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)
Leafy spurge (Euphorbia esula)
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?
35% of county rated to be highly susceptible to leafy spurge
A TEAM Leafy Spurge site was centered around Devils Tower National Monument.

AVIRIS data were acquired in 1999.

Field Plots, Devils Tower (SPOT)
Kappa Analysis – corrects accuracy for agreement due to chance

\[ K-hat = \frac{(Pc - Pe)}{(1 - Pe)} \]

Also calculate variance of \( K-hat \)

Field data of Parker Williams & Hunt

<table>
<thead>
<tr>
<th></th>
<th>LS+</th>
<th>LS-</th>
</tr>
</thead>
<tbody>
<tr>
<td>WISP</td>
<td>86</td>
<td>28</td>
</tr>
<tr>
<td></td>
<td>105</td>
<td>27</td>
</tr>
</tbody>
</table>

\[ K-hat = -0.04, \ s^2 = 0.009, \ Z\text{-statistic} = -0.41 \]

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

Reflectance

Wavelength (nm)

Leafy spurge leaf
Leafy spurge bract
Bright dry soil

Landsat Thematic Mapper

SPOT
Classification using spectral angles (vector algebra)
\approx 1000 \text{ km}^2 \quad 12\% \text{ 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!
<table>
<thead>
<tr>
<th>Texture</th>
<th>Z-Statistic</th>
<th>WISP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Loam</td>
<td>-67.37</td>
<td>*</td>
</tr>
<tr>
<td>Sandy Loam</td>
<td>np</td>
<td>*</td>
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<tr>
<td>Clay Loam</td>
<td>-2.86</td>
<td>*</td>
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<tr>
<td>Silt Loam</td>
<td>1.48</td>
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<tr>
<td>N</td>
<td>26.75</td>
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</tr>
<tr>
<td>E</td>
<td>-6.72</td>
<td>*</td>
</tr>
<tr>
<td>S</td>
<td>-16.38</td>
<td>*</td>
</tr>
<tr>
<td>W</td>
<td>-3.96</td>
<td>*</td>
</tr>
</tbody>
</table>

Not significant: Elevation, Soil pH, precipitation

Significant (negative): distance to roads
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
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
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
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
I thank John Gillham & Randy Hamilton (USDA-FS RSAC, Salt Lake City), Amy Parker Williams (U. Wyoming), and Ralph Roberts (USDA-ARS HRSL)