

Advanced Technology for Precision IPM

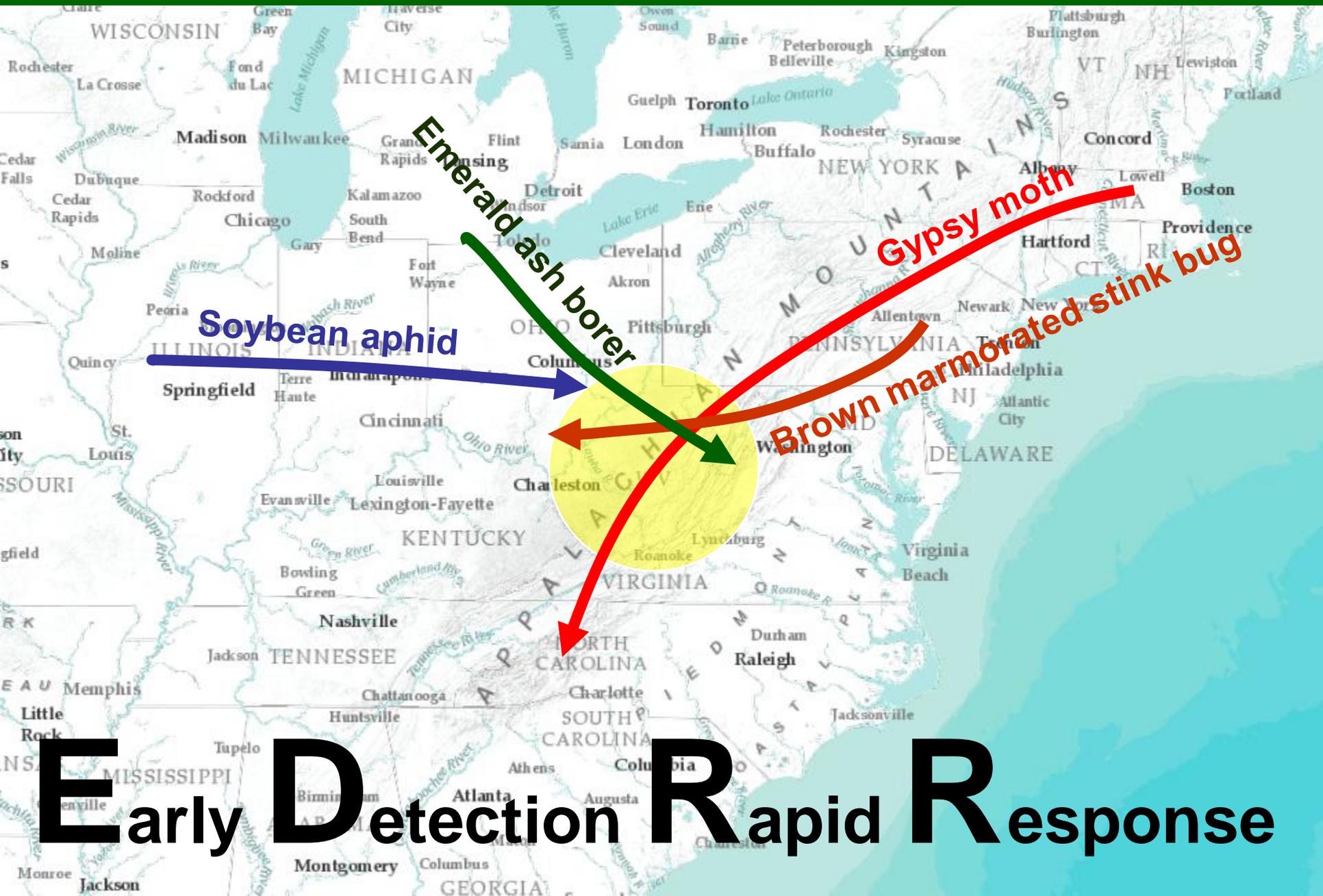
Robotics and Sensors - Examples from the Field



Yong-Lak Park

Entomology @ West Virginia University

Pests in Large Geographic Areas



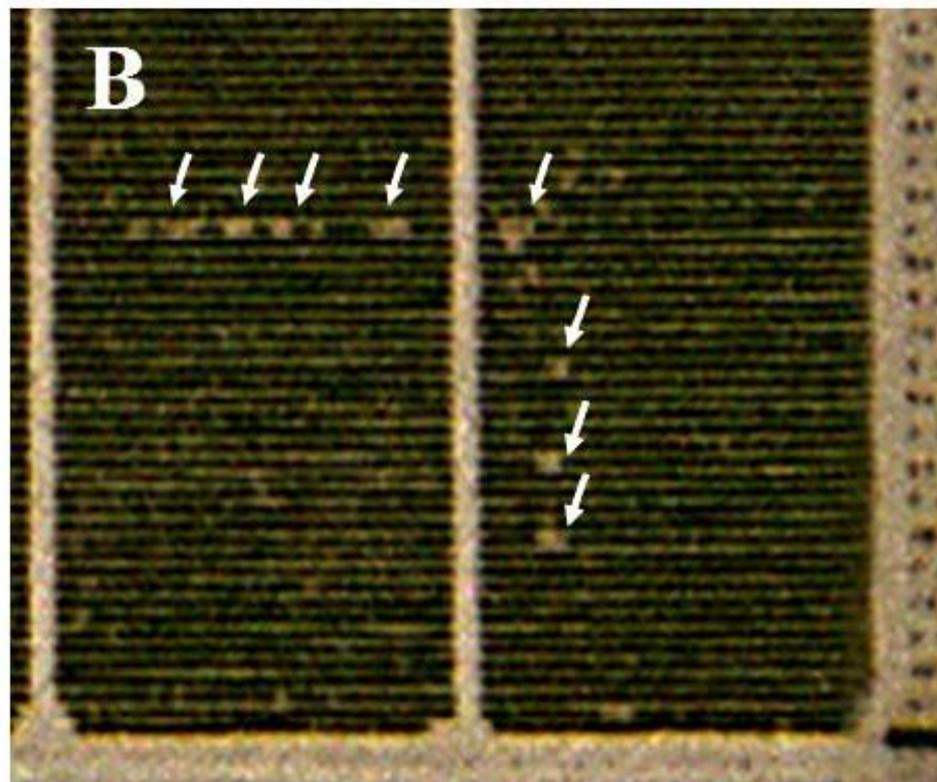
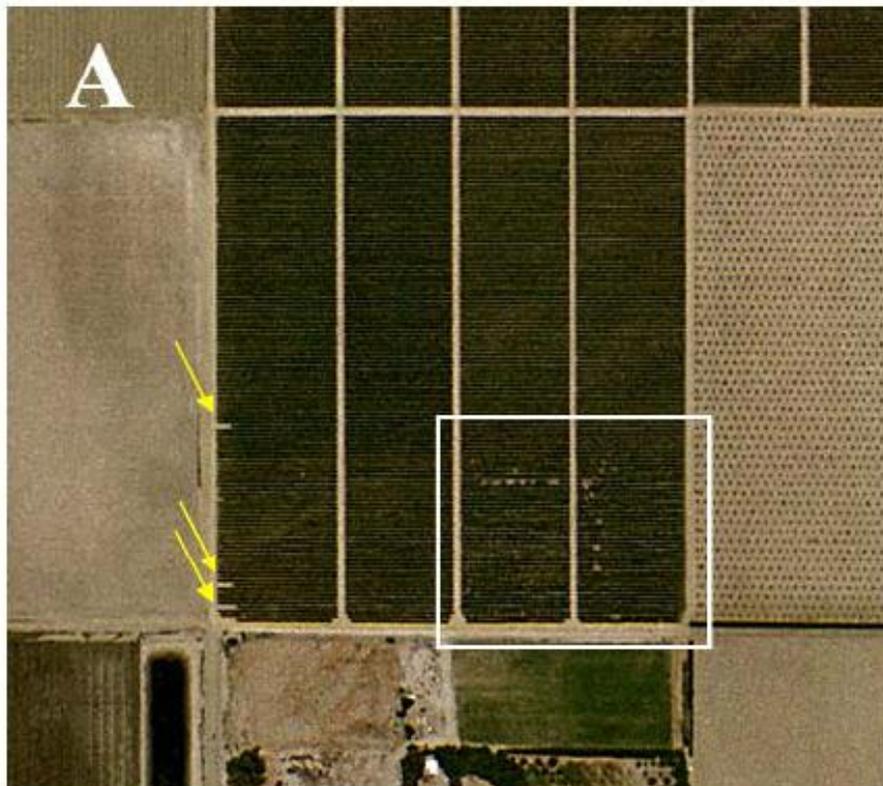
Early **D**etection **R**apid **R**esponse

Remote Sensing



Images are free, but may be outdated

Remote Sensing: Commercial Airplane



Need airstrip, pilot, and \$\$

Aerial Survey: Safety Issues



NEWS RELEASE

USDA Forest Service, Northeastern Area State and Private Forestry
180 Canfield St, Morgantown WV 26505



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Forest Service Employees in Fatal Plane Crash

Two Forest Service employees and a pilot lose lives in [fatal plane crash while conducting aerial surveys](#)

Morgantown, W.Va. June 22, 2010 – It is with great sadness that we confirm the names of the Forest Service employees who tragically lost their lives while conducting an aerial pest survey yesterday. The deceased Forest Service employees are [Rodney Whiteman and Dan Snider](#). A contracted pilot was also on board.

Rodney Whiteman, Forester, was 46 years old and had worked for the Forest Service for 24 years. After graduating from Penn State University, Rod began working for the U.S. Forest Service in 1986 as a Forestry Technician with the Northeast Research Station working on Oak Dominated Forests Research projects. In 1987, he transferred to the Morgantown Field Office, Northeastern Area, State and Private Forestry as a Forester in the Forest Health Protection Group. Over the years, he became an expert in all aspects of the Gypsy moth suppression projects on all federal lands in the Mid-Atlantic States. In addition to his work on the Gypsy moth suppression project, Rod worked extensively as a firefighter and was certified as a Firefighter Type 2, Single-resource Helicopter Manager and Faller B. He served as the

Sometimes, We Need...

Surveying safely

Surveying real-time

Acquiring high-resolution images

Covering large areas in a short period

Monitoring hard-to-reach areas



Use of Unmanned Aerial Vehicle (UAV)

Unmanned Aerial Vehicle (UAV)



No on-board pilot!
Unmanned Aerial System (UAS)
a.k.a. "drone"

UAVs at West Virginia University



Photo Courtesy: Y. Gu & S. Gururajan

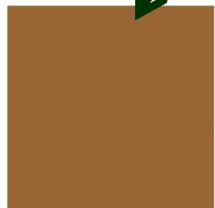
Autonomous UAV

GPS-guided

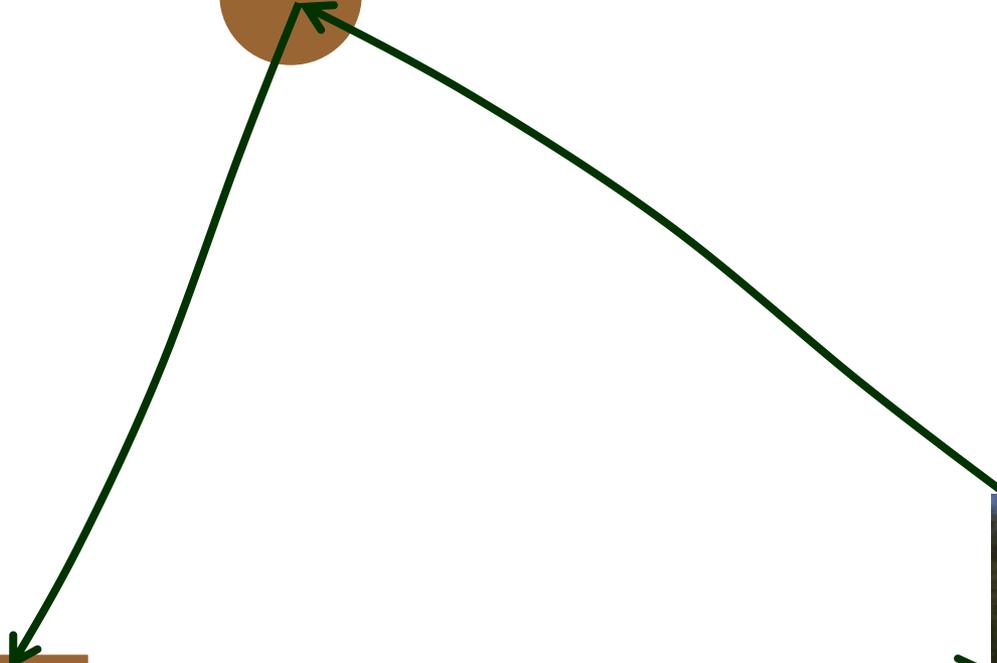
Take picture



No ground pilot



Spray pesticide



Pest Management with UAVs @ WVU

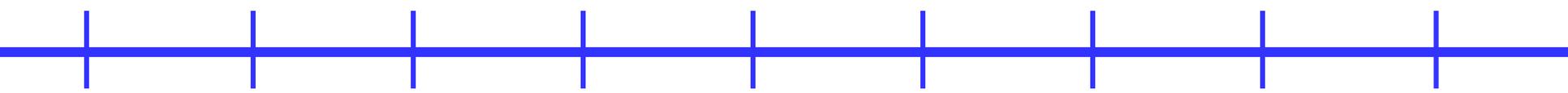
Pilot Study: proof-of-concept study

Aerial weed detection in vineyards

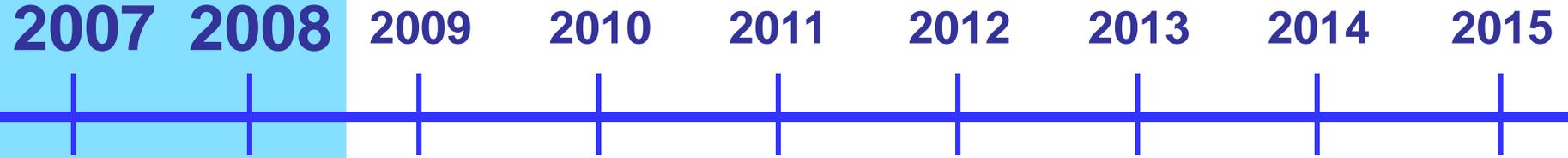
Aerial insect detection

Aerial delivery of predators

2007 2008 2009 2010 2011 2012 2013 2014 2015



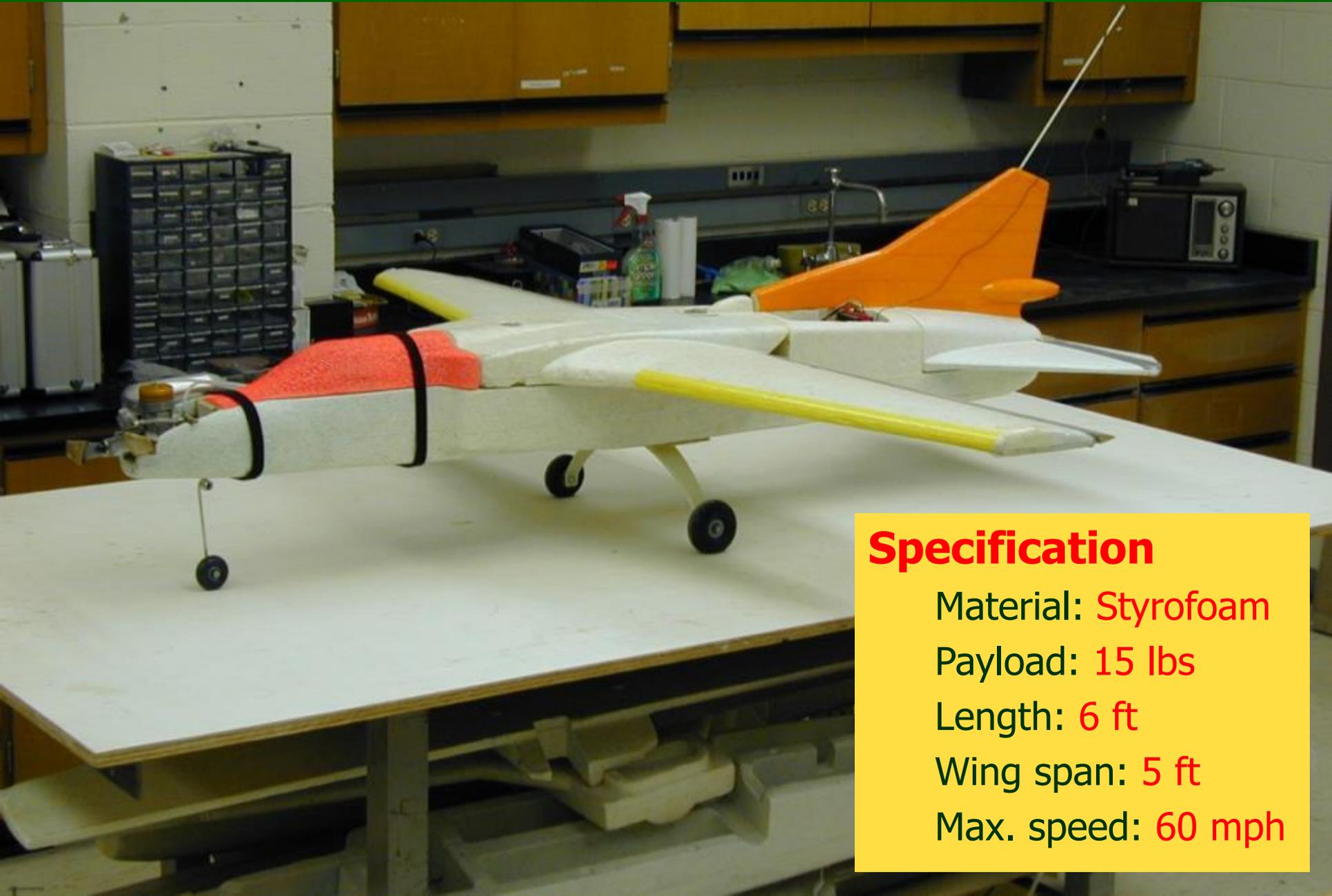
Research on UAV in Agriculture @ WVU



Pilot Study: Early Development of UAV

Jane Lew, West Virginia

UAV for Pilot Study: MiG-29



Specification

Material: Styrofoam

Payload: 15 lbs

Length: 6 ft

Wing span: 5 ft

Max. speed: 60 mph

UAV for Pilot Study

Sensor

Canon Rebel XT
10 MP
55 mm lens
Remote Operation

Data Recorder

Eagletree Systems
Black box
GPS



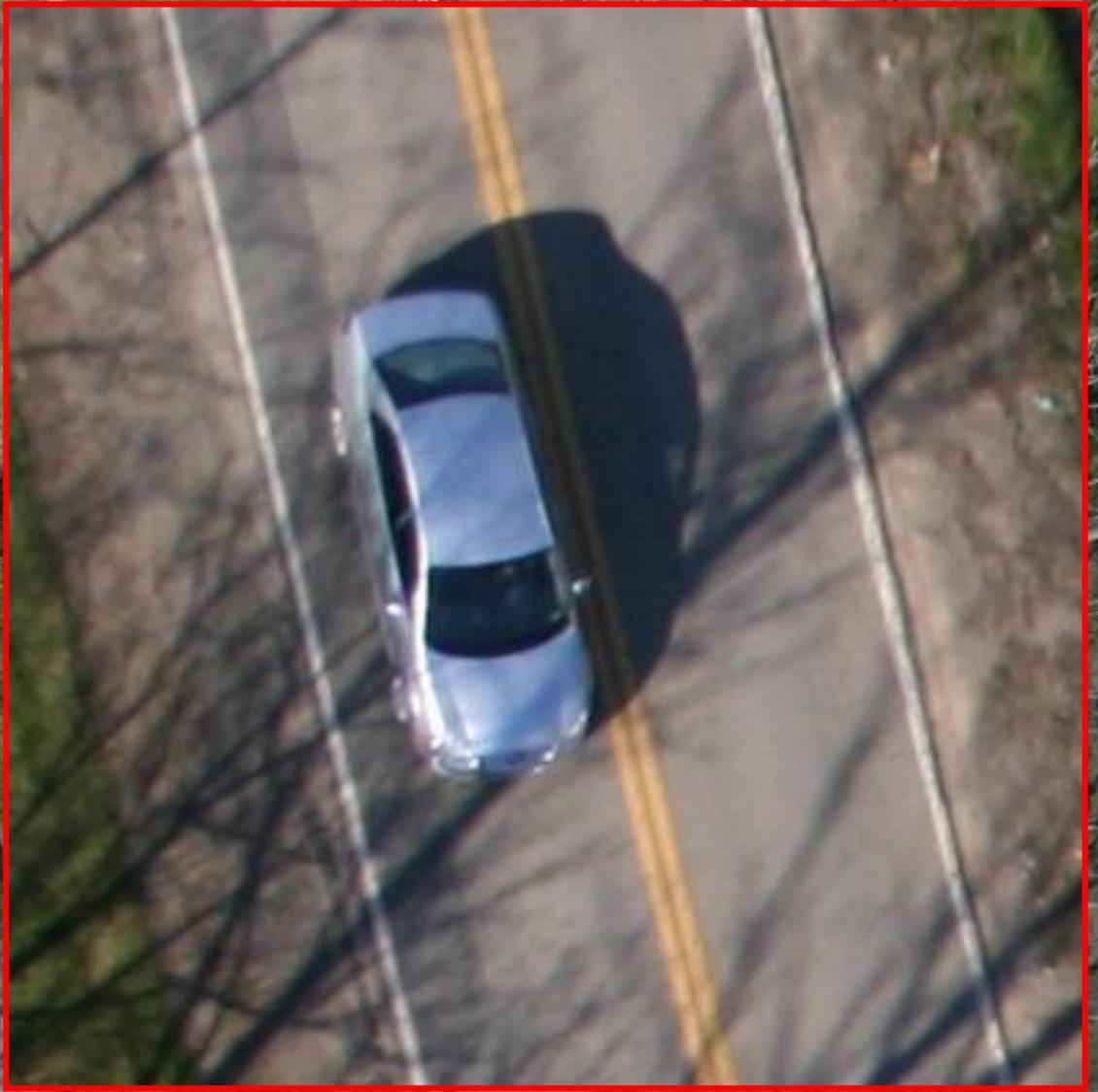
➔ **Design concept: cheap, light, and easy**

Images taken by UAVs



Photo Courtesy: Y. Gu & S. Gururajan

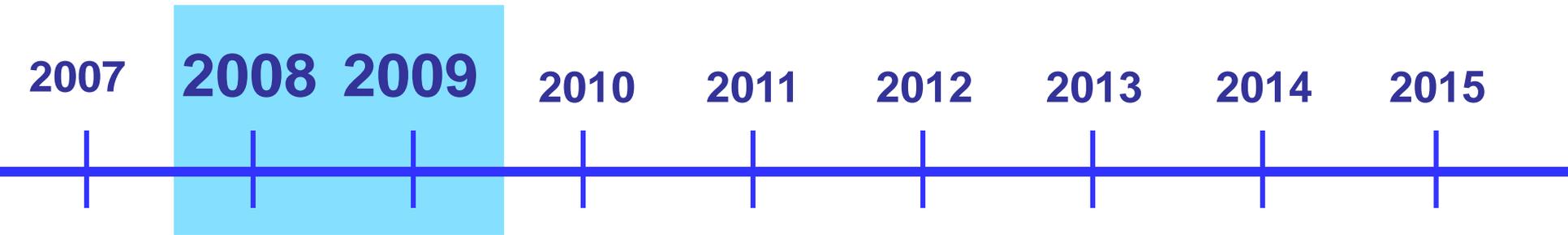
Images taken by UAVs



Images taken by UAVs



Research on UAV in Agriculture @ WVU



Pest Detection in Vineyards

Central Valley, California

Morning Glories in Vineyard



UAV for Aerial Photography



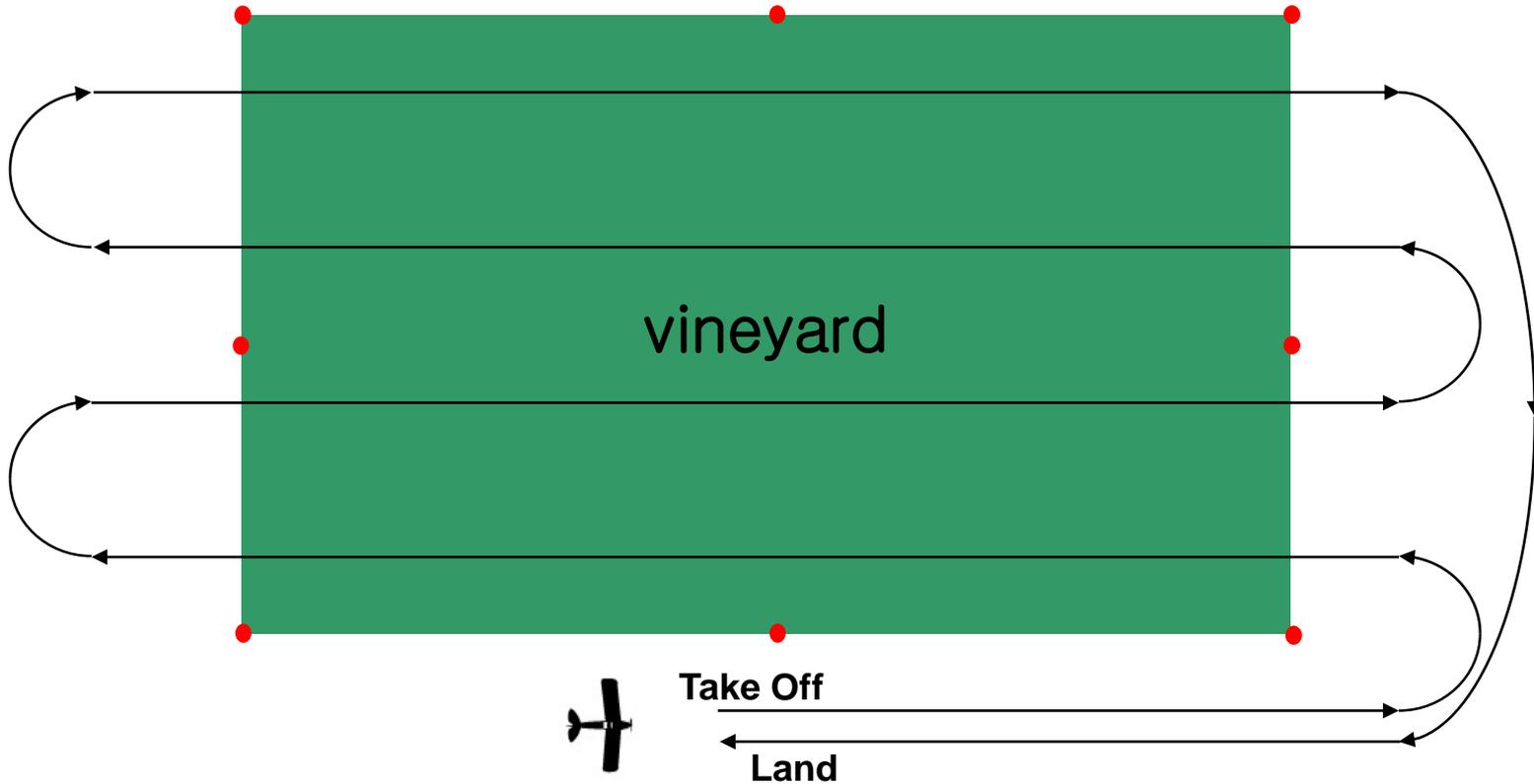
Shipping UAVs from WV to CA



Flight Preparation



UAV Operations



● GPS coordinates of field landmarks

UAV flight path tracked by GPS

In-Field Coordination



In-Field Coordination



UVA Flight



UVA Flight



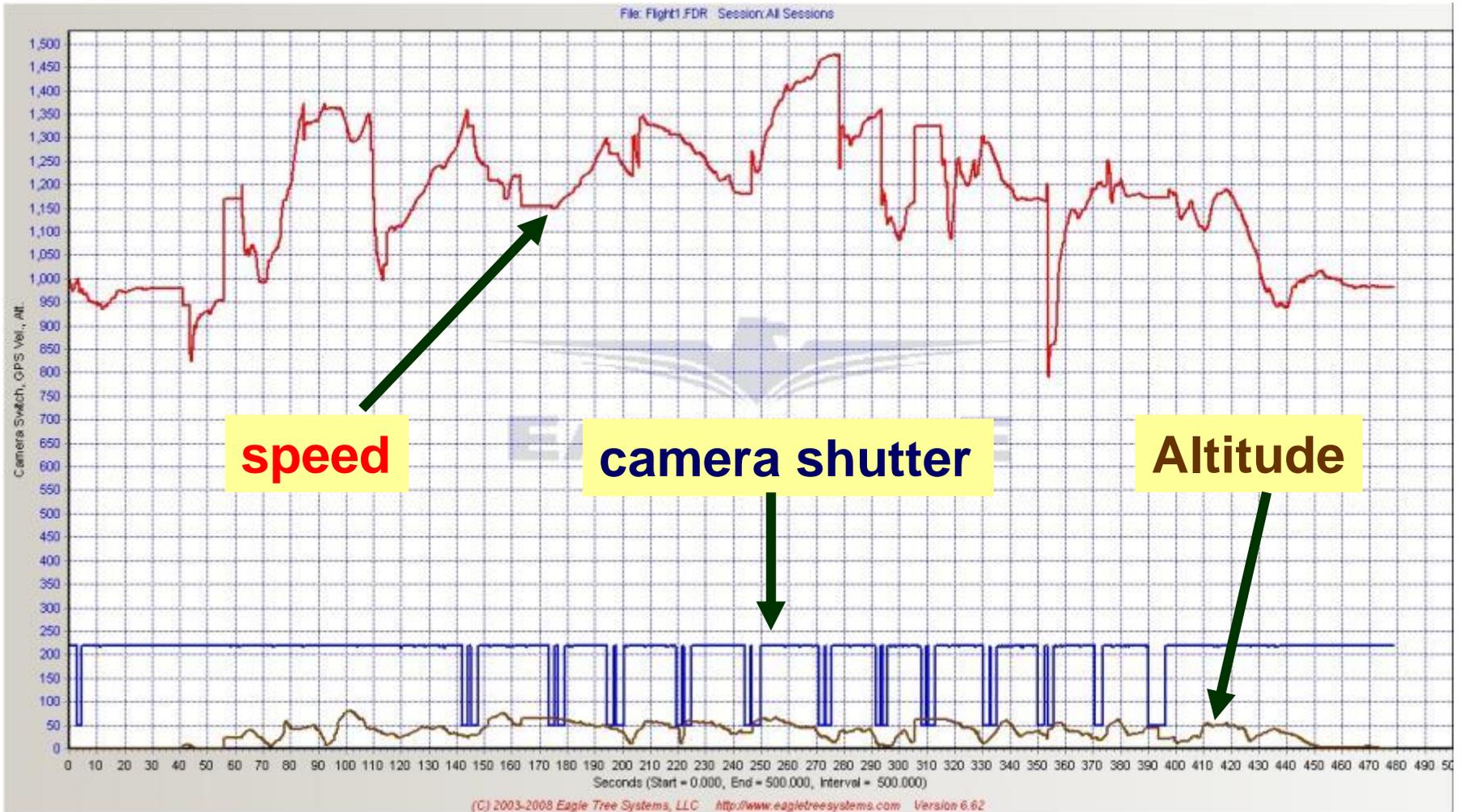
UVA Flight



UVA Flight



UAV Flight Record



time

Aerial Images Taken by UAV

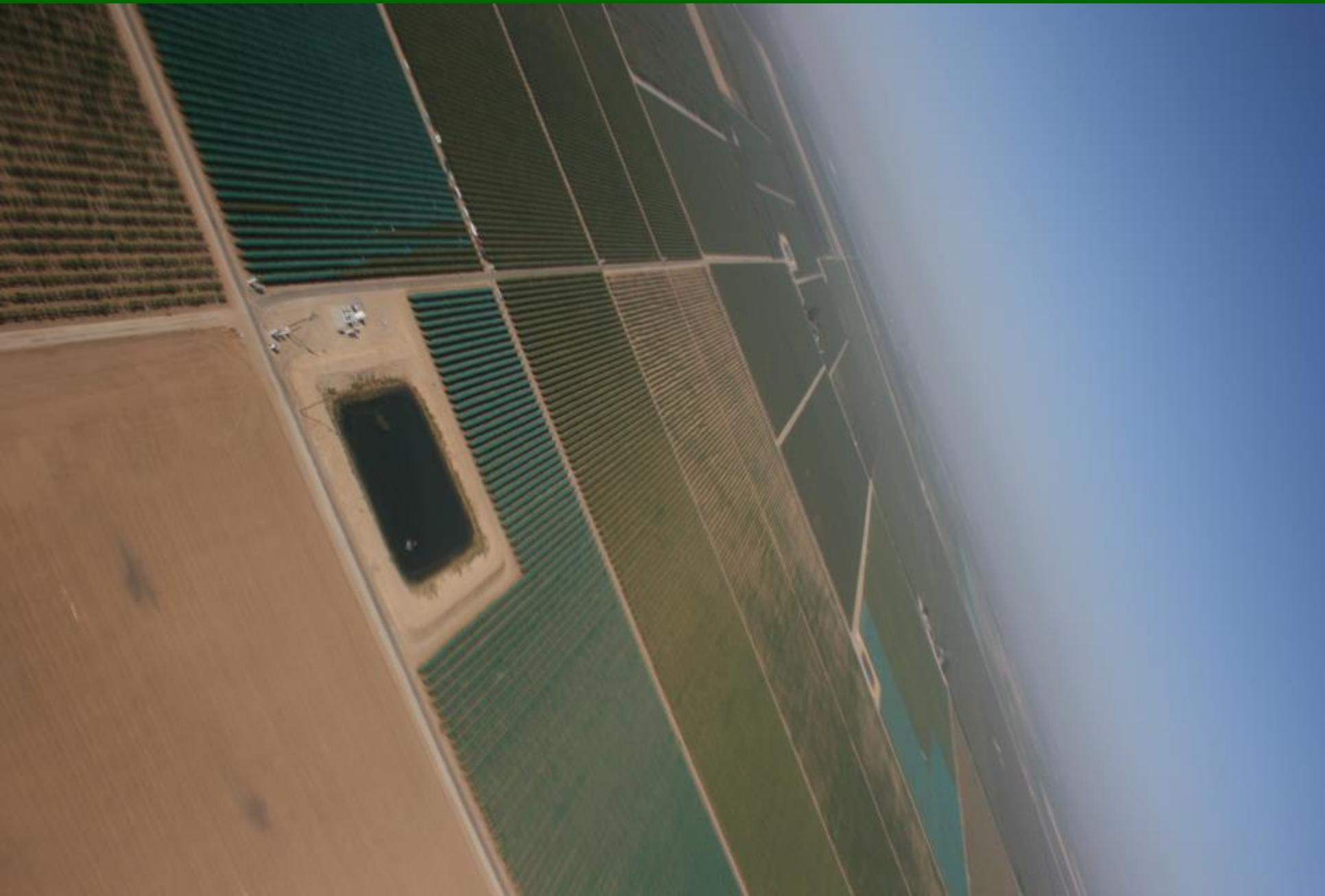


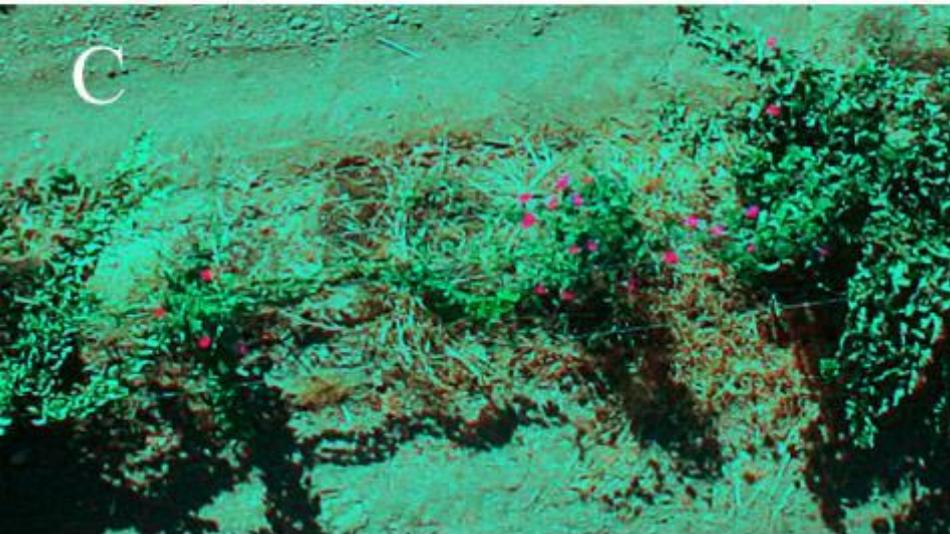
Image Stitching to Produce Composite Image



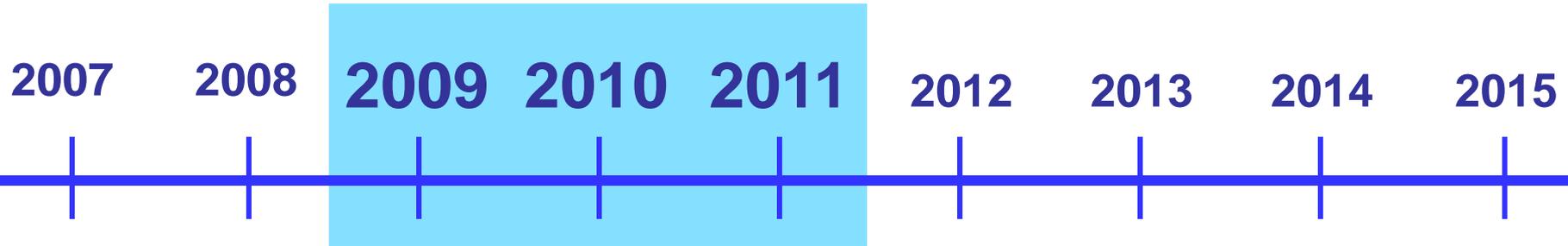
Automated Detection with Image Analysis



Automated Detection with Image Analysis



Research on UAV in Agriculture @ WVU



Detection of Insects on the Ground

Friendship Hill, Pennsylvania

Detecting Insects?



Detecting Insects?



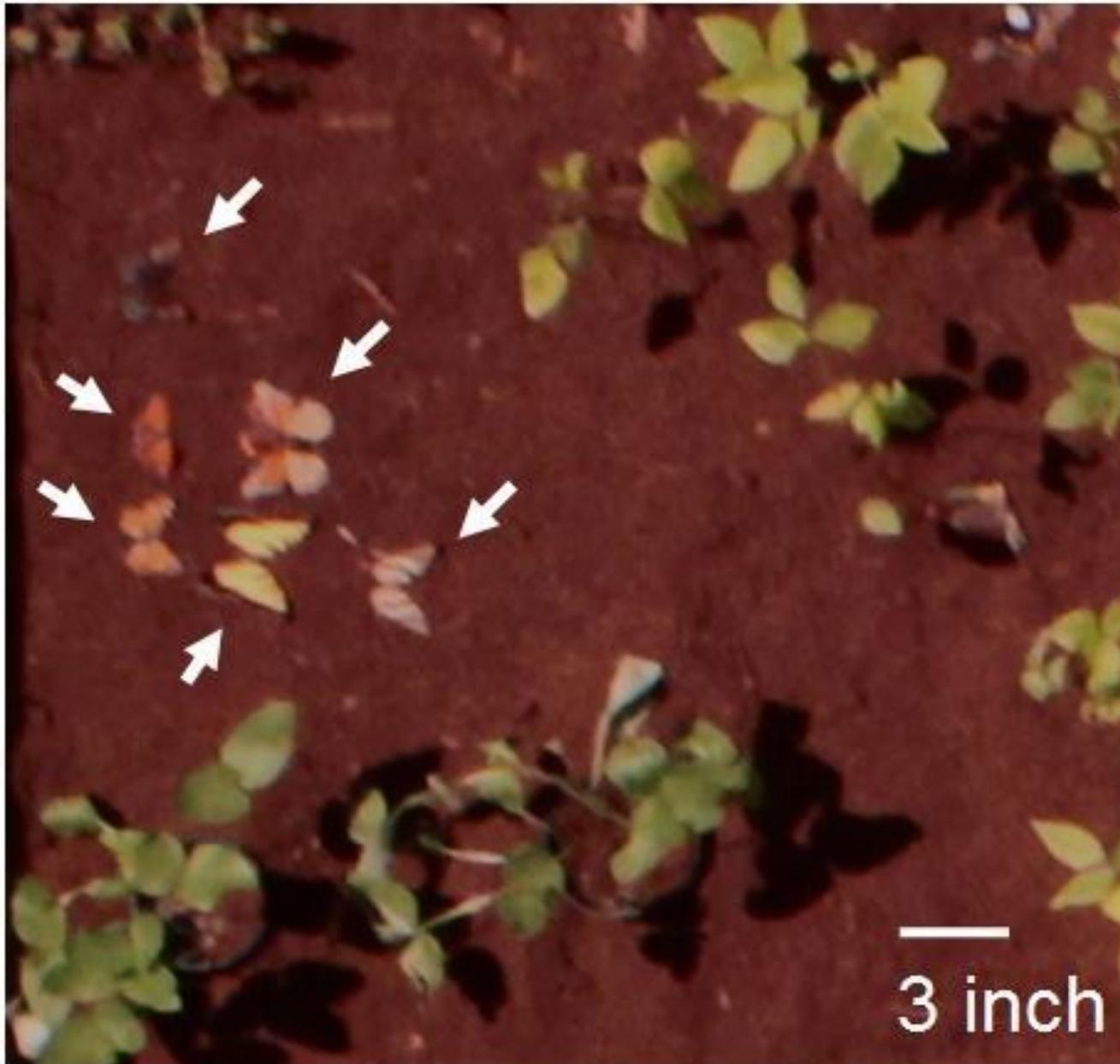
Detecting Insects?

gloves

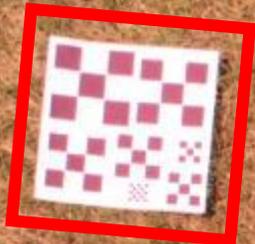


~15 m above ground

Detecting Insects on the Ground

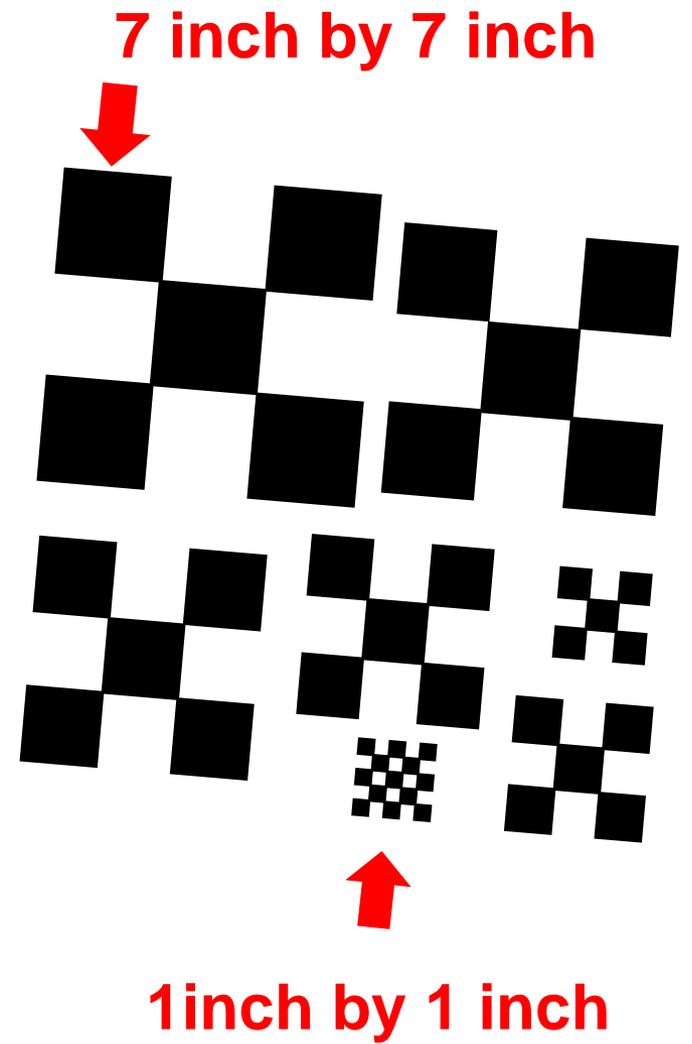
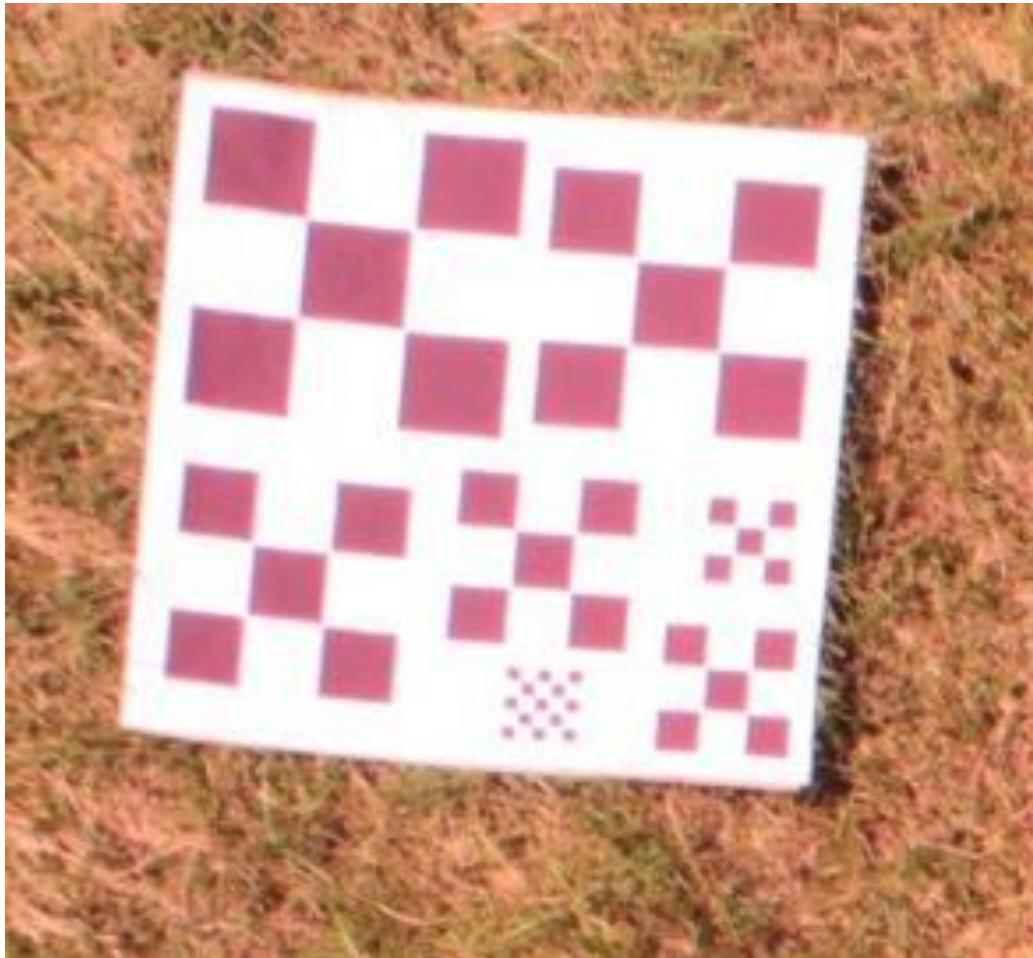


Resolution!



~20 m above ground

Resolution!



Research on UAV in Agriculture @ WVU

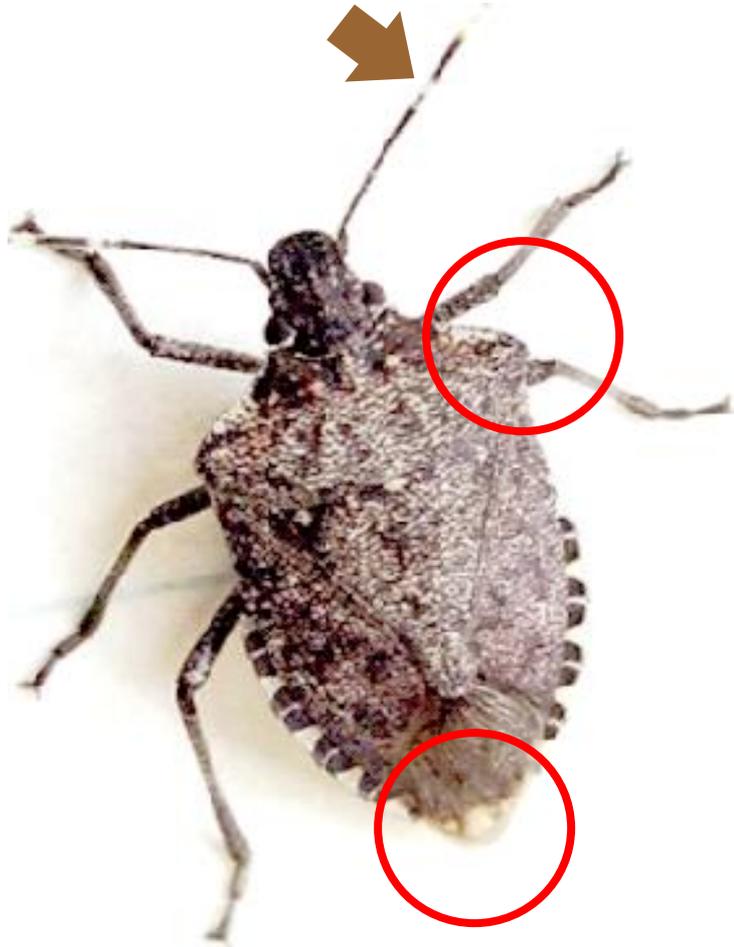


Aerial Delivery of Natural Enemies

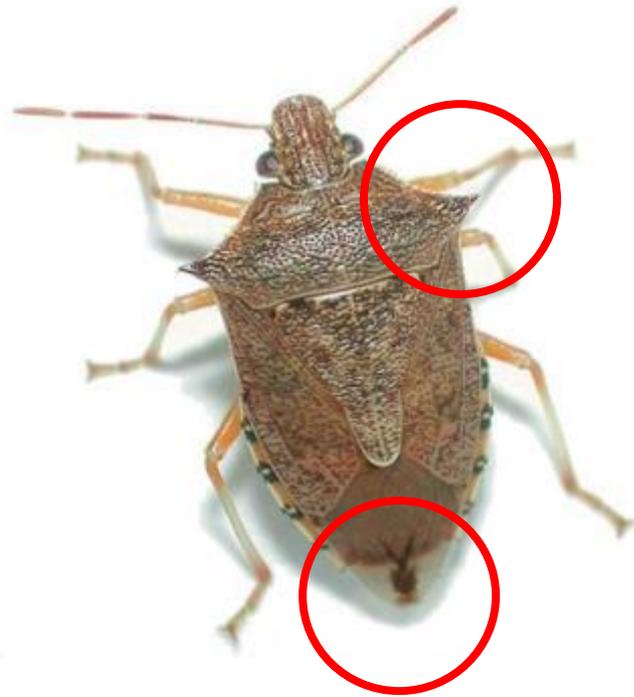
Waynesburg, Pennsylvania

Spined Soldier Bug

Brown marmorated stink bugs



Spined soldier bug



Spined Solder Bug



Spined Solder Bug



Releasing Soldier Bugs



Releasing Soldier Bugs: Bug Cannon

door



Soldier bug house



Pressed air



AIR ONLY

> 60 psi could blow soldier bugs out
Recovery study: no effect on soldier bug

Mile-A-Minute Weed

Polygonum perfoliatum



07/03/2014

Mile-A-Minute Weed



07/03/2014

Mile-A-Minute Infestation



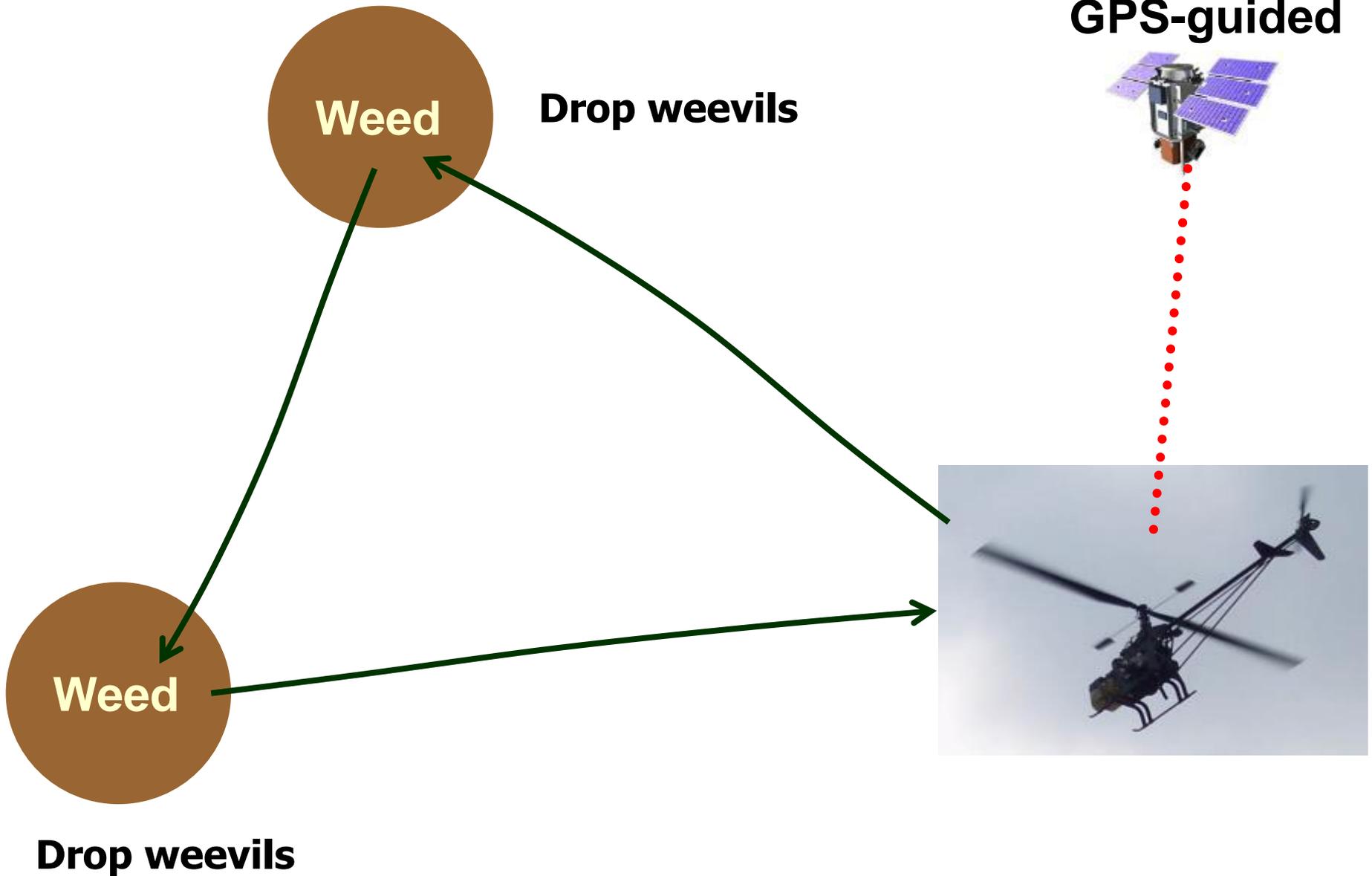
Mile-A-Minute Weevil



Releasing natural enemies in

- large areas
- hard-to-reach areas

Autonomous UAV for Releasing Weevils



Development of Bug-Bomb



Development of Bug-Bomb



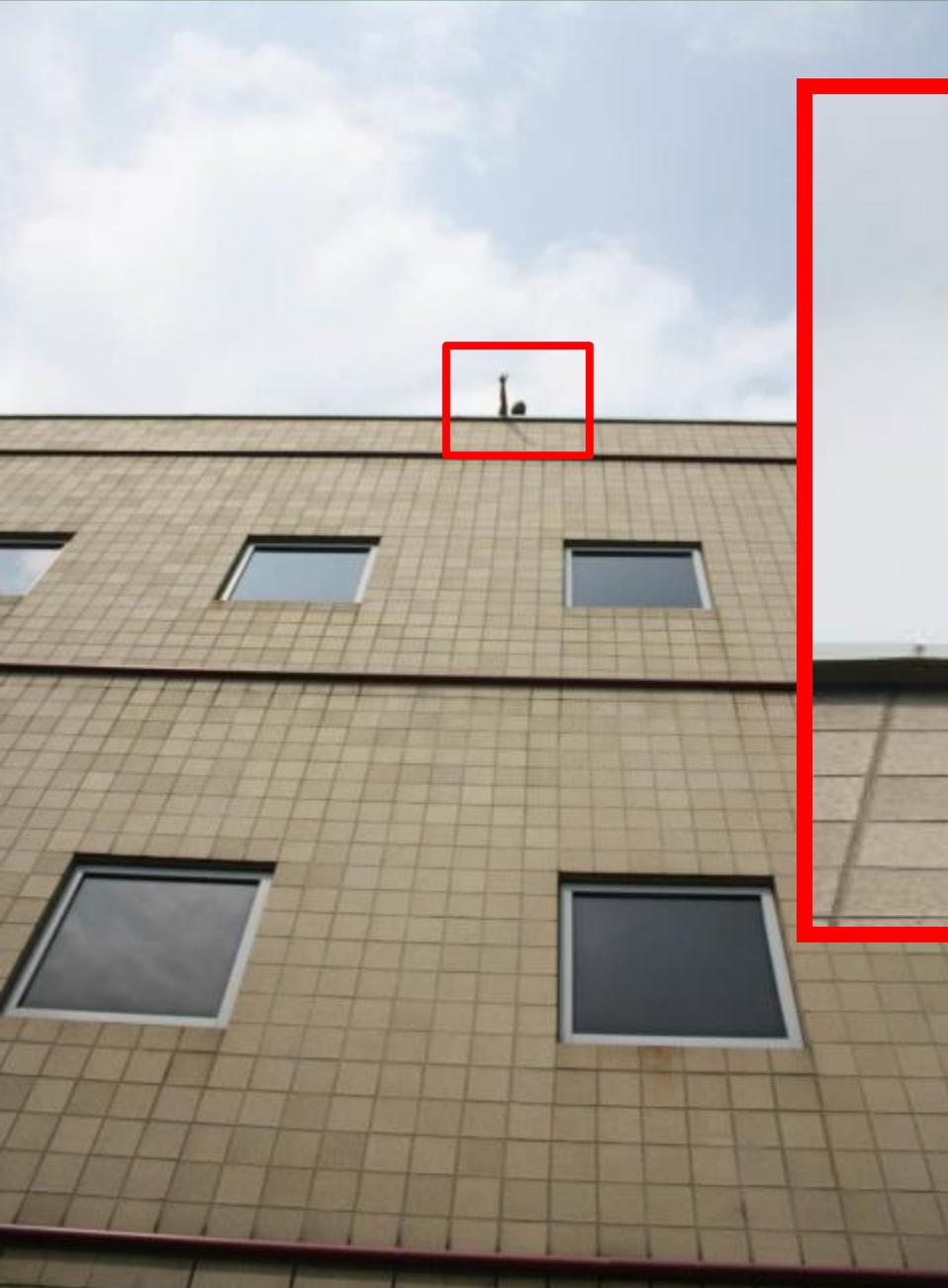
Development of Bug-Bomb



Development of Bug-Bomb



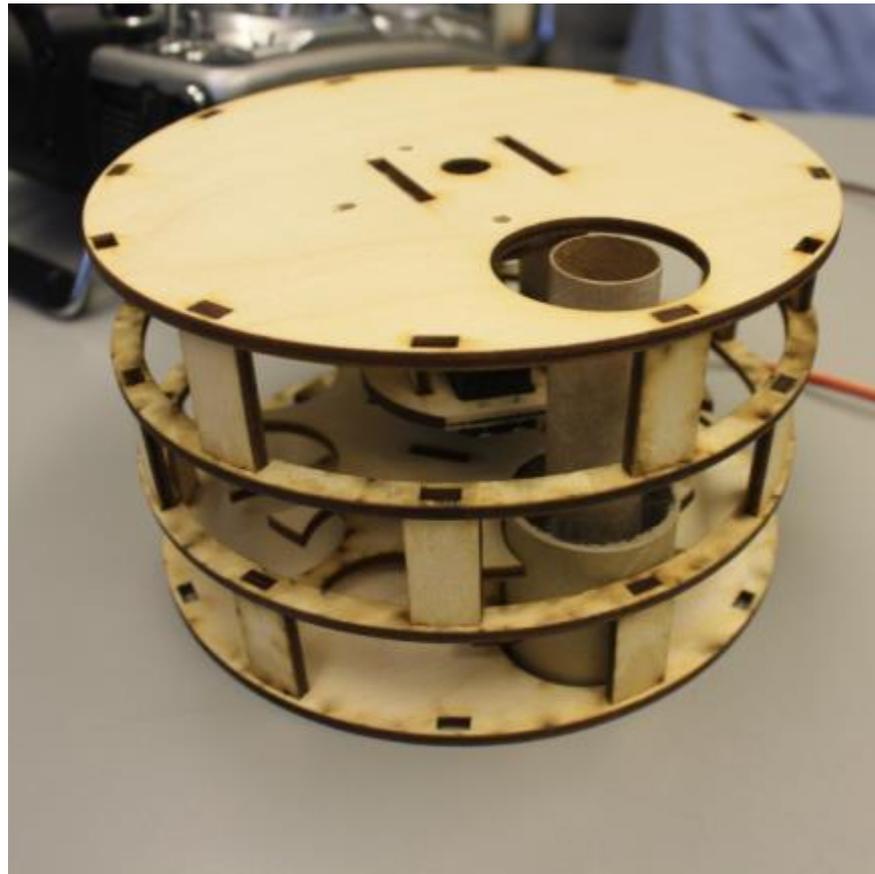
Bug-Bomb Preliminary Study



Bug-Bomb Preliminary Study



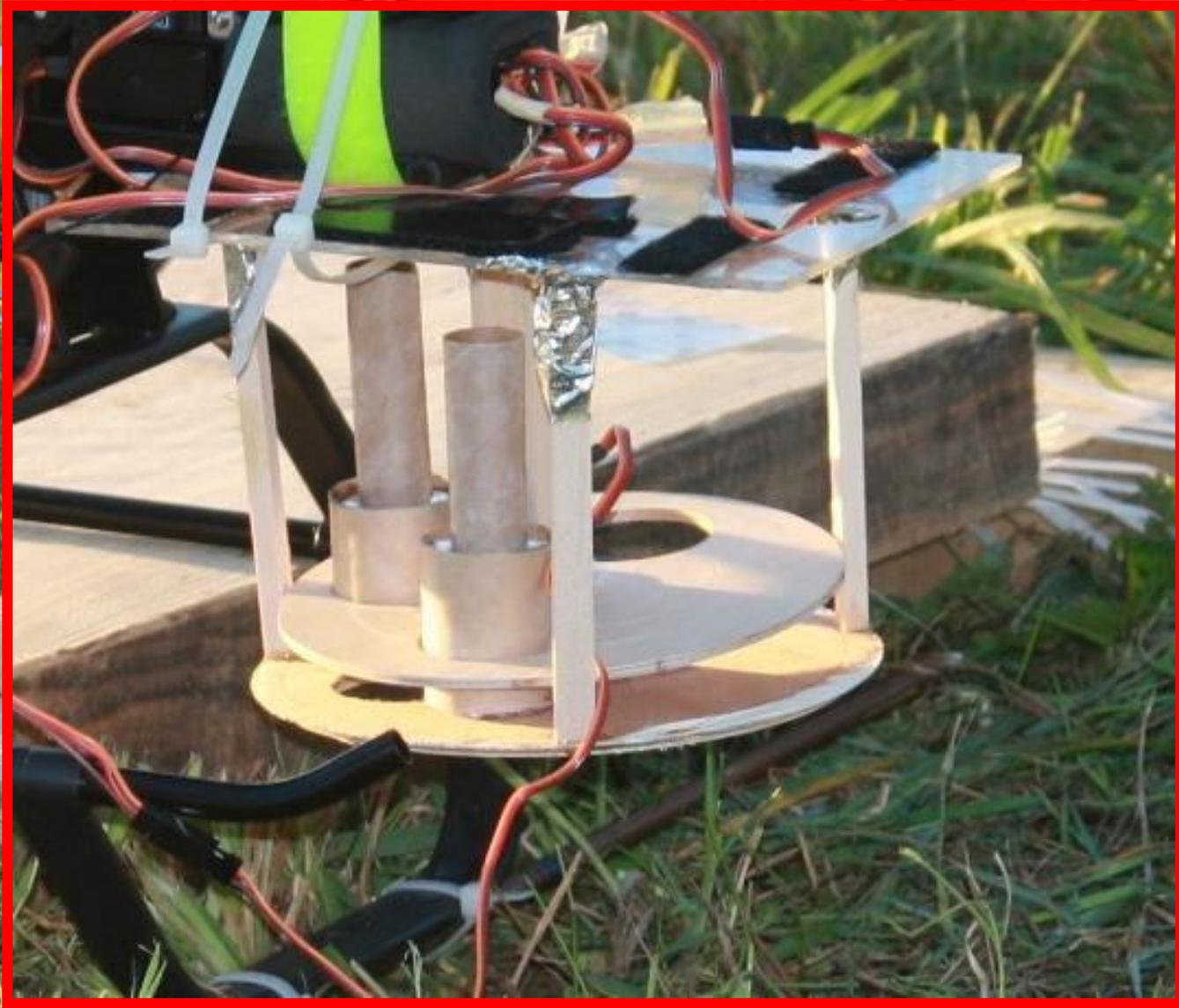
Bug-Bomb Dispenser



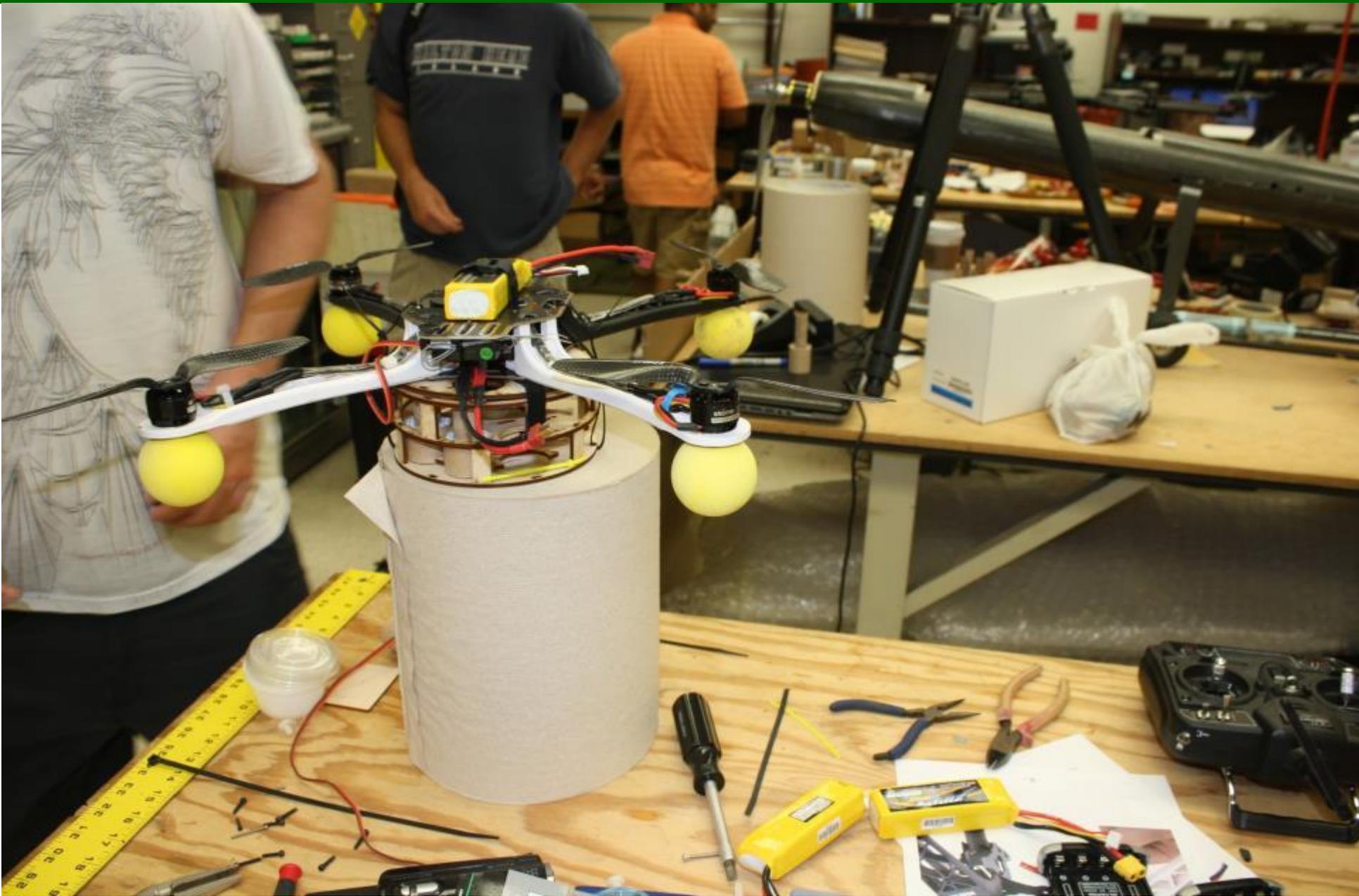
Field Validation



UAV Equipped with Bug-Bomb Dispenser



UAV Equipped with Bug-Bomb Dispenser



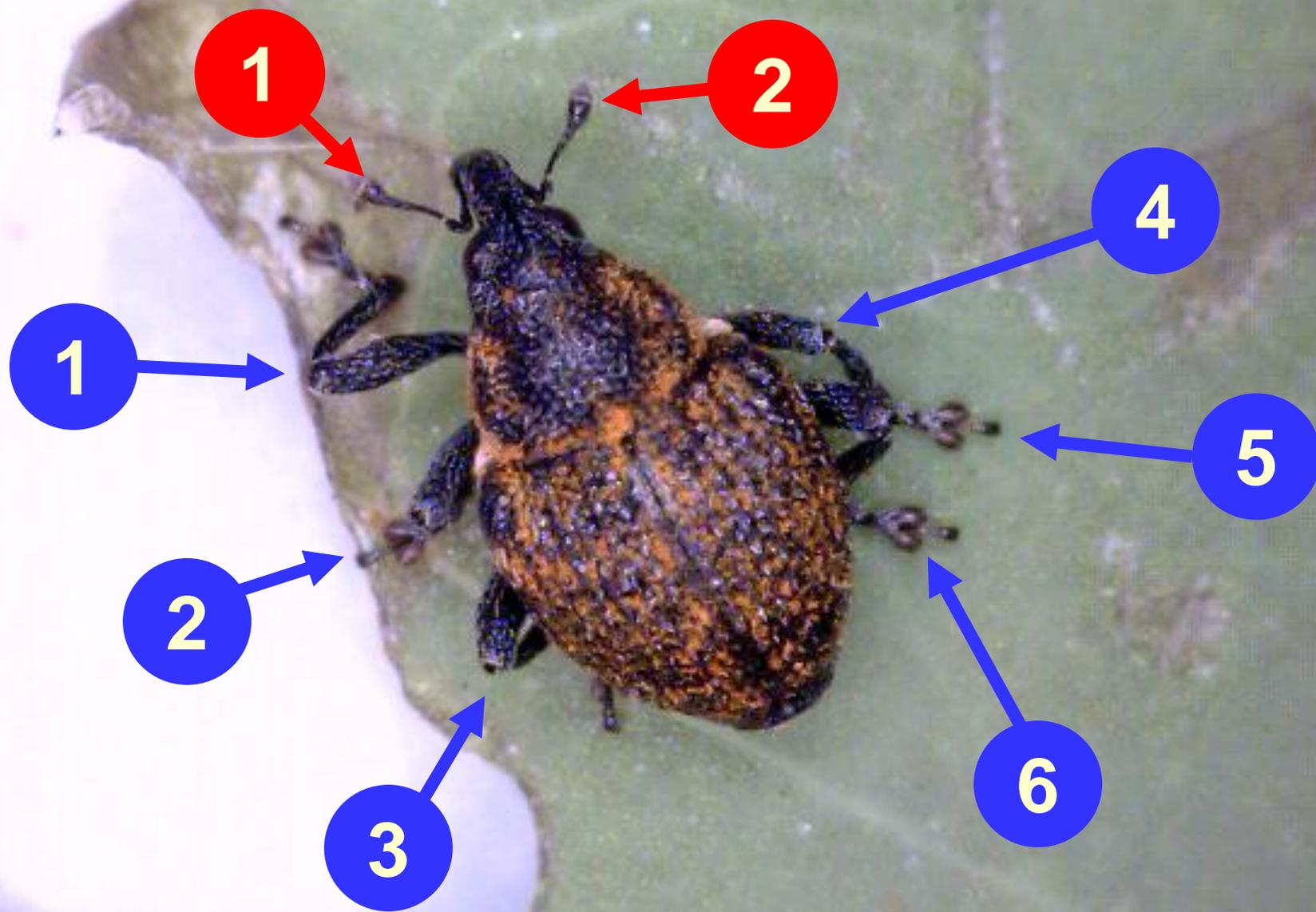
UAV Equipped with Bug-Bomb Dispenser



UAV Equipped with Bug-Bomb Dispenser



Effect of Aerial Delivery on Weevil Damage



Effect of Aerial Delivery on Weevil Behavior

Walking



Mating

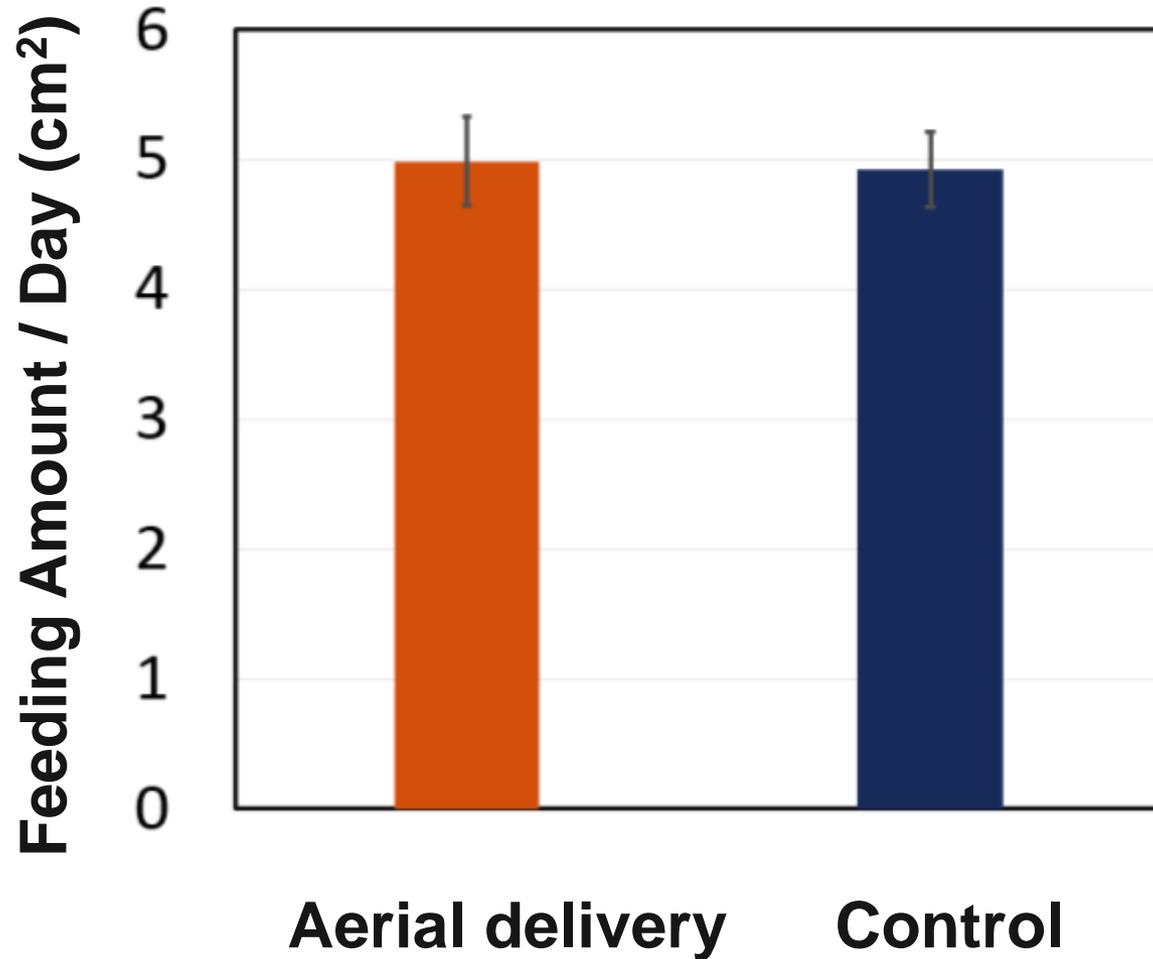


Effect of Aerial Delivery on Weevil Feeding

Feeding



Effect of Aerial Delivery on Weevil Feeding



$t = 0.453$, d.f. = 28, $P > 0.05$

Current UAVs for Research

Design concept

Light (easy to handle)

Cheap

Safe

Easy to Control

Multiple sensors



UAV Crash



UAV Crash



Research on UAV in Agriculture @ WVU

Pilot Study: proof-of-concept study

Aerial weed detection in vineyards

Aerial insect detection

Aerial delivery of predators

2007 2008 2009 2010 2011 2012 2013 2014 2015

➔ Applying to various agroecosystems

Collaborators



Collaborators



Collaborators



Collaborators & Funding Sources

Collaborators

WVU aerospace engineers

Forest Service researchers

Funding sources

