Vegetation Forensics

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Army-Contract MOIE

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Problem

- Using current approaches, it is often difficult to directly detect adversary activity of interest to the national security community.
- Difficulty of detection stems from the *clandestine and transient* nature of activities as well as active *denial and deception (D&D)* techniques employed.
- Direct detection may be especially difficult. Indirect techniques via remote sensing may provide the greatest payoff.

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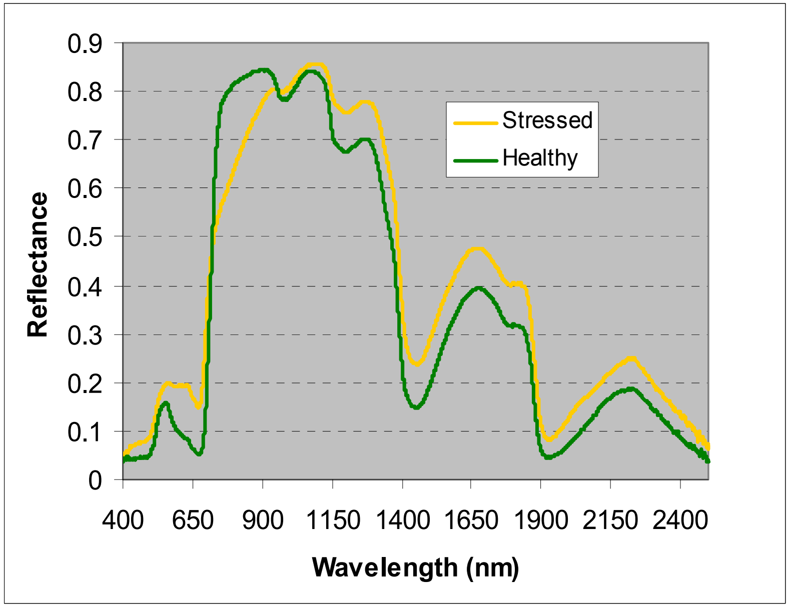
Background

Hyperspectral Remote Sensing of Vegetation Health



Foliage obscures direct detection, but spectral signature indicates possible activity.

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Objective

- To use hyperspectral remote sensing of vegetation stress as an indirect indicator of human activity
- To extend current research to determine the level and type of stress detectable for activities of interest to national security with an initial focus on chemical stress applications

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Activities

- Perform stress studies
  - Chemical stress
  - Drought stress
- Reflectance measurements
  - Determine / verify spectral vegetation indices and other measures for detecting stress
- Chlorophyll fluorescence studies

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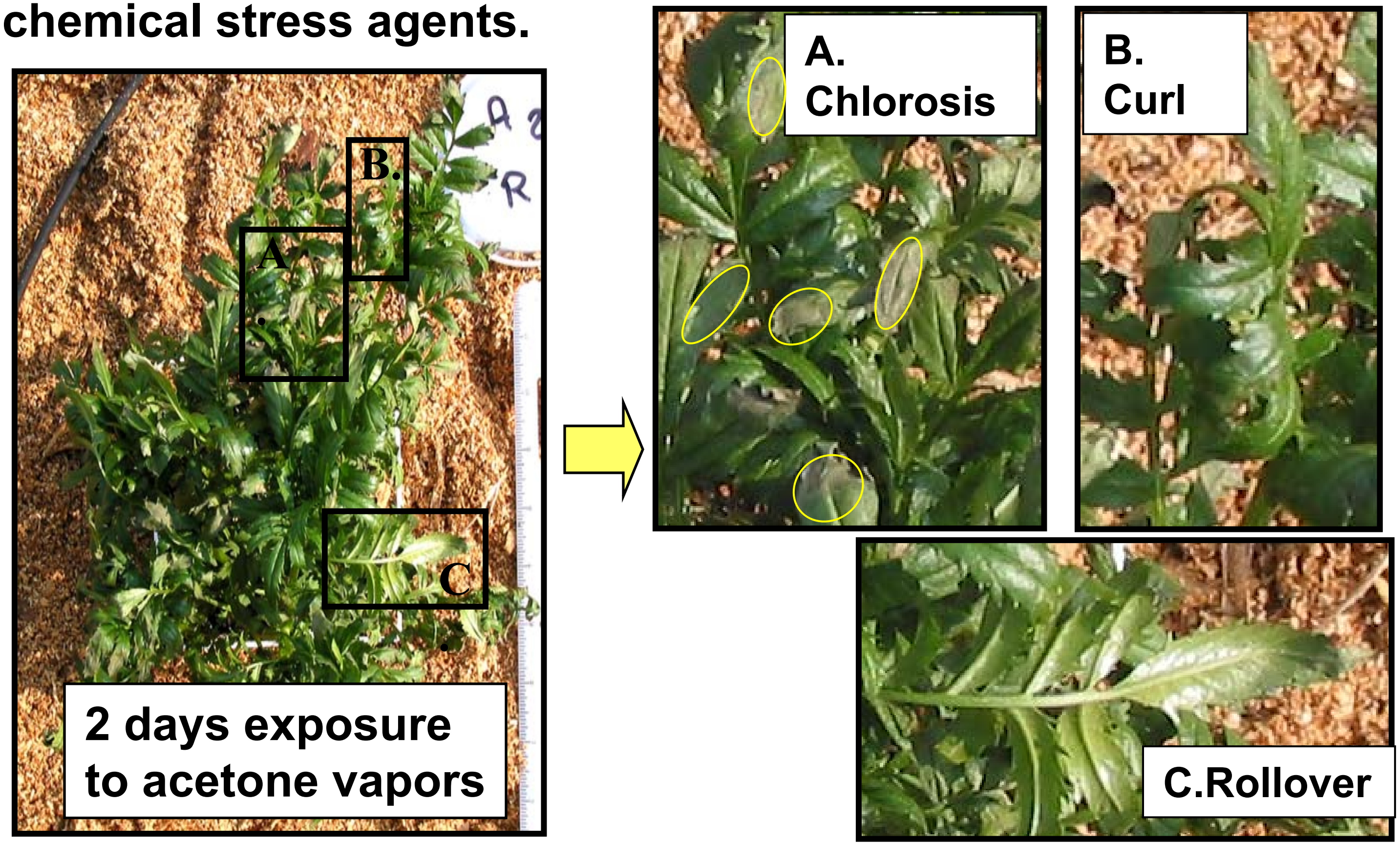
Highlight

Completed preliminary experiments exposing vegetation to chemical stress agents.



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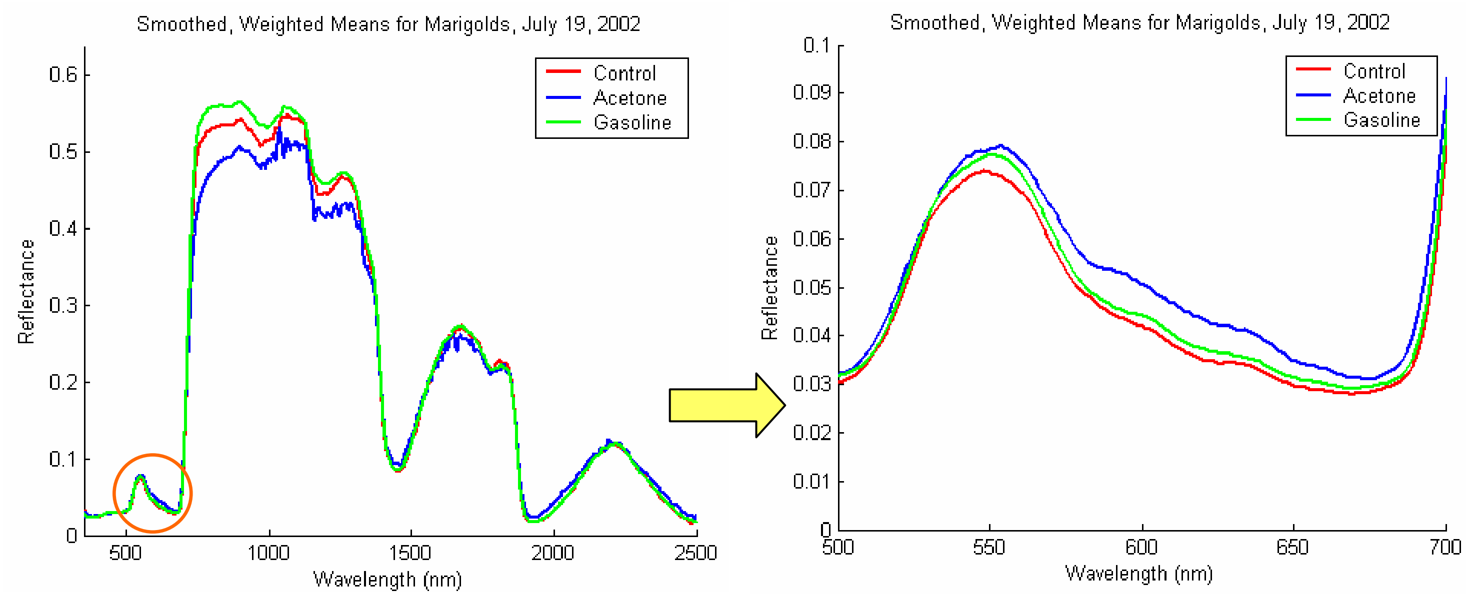
Demonstration



For acetone treatments, chlorosis is evident as an increased reflectance in the yellow-green region of the spectrum, and at the same time a decreased reflectance in the far red/NIR.

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Impacts

- Community collaboration: government, academia, research consultants
- Completed preliminary studies of vegetation stress incurred by the exposure to harmful vapors
  - Plants vary in sensitivity.
  - Preliminary results show differences in band ratios between control and stressed plants.
  - Enhanced results using combinations of stress indices

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Impacts

Vegetation Stress Indices

Marigolds

Band Ratio	Control	Acetone	Gasoline
R800/R685 (biomass)	17.92 ± 0.47	16.33 ± 0.93	17.20 ± 0.88
R750/R700 (chl.)	6.40 ± 0.07	5.87 ± 0.46	5.95 ± 0.24
R750/R550 (chl.)	6.86 ± 0.10	6.44 ± 0.39	6.43 ± 0.26
R760/R690 (Carter's)	14.99 ± 0.30	12.72 ± 0.57	14.30 ± 0.72
NDVI	0.89 ± 0.01	0.87 ± 0.02	0.89 ± 0.00

Impatiens

Band Ratio	Control	Acetone	Gasoline
R800/R685 (biomass)	8.38 ± 0.41	5.83 ± 1.21	7.19 ± 1.00
R750/R700 (chl.)	2.73 ± 0.08	2.37 ± 0.37	2.61 ± 0.17
R750/R550 (chl.)	2.93 ± 0.07	2.77 ± 0.32	2.86 ± 0.13
R760/R690 (Carter's)	6.00 ± 0.24	4.44 ± 0.88	5.32 ± 0.65
NDVI	0.76 ± 0.01	0.72 ± 0.05	0.74 ± 0.03

Red ⇒ Significant difference with control plants (t-test:p < 0.05)

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Impacts

Maximum-Likelihood Detection and Equal Error Rate Analysis

Species	Task	EER % (∗)	Band indices
Impatiens	acetone-vs-control	6.67 ± 3.99	RG
Impatiens	acetone-vs-control	0.0	RG + GS or RG + R750/R550
Impatiens	gasoline-vs-control	30.67 ± 7.38	R800/R685
Impatiens	gasoline-vs-control	14.67 ± 5.66	R800/R685 + YG + R740/R680 + NIR31 + GRPK + NDVI + R695/R760 + TM54
Marigolds	acetone-vs-control	6.67 ± 3.99	NCHL or R695/R760 or R750/R700 or RE31
Marigolds	acetone-vs-control	1.33 ± 1.84	NCHL + CHLMIN + YG + GRPK
Marigolds	gasoline-vs-control	24.00 ± 6.83	CHLMIN
Marigolds	gasoline-vs-control	17.33 ± 6.06	CHLMIN + R750/R550 + NIR31

(∗) Tested on training data. 3 groups, 5 plants/group, 15 spectra/plant (2x75 spectra per task)

Classify the *normalized* distance between index B_i from the sample spectrogram and the mean spectral index m_{Bi} for the "Control" group (7 simple band ratios & 14 broad band indices)

Equal Error Rates (EER) with 95% confidence intervals for detection task (control-or-treated)

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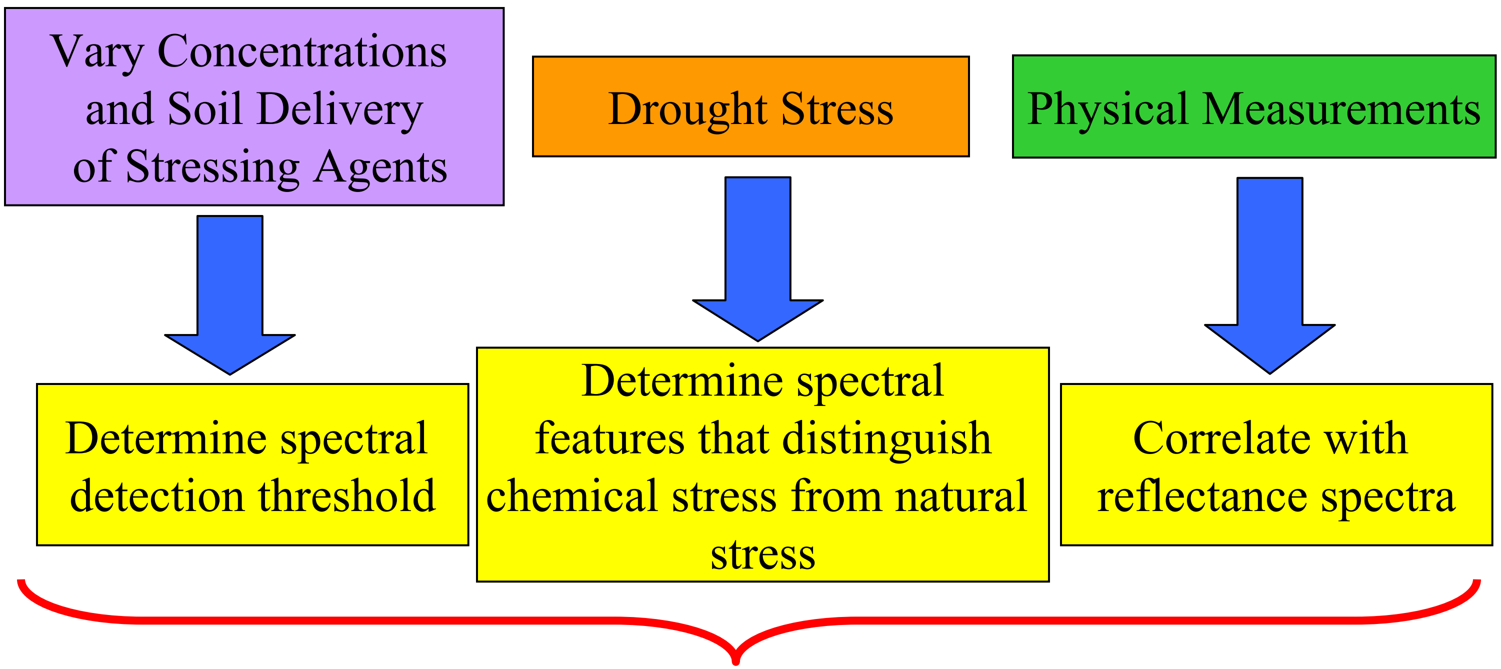
Future Plans

Expanded Plant Level Experiments



Input parameters for classification algorithms

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