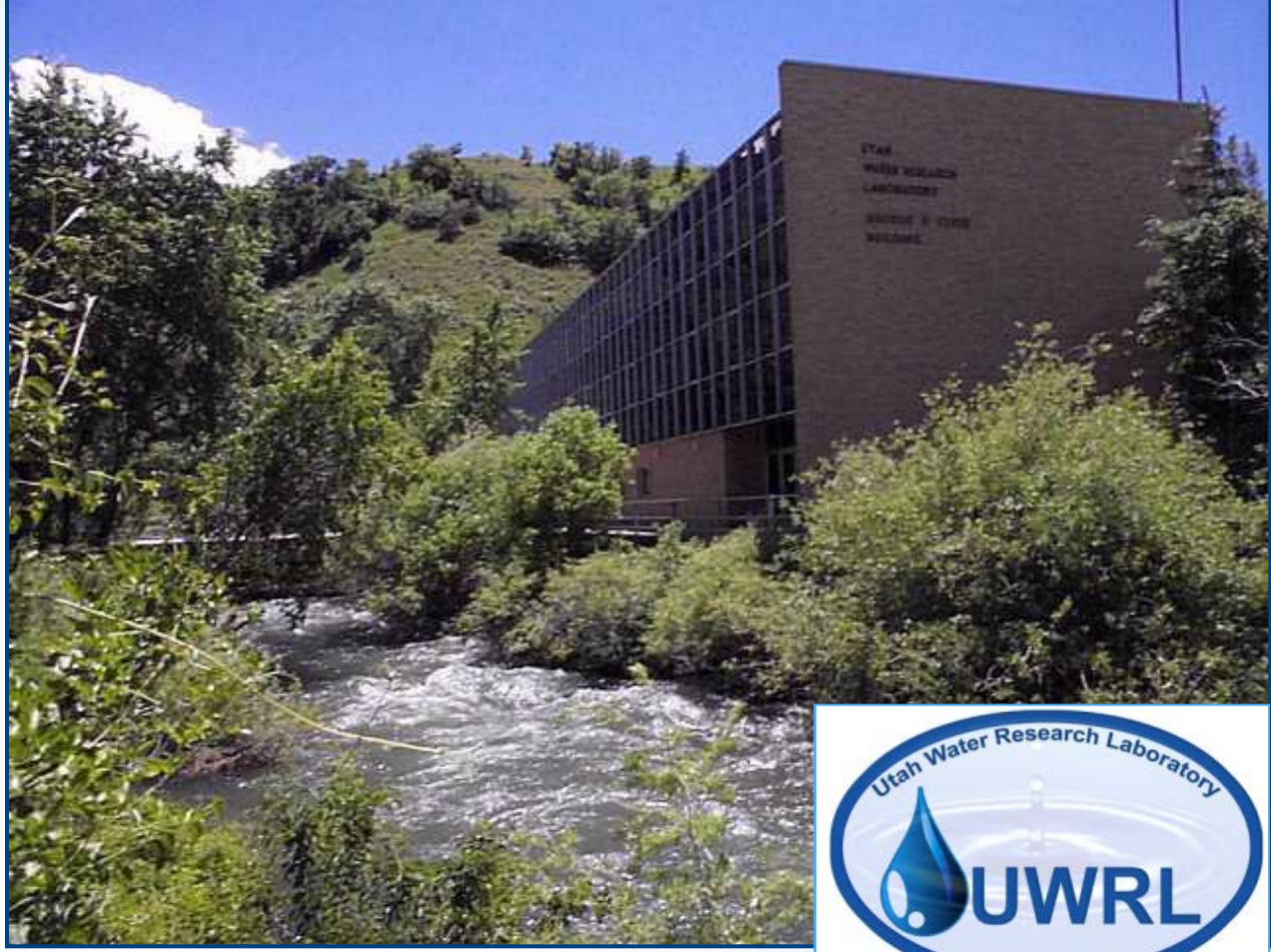
# Applications in Remote Sensing at the Utah Water Research Laboratory



**Mac McKee, Director**

**Utah Water Research Laboratory**

For a Seminar Presented at
UC Merced, June 14, 2013

College of Engineering

Utah State University

# Overview:

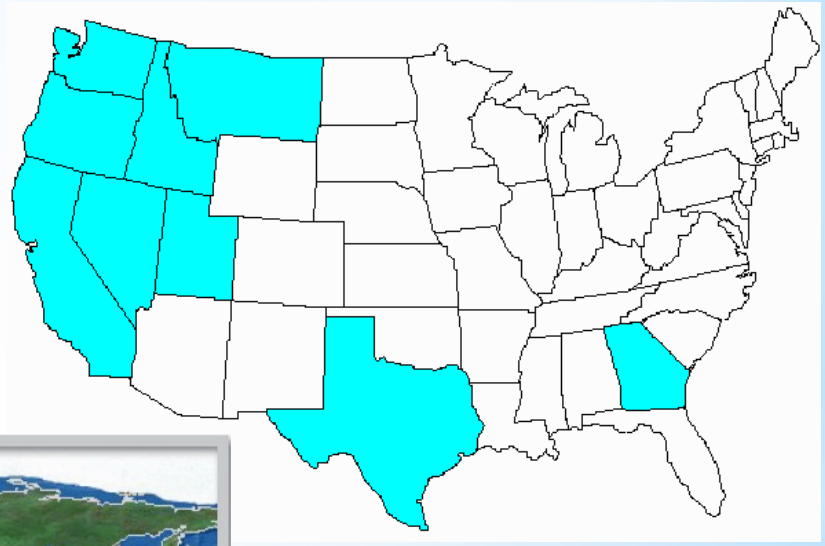
- The Utah Water Research Laboratory (UWRL) at Utah State University
- Remote sensing:  the AggieAir™ UAV platform and example applications
- The future (as we think--or hope--it will be)

# The Utah Water Research Laboratory:

- Oldest and one of the largest of 54 university-based water research centers
- Annual research expenditures: $8 - $12 million
- In total, approximately 200 faculty, staff, and students; we currently fund 85 graduate students
- Research and training projects…


# Research and training projects in:

- all 29 Utah counties,
- several US states, and




- historically, more then 70 countries

# Focus: Applied Research on Water Problems…

**Hazardous/Toxic Waste & Air Quality**

**Water Quality Engineering**

**Bioprocess Engineering**

**Water Resources Planning & Management**

Utah Water Research Laboratory

UWRL

**Groundwater & Contaminant Hydrogeology**

**Hydrology**

**Fluid Mechanics & Hydraulics**

**Water Education & Technology Transfer**

# The AggieAir UAV aircraft for remote sensing:

- Developed in partnership with CSOIS; flown under contract by the AggieAir Flying Circus at the UWRL


- First Generation (flying wing) accumulated more hours of autonomous flight and terabytes of orthorectified scientific imagery than any other comparable platform employed in natural resources mgt.

# The AggieAir UAV aircraft for remote sensing:

- The current platform (second generation):
  - ✓ "Minion" and "Titan" classes:
    - ➢ conventional design with fuselage and tail
    - ➢ larger payload volume and weight
    - ➢ swappable payloads
    - ➢ better flight performance:
      - o climb rate
      - o flight duration and distance
      - o stability


Titan, landing


Minion

# Minion Launch (“Warthog #3”):

# Minion Landing (“Warthog #3”):

# Platforms Under Development:

- Third Generation:
  - ✓ vertical takeoff and landing (VTOL)
    - ➢ same flight control technology
    - ➢ same payloads
  - ✓ testing under field conditions begins this summer

# Early AggieAir VTOL flight tests:

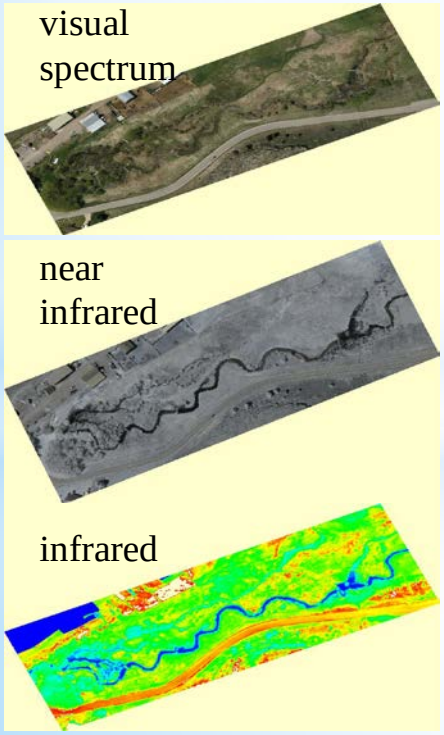
# Platforms Under Development:

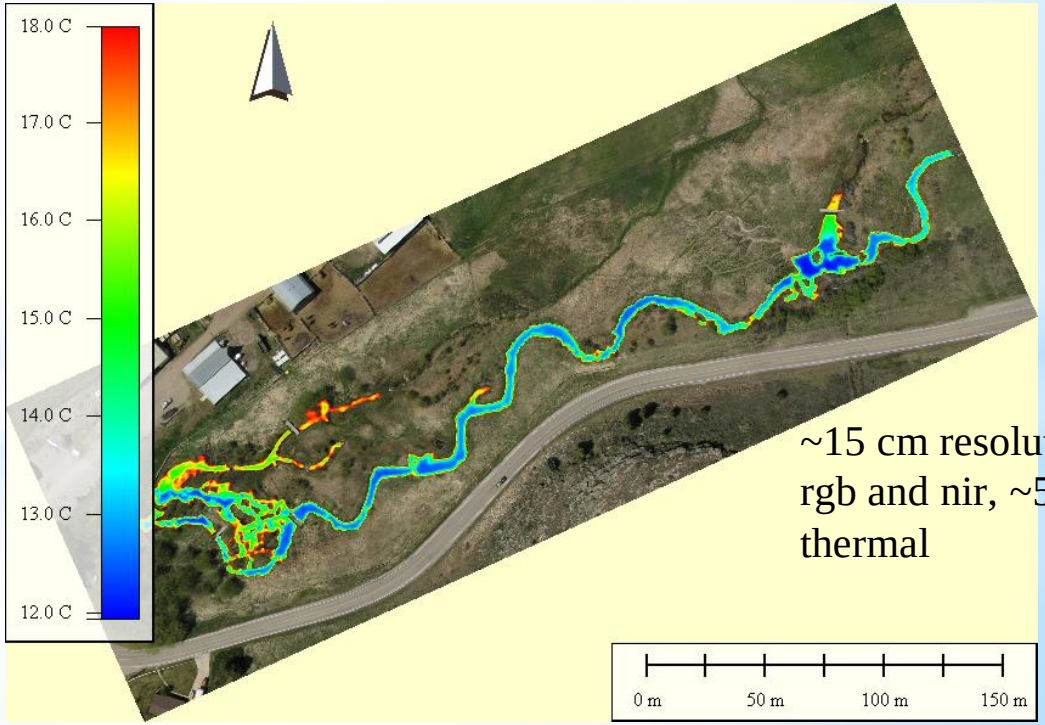
- Fourth Generation:
  - ✓ conventional fuselage and tail, approximately the size of Titan
    - ➢ gas engine with fuel injection; already tested, now being optimized
    - ➢ flight time: several hours
    - ➢ flight distance: up to 1,000 miles

| Specifications | AggieAir Platforms | | | | |
|---|---|---|---|---|---|
| | Flying Wing | Minion | Titan | VTOL | 4th Gen. Titan |
| Wingspan (feet) | 6 | 8 | 11 | N/A | 12? |
| Weight (pounds) | 8 | 12 | 25 | 4 | 30+? |
| Power Source | electric | electric | electric | electric | gas |
| Nominal Ground Speed (miles/hour) | 33 | 35 | 40 | 25 | 80+? |
| Maximum Flight Duration (hours) | 0.75 | 1 | 1.3 | 0.5 | 12? |
| Maximum Flight Distance (miles) | 25 | 35 | 50 | 12 | 1,000? |
| Payload Capacity (pounds) | 2 | 3 | 5 | 1 | 8+? |

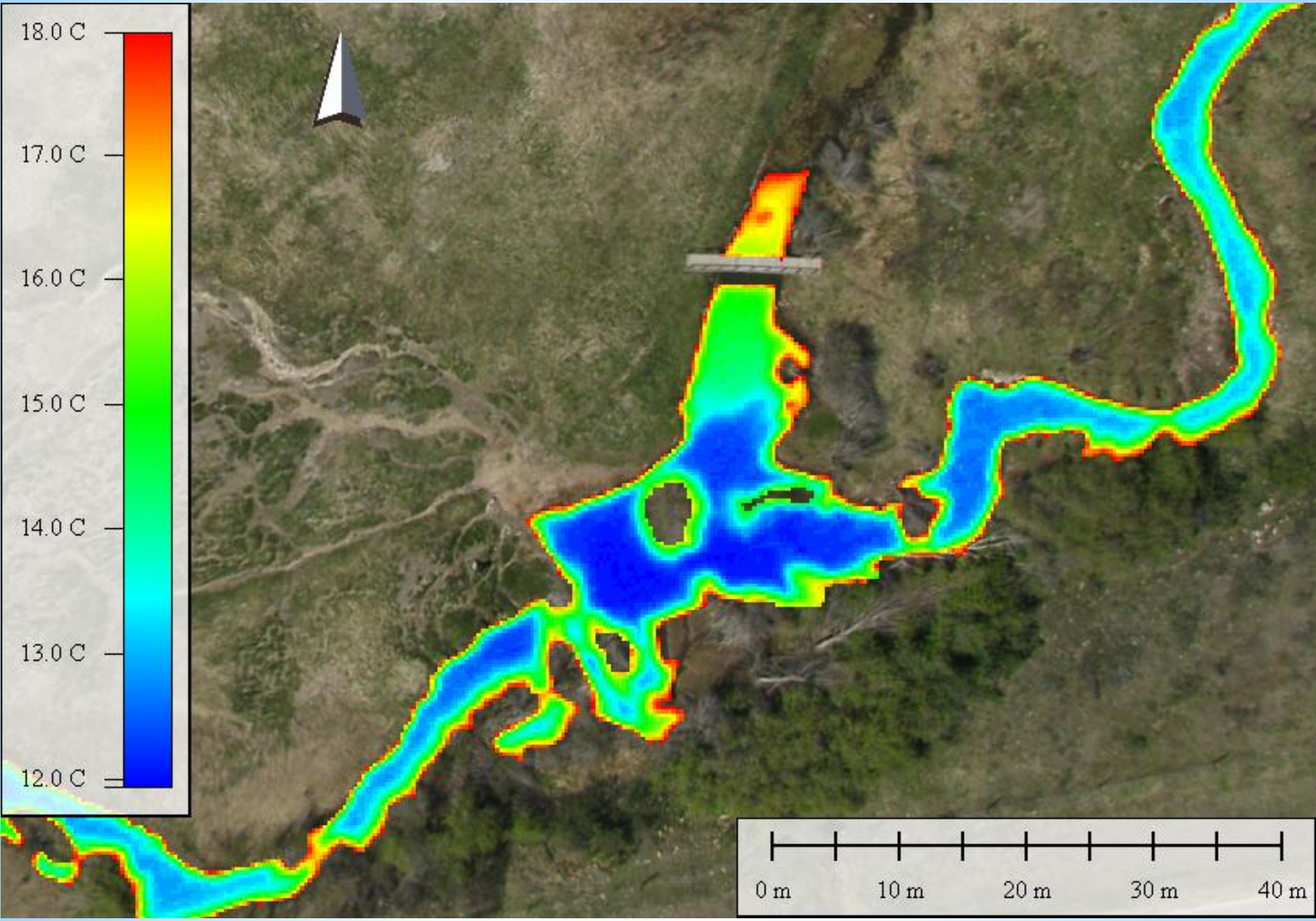
# Example AggieAir Applications:

- Payloads/Sensors:
  - ✓ Imagery: visual, near-infrared, infrared spectra
  - ✓ Fish/wildlife tracker is coming
  - ✓ Air quality sampling equipment has been flown




~15 cm resolution for rgb and nir, ~50 cm for thermal


18.0 C
17.0 C
16.0 C
15.0 C
14.0 C
13.0 C
12.0 C
0 m
10 m
20 m
30 m
40 m

# AggieAir Examples: *Phragmites australis*

RGB

NIR (false grey-scale)

A wetlands application in northern Utah, ~0.25 m resolution @ ~1,000 meters

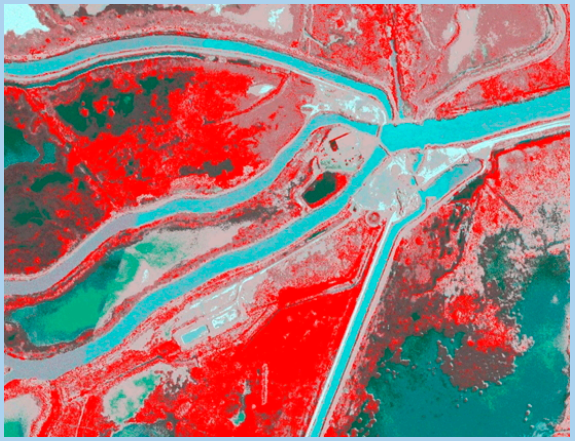
# AggieAir Examples: *Phragmites*

**Image Acquisition and Processing:**

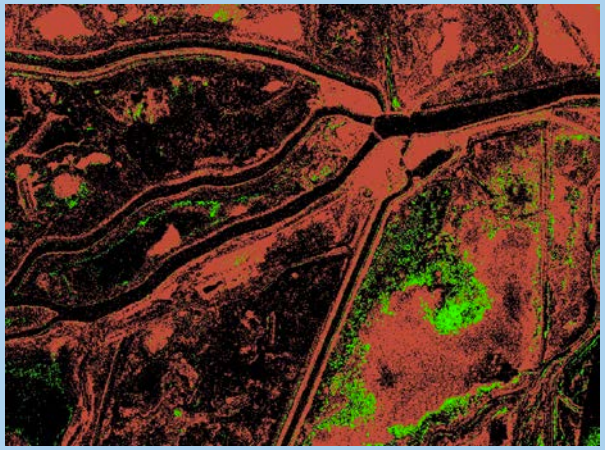
**RGB**

**NIR**

**Analysis:**



**Classification**



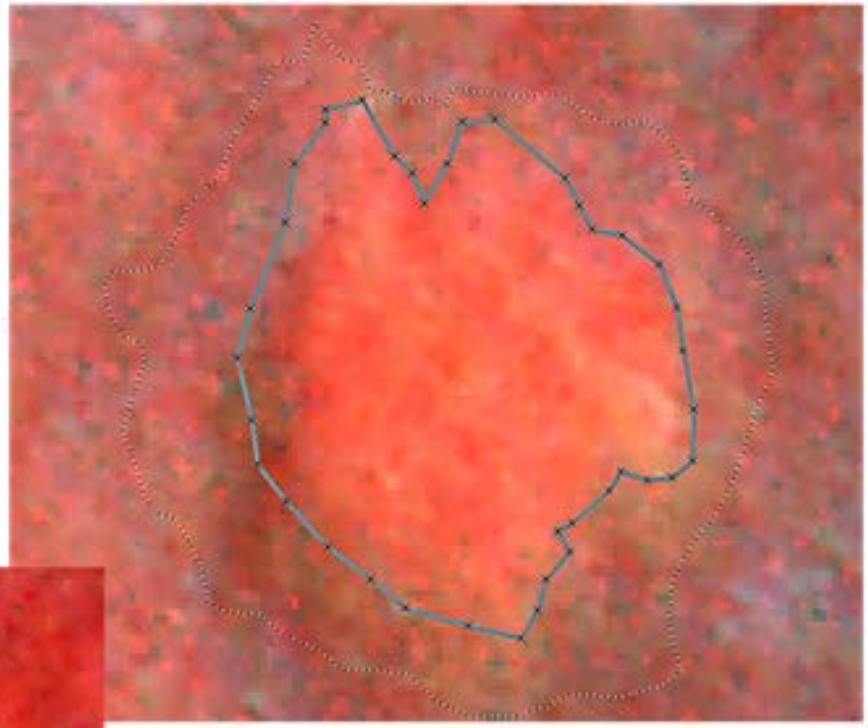
**Change Detection**

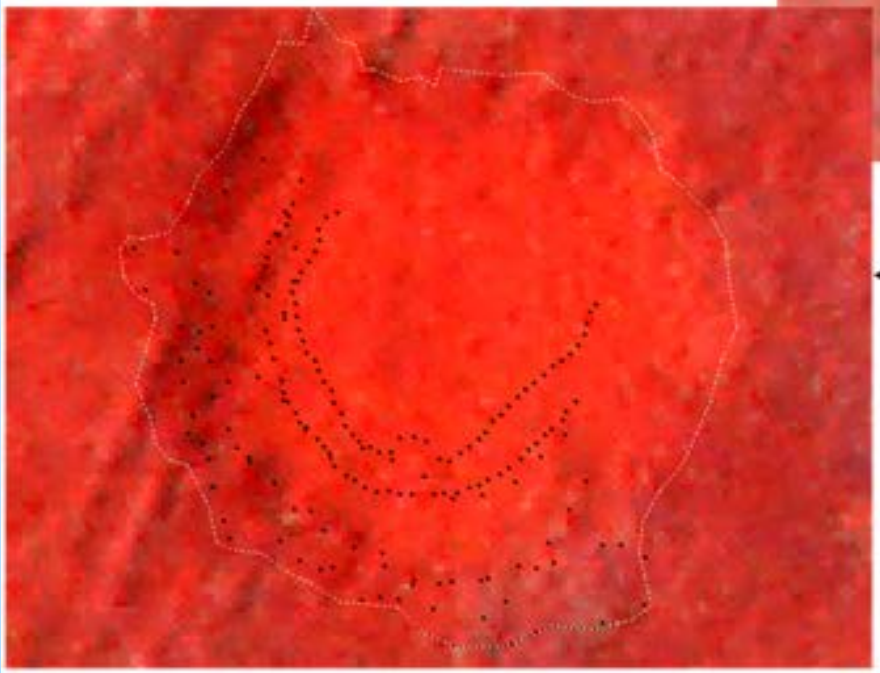
# AggieAir Examples: *Phragmites* genotype ident.

## Patch 3A_01

**Year 2010**

- Imagery acquired on 17 June 2010
- Area of the Patch – 257 sq. meters





**Year 2011**

- Imagery acquired on 23 July 2011
- Area of the Patch – 503 sq. meters

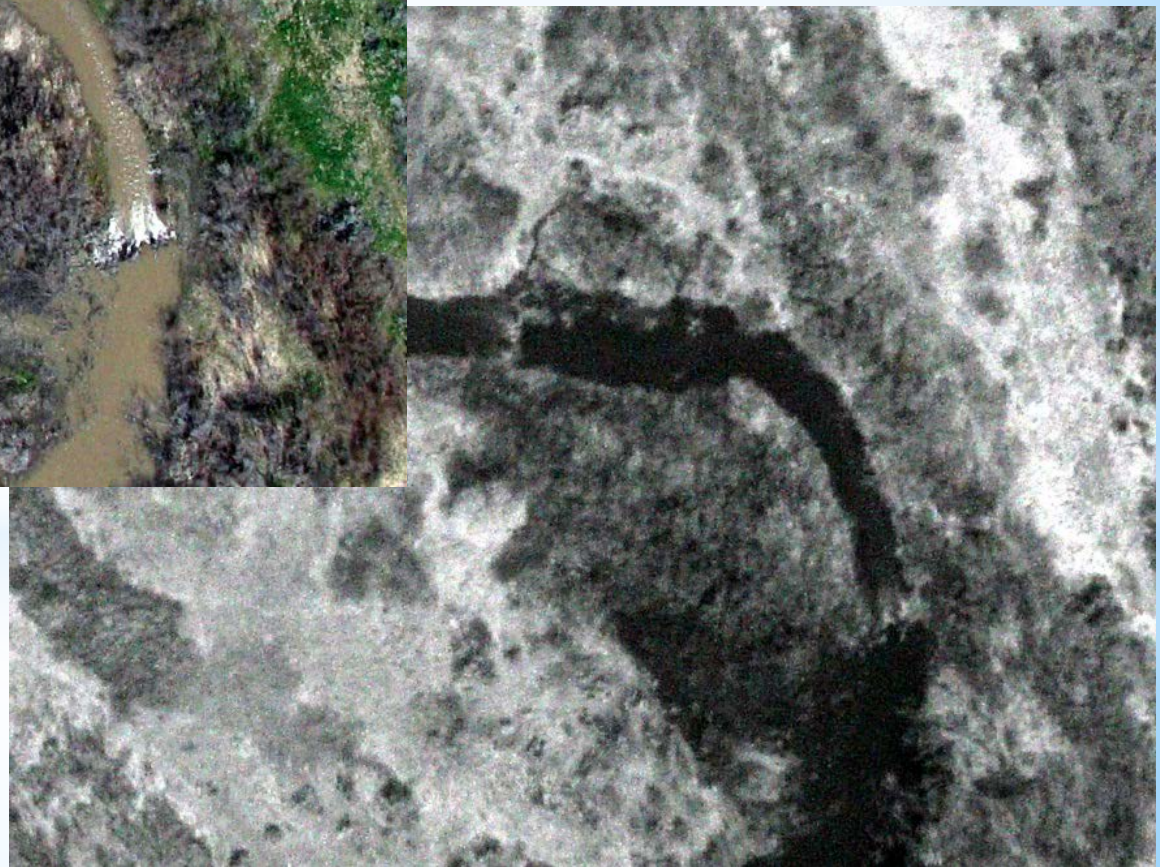
**Increase in size of patch from 2010 to 2011 is 246 sq. meters**

# AggieAir Examples: River Restoration

RGB

Restoration
Monitoring

NIR



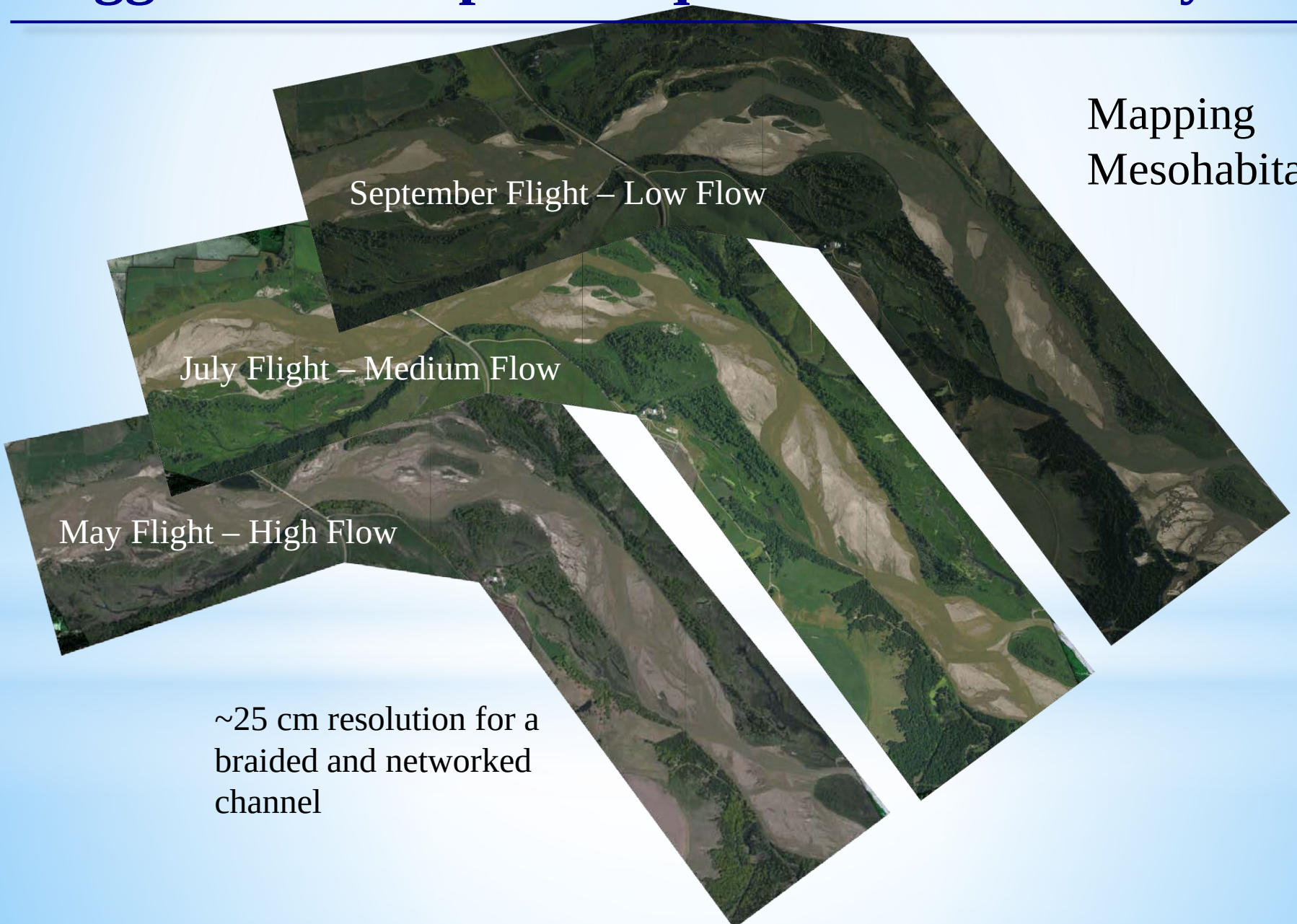
# AggieAir Examples: River Morphology

RGB

NIR

(~10 cm resolution)

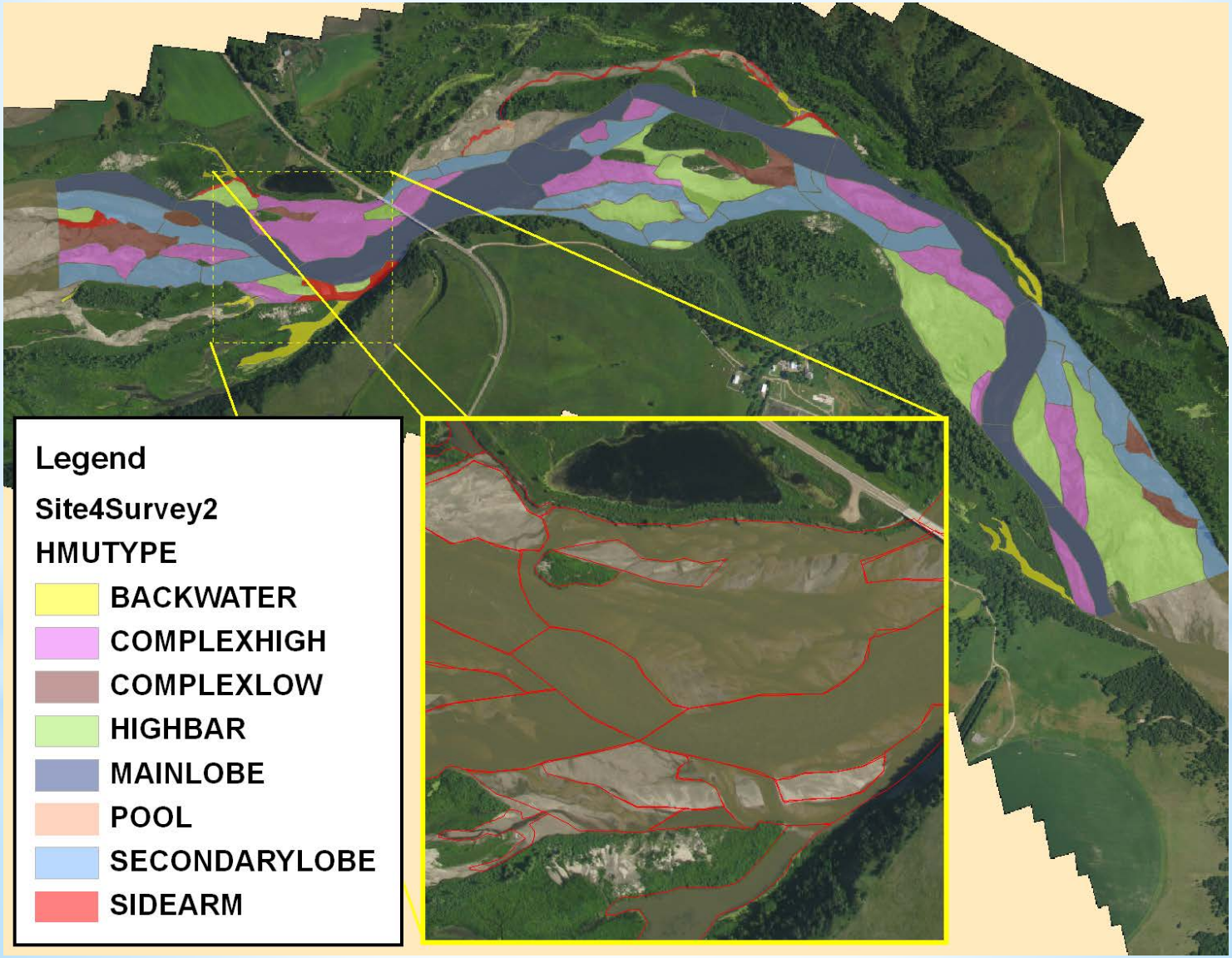
# AggieAir Examples: Aquatic Habitat Analysis

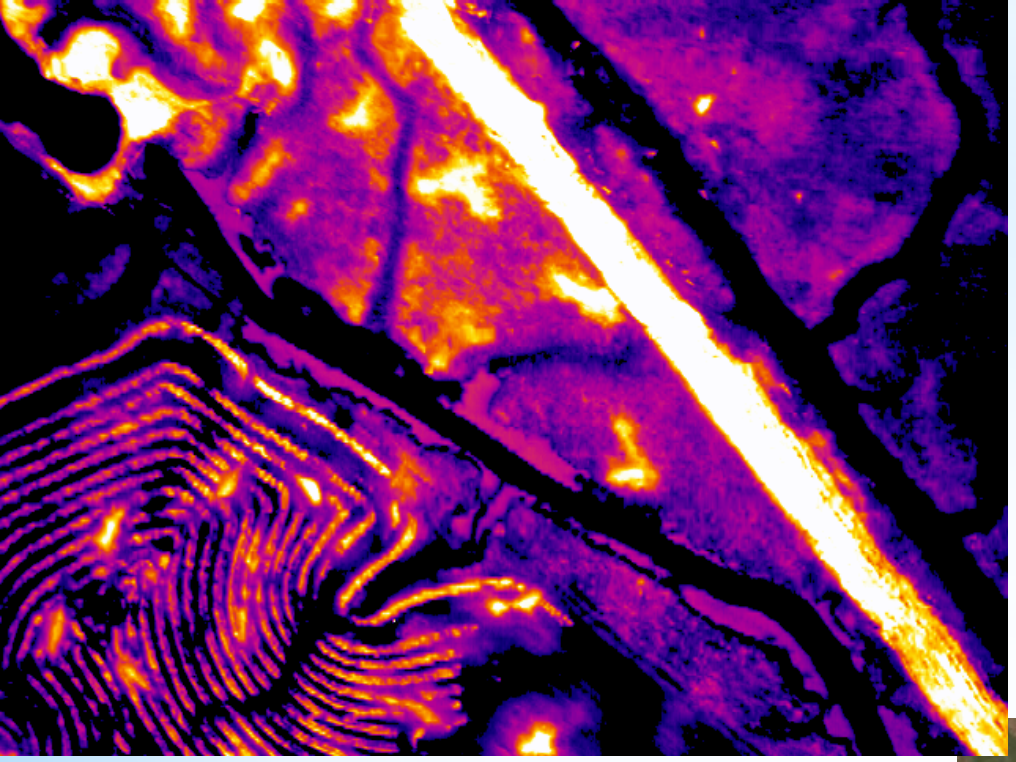



Mapping Mesohabitats

~25 cm resolution for a braided and networked channel

# AggieAir Examples: Aquatic Habitat Analysis





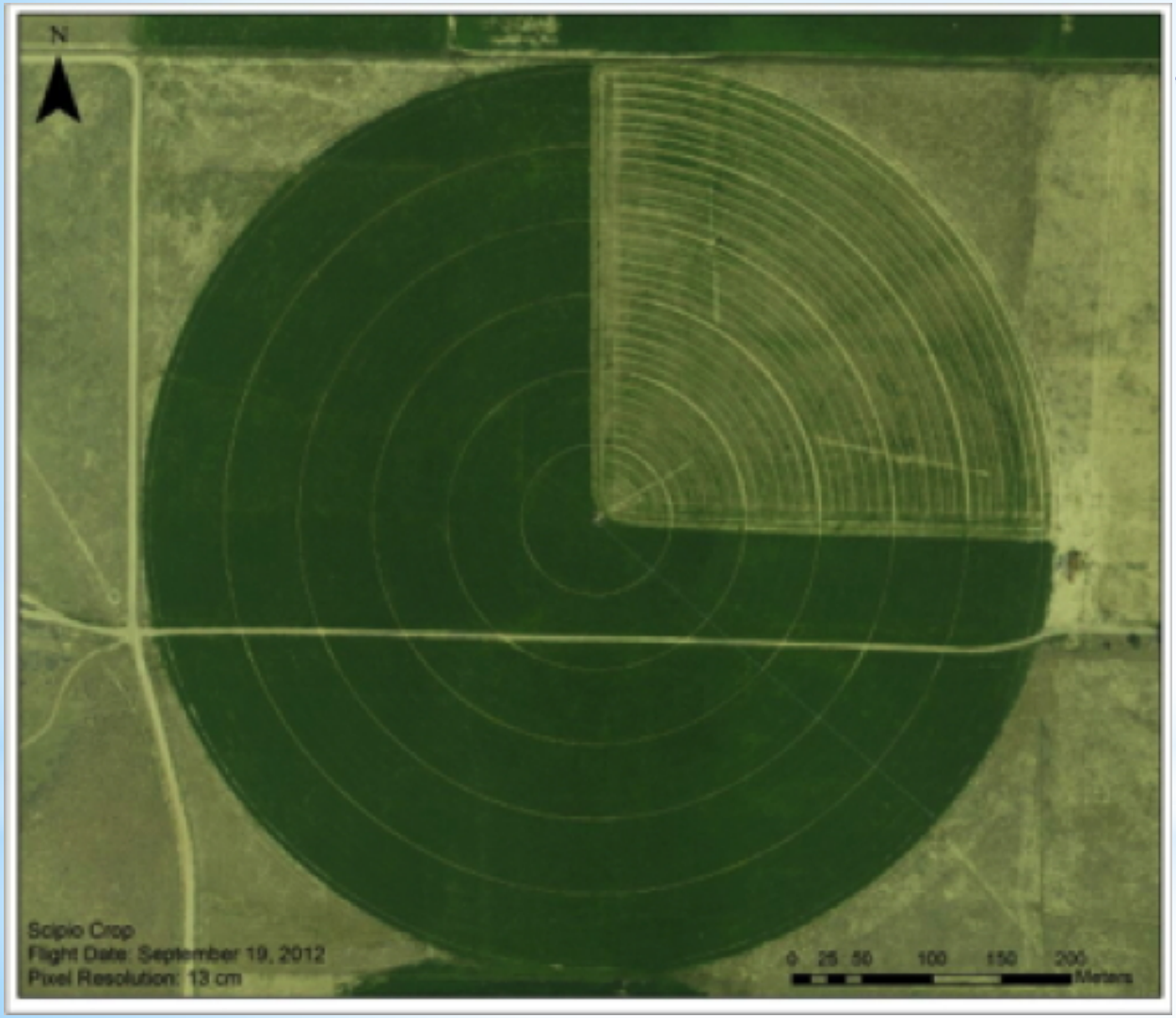
## AggieAir Thermal Imagery

What do you see, here?

OK, cows.

How about deer, antelope, others?

# AggieAir Examples: Precision Agriculture



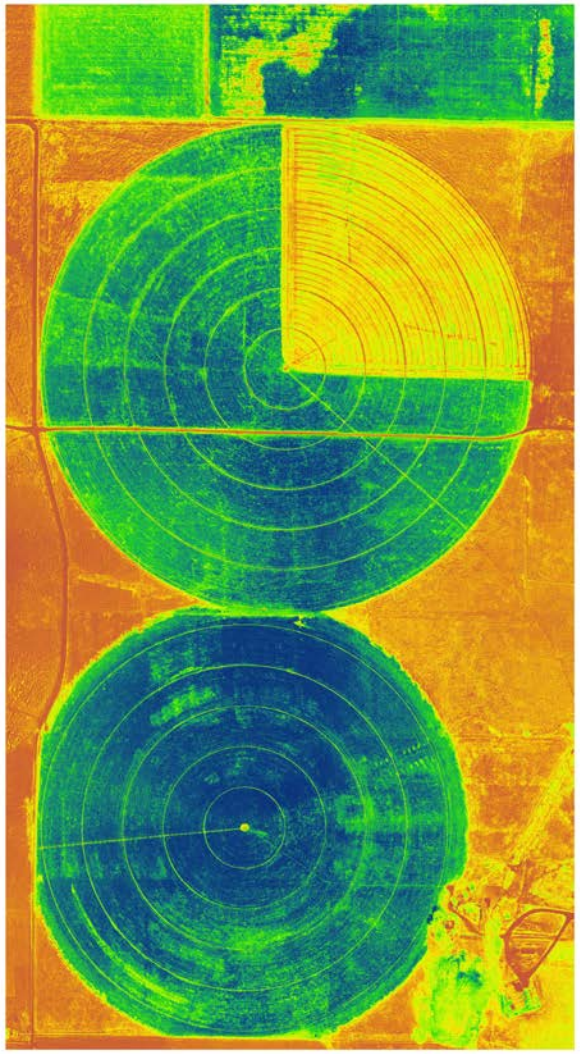

- Objectives:
  - ✓ develop methods for estimating soil moisture, evapotranspiration, and plant nutrition at high resolution
  - ✓ compare results to those available from standard approaches, e.g., derived from Landsat

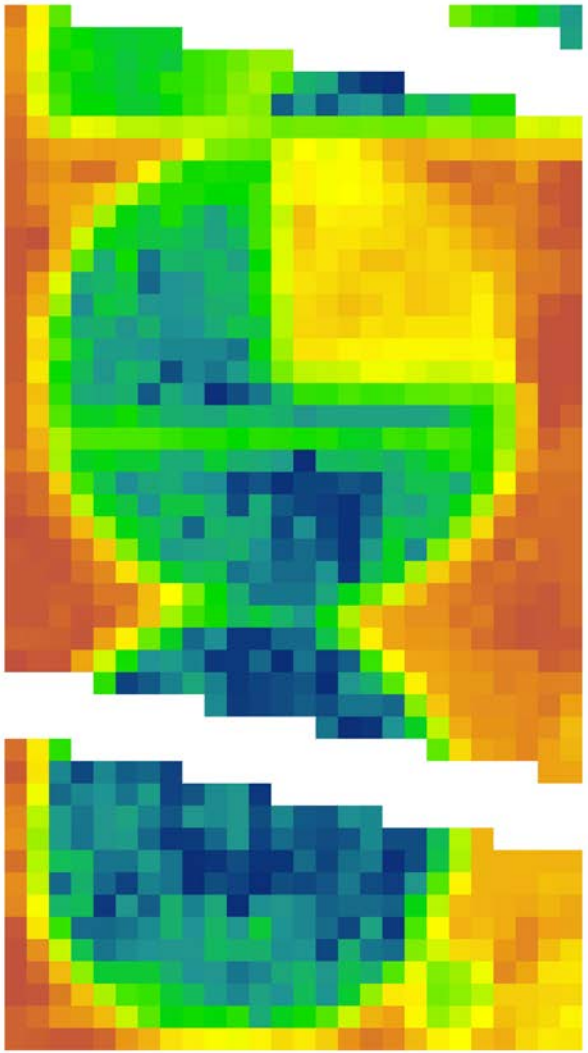
Over a center pivot in northern Utah, RGB imagery at 13-cm resolution

# AggieAir Examples: Precision Agriculture

September 18, 2012; NDVI Imagery

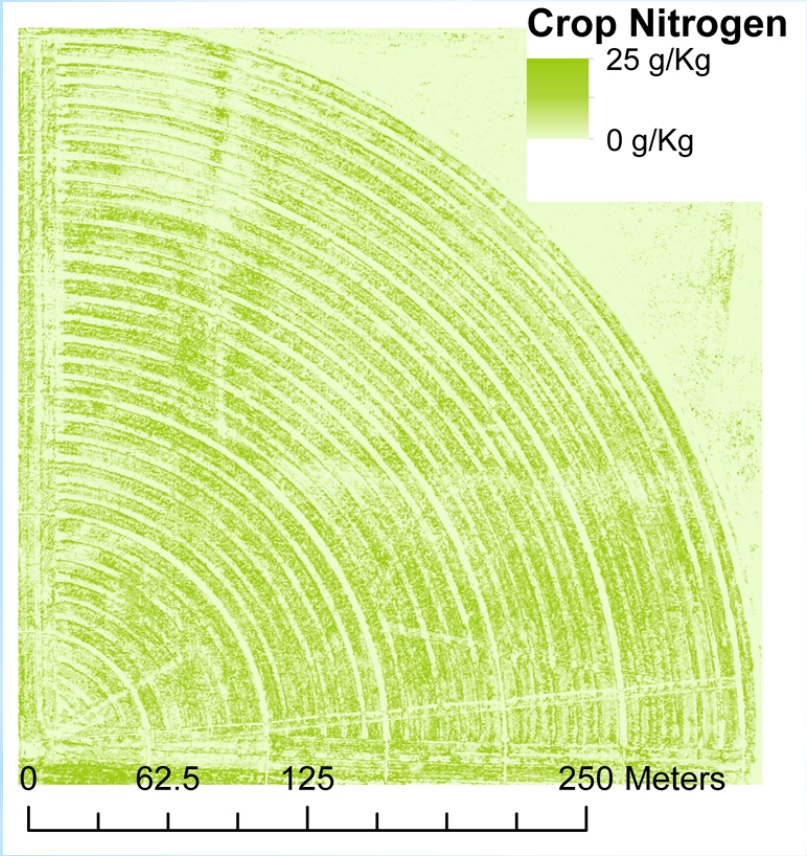
AggieAir: 13-cm resolution

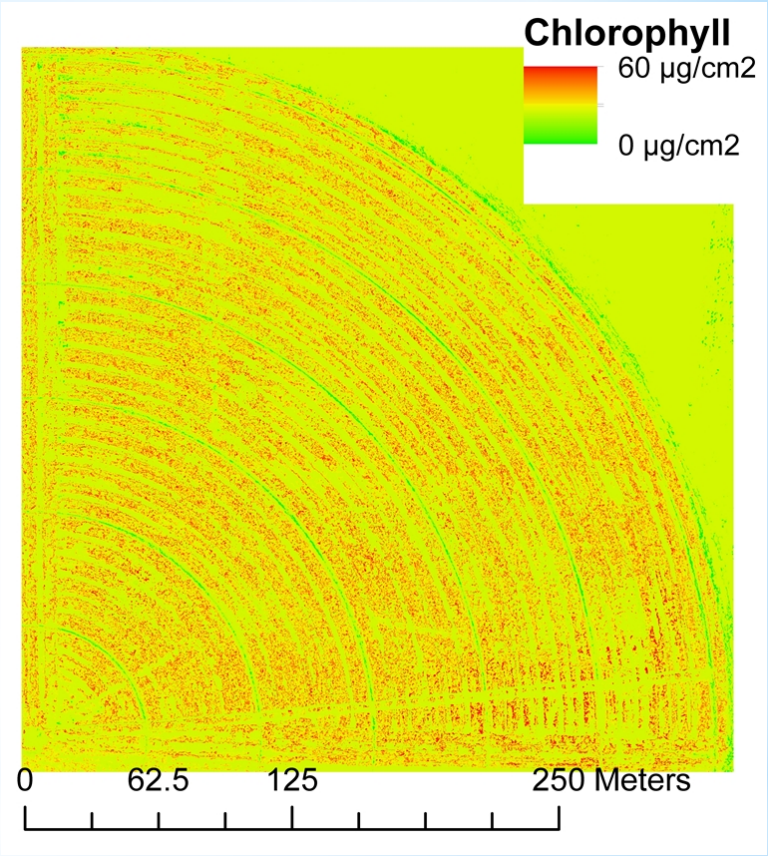




Landsat: 30-m resolution

# AggieAir Examples: Precision Agriculture



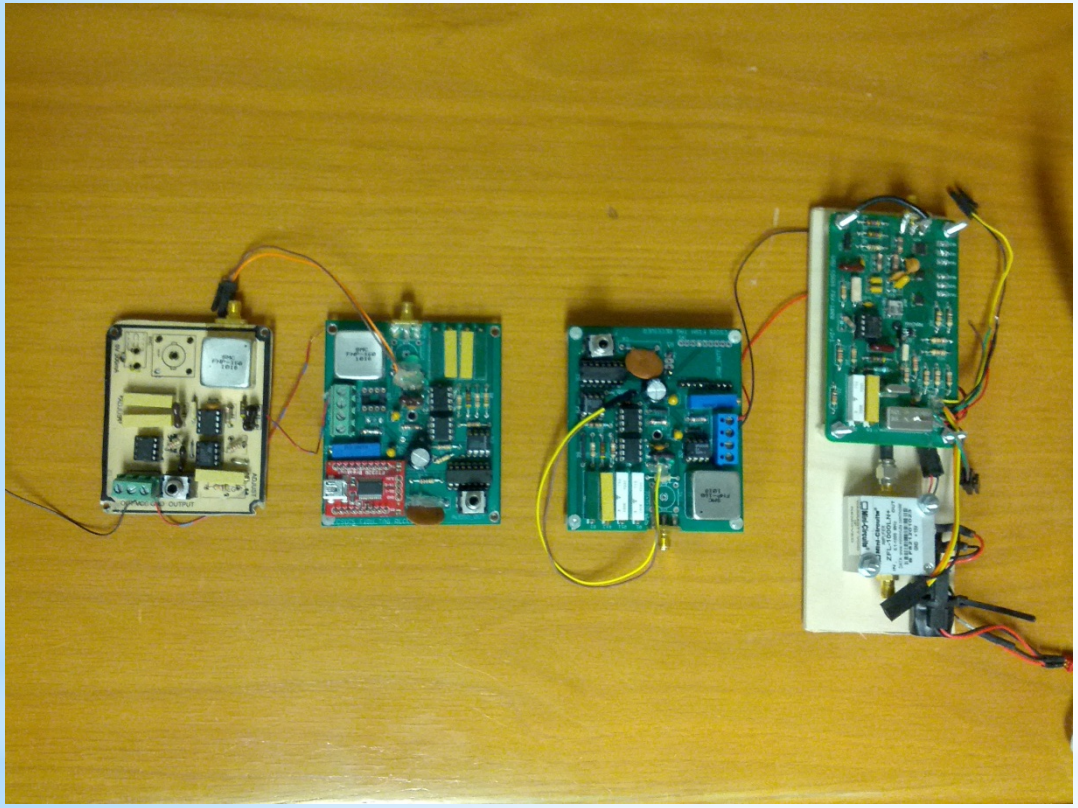




A center-pivot oat crop at 13-cm resolution

Similar resolution for estimates of surface soil moisture, evapotranspiration rates, crop dry-weight biomass, yield forecasts.

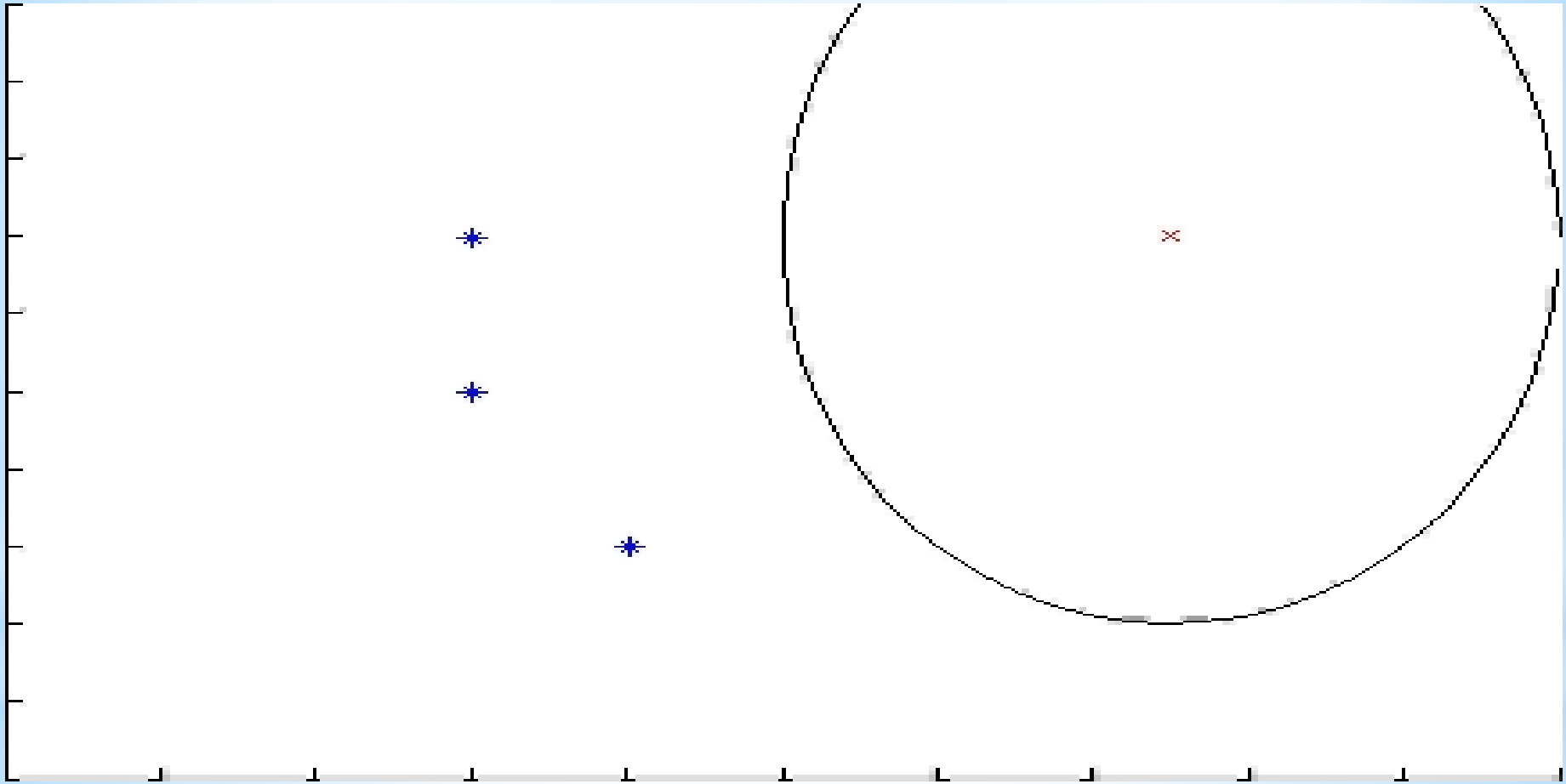
# AggieAir Examples: Radio-tagged Wildlife

## AggieAir

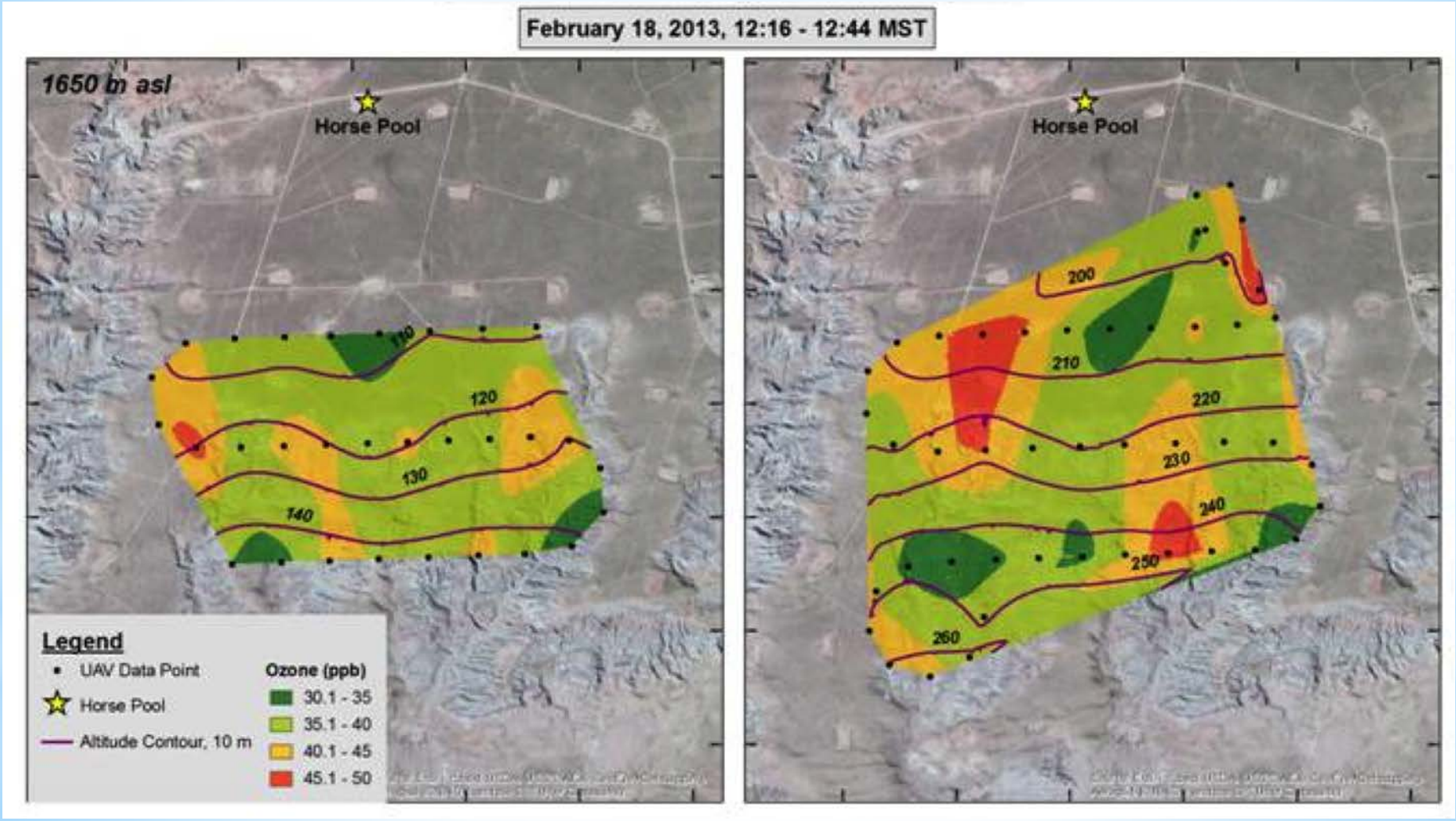


versus:

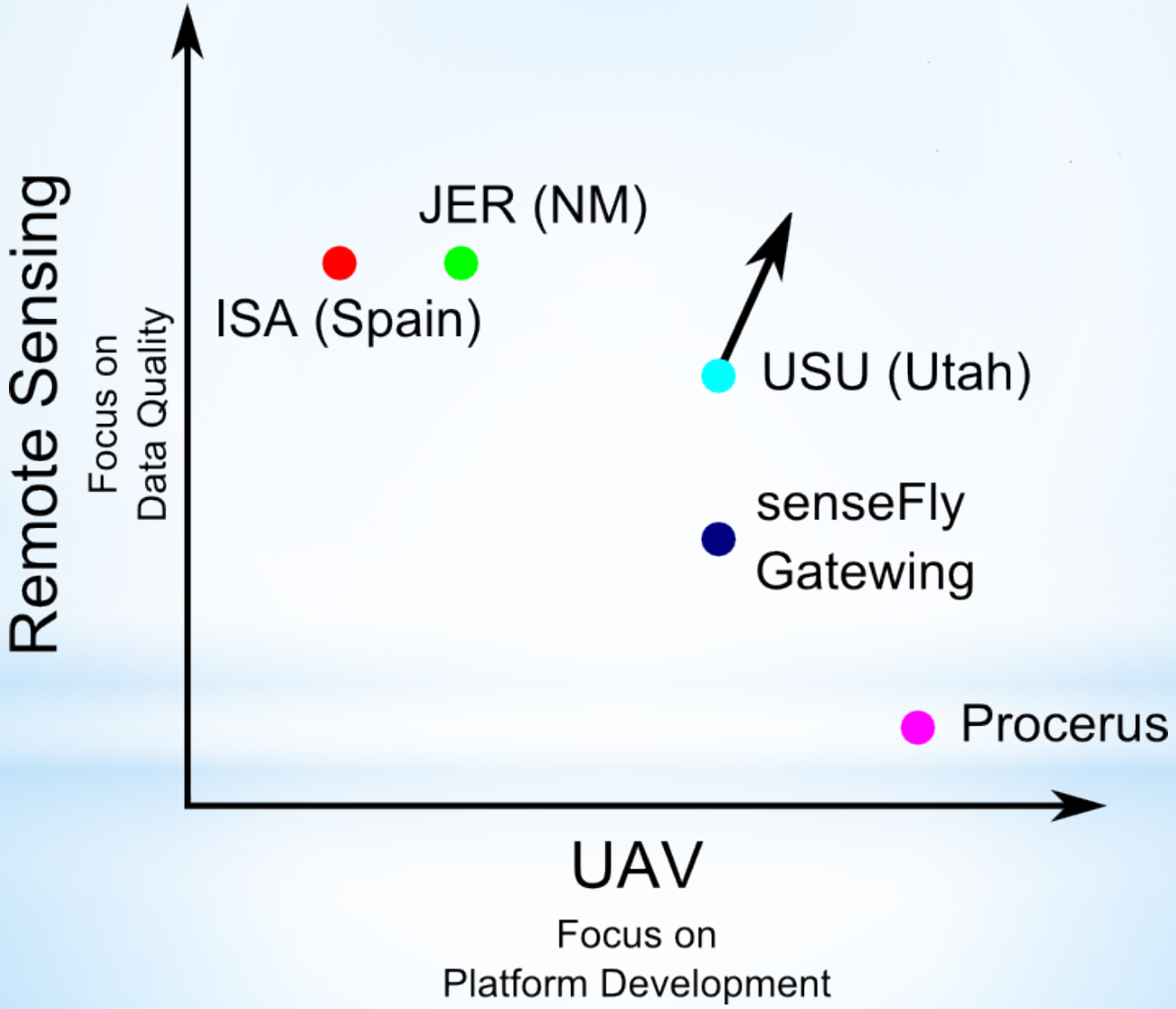
# AggieAir Examples: Radio-tagged Wildlife



# AggieAir Examples: Air Quality Sampling



# The Present State:



# The Future:

- Sensors: miniaturized, scientific-grade instruments must be developed
- Platforms + Sensors: must be designed with end-to-end costs in mind; design must address scientific requirements
- The civilian UAV market: ~$90B by 2020
- UAV air safety: much research to be done
- FAA: a slow march from the 12th to the 21st Century

# The Future (we hope):

## Our ERC Bid to NSF:

- Multi-million-dollar 5-year program (USU, UC-Merced, UC-Davis, Texas State U., BYU)
- "Engineering Research Center for Miniaturized Aerial Sensors and Systems (MASS)"
- A multi-step proposal process has just begun
- The MASS concept:
  - ✓ A piece of scientific equipment to deliver high-quality, scientific-grade remotely sensed data and actionable information at low cost
  - ✓ End-to-end optimization of small aircraft + high-quality/high-value sensors + processing software to minimize full life-cycle costs:
    - ➢ aircraft cost ≤ $50K; weight ≤ 50 pounds; range ≥ 500 miles
    - ➢ sensors: multispectral/hyperspectral, LIDAR, SAR, others
  - ✓ participation of key industries (pay-to-play)


Utah Water Research Laboratory
UWRL

UtahState University

Visit us at: http://AggieAir.usu.edu/
or contact: Mac McKee, 435-797-3188, Mac.McKee@usu.edu
Austin Jensen, 435-797-3315, Austin.Jensen@usu.edu