**NASA DEVELOP National Program**

Fort Collins - North Central Climate Science Center

**Fall 2013**

**Rocky Mountain Ecological Forecasting**

*Mapping Lodgepole Pine Mortality in the Central Rocky Mountains Using NASA Earth Observing System and Boosted Regression Tree Models*

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**Applied Sciences National Applications Addressed:**

Ecological Forecasting

**Study Area:** Arapaho, Medicine Bow, Roosevelt, and Routt National Forests, Colorado and Wyoming

**Study Period:** 1992-2010

**Community Concerns**

Community concerns persist throughout the Rocky Mountain region regarding the mountain pine beetle (*Dendroctonus ponderosae*) epidemic and its continued effects on ecosystem health, economic stability, and human health and safety. These effects include:

* Widespread tree mortality sustained over two decades in Colorado and southern Wyoming.
* Adversely affected ecological processes: degraded watersheds through increased erosion and flooding events, imperiled supplies of critical drinking water, and diminished riparian and upland wildlife habitats.
* Negatively impacted property values, reduced visual aesthetics, and increases in wildfire fuel loads.

The scale and magnitude of these important impacts need to be better understood by natural resource professionals in order to effectively manage within these increasingly complex ecosystem dynamics.

**80-100 Word Blurb**

This project used a procedure established by past NASA DEVELOP Colorado Ecological Forecasting teams to quantify lodgepole pine mortality using Landsat 5 TM imagery and spatial modeling. Combining pre- and post-outbreak Landsat images with field data from the Arapaho, Medicine Bow, Roosevelt, and Routt National Forests, this project provided a detailed assessment of the extent and severity of lodgepole pine mortality at a regional level. Results from this study will be used to enhance forest management efforts in mitigating hazards from standing dead trees and provide a foundation for further research into the impacts of mountain pine beetle on wildlife habitat, hydrology, and recreation.

**Abstract**

The mountain pine beetle has infested over 3.4 million acres of forest in Colorado since 1996 and continues to spread throughout the forests of western North America. Although current detection techniques, such as aerial surveys, have been effectively used in measuring smaller scale rates of spread, they cannot accurately determine the extent of landscape-scale forest overstory affected by beetle-induced mortality. Using a methodology developed by previous Colorado Eco teams, this project identified the extent of lodgepole pine mortality in the Arapaho, Medicine Bow, Roosevelt, and Routt National Forests. The spatial extent and severity of the outbreak were mapped using satellite imagery from the Landsat 5 TM sensor, spectral vegetation indices, image differencing techniques (pre- and post-infestation), and a boosted regression tree model. This approach allowed the team to accurately assess mortality across a forested landscape. This work was a collaboration between the United States Geological Survey, United States Department of Agriculture (USDA) Forest Service, Colorado Forest Restoration Institute, Natural Resource Ecology Laboratory of Colorado State University, and the North Central Climate Science Center. Results from this study will be used to enhance forest management efforts in mitigating hazards from standing dead trees and will provide a foundation for further research into the impacts of mountain pine beetle on wildlife habitat, hydrology, and recreation.

**Partners/Collaborators**

Colorado Forest Restoration Institute: Tony Cheng

Colorado State University Geospatial Centroid: Melinda Laituri

Colorado State University Natural Resource Ecology Laboratory: Paul Evangelista and Nicholas Young

North Central Climate Science Center: Jeffrey Morisette

United States Forest Service: Claudia Regan and Rob Hubbard

United States Geological Survey: Catherine Jarnevich

**Current Management Practices & Policies**

Post-outbreak mitigation of mountain pine beetle (MPB) impacts is of the highest priority for the USDA Forest Service Rocky Mountain Region (Region 2), but progress is limited by funding. The methodology refined in this project uses NASA Earth observing systems and offers cost-effective alternatives for land managers and other decision-makers. Predicting the potential invasion of MPB is difficult, so regional management objectives and research agendas are focusing more on assessing the effects of outbreak on various ecological processes. In response to the epidemic, priority treatment buffer zones have been established for Wildland-Urban Interface (WUI) areas where treatments have gradually transitioned from immediate areas outside community developments (classified as site-level mitigation) to an outer perimeter of the community (stand-level). These treatment methods include pruning and masticating fuels, thinning, and/or commercial salvaging. Managers hope to expand practices to a landscape level, and utilization of these abundant mitigated materials is currently in debate. Issuing firewood collection permits and research in energy production from forest biomass are among these new possibilities. A recent bill for Colorado’s forests proposes more collaboration with the Colorado State Forest Service (CSFS) and federal agencies to facilitate the use of forest biomass as renewable energy. Maps produced from this project can help to identify areas of high lodgepole pine mortality. This knowledge can be used to prioritize treatment areas and plan extraction efforts.

Legislators have worked to address the impacts of the mountain pine beetle. The Region 2 Regional Incident Management Team and Northern Front Range MPB Working Group were created to manage diseased forests, coordinate hazardous tree removal within national forests, and promote cooperation among public and private stakeholders. The Collaborative Forest Landscape Restoration Program is another institute created to encourage collaborative efforts in science-based ecosystem restoration of prioritized forests. In July of 2012, the Healthy Forest Management Act was introduced to specifically address the bark beetle epidemic. This bill aimed to expand the authorities from the 2003 version to address deteriorating forest health conditions, and provide more emergency measures for high-risk wildfire areas. And in 2013, Colorado bills propose to address funding for wildfire risk reduction with the Department of Natural Resources (Senate Bill-269), and prescribed burning programs (Senate Bill-083).

**Benefit to End-User:**

* Results from this project will aid in the assessment of MPB damages as well as provide support tools for managers and mitigation efforts.
* Modeling methods will help further develop change detection techniques to apply to other regions impacted by mountain pine beetle.

**Decision Support Tools**

* Arapaho, Medicine Bow, Roosevelt, and Routt National Forests Lodgepole Mortality Map - For use by the US Forest Service to plan management of forest killed by mountain pine beetle.
* Mountain Pine Beetle Mortality Model - A modeling procedure for modeling mountain pine beetle mortality that can be applied throughout the Rocky Mountains.
* Leaf Area Index Surface of Fraser Experimental Forest- A tool for use in future research efforts at Fraser Experimental Forest.

**Earth Observations & Parameters**

Landsat 5, Thematic Mapper - Land Cover

Landsat 8, Operational Land Imager - Land Cover

**Models Utilized**

USGS Software for Assisted Habitat Modeling (SAHM)

Boosted Regression Trees in R statistical software

**Ancillary Datasets Utilized**

USDA Forest Service Field Data

USDA Geospatial Data Gateway 10m Digital Elevation Model (DEM) and related topographic information

**Software Utilized**

ArcGIS (ESRI) - Visualization, manipulation, and analysis of Landsat imagery and derived indices

ENVI (Exelis) - Landsat imagery manipulation and index derivation

R statistical software - Statistical computing

Adobe Premiere Pro - Video editing

Microsoft Office (Word, Excel, and PowerPoint) - Creation of deliverables

FRAGSTATS – Computation of landscape metrics to analyze spatial patterns in our results

**Imagery & Captions (only to be included in the final draft, not rough draft)**

Image A. NDVI derived from Landsat 5 imagery of Arapaho, Medicine Bow, Roosevelt, and Routt National Forests. A true color image of northern Colorado and southern Wyoming frames our study area.

