Integrating Remote Sensing and Observations into Decision Support Systems for Invasive Weeds

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Objectives

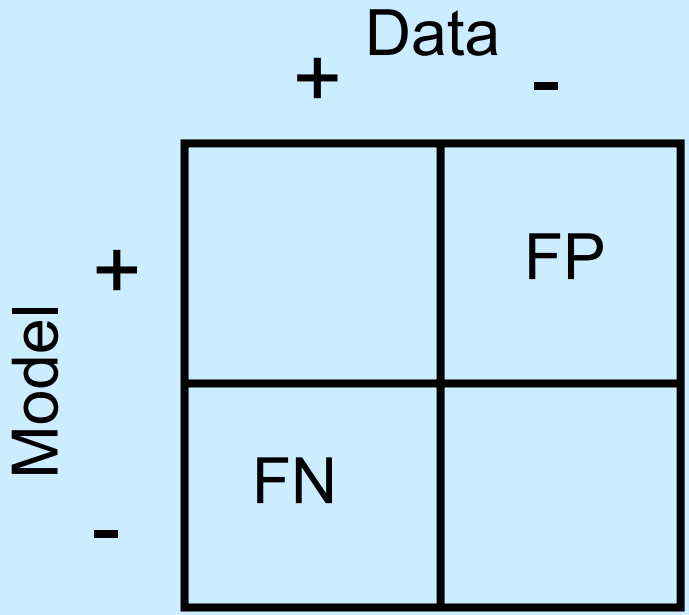
- Predict potential distribution of leafy spurge (*Euphorbia esula* L.) over landscape using the Weed Invasion Susceptibility Prediction (WISP) model
- Use imaging spectroscopy (AVIRIS) data to map actual distribution of leafy spurge
- Test WISP model with remote sensing for association of leafy spurge with landscape features

False Negatives (errors of omission)

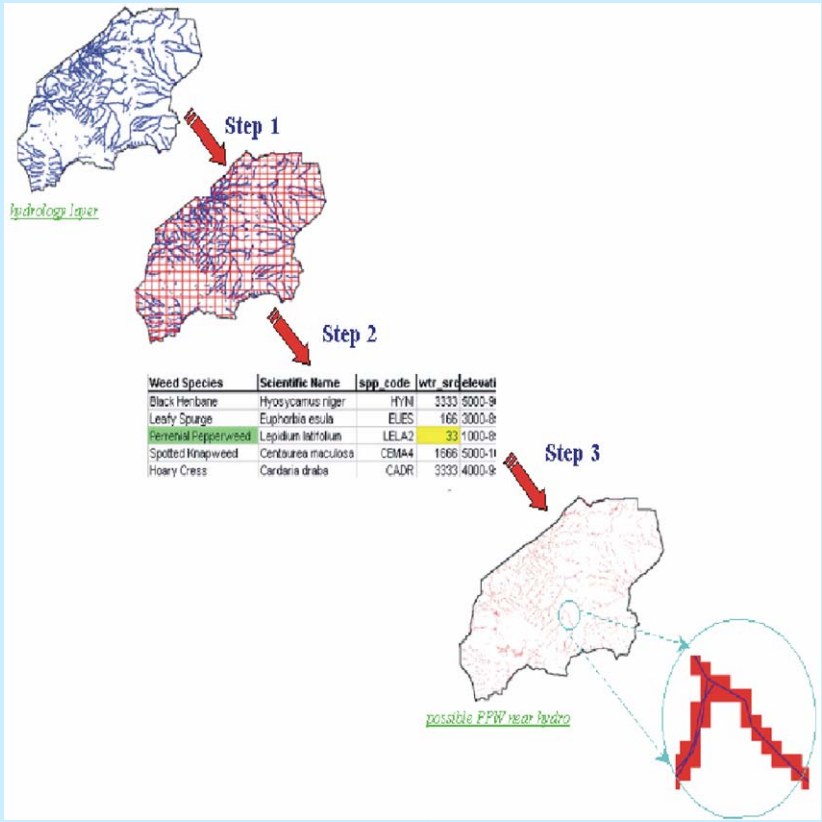
- Weeds observed but not predicted
- 1- producer accuracy
- Field data with GPS

False Positives (errors of commission)

- Weeds predicted by model but not observed
- 1- user accuracy
- *Usually not determined for potential distribution models, because invasive species may not have been introduced at that particular site*

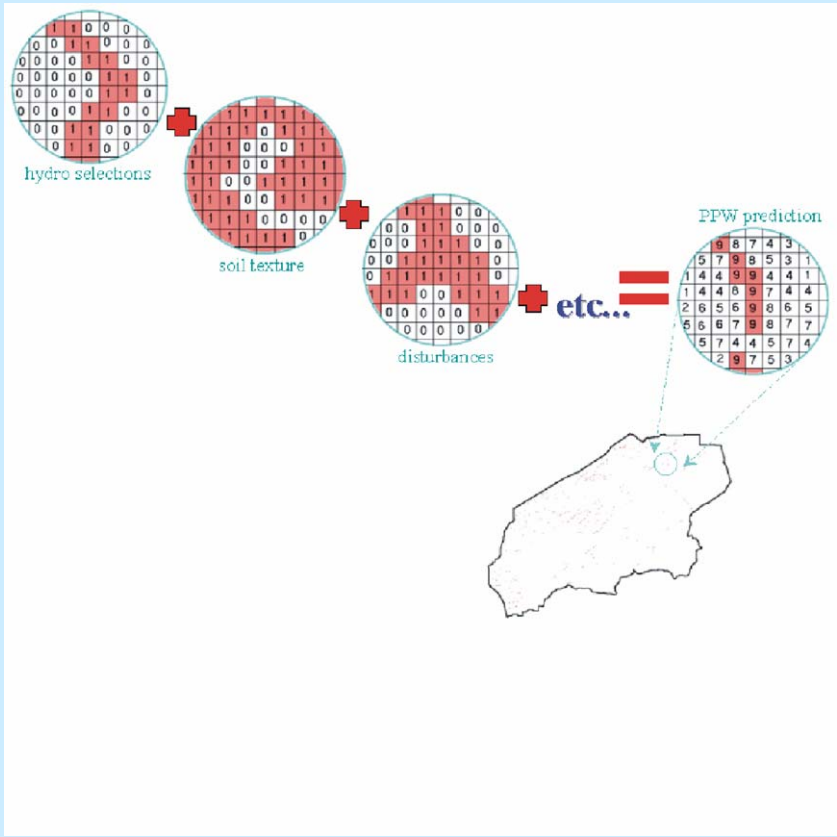


Weed Invasion Susceptibility Prediction (WISP) model (Gillham et al. 2004)

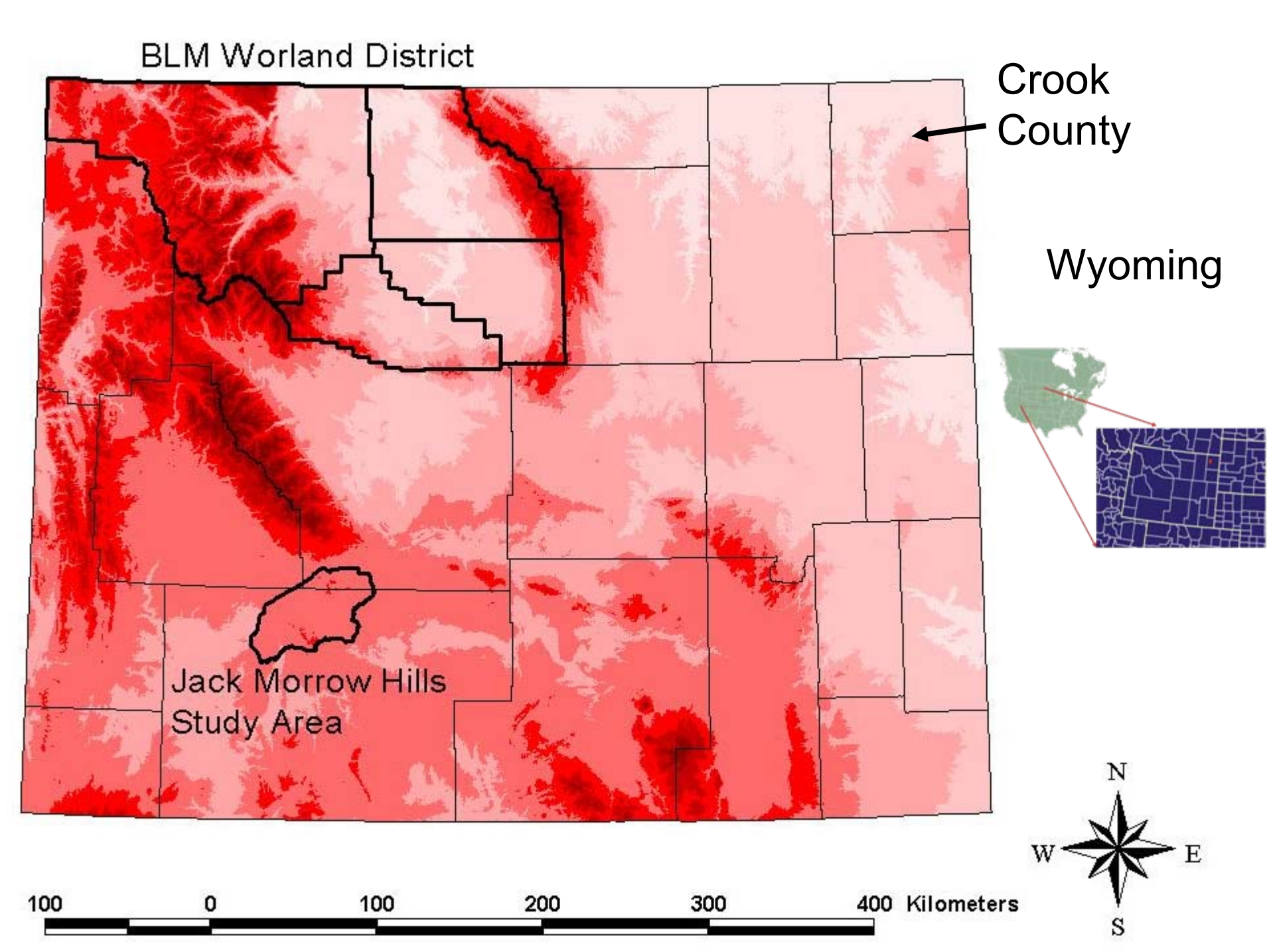


Rule-based model uses gridded GIS layers and environmental parameters to determine if grid cell is favorable (*P* = 1, red) or unfavorable (*P* = 0, white) for that data layer

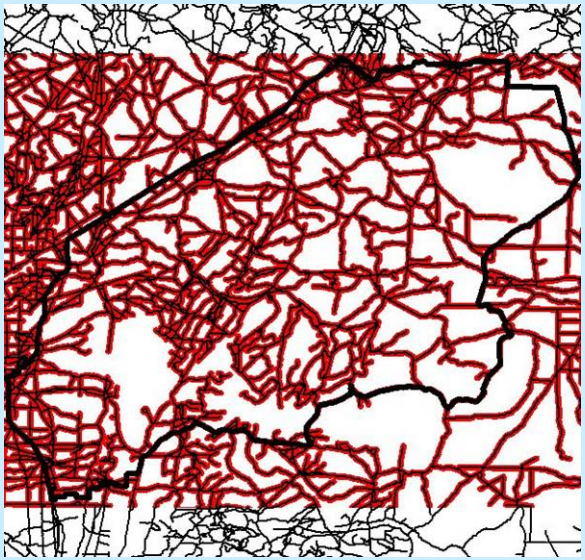
WISP model susceptibility score



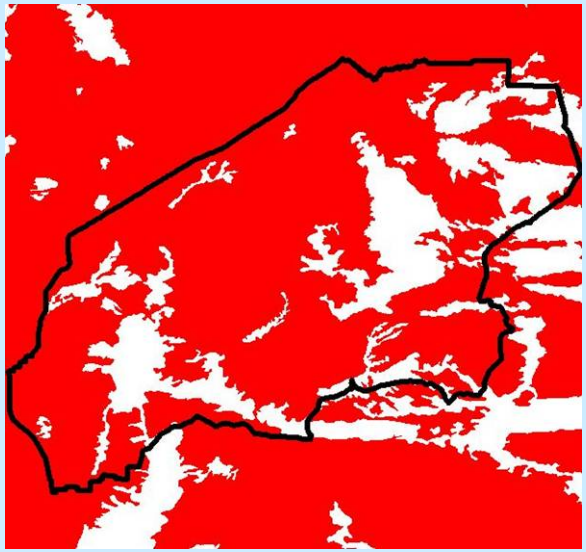
Sum values (1 or 0) for each grid cell, high scores indicate high susceptibility for leafy spurge (all or almost-all factors are favorable)


BLM Worland District
Crook County
Wyoming
Jack Morrow Hills Study Area
N
W
E
S
100 0 100 200 300 400 Kilometers

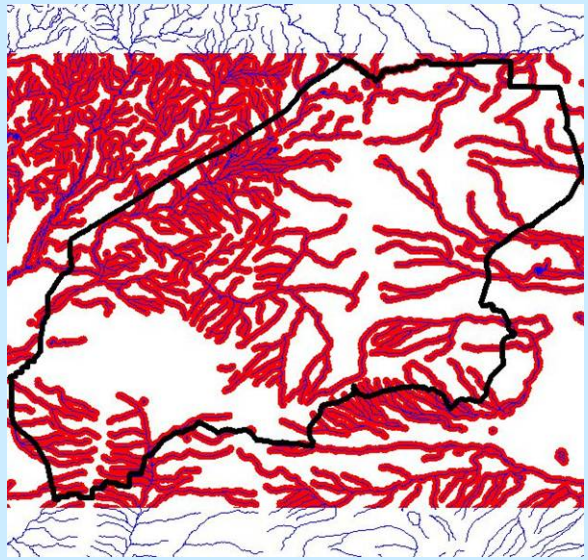
Roads



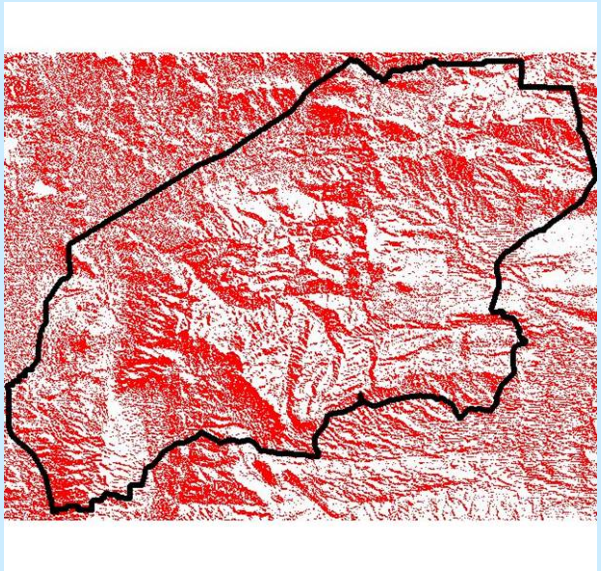
Land cover



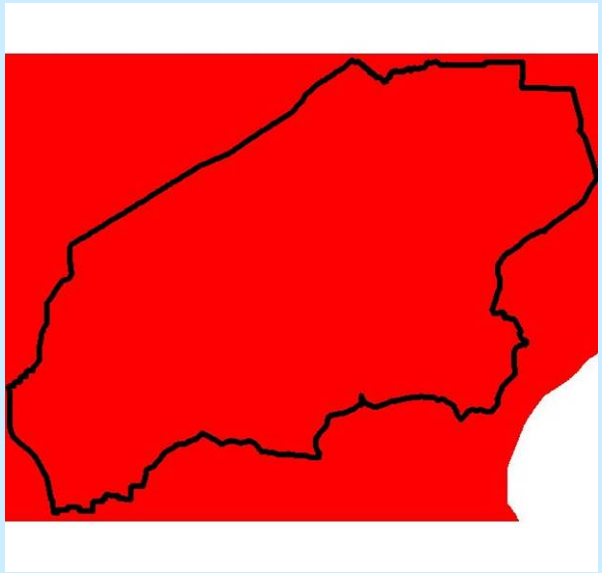
Streams



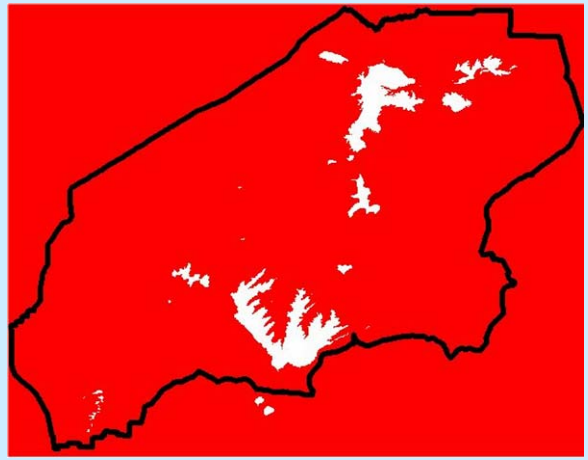
Aspect



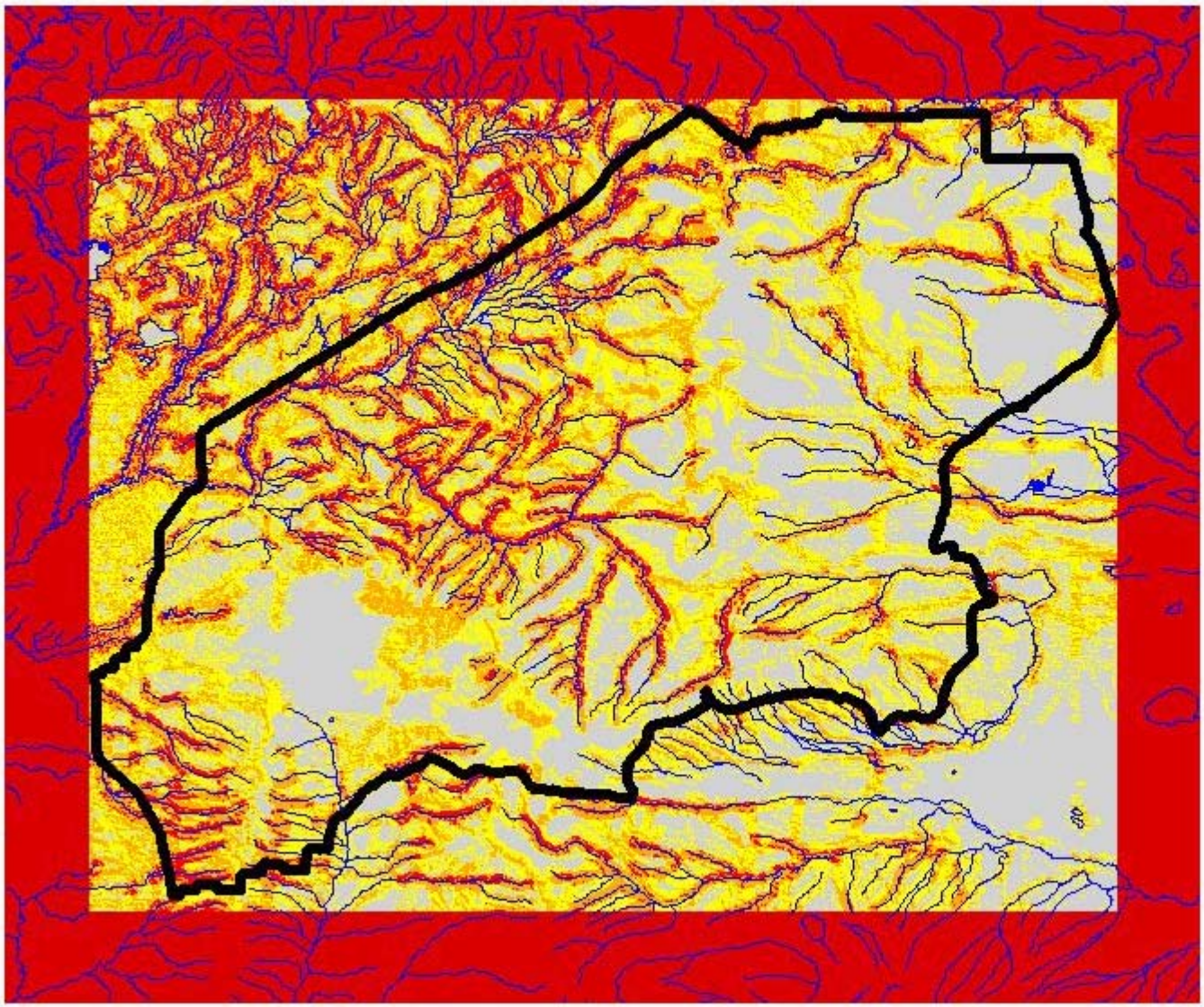
Precipitation



Elevation



Leafy spurge (Euphorbia esula)



Potential for Leafy spurge
No Factors
6 Factors
Maximum Potential

N
W
E
S

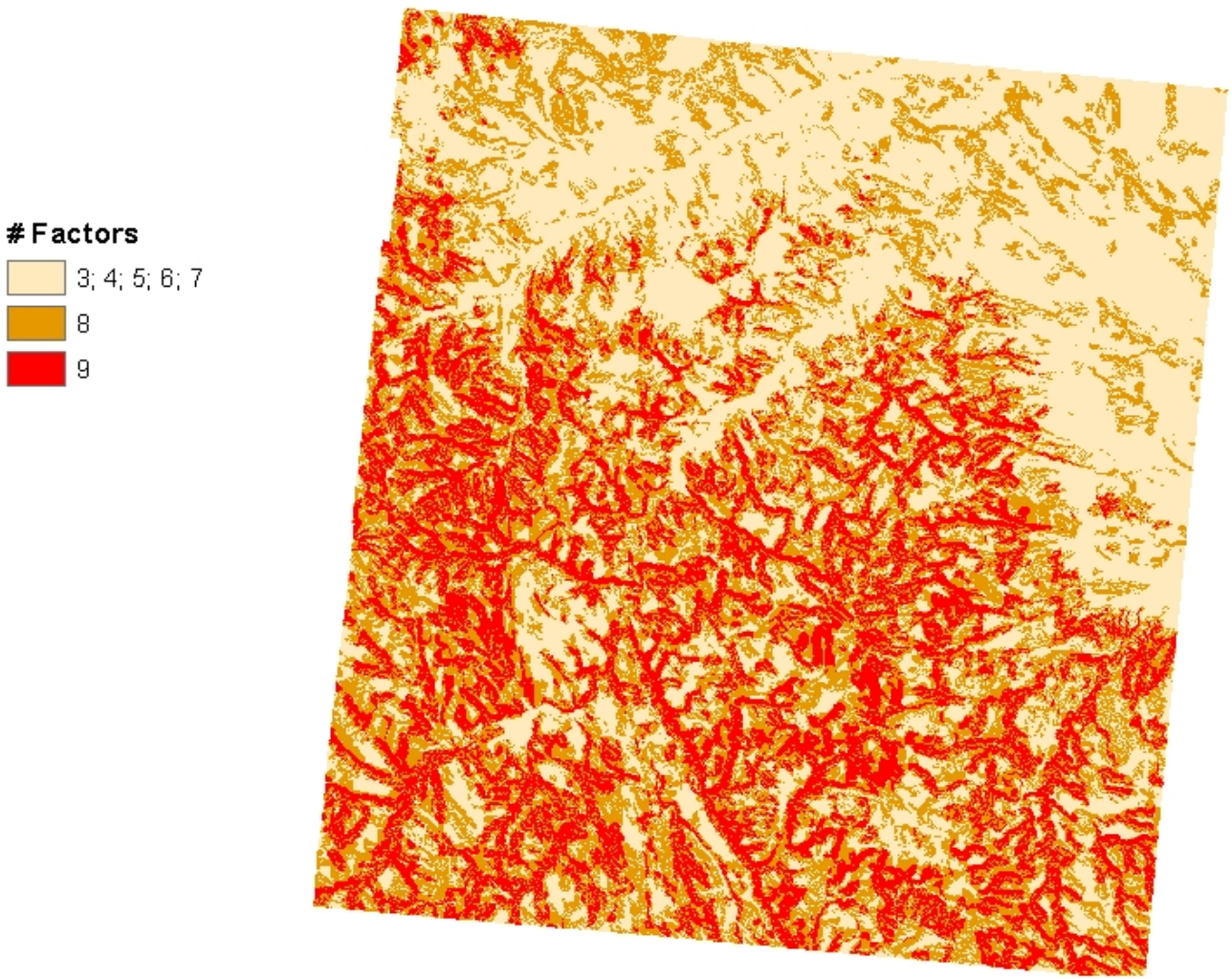
20 0 20 40 Kilometers

Validation of WISP Model (Gillham et al.)

	Producer Accuracy (1-FN)
BLM Worland District	
Leafy Spurge	85.0%
Spotted Knapweed	88.0%
Jack Morrow Hills	
Perennial Pepperweed	85.7%
Black Henbane	96.5%
Hoary Cress	89.7%

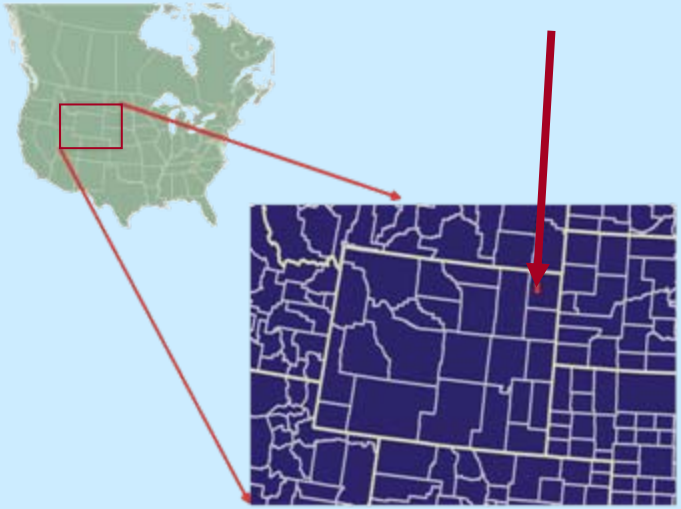
No leafy spurge found at Jack Morrow Hills – model error of commission (FP) or not yet introduced?

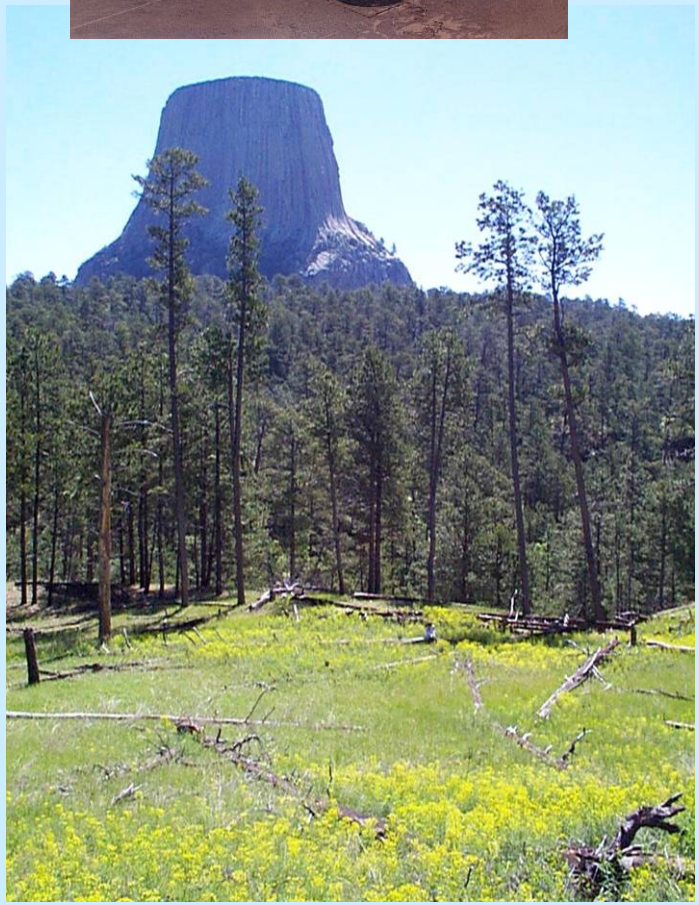
Spurge Susceptibility, Crook County, WY



35% of county rated to be highly susceptible to leafy spurge

Crook County, Wyoming



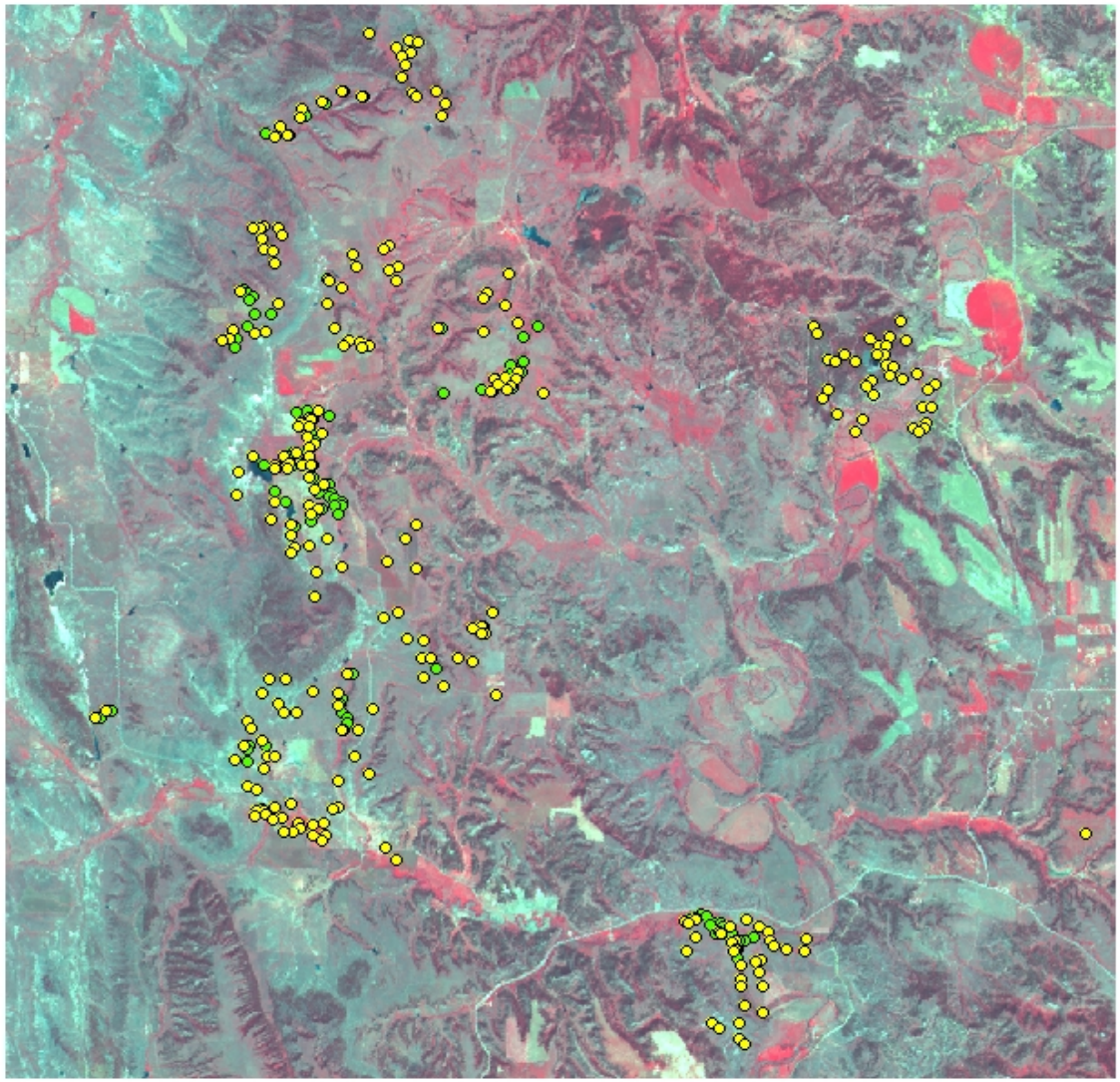


A TEAM Leafy Spurge site was centered around Devils Tower National Monument

AVIRIS data were acquired in 1999

Parker Williams and Hunt (2002, 2004)

Field Plots, Devils Tower (SPOT)



Kappa Analysis – corrects accuracy for agreement due to chance

K-hat = (*Pc* - *Pe*)/(1 – *Pe*)

Also calculate variance of *K-hat*

Field data of Parker Williams & Hunt

		LS+	LS-
WISP	LS+	86	105
	LS-	28	27

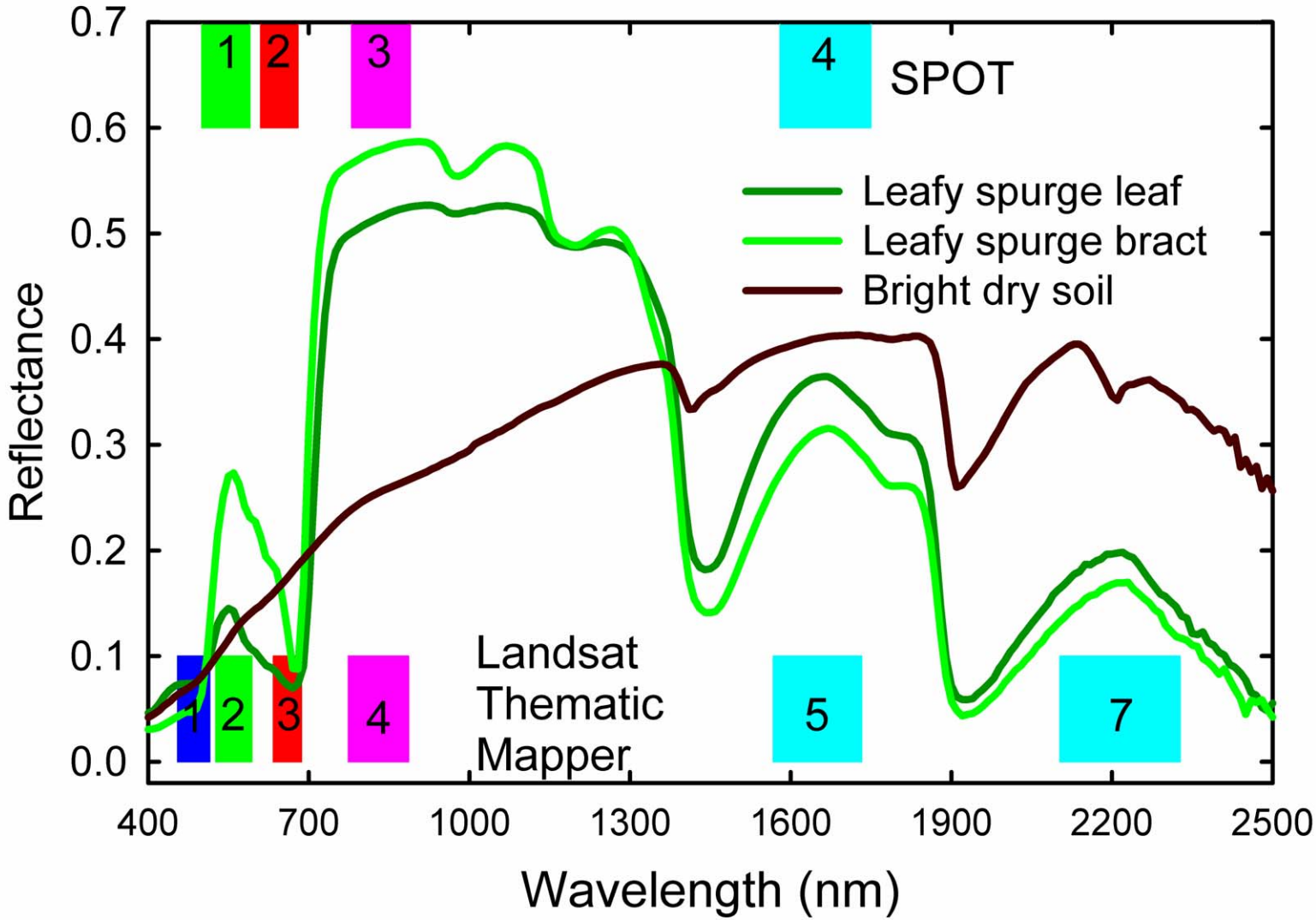
K-hat = -0.04, s^2 = 0.009, *Z*-statistic = -0.41

Not significant, because low N and a relatively large area is predicted to have potential for leafy spurge

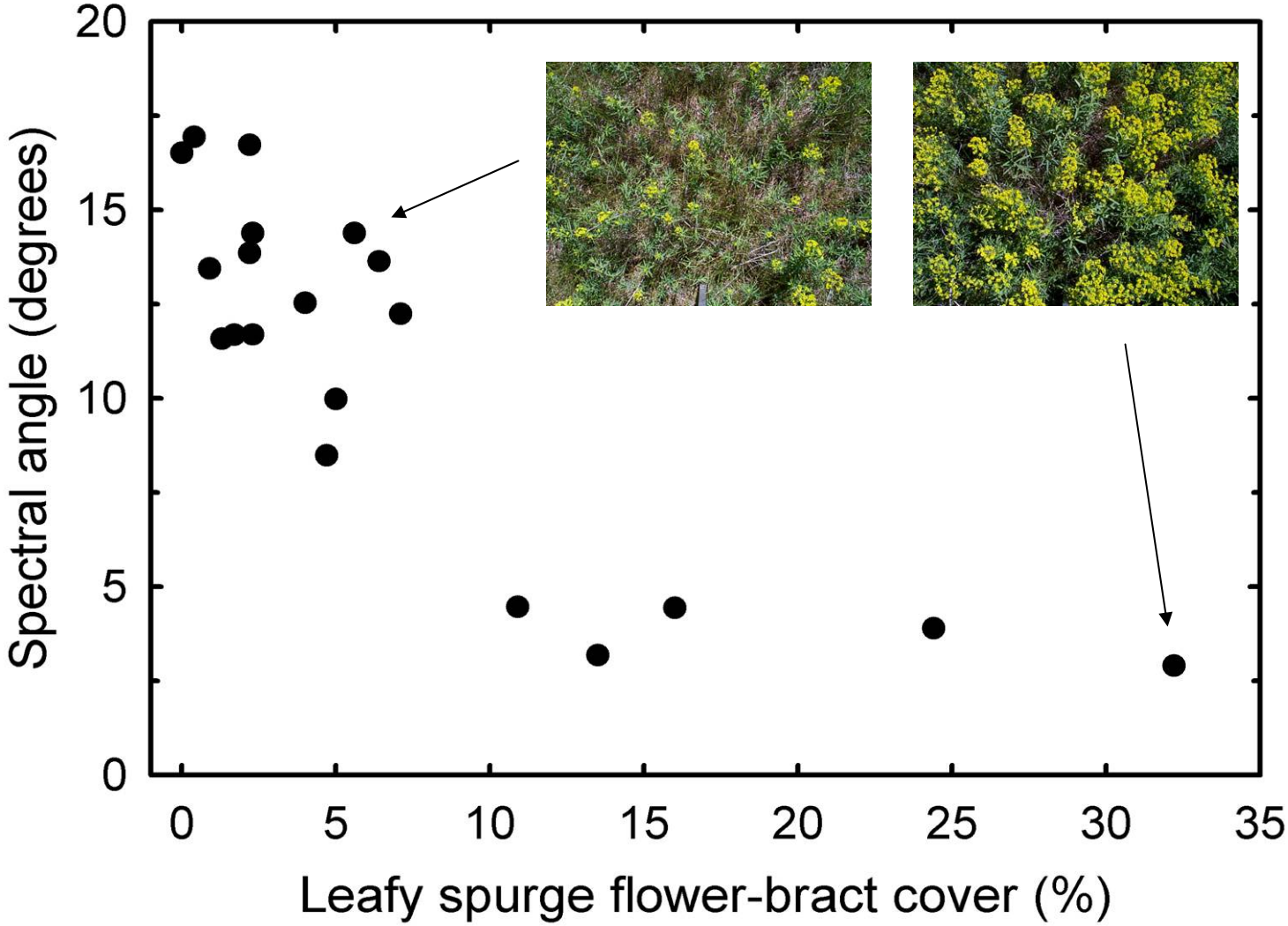
Why is there no leafy spurge in much of the susceptible area?

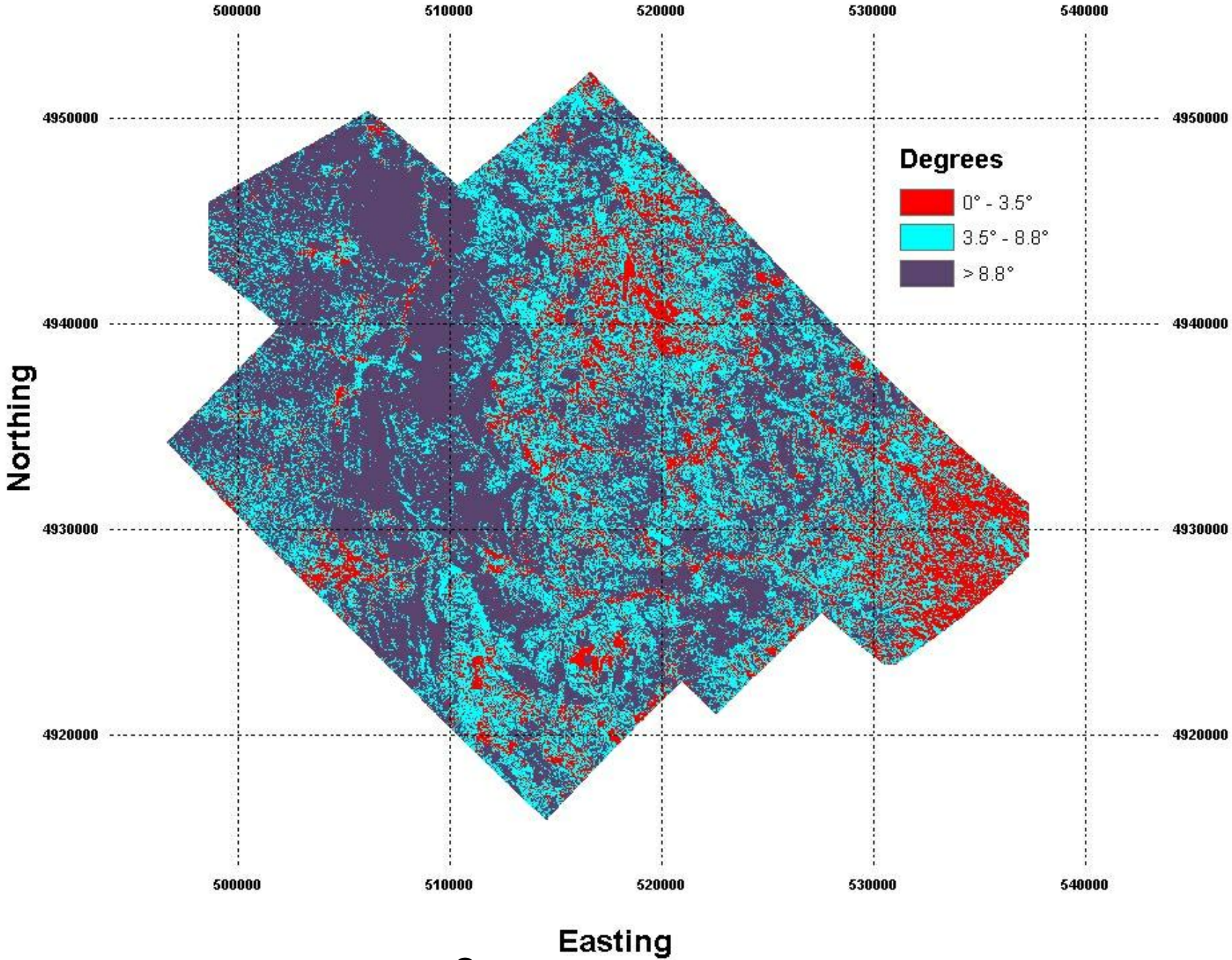
- Application of control measures
- Over-tuned model, model error

Remote Sensing of Leafy Spurge



Classification using spectral angles (vector algebra)



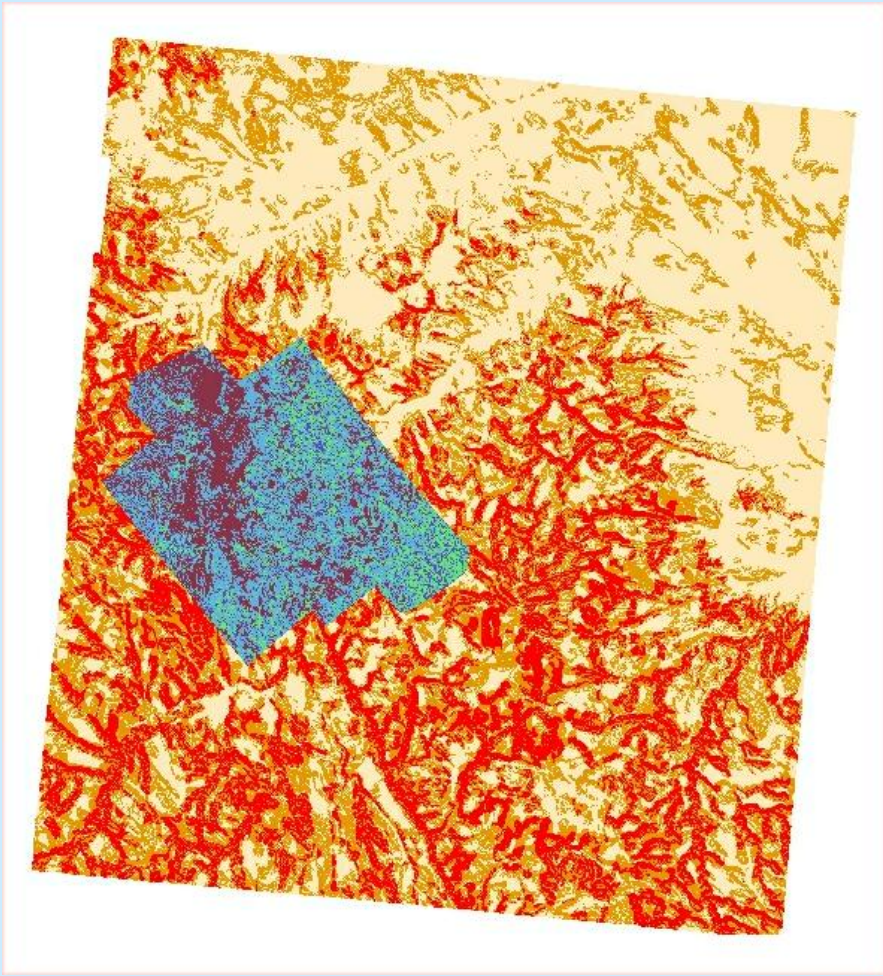


≈ 1000 km^2 12% of area infested

Pixel to pixel test of WISP model with AVIRIS image classification.

Accuracy is 48%

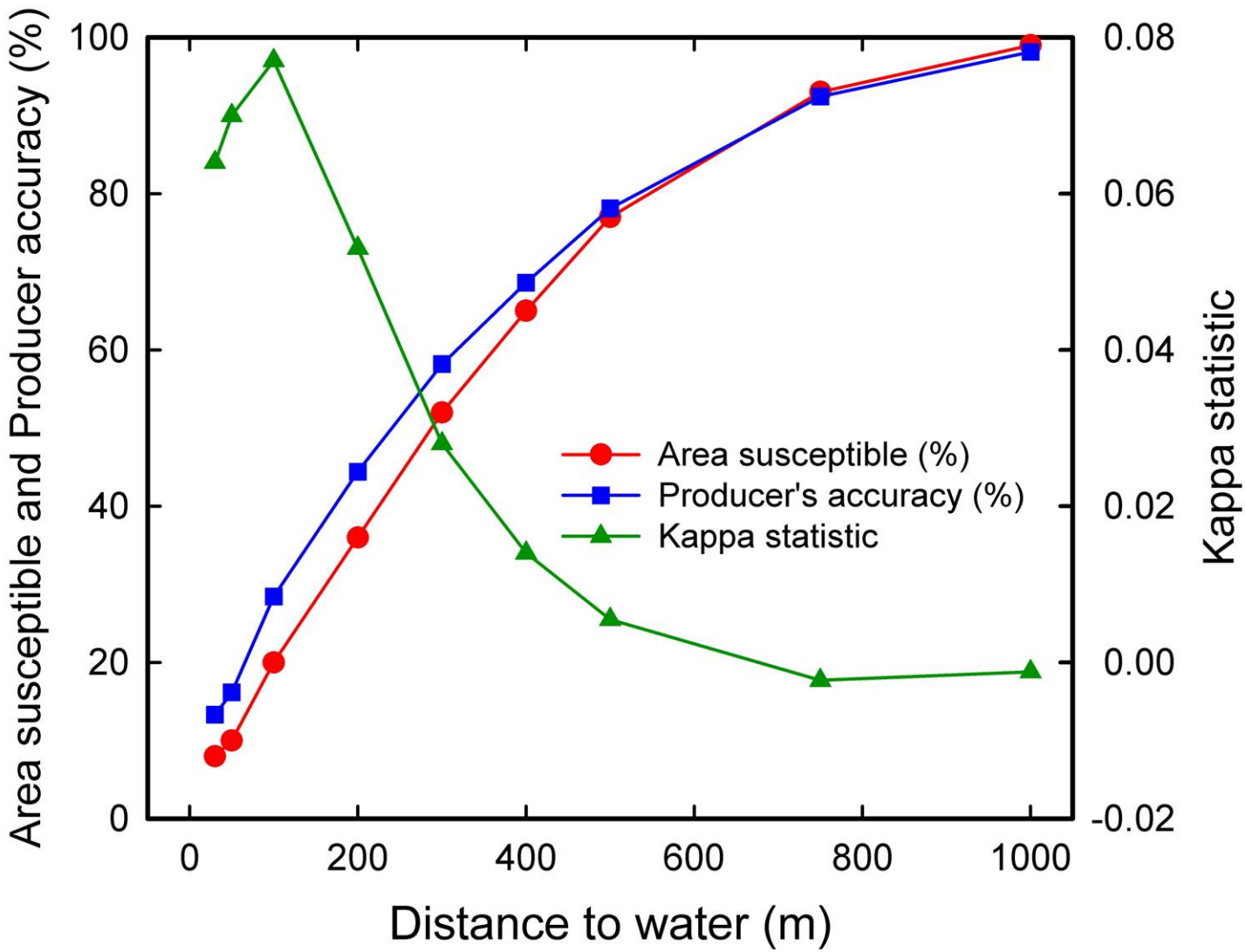
With large N, WISP model does worse than chance!



Texture	***Z*-Statistic**	**WISP**
Loam	-67.37	*
Sandy Loam	np	*
Clay Loam	-2.86	*
Silt Loam	1.48	*
Clay	40.90	
Silty Clay Loam	12.68	
Aspect		
N	26.75	
E	-6.72	*
S	-16.38	*
W	-3.96	*

Not significant: Elevation, Soil pH, precipitation

Significant (negative): distance to roads


Area susceptible and Producer accuracy (%)
Kappa statistic
Distance to water (m)
Area susceptible (%)
Producer's accuracy (%)
Kappa statistic
0
20
40
60
80
100
-0.02
0.00
0.02
0.04
0.06
0.08
0
200
400
600
800
1000

Significant predictors:

Distance to water (200 m)

Fine soil texture

Riparian/woodland

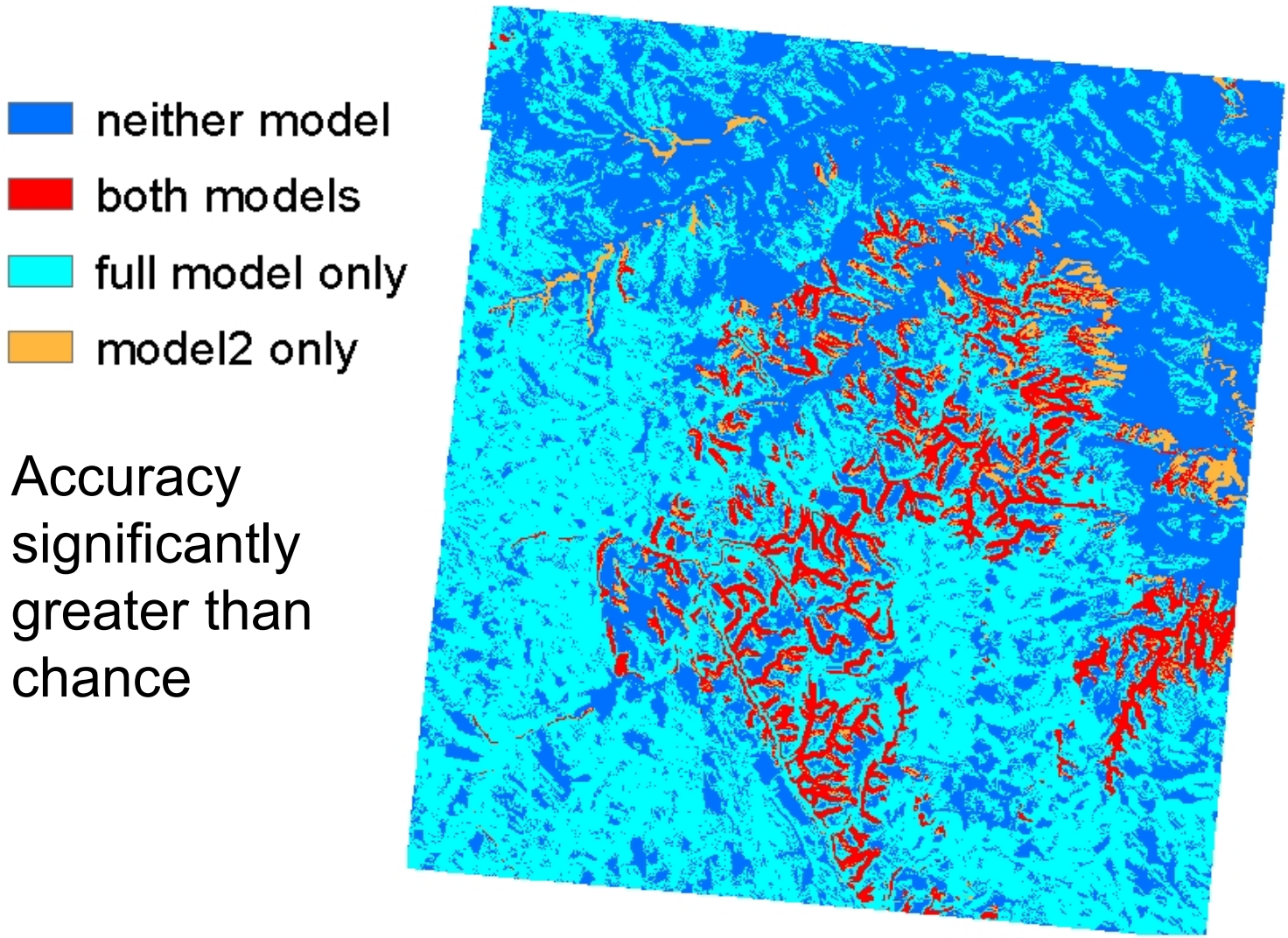
North-facing slopes

Non-significant predictors:

Distance to roads, slope, soil pH

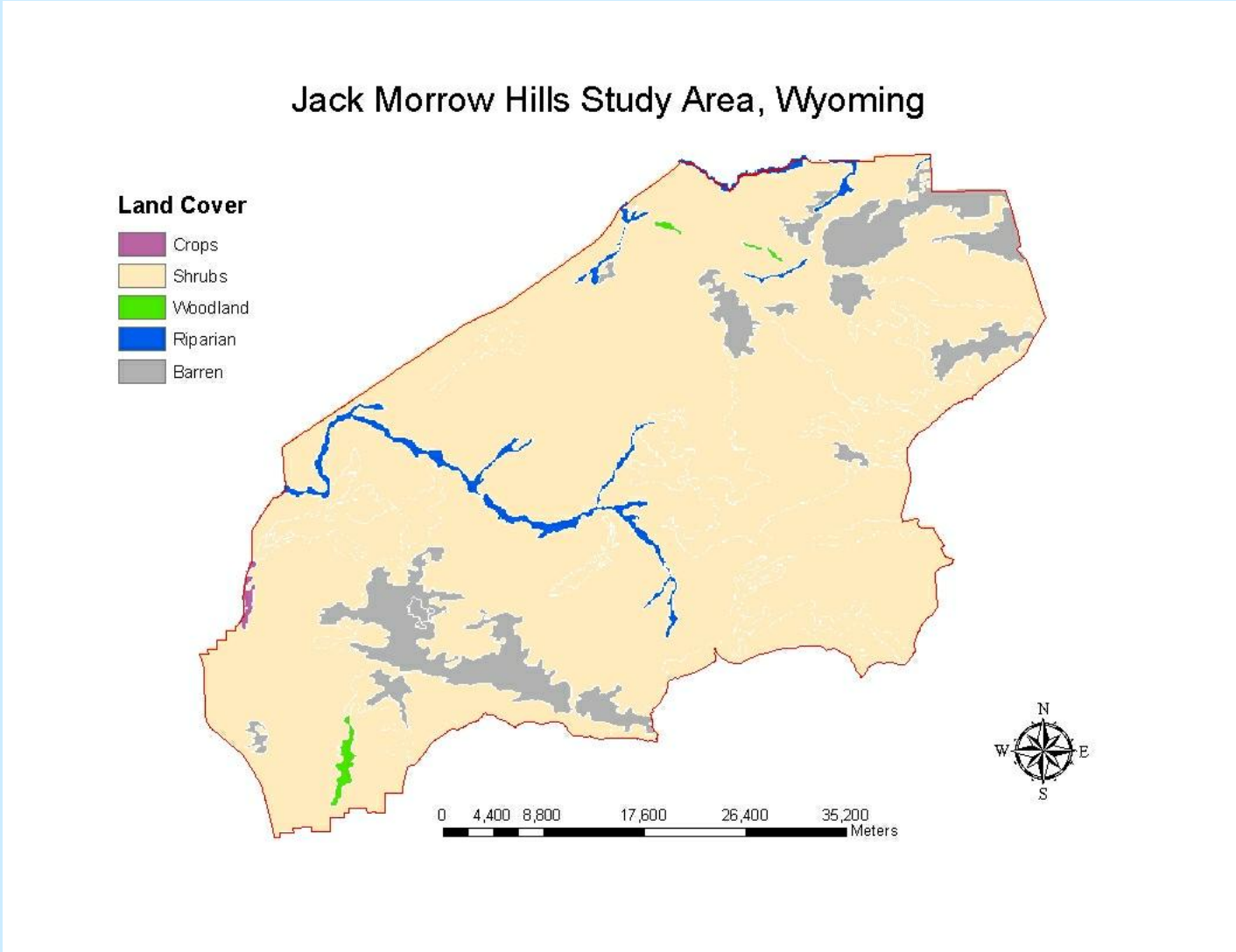
Elevation, Precipitation

Predicted Spurge (Model 2 vs Full Model), Crook County, WY



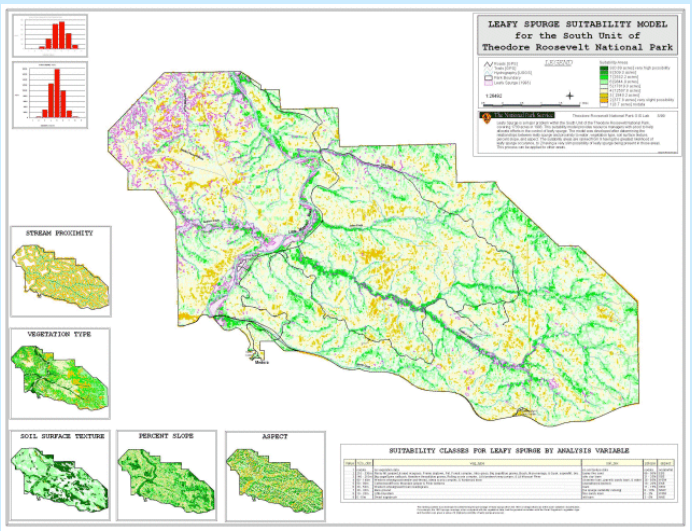
Accuracy significantly greater than chance

No spurge predicted at JMH with WISP2 because of dominance of sandy soils

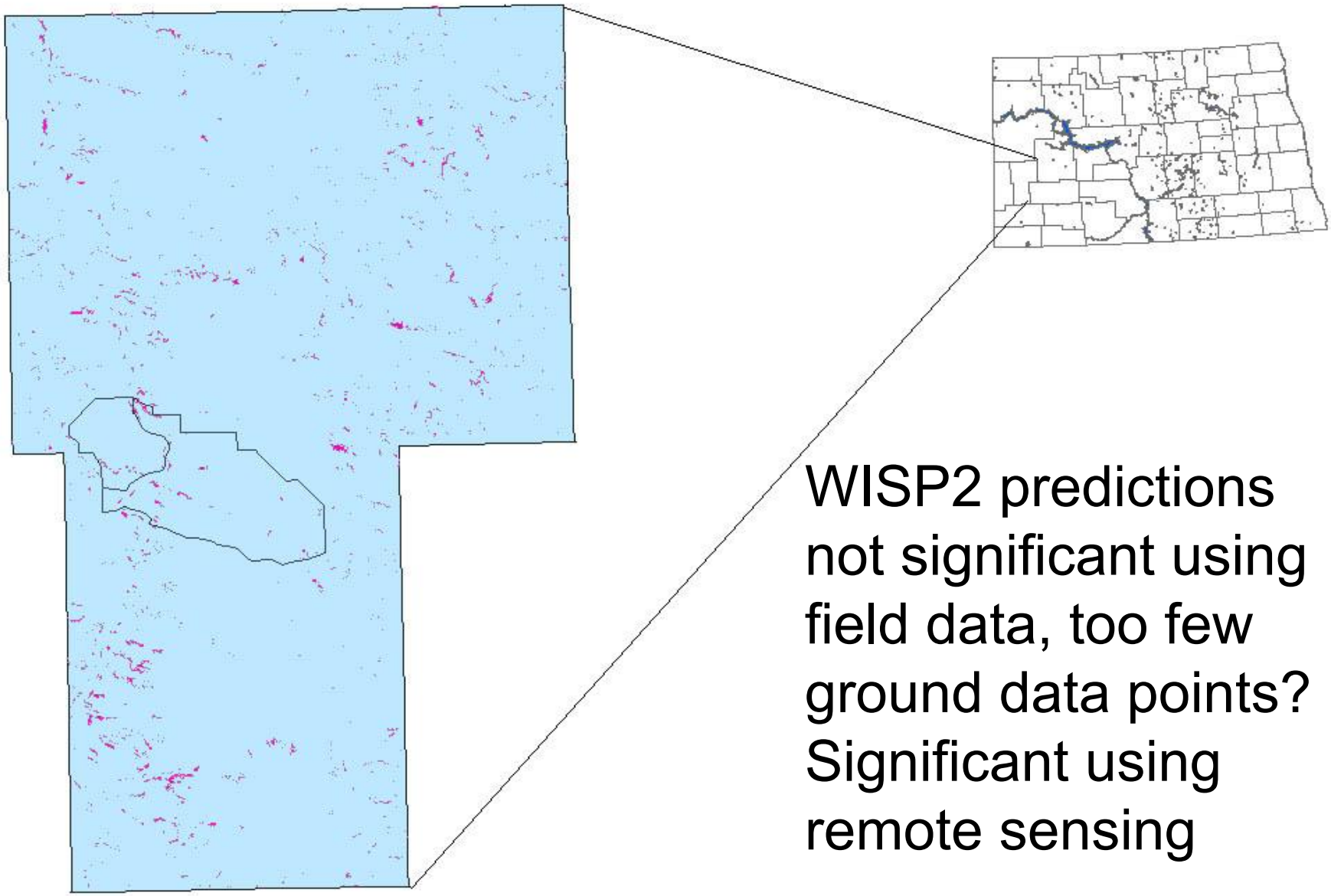


Theodore Roosevelt National Park, South Unit, North Dakota

Leafy spurge is well established throughout the area



Theodore Roosevelt National Park, North Dakota

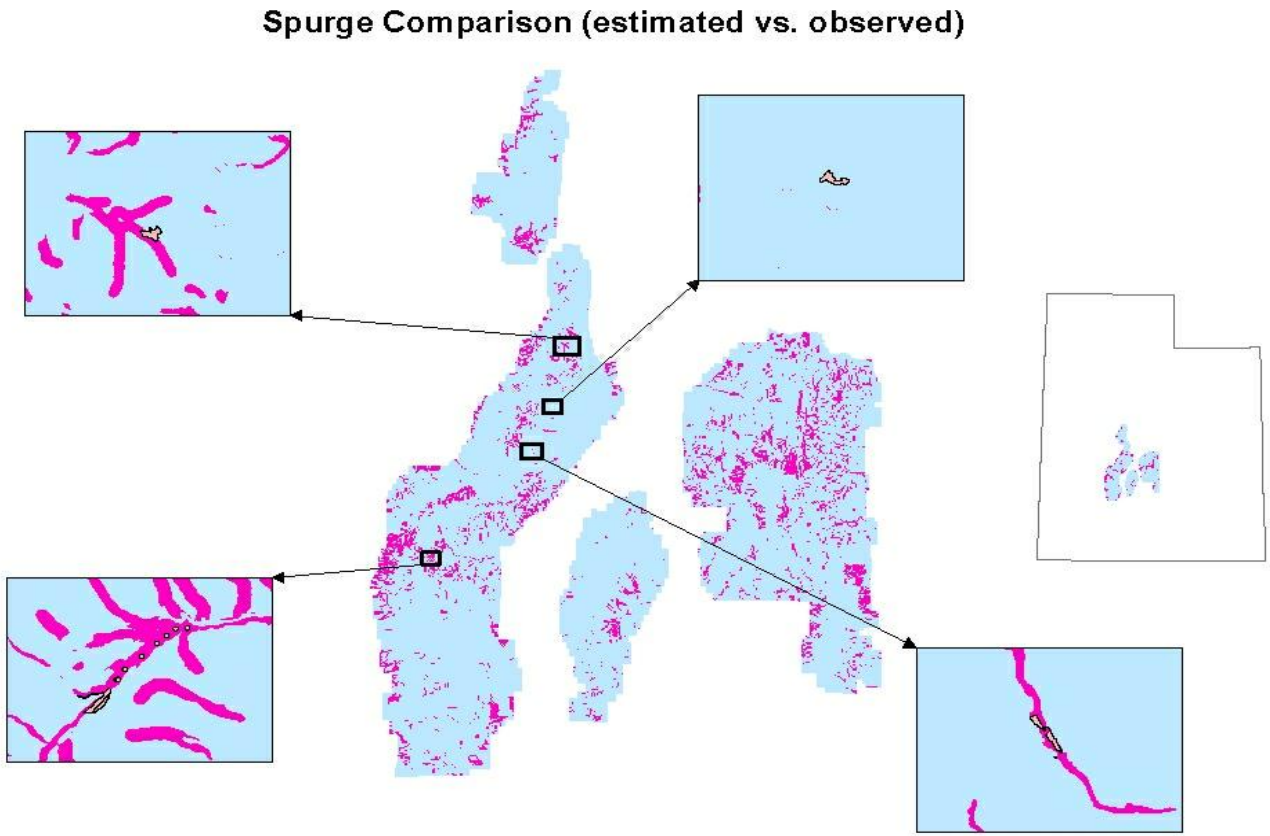


WISP2 predictions not significant using field data, too few ground data points? Significant using remote sensing

Fishlake National Forest, Utah

14 of 17 new infestations found in areas predicted by WISP2

RSAC

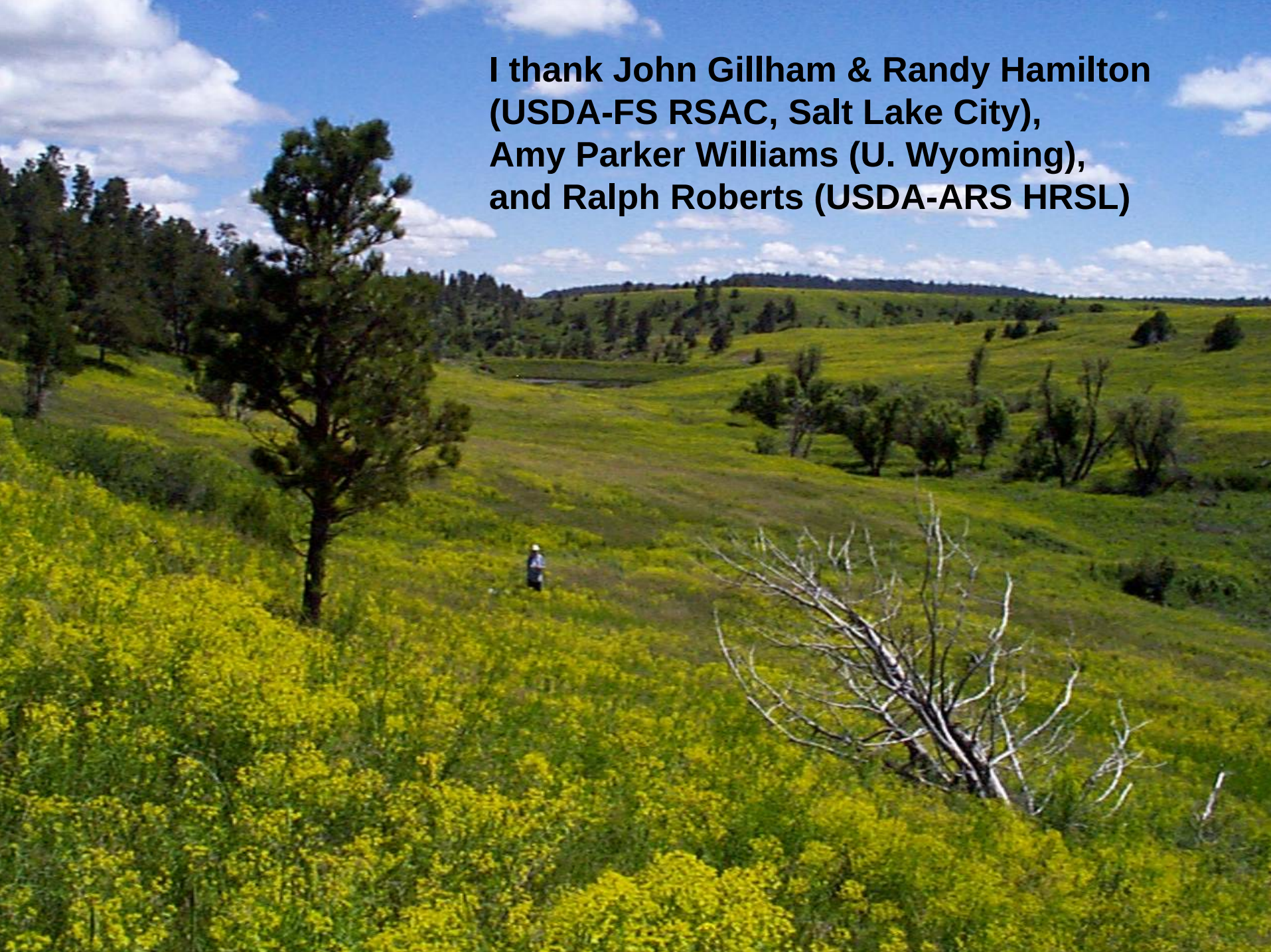


Conclusions

- Invasive species potential distribution models (e.g. WISP) can be over tuned, but there is no predictive power and monitoring very large areas on the ground would not be efficient

- Imaging spectroscopy is not operational; can not be expected to provide wall-to-wall maps for invasive species because only large infestations can be detected

- However imagery can be used to test and refine potential distribution models – smaller areas may be monitored on the ground more efficiently for new infestations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