Wildland Fire Emission Estimation, A Remote Sensing Approach

Title: Development of New Geospatial Tools for Wildland Fire Management and Risk Reduction, Stage 1,
Funded by NASA Headquarters

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California Air Resources Board, Klaus Scott
US Forest service Pacific Wildland Fire Science Laboratory, AirFire Team, Sim Larkin, Sierra Pacific Industries, Ed Murphy

Objectives

Phase 1: Developing remote sensing-aided procedures for estimating/modeling of wildland fuel moisture/condition and burn severity and incorporating these as inputs to the emission estimation models from wildland fires.

Phase 2, under consideration, a living document: Revising and improving FOFEM and Berkeley EES models to accept higher geospatial resolution inputs leading to consequently producing more site-specific and accurate outputs over extensive large areas

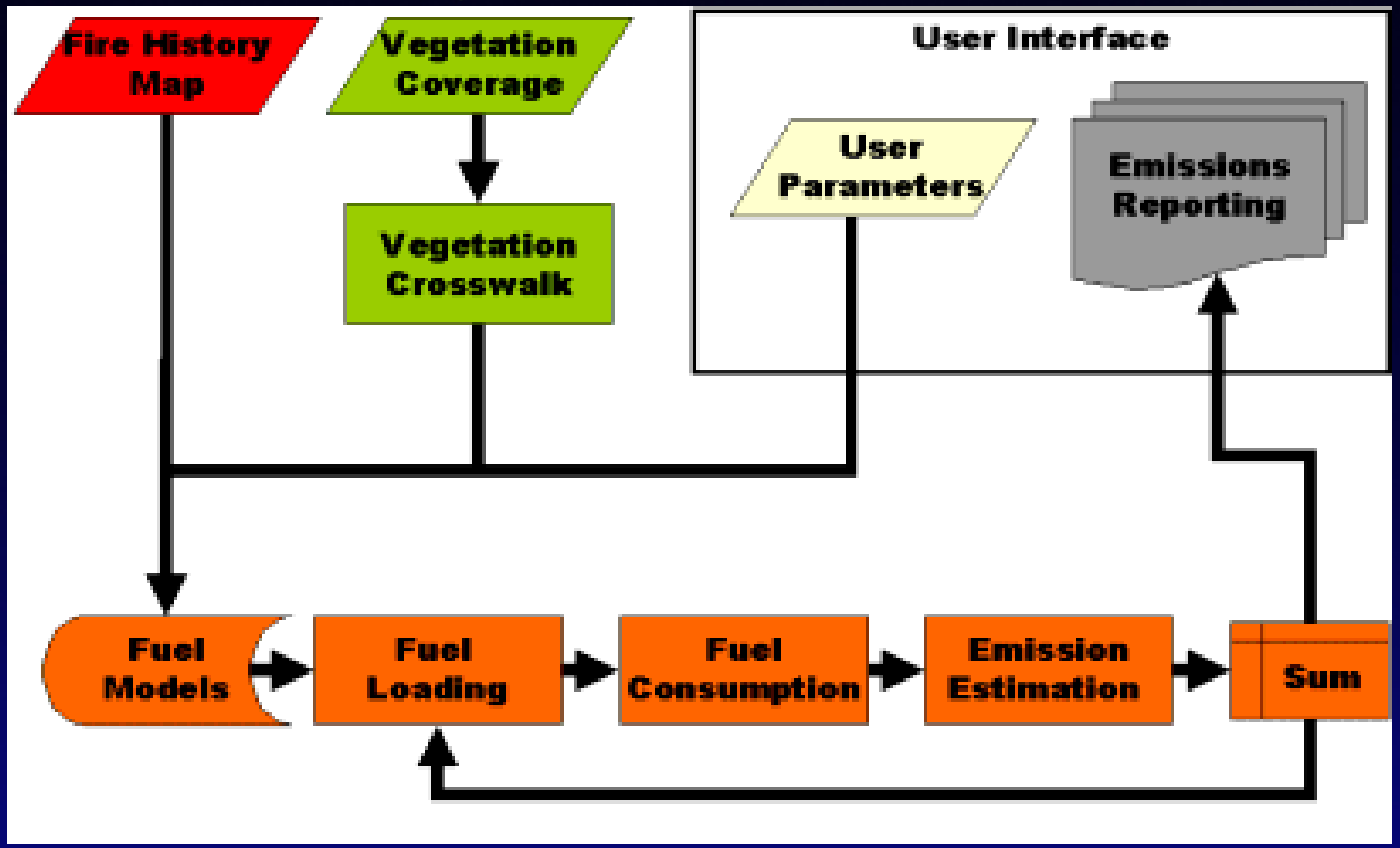
Applying the methodology to other study sites in California (e.g. Big Sur) & Florida (Myakka River State Park) and partnering with FOFEM and EES developers, end users, and decision makers

Proposed Phase 2 Participants: Calif. Air Resources Board, Missoula Fire Science Lab., USFS Air Fire Team , Sierra Pacific Industries, Tall Timbers Research Station.

Berkeley EES (Emission Estimation System) Model

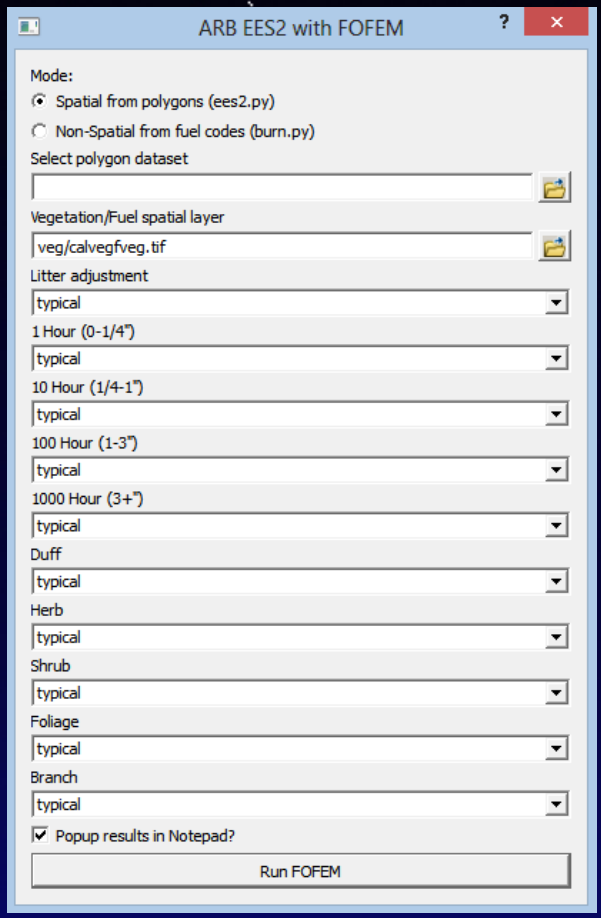
Estimate wildland fire emissions with spatial information

Using Forest Service First Order Fire Effects Model (FOFEM) algorithm for fuel consumption and emission estimation



Model Inputs and Output

- Inputs
  - Fire Perimeter
    - Polygons depicting burnt areas
  - Vegetation Cover
    - CALVEG crosswalked with FCCS
  - Fuel Moisture
    - Interpolated from up-to-date sites of NFDR-TH (Thousand Hour Fuel Moisture) percentage data
  - Non-spatial
    - Fuel Load Adjustment
- Outputs
  - Emission Report for CH4, CO2, PM2.5, PM10, CO, NOX, SO2



Approach to improving ESS
Use field measurements and remote sensing

Relate remote sensing data to field measurements at our two Phase 1 study sites, representing (no fire, light to moderate to severe burn conditions)

We have extensive inventory plots at our sites (diameter, height, stem volume of trees) augmented with fuel biomass and fuel moisture transects

Accuracy assessments of the UAVSAR-based and ETM-based Burn Severity products for the Ponderosa site was performed by means of confusion matrices, and Kappa statistics

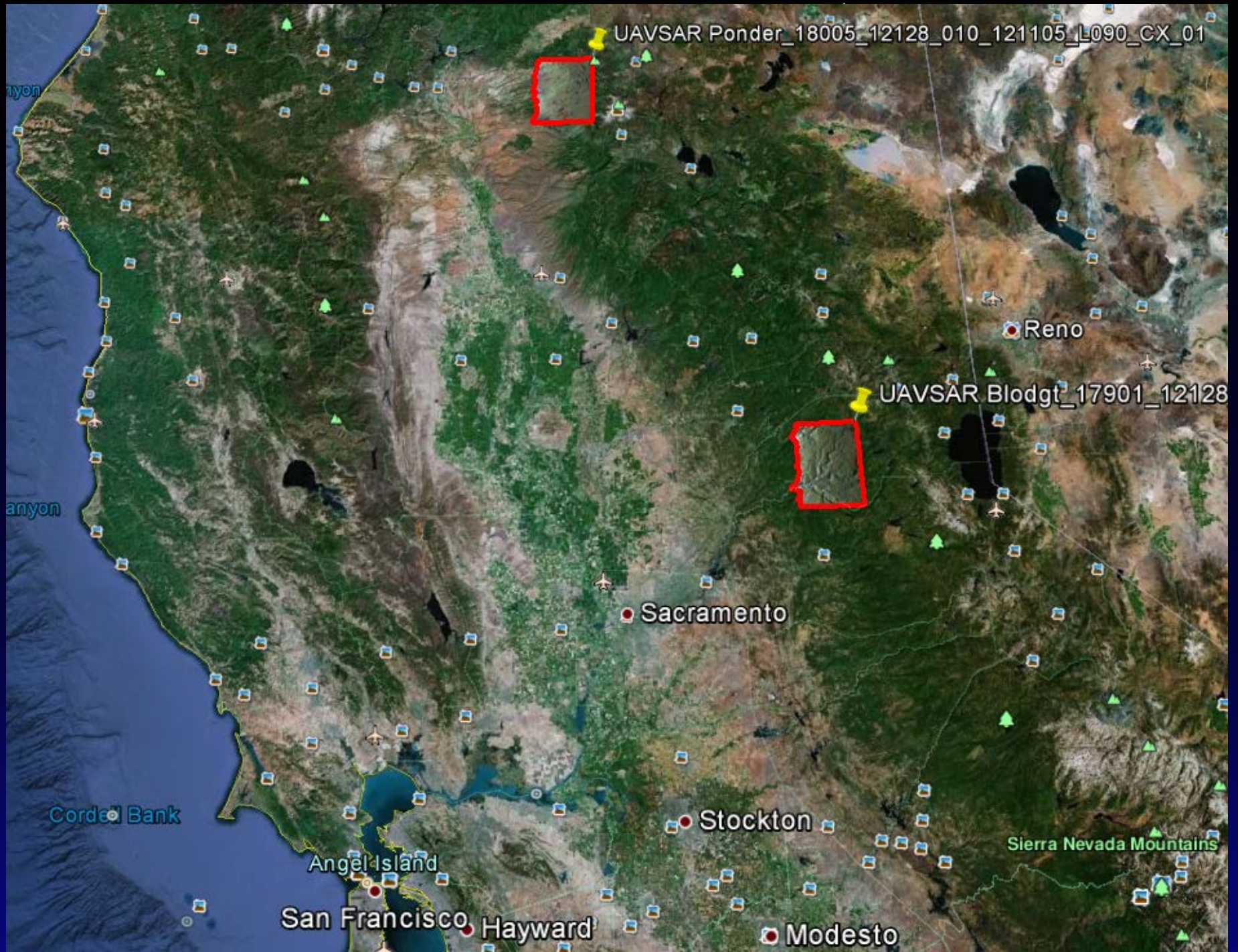
Revising the inputs to FOFEM and EES

Fire Severity Mapping

- Estimating how much CO, CO2, NOX, SO2, PM, etc. has been released to the atmosphere after a fire
- Identifying the severity of burning within a certain cover type
- Updating and correcting out-of-date fuel type maps of CALVEG and Gap Analysis Map

Fuel Load/Moisture Mapping

- Land cover mapping leads to updated fuel type and fuel moisture estimation and more detailed fuel moisture conditions
- Biomass estimation leads to fuel load inputs for the model and consequently more accurate emission estimation.


UAVSAR Ponder_18005_12128_010_121105_L090_CX_01
Reno
UAVSAR Blodgt_17901_12128
Sacramento
Cordell Bank
Stockton
Angel Island
Sierra Nevada Mountains
San Francisco
Hayward
Modesto

Field Sampling for fuels and moisture

We sampled in the field for: Forest fuel biomass:

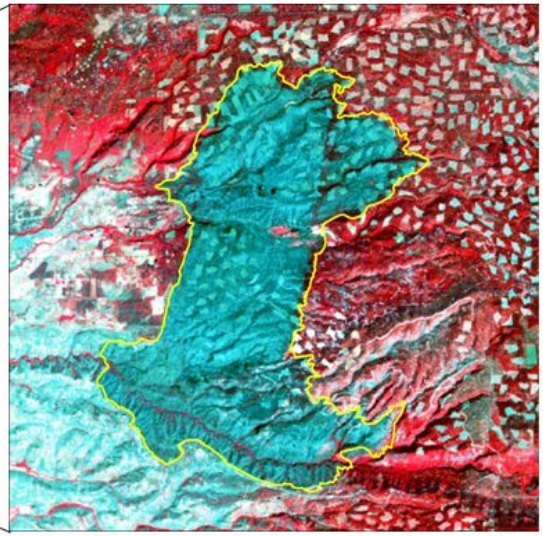
litter, duff, 1 hr, 10 hr and 100 hr fuels

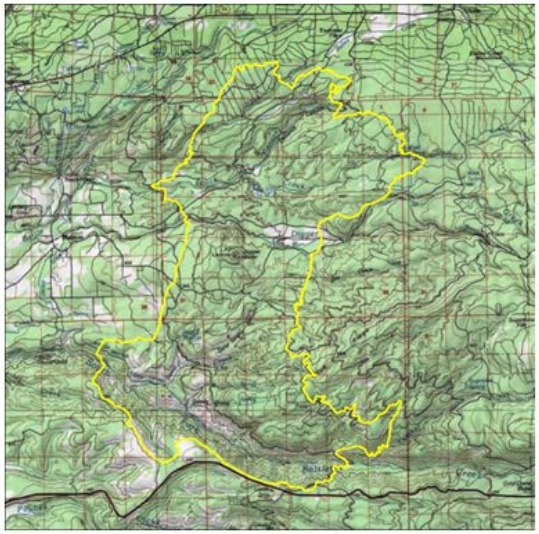
Foliage samples

Data Sources

- UAVSAR
- AVIRIS
- MODIS (too coarse for the study sites, but useful for future implementation over large areas)
- ETM
- LANDSAT8
- SPI CIR digital imagery
- High resolution NAIP Imagery
- Hand held hyperspectral imager
- Field data: dead fuel (1 hr., 10 hr., 100 hr. fuel)
- Soils (duff and litter moisture) and live foliage moisture, tree height and canopy factors.

Ponderosa Fire





Ponderosa Fire in California, 8/26/2012

Projection: UTM Zone 10N

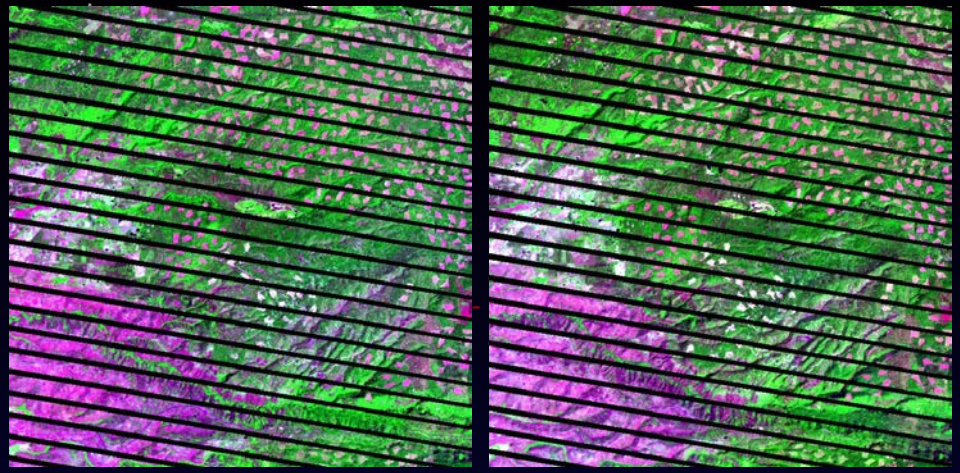
Fire Severity Study

- Remote Sensing Data
  - Pre-fire
    - Landsat ETM+ (7/10/2012 and 8/11/2012 Fusion)
    - 2012 National Agriculture Imagery Program (NAIP, in July)
  - Post-fire
    - Landsat ETM+ (8/27/2012 and 9/12/2012 Fusion)
    - High Resolution Aerial Images provided by SPI
    - UAVSAR (2012 & 2013)
    - AVIRIS Hyperspectral Imagery (2012 & 2013)
- Field Photos and Expertise

ETM+ Fusion

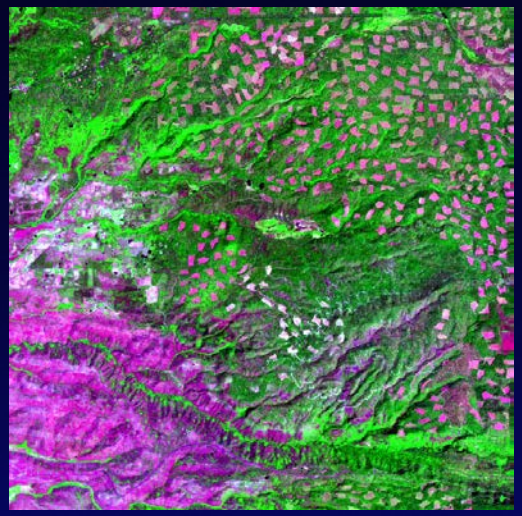
Dark Stripes Filling

- Statistical average match of common areas as color matching method
- Fill dark stripes in image 1 with adjusted values in image 2



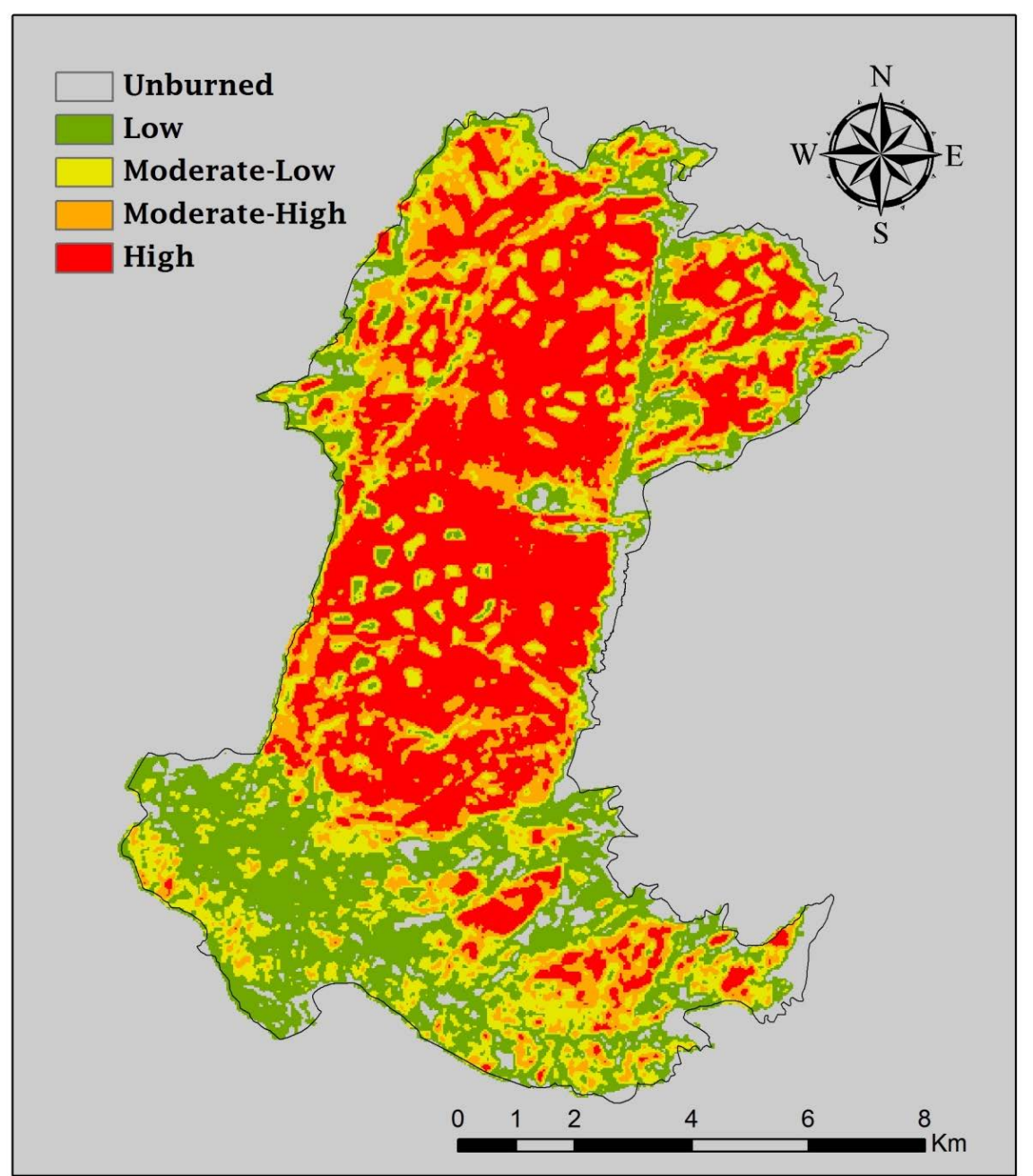
Pre-fire Image 1 in July 10

Pre-fire Image 2 in Aug 11



Merged into the Pre-fire Image

ETM-based Burn Severity Results



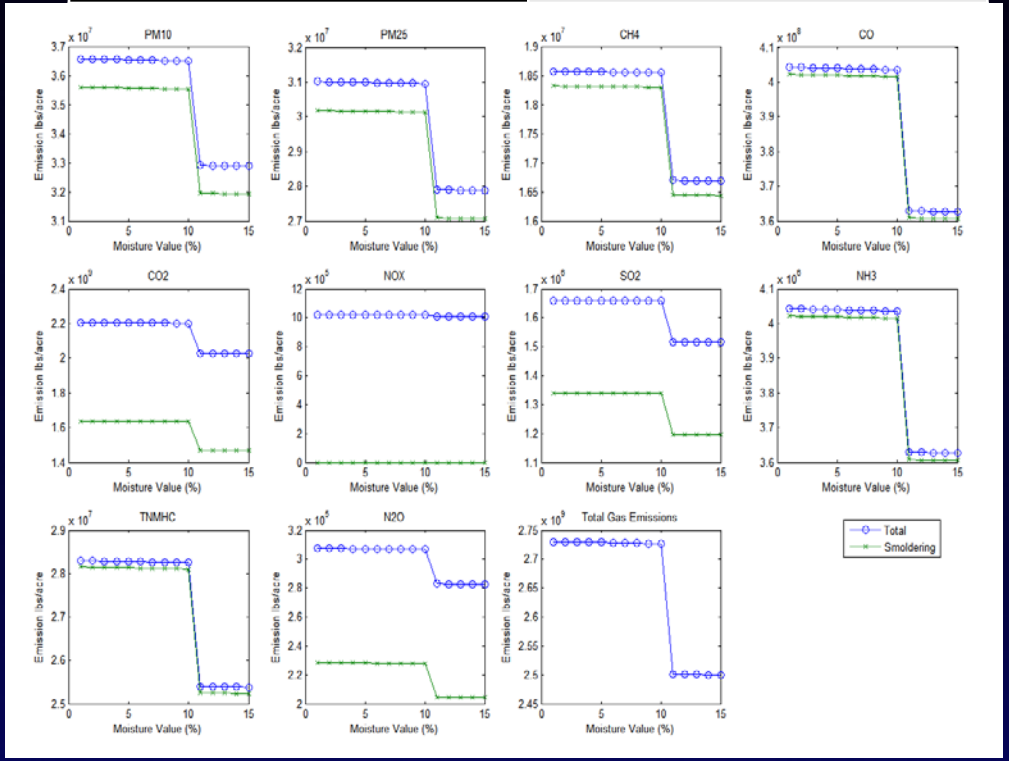
Fuel Moisture

- WFAS NFDRS 1000-hr Fuel Moisture Data
  - Weather Stations
- Field Measurements (2012, Nov)
  - Ground Samples and Photos
- Remote Sensing Images
  - Landsat TM/ETM+
  - AVIRIS
  - UAVSAR
  - SPI Digital Imagery
  - NAIP Imagery

An important input to the EES model

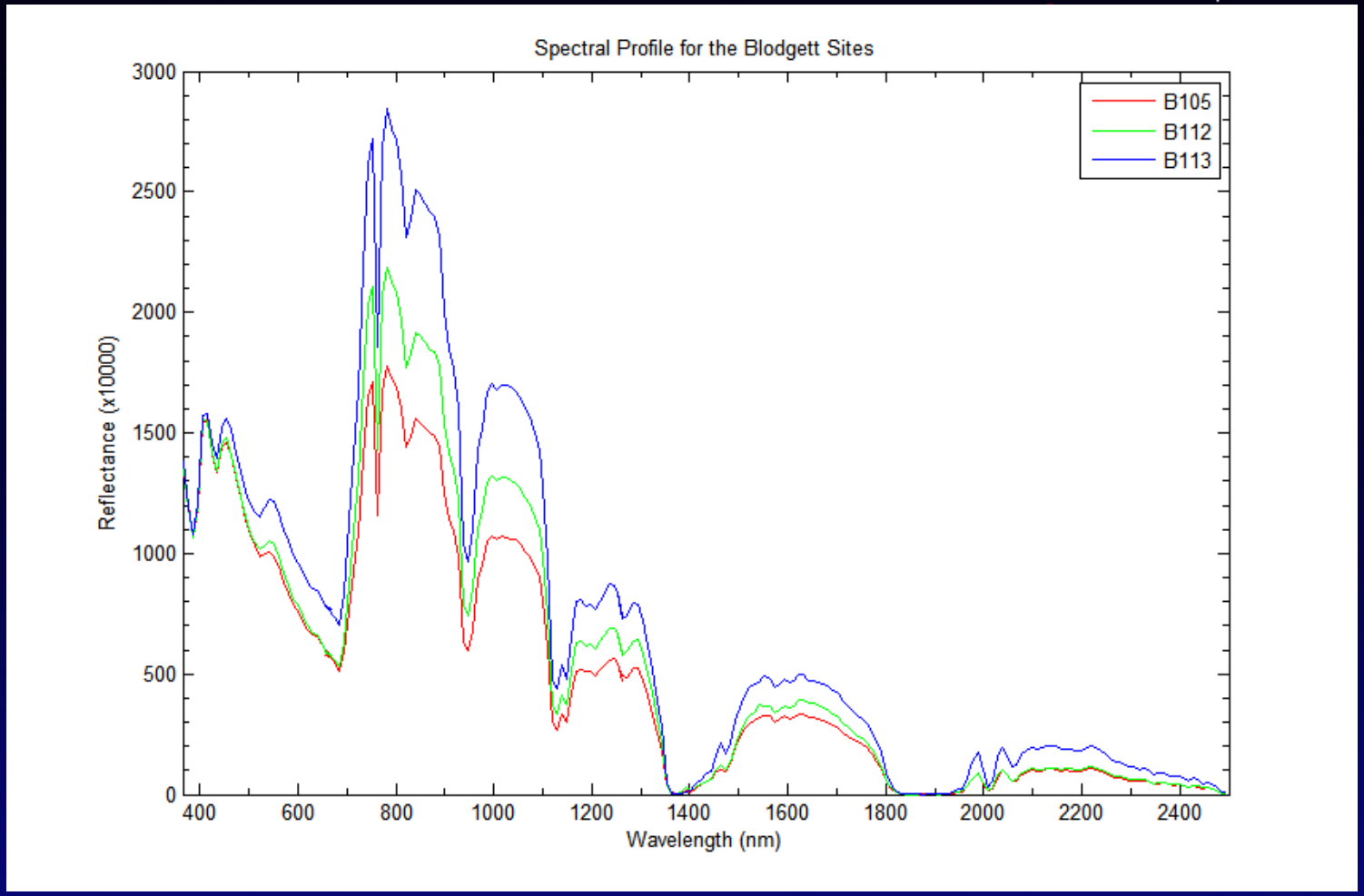
- Sensitivity Test on the Ponderosa Fire
  - Varying 1000-HR Fuel Moisture Value from 1-15%
  - Sudden Change at 10%
  - Moisture Condition Change Has Great Impact on the Model Output (FOFEM)

1000 Hr Fuel Moisture (%)	Moisture Condition Input
1 ~ 10	Very Dry
11 ~ 15	Dry
16 ~ 30	Moderate
30 ~ 100	Wet

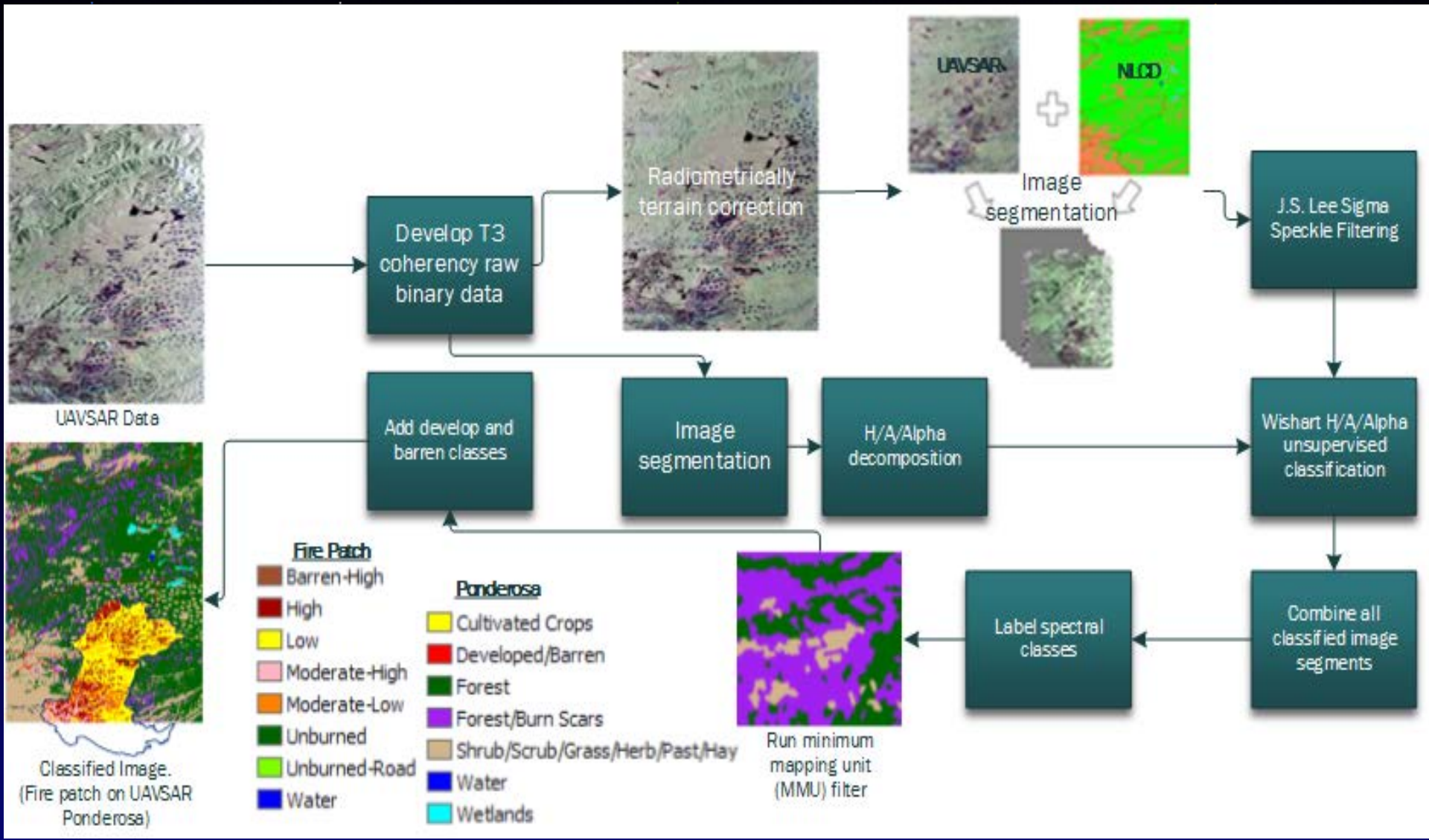


Site Analyses Using AVIRIS Image in 2013 May

Surface Reflectance	Valley (685.2nm)	Peak (782.9nm)	Valley (947.7nm)	Peak (995.9nm)	Valley (1130.0nm)
B105	0.053	0.178	0.060	0.107	0.027
B112	0.053	0.219	0.074	0.132	0.033
B113	0.070	0.285	0.097	0.170	0.044



UAVSAR-based Analysis



Initial Decision Making Impact Analysis

Two Potential Impacts:

- CARB's Smoke Management Program
  - Improved smoke management and forecasting
  - Better information for issuing prescribed burning permits
  - Better quantitative estimates of spatial distribn. of emissions
- Global Warming Solutions Act of 2006 (AB32)
  - Improved baseline estimates of GHGs emissions from wildfires
  - Robust methods to estimate avoided GHGs emission from land management decisions that enhance carbon stocks and reduce fire risk.

Potential Impacts Continued

- set acceptable upper and lower fuel moisture for conducting controlled burns;
- determine the number of acres burned on a given day without exceeding particulate emission limits;
- assess atmospheric effects of wildfire; and
- compare expected outcomes of alternative management interventions.

Thank you