will use Maine Tracking Network disease data to evaluate the relationship between land cover, tick habitat suitability, and the spatial distribution of disease incidence in and around Cumberland County, Maine. Advisors from the Boston University Ecological Forecasting Laboratory will complete original modeling using the team’s data products to provide spatially explicit estimates of tick-borne illness risk. The end user will utilize land cover and risk maps to communicate tick-borne disease risk as a part of existing public health outreach efforts.

***Community Concern:*** Tick-borne illnesses, which include Lyme disease, anaplasmosis, and babesiosis, are of great concern to communities and recreationists in Maine. The Maine Department of Health and Human Services reported 1,769 confirmed or probable cases of Lyme disease in the state during 2017, and recent estimates suggest that as little as 1 in 10 cases of Lyme disease are reported in Maine. This tendency to underreport often makes medical intervention difficult, thus considerable public health efforts are made to prevent and mitigate contact with ticks that may carry disease. Efforts to identify community-level locations of high tick encounter risk are necessary to provide the public with informative disease risk advisories.

***Source of Project Idea:*** The Massachusetts – Boston Center Lead approached Tess McCabe and John Foster of the Boston University Ecological Forecasting Lab to gauge their interest in working on a tick project related to their Ph.D. research. Maine was selected as this project’s study area due to both the prevalence of tick-borne illness in the state, and its locational proximity to the Massachusetts – Boston Node. Scientists at the MMCRI were contacted and expressed enthusiastic interest in the project. Objectives and potential end products were then developed with the MMCRI’s public health initiatives in mind.

***National Application Area Addressed:*** Health & Air Quality

***Study Location:*** Southern Maine

***Study Period:*** April 2013 – June 2019

***Advisors:*** Dr. Cedric Fichot (Boston University), Dr. Valerie Pasquarella (Boston University), Tess McCabe (Boston University), John Foster (Boston University)

**Partner Overview**

***Partner Organizations:***

|  |  |  |  |
| --- | --- | --- | --- |
| **Organization** | **POC (Name, Position/Title)** | **Partner Type** | **Boundary Org?** |
| **Maine Medical Center Research Institute, Lyme & Vector-Borne Disease Laboratory** | Chuck Lubelczyk, Field Biologist; Dr. Rob Smith, Director and Co-Founder; Susan Elias, Research Associate | End User | Yes |
| **Bigelow Laboratory for Ocean Sciences** | Dr. Nick Record, Senior Research Scientist | Collaborator | No |

***End-User Overview***

***End User’s Current Decision-Making Process:***The MMCRI monitors the geography of tick-borne illness risk, researches ways to mitigate tick encounters, and conducts public health outreach to inform community memebers about what steps they can take to avoid tick-borne illness. The organization’s research and outreach efforts are completed in partnership with government and academic institutions. Disease risk communicated to partner organizations and community members is completed predominantly with *in situ* data. The end user is familiar with spatial analysis; however, remote sensing is not currently involved in their decision-making practices.

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

*Maine Medical Center Research Institute, Lyme & Vector-Borne Disease Laboratory* – The end user does not directly use NASA Earth observations in its research and threat assessments, but there are some members in the organization aware of potential satellite remote sensing applications. Their use of GIS and spatial analysis postures them well to incorporate NASA EO data products into their work. This project would build their capacity to locate relevant NASA data products and understand the technical process of performing a land cover and environmental parameter assessment.

***Collaborator & Boundary Organization Overview***

***Collaborator Support:***

*Bigelow Laboratory for Ocean Sciences* – Dr. Nick Record created a platform using the MaxEnt model to forecast tick encounters in New England. The forecast predominantly uses data from NOAA’s North American Mesoscale Forecast System, the National Weather Service, and MODIS. Dr. Record will provide the team with expertise on how to assess tick encounter risk with multiple datasets. He is also interested in seeing how NASA data products used during the term may be useful to his forecasting efforts.

***Dissemination by Boundary Organizations*:**

*Maine Medical Center Research Institute, Lyme & Vector-Borne Disease Laboratory* – The MMCRI will share the results and methodology of the project with its research partners (including the University of Maine) to better communicate the practical applications of satellite remote sensing. They also have experience translating science into public outreach and awareness efforts. Members of the MMCRI will present end products to community organizations. Maps and conclusions may also be disseminated via their website or another online platform.

***Project Communication & Transition Overview***

***In-Term Communication Plan*:** Partners will meet with the team on a weekly basis during the term. One or two of these meetings may take place in-person due to the Massachusetts – Boston Node’s proximity to southern Maine. The Project Lead will act as the main point of contact for partner communications. Communications support will be provided by the Center Lead, if necessary.

***Transition Plan*:** A handoff will take place in week 9 or 10 of the term. The handoff will ideally be in person, either at the Maine Medical Center or at the Boston University Center for Remote Sensing. If an in-person event is not possible, the handoff will take place via teleconference and WebEx. The team will give the project presentation to partners, walk them through end products, and answer any questions they may have. Maps and the time series analysis outputs will be immediately integrated into the end user’s public awareness activities and research. Code for the land cover classification and environmental parameters time series will be shared with partners after the software release process is complete. The partner will use this code to create land cover maps and monitor environmental conditions for future years.

**Earth Observations Overview**

***Earth Observations:***

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| --- | --- | --- |
| **Platform & Sensor** | **Parameters** | **Use** |
| **Landsat 8 OLI** | Surface Reflectance | Landsat 8 OLI data will be used to complete land cover classifications for Cumberland County, ME.  |
| **Terra MODIS** | NDVI, Surface Temperature | Terra MODIS data will be used to incorporate vegetation and surface temperature measurements into the assessment of the relationship between disease incidence and environmental parameters. This relationship analysis will contribute to risk assessment. |
| **Aqua MODIS** | NDVI, Surface Temperature | Aqua MODIS data will be used to incorporate vegetation and surface temperature measurements into the assessment of the relationship between disease incidence and environmental parameters. This relationship analysis will contribute to risk assessment.  |
| **Aqua AIRS** | Humidity | Aqua AIRS data will be used to incorporate humidity measurements into the assessment of the relationship between disease incidence and environmental parameters. This relationship analysis will contribute to risk assessment.  |
| **GPM IMERG** | Precipitation | GPM IMERG data will be used to incorporate precipitation measurements into the assessment of the relationship between disease incidence and environmental parameters. This relationship analysis will contribute to risk assessment. |

***Ancillary Datasets:***

USDA Forest Inventory and Analysis (FIA) – Data will be used to refine land cover classifications and improve tick encounter risk assessment.

State of Maine Tracking Network Tick-Borne Disease Data – Tick-borne illness incidence data will be used to estimate relationships between disease incidence, land cover, and environmental parameters related to tick habitat suitability. This analysis will ultimately serve as the basis for tick encounter risk assessment.

***Modeling:***

Boston University Ecological Forecasting Lab Simple Bayesian Modeling using JAGS (POC: John Foster, Boston University; Tess McCabe, Boston University)

***Software & Scripting:***

Google Earth Engine API – Data processing and retrieval, land cover classification, and map creation

R – Time series analysis and modeling

Esri ArcGIS Pro – Map creation and data visualization

**Decision Support Tool & End Product Overview**

***End Products:***

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| --- | --- | --- | --- |
| **End Product** | **Partner Use** | **Datasets & Analyses** | **Software Release Category** |
| **Cumberland County Current Land Cover Map and GEE Code** | The partner will use this map to target areas for tick monitoring efforts and advise community members on the location of land cover types predisposed to high risk of tick encounter. Code will also be shared with the partner for future land classification efforts. | This end product will be created in Google Earth Engine using Landsat 8 imagery and ancillary data from the USDA FIA to create an up-to-date estimate of land cover classifications within the study area. | IV |
| **Vegetation, Humidity, and Precipitation Time Series Tool** | The partner will use this time series tool to see how changes in environmental parameters contribute to the spatial distribution of tick-borne disease risk.  | Data from Terra MODIS, Aqua AIRS and MODIS, and GPM IMERG will be used to display a time series of parameters relevant to tick distribution. Google Earth Engine will be used to collect and process imagery, and a graphical user interface will be used to display a time series of data. | IV |
| **Modeled Tick-Borne Disease Risk Map** | A tick-borne disease risk map will be used by the partner in public health outreach efforts to communicate the location of high tick-borne disease risk areas within Cumberland County, ME. | Data inputs from Landsat 8 OLI, Terra MODIS, Aqua AIRS and MODIS, and GPM IMERG will be used to model tick-borne disease risk using R. Advisors from Boston University will use the team’s products to run a simple Bayesian modeling to assess risk based on land cover classification, remotely-sensed environmental parameters, and Maine Tracking Network Tick-Borne disease data. | I |

***End-User Benefit*:** An accurate land cover map and a map displaying modeled tick-borne disease risk will allow for improved public awareness of those areas conducive to high tick abundance and disease risk. The time series analysis will inform the end user’s research related to the impact of environmental parameters on tick distribution. These end products will ultimately save the end user time, money, and resources that would be spent creating land classifications and attempting to utilize NASA Earth observations data products without the assistance of a DEVELOP team. Overall, the end user will use these tools to improve their current tick-borne illness mitigation efforts and to explore further research options utilizing NASA Earth observations.

**Project Timeline & Previous Related Work**

***Project Timeline:*** 1 Term: 2019 Summer

***Related DEVELOP Work:***

2017 Fall (GSFC) – Western Europe Health & Air Quality: Monitoring Mosquito Abundance and Distribution to Assist Vector-Borne Disease Management in Western Europe

2018 Spring (GSFC) – Western Europe Health & Air Quality II: An Interactive Model of Mosquito Presence and Distribution to Assist Vector-Borne Disease Management in Western Europe

**Notes & References:**

***Notes*:** The end user has expressed a lot of interest in an accurate land cover map of Cumberland County, ME. Land cover analysis done on a wider scale by federal agencies is often inaccurate and difficult to use in their community-based public health outreach efforts. The end user has also expressed interest in the participation of team members in ground-truthing efforts during the 2019 summer term. They have also mentioned that any attempts at modeling using remotely-sensed data products would complement current modeling efforts based on mostly *in situ* data.

***References:***

Kalluri, S., Gilruth, P., Rogers, D., & Szczur, M. (2007). Surveillance of arthropod vector-borne

infectious diseases using remote sensing techniques: A review. *PLoS Pathogens,* *3*(10),

e116. https://doi.org/10.1371/journal.ppat.0030116

Maine Medical Center Research Institute. (2017). *Prevention & control*. Retrieved from http://mmcri.org/ns/?page\_id=3623

Ozdenerol, E. (2015). GIS and remote sensing use in the exploration of Lyme disease epidemiology. *International Journal of Environmental Research and Public Health, 12*(12), 15182-15203. https://doi.org/10.3390/ijerph121214971

State of Maine. (2019). *Tickborne diseases*. https://data.mainepublichealth.gov/tracking/tickborne-content