

NASA DEVELOP National Program

Spring 2016 Project Proposal

USGS at Colorado State University – Fort Collins, CO

Gunnison National Forest Agriculture

Mapping Spruce Beetle Outbreak Severity and Distribution in Gunnison National Forest Using Landsat and Integrative Spatial Modelling

Project Overview

Objective: To map spruce beetle (*Dendroctonus rufipennis*) outbreak severity and distribution in the Gunnison National Forest for use in biomass estimation, forest management, and as a predictor for future wildlife distribution studies. The project will also test a novel integrative spatial model that has never been applied in Colorado or with spruce beetle outbreaks as a disturbance of focus.

Community Concern: A spruce beetle outbreak is actively occurring in the Gunnison National Forest. Since 1996, it is estimated that nearly 1.4 million acres of forest have been affected by the beetle, and that it is likely increasing in severity through time. Land managers are concerned that increased tree mortality will: 1) result in less favorable habitats for species that rely on spruce forest characteristics; 2) that the epidemic will increase wildfire risk; and 3) that dead and falling trees will pose a hazard to forest visitors engaging in recreational activities.

National Application Area Addressed: Agriculture

Study Location: Gunnison National Forest, CO

Study Period: 2009-2015

Advisors: Dr. Paul Evangelista, Nick Young, Ryan Anderson (Natural Resource Ecology Laboratory)

Source of Project Idea: The USFS, Natural Resource Ecology Laboratory, and Spatial Sciences Center are currently collaborating on a project to analyze the relationship between forest disturbance and habitat degradation for forest focal species. The group approached the DEVELOP Fort Collins node directly about the possibility of launching the spruce beetle outbreak modeling project.

Partner Overview

Partner Organizations:

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

Spatial Sciences Center, Montana State University (End-User, POC: Dr. Rick Lawrence, Professor)

Natural Resource Ecology Laboratory (NREL) (End User, POC: Nick Young, Research Scientist)

USFS, Gunnison District (End User, POC Gunnison District: Matt Vasquez, District Wildlife Biologist)

USFS Rocky Mountain Research Station (End User, POC: Dr. Mike Battaglia, Research Scientist)

End-User Current Decision Making Process:

The NREL and the USFS Rocky Mountain Research Station have recently engaged in a collaborative research project aimed at creating a better understanding of habitat availability of the Canada lynx within the Gunnison National Forest. The group believes that there is a correlation between spruce beetle caused tree mortality and habitat availability for the lynx,

and seeks to provide recommendations for management of spruce-dominated lynx habitat. The USFS Gunnison District also provides district-wide management recommendations for areas of the forest affected by insect and disease outbreaks.

The Spatial Sciences Center at Montana State University recently developed a novel two-stage tree mortality model that they have applied in areas affected by the mountain pine beetle epidemic in Montana and Idaho. The group is looking to test the model in new areas so that it can be validated and shared with organizations throughout the Rocky Mountain region.

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 researching the feasibility of establishing an economy converting beetle-killed wood to an automobile-ready biofuel.

NASA Earth Observations Capacity:

BANR – This group has used remote sensing products and NASA earth observations in past research; however, the organization does not have the funding or personnel required to add additional study areas, such as those represented in this project. The BANR has also focused the majority of its research on the mountain pine beetle epidemic and would not have the resources necessary to study the impacts of the spruce beetle without the support of this DEVELOP project.

NREL, USFS RMRS, USFS Gunnison District –Although this collaborative group has used NASA earth observations in past research, they have focused their research at the plot based level for this project, and do not currently have the resources or personnel required to conduct a study on spruce beetle severity at the landscape scale.

The Spatial Sciences Center – This group is the creator of the model that will be applied in this project. Although they are regular users of NASA Earth Observations, they do not currently have capacity to test the model in new areas or with new focal species.

Communication Plan & Transition Approach:

The node has an excellent working relationship with each of the partners. The team will meet with local partners in person on a weekly or biweekly basis, and will include out-of-area partners via web conference. An in-person hand off will be held at the NREL near the end of the spring term.

End-User Benefit:

The end-users plan to begin using these products in a variety of ways as soon as they are available:

The USFS RMRS and the NREL will integrate the maps as a predictor in a species distribution model of the Canada lynx. This project will allow these organizations to save time and money over conducting similar research at a plot based level. The USFS Gunnison District will use the products to begin planning habitat improvements and to make management recommendations for spruce-dominated forests present in the district.

BANR will use the spruce beetle outbreak severity map to improve quantification of forest-wide biomass estimations and inform site selection for wood-to-biofuel production. BANR has provided a letter of support for this project.

The Spatial Sciences Center will use the end products to further test the two-stage tree mortality model in new scenarios and to disseminate the model to new organizations seeking to map and model beetle-caused tree mortality. Since the model has never been applied in CO or with spruce as a focal species, this project will test the viability of the model in new areas.

Earth Observations Overview

Earth Observations:

Platform	Sensor	Geophysical Parameter
Landsat 5	Thematic Mapper (TM)	Surface Reflectance
Landsat 7	Enhanced Thematic Mapper Plus (ETM+)	Surface Reflectance
Landsat 8	Operational Land Imager (OLI)	Surface Reflectance
National Agricultural Imagery Program (NAIP)	Digital Sensors on Aircraft	Surface Reflectance
Space Shuttle	SRTM V2	Elevation, slope, aspect

NASA Earth Observations Use:

Landsat 5 TM – This dataset provides the temporal (16 days) and spatial (30 m²) resolution needed for modeling and mapping spruce beetle outbreak severity, and provides data for the 2009-2012 portion of our study period.

Landsat 7 ETM+ – This dataset provides the temporal (16 days) and spatial (30 m²) resolution needed for modeling and mapping spruce beetle outbreak severity, and provides data for the 2012-2013 portion of our study period.

Landsat 8 OLI – This dataset provides the temporal (16 days) and spatial (30 m²) resolution needed for modeling and mapping spruce beetle outbreak severity, with images beginning in 2013 and going through the end of our study period, 2015.

Space Shuttle SRTM V2 – This dataset will be used to derive topographic data to be used as indicators of spruce presence in the study area.

National Agricultural Imagery Program (NAIP) – This dataset provides the spatial resolution (1 m²) necessary to collect training data for the Two-Stage Tree Mortality model for 2009, 2011, 2013, and 2015.

Ancillary Datasets:

Administrative Boundaries- provided by United States Forest Service;

Digital Elevation Model- from USGS National Elevation Dataset;

National Land Cover Dataset (NLCD) - from Multi-Resolution Land Characteristics Consortium

Models:

Montana State University Two-Stage Tree Mortality Model (POC: Dr. Rick Lawrence, MSU)

Decision Support Tool & End-Product Overview

Proposed End Products	Decision to be Impacted	Current Partner Tool/Method
Spruce Beetle Outbreak Severity and Distribution Map for the Gunnison National Forest- 2009-2015	Assessing available biomass for biofuel conversion, mammal habitat availability, and forestry treatment recommendations, biomass availability through time	Field surveys, national scale outbreak maps, and statewide aerial survey data
Statistical Overview of Model Performance identifying spruce beetle outbreak severity	Model applicability in new regions and with different focal species	This model has not been applied in any area outside of Idaho/Montana

Beetle Outbreak Severity and Distribution Map – This product will be developed using Landsat 5-8, topographic indices from SRTM V2, and high resolution imagery products from the National Agricultural Imagery Program. The team will employ these datasets within the two-stage tree mortality model developed by the Spatial Sciences Center at Montana State University to produce the most up-to-date spruce mortality map available for the forest. By employing a NAIP and Landsat time series, the team will also be able to map the distribution and severity of the spruce beetle outbreak throughout recent time (2009-2015).

Statistical Overview of Model Performance identifying spruce beetle outbreak severity – This product will provide a statistical overview of model performance to the Spatial Sciences Center, which will use this data to evaluate the model's performance in new areas and with a new focal species. It can then be modified as necessary and disseminated and applied across the Rocky Mountain region.

Project Timeline & Previous Related Work

Project Timeline: 1 Term: Spring 2016

Previous Related DEVELOP Work:

Spring 2015 (Fort Collins) – Colorado Agriculture I: Reconstructing Forest Harvest History in Northern Colorado and Southern Wyoming Using the Landsat Time Series

Summer 2015 (Fort Collins) – Colorado Agriculture II: Reconstructing Forest Harvest History in Northern Colorado and Southern Wyoming Using the Landsat Time Series

Project Needs/Requests

Participants Requested: 4

Software & Scripting:

Program R – Model Execution

ArcGIS– Production of final maps

ENVI/IDL– Preprocessing satellite imagery