Introduction

Growers need maps of the distributions of weeds in their fields to reduce herbicide use with site-specific weed management (SSWM). Methods of varying cost and complexity are needed for the widest adoption of SSWM.

Our objective is to develop a system for mapping the variability of the distributions of weeds in dryland crops that is low cost, easy to use, and does not require expensive GIS, GPS and image analysis software.

Overview

We propose using observations of weed cover during control operations in the fallow period to predict the distribution of weeds in the crop rotation for SSWM because:

- Mapping during fallow avoids expensive technology for differentiating between weeds and the crop.
- Growers could collect data during the 3 to 5 trips across a fallow field to control multiple flushes of weeds.
- All weed species of the crop rotation are observed during fallow.
- Weed patches are spatially stable.

Our system includes a consumer digital camera and GPS unit, commercial software to map locations of images and view the image at each location, and image analysis and map viewing software that we developed.

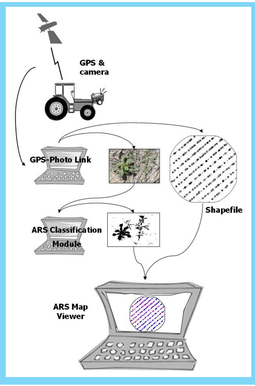


Image Collection

JPEG images are collected every 4 sec while driving 8 to 11 km/hr

Equipment

- Canon* EOS 10D camera (6.3 effective megapixels)
- Entry level wide angle lens (Canon* EF24 mm f/2.8)
- Remote camera control (Canon* TC-80N31)
- Garmin* GPS60 unit (any GPS unit can be used)

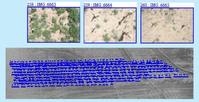
Camera Settings

- Shutter Priority mode (aperature automatically adjusted)
- Shutter speed of 1/4000 sec
- 1600 ISO
- Autofocus

Georeferencing Images

Images are linked to GPS coordinates using commercial software (GPS-Photo Link*).

- The program creates an ERSI* shapefile with the name of each image and associated GPS coordinates.
- We modify this shape file to create weed maps with our software.
- GPS coordinates are identified by matching camera and GPS time.



* Mention of a trade name or proprietary product does not constitute a guarantee or warranty by the U.S. Department of Agriculture and does not imply approval to the exclusion of other products that may be suitable.

ARS Classification Module

Weed Classification Algorithm

Weed cover in an image is estimated as a percentage of green pixels.

The color of a pixel in a JPEG image is described with three values, or bands, that represent the primary colors of light. Each band has a value from 0 (black) to 255 (maximum intensity of red, green or blue).

The green weed pixels are identified by calculations based on the three JPEG color bands. The first step in identifying pixels is calculating a pseudo Normalized Difference Vegetation Image Index (NDVI) with Band 2 representing near-infrared and Band 3 being red.

$$\text{Pseudo NDVI} = \frac{\text{Band 2 - Band 3}}{\text{Band 2 + Band 3}}$$

All pseudo NDVI values greater than zero are initially classified as weed.

Additional processes refine this classification:

- **Remove background shadow effects.**

  Weed pixels with either of these two groups of characteristics are reclassified as non-weed:

  Part A: ABS(Band 1 - Band 2) < 18 AND
  ABS(Band 2 - Band 3) < 16 AND
  ABS(Band 1 - Band 3) < 25

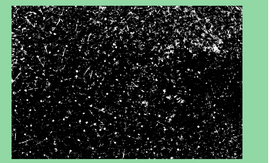
  Part B: Band 1 > Band 2
  AND
  Band 1 > Band 3

- **Identify weeds in overexposed portions of the images.**

  Non-weed pixels with these characteristics are reclassified as weed if there are few corn stalks in the field.

  Band 1 > 200 AND
  Band 2 > 200 AND
  Band 3 > 140 AND
  Band 3 < 200 AND
  Band 1 > Band 3 AND
  Band 2 > Band 3 AND
  Band 2 - Band 3 > 40

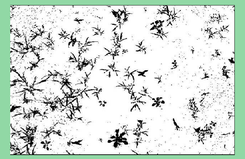
0.4 % Weed Cover



92.8% Weed Cover

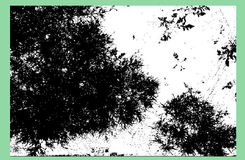
Image Classification

Small weed seedlings are detected and correctly classified in images collected while driving 8 to 11 km/hr.



10.6 % Weed Cover

Weed cover is correctly classified in shadows (center of image) and overexposed areas (top right hand corner).



53.5 % Weed Cover

All species in the fields could be detected.

31.6 % Weed Cover

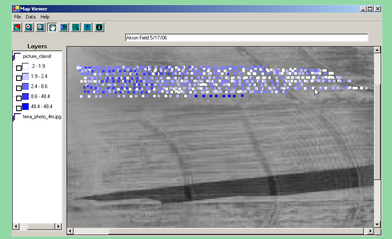
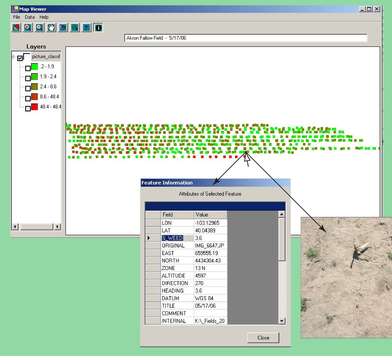
8.5 % Weed Cover

Accuracy Assessment. A formal accuracy assessment is not possible until an error in the commercial raster imaging library is corrected. This error sometimes causes misclassification of pixels. Even with this problem, however, errors of both commission and ommission appear small.

ARS Map Viewer

Features of the Map Viewer:

- View a map of % weed cover
- View classified or original image at any point
- Use aerial photograph or topographic map for the background
- Display additional GIS data in a variety of formats

Conclusions

- **Our classification algorithm appears to be suitable for describing the variability of weed cover of fallow fields in dryland farming.**

  Weeds are detected in images of varied exposures, shadows from plant residue and equipment, and with different soil colors.

- **We have made three important steps toward our goal of an inexpensive, easy-to-use system:**
  - Natural lighting is sufficient for image collection.
  - The algorithm does not have to be calibrated for individual fields.
  - We were able to program the complex tasks of classification and mapping without using any libraries that required royalties for distribution.