**NASA DEVELOP National Program**

**Maryland - Goddard**

*Project Summary – Summer 2018*

**New England Agriculture & Food Security**

*Incorporating NASA Earth Observations into an Assessment Tool to Identify Correlations Between Factors Associated with Bee Health*

**VPS Title:** Honey Doesn’t Grow On Trees

**Project Team**

***Project Team*:**

Jeremy Rapp (Project Lead), rappjer1@gmail.com

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***Advisors & Mentors*:**

Sean McCartney (Science Systems & Applications Inc., NASA Goddard Space Flight Center)

Dr. John Bolten (NASA Goddard Space Flight Center)

**Project Overview**

***Project Synopsis*:**

The honey bee (*Apis mellifera*) plays a critical role in the pollination of agricultural food crops, contributing to the success of more than 70 fruits and vegetables that make up American diets. The New England Agriculture & Food Security team created a honey bee health assessment tool in Google Earth Engine that provides NASA Earth observations at critical temporal windows relevant to honey bee health cycles. These Earth observations data were correlated with local beehive health data provided from collaborators to further understand the relationships between environmental, seasonal, and regional changes and honey bee hive success.

***Abstract*:**

Honey bees (*Apis mellifera*) are a vital component to global agriculture, however, over recent decades their populations have been declining. Honey bees provide pollination services to more than 90% of the leading 107 global crop types, and without them it is estimated that 5-8% of global production would be lost. Anthropogenic drivers such as land use change, habitat fragmentation, existence of vegetative land cover (native or agricultural), climate, and the use of fertilizers and pesticides, contribute to honey bee health complications and annual population losses. Also, the presence of invasive pests (Varroa mite [*Varroa destructor*], tracheal mites, and small hive beetles) and pathogens (e.g. *Nosema*) further compound these issues. Leveraging citizen science, NASA Earth observations, and nationally reported statistics, a comprehensive methodology was developed to illuminate environmental variables that are linked to honey bee prosperity in the New England region of the United States from 2015 to 2018. The team created a tool harnessing Google Earth Engine to incorporate *in situ* data collected from local hives and apiaries and biophysical variables, such as vegetation indices, and soil moisture collected from satellite data. The tool will aid in the development of historical trends in honey bee welfare and will provide insight for better understanding of bee habitat suitability conditions.

**Keywords:**

Honey bees, Honey Bee Health Correlation Tool, Remote Sensing, Varroa mites, citizen science

***National Application Area Addressed:*** Agriculture & Food Security

***Study Location:*** New England; CT, MA, NH, RI

***Study Period:*** 2015 – 2018 (January – May)

***Community Concerns:***

* More than one-third of global food crops depend on honey bees for pollination.
* It is economically unsustainable to maintain high (30% or higher) annual beehive losses every year.
* While large amounts of *in situ* data have been collected for beehive health and resilience, it has been historically difficult to couple *in situ* measurements with Earth observations due to historical computational and storage limitations.
* A correlation analysis between environmental parameters and annual honey bee health will provide new insight into the ongoing struggle of maintaining the essential agricultural component of honey bee pollination.

***Project Objectives:***

* Utilize the computational power of Google Earth Engine to help visualize and summarize important environmental and remotely sensed attributes, such as normalized difference vegetation index (NDVI), at an appropriate scale
* Determine an effective way to sample urban “green” areas relevant to urban honey bee populations
* Provide a map highlighting areas with less than average losses, within the state boundary of Massachusetts
* Quantify areas with less than average losses with similar environmental attributes and report these to our collaborators with visuals

**Partner Overview**

***Partner Organizations:***

|  |  |  |  |
| --- | --- | --- | --- |
| **Organization** | **POC (Name, Position/Title)** | **Partner Type** | **Boundary Org?** |
| **Urban Beekeeping Laboratory and Bee Sanctuary, Inc.** | Dr. Noah Wilson-Rich, Chief Scientific Officer | End User | Yes |
| **The Bee Informed Partnership, Inc.** | Dr. Dennis vanEngelsdorp, Project Director | End User | Yes |
| **University of Maryland, vanEngelsdorp Honey Bee Research Lab** | Dr. Nathalie Steinhauer, Post-doctoral researcherKelly Kulhanek, Researcher | Collaborator | No |
| **BeekeepingIO** | Dave Strickler, Founder and Chief Technology Officer | Collaborator | No |

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

*The Urban Beekeeping Laboratory and Bee Sanctuary, Inc. -* The Urban Beekeeping Laboratory and Bee Sanctuary (UBL) works directly with 65 beekeepers at The Best Bees Company to evaluate both best practices for beekeeping, as well as ecological variables that impact bee health. Data are collected using the FileMaker Pro database platform, for which code is written in-house. In addition, real-time data sensing SmartHiveTM gather and transmit local hive data, including temperature, humidity, and hive weight. Results are reported in scientific publications, general media, and subsequent studies. UBL aims to use this data to improve bee health research.

*Bee Informed Partnership, Inc.* – The Bee Informed Partnership studies honey bee health via country wide survey data and direct communication with beekeepers. The partnership relies heavily on national survey results to determine the current leading factors affecting bee health, especially factors which beekeepers have difficulty combating such as Varroa mites. Bee Informed Partnership aims to create bee health solutions that will be implemented by bee keepers.

***Project Benefit to End Users***:

The Honey Bee Health Correlation Tool will be used by both the UBL and the Bee Informed Partnership to supplement their current studies with environmental data from NASA Earth observations and to standardize methods to measure and forecast colony health. The tool will provide both end users with the ability to conduct immediate analyses using a collection of data in a convenient portal. The correlations produced from this tool will be used by both users to bolster future bee health studies.

**Earth Observations & End Products Overview**

***Earth Observations:***

|  |  |  |
| --- | --- | --- |
| **Platform & Sensor** | **Parameter** | **Use** |
| **Landsat 8 OLI** | Spectral vegetation indices, phenology | Environmental factors, vegetation data, and phenological information derived from this dataset were correlated with bee health data.  |
| **Landsat 7 ETM+** | Spectral vegetation indices, phenology | Environmental factors, vegetation data, and phenological information derived from this dataset were correlated with bee health data.  |
| **Sentinel-2 MSI** | Spectral vegetation indices, phenology | Environmental factors, vegetation data, and phenological information derived from this dataset were correlated with bee health data. |
| **SMAP** | Soil Moisture | Soil moisture data derived from this dataset were correlated with bee health data. |
| **SRTM** | Elevation | Elevation data derived from this dataset were correlated with bee health data. |
| **GPM IMERG** | Precipitation | Precipitation data derived from this dataset were correlated with bee health data. |

***Ancillary Datasets:***

ALOS Global Digital SM: Global 30m – Elevation

Urban Beekeeping Laboratory and Bee Sanctuary bee health data – Overwintering survival rate and bee health data for hives in New England

Urban Beekeeping Laboratory and Bee Sanctuary SmartHive data – Environmental data collected from bee hive sensors

Bee Informed Sentinel Apiary Program – Longitudinal colony health and management data

Bee Informed Honey Bee Health Database – Colony health data for hives throughout the United States

Bee Informed Loss and Management Survey Data – Beekeeper reported colony losses and management techniques

BeekeepingIO Data Access API – National hive weight, internal humidity, and internal temperature data

USDA Animal Plant Health Inspection Service (APHIS) National Honey Bee Survey – National apiary health data

USDA National Agricultural Statistics Service Cropland Data Layer (CDL) – Agricultural land use information, including crop types, pesticide use, honey production measures, distance to cropland

USGS National Land Cover Database (NLCD) – Land cover at 30 meter resolution

NASA Global Land Cover Facility Landsat Global Inland Water – Distance to bodies of water

PRISM Climate Group Daily Spatial Climate Dataset – Minimum and maximum daily temperature and precipitation

NASA North American Land Data Assimilation System (NLDAS) – Humidity

NASA Global Land Data Assimilation System (GLDAS) – Modeled data for evapotranspiration, soil temperature, soil moisture, air temperature, transpiration

***Software & Scripting:***

Google Earth Engine API – Image processing and delivery platform

Esri ArcGIS – Image enhancement and map creation

***End Products:***

|  |  |  |  |
| --- | --- | --- | --- |
| **End Products** | **Earth Observations Used**  | **Partner Benefit & Use** | **Software Release Category** |
| **Honey Bee Health Correlation Tool using Google Earth Engine Repositories** | Landsat 8 OLI, Landsat 7 ETM+, SRTM, SMAP, GPM IMERG, Sentinel-2 MSI | Partners will use the Google Earth Engine interface to access Earth observation imagery and data that relates to the local areas surrounding partner collected beehive data. This platform will be publicly available for citizens, stakeholders, and policy makers to further understand the relationship between bee hive resilience and changing environmental parameters.  | IV |
| **Open Source Google Earth Engine Tutorial**  | N/A | This step-by-step guide will allow partners and future users to use the Honey bee Health Correlation Tool | N/A |

**Project Handoff Package**

**Transition Plan:**

During week 10, end products were transitioned remotely during a virtual and in-person handoff, during which the team discussed results and answered questions regarding the products. Tools and scripts were then handed off after the NASA software release process. A tutorial for the tools was provided.

*Software Release Plan*: Upon completion of the project term, the tool went through the standard NASA software release process, which resulted in a deferral of immediate delivery of the toolset to the end users. John Dilger, a Geoinformatics Fellow at NASA DEVELOP, reviewed the software and its accompanying components for approval. The software was supported through the process by the software release POC.

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**Partner POC**: Noah Wilson-Rich, noah@bestbees.com

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**Handoff Package:**

* Project Summary
* Technical Paper
* Poster
* Presentation
* Video Presentation
* Honey Bee Health Correlation Tool (following Software Release)
* Tutorial on utilizing Open Source Google Earth Engine product

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