

# Using aerial imagery to map & monitor rangeland plant abundance while accounting for observation error

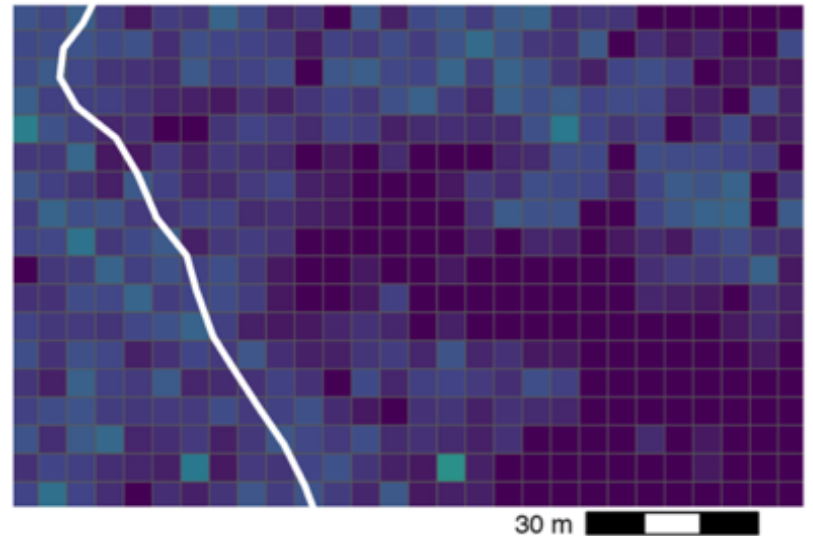
*Andrii Zaiats, T. Trevor Caughlin, Jennyffer Cruz, David S. Pilliod, Megan E. Cattau, Rongsong Liu, Richard Rachman, Maisha Maliha, Donna Delparte, John D. J. Clare*



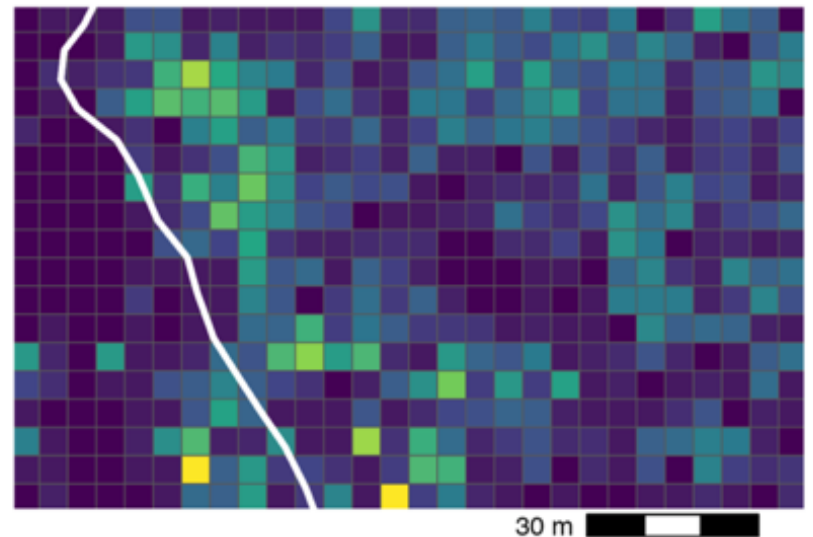
**BOISE STATE UNIVERSITY**



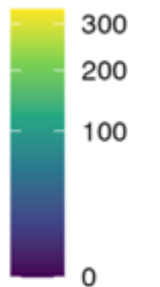
Adult



Juvenile



Abundance



# Sagebrush Steppe Degradation

- Disturbance
- Climate
- Exotic Annuals



# Limitations of Demographic Monitoring



National Park Service  
U.S. Department of the Interior



Natural Resource Stewardship and Science

## Sagebrush Steppe Vegetation Monitoring in City of Rocks National Reserve

*2012 Annual Report*

Natural Resource Data Series NPS/UCBN/NRDS—2012/407



# Multi-Scale Imagery-Based Monitoring

Map **Satellite** Search for a location

Rangeland Analysis Platform

Vegetation

Cover **Shrub** 2022

0 100%

Biomass **Herbaceous** 2022

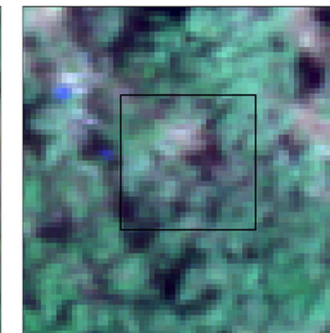
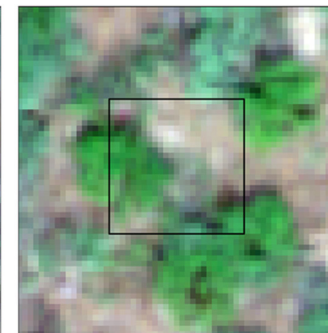
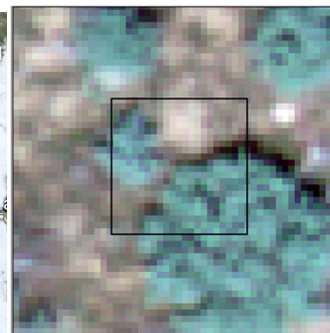
Exclude croplands, development, & water

Draw features Clear map Upload shapefile

Low

Middle

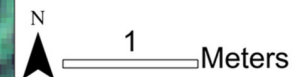
High



Field Plots

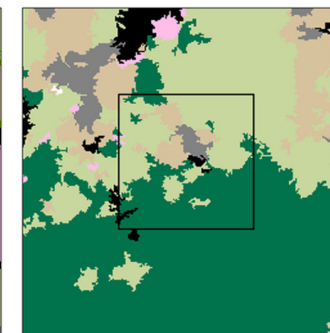
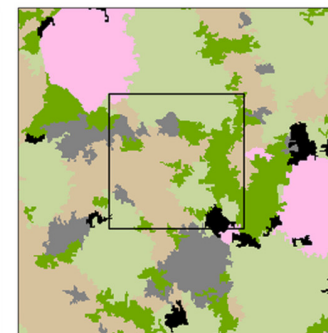
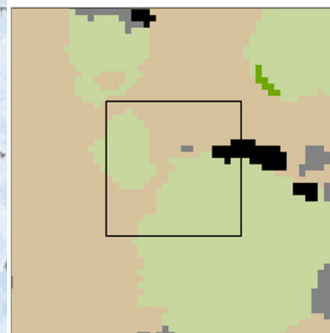
True color imagery

1 m<sup>2</sup>

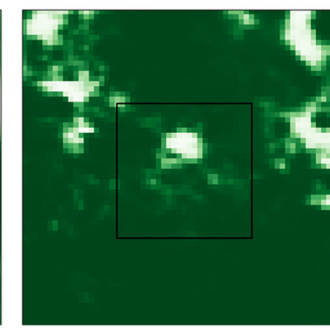
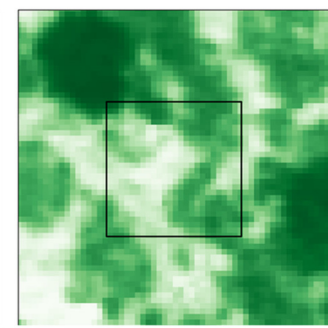
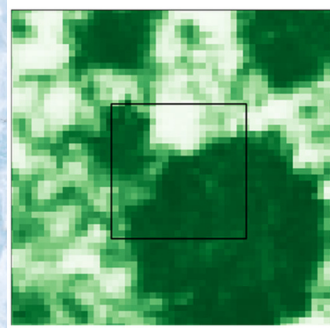


Class Name

- Ground
- Sagebrush Shrub
- Forb
- Grass
- Snowberry Shrub
- Dead Shrub
- Shadows



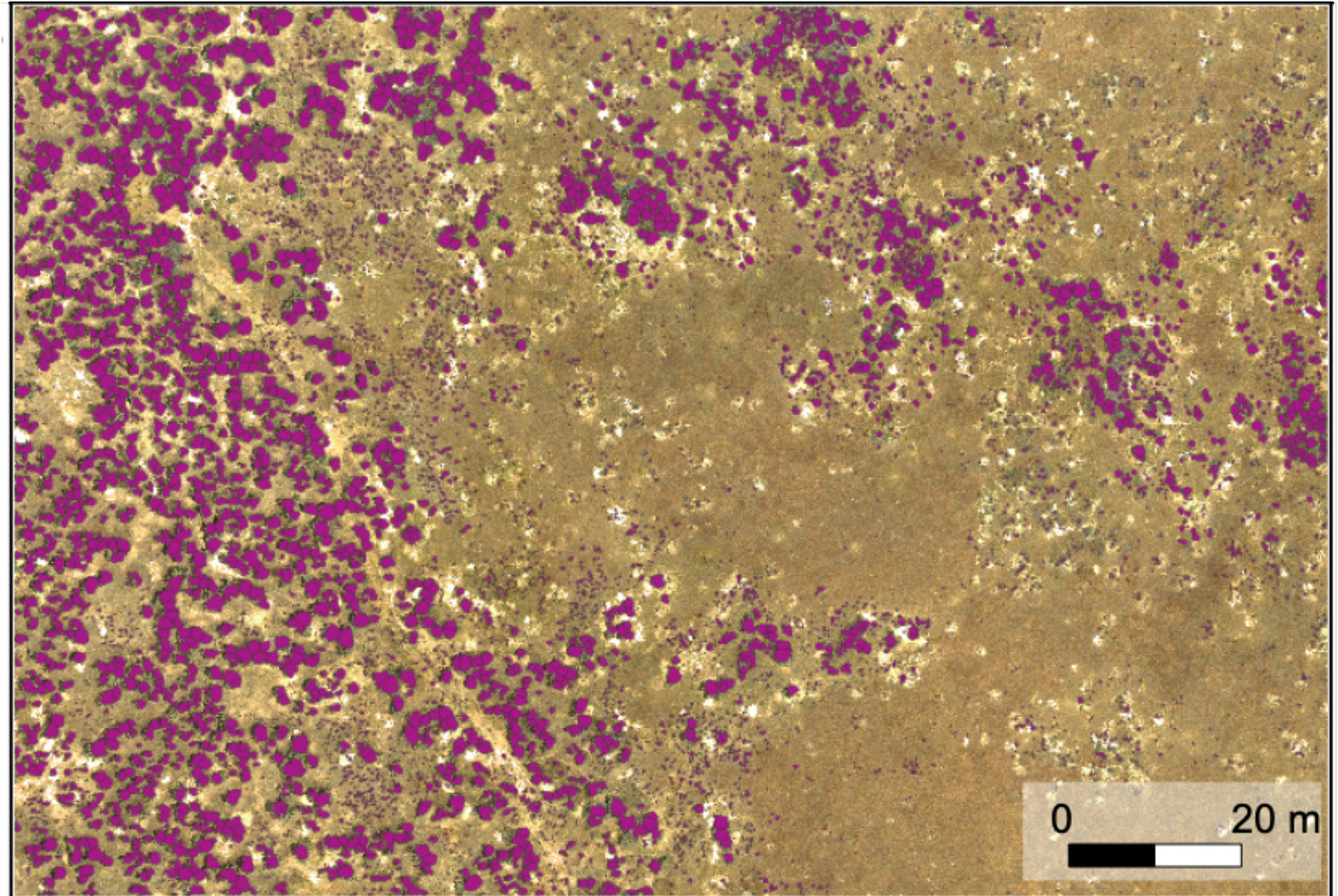
Fractional Photosynthetic Cover



# Emerging Frontier: Remote Individual Detection

## Object-Based Image Analysis

- Reflectance
- Structure
- Geometry
- ...etc

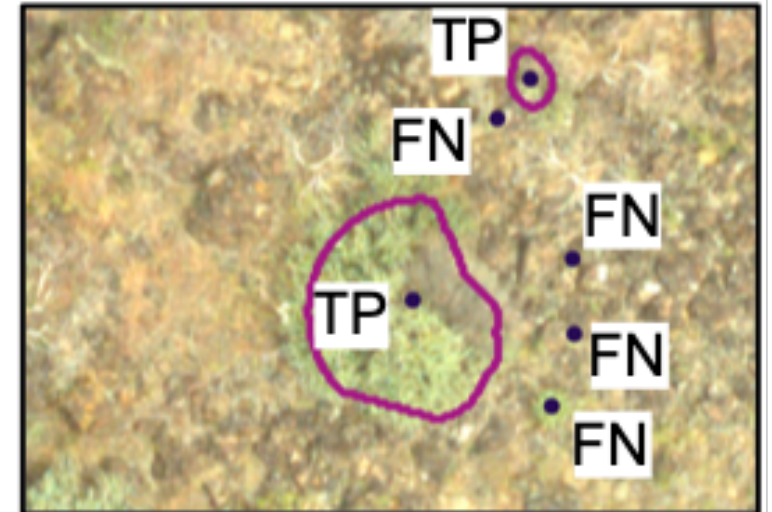
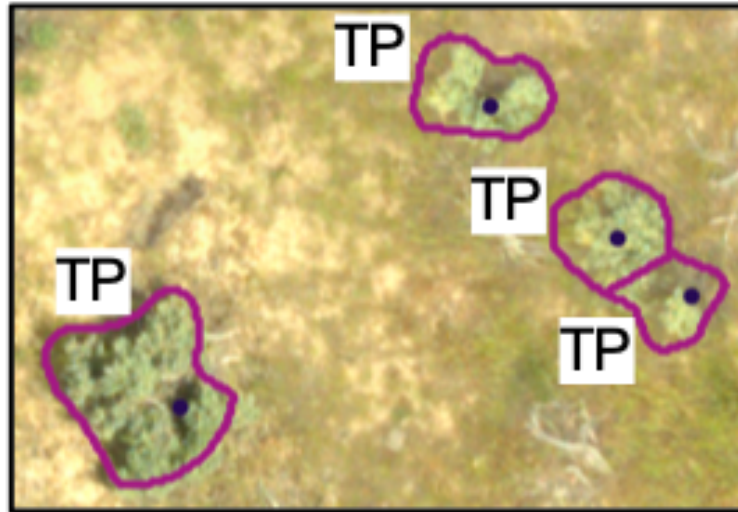
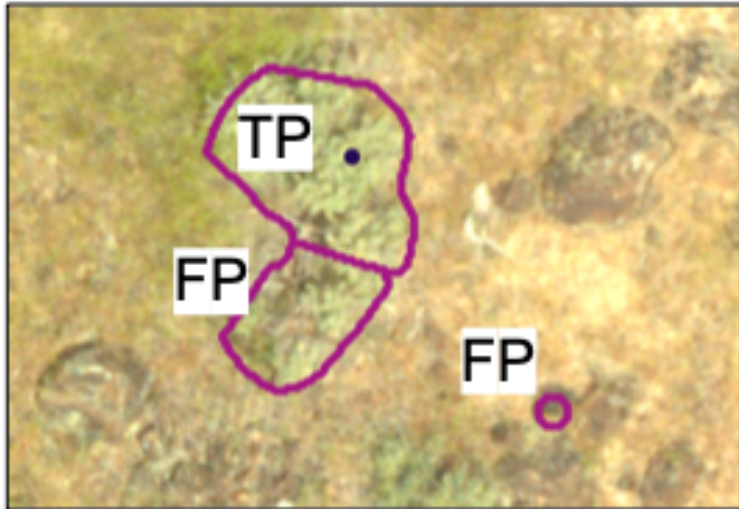


# But It Remains Imperfect!

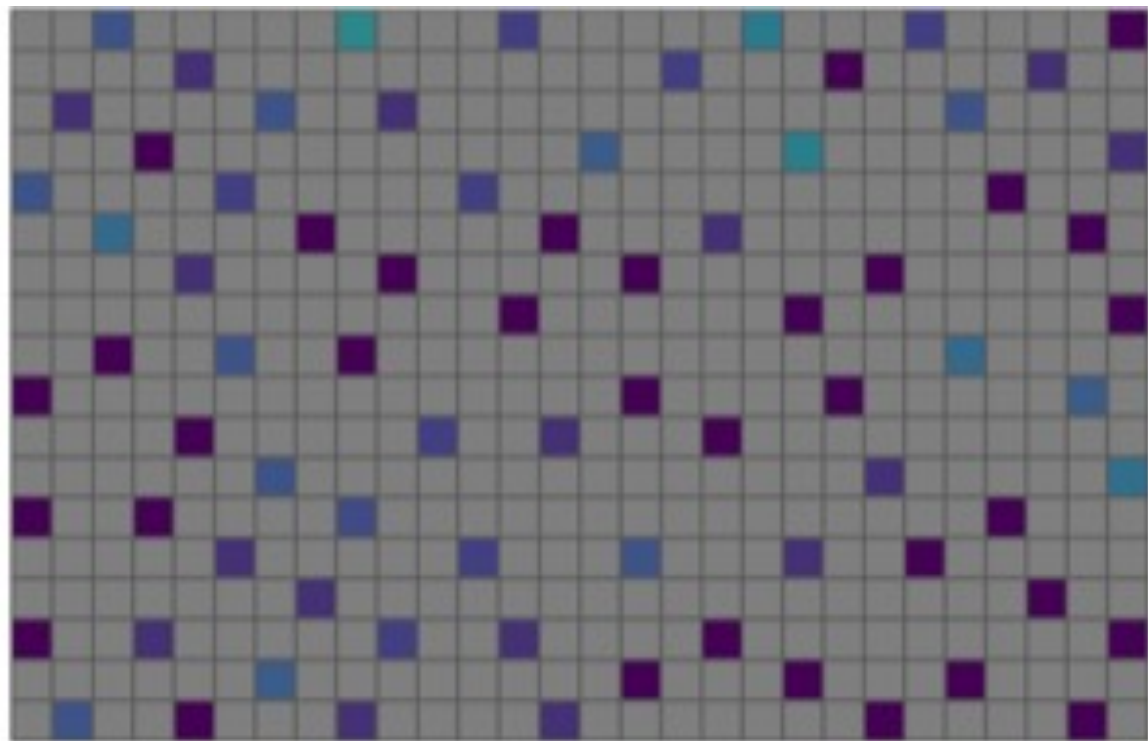
- Field-mapped sagebrush



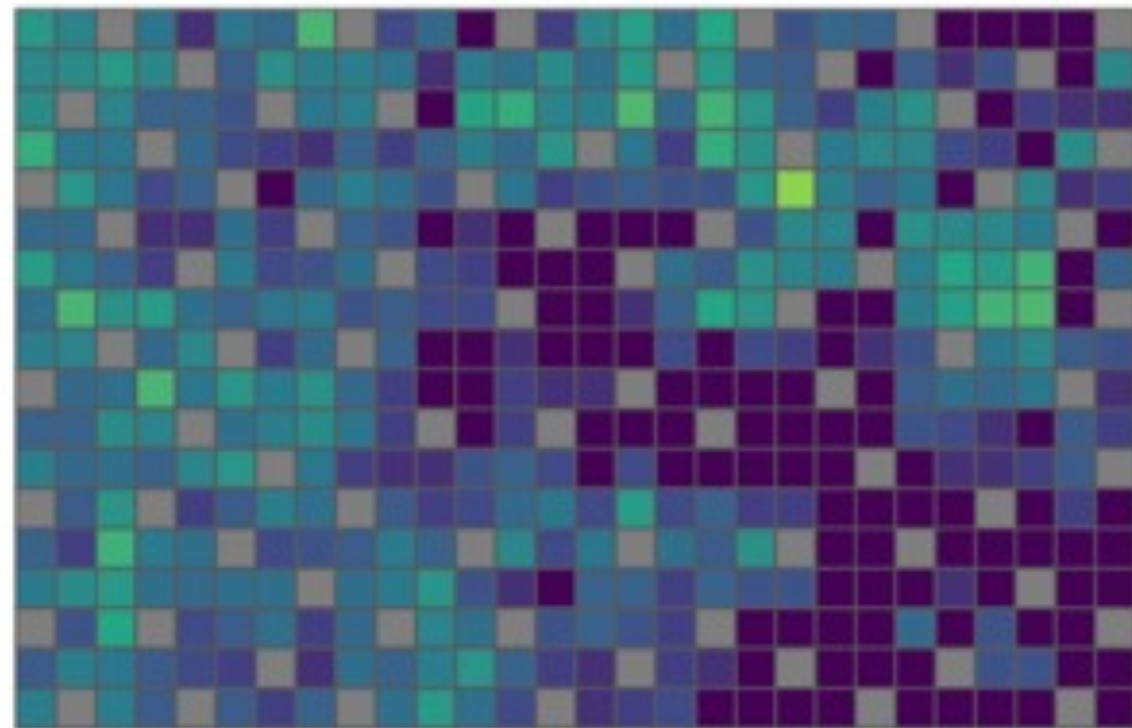
Automatically detected sagebrush



$$c_j^{true} = f(c_j^{image} + X_j) + \epsilon_j$$



Validation data



Aerial data



Aerial & Ground   

$$N_j \sim \text{Poisson}(\lambda^{TP})$$

$$c_j^{TP} | N_j, p \sim \text{Binomial}(N_j, p)$$

$$c_j^{FP} | \lambda_j^{FP} \sim \text{Poisson}(\lambda_j^{FP})$$

Extensible to situations where ground data is also imperfect!

Aerial Data Only  

$$N_j \sim \text{Poisson}(\lambda^{TP})$$

$$[c_k^* | N_k^{TP}, p, \lambda^{FP}] =$$

$$\sum_{c_k^{TP}=0}^{c_k^*} [c_k^{TP} | N_k^{TP}, p] [(c_k^{FP} = c_k^* - c_k^{TP}) | \lambda^{FP}]$$

*\*Process for Abundance/Density (assumed true for ground)*

*\*Process for failing to detect real plants (aerial)*

*\*Process for introducing false positives (aerial)*

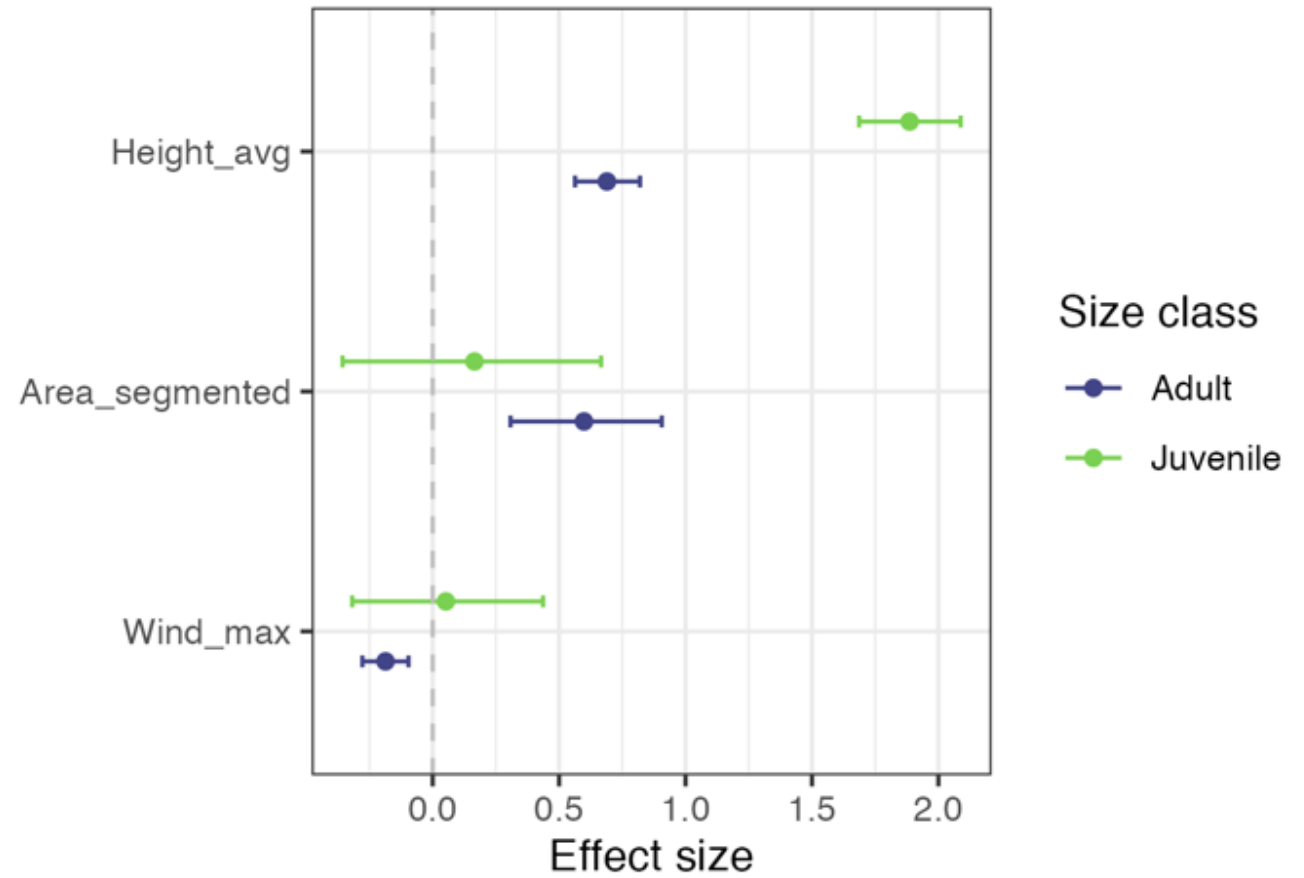
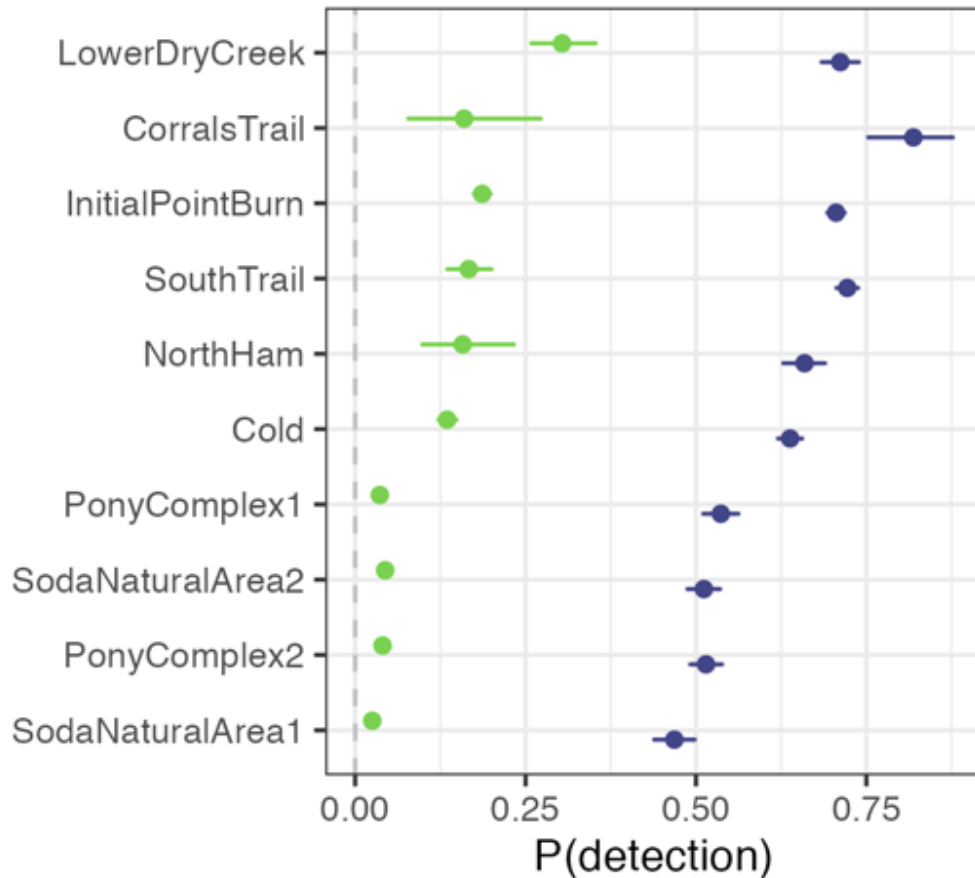
*\*Mixture of true and false positive processes (aerial)*



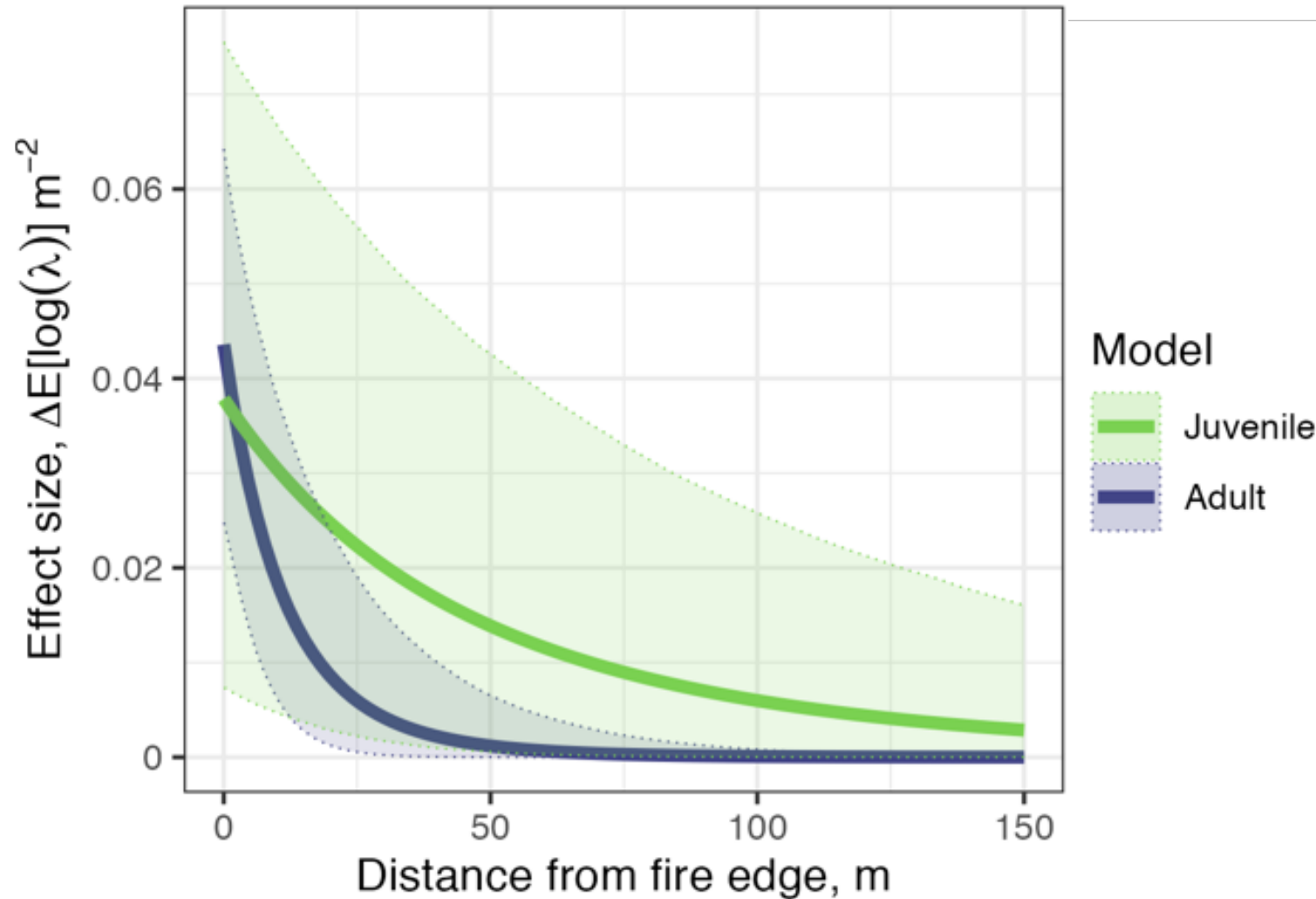
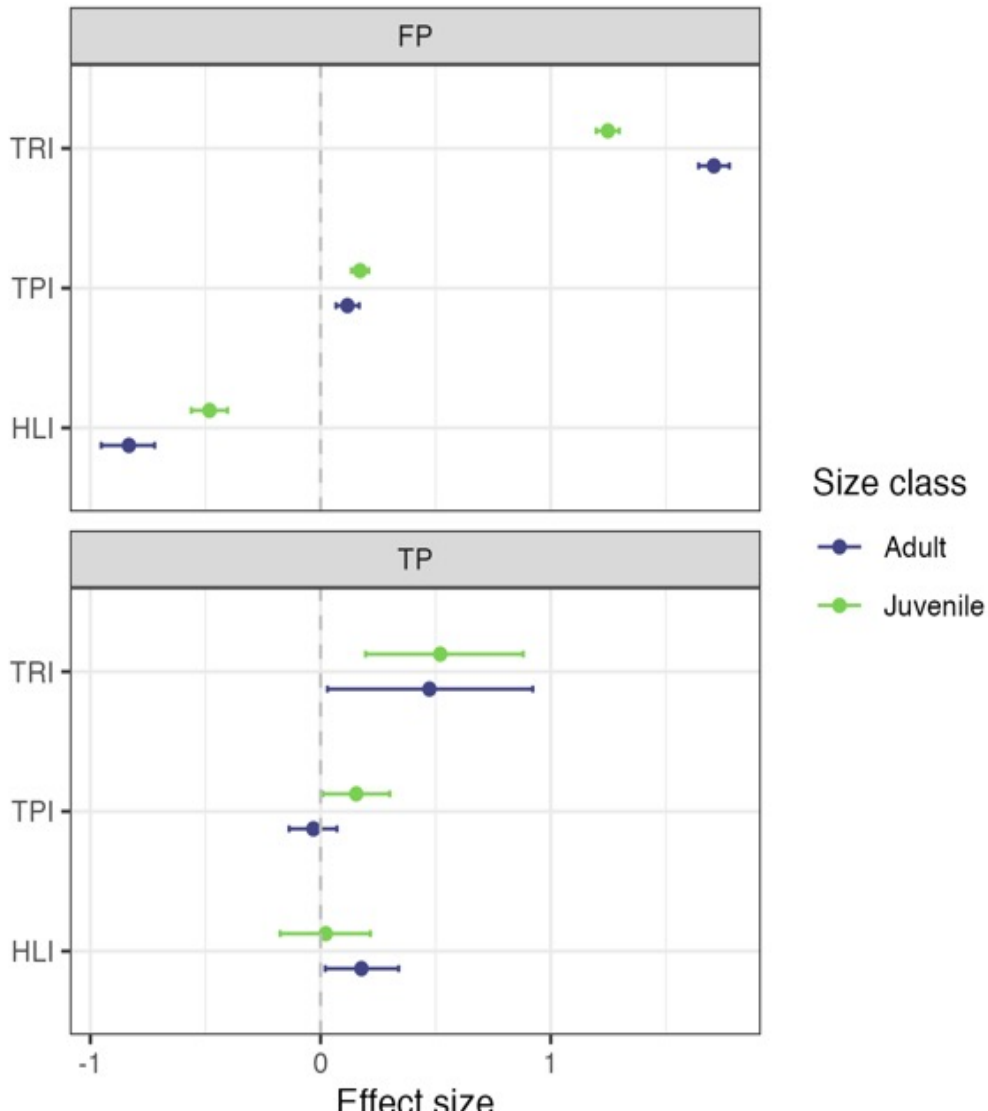
# Variation in False-Negative Error...

Associated With Plant Size

Associated With Flight/OBIA parameters



# Variation in False-Positive Error and Abundance...



# Integrated State-Space Approach: Improved Scalability/Rigor Combination

