

We're not spying on you;
it's more interesting watching grass grow-

Using Unmanned Aircraft Systems in Rangeland Monitoring

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On this journey we will see....

The Jornada

Unmanned aircraft

FAA UAS flight requirements

Flights on the Jornada – how we do what we do

Data applications

Possibilities

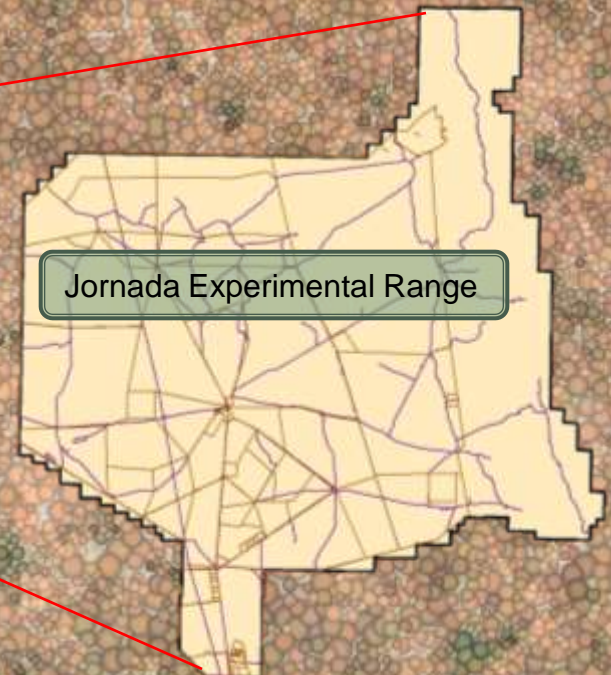
USDA Agricultural Research Service
Jornada Experimental Range
Las Cruces, NM

Established 1912



The Jornada
Experimental
Range is located
in southern
New Mexico

780 km²



ARS Project Plan 2013 - 2017

Management Technologies for Conservation of Western Rangelands

“The goal of the Jornada is to develop ecologically based knowledge systems and technologies for management, conservation, monitoring, and assessment of western rangelands.”

<http://jornada.nmsu.edu/plans-reports/usda-projects>

How does the UAS program fit into this?

Developing both knowledge systems and technologies.

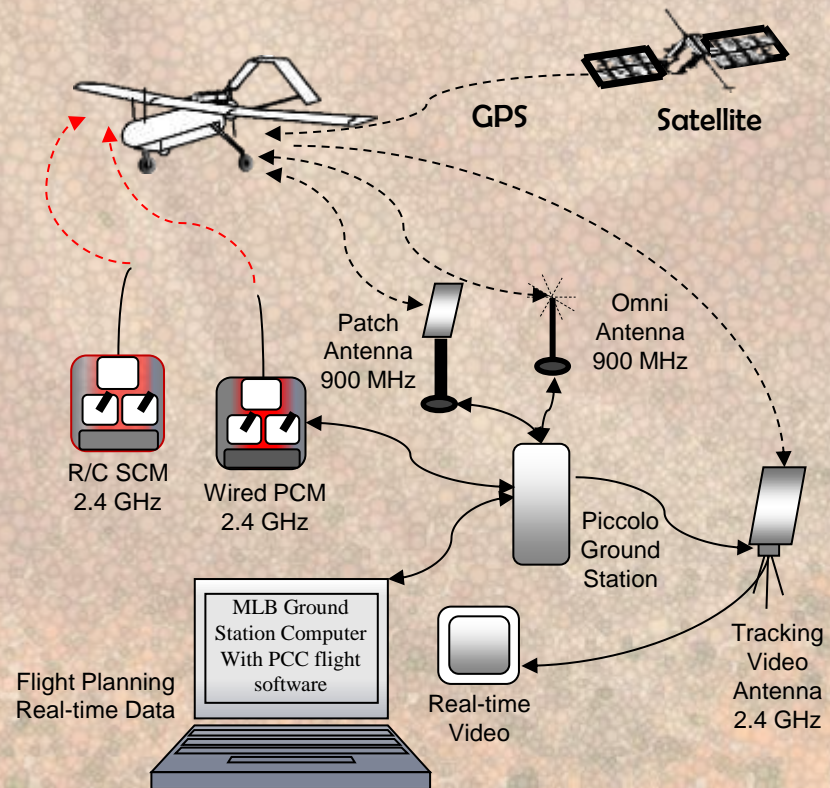
Using the MLB Co. Bat 3 and Bat 4 UAS to acquire high resolution aerial imagery for analyses and interpretation.

What is a UAS?

UAS – Unmanned Aircraft System

Components:

- Aircraft
- Ground station
- Computer
- PGS
- RC transmitter(s)
- Antennas
- Communication
- GPS
- Video
- Video recorder



What is a UAV or UA?

UAV – Unmanned Aerial Vehicle
Unmanned Aircraft



A component of the Unmanned Aircraft System

What is an RPA or ROA?

RPA – Remotely Piloted Aircraft

ROA – Remotely Operated Aircraft



Military terminology for UAV

What is a Drone?

Common designation for UAS, UAV, UA, RPA, ROA; originally an unpowered aerial target.



FAA Requirements for UAS Flights in the National Airspace System (NAS):

Crew – Flights under 400' Above Ground Level

FAA Private Pilot Knowledge test – 2 year

FAA Class 2 medical – commercial, 1 year

Flights above 400' AGL

FAA Private Pilot Knowledge test

FAA Class 2 medical

FAA Private Pilot certification - current

FAA Requirements for UAS Flights in the National Airspace System (NAS), continued:

Certificate of Authorization

Only public agencies may receive a COA.

A COA is for a specific location, aircraft, and time.

Public agencies are government agencies, or academic institutions that receive government funding.

Three to six months for approval.

Recipient is responsible for all FAA notifications and reports.

Another FAA Requirement for UAS flights in the NAS:

UAS Registration

A new requirement for unmanned aircraft flown under a COA.

Submit documentation to the FAA to receive an aircraft N-number (tail number).

Requirements for UAS Flights on the Jornada:

National Airspace System

A Certificate of Authorization (COA)

The COA covering the Jornada belongs to NMSU Physical Science Laboratory UAS Flight Test Center and covers all of southern NM.

- PSL FTC participation is required for all Jornada flights.
- They are responsible for all FAA interactions.
- They supply a Mission Commander, data collector, and observers, if necessary.

More requirements for UAS Flights on the Jornada:

National Airspace System

Qualified Jornada crew:

- Pilot in Command (licensed pilot)
- External Pilot – radio control of aircraft
- Internal Pilot – computer flight control
- Visual Observer – incoming aircraft alert

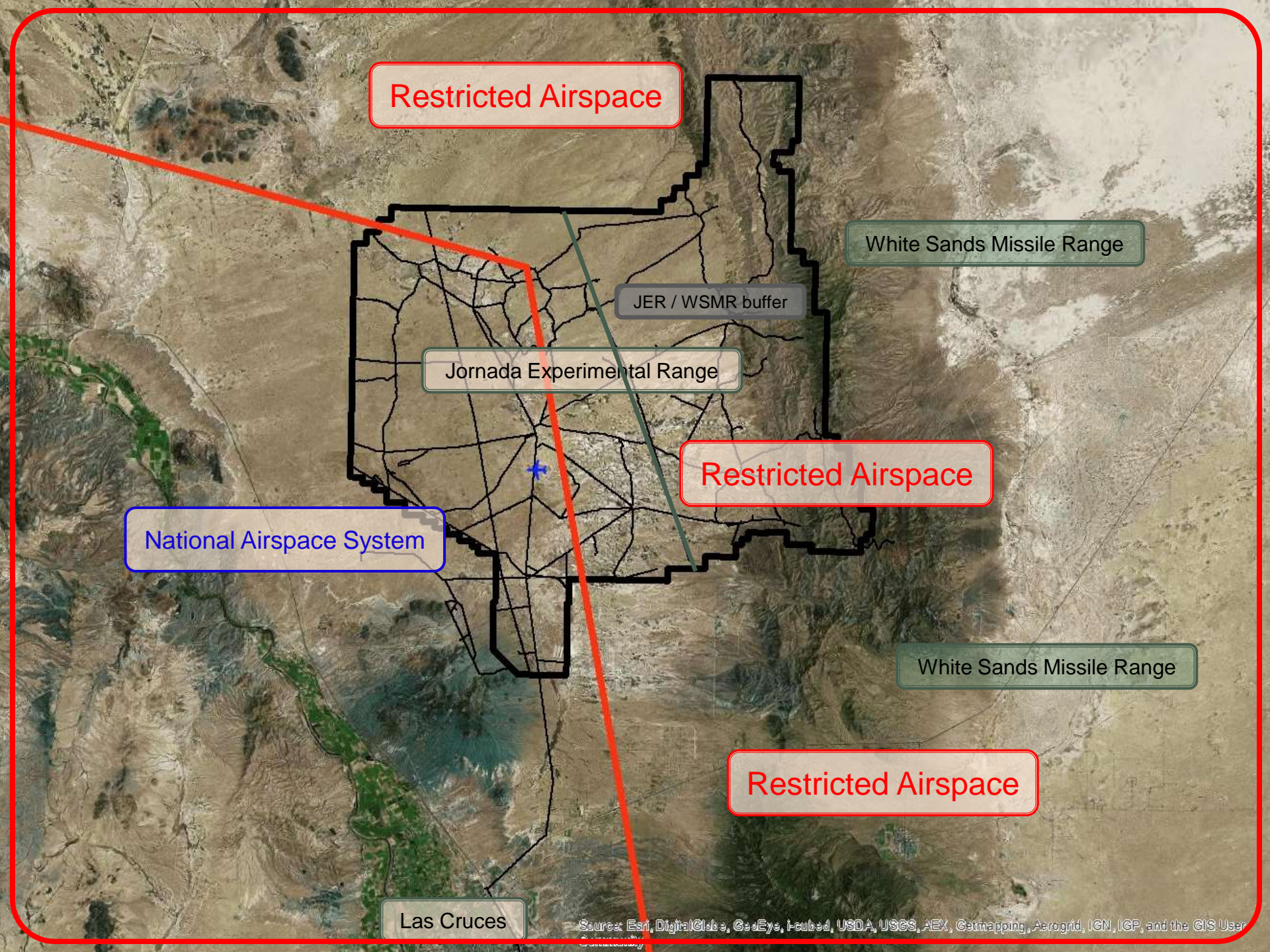
Additional crew:

- Ground support – aircraft setup and checks
- Payload specialist – ground station setup, preflight and post-flight checks
- EP comms – communication between EP and IP

Requirements for UAS Flights on the Jornada, continued:

White Sands Missile Range Restricted Airspace

- Memorandum of Understanding – no \$\$\$\$
- Data Request Letter – detailed information about UAS
- Frequency Request Authorization – unlicensed communication frequencies, 900 MHz and 2.4 GHz
- Clearance – two weeks before flight request airspace scheduling. Receive clearance code prior to flight. Day of flight at scheduled time call for “green range”.



Restricted Airspace

White Sands Missile Range

JER / WSMR buffer

Jornada Experimental Range

Restricted Airspace

National Airspace System

White Sands Missile Range

Restricted Airspace

Las Cruces

More Jornada flight requirements:



- Good Weather – clear sky, light breeze within two hours of solar noon
- Crew – qualified pilots and observers
- Clearance – NAS or WSMR Restricted Airspace

What do we fly?

MLB Bat 3 – 1.8 m wingspan
10 kg with payload
5 hr flight time
\$50,000 in 2006



MLB Bat 4 – 4 m wingspan
38 kg with payload
5 hr flight time
\$170,000 in 2013

Flights – 200+
Hours – just under 200
Images – 130,000+
Mosaics from images – 200+

MLB Bat 3 – catapult launched

6-band multispectral camera mounted in nose

Canon SD900 mounted in wing



MLB Bat 4 – manual rolling take off, runway required
6-band multispectral camera mounted in payload bay
Canon EOS 5D Mark II mounted in payload bay



Sensors



Tetracam mini-MCA
6-band multi-spectral
Bat 3, Bat 4



Canon EOS 5D Mark II 21 mp
Bat 4



Video
Bat 3, Bat 4



Canon SD900 10 mp
Bat 3

Potential Sensors



Thermal infrared



Color Infrared – converting SLR with internal filter change



LIDAR - Light Detection and Ranging

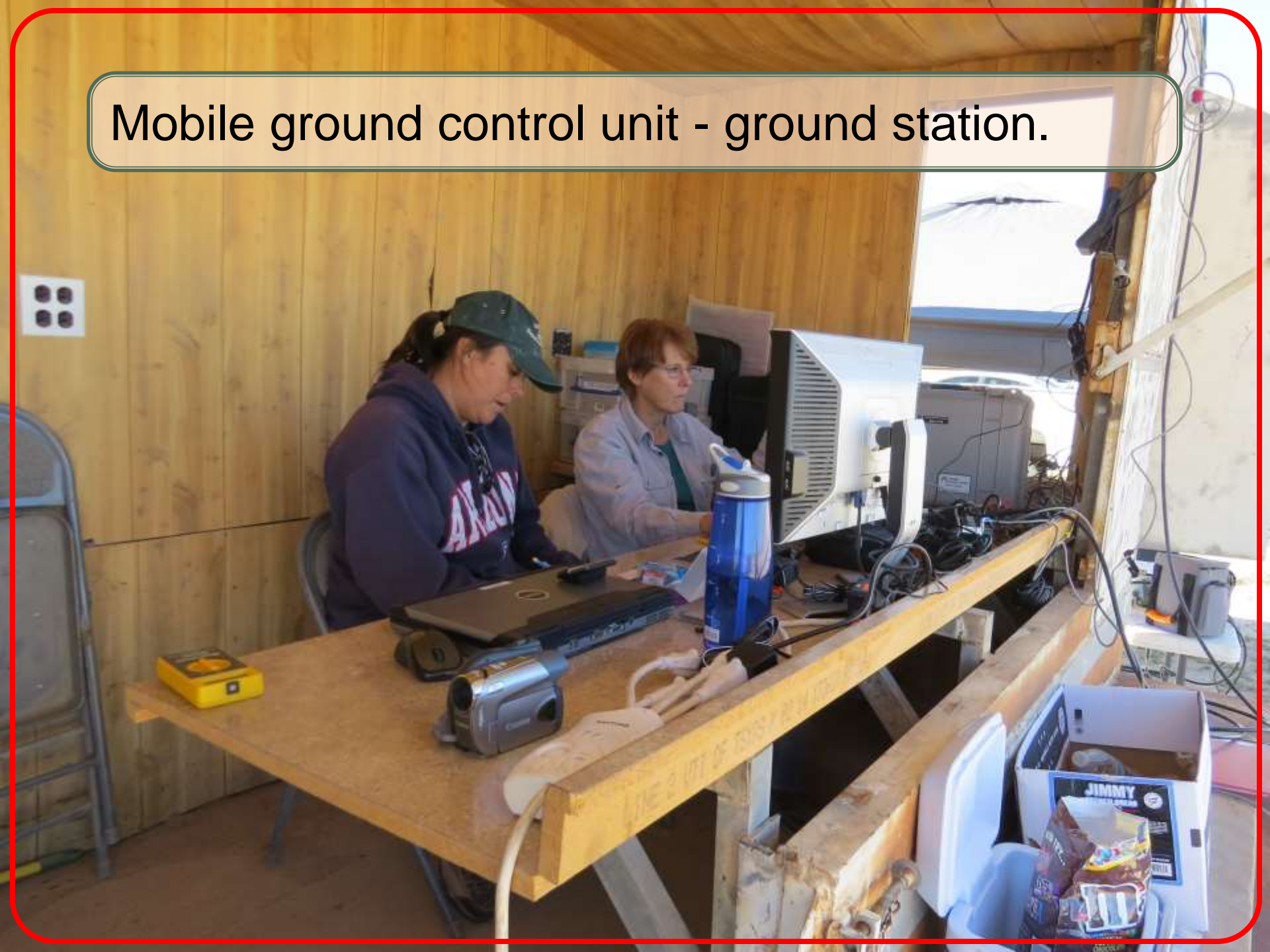


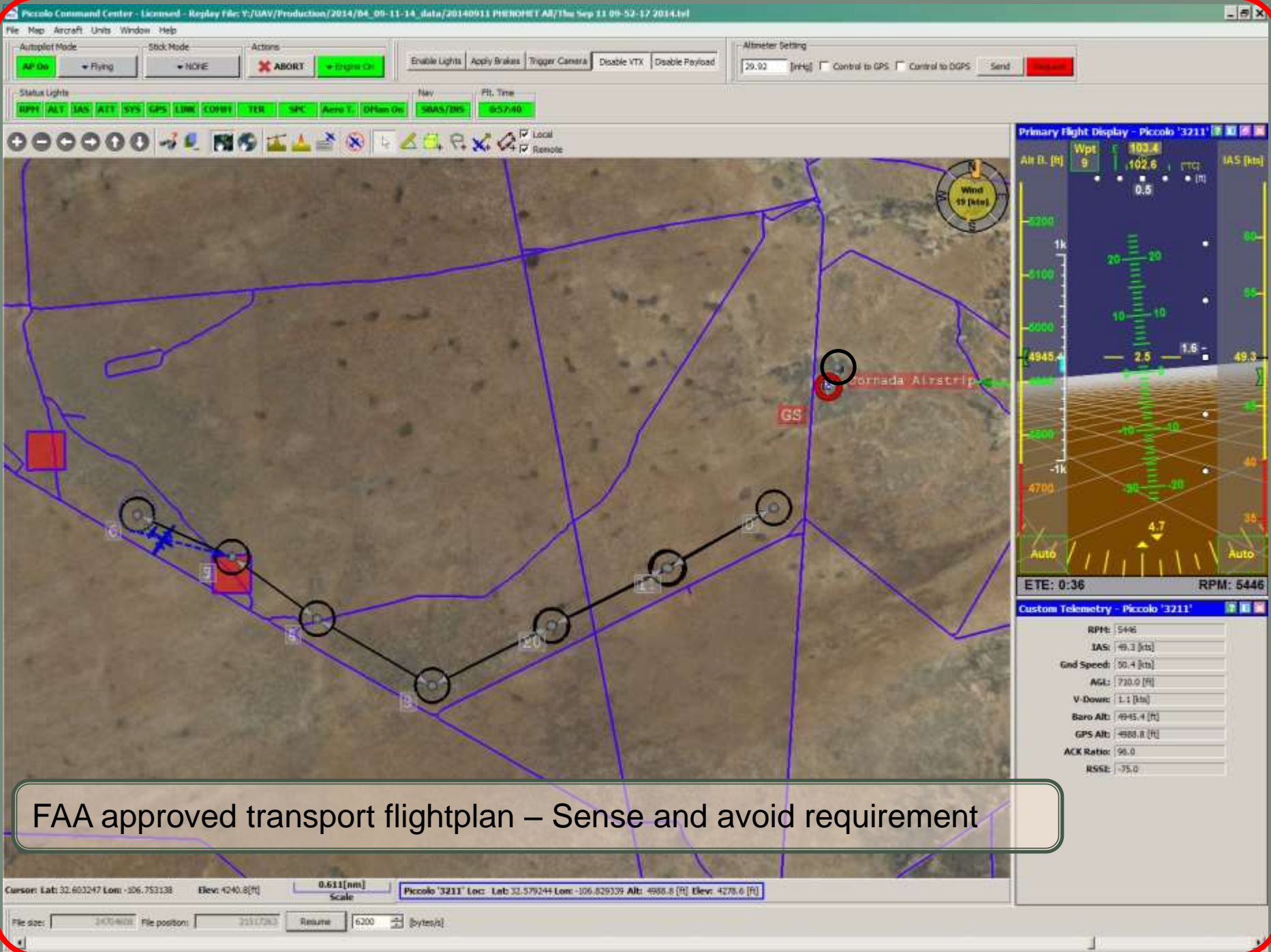
Stereo camera

Mobile ground control unit.



Mobile ground control unit - ground station.





FAA approved transport flightplan – Sense and avoid requirement

What do we do?

40% side lap

75% forward lap

Acquire imagery for mosaics.



Outlined area covered by previous slide.

Mosaic finished product from previous imagery.

Data Applications

Watching grass grow

Invasive species detection and monitoring

Monitoring soil disturbance and erosion

Extraction of fine-detail digital surface models

Phenology

Comparing data collection techniques

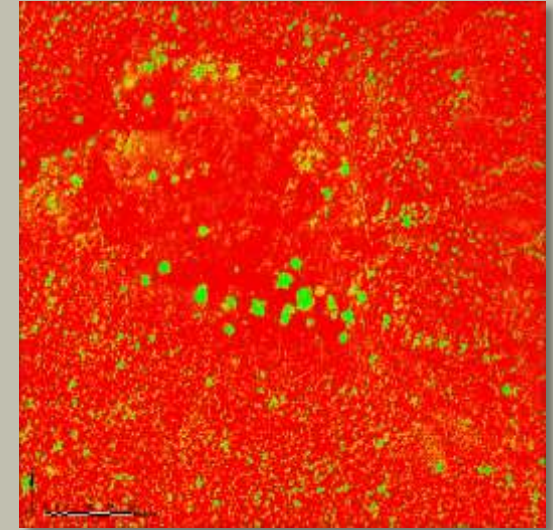
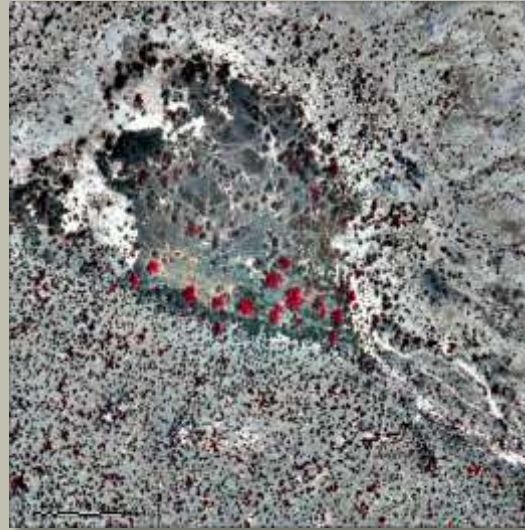
Watching grass grow....

Red Green Blue

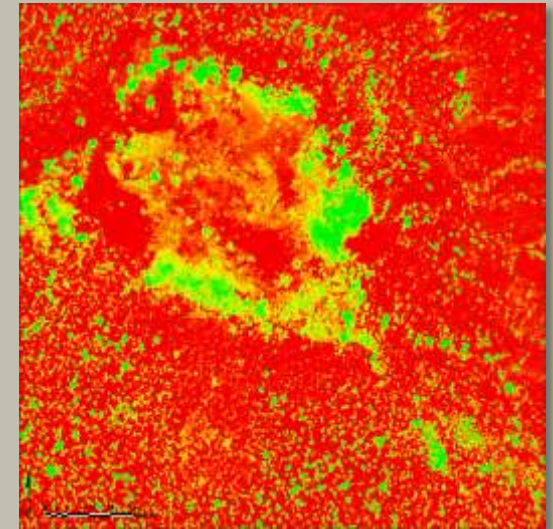
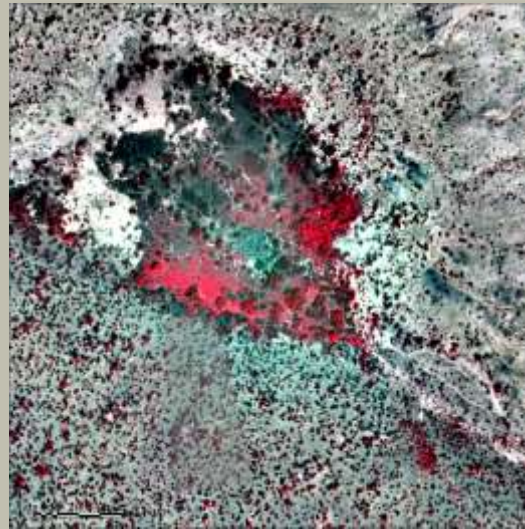
Color Infrared

Normalized Difference
Vegetation Index

May 2011
Pre-monsoon



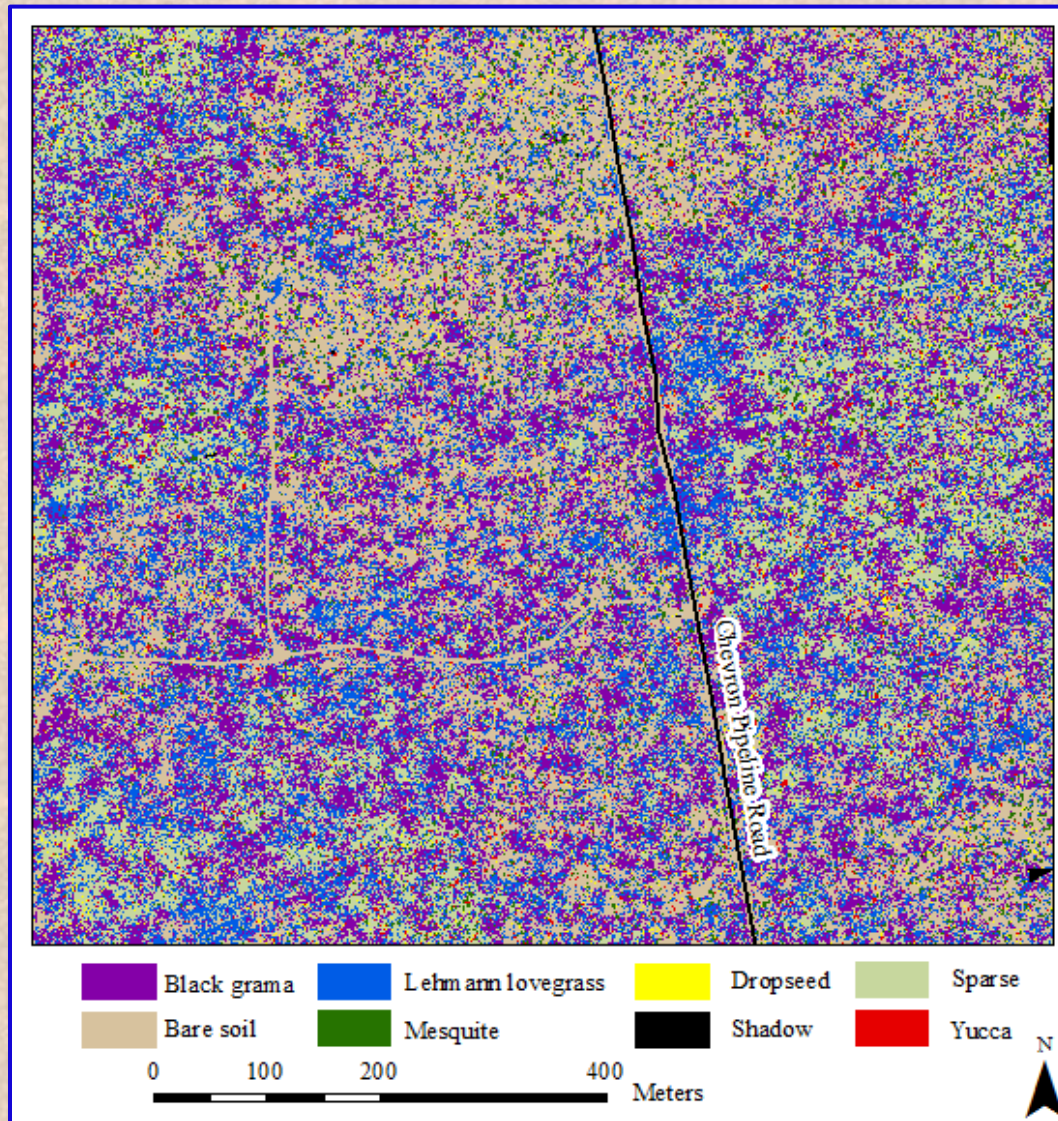
August 2011
Late-monsoon



Aerial imagery collected by the Jornada Experimental Range UAS team and prepared by Craig Winters and Amy Slaughter.

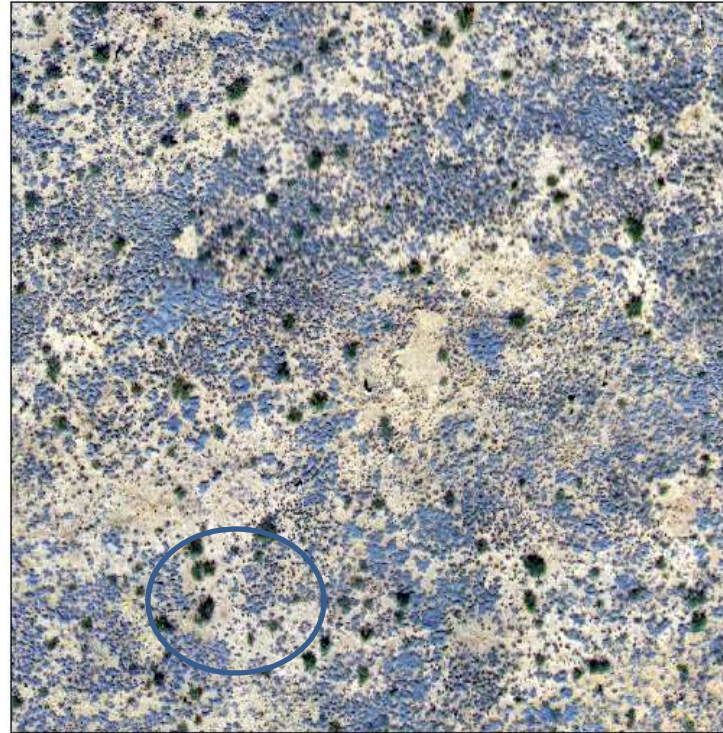
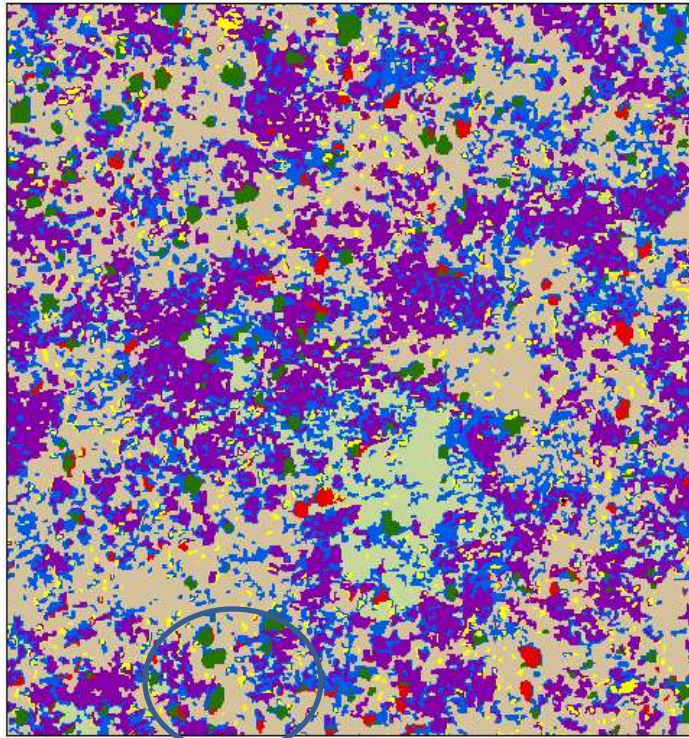
JER Vegetation and Soil Classification Map









Invasive Species Detection and Monitoring – Object Based Image Analysis

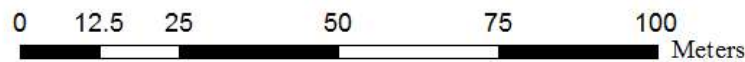


Aerial imagery collected by the Jornada Experimental Range UAS team and prepared by Amy Slaughter.

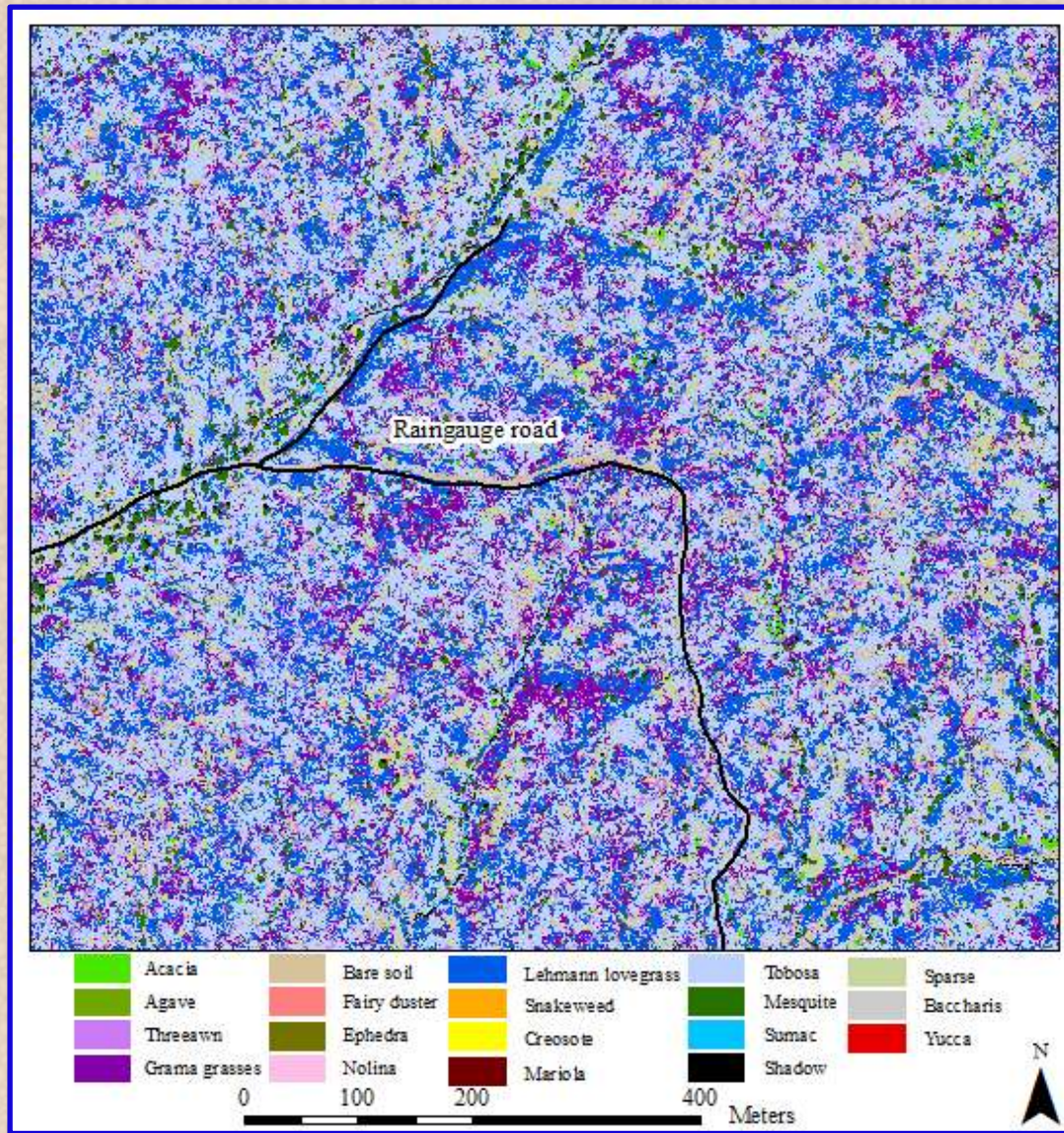
Zoomed-in View



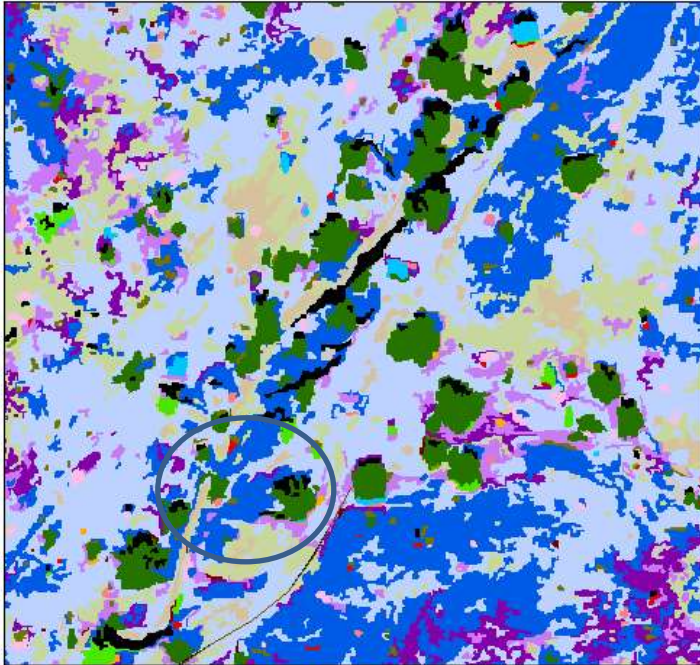
- | | | | |
|---|---|--|--|
|  Black grama |  Lehmann lovegrass |  Dropseed |  Sparse |
|  Bare soil |  Mesquite |  Shadow |  Yucca |

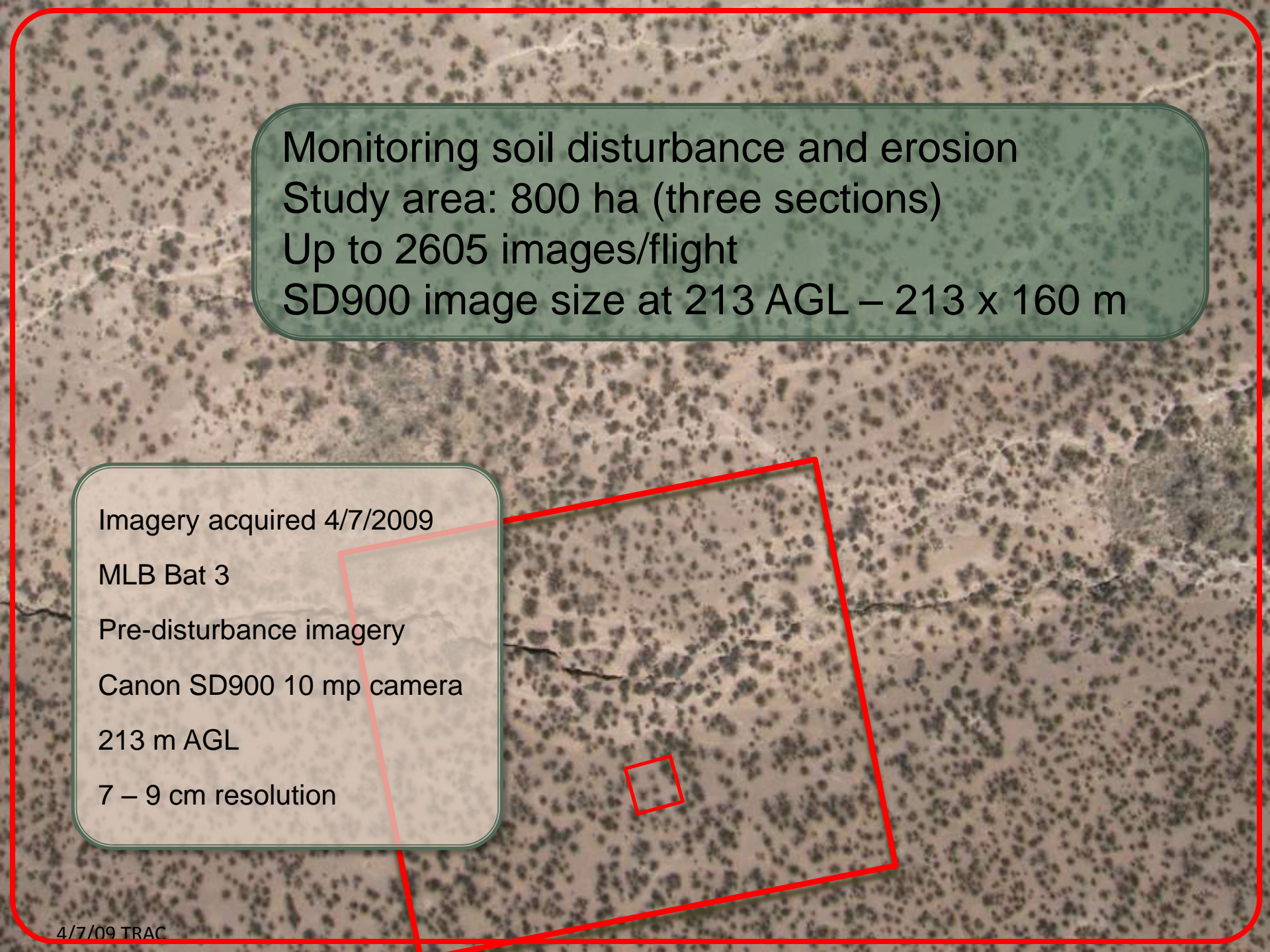


WGEW Classification Map



Zoomed-in View





Monitoring soil disturbance and erosion
Study area: 800 ha (three sections)
Up to 2605 images/flight
SD900 image size at 213 AGL – 213 x 160 m

Imagery acquired 4/7/2009

MLB Bat 3

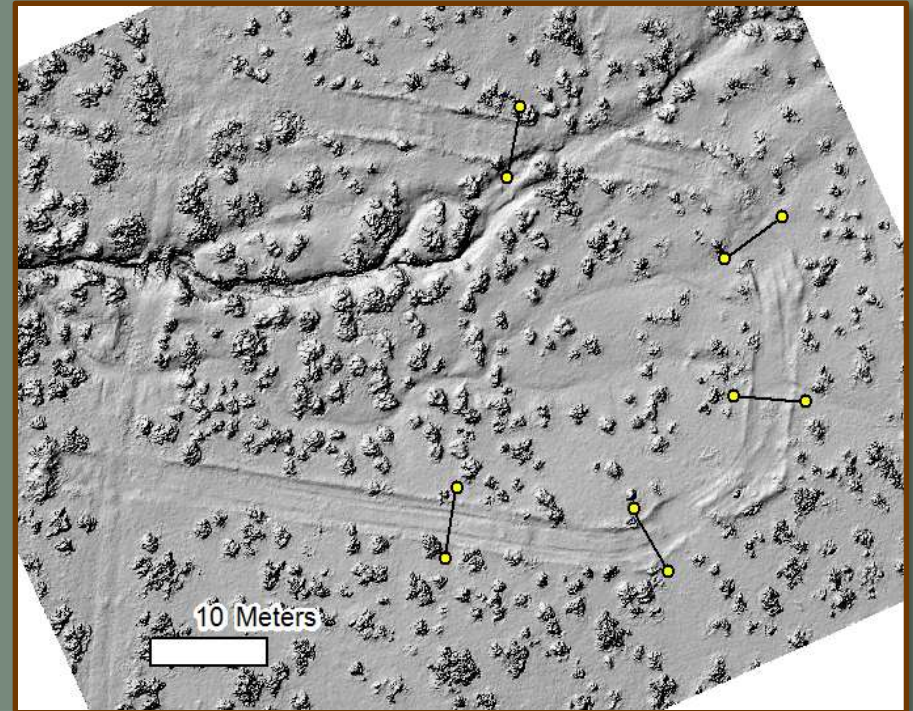
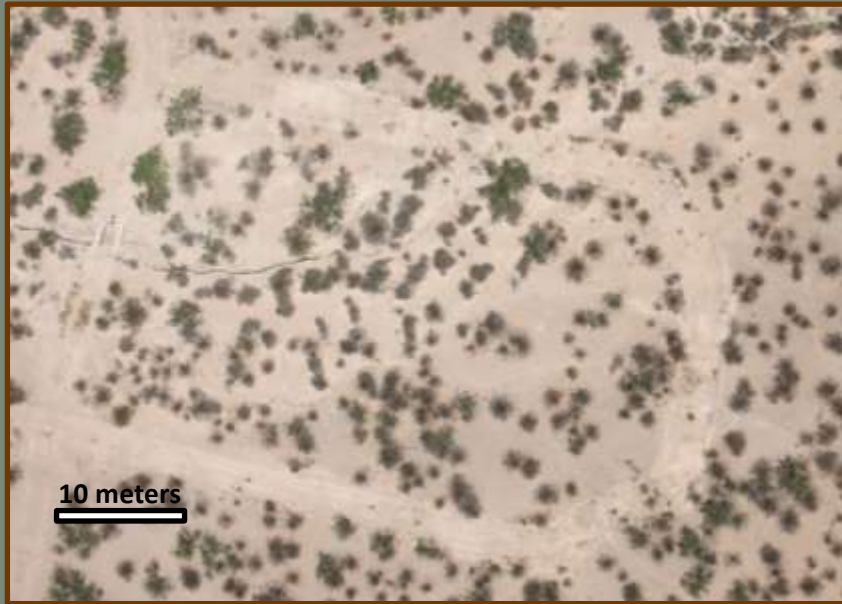
Pre-disturbance imagery

Canon SD900 10 mp camera

213 m AGL

7 – 9 cm resolution

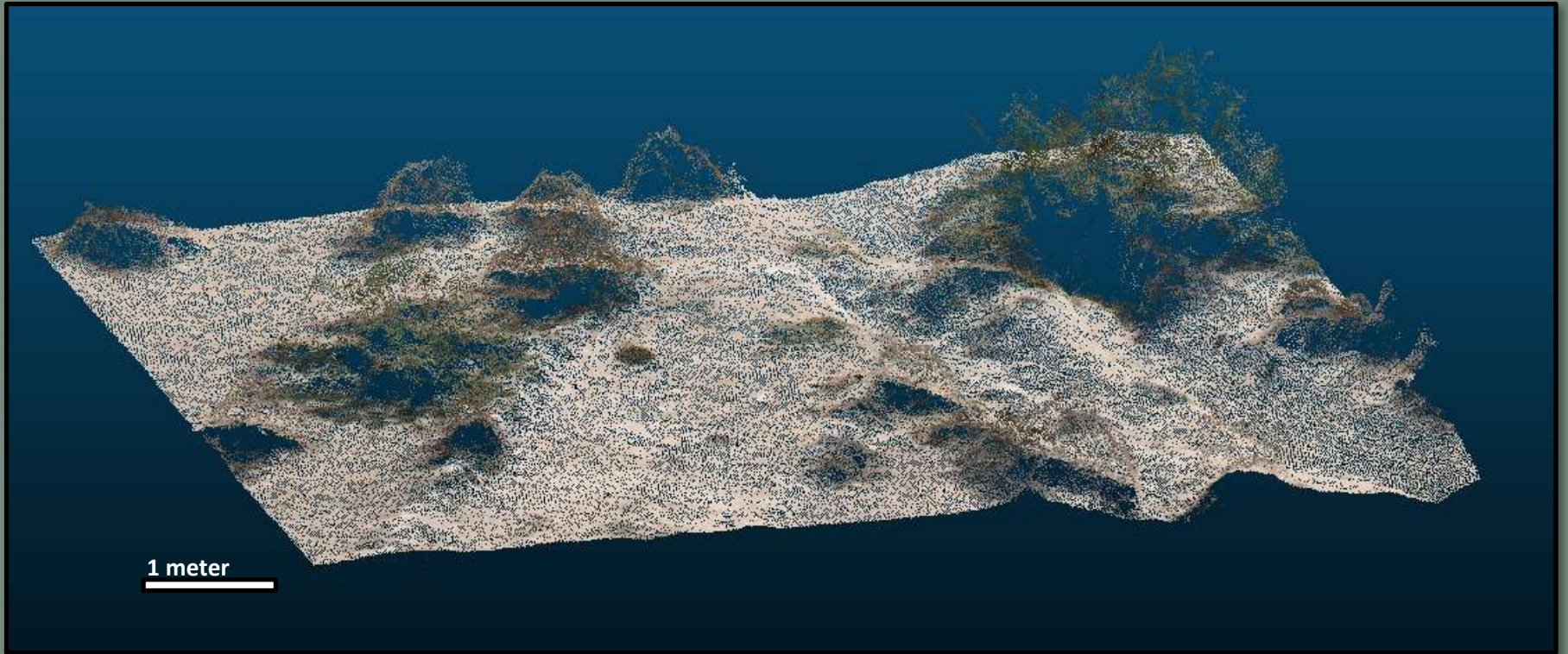
Tracking Soil Erosion: UAS



- Imaged six 50m x 50m test plots
- 152.4 m flying height (500 ft)
- 2.7 cm resolution
- ~20 images used to reconstruct Digital Elevation Models for each plot
- Images acquisition was very haphazard due to wind

Tracking Soil Erosion: UAS

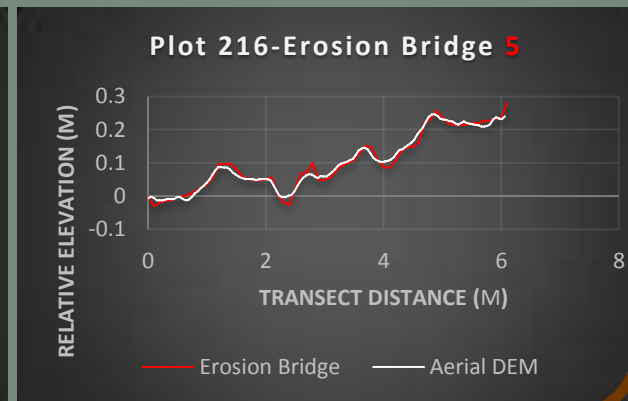
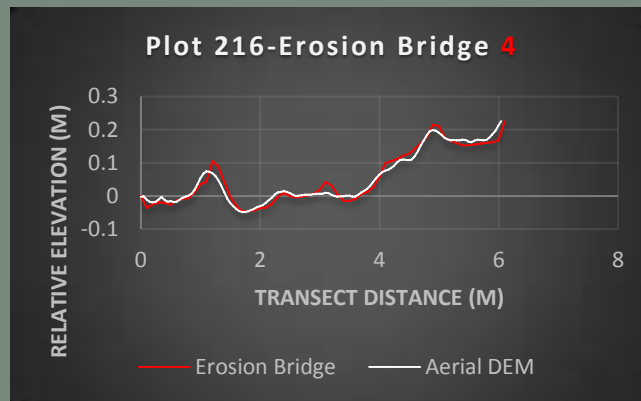
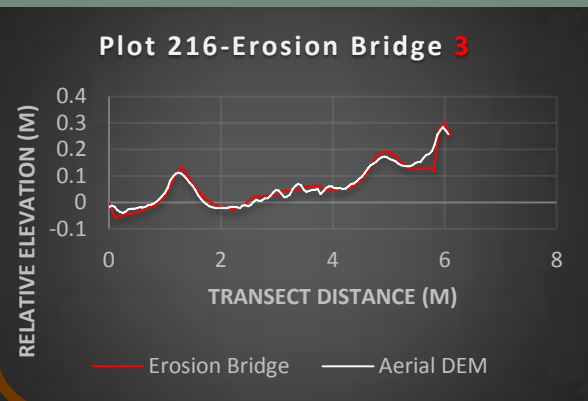
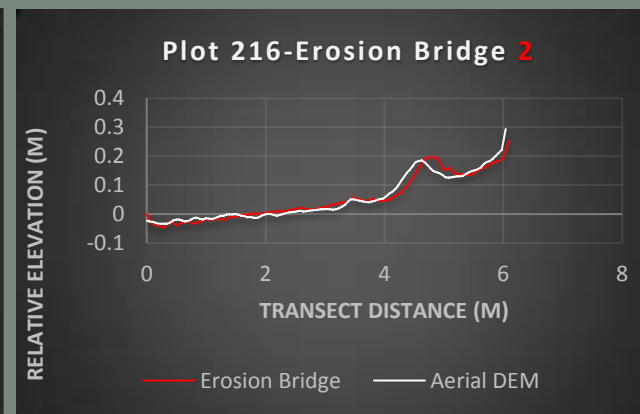
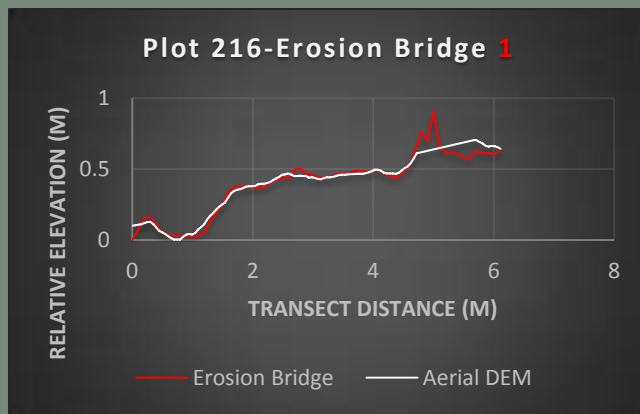
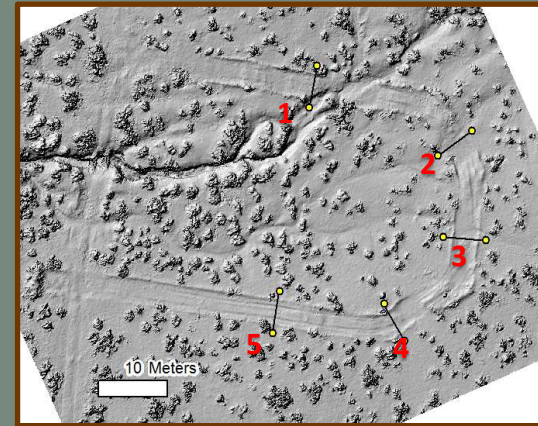
Surface Point Cloud using Agisoft PhotoScan



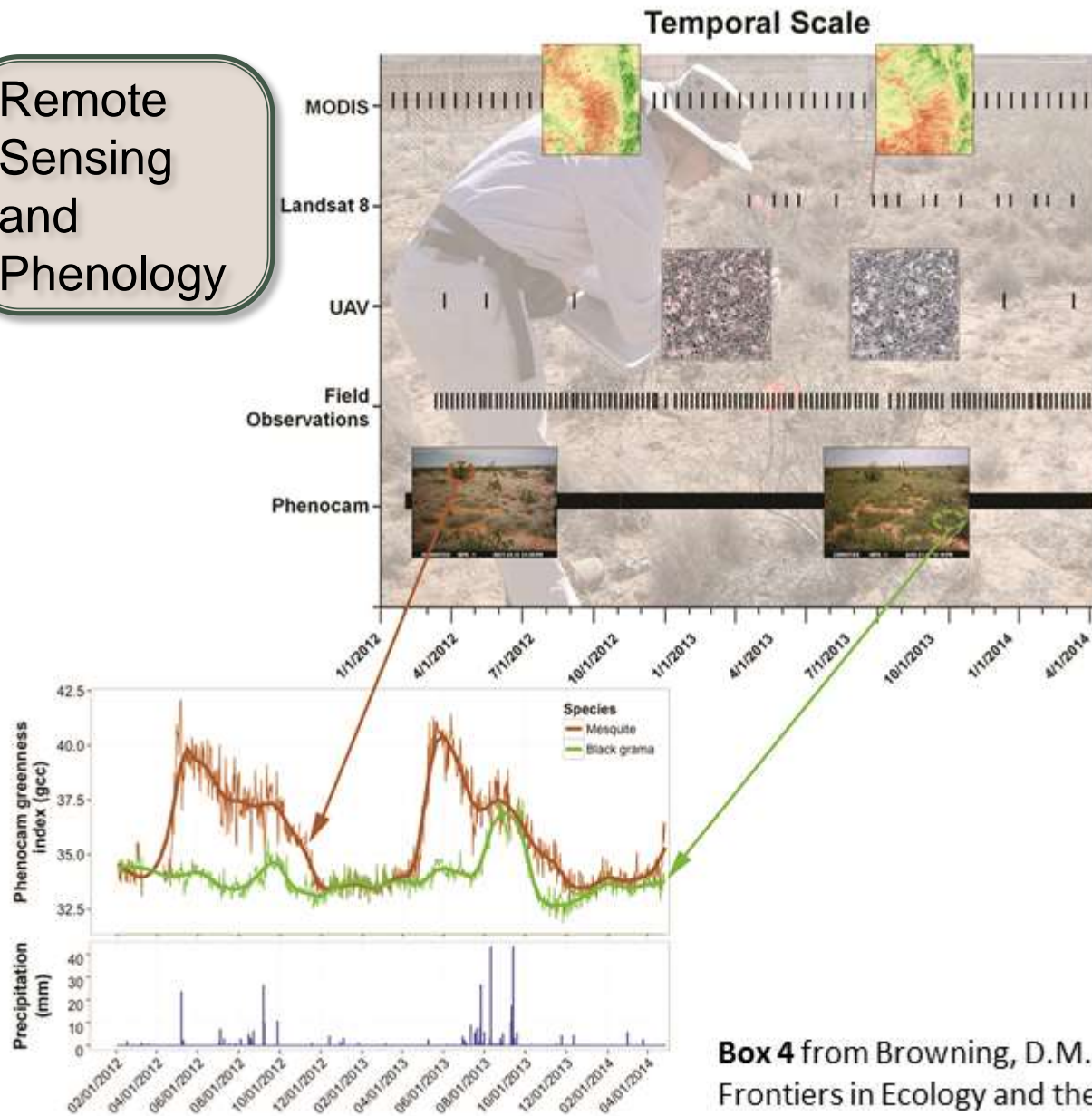
UAS Results



V.



Remote Sensing and Phenology



Box 4 from Browning, D.M. et al. *In Press*.
Frontiers in Ecology and the Environment

Reynolds Creek Experimental Watershed, Idaho

National Airspace System – COA required

Runway built for UAS flight

Bat 3 with Canon SD900 camera at 213 m AGL



When there are more than eight plots imagery analysis is more cost effective.

Data collection technique comparison – UAS imagery and ground data
Correlation values for bare ground, total veg, grass and forb, and shrubs were .9827, 0.9892, 0.9283 and 0.9782 (pretty good!) September 2008

Walnut Gulch Experimental Watershed, AZ

National Airspace System – COA required

Used local road as runway

Bat 3 with Tetracam 6-band MCA (Multi-Camera Array) and Canon SD900 at 213 m AGL

Multispectral

RGB

Methods for identifying and monitoring invasive species – UAS imagery and ground data
October 2011

Oliktok Point, Alaska

Sandia National Labs, Atmospheric Radiation Monitoring (ARM)

Climate Research Facility

North Slope of Alaska on Arctic Ocean

Established runway

Restricted airspace – no COA required

Bat 3 with Canon SD900 camera at 213m AGL

Testing small UAS under Arctic conditions for atmospheric monitoring
October 2012

Central Plains Experimental Range, CO

National Airspace System – COA required

Runway to be built for UAS flight

Bat 3 with Canon SD900 and Tetracam 6-band MCA (Multi-Camera Array) at 213 m AGL

Compare ground measures of plant biomass to estimates derived from imagery. Slated for August 2015

2413 m

Google earth

What do you do if you're not a public agency?

Commercial Exemptions issued by FAA

Fourteen issued within the last few months for:

- Film and video production

- Aerial surveying

- Construction-site monitoring

- Oil-rig inspections

- Real estate photography

- Precision agriculture

Much easier to obtain for remote, unpopulated areas.

Myths

Myth #1: The FAA doesn't control airspace below 400 feet

Fact—The FAA is responsible for the safety of U.S. airspace from the ground up.

Myth #2: Commercial UAS flights are OK if I'm over private property and stay below 400 feet.

Fact—Commercial operations are only authorized on a case-by-case basis.

Requires - a certified aircraft
a licensed pilot
operating approval

You may not fly a UAS for commercial purposes by claiming that you're operating according to the Model Aircraft guidelines (below 400 feet, 3 miles from an airport, away from populated areas).

More Myths...

Myth #3: Commercial UAS operations are a “gray area” in FAA regulations.

Fact—There are no shades of gray in FAA regulations.

Anyone who wants to fly an aircraft—manned or unmanned—in U.S. airspace needs some level of FAA approval.

Private sector (civil) users can obtain an experimental airworthiness certificate to conduct research and development, training and flight demonstrations.

Flying model aircraft solely for hobby or recreational reasons does not require FAA approval. Hobbyists are advised to operate according to the Model Aircraft guidelines.

Read more myths at: <http://www.faa.gov/news/updates/?newsId=76240>

So, you really want to fly some sort of UA.....



senseFly eBee \$12,000



DJI Phantom \$759 - \$1359

Wish List:

- Inexpensive
- Simple to operate
- Reliable
- Durable
- Portable
- Long-lasting battery
- Payload



Zephyr 2 UAV \$17,995

What we've seen....

The beautiful Jornada

Unmanned aircraft

FAA requirements

How we conduct flights on the Jornada

How the imagery is used in data
applications

Possibilities

Acknowledgements:

Jornada Bat Flight Crew

NMSU PSL UAS FTC

Craig Winters

Amy Slaughter

Dawn Browning

Jeff Gillan

Andrea Laliberte

Thank
You!!

