Remote Mapping of Leafy Spurge in the Yampa River Basin

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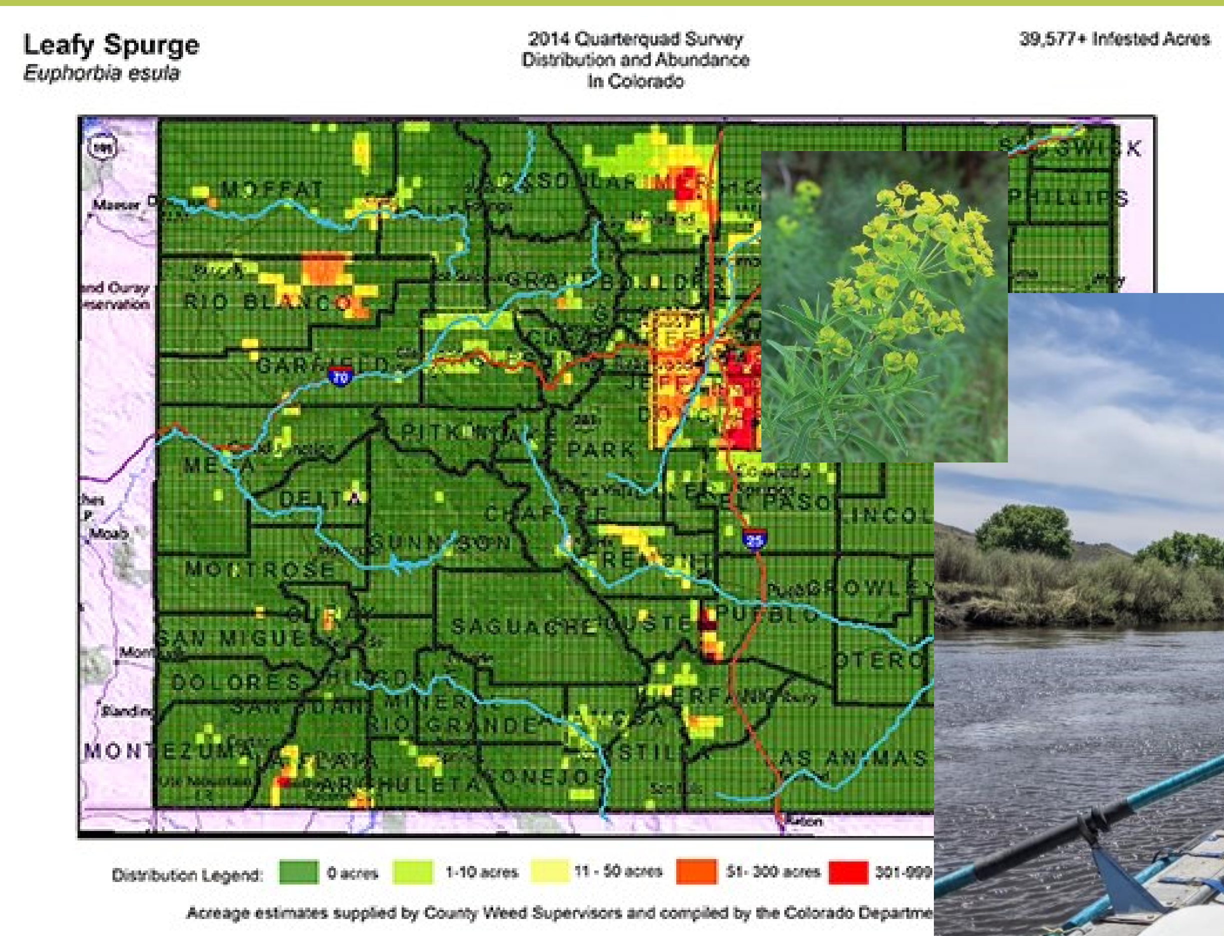
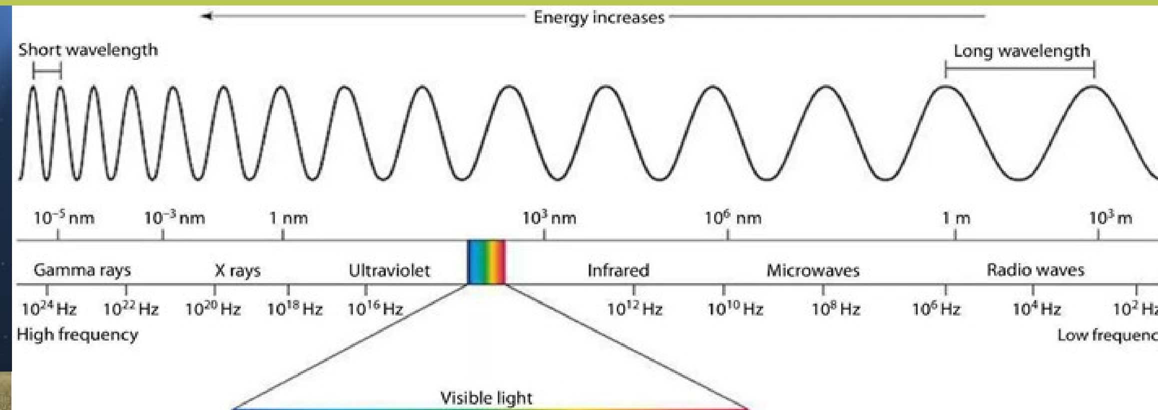
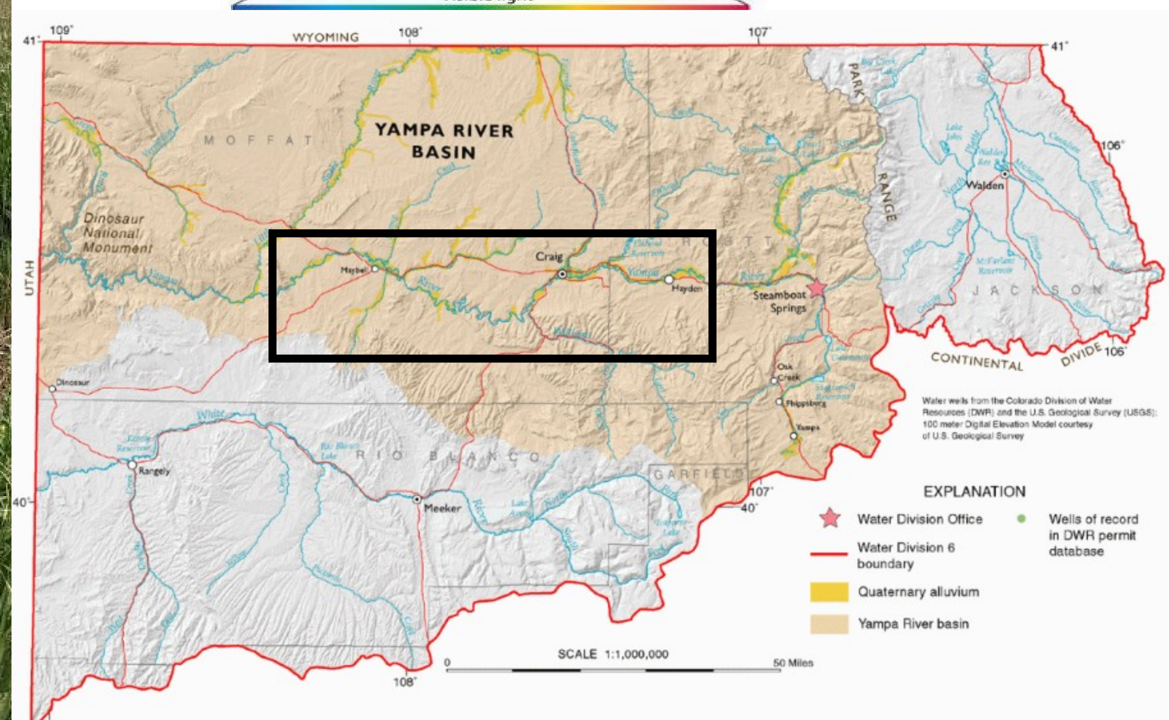
Leafy spurge (*Euphorbia esula)* has established in the Yampa River Basin…



And massive mapping efforts have taken place!
But we still don't know the full extent of leafy spurge

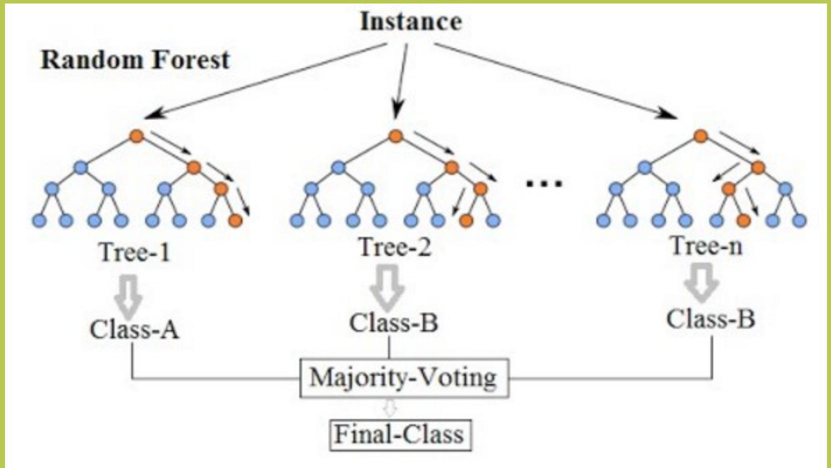
Objective 1: Map leafy spurge in the Yampa River Basin using satellite imagery

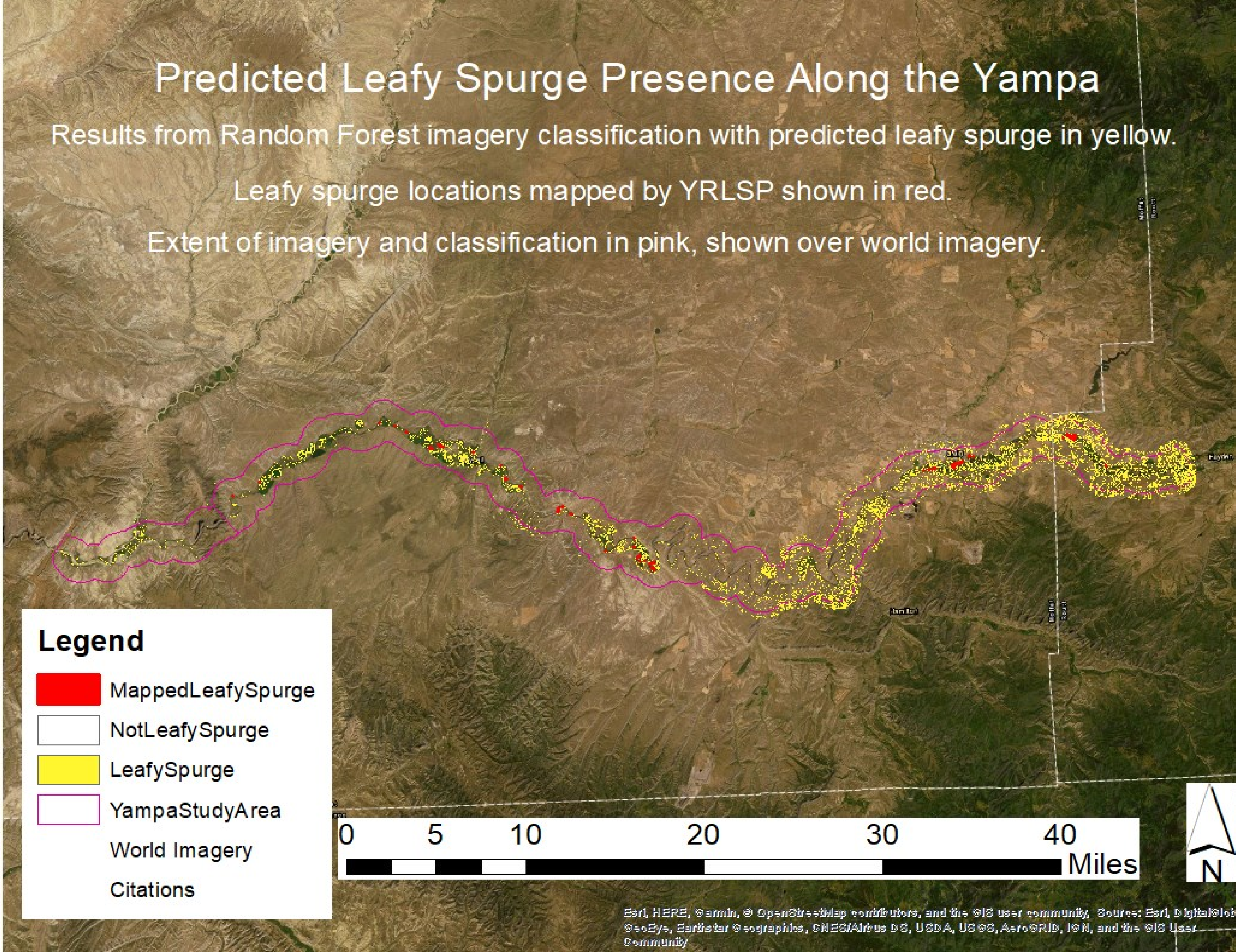




Satellite Mapping Methods

- Digitized training samples using imagery interpretation
- Used spectral signature of leafy spurge training samples to classify imagery
- Classification technique used was Random Forest, a machine learning technique



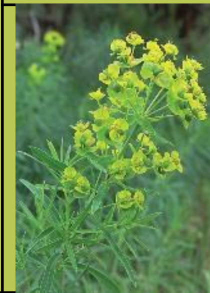
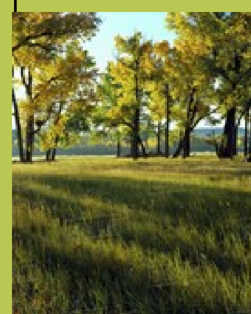

Predicted Leafy Spurge Presence Along the Yampa
Results from Random Forest imagery classification with predicted leafy spurge in yellow.
Leafy spurge locations mapped by YRLSP shown in red.
Extent of imagery and classification in pink, shown over world imagery.
Legend
MappedLeafySpurge
NotLeafySpurge
LeafySpurge
YampaStudyArea
World Imagery
Citations
0
5
10
20
30
40
Miles
N
Esri, HERE, Garmin, © OpenStreetMap contributors, and the GIS user community. Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Classification Results

- Overall accuracy was 92%
- Leafy spurge was classified with 96% accuracy
- The coefficient of agreement, or Kappa statistic = 0.834

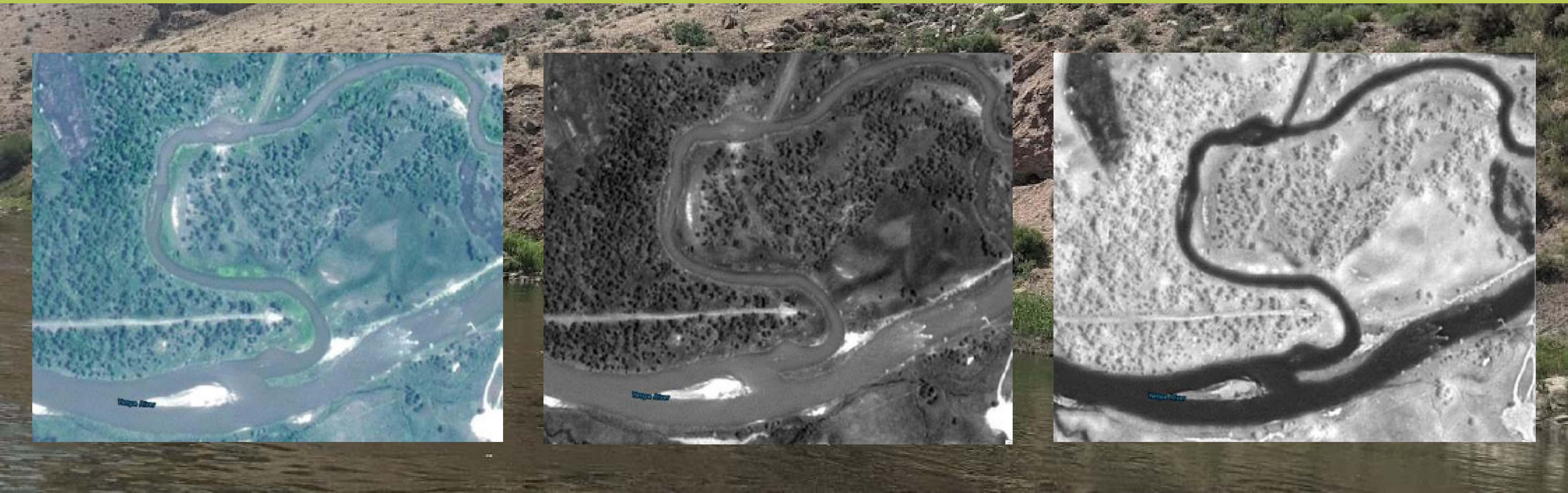
-1 0 1

Random
Disagreement Perfect agreement

		Data from training samples			
				Totals	Accuracy
Class assigned from imagery classification		86 True Positive	4 False Positive	N = 90	96%
		10 False Negative	70 True Negative	N = 80	88%
	Totals	N = 96	N = 74	170	
		90%	95%		Accuracy 92%

There were some misclassified leafy spurge training samples, but did reflectance differ between correctly and incorrectly classified leafy spurge training samples?

	Band of Light of Multispectral Imagery							
	Red		Green		Blue		Near Infrared	
Class	Mean	p-value	Mean	p-value	Mean	p-value	Mean	p-value
Spurge	308	0.8	434	0.1	368	0.6	1359	0.03***
Missed Spurge	309		433		367		1323	



Conclusions

- Classified over 95% of training samples correctly, with a 92% overall accuracy
- 83% agreement with model and training samples
- Near infrared reflectance is more useful for identifying leafy spurge than red, green, or blue bands

But we had even more questions…

How can we increase our classification accuracy of leafy spurge?

What ground factors influenced misclassification?

Validation Mapping, Summer of 2021

Objective 2: Visit validation locations to describe differences between correctly and incorrectly classified leafy spurge for improved invasion maps

Validation Mapping

Classified imagery was examined using ground mapped data,

and mismatches were identified

- Validation points were visited, 271 in total

Validation Mapping Data Collected

At each validation location we evaluated model performance

And, we recorded:

- % leafy spurge cover
- Other vegetation
- % bare ground
- % overstory canopy cover

Validation Mapping Analysis

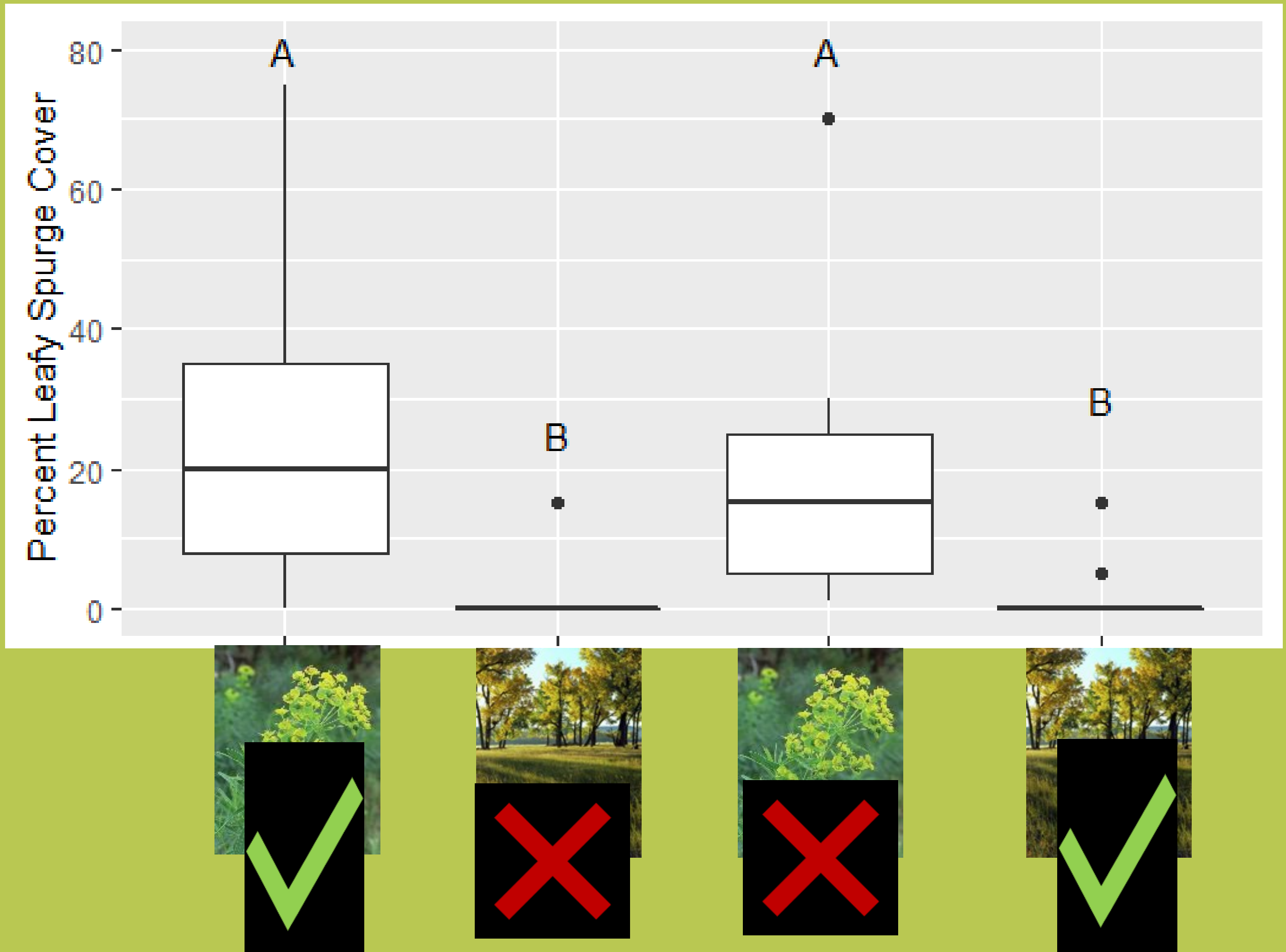
- 271 validation locations were sorted into:

	Classed	True/False	Ground
1. True positives			
2. False positives			
3. False negatives			
4. True negatives			

Validation Mapping Results - Summary

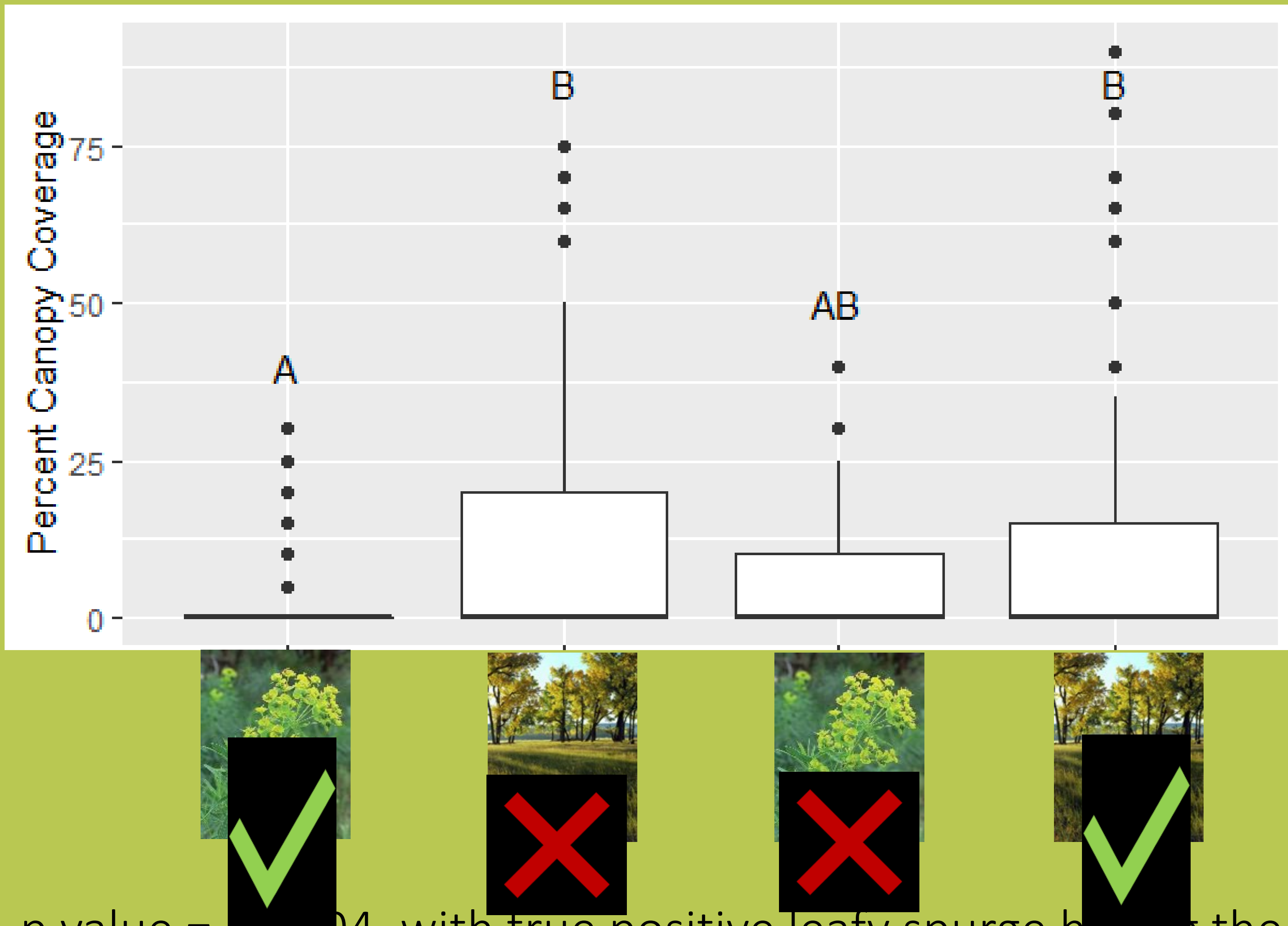
- Of 126 leafy spurge locations, 102 were correctly classified as leafy spurge, or 81% true positives
- Of 126 leafy spurge locations, 24 were missed, or 19% false negatives
- Of 145 not-leafy spurge locations, 88 were classified as leafy spurge, or 61% false positives

Validation Results - % Leafy Spurge Cover



p value = <2e-16, with true positive spurge having the highest average leafy spurge cover, but not significantly more than missed leafy spurge

Validation Results - % Overstory Canopy Cover



p value = [redacted]04, with true positive leafy spurge h[redacted]g the least canopy cover, with missed leafy spurge between

Conclusions and Discussion from Validation Mapping

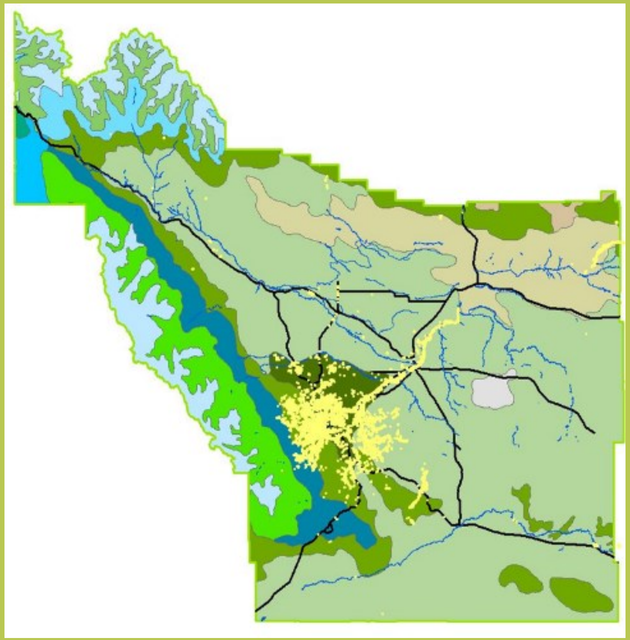
- Of variables measured, only overstory canopy coverage significantly impacted detection of leafy spurge
- Model predicted presence in some Yampa tributaries where validation mapping found leafy spurge to be absent
- Next step in mapping – Incorporate hydrology and/or vegetation type into presence mapping model

We have a predicted presence map of leafy spurge, ground mapped leafy spurge, and validation mapped leafy spurge…

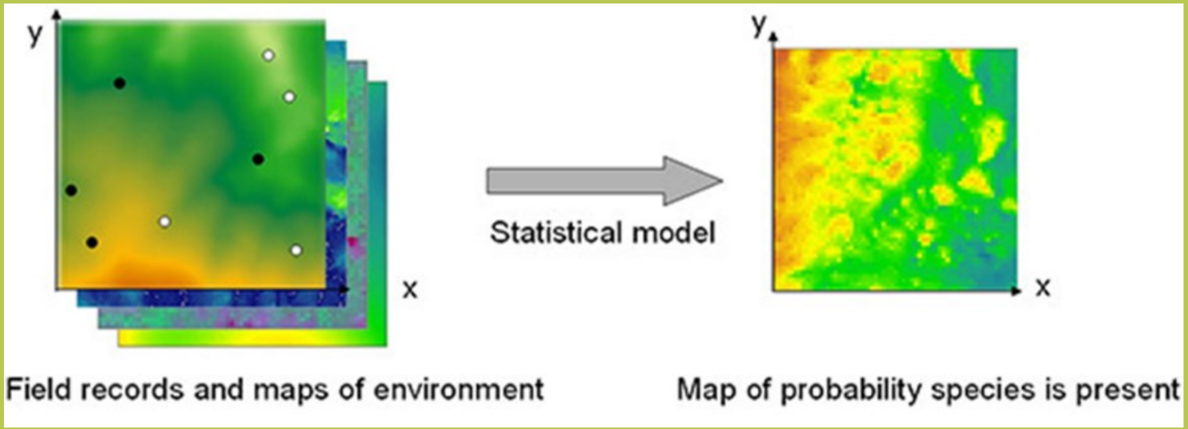
But where COULD leafy spurge spread on the landscape?

Ecological Niche Modeling Methods

- Over 17,000 leafy spurge presence locations were used, between the Yampa River Basin and Fremont County, Wyoming



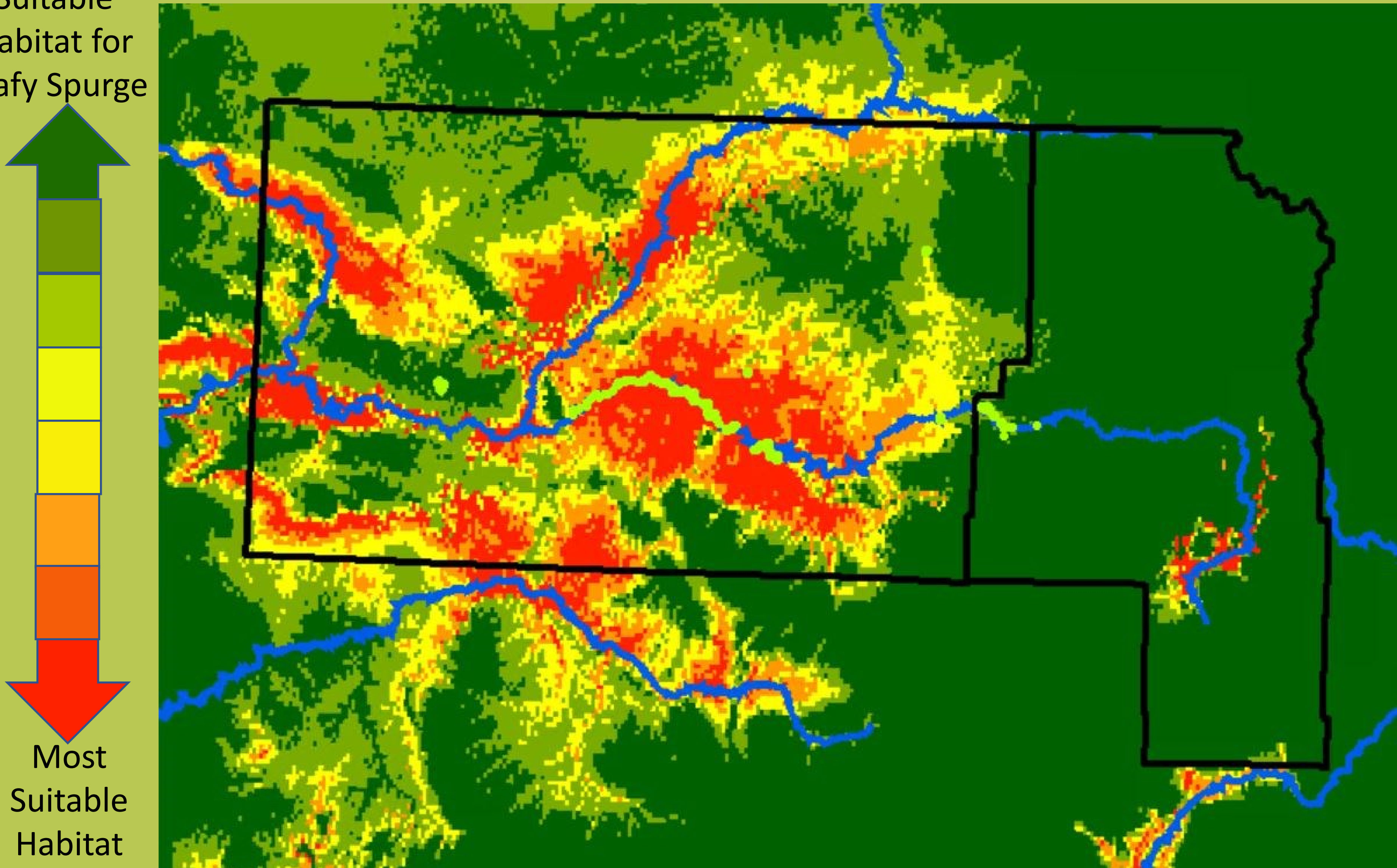
- Environmental predictors used:
  - Bioclimactic variables,
  - Soil characteristics,
  - Land cover classes,
  - Topography



- Based on these parameters, a model was built to best explain leafy spurge presence

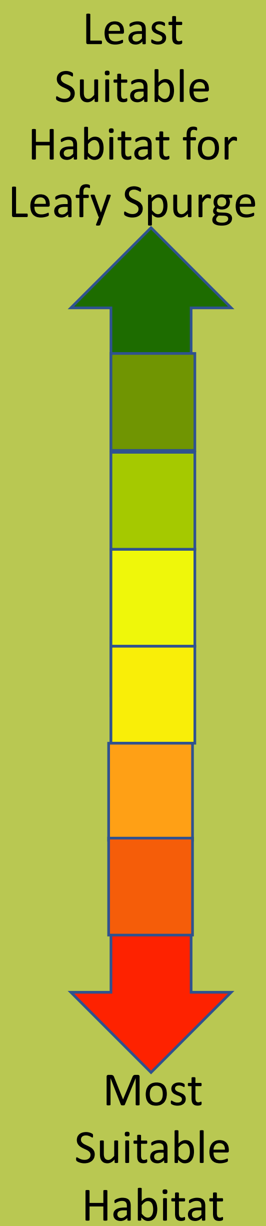
Conservative Model with Climate Predictors
Maximum Entropy Model, Kappa = 0.131

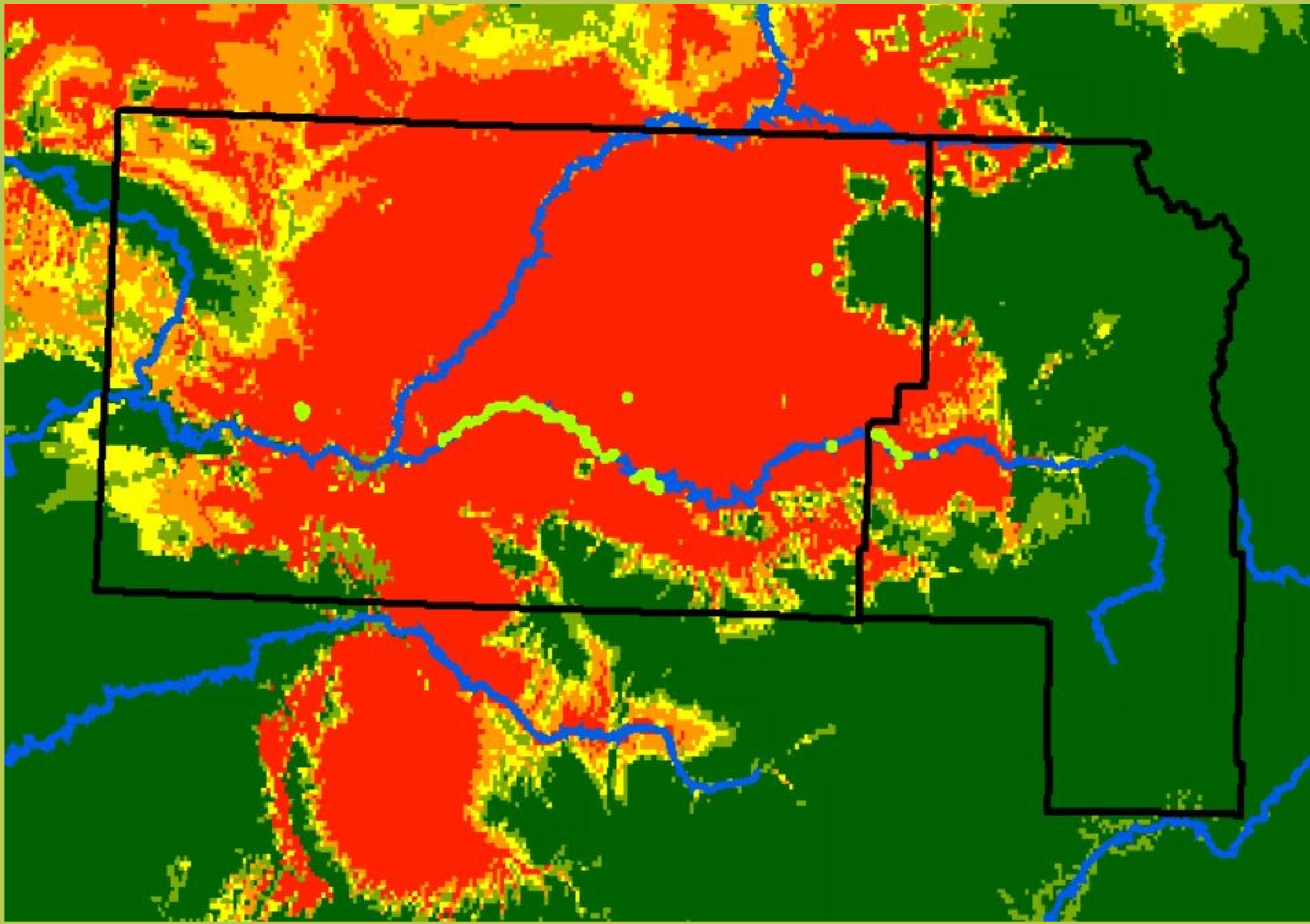
Least Suitable Habitat for Leafy Spurge



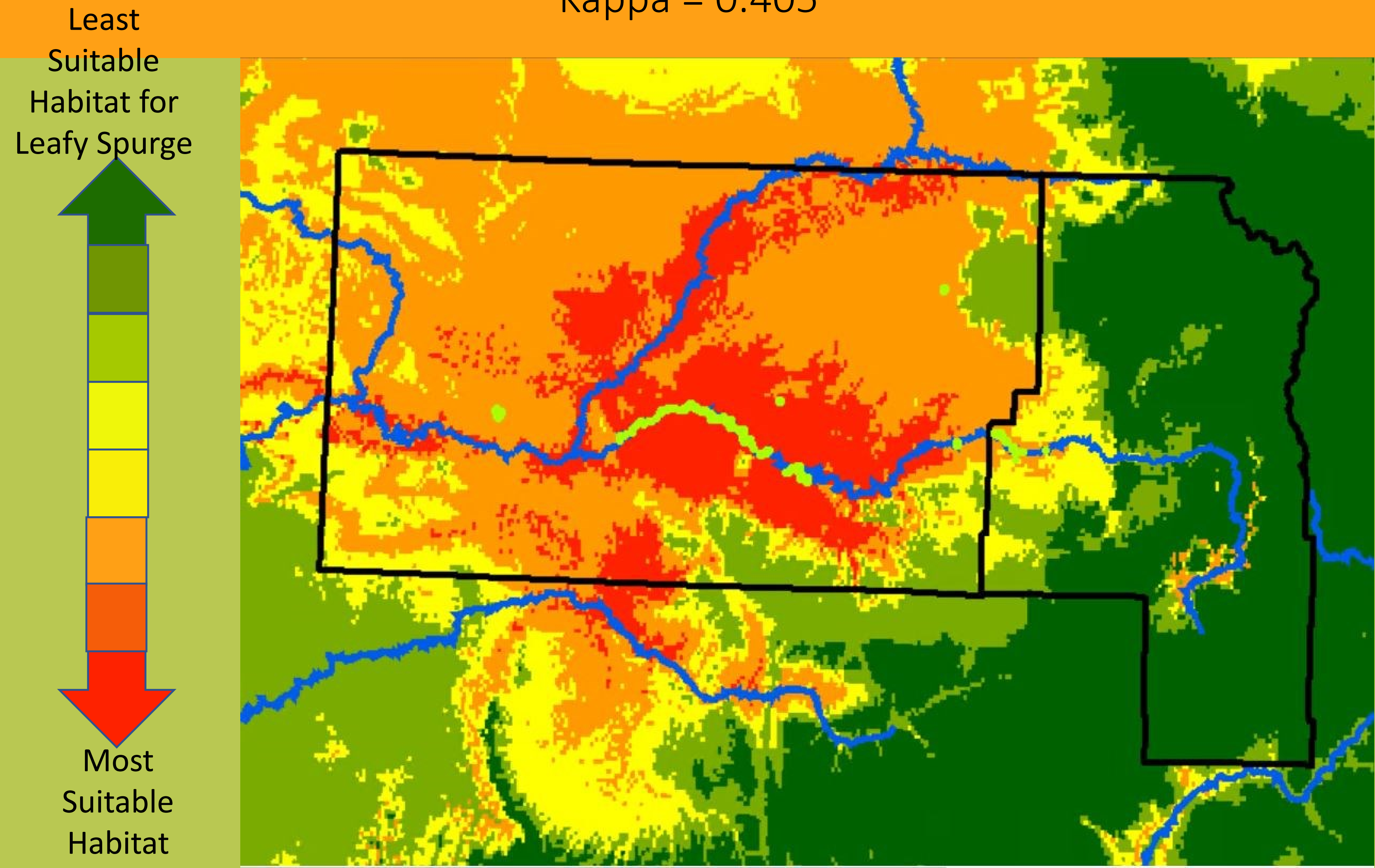
Most Suitable Habitat

Best Fitting Model with Climate Predictors
Support Vector Machine, Kappa = 0.935



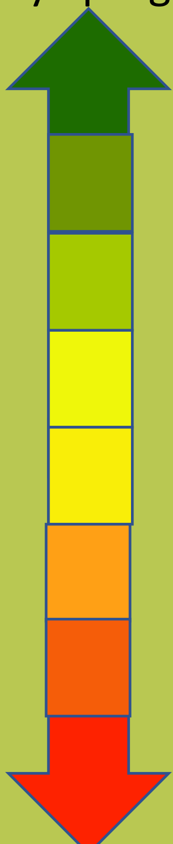


Ensemble model, combining all three methods
(Random Forest, Maximum Entropy, and Support Vector Machine)
Kappa = 0.405

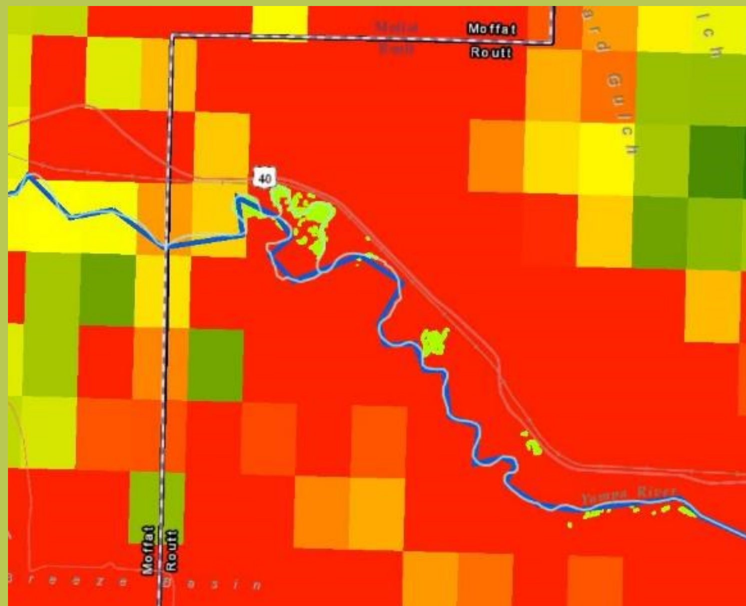


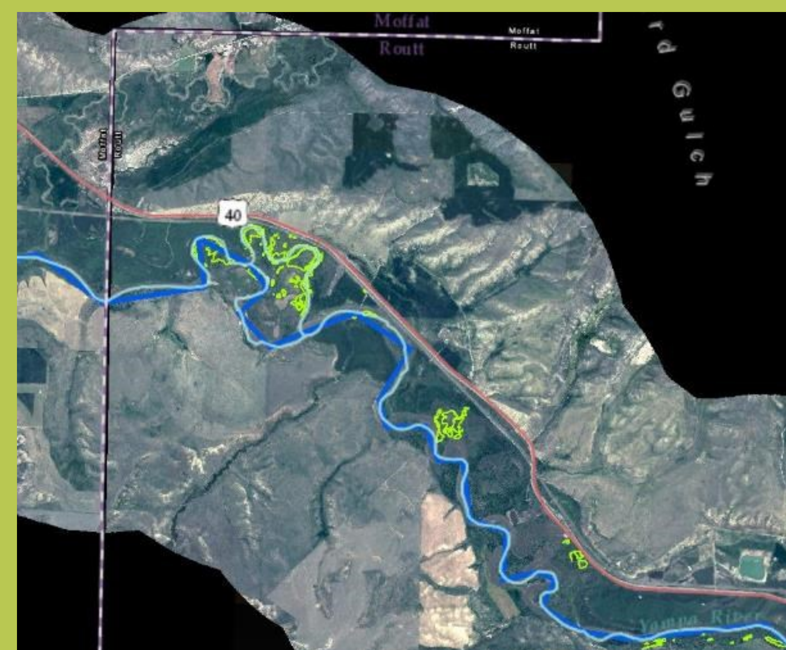
Zooming in on some mapped spurge…

Least Suitable Habitat for Leafy Spurge



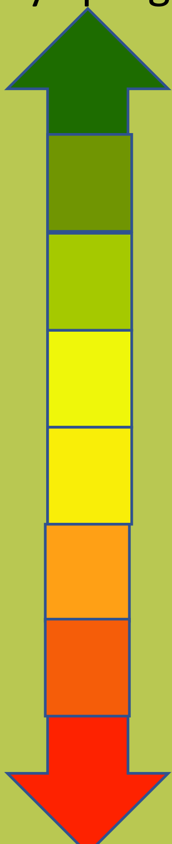
Most Suitable Habitat



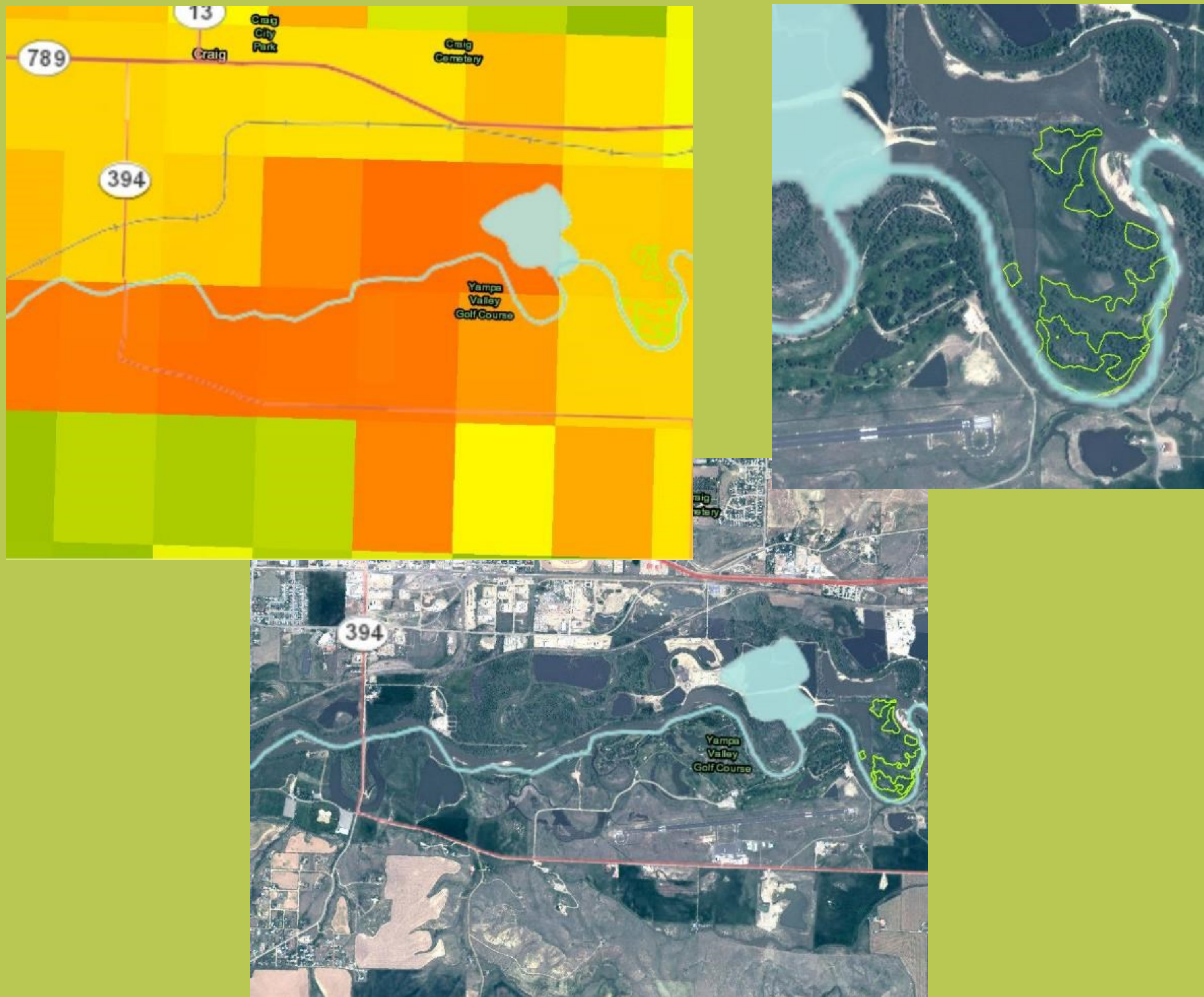


Zooming in on some mapped spurge…

Least
Suitable
Habitat for
Leafy Spurge



Most
Suitable
Habitat

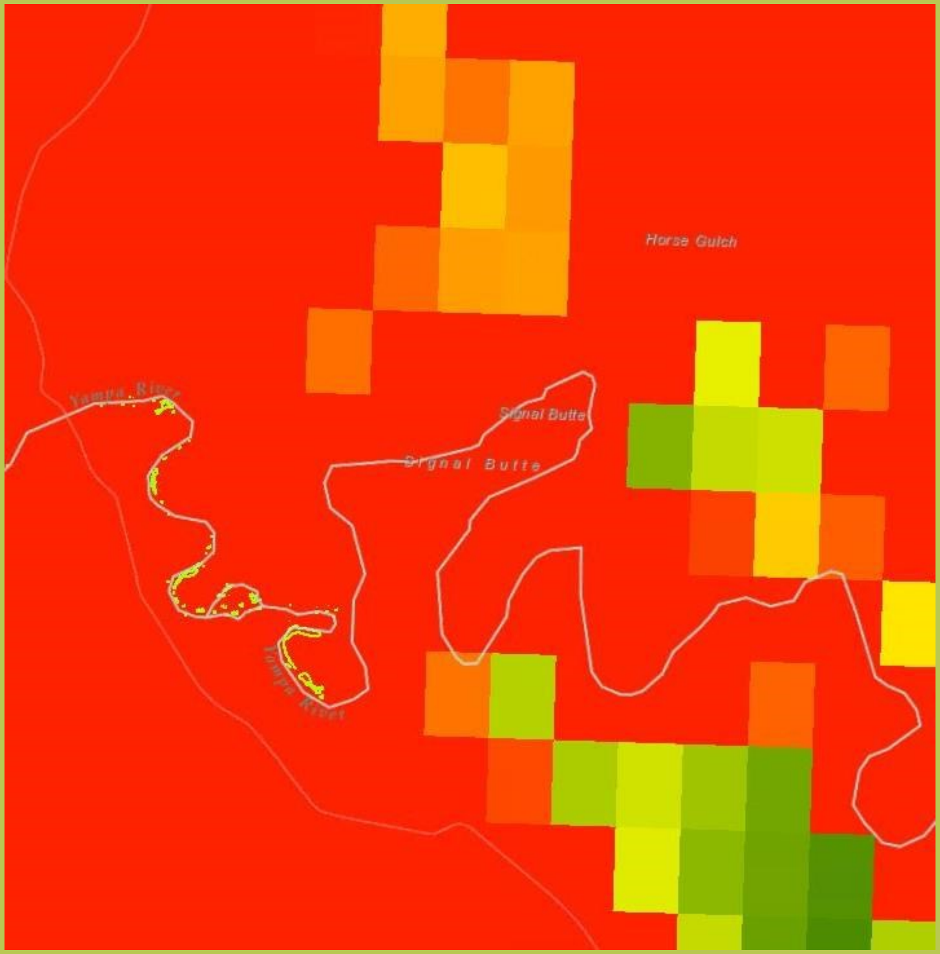


Next Steps – Comparison of Invasion Risk Prediction with Mapped Data

- Calculate area of pixels that have high likelihood of leafy spurge invasion

- Compare this area with
  - Ground mapped data (and variables)
  - Imagery classification
  - Validation mapped data, using change detection and calculations between rasters

- Compare results between full model (Yampa and Fremont) and Yampa model



Final results and report – November 2021

Thank you so much for your attention!

Any questions?
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