REMOTE SENSING OF WOOLLY CROTON USING MANNED AND UNMANNED AERIAL IMAGING SYSTEMS – A FEASIBILITY STUDY

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Abstract

Woolly croton is an annual weed that serves as an overwintering host for the cotton fleahopper. It is therefore important to determine the distribution and density of woolly croton for the management of the insect pest. The objective of this study was to evaluate the feasibility of using aerial imagery captured from manned and unmanned aircraft to detect and map woolly croton infestations. An unmanned aircraft system (UAS) and a manned aircraft were used for image acquisition from a pasture infested with woolly croton. The UAS was equipped with a pair of red-green-blue (RGB) and near-infrared (NIR) cameras and a five-band camera, while the manned aircraft carried a different pair of RGB and NIR cameras. UAS images were acquired at 400 ft above ground level (AGL), while manned aircraft images were captured at approximately 2200 ft. The two types of multispectral images from the UAS were mosaicked, respectively. The two mosaicked UAS images and a single multispectral image from the manned aircraft were then classified, and the three classification maps were compared for the identification of woolly croton infestations. Preliminary accuracy assessment based on training samples used for image classification showed that high resolution aerial imagery from both manned and unmanned aircraft has the potential for mapping woolly croton infestations, though other classification techniques need to be evaluated with more thorough and robust accuracy assessment.

Introduction

Woolly croton (*Croton capitatus* Michaux), also known as hogwort or goatweed, is an annual weed growing to about 3 ft tall. The plant is covered with dense woolly hairs on its stems and leaves, giving it a grayish appearance. It tends to grow in overgrazed pastures and disturbed areas across the southern United States and elsewhere. Croton typically begins to emerge in early summer and continues until the fall when plants begin to senesce. Multiple phenological stages can exist simultaneously on a single plant, including blooming, developing seeds, shattering, and senescing.

Woolly croton serves as a host to the cotton fleahopper, *Pseudatomoscelis seriatus* (Reuter), which is an economically important insect pest of cotton. The cotton fleahopper became the number one cotton pest in 1999 with economic damage estimated to be $196 million (Williams, 2000). The fleahopper has consistently been considered one of the most destructive insect pests of cotton in Texas and Oklahoma (Predel et al., 2012). Woolly croton not only serves as a food source and reproductive host throughout the growing season, it also is the primary overwintering host for fleahopper eggs (Almand et al., 1976; Nyffeler et al., 1987). Diapausing eggs laid in the stems of croton in the fall survive the harsh winter conditions and hatch in the spring under required temperature and moisture conditions to become an early season cotton pest (Gaylor and Sterling 1977; Hakeem and Parajulee, 2015). Fleahoppers hatching from the eggs feed on developing terminals and squares, resulting in plant damage and yield loss (McLoud et al., 2016).

Given that woolly croton is the primary late-season and overwintering host of the cotton fleahopper, determination of the distribution and density of woolly croton may be useful for managing this insect pest. However, little work has been reported in the literature on the use of remote sensing for detecting and mapping woolly croton infestations. Woolly croton has a light grayish appearance, which is helpful for its identification. However, it is not so distinctive from associated plant species, especially when being viewed from a far distance or high altitude. The spatial resolution of traditional airborne and satellite imagery may not be fine enough, but high resolution airborne and UAS imagery obtained at lower altitudes may have the potential for mapping this important weed. The objective of this study was to evaluate the feasibility to detect and map woolly croton infestations using aerial imagery captured from manned and unmanned aircraft.

Materials and Methods

Study Site

This study was conducted in a 40-acre pasture (30°33'49"N, 96°30'51"W) near Snook, TX. The pasture and the surrounding areas are infested with woolly croton.

Image Acquisition

Both a manned and an unmanned aircraft were used to collect images. The manned aircraft was a Cessna 206 equipped with a multispectral imaging system. The imaging system consisted of two Nikon D810 digital cameras with a 7360 × 4912 pixel array. One camera captured normal RGB color images, while the other camera was equipped with an 830-nm long pass filter to obtain NIR images.

The unmanned imaging platform was a HSE-UAV AG-V6A hexacopter (Homeland Surveillance & Electronics LLC, Seattle, WA) equipped with two multispectral imaging systems. One multispectral system consisted of two Nikon D7100 digital cameras with a pixel array of 6000 × 4000 pixels (one RGB camera and one modified NIR camera with an 830-nm long pass filter). The other multispectral system was a MicaSense RedEdge 3 camera (MicaSense, Inc. Seattle, WA). The RedEdge 3 camera had five narrow bands (each with its own global shutter imager), including Blue (475±10 nm), Green (560±10 nm), Red (668±5 nm), Red Edge (717±5 nm), and NIR (840±20 nm).

The manned and unmanned aircraft were flown at 2200 ft and 400 ft, respectively, above ground level (AGL) for image acquisition. The manned aircraft was able to cover the whole study area with one single image, while the UAS was flown along 10 flight lines as shown in Figure 1. Mission Planner (free software available at http://ardupilot.org/planner/) was used to create the flight lines. Aerial images were acquired under sunny conditions on August 17, 2018 while croton was primarily at the blooming stage with an average height of 71 cm. Pixel size achieved was 2 cm, 8 cm and 16 cm for the Nikon D7100, MicaSense RedEdge 3, and Nikotn D810 images, respectively.

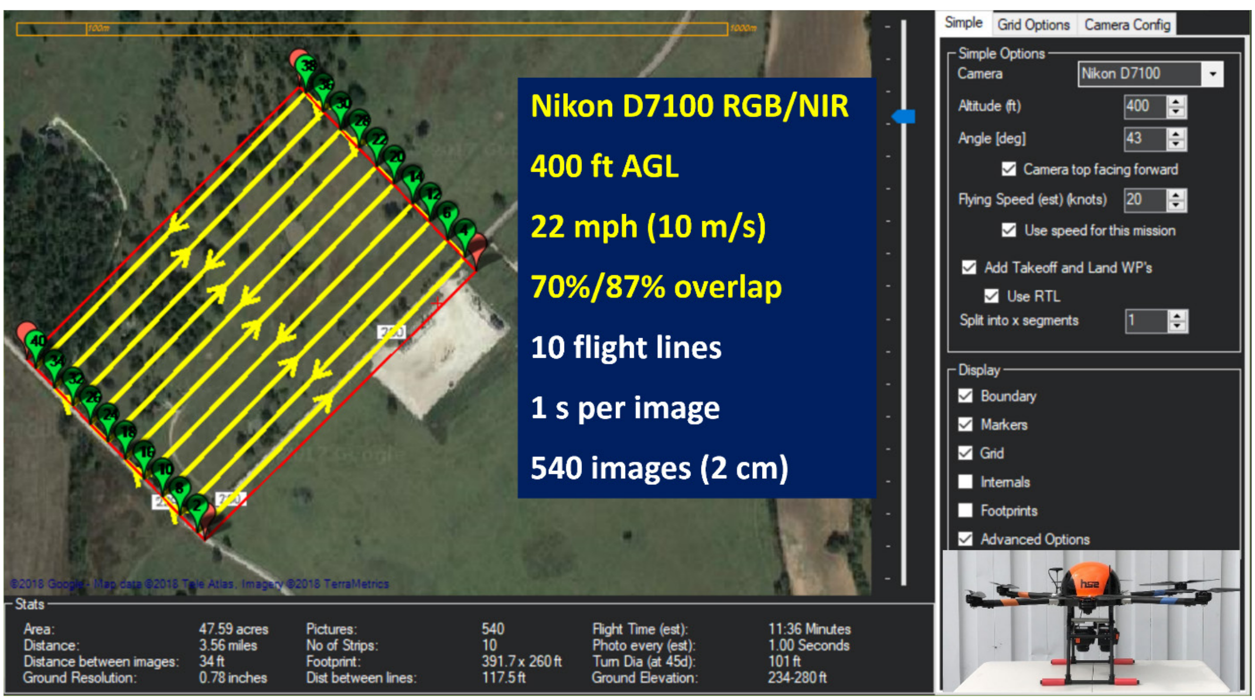

Figure 1. Flight parameters for taking images using a pair of Nikon D7100 RGB/NIR cameras and a MicaSense RedEdge 3 camera on a UAS.

Image Mosaicking

Pix4Dmapper (Pix4D SA, Lausanne, Switzerland) was used to process the UAS images from the two imaging systems into 2D orthomosaics and 3D digital surface models (DSMs). The two orthomosaics from the Nikon D7100 RGB and NIR images and the five band orthomosaics from the MicaSense images were stacked into a RGB/NIR composite image and a five-band composite image, respectively, using Erdas Imagine (Intergraph Corporation, Madison, AL). The Nikon D810 RGB and NIR images were aligned, stacked and rectified to the same UTM coordinate system as the two UAS composite images. As the pixel size of the D810 composite image was 16 cm, the two UAS composite images were resampled and degraded to 16 cm for analysis and comparison.

Image Classification

The study area had diverse cover types including woolly croton at different stages, trees with different canopy tints, mixed vegetation (grass, shrubs, and mixed herbaceous species), and non-vegetation (bare soil, roads, waterbodies and residential areas). A total of 22 subclasses were identified and the corresponding training areas were digitized from the Nikon D7100 composite image for each subclass. The three 16-cm composite images, one for each imaging system, were first classified into 22 classes based on the training samples extracted from each image using maximum likelihood classification. The 22 subclasses were then grouped into four major classes (croton, trees, mixed vegetation and non-vegetation). For preliminary accuracy assessment, the training samples extracted for image classification were used to determine the error matrix for each classification. Overall accuracy, producer's accuracy, user's accuracy, and kappa coefficient were calculated.

Results and Discussion

Figure 2 shows the RGB mosaic from the images acquired by the UAS-mounted Nikon D7100 camera for the pasture. The cover types that could be visually distinguished from the image included trees, roads and waterbodies. The grasses growing around the two ponds and the green herbaceous plants between the two ponds had a distinct green color, while the rest of the pasture had a grayish to lime greenish tone. Woolly croton has a grayish color as can be seen on the ground, but it is difficult to distinguish it from other mixed herbaceous plants by visualizing the images.

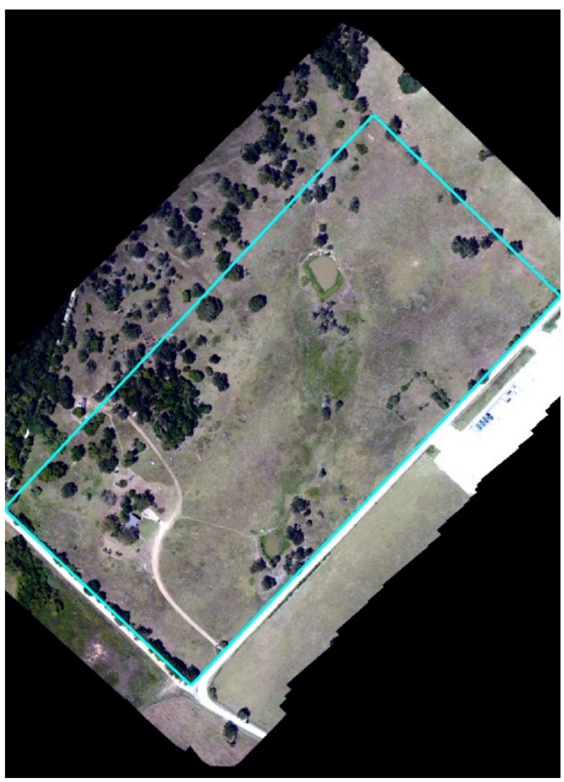

Figure 2. RGB mosaic from images acquired by a UAS-mounted Nikon D7100 camera for a woolly croton-infested pasture near Snook, TX.

Figure 3 shows the classification maps for the mosaicked image shown in Figure 2 based on the maximum likelihood classifier. Preliminary accuracy assessment based on the training samples showed that overall accuracy was 91.4%, 83.5% and 95.9%, respectively, for the Nikon D7100, MicaSense RedEdge 3 and Nikon D810 images. The estimated croton coverage was 25%, 18% and 30% from the three respective images. It should be noted that the accuracy values were only based on the training samples and a more thorough accuracy assessment scheme based on a random stratified pattern is needed.

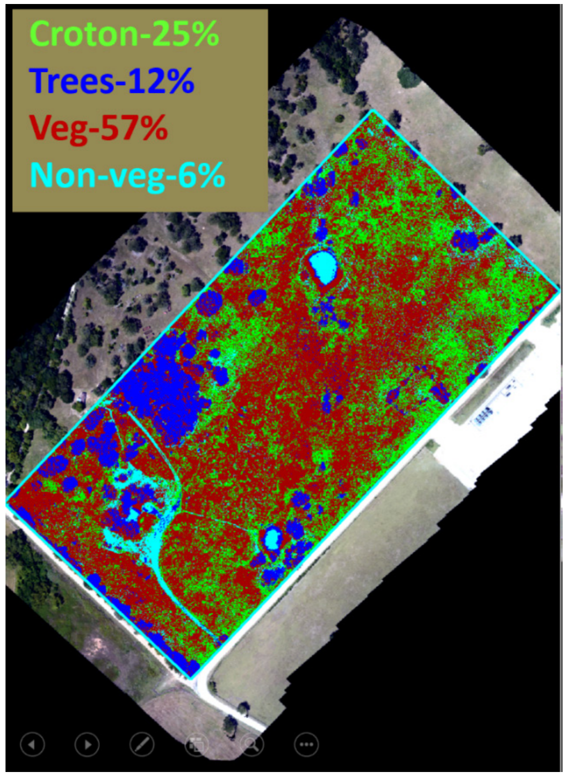

Figure 3. A classification map of the mosaicked image shown in Figure 2 for a woolly croton-infested pasture near Snook, TX.

Summary

Preliminary results from this pilot study indicate that woolly croton can be detected and mapped from aerial multispectral imagery. High resolution imagery from UAS may help distinguish croton from other associated plant species, but it takes more time to use UAS for image acquisition and processing. Imagery from manned aircraft is more practical for mapping croton infestations over large geographical areas. Nevertheless, UAS imagery will be useful for training sample identification and for accuracy assessment. Further research is needed to evaluate different imaging systems and aircraft platforms as well as different image classification methods for croton identification.

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