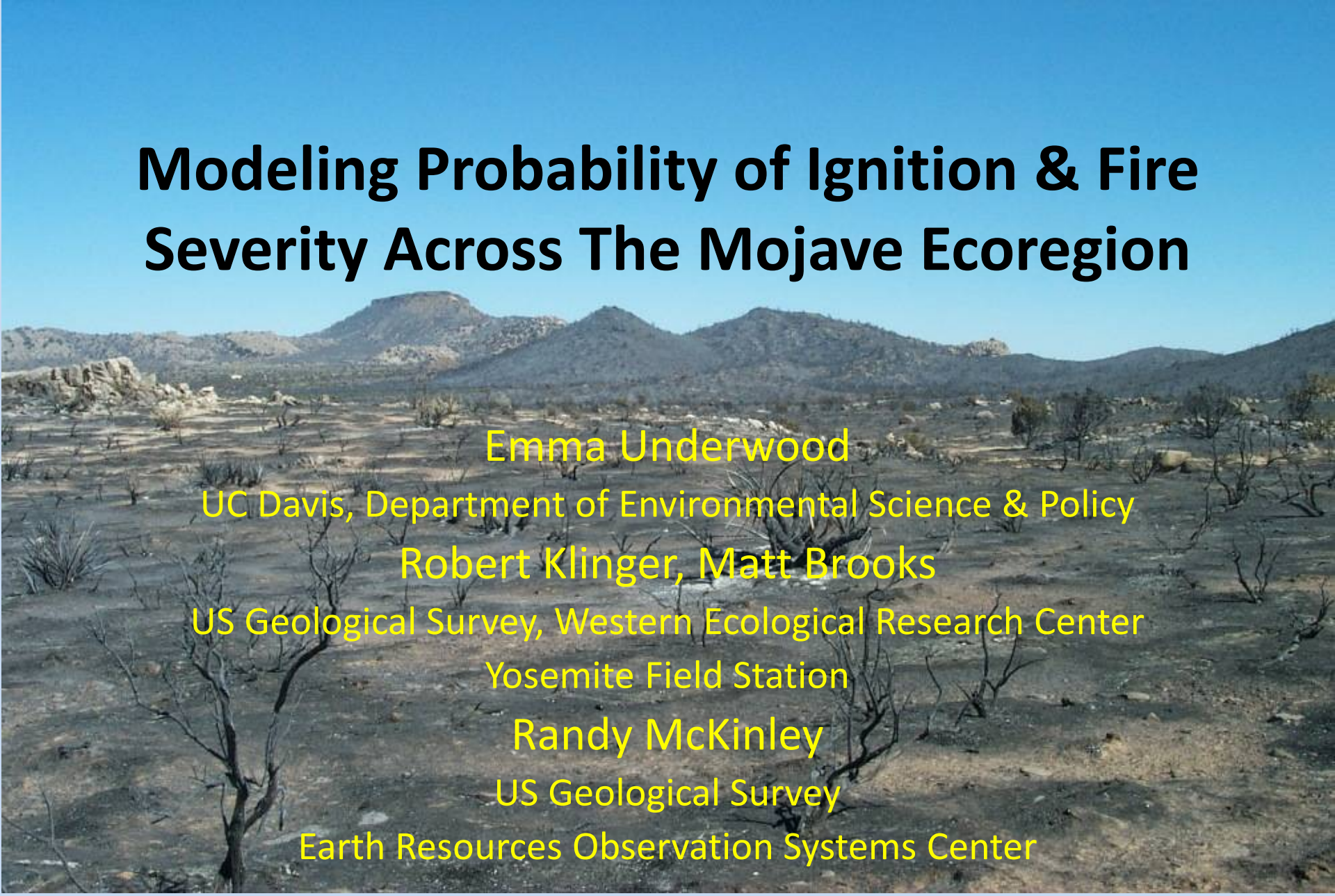
Modeling Probability of Ignition & Fire Severity Across The Mojave Ecoregion



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Rationale

- Ecological
  - Landscape scale extension of the vegetation dynamics analyses
  - Identify areas where vegetation transitions are most likely to occur
- Management
  - Inform long-range planning and land use

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Integrated Multi-Scale Project

Remote Sensing Data

Fire

Climate

Lightning

NDVI

Vegetation Plots (Chronosequence)

Structure

(Cover, biomass, density)

Composition

(Identity, relative abundance)

SDM's

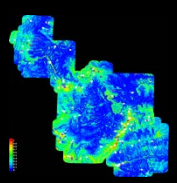
Presence/absence

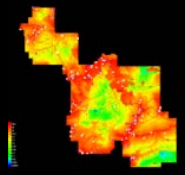
Abundance

(*B. rubens, B. tectorum, E. cicutarium, S. barbatus*)

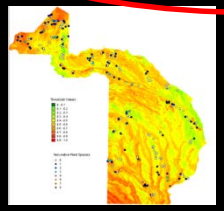
Spatio/Temporal Patterns

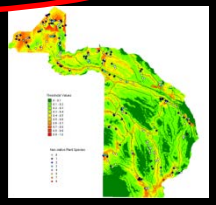
1972 - Present





Vegetation State-Transition & Fire Hazard Models





Approach

- Two components
  - Probability of ignition
  - Severity
    - dNBR

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Ignition

- Aim
  - Predict the likelihood for ignition across the ecoregion
- Model structure
  - “Presence-Absence” or Incidence-only model?
  - We knew where fire had occurred from 1972 – 2010
    - Fires > 405 ha
  - We could ***not*** be sure where fire had ***not*** occurred
    - Fires < 405 ha (1984 – 2010)
    - Fires prior to 1971

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Ignition

- Decision
  - Incidence only model
- Model structure
  - “Presence-Absence” or Incidence-only model?
  - We knew where fire had occurred from 1972 – 2010
    - Fires > 405 ha
  - We could ***not*** be sure where fire had ***not*** occurred
    - Fires < 405 ha (1984 – 2010)
    - Fires prior to 1971

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Decision

- Incidence-only (“single-class”) model
  - Maximum Entropy algorithim suitable where only presence data (no absence data)
  - Extremely sound theoretical foundation

Methods

- Generated 10,000 points within burns (>1000 acres)
- Predict suitability relative to “background” sample of environmental variables
- Converts relativized frequency to “logistic “(0-1 scale…sort of)
- Shift in interpretation though
  - Not likelihood *per se*
  - Relative suitability

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Maxent Predictor Variables

Climate (1949-2005)	Soil & topography	Vegetation & NDVI	New Data
- Temp: mean - Precip: annual	- Aspect - Slope - PRR - Rugged terrain	- Vegetation - % tree cover - NDVI peak **- Inv Annuals SDM**	- Neg Lightning Str.k (10, 100, 1000 km2) - Pos Lightning Strk (10, 100, 1000km2) -Road density

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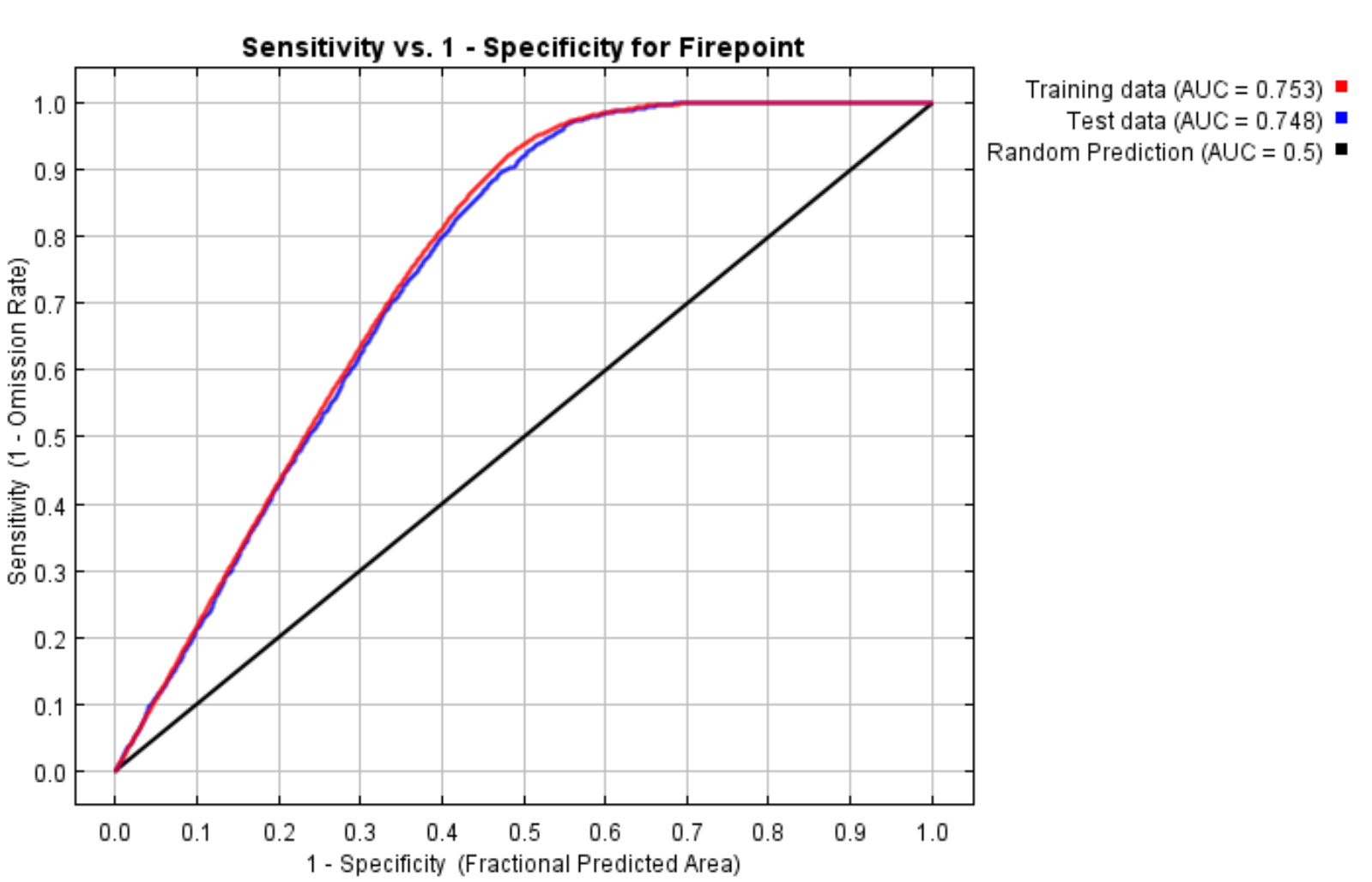
Performance of Maxent Model



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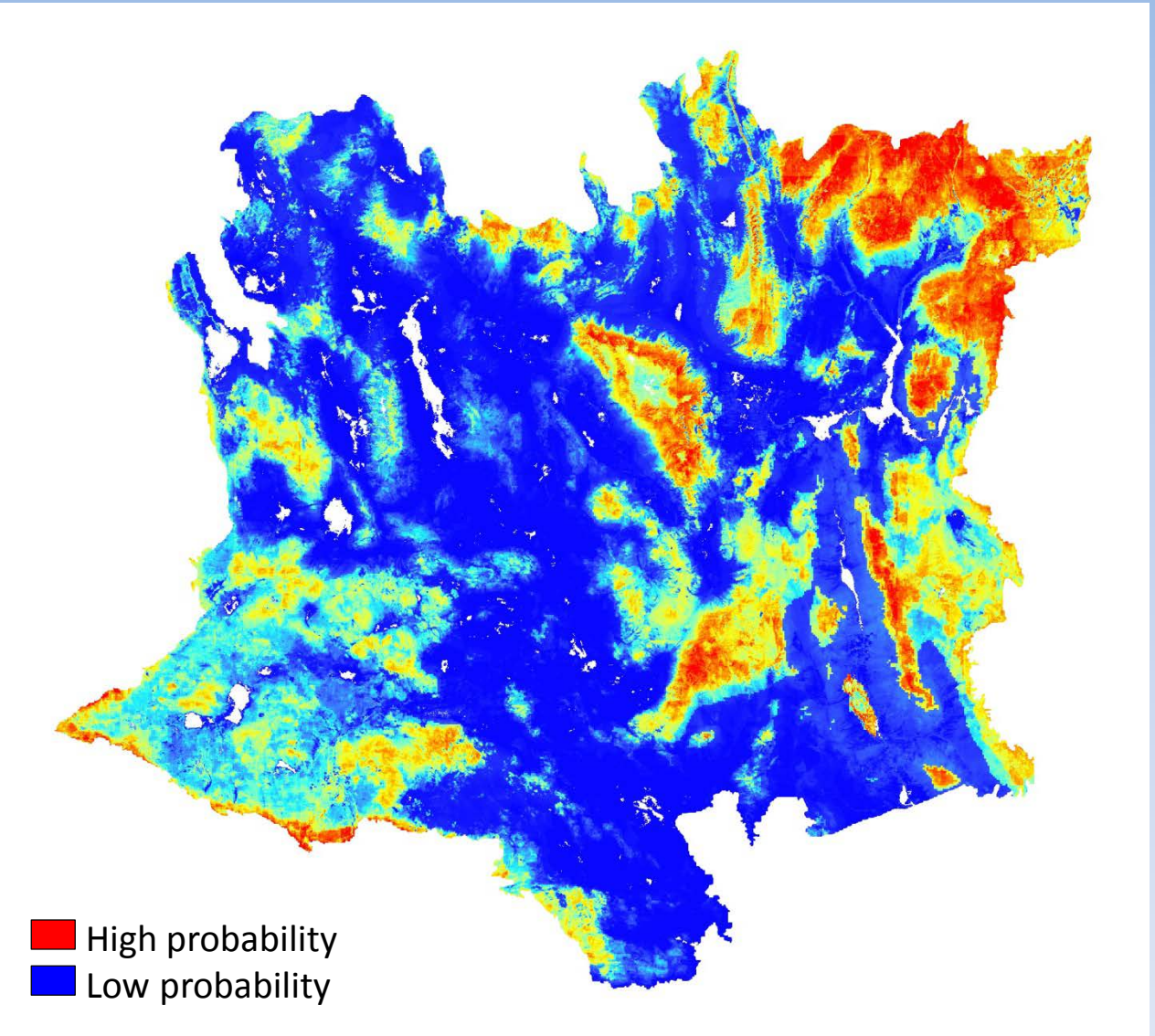
Spatial Modeling of Ignition Probability



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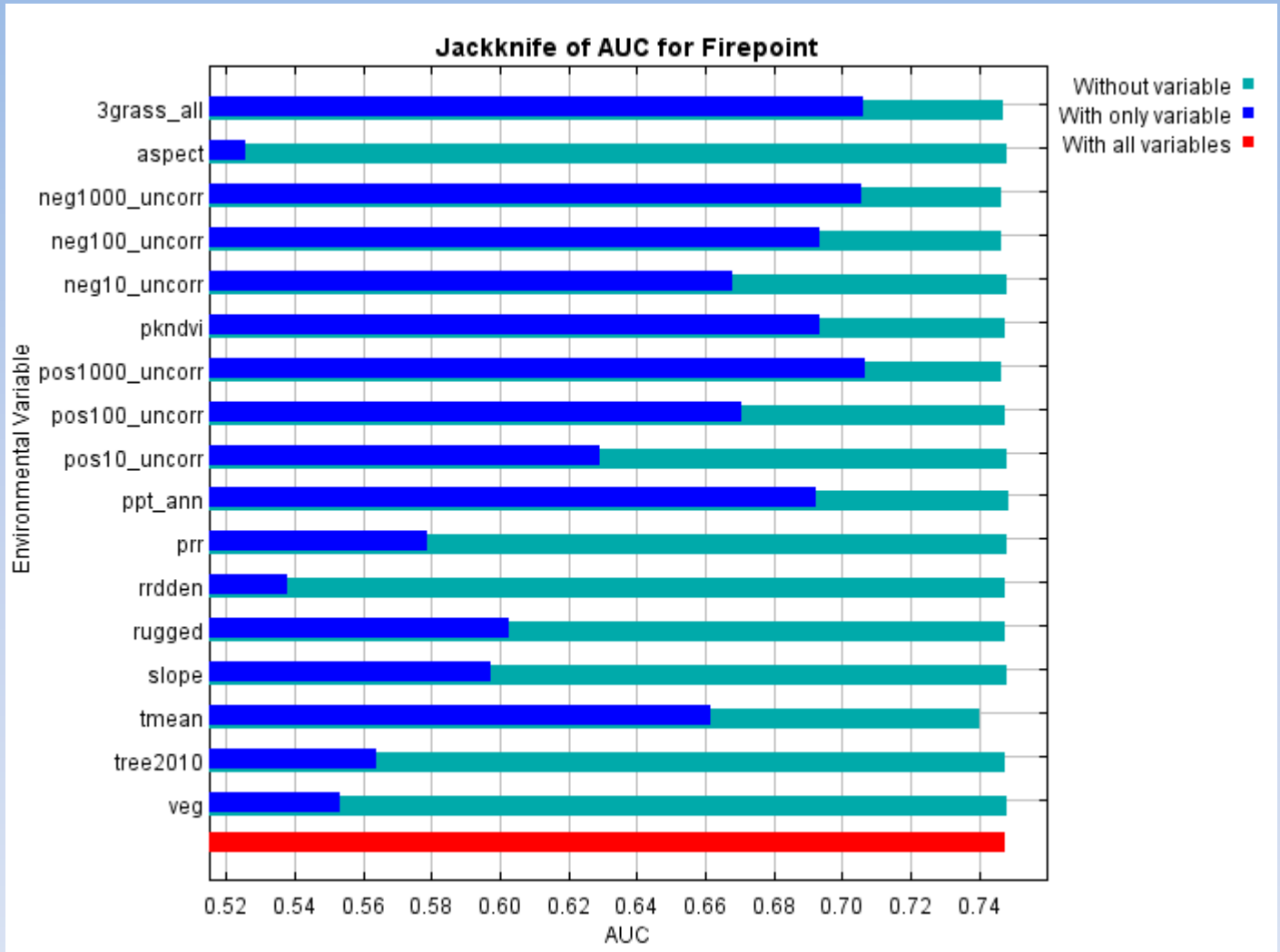
Relative Performance of Variables



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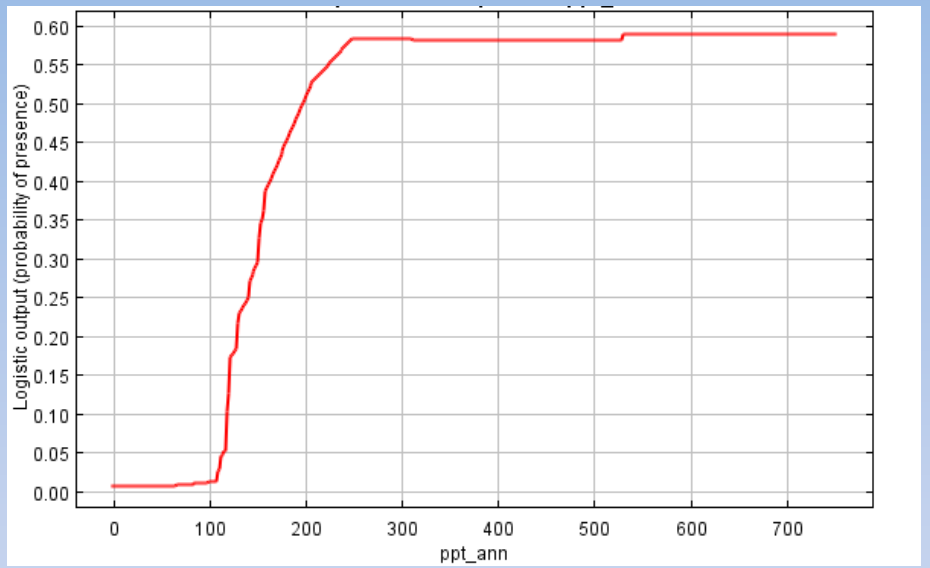
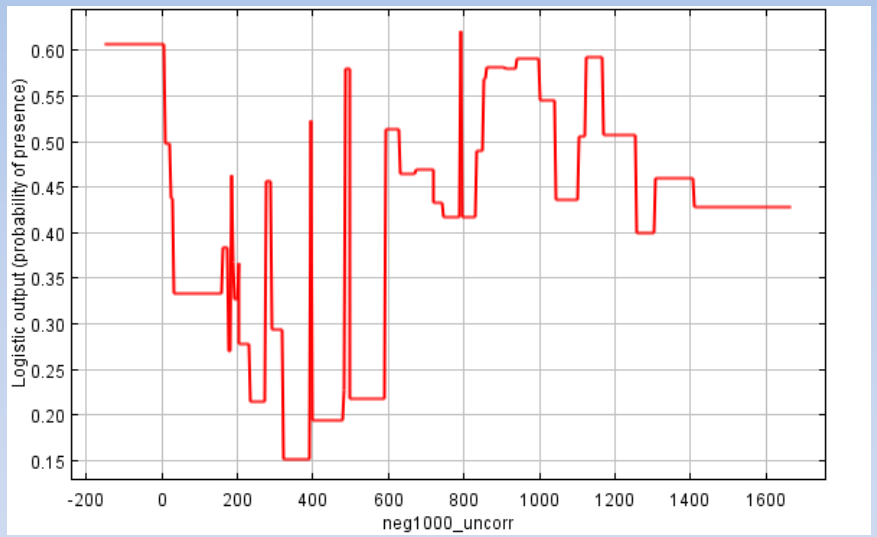
Key variables for Ignition Suitability

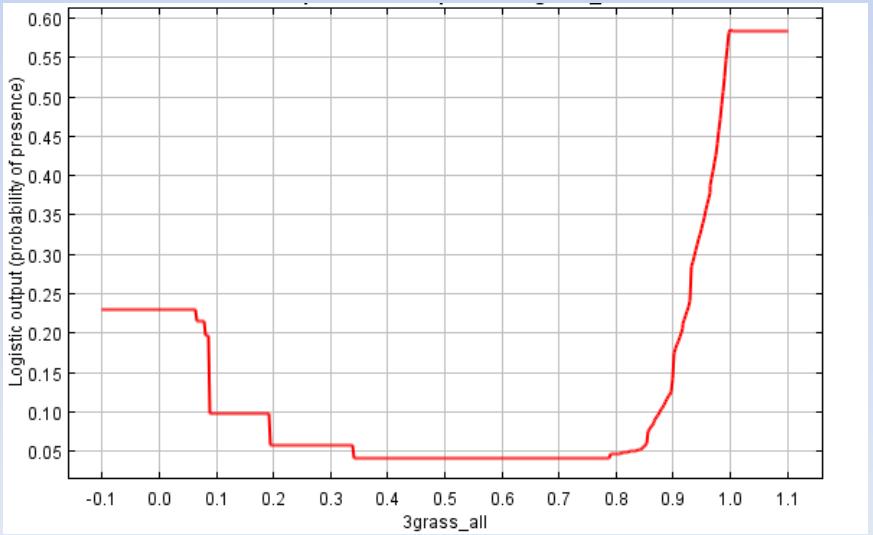
Annual precipitation



Negative Lightning Strikes (1000km^2)



Invasive Annuals SDM



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So If A Patch Of Ground ***DOES*** Burn…

- What is the likely level of severity?

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Model Specifications

- dNBR = measure of burn severity
  - Biomass loss more ecologically relevant than coarse measure of mortality

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Model Specifications

- Factors likely related to burn severity include:
  - Climate
  - Topography
  - Fuels

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Model Specifications

- Factors related to burn severity include:
  - Climate
    - Winter precipitation
    - Monsoon precipitation
    - Mean maximum July temperature
      - r = 0.983 mean minimum January temperature

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Model Specifications

- Factors related to burn severity include :
  - Topography
    - Elevation
    - Slope
    - “Hillshade”
    - “Ruggedness”
    - Photosynthetically active radiation

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Model Specifications

- Factors related to burn severity include :
  - Fuels
    - NDVI
    - *Bromus* spp. (SDM's)
    - *Schismus barbatus* (SDM's)

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Model Calibration & Selection

- Training
  - N = 45,183 random points
  - N = 239 fires
- Poisson process

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Maxent Predictor Variables

Climate (1949-2005)	Soil & topography	Vegetation & NDVI	New Data
- Temp: mean *July maximum* - Precip: annual *Mean winter* *Mean monsoon*	- ~~Aspect~~ - Slope - PRR - Rugged terrain - *Elevation* - *Hillshade*	- ~~Vegetation~~ - ~~% tree cover~~ - NDVI peak **- Inv Annuals SDM**	- Neg Lightning Str.k (10, 100, 1000 km2) - Pos Lightning Strk (10, 100, 1000km2) -Road density

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Model Calibration & Selection

- Four models
  1. Some non-linear and some multiplicative effects
  2. Non-linear additive effects
  3. Linear and some multiplicative effects
  4. Linear additive effects
- Information-theoretic comparison and selection

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Model Validation

- Two approaches
  - 10-fold cross-validation
    - N = 100 replications
  - Independent test set
    - N = 19,364 random points
- Root mean square error

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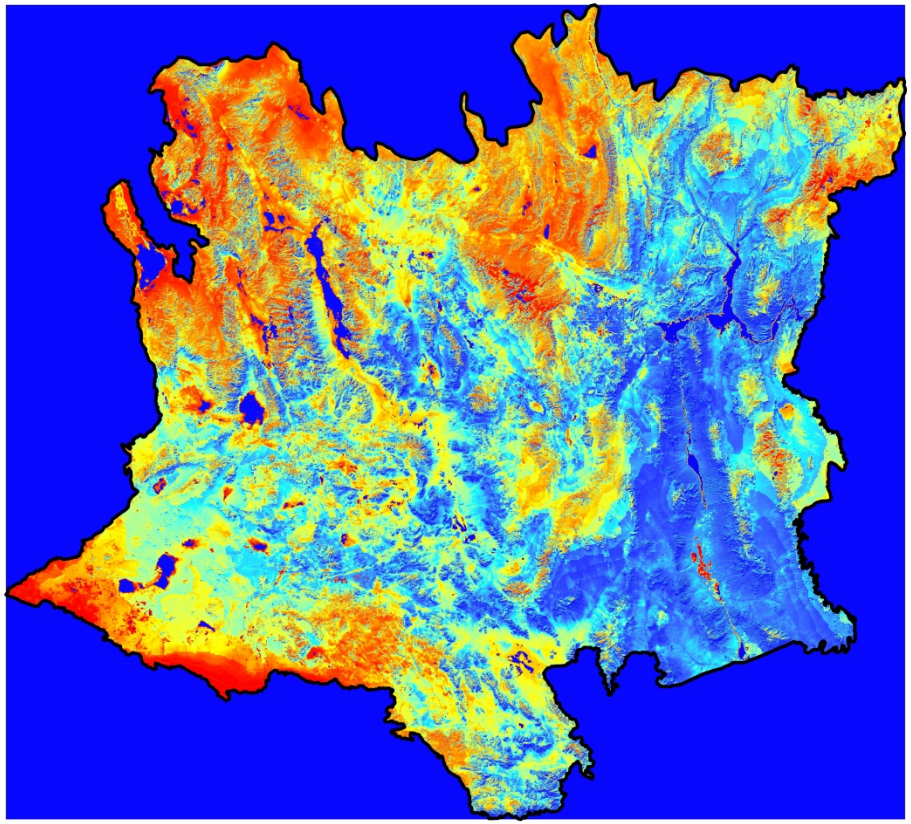
Predictions

- Best model was most complex one
  - Nonlinear and multiplicative terms
- Mean maximum July temperature only variable “not important”
  - 95% CI’s overlapped zero



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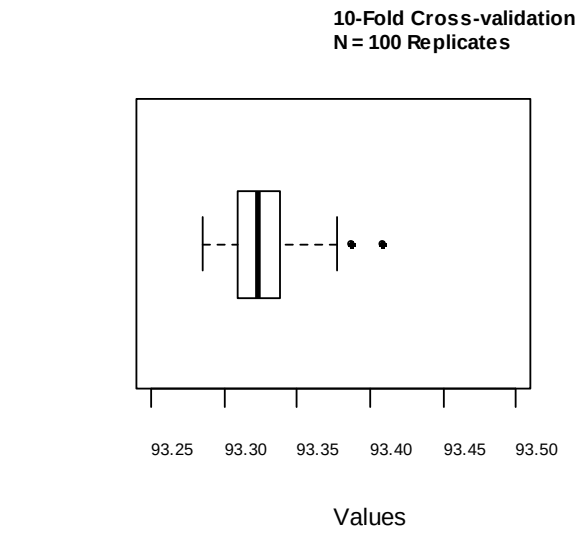
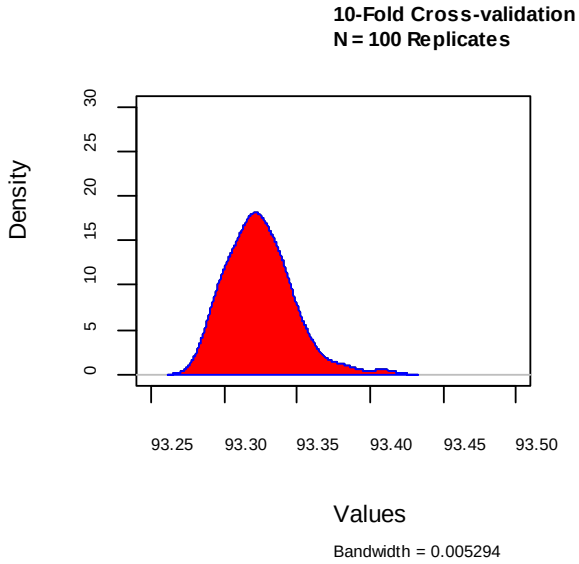
Prediction Uncertainty

- RMSE from 10x cross-validation = 93
  - ≈ 8% error
  - MAPE = 70
- ***Very*** precise RMSE estimates





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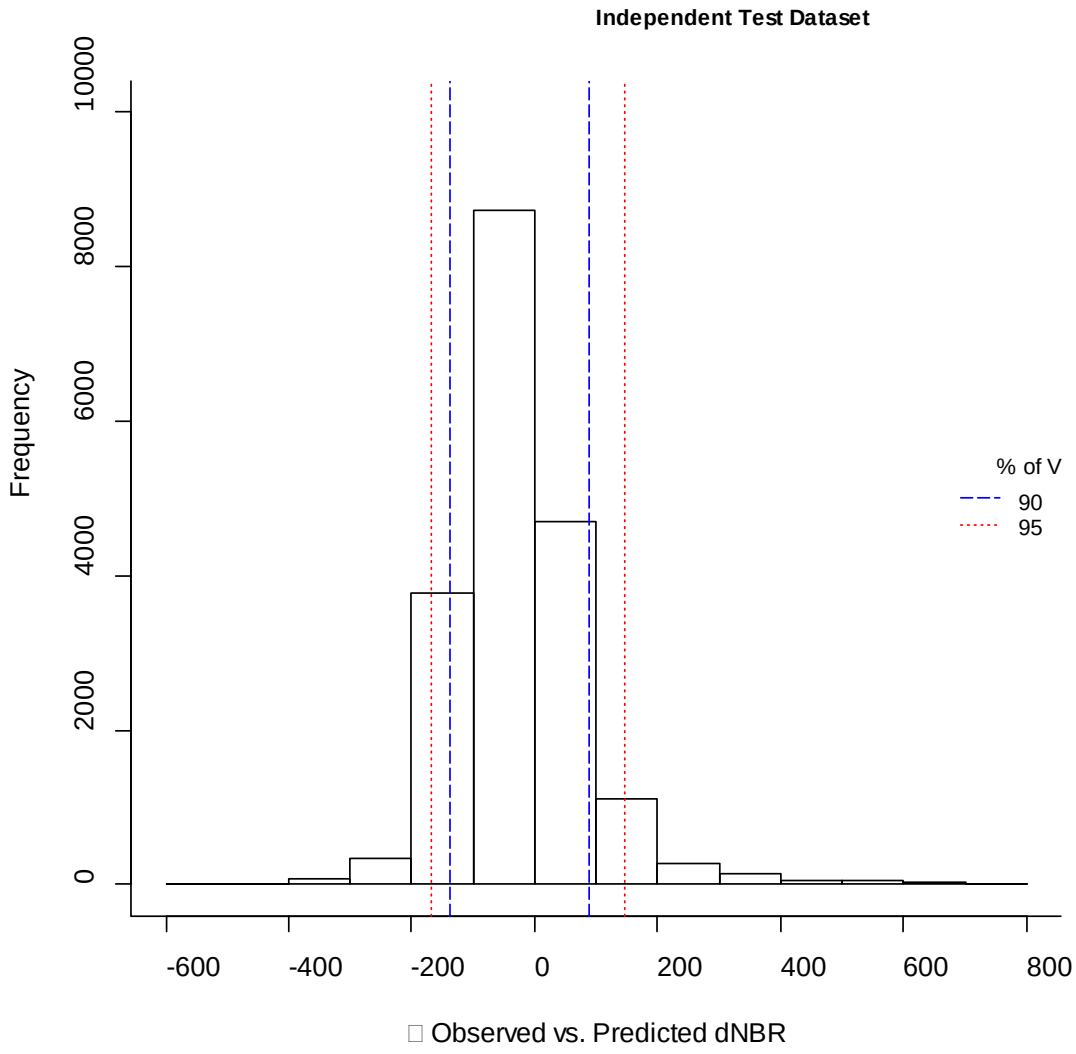
Prediction Uncertainty

- RMSE from independent test dataset
  - 12% error
  - 95% of values ± 141
  - 90% of values ± 89



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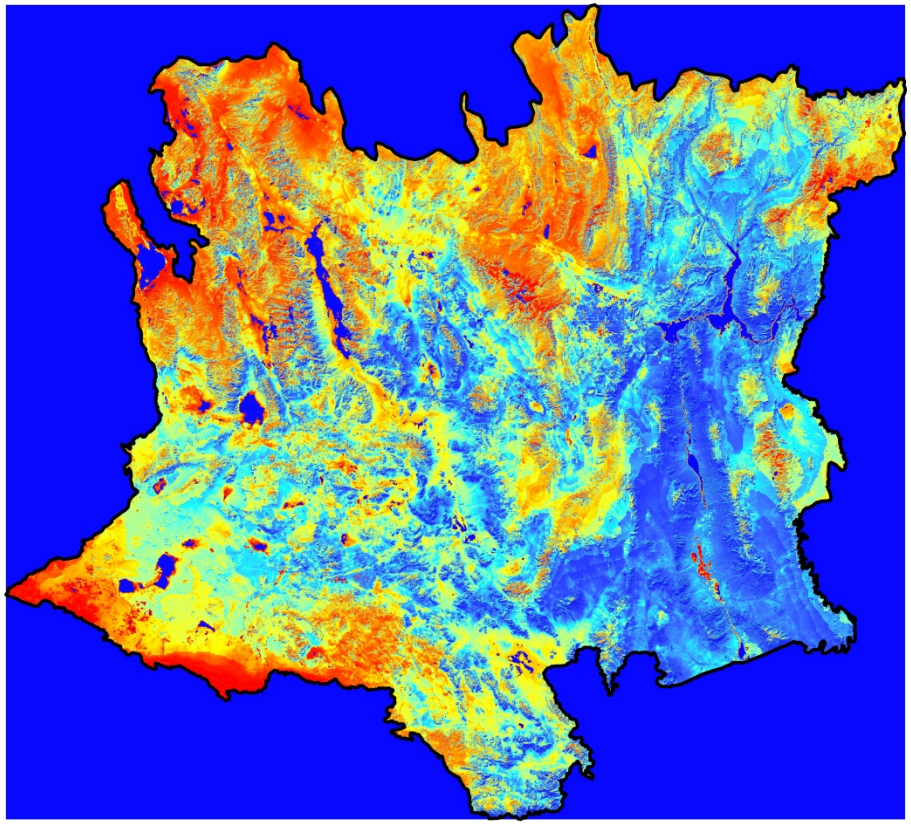
OK, this is a very pretty map and all, ***but***…

- How can you meaningfully quantify predicted dNBR for comparisons?
- Want a measure that captures range, rate of change in the range, estimates proportion of values within a given segment of the range, and has a standardized scale
  - Effective comparisons
  - Can be analyzed statistically
- Means, medians and SD's?
    - Nah
- Quantiles?
    - Nah



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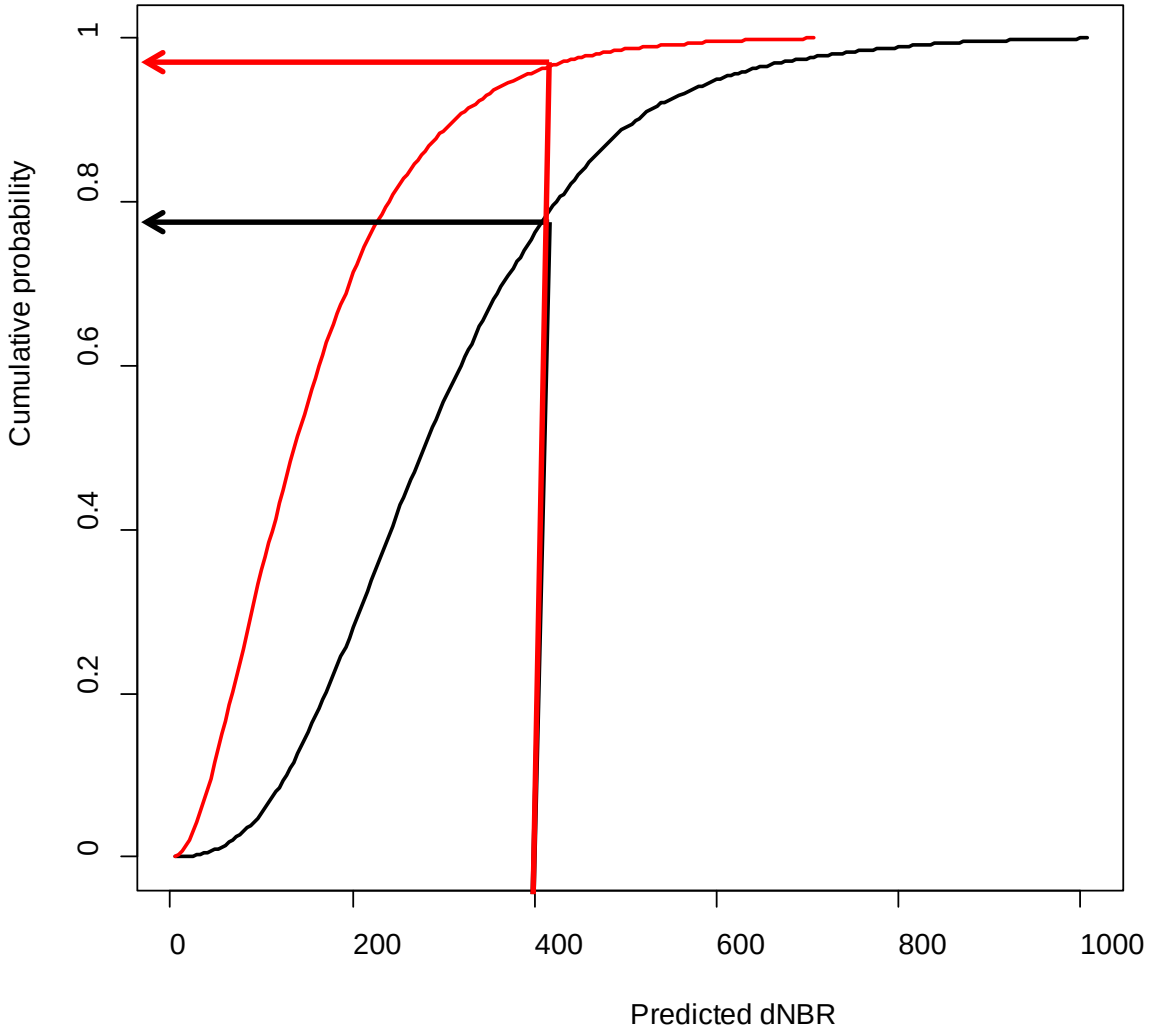
Empirical Cumulative Distribution Function (ECDF)



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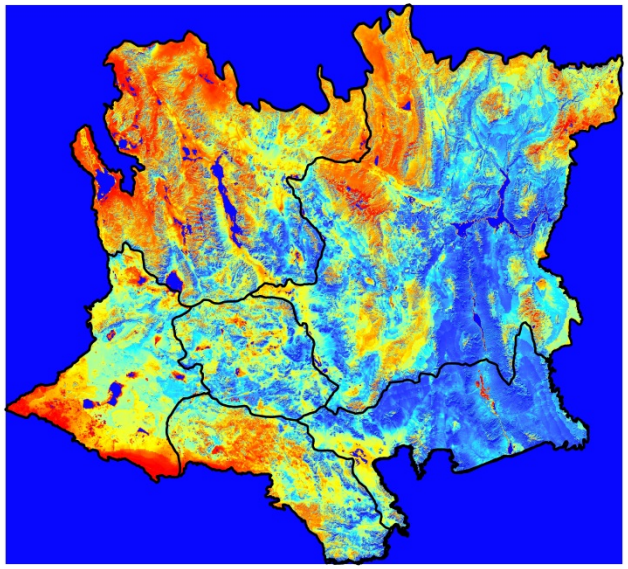
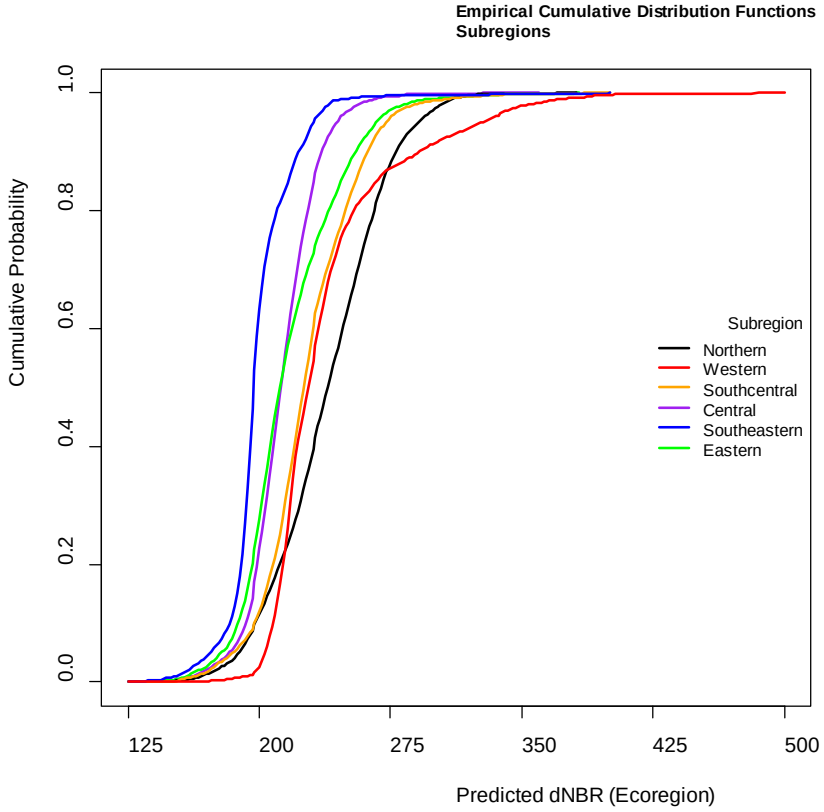
Predicted Patterns

Subregions





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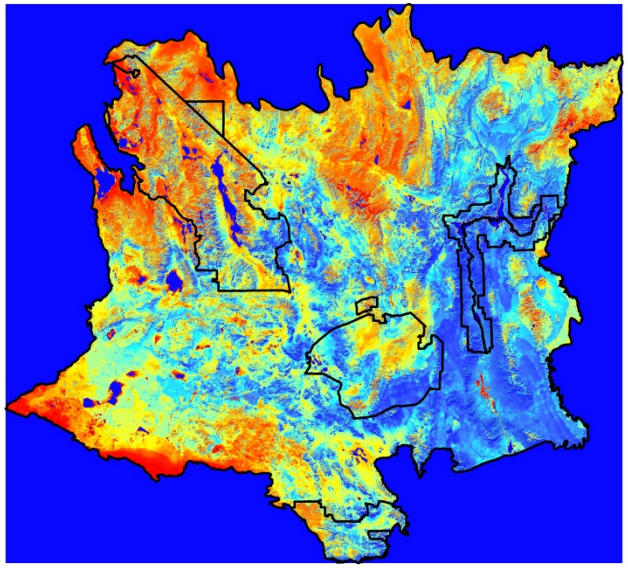
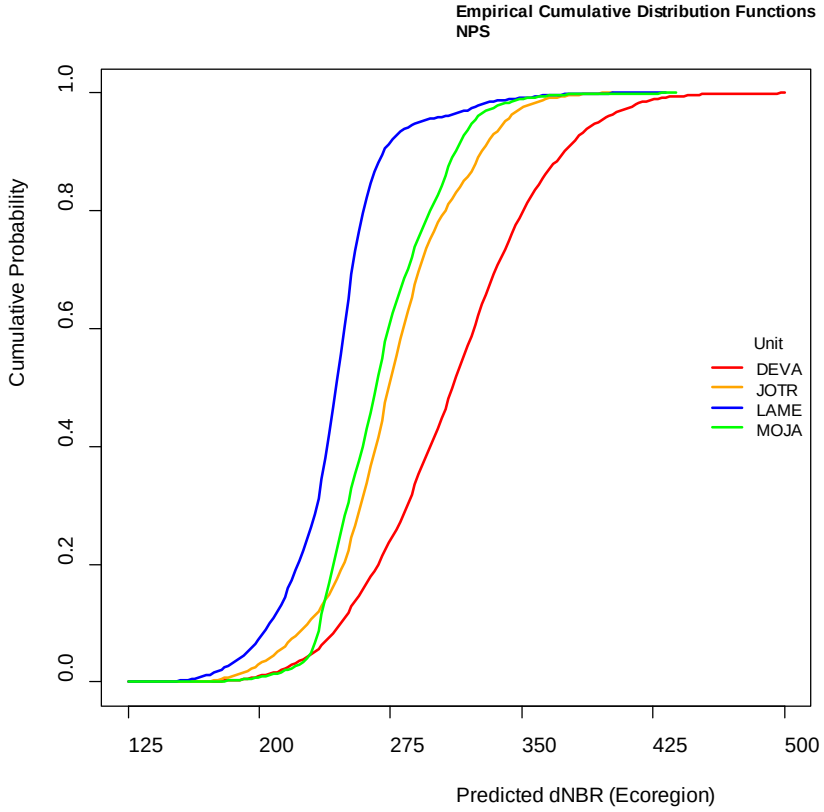
Predicted Patterns

National Park Service





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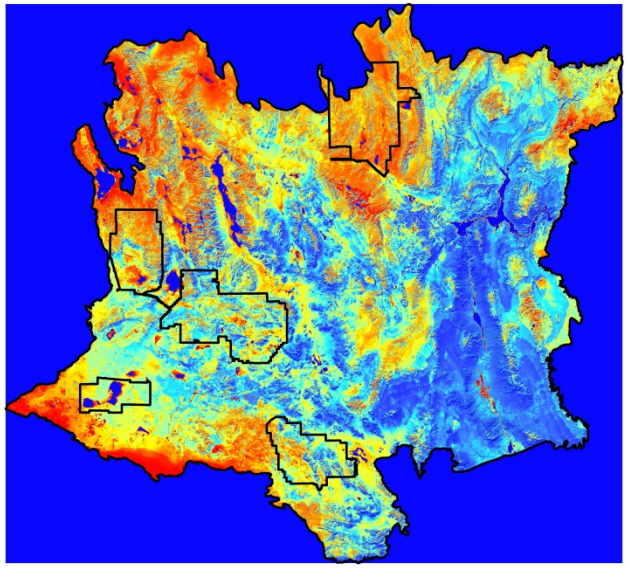
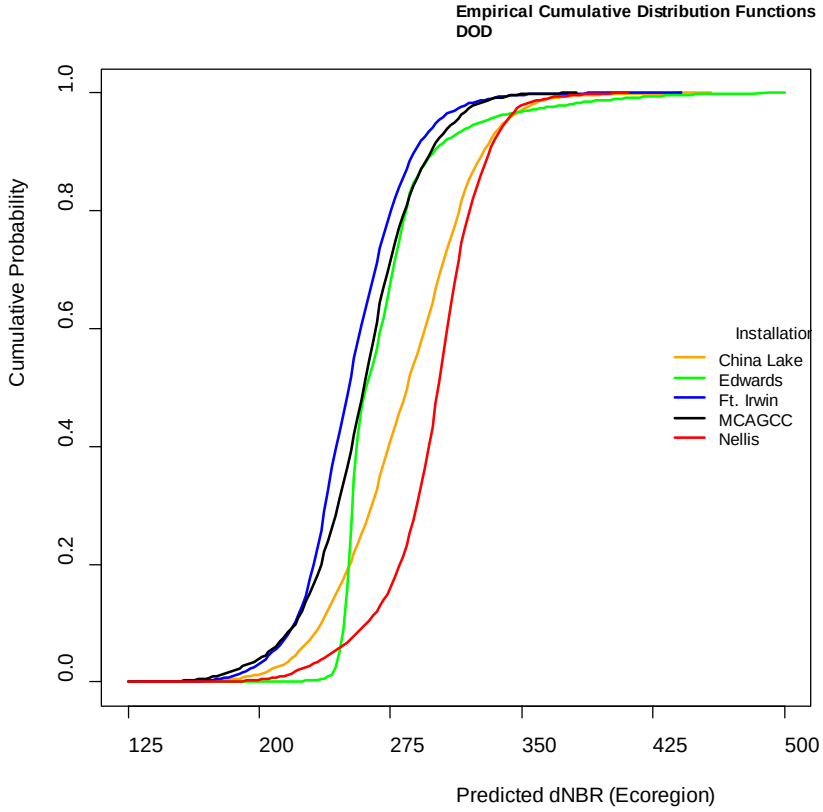
Predicted Patterns

Department of Defense





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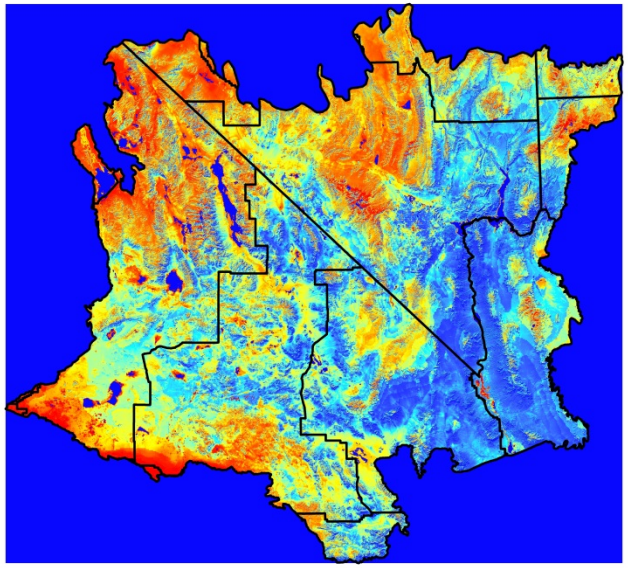
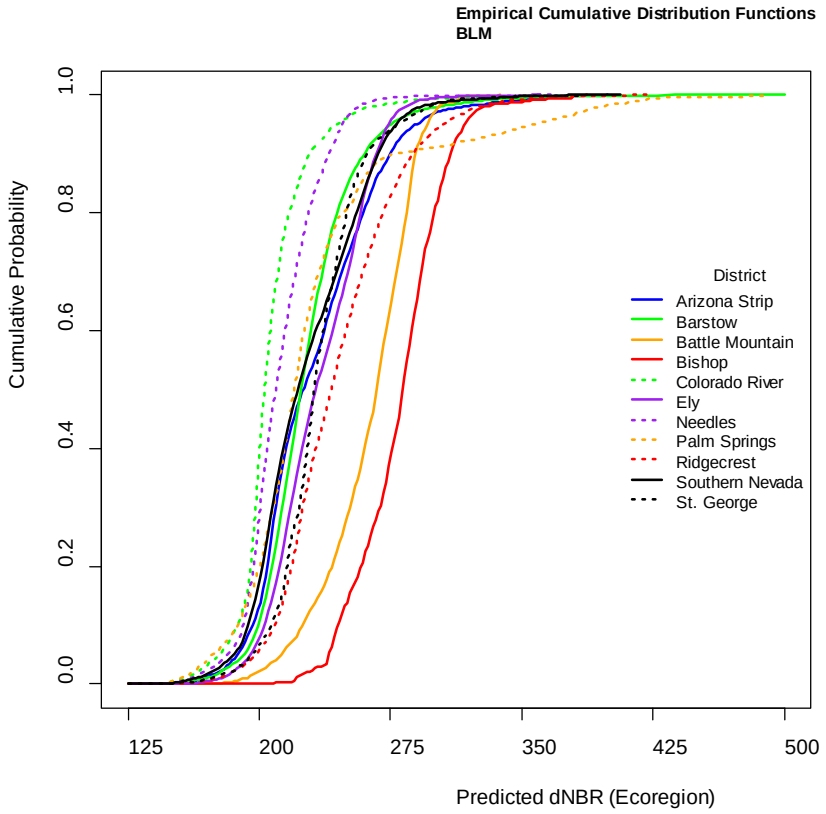
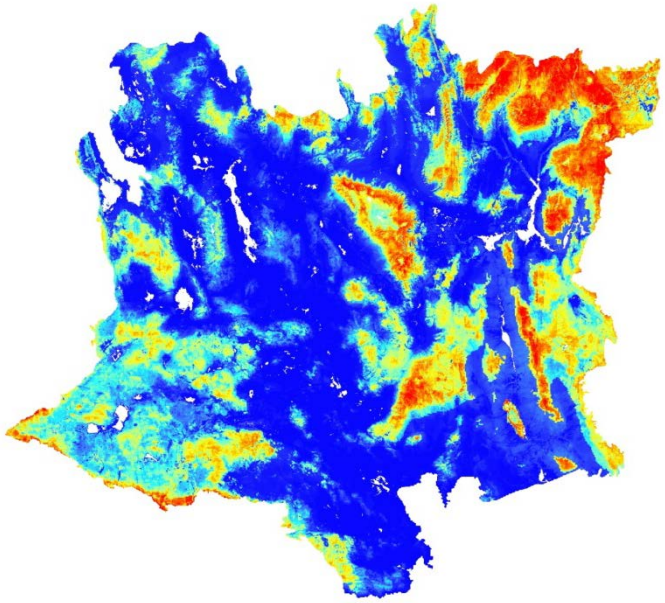
Predicted Patterns

BLM

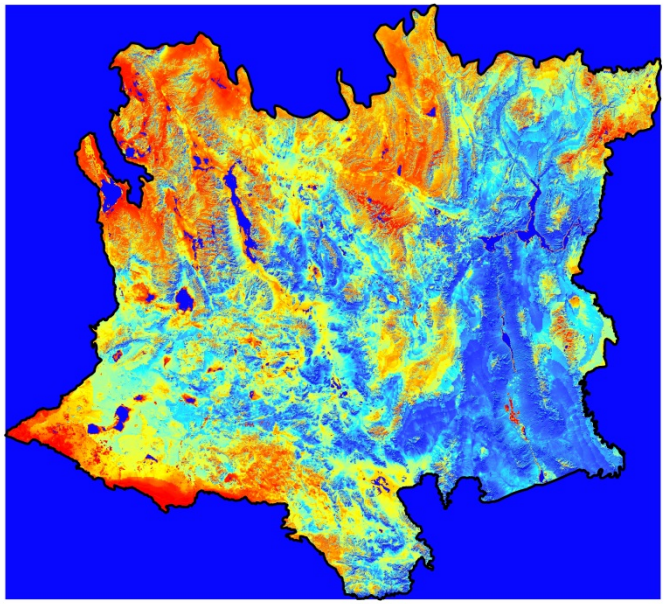




How Do Predicted Ignition & Severity Line Up?



Ignition



Severity

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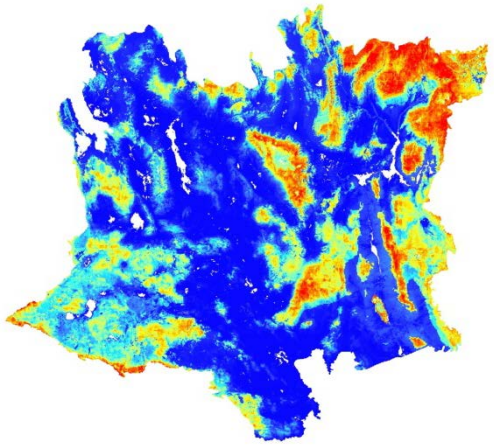
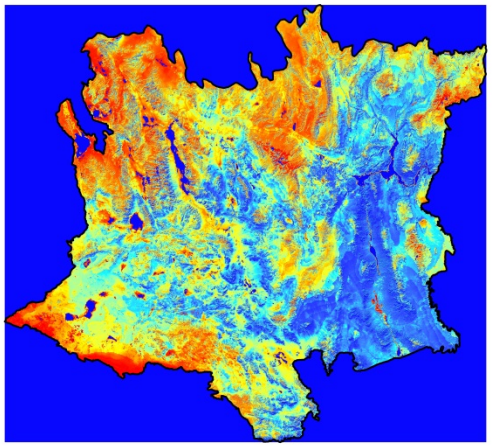
Interpretation and Application

- Interpretation
  - Areas predicted to be most suitable for fire starts may not necessarily have large proportion of high severity
  - Rare events in low ignition areas may have proportionally high ecological effects
    - Alternative vegetation states
- Application
  - Sensitive/T & E species
  - Near-term land use
  - Longer-term planning
  - Future climate scenarios





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