Mapping the distribution & abundance of the invasive weed Centaurea solstitialis using hyperspectral imagery

Sarah Swope1,2 Ray Carruthers1 Ingrid Parker1
1Dept. of Ecology & Evolutionary Biology University of California, Santa Cruz 2USDA ARS Exotic & Invasive Weeds Research Unit, Albany, CA

INTRODUCTION
Effectively managing exotic plant invasions requires accurate data on the abundance and distribution of the invader across the landscape. Of particular importance is the ability to detect small, incipient populations before they become large, persistent invasions. Remotely sensed data is potentially the best way to collect these data because such data can be rapidly gathered over large areas, across management and habitat boundaries, with high spatial resolution. Here we test the ability of hyperspectral imagery to map the distribution and abundance of the invasive plant Centaurea solstitialis L. (Asteraceae) across a 21 km² watershed in a California grassland.

METHODS

Image acquisition and preparation. Hyperspectral imagery was gathered over our study site in late July, 2005 (peak biomass for C. solstitialis) using a CASI2 pushbroom imager (spectral resolution: 450-970nm, 48 bands, 5.8nm channel width; spatial resolution 2m x 2m) (Figure 1).

Using ENVI v.4.1, we applied 2 principle components analyses to segregate noise from signal and retained only informative data for subsequent processing (15 PCA bands, Figure 2).

RESULTS AND DISCUSSION

The result is a gray-scale image in which abundance values, estimated to the nearest half a percent, are embedded in each pixel (Figure 3). We collapsed the abundance data in Figure 4 into categories most useful to land managers and then color-coded them for ease of visual interpretation (Figure 5).

Overall accuracy was 95% (Table 1). The classification was always correct when it indicated that C. solstitialis was present; however, it failed to detect C. solstitialis in 10 cases. C. solstitialis abundance in misclassified pixels was variable but in some cases very high (367g/m² SE, range: 17-835g/m²) indicating that the failure was not attributable to a weak spectral signal driven by extremely low quantities of the plant. Rather, in these cases the plants were growing in particularly xeric microsites and were well into senescence at the time of image acquisition (Figure 6) and water stress is known to alter spectral signatures.

Unfortunately, plant physiological condition, which drives the change in spectral signature, is likely to vary significantly over the spatial scales relevant to remote sensing. A solution to this problem is to identify a priori spectral signatures for the plant under different environmental or phenological conditions (i.e., the target species will have more than one spectral signature). While this is time consuming, errors of omission are especially problematic in invasive species management and such additional effort is likely justified.

The classification predicted canopy cover rather poorly (r²=0.51, df=186, p=0.001) but did a better job of predicting biomass (Figure 7). With the exception of the misclassified pixels, the classification was able to reliably detect C. solstitialis with as little as 1% cover and 5g of aboveground biomass (Figure 8). Detecting exotic plants at low levels of abundance over a large spatial extent, is an invaluable tool in proactively managing incipient invasions. 

![Figure 1: Hyperspectral Image of Study Site](image1.png)
![Figure 2: Noise-whitened Version of Image Following 2 PCAs](image2.png)
![Figure 3: Gray-scale Image with Sub-pixel Abundance Values for Centaurea solstitialis](image3.png)

---

**Table 1. Summary of the accuracy of the classification.**

<table>
<thead>
<tr>
<th>Field</th>
<th>Present</th>
<th>Absent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accuracy</td>
<td>88%</td>
<td>100%</td>
</tr>
<tr>
<td>Overall Accuracy</td>
<td>95%</td>
<td></td>
</tr>
</tbody>
</table>

---

**Figure 7: Ability of classification to quantify biomass cover of target weed**

**Figure 8: Detection Threshold**

---

**Figure 4: Abundance data (Figure 6) has been collapsed into categories most useful to land managers & color-coded for ease of visual interpretation.**

---

**Figure 6: Senescent plants in dry microsite**

---

**REFERENCES CITED**