DETECTION OF POTATO BEETLE DAMAGE USING A SMALL UNMANNED SYSTEM

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ABSTRACT

Colorado potato beetle (CPB), *Leptinotarsa decemlineata* Say, adults and larvae devour leaves of potato, *Solanum tuber*osum L., and other solanaceous crops and weeds. With early detection of CPB damage, more options are available for precision integrated pest management, which reduces the amount of pesticides applied in a field and reduces pesticide resistance. Remote sensing with small unmanned aircraft systems (sUAS) has potential for CPB detection because low flight altitudes allow image acquisition at very high spatial resolution. Thus, a five-band multispectral sensor and light sensors were mounted on a six-rotor sUAS, which was flown at altitudes of 30 and 60 m in June 2014. Plants went from visibly undamaged to having some damage in just 1 day. Whole-plot normalized difference vegetation index (NDVI) and the number of pixels classified as damaged (0.70 ≤ NDVI ≤ 0.80) were not correlated with visible CPB damage ranked from least to most. Area of CPB damage estimated using object-based image analysis was highly correlated to the visual ranking of damage. Furthermore, plant height calculated using structure-from-motion point clouds was related to CPB damage, however, this method required extensive operator intervention for success. Object-based image analysis has potential for early detection based on high spatial resolution sUAS remote sensing.

INTRODUCTION

- Potatoes (*Solanum tuberosum* L.) were the first crop for which insecticides were routinely used.
- One of the most important insect pests of potato is the Colorado potato beetle (CPB), *Leptinotarsa decemlineata* Say, (Coleoptera: Chrysomelidae).
- Larvae and adults are voracious leaf eaters that can rapidly defoliate a field of potatoes.
- Early detection allows for more IPM options, including reducing amount of insecticides applied for control.
- Insect defoliation of a crop canopy may be remotely sensed by the reduction of leaf area or biomass as measured by spectral vegetation indices, such as the normalized difference vegetation index (NDVI).

Objective:

Early detection of CPB using a sUAS

CPB larvae feeding on potato leaves

CPB larvae

Adult CPB

Field destroyed by CPB

METHODS

- The study was conducted at Oregon State University's Hermiston Agricultural Research and Extension Center (HAREC) located in Hermiston, Oregon (45.82021°N and 119.28364°W, 180-m elevation).
- Small plots of potatoes (Ranger Russet) were established on 22 April 2014, using a randomized block design with four treatments and four replications (Fig. 1a).
- On 9 June 2014, different numbers of CPB were placed in each plot and by 24 June 2014, the damage on the potatoes was obvious.
- The Environment for Visualizing Images (ENVI) version 5.3 (Harris Geospatial Solutions, Boulder, Colorado) was used to calculate various spectral vegetation indices (Fig. 1b and 1c).
- The 16 plots were visually ranked from the least damaged to the most damaged.

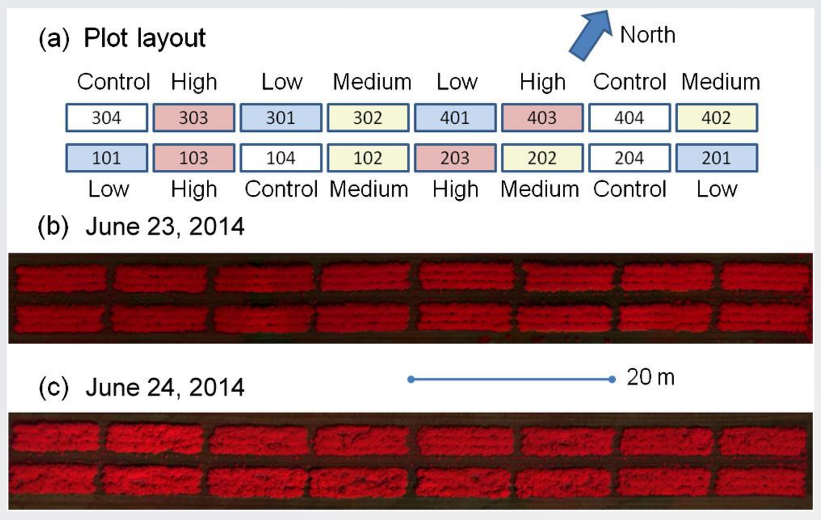


Fig. 1 (a) Plot layout for additional CPB on "Ranger Russet" potatoes. Treatments consisted of placing additional CPB per plant: control, 0; low, 1.5; medium, 4.5; and high, 7.5. (b) Color-infrared orthomosaic image from flights on June 23, 2014, at 60-m altitude above ground level. (c) Colorinfrared orthomosaic from flights on 24 June 2014, at 60-m altitude.

RESULTS

- There was no indication of potato leaf loss or plant damage from the images acquired on 23 June 2014. There were visibly damaged areas in all plots on the very next day, 24 June (Fig. 2a & 2b).
- For undamaged areas, pixel-based NDVI showed a much larger range from 0.78 to 0.93 (Fig. 3), which was not apparent in the whole-plot averages (Fig. 2b).
- The cumulative frequency distribution of pixel NDVI from both altitudes, 30 and 60 m, was used to determine that a threshold of NDVI ≤ 0.8 was a good criterion for distinguishing between damaged and undamaged plants within a plot.
- For the most impacted plot [plot 102, Fig. 1(a)], the area classified as damaged was less than 10%, which was too small to have a strong effect on whole-plot mean NDVI (10% area × 0.75 þ 90% area × 0.85 ¼ 0.84).

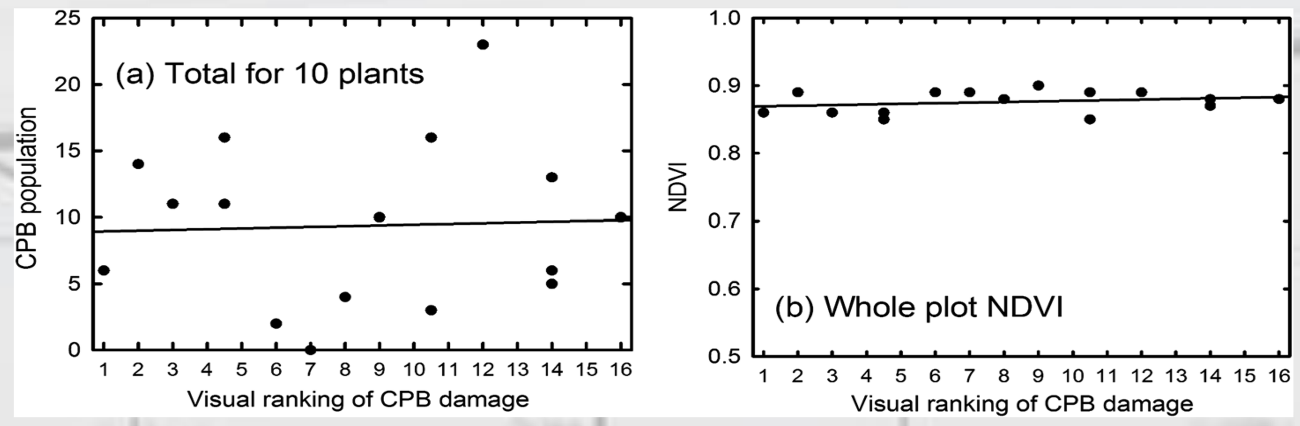


Fig. 2 CPB damage per plot was ranked from least to most. (a) The number of CPB counted on ten plants on July 2, 2014. (b) Whole-plot-mean NDVI on June 24, 2014, from an altitude of 30 m. The Spearman rank correlation coefficients were not significant.

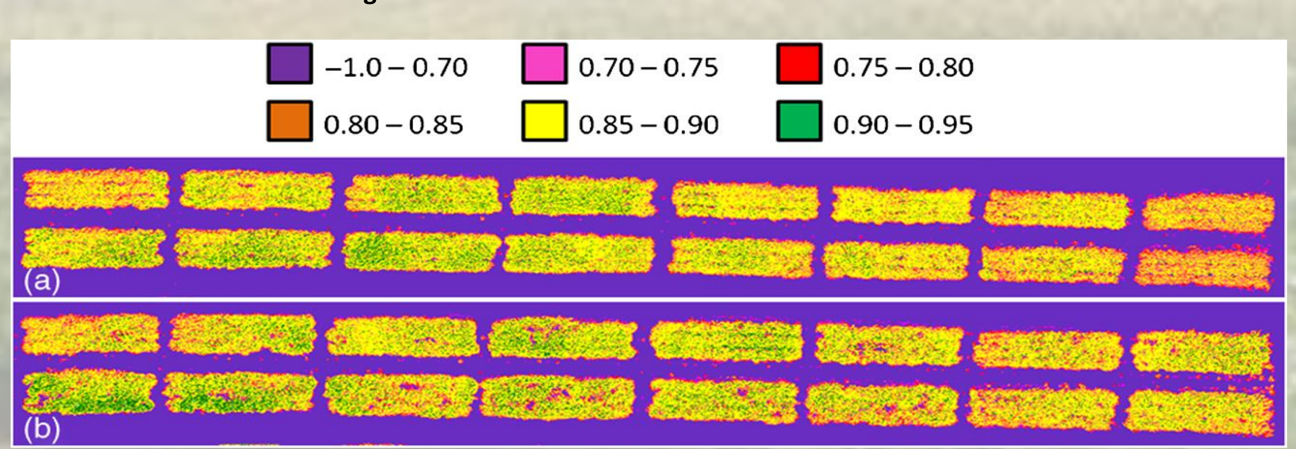
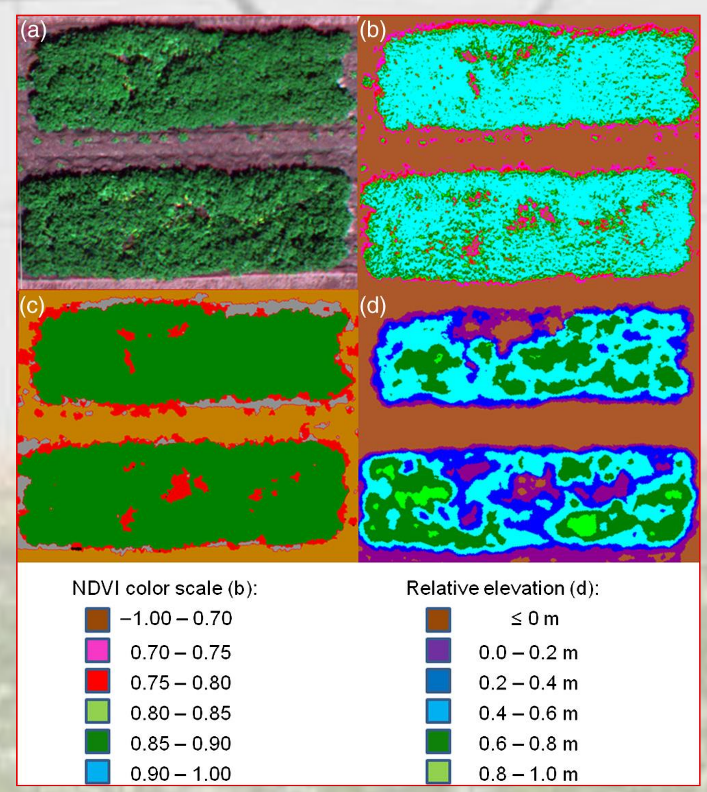
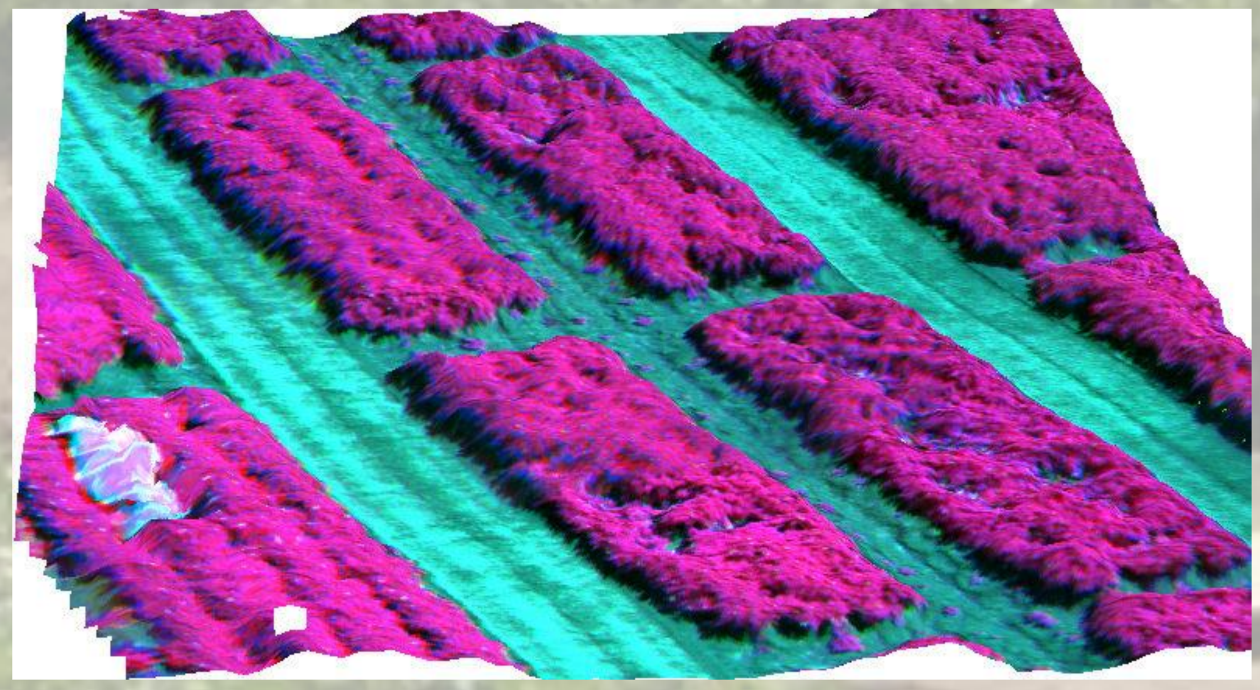


Fig. 3 NDVI on (a) June 23, 2014 and (b) June 24, 2014, from orthomosaic images acquired at 30-m above ground level. Plots are aligned the same as in Fig. 1(a).



True color subset of plots 302 (top) and 102 (bottom) from the 24 June 2014, orthomosaic acquired at 30-m altitude. These two plots were near the center of the point cloud, which had the least overall curvature. Plot 102 was visually ranked 16th (the most visual damage), whereas plot 302 was ranked 7th. Edge pixels were not included in the analyses. (b) NDVI with color ranges selected to show damage. (c) Rule-based classification of damage (red) and no damage (green). (d) Relative elevation above ground level determined from the point cloud.



CONCLUSIONS AND IMPLICATIONS

- Leaf and plant damage caused by CPBs was spatially unpredictable and appeared just over 1 day, so frequent sUAS flights with extensive coverage were needed for early detection.
- We compared three methods for supervised classification of early CPB damage: pixel-based NDVI thresholds, object-based image analysis, and plant height.
- Using an orthomosaic image, all three methods found small areas of CPB damage on the day that the damage was first visually detectable.
- When compared to a visual damage ranking, feature extraction based on object-based image analysis was the most accurate method for detecting the relative amount of plant damage.

Acknowledgements. The project was funded in part by Boeing Research & Technology, Kent, Washington, United States. We thank Alan E. Bruce and Robert W. Turner from Boeing Research & Technology for the initial image processing. Also, we thank Josh J. Brungardt from Paradigm ISR (Bend, Oregon, United States) for managing the UAS and FAA COA. Thanks to Philip B. Hamm for facilitating the research at the Hermiston Agricultural Research and Extension Center and to Jonathan Macias for helping organize this poster

E. Raymond Hunt Jr & Silvia I. Rondon. 2017. Detection of potato beetle damage using remote sending from small unmanned aircraft systems. J. Appl. Remote Sens 11(2): 026013. doi: 10.1117/1.JRS.11.026013

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