Using aerial imagery to map & monitor rangeland plant abundance while accounting for observation error
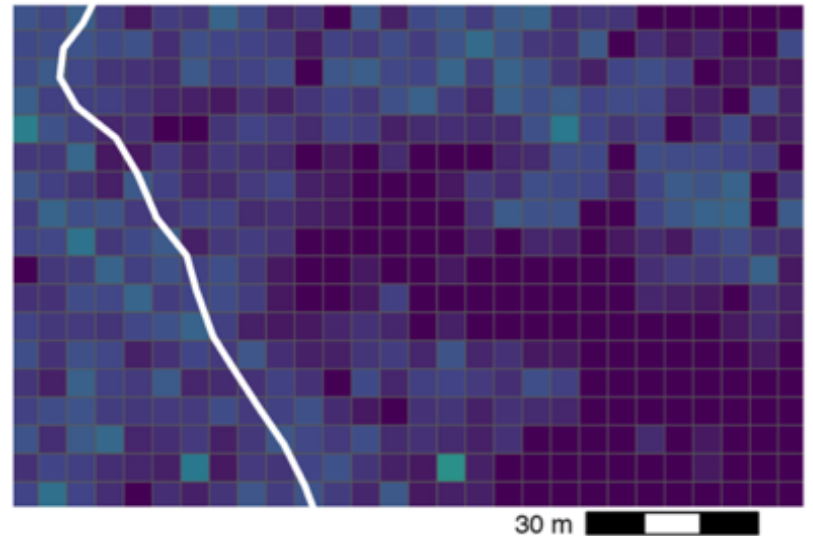
Andrii Zaiats, T. Trevor Caughlin, Jennyffer Cruz, David S. Pilliod, Megan E. Cattau, Rongsong Liu, Richard Rachman, Maisha Maliha, Donna Delparte, John D. J. Clare
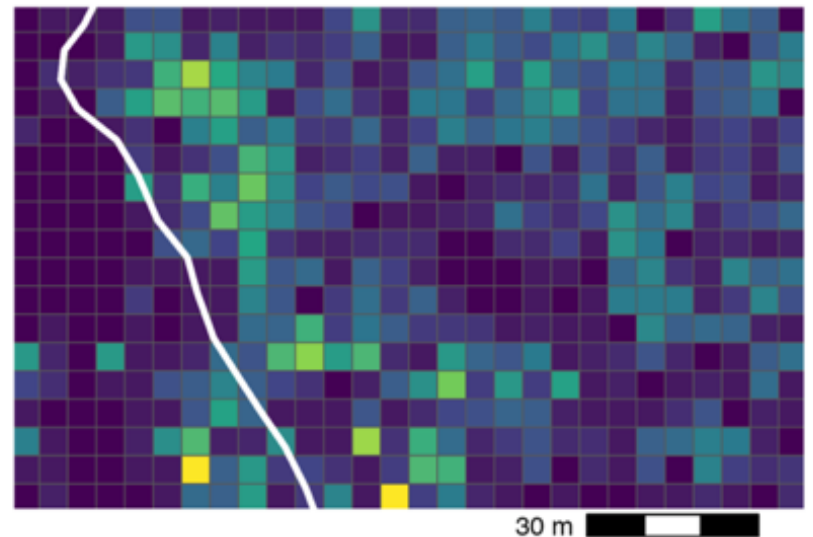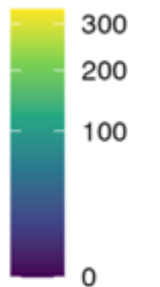
BOISE STATE UNIVERSITY

Sagebrush Steppe Degradation

- Disturbance
- Climate
- Exotic Annuals

Limitations of Demographic Monitoring

Multi-Scale Imagery-Based Monitoring
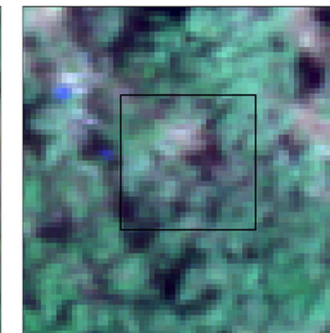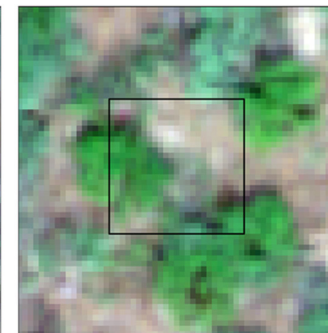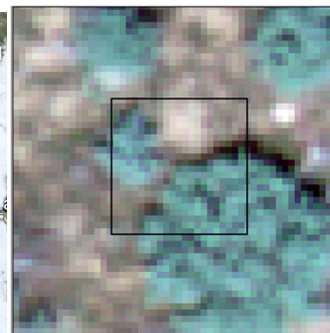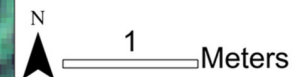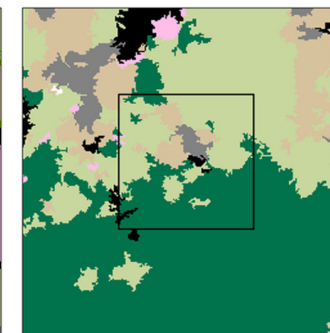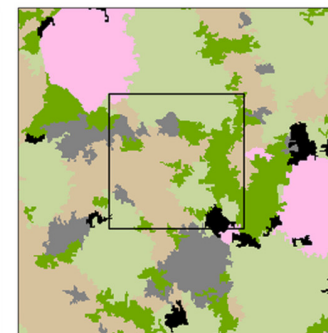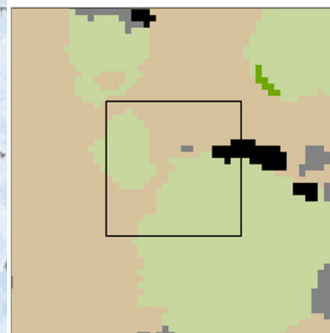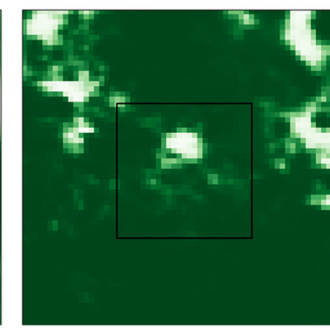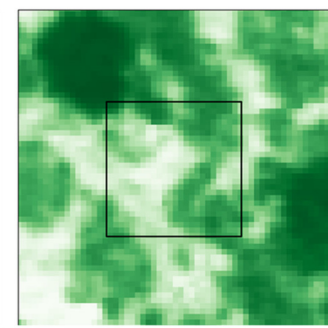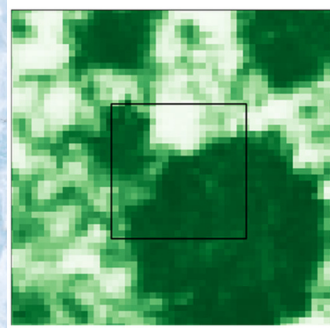
Emerging Frontier: Remote Individual Detection

Object-Based Image Analysis

- Reflectance
- Structure
- Geometry
- …etc

But It Remains Imperfect!

- Field-mapped sagebrush   ⬭ Automatically detected sagebrush

$$c_j^{true} = f\left(c_j^{image} + X_j\right) + \varepsilon_j$$

Validation data

Aerial data

Aerial & Ground 🚁 📐

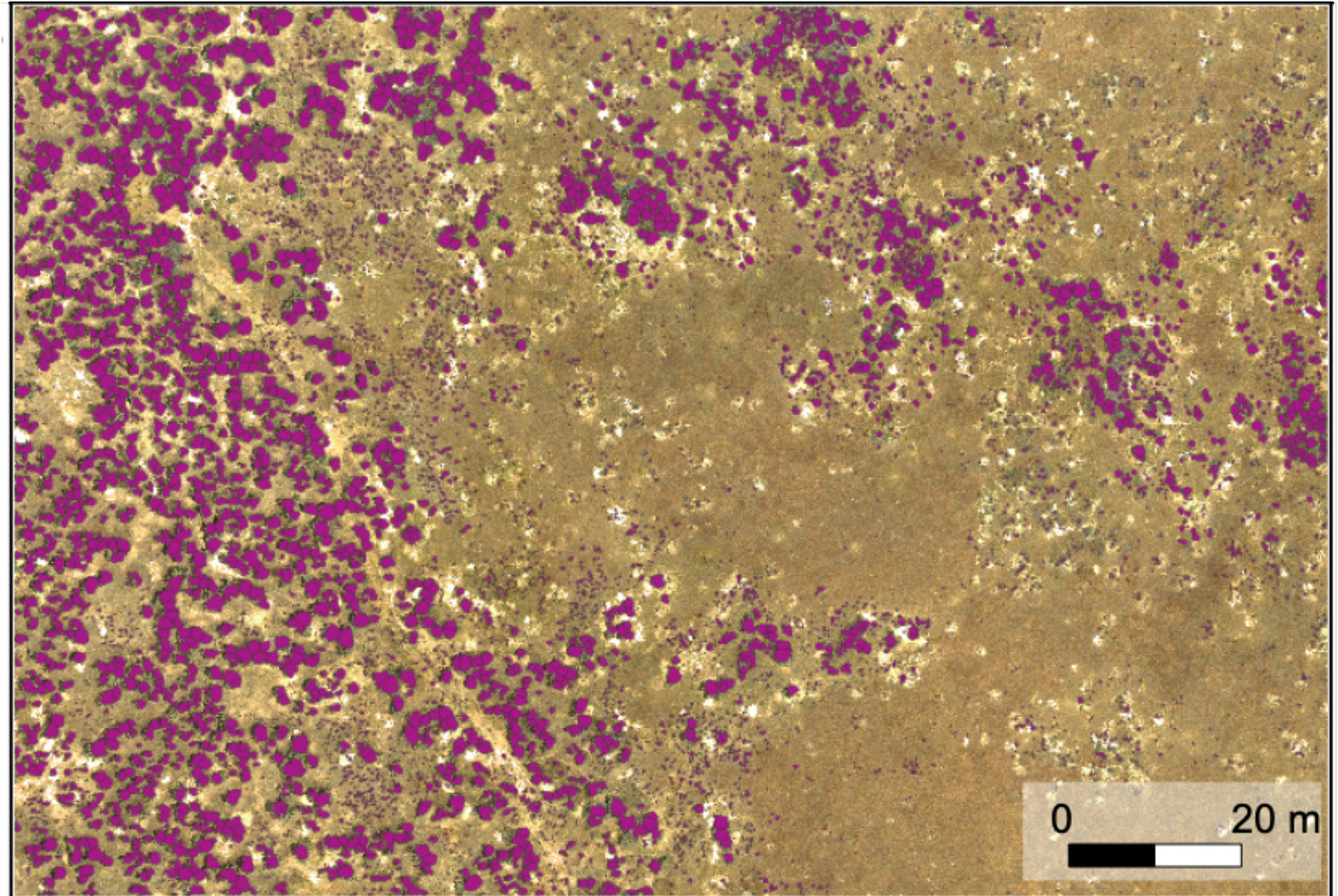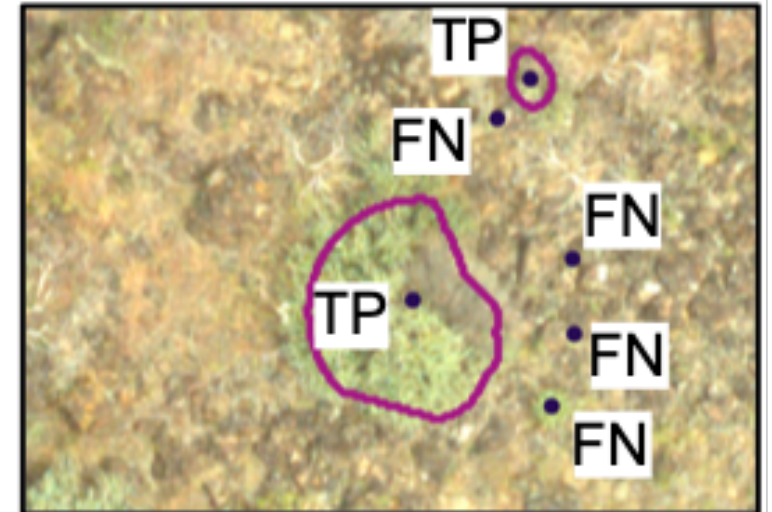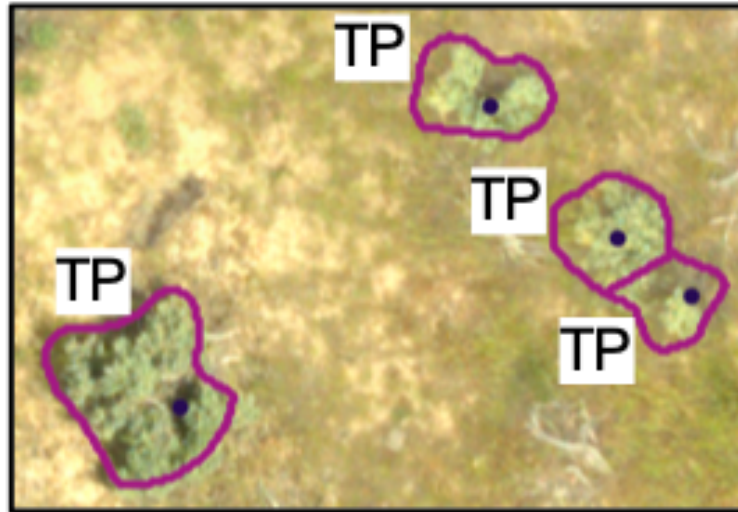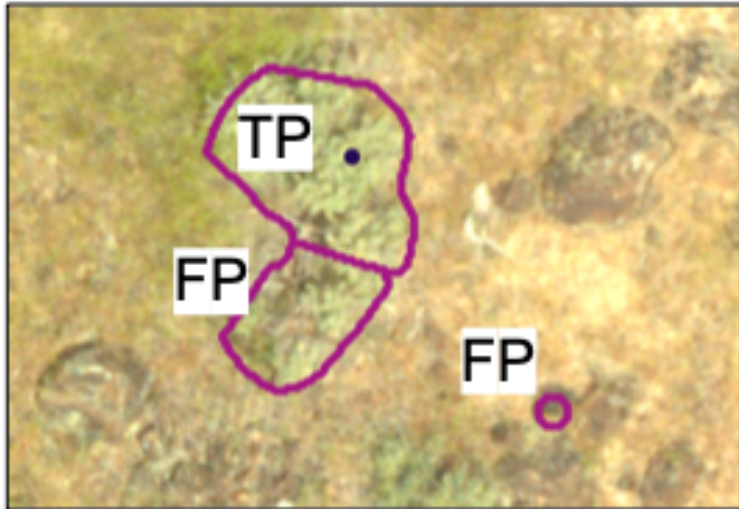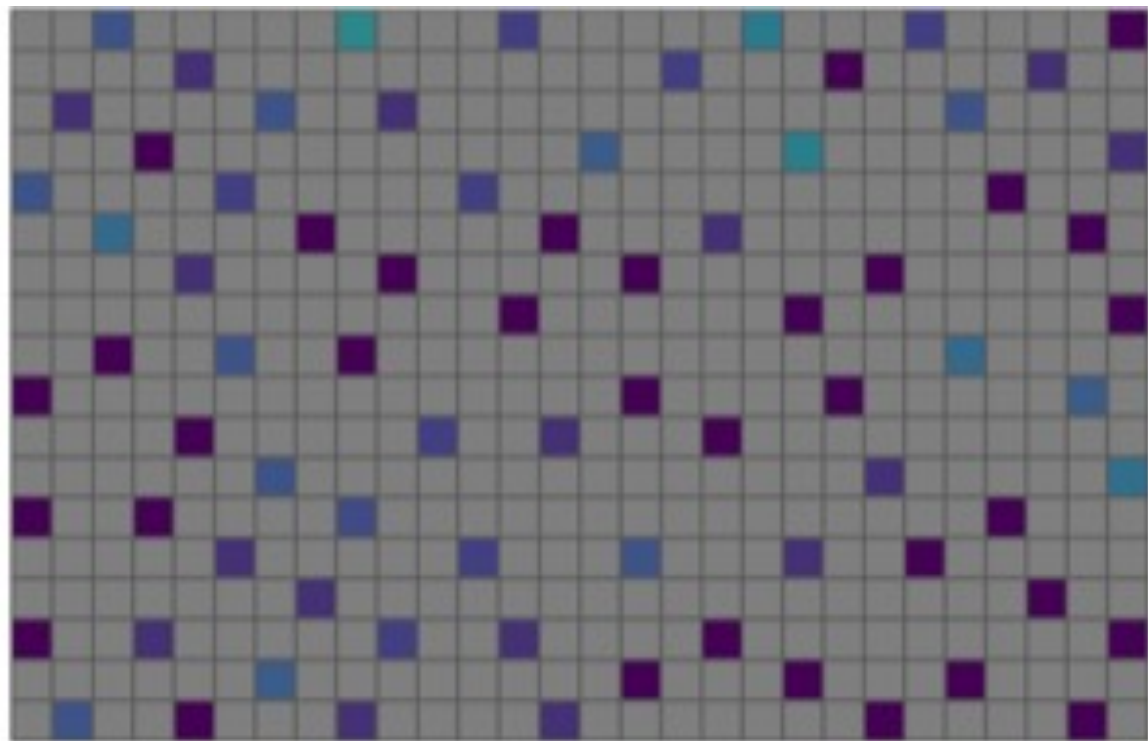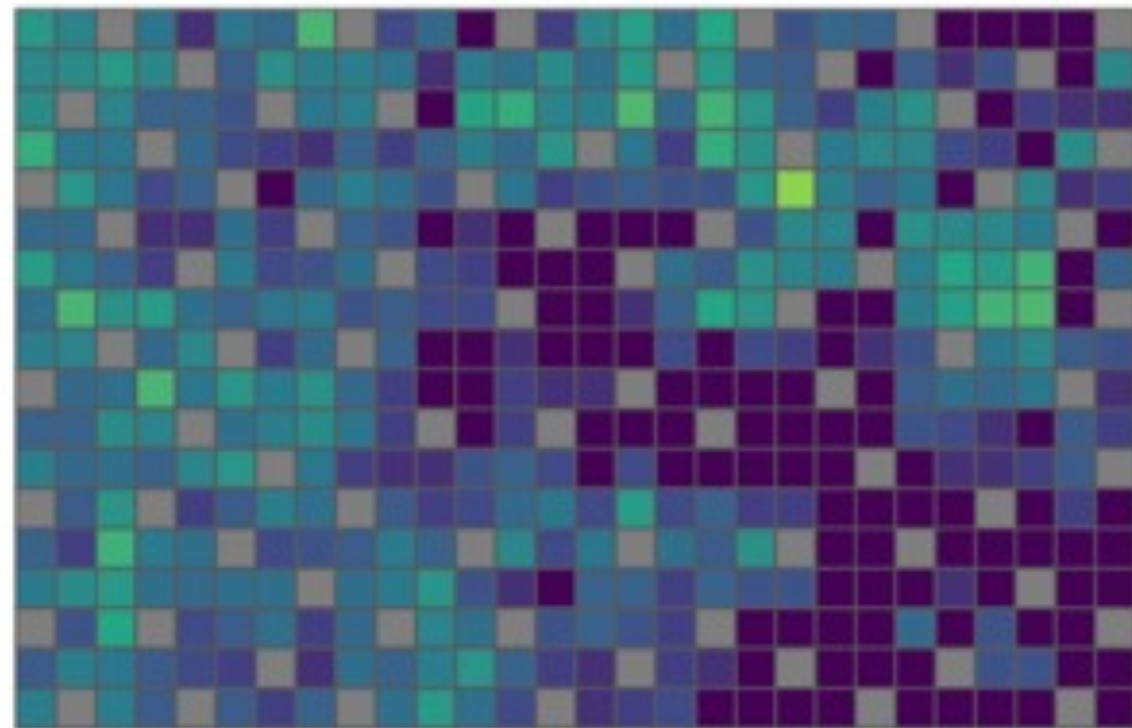$N_j \sim \text{Poisson}(\lambda^{TP})$

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

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

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)
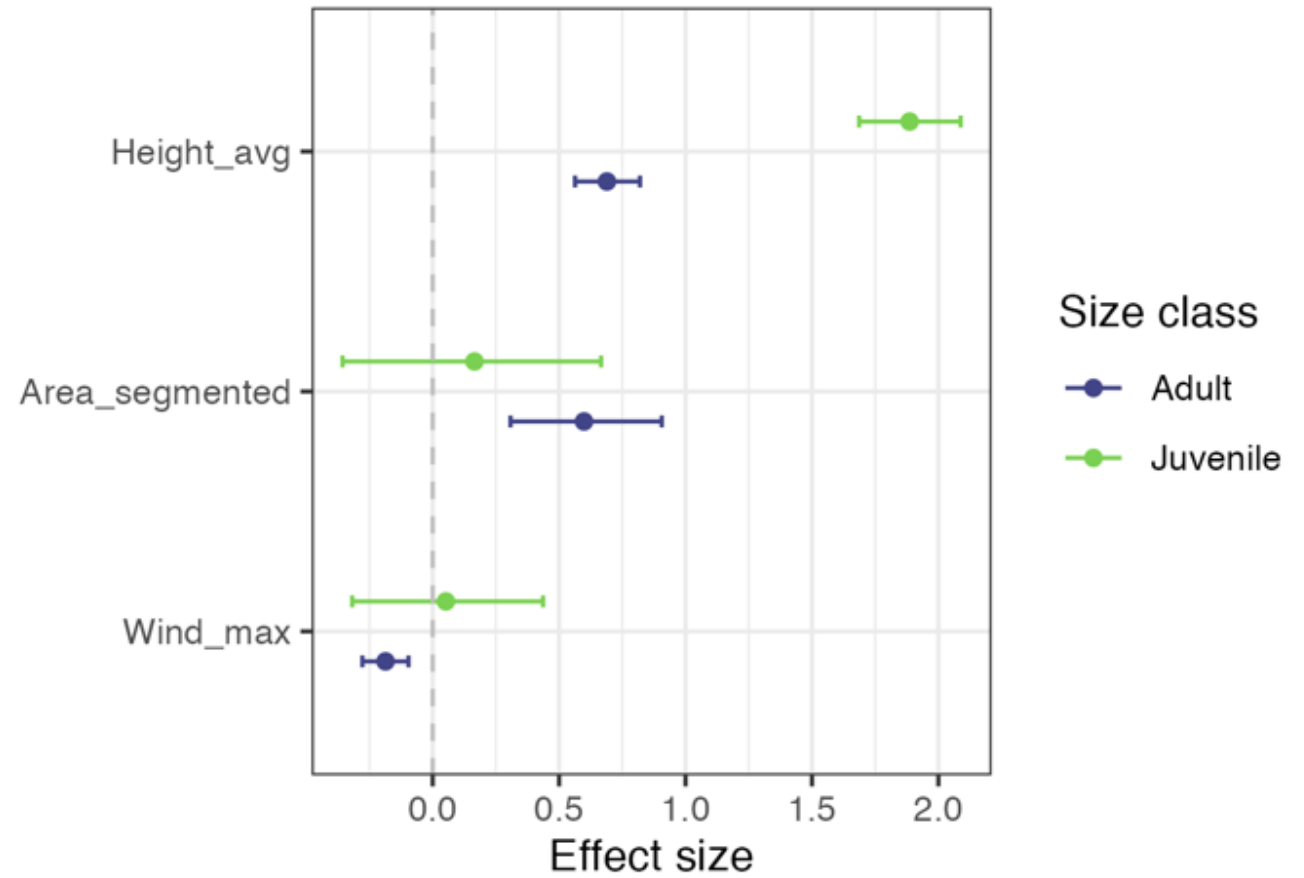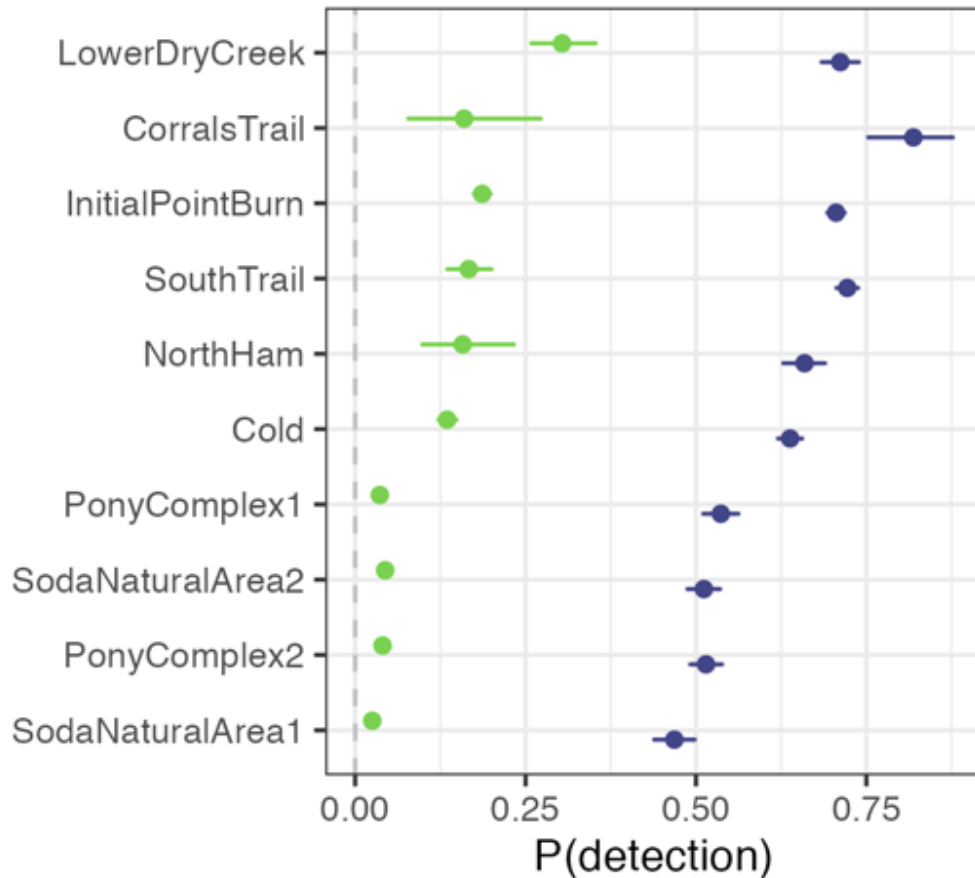
Process for introducing false positives (aerial)
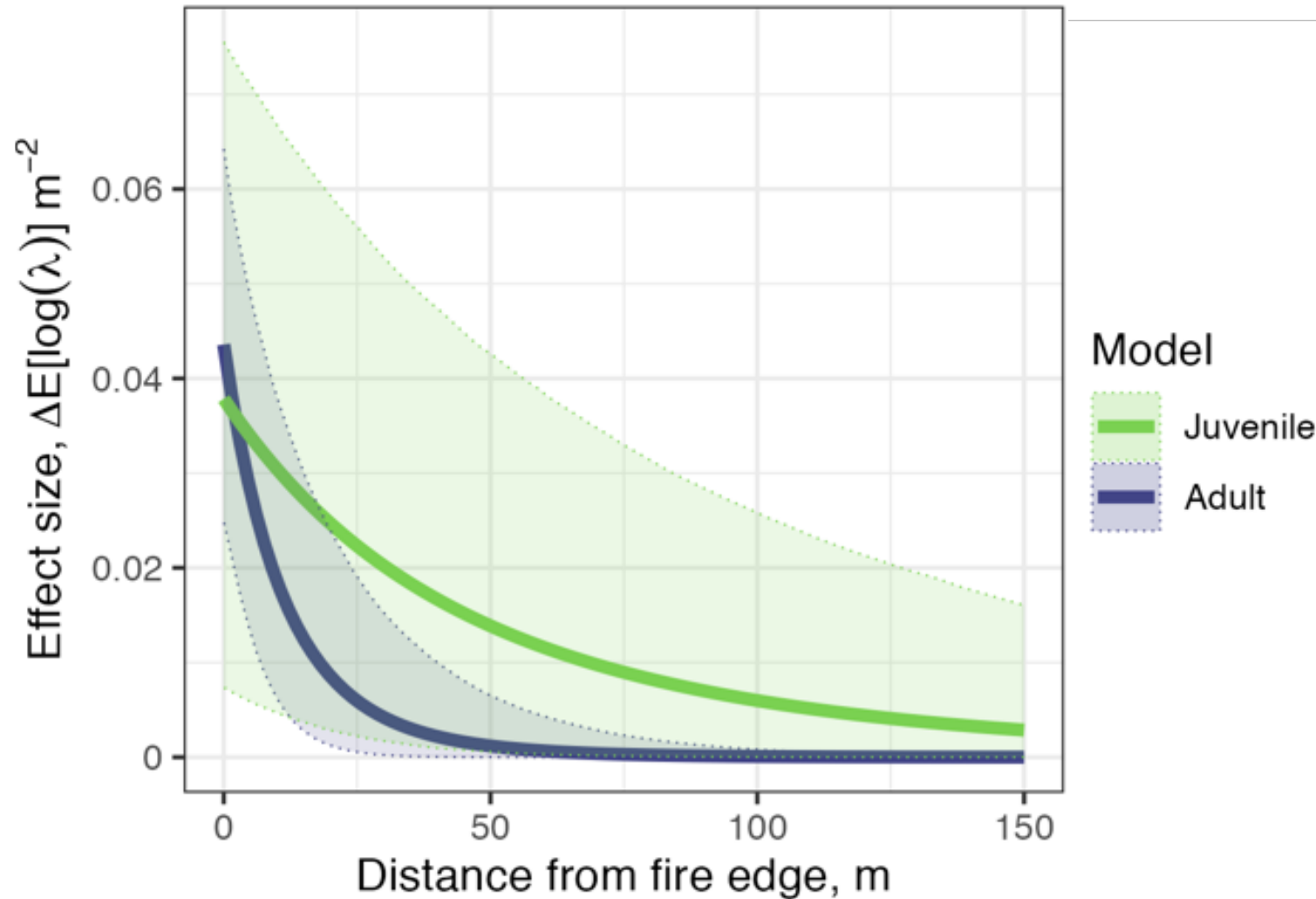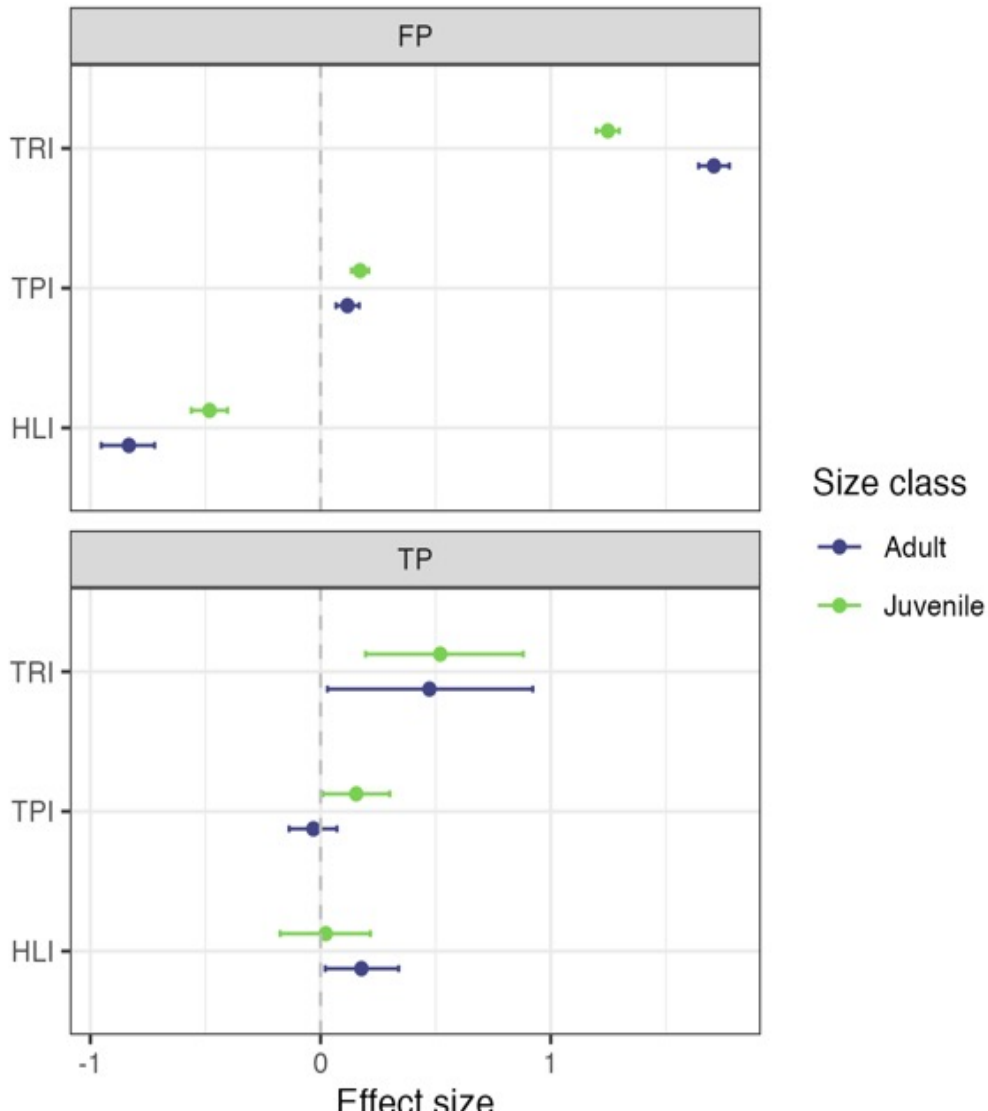
Mixture of true and false positive processes (aerial)

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