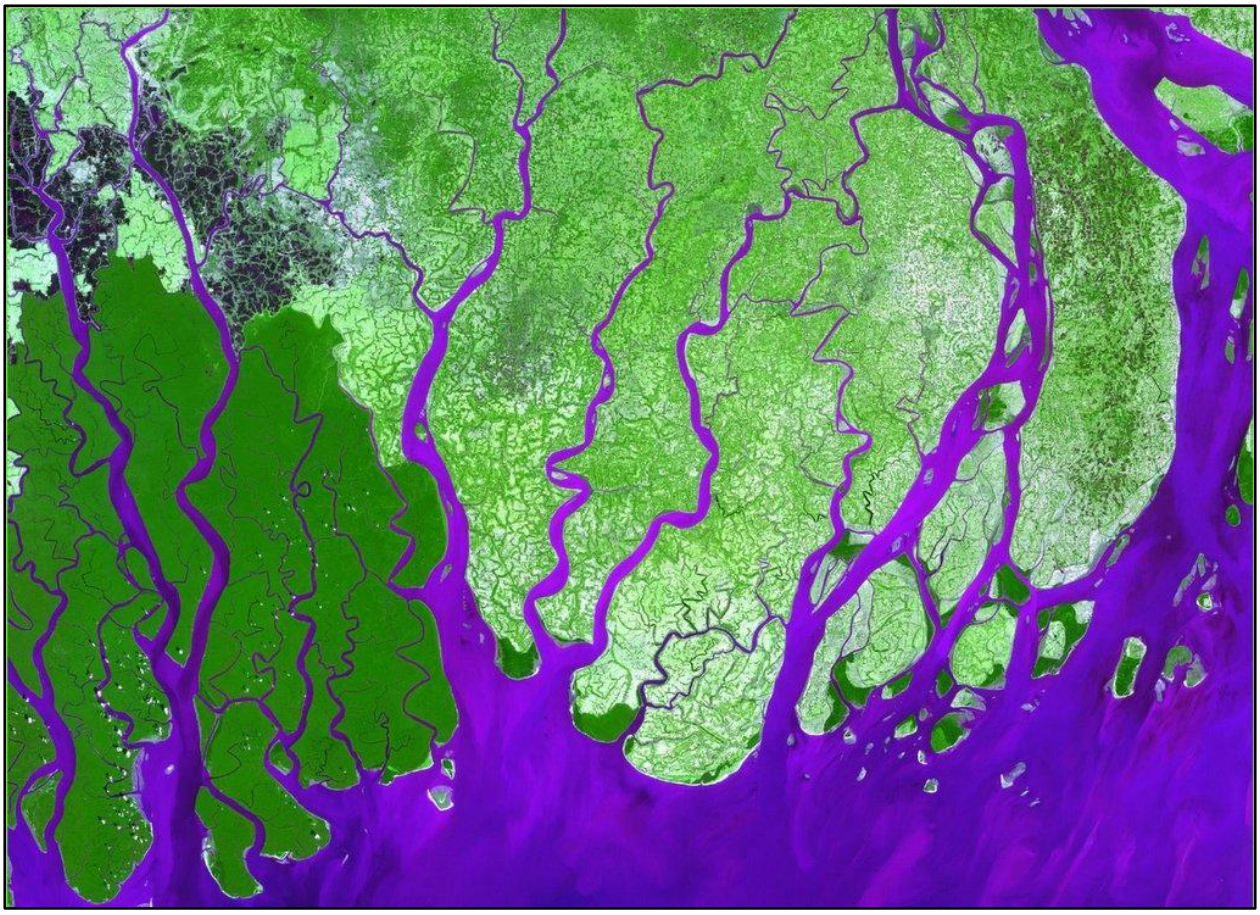
DEVELOP National Program

Agriculture Project Proposals

Summer 2015



Proposal Snapshot

1. Colorado Agriculture II: Mapping Forest Harvest History Using Landsat Imagery (Fort Collins)
Objective: Continue and complete the delineation of the location and age of forest harvests occurring between 1987 and 2012 in Landsat scenes covering northern Colorado and southern Wyoming.

2. Northwest US Agriculture III: Assessing Current and Future Plant Hardiness Zones for Apple Production in Washington State using Climate Models and NASA Earth Observations (Langley)
Objective: Build on the growing degree day maps and chill hour accumulation maps generated by Northwest US Agriculture I and II teams from the fall 2014 and spring 2015 terms. This project will determine plant hardiness zones for apple orchards in Washington State, using similar procedures as the United State Agriculture project from the spring 2014 term.

3. Thailand Agriculture: Monitoring Food Crop Health and Stress Due to Changing Climate for Enriched Agricultural Land Management (Marshall & Wise County)
Objective: Assess changing climate patterns to improve understanding of environmental variables such as precipitation and temperature, to understand risks and impacts of floods, storms, drought, invasive species, and sea level rise on the agricultural lands.

Partners Snapshot

State Partners

- Colorado State Forest Service (End-User, POC: John Twitchell, Steamboat District Forester)

Regional Partner

- Bioenergy Alliance Network of the Rockies (BANR) (End-User, Partner, and Boundary Organization, POC: Anthony Vorster, Feedstock Supply Team Task Manager)

Federal Partners

- USDA Agriculture Research Service (Partner, POC: Dr. Michael Glenn)

International Partner

- Royal Thai Embassy (Collaborator/Boundary Organization, POC: Bunyakiat Raksaphaeng, Office of Science & Technology)
- Asian Disaster Preparedness Center / SERVIR Mekong (Collaborator/Boundary Organization, POCs: Pete Cutter, Science & Data Co-Lead & Bill Crosson, Hub Science Coordinator)
- Thailand's Ministry of Agriculture and Cooperatives, Rice Department – Bureau of Rice Research and Development (End-User, POC: TBD)
- National Safety Council of Thailand (End-User, POC: TBD)

Private Company Partners

- Ben Delatour Scout Ranch (End-User, POC: Robert Sturtevant, Conservation Committee Chair)

Project Proposals

1. Colorado Agriculture II (Fort Collins)

Mapping Forest Harvest History Using Landsat Imagery

Objective:

The purpose of this project is to continue and complete the delineation of the location and age of forest harvests occurring between 1987 and 2012 in Landsat scenes covering northern Colorado and southern Wyoming.

Community Concern:

Timber harvests in northern Colorado support the local economy, maintain forest health in the absence of fire, reduce the risks of extreme wildfires, and serve as a means to protect critical infrastructure from falling trees after the recent mountain pine beetle outbreak. Forest managers need to understand past harvest activity to prioritize current harvests and thinning, maximize benefits and minimize undesired results. While some forest managers have records of past harvests, they are generally incomplete or inaccurate and often not spatially explicit (i.e., mapped). Accurate maps of harvest history will provide valuable insight to forest susceptibility to beetle infestation, while providing economic data (related to timber sales) that may support alternative energy.

End-Users/Partners/Boundary Organizations:

Ben Delatour Scout Ranch (End-User, POC: Robert Sturtevant, Conservation Committee Chair)
Bioenergy Alliance Network of the Rockies (BANR) (End-User, Partner, and Boundary Organization, POC: Anthony Vorster, Feedstock Supply Team Task Manager)
Colorado State Forest Service (End-User, POC: John Twitchell, Steamboat District Forester)

The team has been in communication with end-users for the past year and has an excellent working relationship. A map showing the location and age of forest harvests for the last 25 years has emerged as a need for all three end-users. These groups currently work together, communicate frequently, and share data. DEVELOP participants will tap into this existing working relationship to communicate progress and to distribute final products. The Ben Delatour Scout Ranch and the Colorado State Forest Service will use the maps to plan upcoming management such as harvests and thinning. The Bioenergy Alliance Network of the Rockies (BANR) will use the product to inform study design of ecological impacts of harvesting and as a data source for the estimation of potential feedstock for biofuel conversion. The team will hand-off products through presentations for the BANR and the Ben Delatour Scout Ranch. Products will be shared with the Colorado State Forest Service at a meeting at their headquarters.

Decision Making Process:

The Colorado State Forest Service (CSFS) and Ben Delatour Scout Ranch adaptively and actively manage their forests by continuously planning timber harvests and monitoring the effectiveness of their actions. The CSFS uses National Agricultural Imagery Program (NAIP) imagery from the United States Department of Agriculture (USDA). These organizations do not have an accurate map of past harvests. A map showing the location and age of timber harvests for the past 25 years would help prioritize forest management. Mapping harvests will allow for concise and active management of areas near critical infrastructure.

BANR will use this map of harvest history to inform two tasks: (1) The map will assist research analyzing the ecological impacts of timber harvests to study forest health in a chronosequence

of past harvests; (2) The proposed map of harvest history would also be used by BANR to estimate potential feedstock for the wood-to-biofuel industry. Harvest history could be used with other variables to model species composition, total biomass, beetle-killed biomass, and the type of feedstocks that may be available at a given site.

Earth Observations

Platform	Sensor	Geophysical Parameter
Landsat 5	Thematic Mapper (TM)	Surface Reflectance
Landsat 8	Operational Land Imager (OLI)	Surface Reflectance
National Agriculture Imagery Program (NAIP)	Digital Sensors on Aircraft	Surface Reflectance

NASA Earth Observations to be Highlighted:
The extensive historic record of data captured by the Landsat 5 program, in combination with change detection models, provides an opportunity to assess past forest disturbance where records on timber harvests are incomplete or missing. Twenty-five years of continuous satellite imagery data collection will allow us to fill the gaps in past timber harvest records and validate it with high resolution imagery to inform and improve management decisions and, in turn, forest health. Landsat 8 will be used as ancillary data and to compare historical harvests to current forest conditions.

Ancillary Datasets:
National Land Cover Dataset (NLCD) - from Multi-Resolution Land Characteristics Consortium
Management Boundaries- Provided by the Colorado State Forest Service

Models:
Landsat-based Detection of Trends in Disturbance and Recovery (LandTrendr) (POC: Robert Kennedy, Boston University)

Decision Support Tools & Analyses:

Proposed End Products	Decision Impacting	Current Partner Tool/Method
Map Showing the Location and Age of Forest Harvests From 1987-2012	Locating sites for upcoming harvests and thinning. Studying ecological impacts of timber harvests and estimating biomass and potential biofuel feedstocks.	Aerial imagery, field surveys, and historical records

Map Showing the Location and Age of Forest Harvests from 1987-2012 – multiple raster layers showing the start date, duration, and magnitude of forest harvests within the study site. Landsat Thematic Mapper (TM) images from 1987-2012 will be used with the LandTrendr model. The harvest map stops in 2012 because 2012 is the last year in which suitable images were captured by Landsat 5 TM. We are only using Landsat 5 TM, and not Landsat 8 OLI, to map harvest history for consistency in each band's wavelength.

Project Details:
National Application Area Addressed: Agriculture

Source of Project Idea: This project originated from observations of an overlapping need of the three end-users. The team noticed in the field that we need an accurate map of forest harvest to understand current forest attributes such as biomass and mountain pine beetle and spruce beetle outbreak severity. Additionally, the need of the Colorado State Forest Service and the Ben Delatour Scout Ranch for a central, comprehensive, and accurate map of forest harvests became clear. BANR also realized that understanding where and when past harvests occurred will be of paramount importance to understand the impacts of past harvest and to estimate the amount of various feedstocks for a potential biofuel economy.

Advisor: Paul Evangelista (Natural Resource Ecology Lab, Colorado State University)
# of Participants Requested: 5

Project Timeline: 3 terms: 2015 Spring to 2015 Fall
Study Location: Northern Colorado and Southern Wyoming, USA: includes Colorado State Forest State Park, Ben Delatour Scout Ranch, Arapaho National Forest, Roosevelt National Forset, Routt National Forest, and Medicine Bow National Forest (Landsat Scene Path 34 Row 32)
Period being Studied: 1987-2012

Previous Related DEVELOP Work:
Colorado Agriculture
Reconstructing Forest Harvest History Using Landsat Imagery
Spring 2015 (Fort Collins)

Multi-Term Objectives:
Note: This proposal is a continuation of the Colorado Ag Spring 2015 project. Issues with IDL code prevented the team from completing the project to a level that would be an acceptable product for the project partners. So, we propose continuing this valuable project for Summer 2015. The Summer 2015 team will continue where the Spring 2015 team left off. If there is time left after running LandTrendr and analyzing the output, the Summer 2015 team will also classify past harvests as clearcuts or thinning treatments.

- **Term 1** – DEVELOP participants began mapping forest harvest history from 1987-2012 in northern Colorado and southern Wyoming. Preprocessing and troubleshooting the IDL code for LandTrendr slowed progress. These efforts in Term 1 were an excellent learning experience and will inform the team's decision making process for pre-processing and code execution in the next term. Three team members from Term 1 have reapplied with hopes to successfully apply what they have learned in Term 1 to successfully complete the goals of the project in Term 2.
- **Term 2 (Proposed Term) –** DEVELOP interns will continue the efforts of Term 1 to obtain a higher quality, more refined product. They will complete troubleshooting of the LandTrendr code, successfully complete LandTrendr evaluation mode to refine their imagery, and then begin classification of the outputs. The team will also characterize harvests as clearcuts or thinning treatment, time permitting.
- **Term 3-** The team will map tree species composition using correlative models with Landsat 8 imagery, field data, and ancillary datasets at the Colorado State Forest State Park.

Notes:
The Bioenergy Alliance Network of the Rockies (BANR) is a USDA-funded consortium of an industry partner and researchers from several federal agencies and universities in Colorado, Wyoming, Montana, and Idaho researching the feasibility of establishing an economy converting beetle-killed wood to an automobile-ready biofuel. Visit banr.colostate.edu for more information.

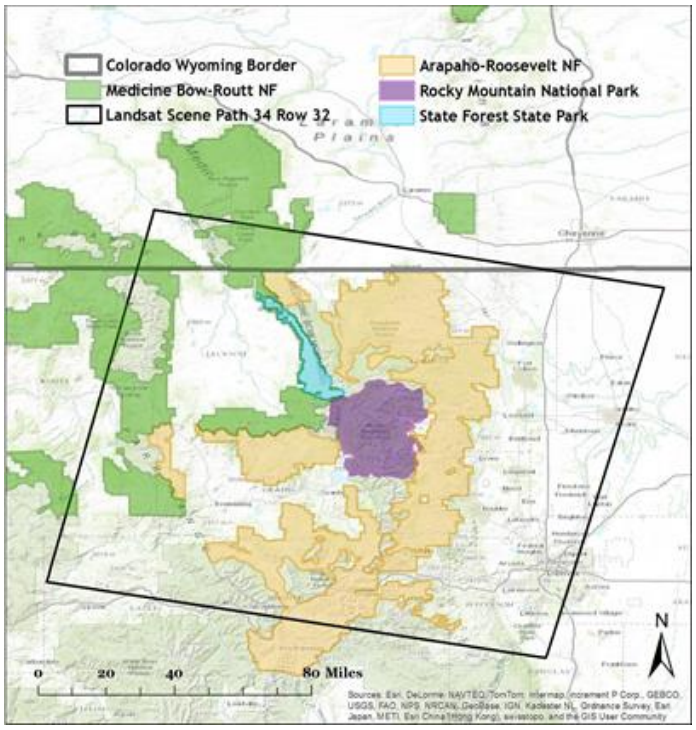


Figure 1. Map showing the location of Colorado State Forest State Park and where it falls within the Path 34 Row 32 Landsat scene.

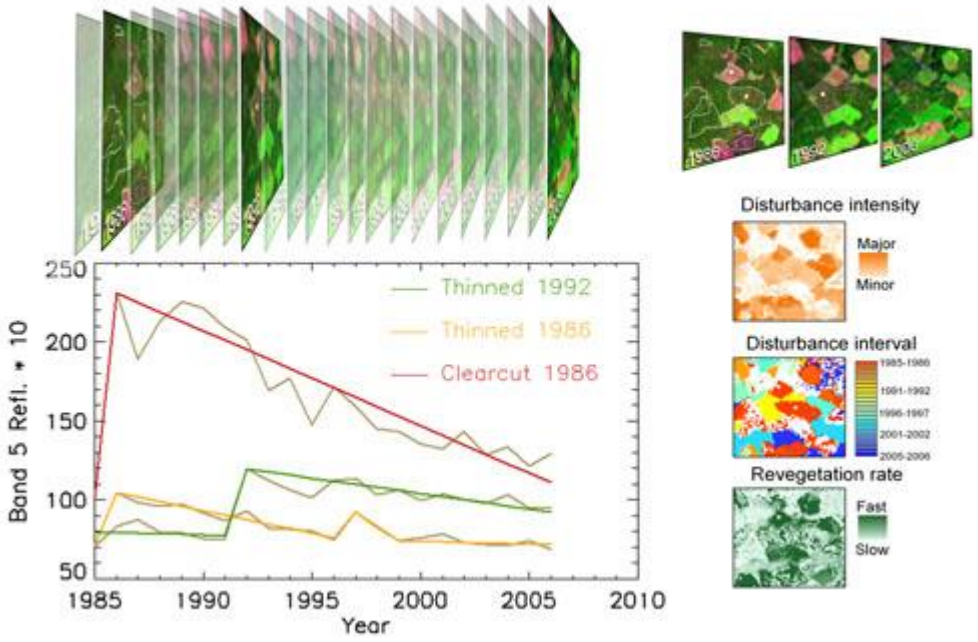


Figure 2. This figure shows how LandTrendr tracks forest disturbances using the trajectory of three pixels from Landsat images from 1985- 2006 as an example. Intense, short disturbances correspond to a clear cut, while moderate, short disturbances indicate thinning. Three of the outputs are shown on the right: disturbance intensity, disturbance interval, and revegetation rate. (http://landtrendr.forestry.oregonstate.edu/)

2. Northwest US Agriculture III (Langley)

Assessing Current and Future Plant Hardiness Zones for Apple Production in Washington State using Climate Models and NASA Earth Observations

Objective:
The goal of this project is to build on the growing degree day maps and chill hour accumulation maps generated by Northwest US Agriculture I and II teams from the fall 2014 and spring 2015 terms. This project will determine plant hardiness zones for apple orchards in Washington State, using similar procedures as the United State Agriculture project from the spring 2014 term.

Community Concern:
In 2012, Washington State accounted for 70% of apple production in the United States. With the evolving nature of the regions' climate, the optimal locations for apple growth will change. Understanding where and when these shifts in locations will occur will help apple orchard owners better prepare for the future.

End-Users/Partners/Boundary Organizations:
USDA Agriculture Research Service (Partner, POC: Dr. Michael Glenn)

Dr. Glenn has been an active partner with Langley DEVELOP for multiple terms. Communication has been ongoing throughout the fall 2014 and spring 2015 terms. He is interested in this project becoming a publication and is willing to take on that responsibility. He also would like the USDA ARS to apply the methodology and scripts from this project more broadly to all U.S. states. Transition of methodology, scripts, and results will occur either through virtual presentation or in-person.

Decision Making Process:
Apple growers currently use NOAA's climate prediction center and the models used there, including those for the effects of El Niño Southern Oscillation, to determine future conditions for their fields. Potential evapotranspiration calculations are used to determine how much water will be required by the apple trees to keep them healthy and prevent sunburn. Water rights allocations may be restricted from junior water rights holders if there is not enough water in the reservoir system, which may affect irrigation capabilities of apple growers.

Earth Observations:

Platform	Sensor	Geophysical Parameter
Aqua & Terra	MODIS	Land Surface Temperature

NASA Earth Observations to be Highlighted:
Aqua and Terra MODIS Land Surface Temperatures have been useful in helping to determine long term temperature averages for past projects including the two previous terms of the Northwest US Agriculture project. Plant hardiness zones will be determined in order to better show how the locations for apple orchards in Washington will change under future climate scenarios.

Ancillary Datasets:
- CMIP5 air temperature forecasts
- NOAA weather station data

Decision Support Tools & Analyses:

Proposed End Products	Decision Impacting	Current Partner Tool/Method

Plant Hardiness Zone maps	Determine areas optimal for the growth of apples in Washington to have a baseline when comparing future regions of apple growth.	Agriculture climate records
Forecasted Plant Hardiness Zone maps	Highlight regions of future growth of apples to help orchard owners prepare for the changing climate conditions.	none

Plant Hardiness Zone maps – Static map estimation of plant hardiness zones based on MODIS LST records

Forecasted Plant Hardiness Zone maps – Maps showing the future plant hardiness zones based on CMIP5 climate forecasts

Project Details:
National Application Areas Addressed: Agriculture, Climate
Source of Project Idea: Dr. Michael Glenn is looking for consistency between all 3 of the projects showing Growing Degree Days, Chill Hours, and Plant Hardiness using the same climate models, MODIS data, and study location. The methodologies and results will be sent forward for a publication.

Advisor: Dr. Kenton Ross (NASA DEVELOP National Program)
# of Participants Requested: 4

Project Timeline: 3 Terms: 2014 Fall to 2015 Summer
Study Location: Washington State, United States
Period being Studied: 2003 – 2065

Previous Related DEVELOP Work:
Northwest United States Agriculture: Evaluating Habitat Suitability of Cydia pomonella in Washington State from 2003 to 2065 - Fall 2014 (LaRC)

Northwest United State Agriculture II: Analyzing Impacts of Potential Temperature and Precipitation Changes on Apple Crop Production - Spring 2015 (LaRC)

United State Agriculture: Identifying Current and Future Optimal Regions for Apple Production Utilizing Aqua MODIS and PRISM Data in a Warming Climate - Spring 2014 (LaRC)

Multi-Term Objectives:
- **Term 1** – The goal of the first term was to identify future habitats of the Codling Moth using Growing Degree days for the state of Washington. The Codling Moth is a major pest to Apple production in the state.
- **Term 2**– The goal of the second term was to identify future regions or the changes to current regions of apple orchards using chill hour accumulations and precipitation amounts for the state. A major accomplishment of Term 2 was the creation of diurnal temperature estimations in the region that can be applied to MODIS LST data.
- **Term 3 (Proposed term)** – The goals of this term will be to determine conditions of optimal apple production in the state, finalize the script handoff to the partners, complete the future climate model forecasted maps, and prepare the work of all three terms for publication.

3. Thailand Agriculture (Marshall & Wise County)

Monitoring Food Crop Health and Stress Due to Changing Climate for Enriched Agricultural Land Management

Objective:

This project focuses on assessing changing climate patterns to improve understanding of environmental variables such as precipitation and temperature, to understand risks and impacts of floods, storms, drought, invasive species, and sea level rise on the agricultural lands.

Community Concern:

Climate change has the potential to impact agriculture and specifically, rice cultivation, in Thailand. As the country's main export and a traditional food crop, improving monitoring capabilities will assist farmers and land managers with their management practices to mitigate the impact of floods, storms, and drought.

End-Users/Partners/Boundary Organizations:

Royal Thai Embassy (Collaborator/Boundary Organization, POC: Bunyakiat Raksaphaeng, Office of Science & Technology)

Asian Disaster Preparedness Center / SERVIR Mekong (Collaborator/Boundary Organization, POCs: Pete Cutter, Science & Data Co-Lead & Bill Crosson, Hub Science Coordinator)

Thailand's Ministry of Agriculture and Cooperatives, Rice Department – Bureau of Rice Research and Development (End-User, POC: TBD)

National Safety Council of Thailand (End-User, POC: TBD)

The Royal Thai Embassy initiated contact with NASA to discuss potential collaboration which sparked engagement with DEVELOP. Since May of 2014, the DEVELOP National Program Office has met multiple times with officials at the Embassy to discuss the collaboration - projects involved and the engagement of Thai Scholars on DEVELOP projects. Through these meetings the project topics were selected and the Embassy will serve as a liaison to organizations and decision makers in Thailand.

Decision Making Process:

The Rice Program was an initiative by Thailand's government that focused on developing technologies to increase the production of rice. This was done by breeding a variety of rice that were more resistant to pests, could adapt to environmental changes due to climate, and developing techniques that reduce the costs associate with planting and harvesting. Other aspects of the program helped to improve milling of rice by reducing milling waste and energy use. According to Ricepedia, The Rice Program also had a focus in technologies that assisted with water and soil management.

In 2013, the Regional Centre for Mapping of Resources for Development (RCMRD) released a study in collaboration with the Thailand Rice Department that used remotes sensing in various South and South-east Asian countries, including Thailand.

Earth Observations:

Platform	Sensor	Geophysical Parameter
Landsat 5, 7, 8	TM, ETM+, OLI / TIRS	Spectral Vegetation Indices, Land Cover Classifications, NDVI, NDWI, NMDI
Terra	ASTER	Digital Elevation Model
TRMM	PR	Precipitation data
Terra/Aqua	MODIS	Land Surface Temperature MYD11A1 data
Suomi NPP	VIIRS	Land Surface Temperature

NASA Earth Observations to be Highlighted:
Landsat 5 TM, 7 ETM+, and 8 OLI/TIRS are proposed for this project due to its ability to detect vegetation with its red and infrared bands to produce vegetation indices and land cover classifications. The Landsat series also offers the appropriate spatial and temporal resolution needed for the project. Normalized Difference Vegetation Index (NDVI), Normalized Difference Water Index (NDWI), and Normalized Multi-band Drought Index are important to the study in determining the overall health of the rice crops and locations of water bodies.

Terra ASTER DEM will provide elevation data for the study area. This will determine different growing regions of rice as well as changes in sea level.

TRMM PR will provide precipitation data to identify areas of flooding, low moisture and how this has changed over time due to climate change.

Terra and Aqua MODIS MYD11A1 data product, as well as Suomi NPP VIIRS, will be used to delineate land surface temperature. These datasets will help determine the rice crops' susceptibility to invasive species and poor health. MODIS will be used to obtain daily coverage while the use of Suomi will be to obtain higher spatial resolution of the study area.

Ancillary Datasets:
Climate data, National Climatic Data Center (NCDC), to determine climate change in Thailand
Soil data, USGS, to determine soil types and classify rice-growing environments by region

Models:
- Maximum Entropy Model (MaxEnt) (POC: Jeffry Ely, DEVELOP, Team Lead of Great Basin Climate)
- Coupled Model Intercomparison Project (CMIP5) (POC: Jeffry Ely, DEVELOP, Team Lead of Great Basin Climate)

Decision Support Tools & Analyses:

Proposed End Products	Decision Impacting	Current Partner Tool/Method
Vegetative Indices Catalog	Allow decision-makers to identify potential areas with crop health issues	Field surveys
Pest Risk Map	Where the Rice Department should prioritize pest-resistant crops	None
Pest Forecast Map	Where the Department of Agriculture Rice Department should focus conservation efforts	None

Vegetative Indices Catalog - This will show which areas are potentially experience crop health issues using the Normalized Difference Vegetation Index (NDVI), Normalized Difference Water Index (NDWI), and Normalized Difference Multi-band Drought Index (NMDI). This will be divided into four rice-growing regions: central, north, northeast, and south. Each rice-growing area has distinct ecosystems that vary from irrigated to rain-fed fields. By assessing the amount of water in rice-growing areas, it will help determine each of the growing regions.

Pest Risk Map - This map will show which areas are at risk of a pest infestation and which areas need pest-resistant crops. This will be divided into four regions: central, north, northeast, and south.

Pest Forecast Map - This map will show which areas need the highest amount of conservation efforts due to the potential of a pest infestation. This will be divided into four regions: central, north, northeast, and south.

Project Details:
National Application Areas Addressed: Agriculture, Climate
Source of Project Idea: Royal Thai Embassy officials suggested during meetings with DEVELOP.

Advisor: Dr. Jeff Luvall (Marshall/NASA)
# of Participants Requested: 5

Project Timeline: 1Term: 2015 Summer (Start/Completion)
Study Location: Thailand
Period being Studied: 2000 to present

Previous Related DEVELOP Work:
Northwest US Agriculture I & II: Evaluating Habitat Suitability of Cydia pomonella in Washington State from 2002 to 2065. 2014 Fall – 2015 Spring (DEVELOP Langley)

Great Plains Agriculture: Monitoring Drought Conditions for Enhancement of Rangeland Management - 2013 Summer (DEVELOP Langley)

Southeast Asia Disasters I, II & III: Utilizing NASA Earth Observations to Enhance Flood Impact Products and Mitigation in the Lower Mekong Water Basin - 2014 Spring to 2014 Fall (DEVELOP Goddard)

Great Basin Climate I & II: Evaluating Current and Future Rangeland Ecosystem Health in the Great Basin Ecoregion Using NASA Earth Observing Systems and a Long-Term Ground Monitoring Network. 2014 Summer & 2014 Fall (DEVELOP Ames)