

Soundscapes to Landscapes (S2L)

Monitoring Animal Diversity from Space Using Citizen Scientists

Matthew Clark (PI, Sonoma State Univ.)

Scott Goetz (Northern Arizona Univ.)

Steven Hancock (Univ. of Maryland)

Patrick Jantz & Pat Burns (NAU)

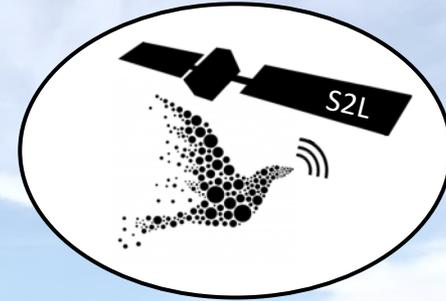
David Leland (Audubon California)

Lisa Micheli (Pepperwood Preserve)

Shawn Newsam (UC Merced)

Leo Salas (Point Blue Conservation Science)

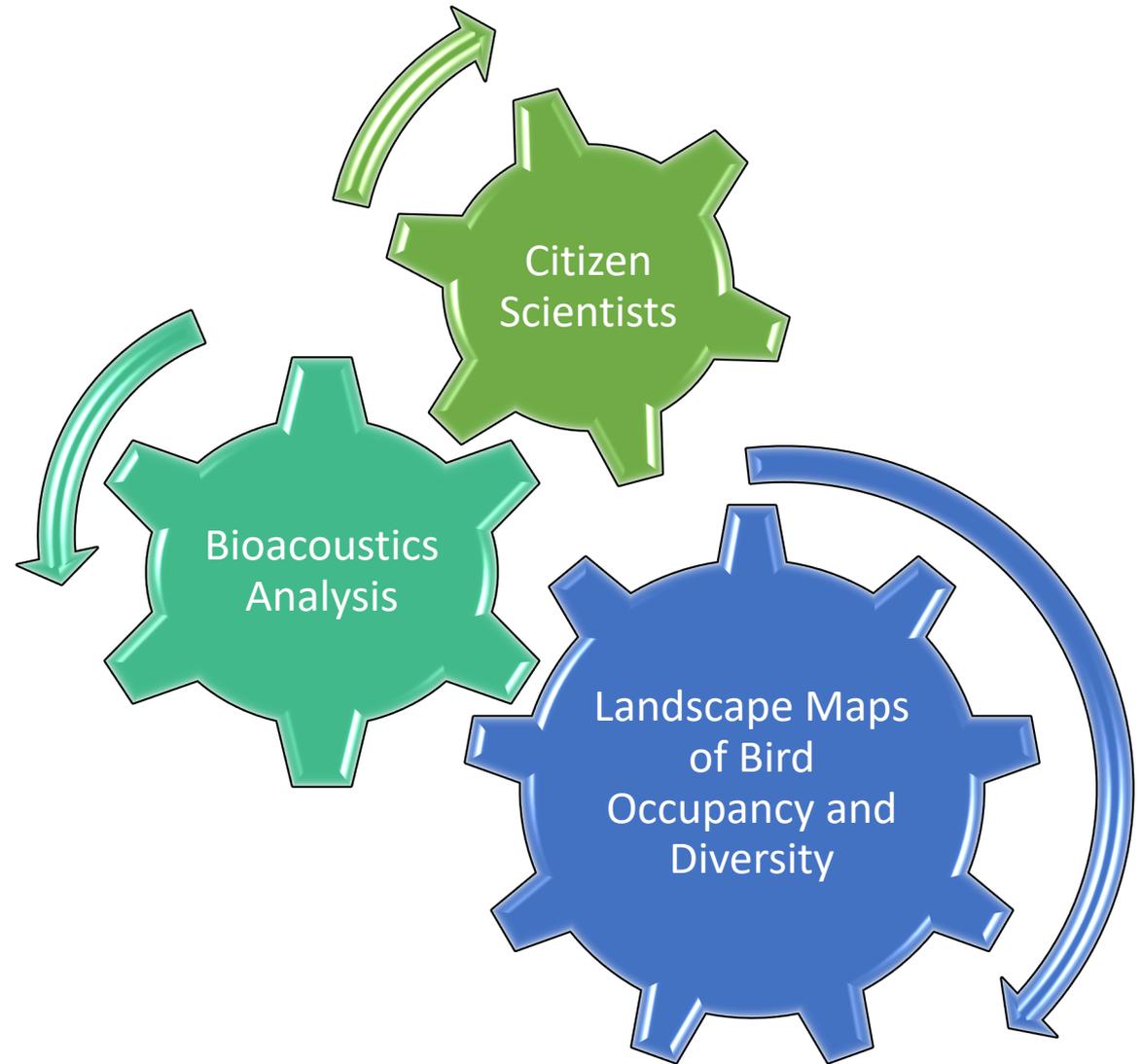
Wendy Schackwitz (Audubon California)



Funding: NASA's Citizen Science for Earth Systems Program (16-CESP 2016-0009)

Soundscapes to Landscapes (S2L)

Seeks to advance
animal diversity
monitoring from
next-generation and
existing Earth-
observing satellites.



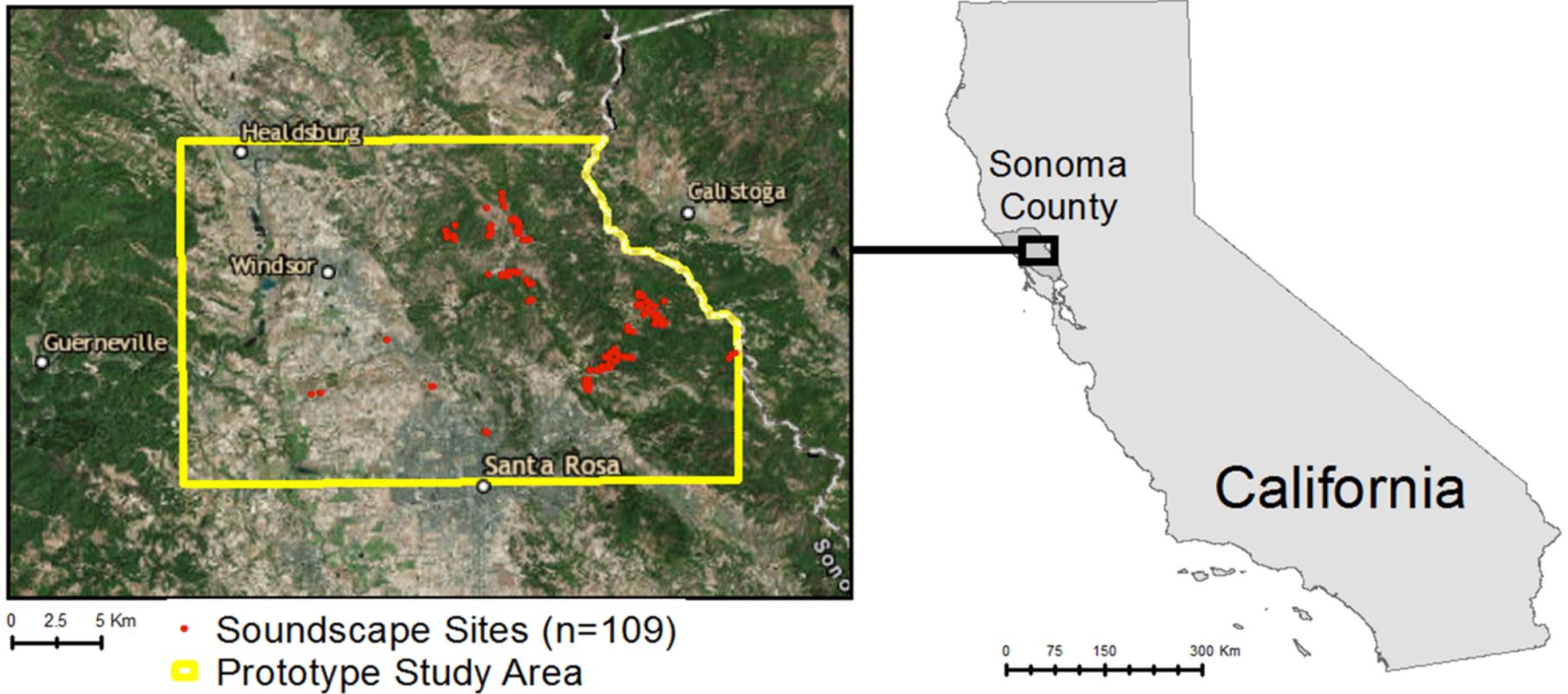
Project Goals



Audubon

1. Involve citizen scientists in collection of bird diversity data through bioacoustics
2. Assess bioacoustics for detection and monitoring of birds
3. Species distribution modeling (SDM) of bird diversity
 - Simulated spaceborne imaging spectroscopy (HyspIRI)
 - Simulated spaceborne lidar (GEDI)
 - Synthetic aperture radar (Sentinel-1)
 - Multi-multispectral optical (Landsat, Sentinel-2)
 - Climate and other GIS-based variables
4. Use SDM outputs for conservation planning and identifying areas of overlap with ecosystem services (e.g., carbon)

Prototype Study Area: Markwest Watershed, Sonoma County, CA



Project collaborator Pepperwood Preserve is located in the watershed.
Network of landowners interested in conservation and watershed management.

Citizen Scientists

Types

- Birders
- Undergraduate students
- Landowners

Recruitment

- Audubon California
- Watershed groups
- University email

Main tasks

- Local knowledge of bird ecology
- Bird observations in the field
- Place/retrieve sound recorders
- Bird call identification and modeling
- Review bird-call classification results



Soundscape Collection

Recorders are Android smartphones with extended battery, mic, and ARBIMON app



In the prototype phase, recorder deployment to remote areas was mostly done by student interns



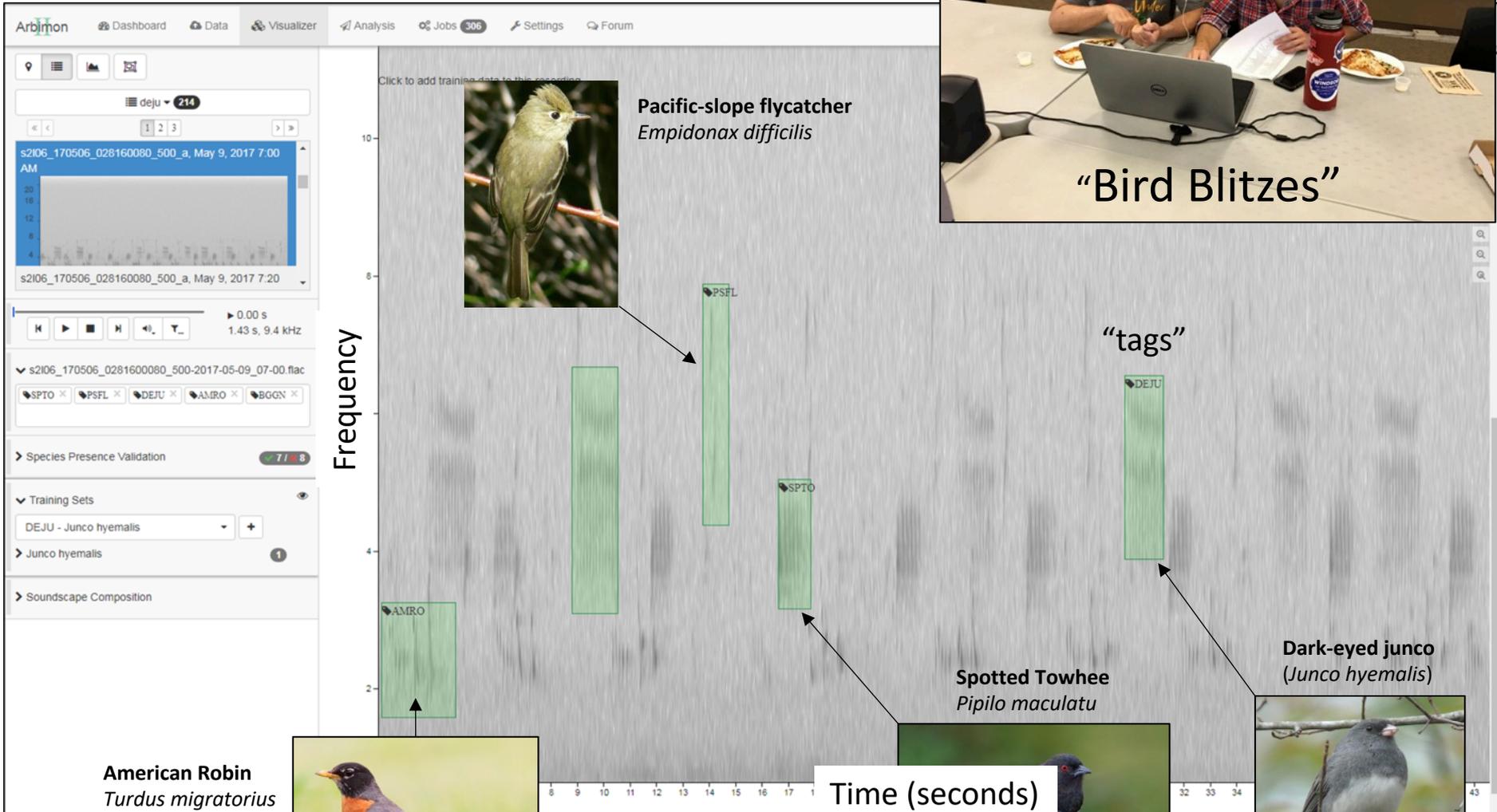
1-minute recording every 10 minutes, with 3-4 days at each site



Prototype:
>1,100 monitoring hours
(66,395 minutes)

533 hours or \$13,133 of Citizen Science labor for field collection

Bioacoustics Analysis



ARBIMON used to both hear and view recording spectrograms (time vs. frequency) for bird-call reference data that then feed into machine learning models for species detection.

Bioacoustics Analysis

Dark-eyed junco
(*Junco hyemalis*)



Arbimon [Dashboard](#) [Data](#) [Visualizer](#) [Analysis](#) [Jobs](#) 306 [Settings](#) [Forum](#)

- Models
- Classifications
- Soundscapes
- Audio Event Detection

[← back](#)

Model details

Name:	DEJU_02d
Type:	Pattern Matching
Creation date:	Sep 3, 2017 12:35 PM
Last updated:	Sep 3, 2017 12:35 PM
Creator:	Matthew Clark
Species:	Junco hyemalis
Sound:	Mechanical Song

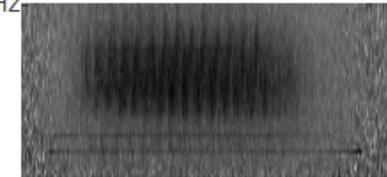
Training set

Name:	DEJU - Junco hyemalis
Creation date:	May 16, 2017 5:00 PM
Pattern ROI Count:	25
Pattern Bandwidth:	5,030.783Hz

Training set pattern:

Zoom: [Q](#) [Q](#)

7,355.783Hz



0s

2.654s

2,325Hz-

Regions of Interest (refined tags) used to create training sets. Passed through validation recordings for model verification.

Model validation details

Total validations used	226		
Present:	100	Absent:	126
In fitting:	50	In fitting:	76
In verification:	50	In verification:	50

Random Forests model verification

Statistics

Accuracy:	0.84
Precision:	0.886363636364

Predicted

Actual	P	A
P	39	11
A	5	45

P = Present, A = Absent

Bird-call models were applied to all soundscape recordings to classify P/A.

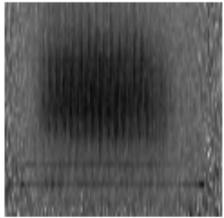
Classification Details

Name DEJU - All Recordings, April (9/19/17)

Playlist [All Recordings - April 2017](#)

Results 

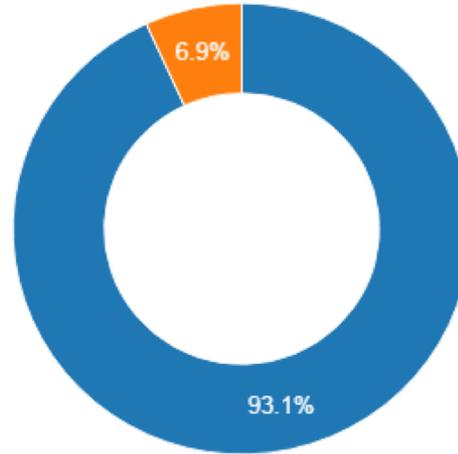
Model used



Name [DEJU_02d](#)

Species Junco hyemalis

Sound Mechanical Song



■ absent ■ present ■ skipped

Absent	15974
Present	1175
Total	17149

▼ Show details per recording

Close

Classified >33k minutes of recordings between 5 am – 9 pm.

Citizen scientists review classifications of detected species by site.

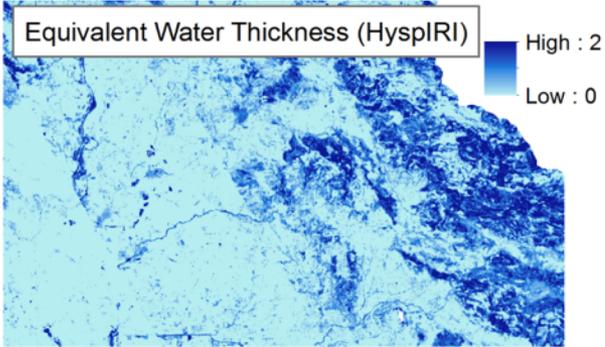
Reviewed recordings ID'd as “present” to confirm actual presence.

Bioacoustics analysis:
628 hours →
\$15,161 Citizen
Science labor

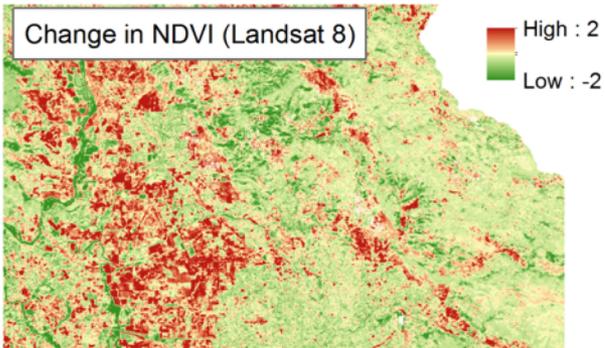
Dark-eyed junco
(*Junco hyemalis*)



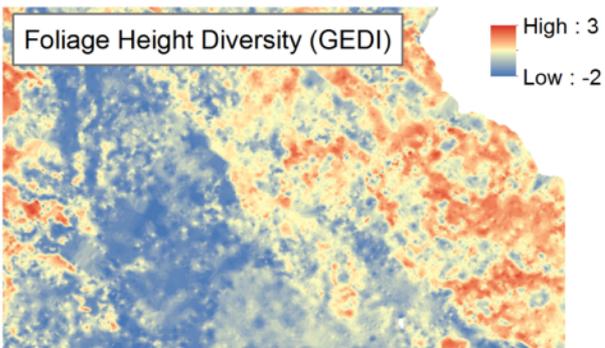
Species Distribution Modeling Predictors



Hyperspectral Infrared Imager (HyspIRI), simulated from June 2017 AVIRIS data



Predictors include simulated HyspIRI and GEDI metrics + Sentinel-1 (SAR), Landsat 8, climate & other GIS-based variables (30-m spatial resolution)



Global Ecosystem Dynamics Investigation (GEDI). Footprint waveforms simulated from airborne lidar, then Empirical Bayesian Kriging for interpolated surface.

Species Distribution Modeling

Four models applied

1. Random Forests
2. Support Vector Machine
3. Boosted Decision Trees (AdaBoost.M1)
4. Gradient Boosted Regression Trees

Ensemble of SDM
predictions with weighting
based on RMSE

Maps show probability of
occupancy

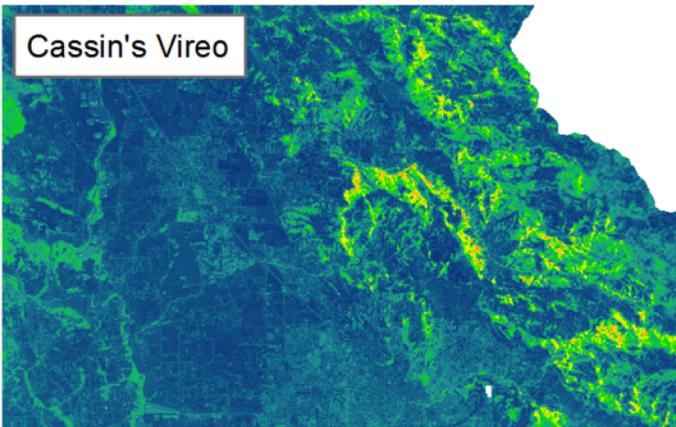
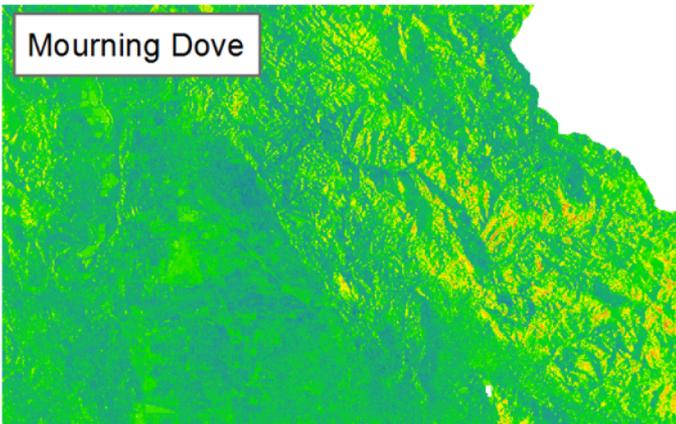
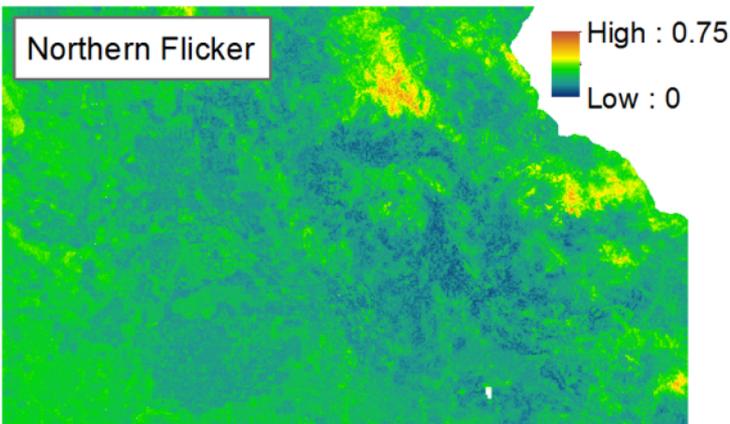


Photo: Glenn Bartley

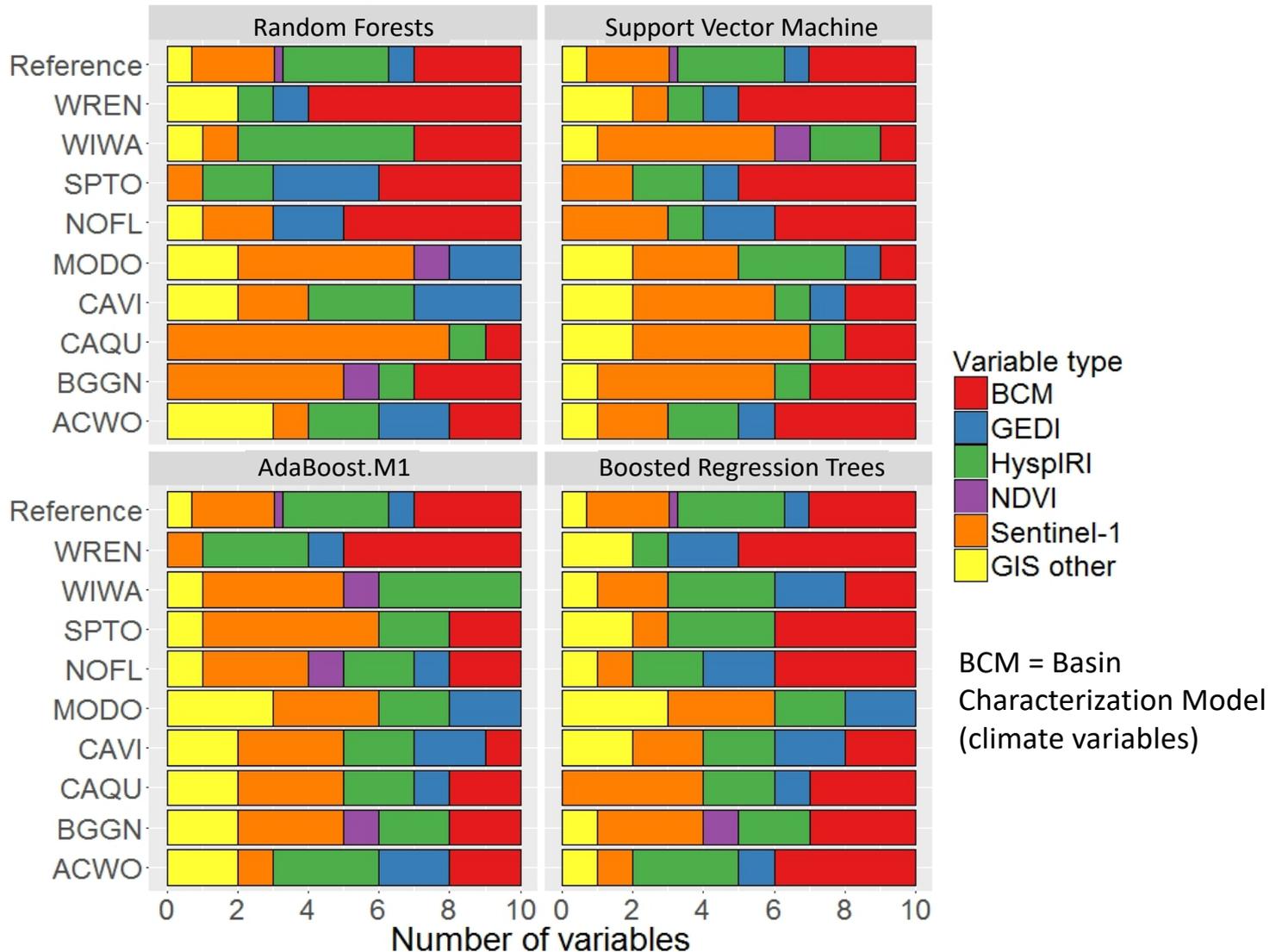


www.naturespicsonline.com



© Jim Zipp www.naturespicsonline.com

Variable Importance – top 10

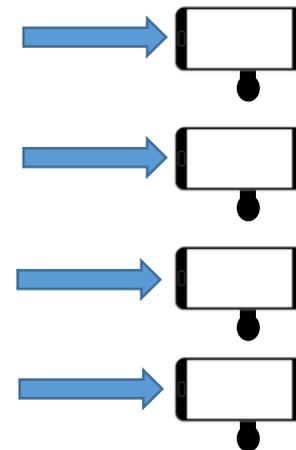


Implementation Phase: Expanding to the County Scale

“Mail & Deploy”: Deployment of recorders to landowners by mail

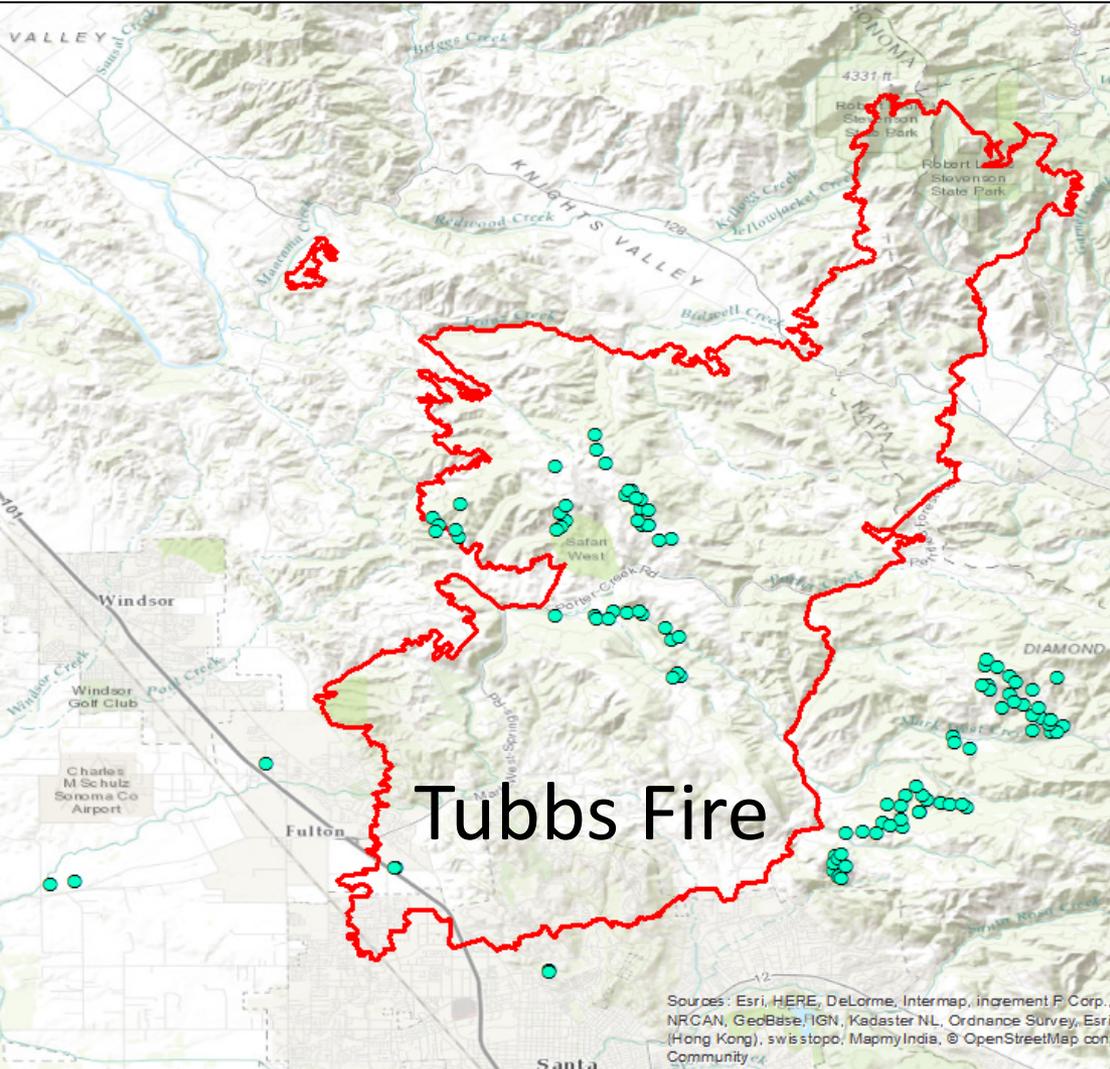


“Cluster Deploy”:
Distribution of recorders to properties through groups (e.g., school science classes, neighborhood associations)



Post-fire monitoring across burn severity gradients

We will re-deploy recorders to 27 burned sites in the Pepperwood Preserve and use unburned sites as a control.



Sonoma & Napa Counties Fires, October 2017

Pepperwood Preserve – April 14, 2018

A wide-angle landscape photograph showing a valley with rolling green hills. The foreground is a lush green field with scattered rocks. In the middle ground, there are hills covered in a mix of green and brown trees, indicating a post-fire recovery. The background shows more distant hills under a bright blue sky with wispy white clouds. A semi-transparent white box with the text "Thank you" is centered in the upper half of the image.

Thank you

Pepperwood Preserve – post-fire, Nov 18, 2017