Department of the Interior
Unmanned Aircraft Systems (UAS) Activities

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Why Unmanned Aircraft Systems?

Department of the Interior (DOI) manages more than one-fifth of U.S. land

- UAS can address information gaps in remote areas
- Manned aircraft pose safety risks, are more expensive and more weather dependent
- Satellite observations are hindered by weather, low resolution, and long data acquisition intervals
- Field surveys can be costly, challenging and geographically limited

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Factors For Increased UAS Usage

UAS technology is developing at extraordinary rates

- U.S. Universities involved with UAS related programs- 165
- Countries involved with UAS manufacturing- 65
- US UAS related manufactures- 200
- Global UAS related manufactures- 715
- Global UAS platforms- 2400

Federal Aviation Administration Reauthorization Act

- Establishes a 2015 deadline for integration of UASs into the National Airspace System (NAS)
- Requires that small UASs be allowed to routinely fly in the NAS by May 2014
- Requires the FAA to establish six UAS test sites*
- Supports UAS operations in the Arctic

Association for Unmanned Vehicle Systems International predicts that three years after being integrated into the NAS, UASs will-

- Provide more than 70,000 U.S. jobs
- Add more than $13 billion to U.S. economy

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Who Can Fly in the NAS?

FAA regulations

Can a civilian company operate an UAS as part of a business?

Currently, civilian companies may not operate a UAS as part of a business without obtaining a Special Airworthiness Certificate - Experimental Category (SAC-EC). However, this SAC-EC is very limited in scope of operational use. FAA Order 8130.34.

Who can receive a Certificate of Authorization (COA) to fly a UAS in the NAS?

Only public agencies operating an unmanned aircraft.

What is a "Public Agency?

Any agency that operates a public aircraft (14 CFR Part 1.1). If you receive funding from the federal government at some level, you are probably a "Public Agency." A public agency can never operate under the guidelines of Advisory Circular 91-57 (Model Aircraft)

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FEDERAL AVIATION ADMINISTRATION

Outstanding Issues….

Issues that need to be addressed:

- Standards (ASTM F-38 and RTCA SC203)
- Definitions
- *Secure command and control links*
- Aircraft certification/registration
- Operator training/certification/registration/licensing
- Air traffic requirements/procedures
- Spectrum allocation
- *Sense and Avoid*
- *Secure GPS*
- Lost link procedures
- Safety analysis/risk acceptance
- Insurance
- Liability
- Public perception
- *Privacy……*

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Privacy Concerns

- Fourth Amendment provides protection against unreasonable searches and seizures; also requires that search warrants are based on probable cause.

- U.S. Courts have repeatedly held that data from airborne technology, in public airspace, observing anything in "plain view," without using "sense-enhancing technology" will be admissible without a warrant.

- State and Congressional legislation
  - Focus is primarily on law enforcement,
  - Support resource management, scientific, environmental and emergency management

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Unmanned Aircraft Systems National Project Office

Supports the technology transfer of UAS capabilities to enhance the informed decision making across the Department

- **Collaborates on operational test and evaluation missions with other DOI agencies**
- **Evaluates emerging technologies and software**
- **Host for monthly DOI UAS User call**

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DOI UAS Platforms

AeroVironment – Raven RQ-11 A

Wing Span	55 inches
Air Vehicle Weight	4.2 lbs
Range	10+ km (LOS)
Airspeed	27-60 mph
Altitude	>400 AGL
Endurance	90 min Lithium Battery
Payload	EO/IR Full Motion Video
	GPS- Radio uplink & down link
GCS/RVT	- Combined Weight – 14 lbs

Honeywell – T-Hawk RQ-16

AV Weight	18 lbs
System Weight	51 lbs
Range	10 km
Endurance	47 minutes - Gas Powered
Payload	EO/IR Sensor
Max Speed	45 mph
Flight Characteristics	Hover and Stare Capable

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Office of Aviation Services (OAS)

- Aviation Safety
- Aircraft Management
- Coordination of Assets
- New Technology
- Procurement of Systems

UAS Procedures

- Pilot Certification
- Aircraft Airworthiness
- Certificate of Authorization (COA) Process

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OAS Memorandums & Agreements

MEMORANDUM OF AGREEMENT

between

AVIATION MANAGEMENT DIRECTORATE

and

US GEOLOGICAL SURVEY UNMANNED AIRCRAFT SYSTEMS PROJECT OFFICE

1. **PURPOSE**. The purpose of this Memorandum of Agreement (MOA) is to define the roles and responsibilities of the Department of the Interior Aviation Management Directorate (AMD) and the United States Geological Survey, Unmanned Aircraft Systems Project Office (USGS-PO) for the assignment of RQ-11A RAVEN and RQ-16 THawk III (gMAV) Unmanned Aircraft Systems (UAS).

2. **REFERENCES**
   a. DOI Departmental Manual (DM) 352
   b. DOI AMD Operational Procedures Memorandum (OPM) 9-11
   c. DOI AMD Operational Procedures Memorandum (OPM) 11-11
   d. FAA Modernization and Reform Act of 2012

3. **BACKGROUND.** In February 2012, the United States Geological Survey, UAS Project Office provided an Operational Test and Evaluation (OT&E) proposal for the assignment and OT&E of Small Unmanned Aircraft Systems (sUAS). These systems will support USGS-PO on-going missions, as well as sensor and systems evaluations. USGS maintains a leading role as the Department of the Interior's UAS Center of Expertise for Scientific Applications and has supported the development and use of UAS technology in its scientific research investigations, monitoring of environmental conditions, climate change impacts and myriad related land management decisions. In the absence of appropriations language authorizing Department of the Interior to assume full ownership of these sUAS, or an Aviation Board of Directors (ABOD) approved UAS Concept of Operations (CONOPS), a MOA is required to document authority and responsibilities for employment of these systems.

4. **SCOPE**. This document establishes an agreement to assign USGS operational control of the equivalent of 5 RQ-11A Raven and 3 RQ-16 THawk III systems and specifies requirements and responsibilities associated herewith.

5. **UNDERSTANDING/AGREEMENT, SUPPORT, and RESOURCE REQUIREMENTS**. Nothing contained in this agreement shall be considered as binding the DOI-AMD or USGS-PO to expend in any one fiscal year any sum in excess of appropriations made by Congress for the purposes of this agreement for that fiscal year, or other obligations for the further expenditure of money in excess of such appropriations. Support and resource requirements necessary to execute this agreement's provisions are as follows:

United States Department of the Interior

U. S. GEOLOGICAL SURVEY
Denver Federal Center
Denver, Colorado 80225

IN REPLY REFER TO:
Rocky Mountain Area

February 13, 2012

From: Dr. Randall G. Updike, Executive, U.S. Geological Survey Rocky Mountain Area

To: Mark Bathrick, Associate Director, Department of the Interior, Aviation Management Directorate

Subject: Unmanned Aircraft System (UAS) Request

1. Requesting Office: (Responsible Individual/Contact Information)
   Robert H Diehl
   Research Ecologist
   Northern Rocky Mountain Science Center (NOROCK)
   2327 University Way, Suite 2
   Bozeman, MT
   59715
   406-994-6556
   rhdiehl@usgs.gov

2. Is this a new requirement?
   No, requesting to have Raven-A Kit #10 returned to the Northern Rocky Mountain Science Center.

3. Assets Requested: One Raven-A system (Kit#10)

4. Proposed Start and End Dates: 2/10/2012-1/31/2013

5. Proposed/Planned/Anticipated Tests to Be Conducted:

   Pilot Currency-Simulator: We currently have three trained Raven pilots who require a Raven-A system to maintain currency through the simulator. Dates are ASAP until our flight training COA, draft #2809, is approved (see below). Simulator currency flights will be conducted at NOROCK to support the USGS UAS Project Office, with the objective of maintaining pilot currency so that we can assist and conduct planned and future DOI missions. Total number of flight hours will depend on the time required for COA #2809 to be approved, but will require a minimum of 12 hours.

   Pilot Currency-Flight Operations: We currently have three trained Raven pilots who require a Raven-A system to maintain currency through flight operations. Dates of currency flights will begin when COA #2809 is approved and continue at approximately 90 day intervals. Currency flights will be conducted near Pipestone, MT to support the USGS UAS Project Office, with the objective of maintaining pilot currency so that we can assist and conduct planned and future DOI missions. Total number of flight hours for the season will depend on the time required for COA #2809 to be approved, but will require a minimum of 36 hours.

Sample DOI UAS Applications

Wildlife Management

- Migratory Birds-
  - Sandhill Cranes, Whooping Cranes, Trumpeter Swans, Geese, Ducks
- Pygmy Rabbit, Fish Habitat
- Large Animals
  - Grizzly Bear, Elk, Big Horn Sheep, Wild Horses, Mule Deer, Goats, Wild Hogs
- Sage Grouse Inventory
- Sea Turtles
- Eagle & Swan Nest

Public Safety

- Abandoned Mine Lands (AML)
- Coal Seam Fire Detection
- Wildfire Incident Support
- Monitor Volcanic Activity
- Monitor Landslides
- Flood Mapping
- Search and Rescue
- Dam- Levy Inspections
- Hunting Regulation Enforcement
- Law Enforcement Support

Inspections- Mapping

- Fence, Pipeline, Powerlines
- Mine Reclamation
- Riparian Zone Surveys
- Vegetation – Invasive Surveys
- Archeological Site Surveys
- Environmental Survey- Palmyra Atoll
- Damage Assessments
- Easement Verification
- Volumetric Calculations
- Geologic Mapping

Earth Science Research

- Assess Impacts of Dam Removal
- Hydrographic Surveys
- Fire Science Research
- Monitor Forest & Rangeland Health
- Erosion Studies
- Rupture Zone Identification
- Geologic Resource Mapping
- Climate Change
- Sensor Research
- Image Processing Research

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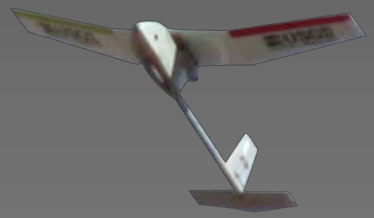
DOI UAS Projects

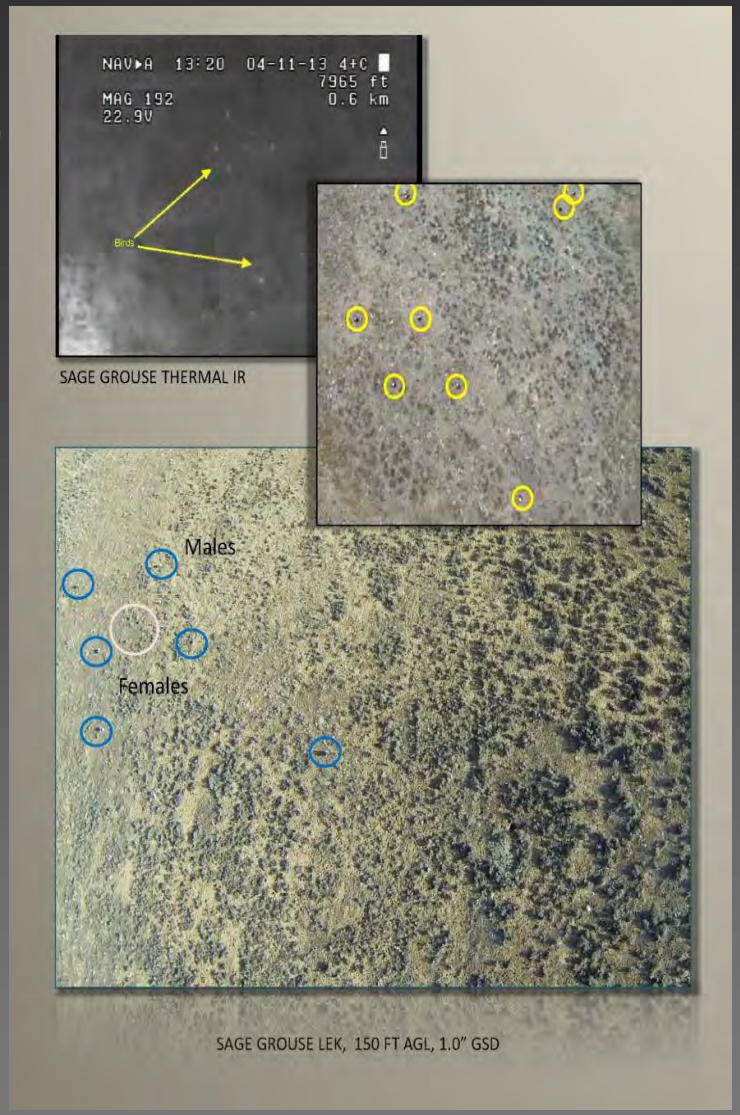
Completed:

- Wildfire/RX Support - (AZ, FL, CO- BLM, NPS, USGS)
- Sandhill Crane Population Inventory (CO – FWS, USGS)
- Rangeland Health Survey - Pygmy Rabbit Habitats (ID – BLM, BSU, USGS)
- Thermal Surveys of Lakes and Streams (MT – FWS, USGS)
- Monitor Impacts of Missouri River Flooding (SD-USGS)
- Coal Seam Fires and Mine Monitoring – (WV-OSM, USGS)
- Rush Skeleton Weed Survey – (ID-BLM)
- San Simon Watershed Project – (AZ-BLM)
- Monitoring Impacts Elwha Dam Removal –(WA- NPS, BOR, USGS, BLM
- Greater Sage Grouse Lek Survey – (CO-USGS, BLM, COGF)
- Climate Change Studies (CO-USGS)

In Work (Partial List):

- Dogtown Mine AML/HazMat- (AZ-BLM)
- Coal Seam Fires – (MT and CO BLM)
- Dwarf Bear Poppy Survey – (Utah BLM)
- AIM and Riparian NorCal – (Cal BLM)
- Rush Skeleton Weed/Sage Brush – (ID-BLM)
- NLCS Aqua Fria Support – (AZ- BLM)
- Palmyra Atoll - (Pacific- USGS)
- Elk Habitat Survey - (WA- BIA/USGS)
- National Petroleum Reserve – (AK-BLM)
- Landslides- (CO, USGS/BLM)
- Big Horn Sheep/ Elk Survey- (NV- FWS/USGS)
- Water Fowl Surveys- (NV/CA- FWS, USGS)
- Vegetation/ Aquatic Marsh Study- (CA/AZ- FWS/USGS)
- Post Fire Imacts- (ID/MT- OWFC)





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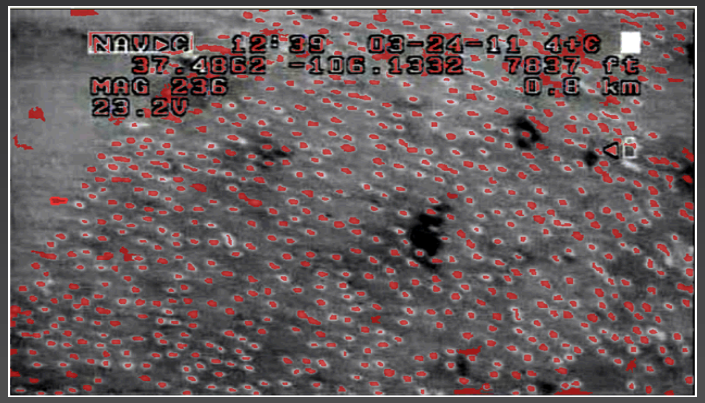
Sandhill Crane Research



UAS data showing individual cranes (red)

Findings-

- Aviation safety concerns were mitigated
- Cost effective method
- Birds were not disturbed
- Images archived for future analysis
- Semi-automated process
- Reduced requirement on field staff
- Validation with historic survey methods
- Potential to use data for multiple purposes

Method	Costs
Fixed Wing Survey (Ocular Survey)	$4,310
Fixed Wing Survey (Remote Sensing - Contractor)	$35,000
UAS Survey (Remote Sensing)	**$2,645**

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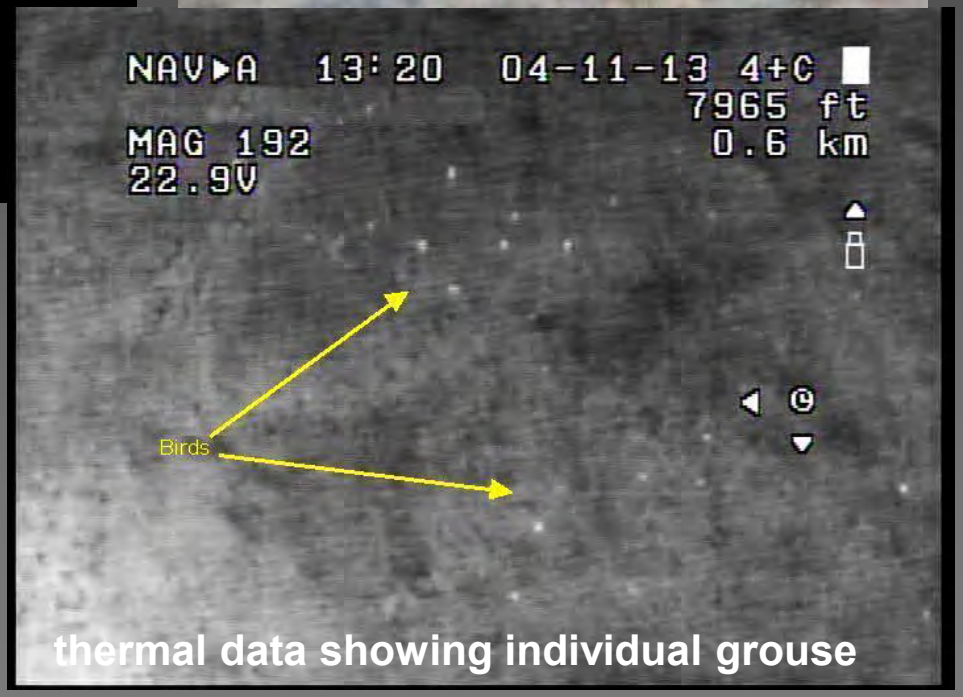
Sage Grouse Research



thermal data showing individual grouse

Findings-

- Demonstrated the potential of an aircraft to support inventory efforts
- Birds were not disturbed
- Images archived for future analysis
- Requires on the ground scientists
- Need higher resolution thermal cameras

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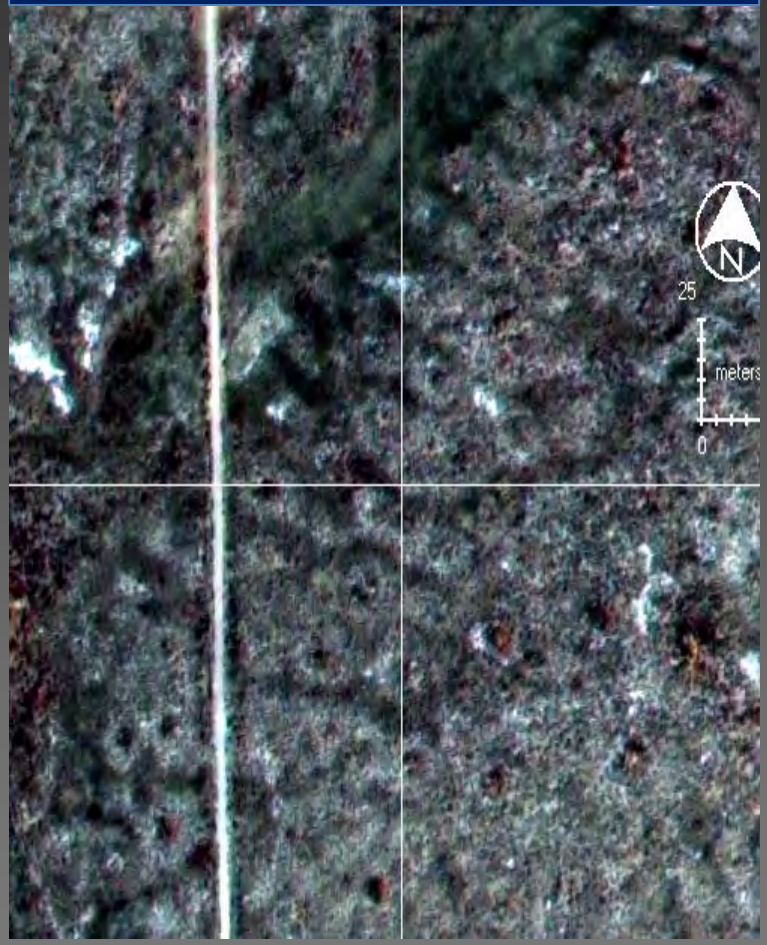
Pygmy Rabbit Habitat

Satellite (WorldView2) Image - 0.5m



UAS Image - 2.5 cm

Automated Feature Extraction

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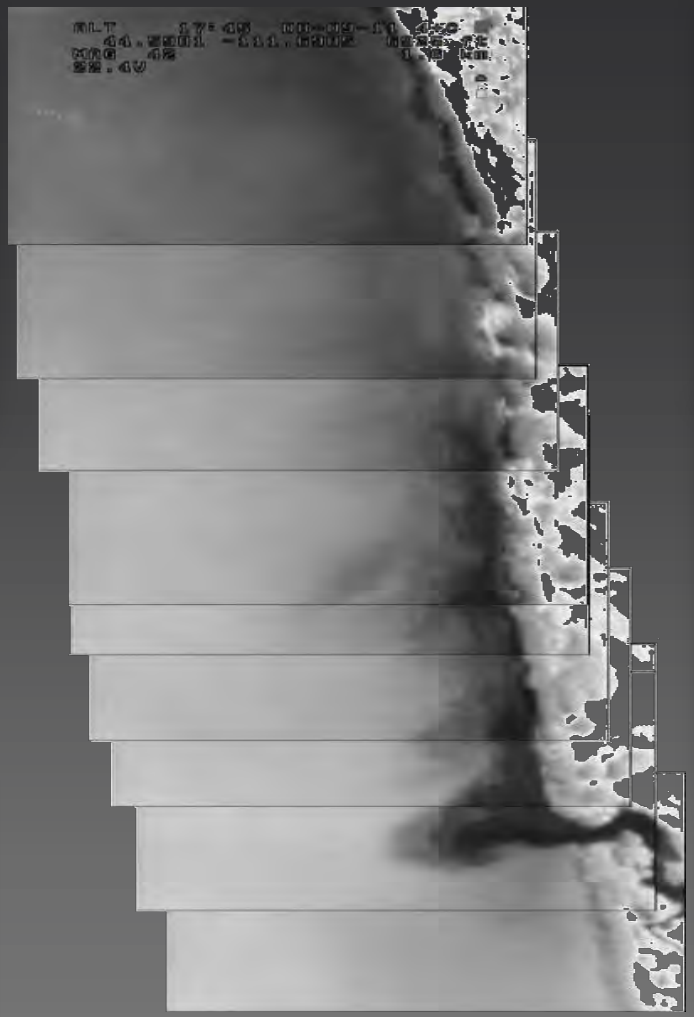
Hydrography Research



Riparian Vegetation Mapping
Erosion Studies
Thermal Surveys

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Wildfire

Optical data of prescribed burn

Post-fire Impacts

thermal data of prescribed burn

In Development

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Boundary/Fence line Inspections

Haleakala National Park, Maui

USGS and NPS personal
setting up UAS ground station

UAS data enhances identifying vegetation health and invasive vegetation species

UAS data enhances locating animal populations, tracking movements assessing damage to native ecosystems

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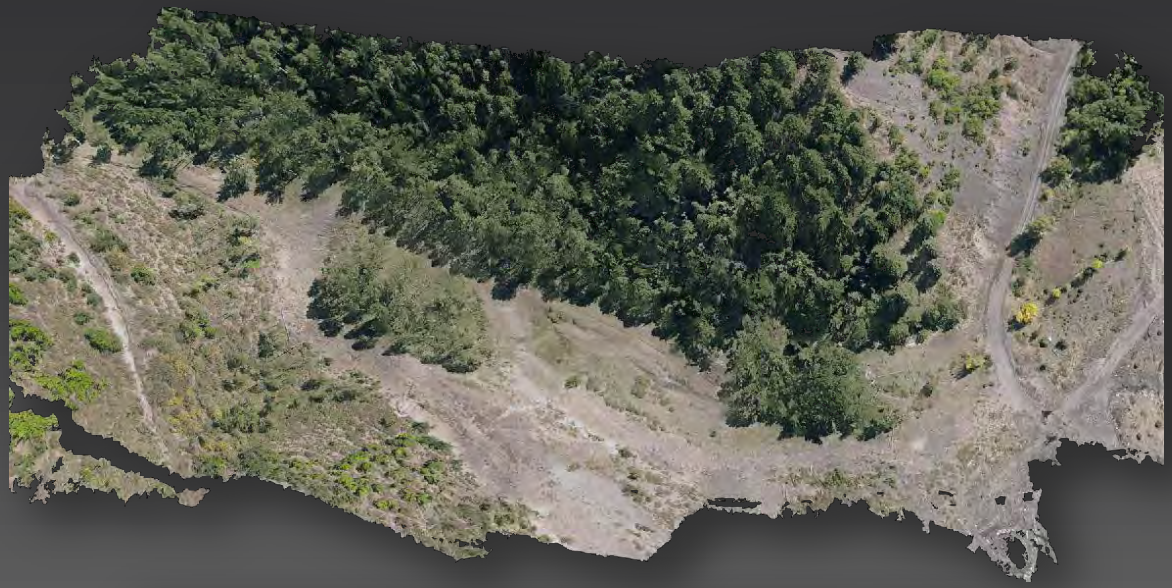
Abandoned Mine Land Surveys

Pitkin County, Colorado



UAS data supports inspections of conditions at abandoned mines saving time, reducing costs and potential vehicle damage

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Climate Change Studies

Conifer & Niwot Ridge, Colorado

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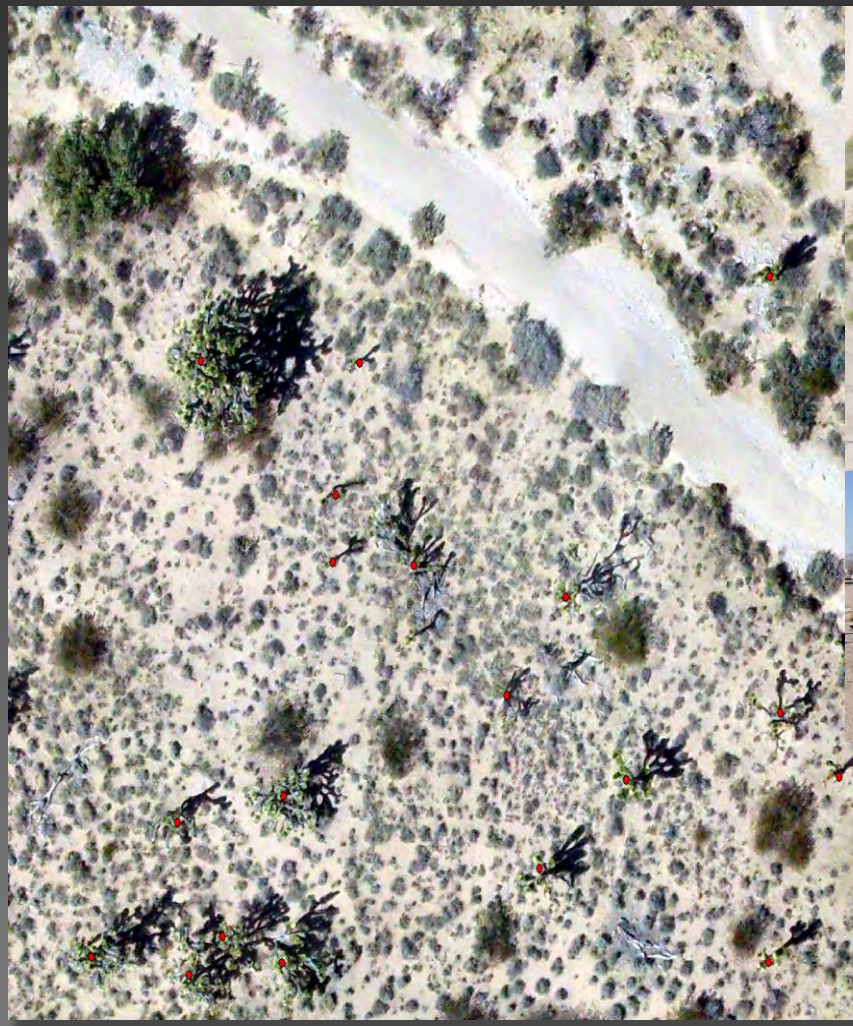
Abandoned Material Inventory

Joshua Tree Inventory*
Mojave National Preserve, California



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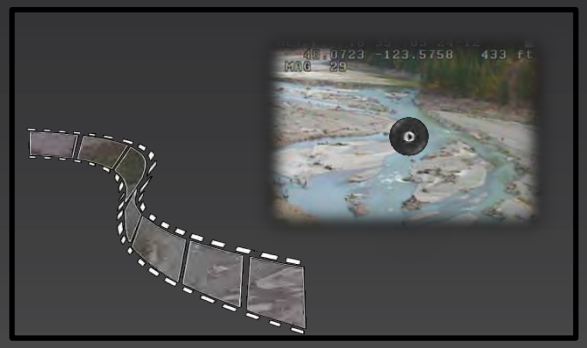
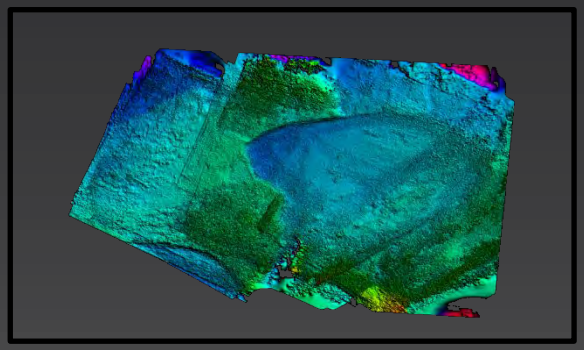
Geospatial Data

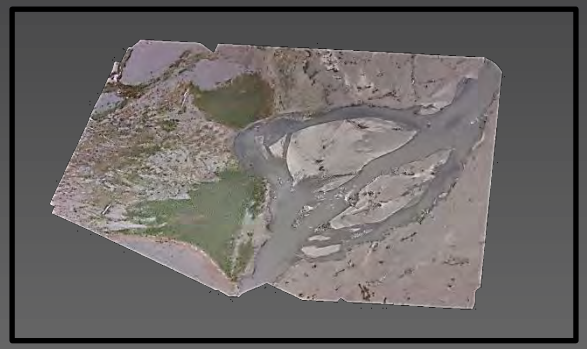


FULL-MOTION VIDEO

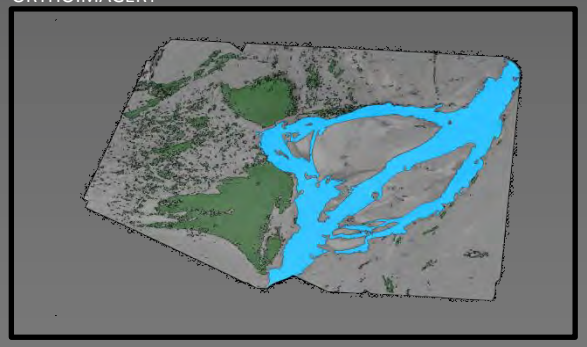
3-D POINT CLOUD DATA



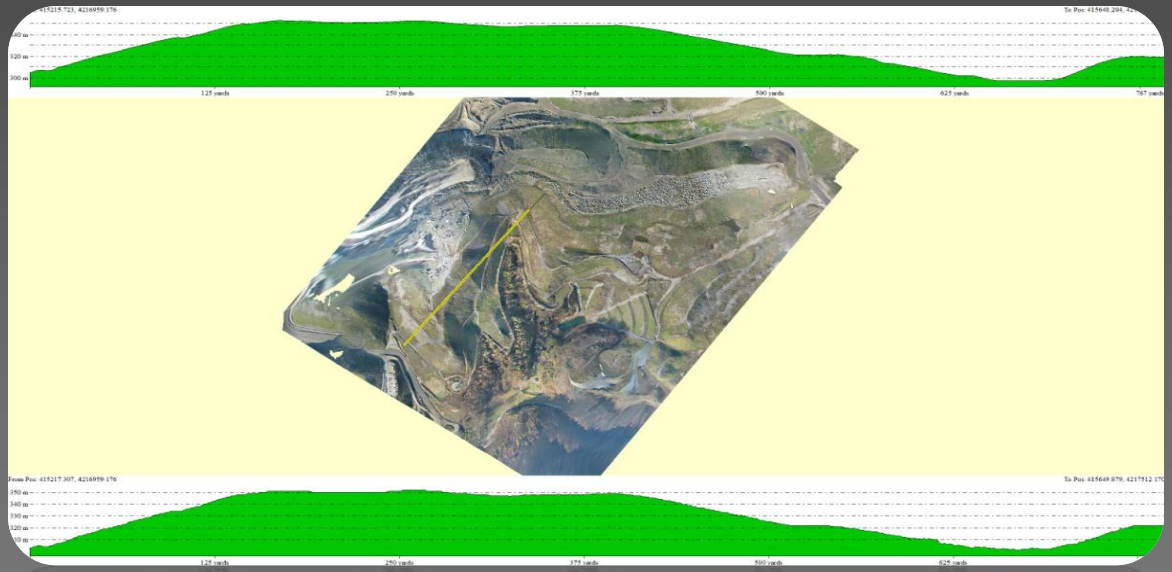
ELEVATION MODELS



ORTHOIMAGERY



SEGMENTATION AND CLASSIFICATION



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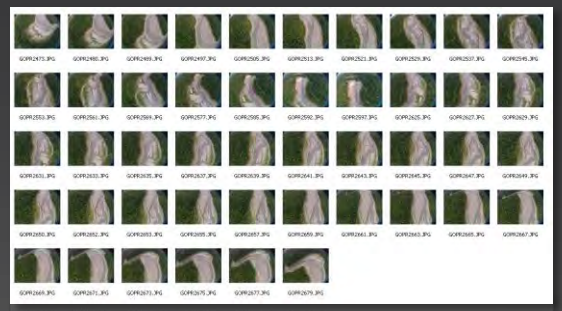
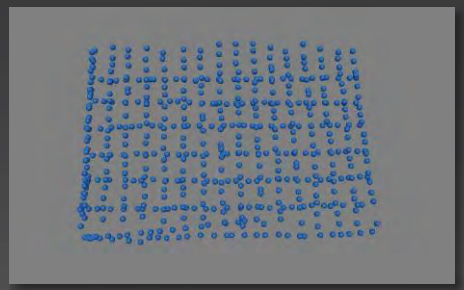
UAS Point Cloud, Dem, Orthophoto Data Processing

General Workflow (Photoscan)

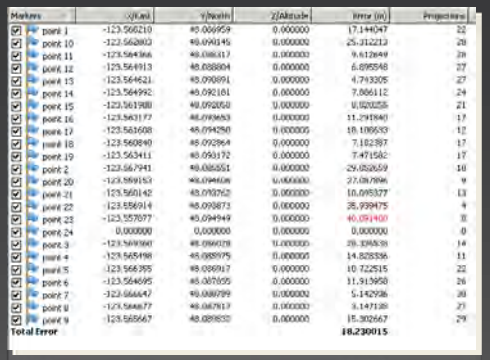
Image Collection



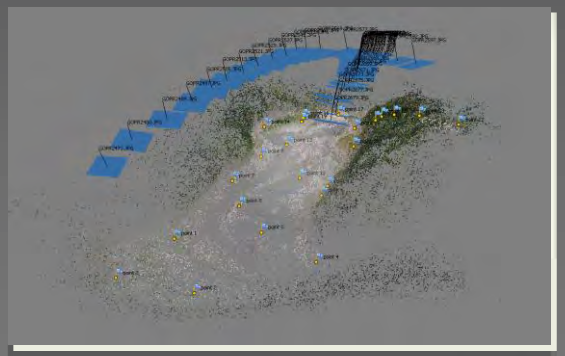
Review Image Tags and Image Alignment



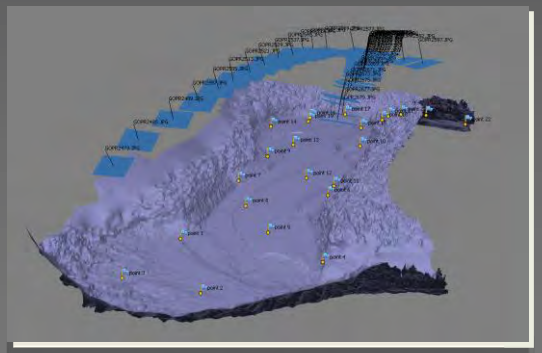
Adding Control



Point Cloud Generation, Camera Calibration and Optimization



Build Geometry



Build Texture and Export Products

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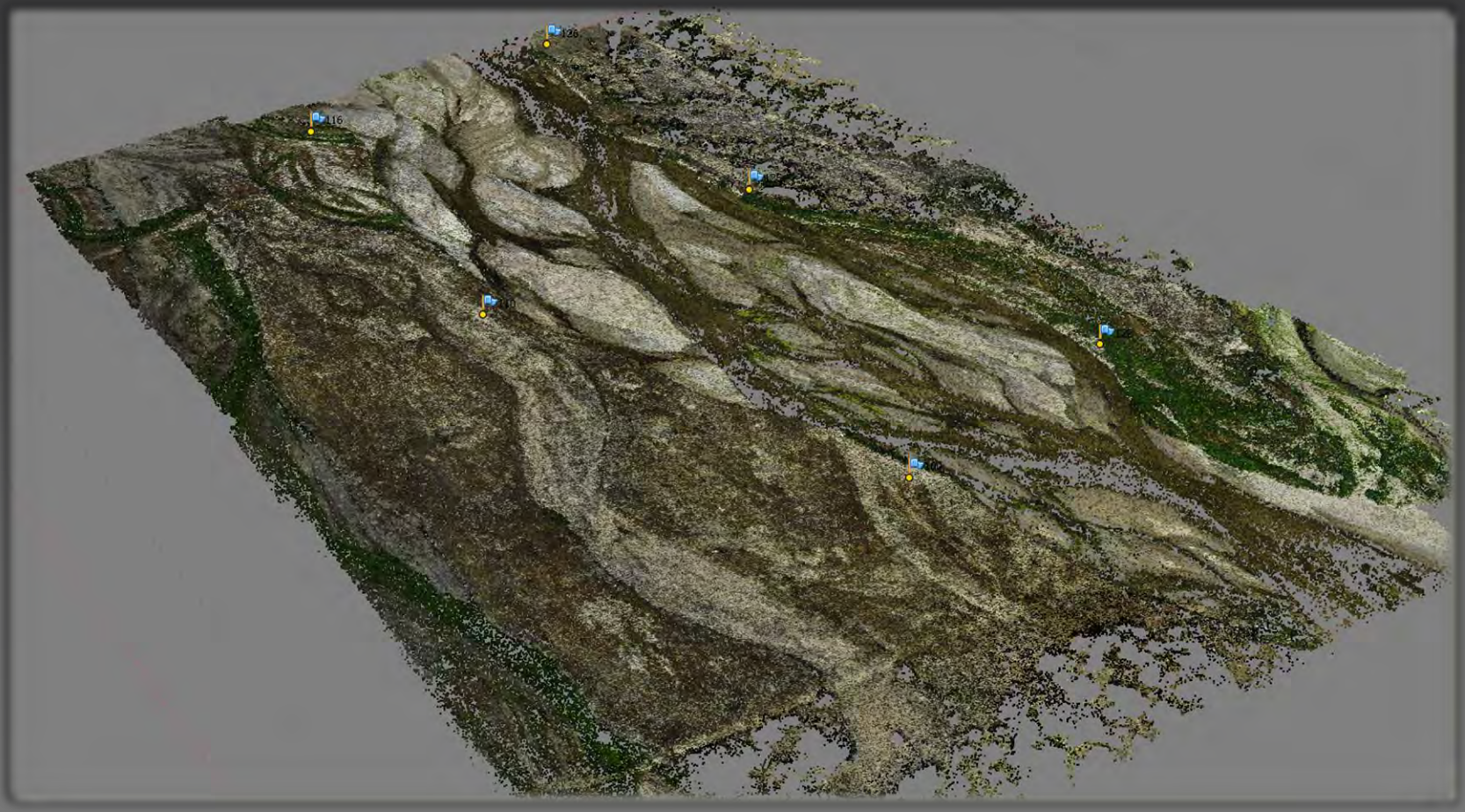
UAS Point Cloud, Dem, Orthophoto Data Processing

Point Cloud

1.8 million points

Area: 0.5 km x 0.4 km



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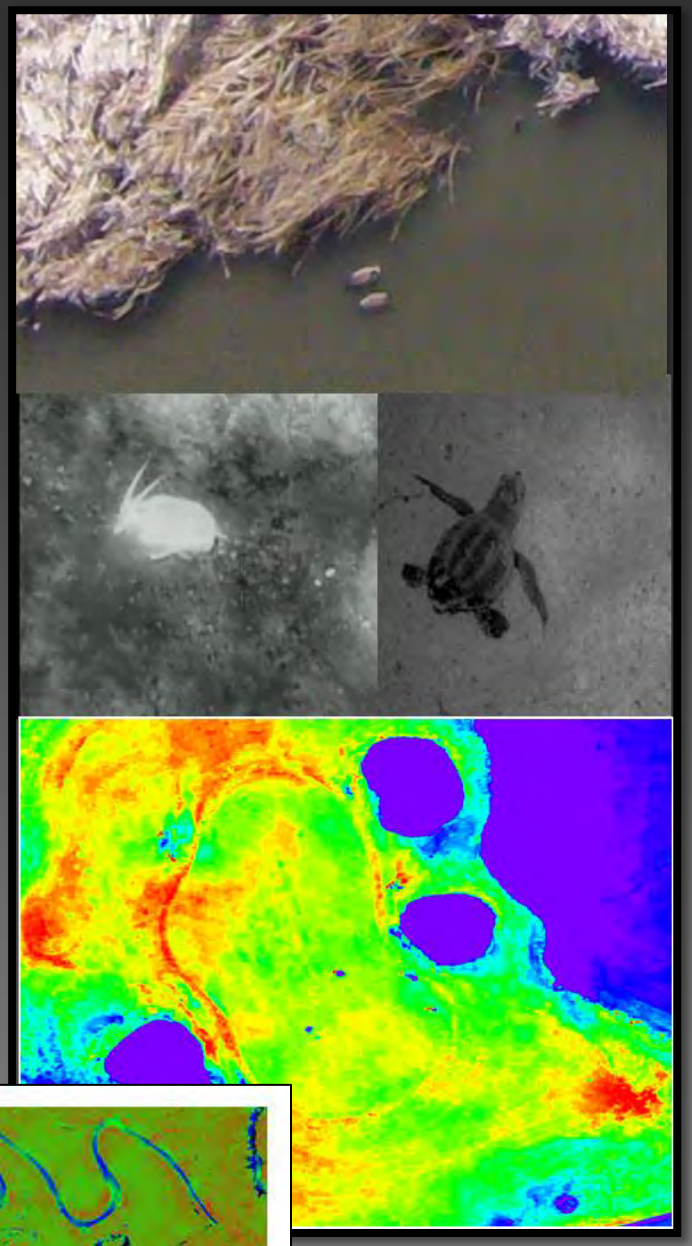
Sensors

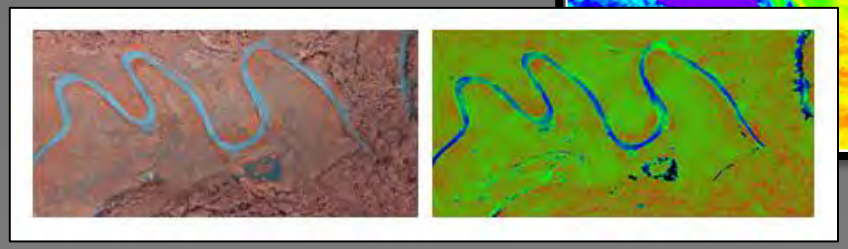
Current Enhancements:

- GoPro Hero 2 & 3 - 1080P HD camera (still frame and video)
- Canon SX260HS – GPS enabled (RGB) – CHDK
- Canon SX230HS- GPS Enabled (RGB and IR) - CHDK
- I-buttons (temp. & humidity)

Future Investigations:

- Multispectral, Hyperspectral, LIDAR, RADAR, Thermal
- Chemical/Air Sampling
- Radio Relay/Tracking





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UAS Data Processing

Color Infrared & Normalized Difference Vegetation Index (NDVI)

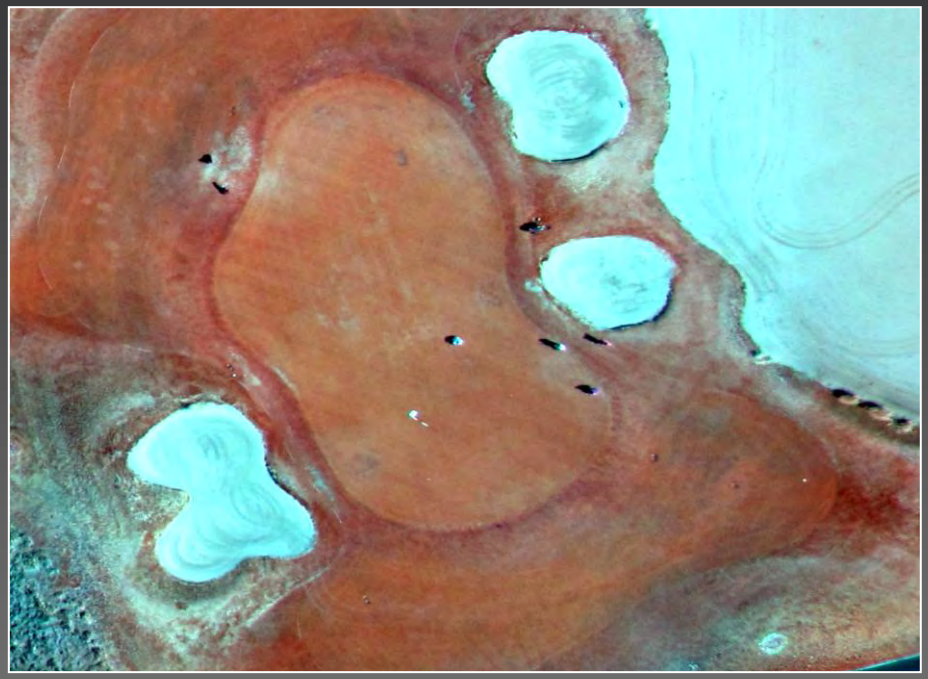
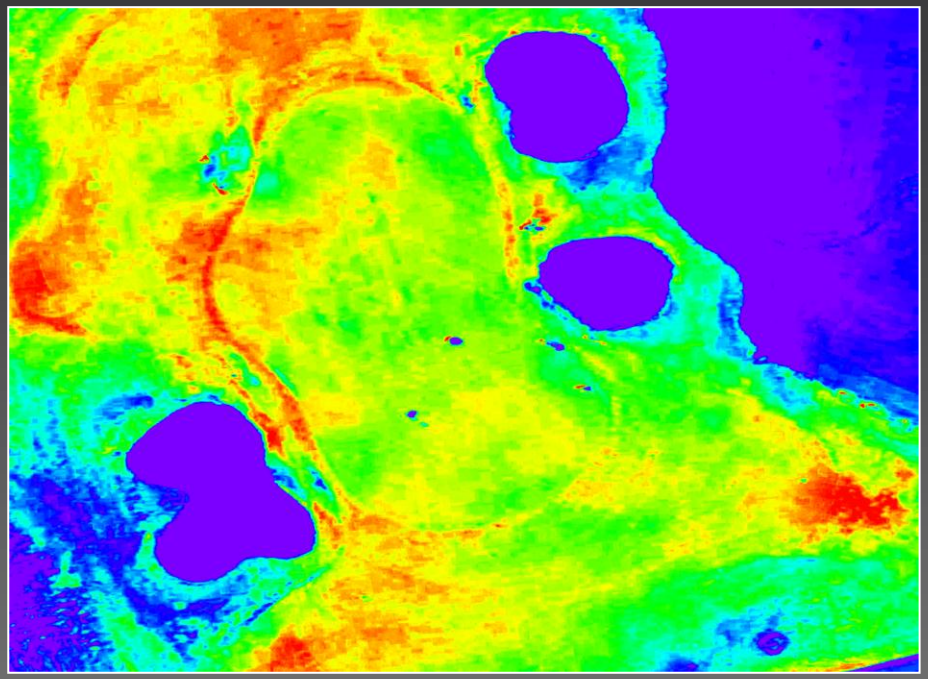


Image collected from UAS – Canon SX230 HS – 400'



NDVI Low NDVI High

$$\mathrm{NDVI} = \frac{(\mathrm{NIR} - \mathrm{VIS})}{(\mathrm{NIR} + \mathrm{VIS})}$$

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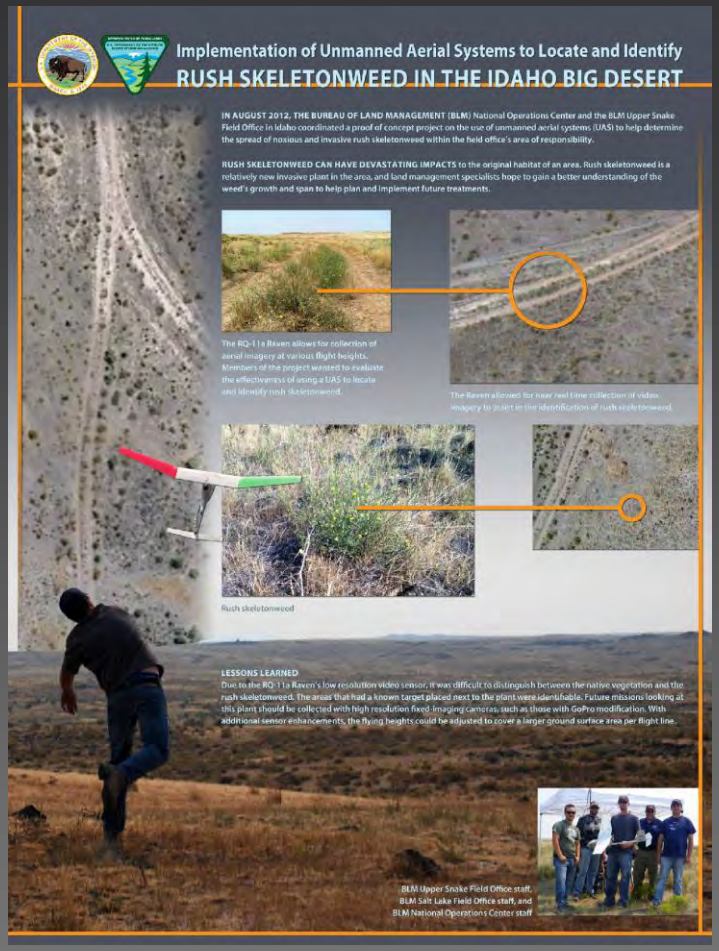
Collaboration is the key



Partners with DOI bureaus; also NOAA, NASA, FAA, USFS, academia, commercial entities, state and local government

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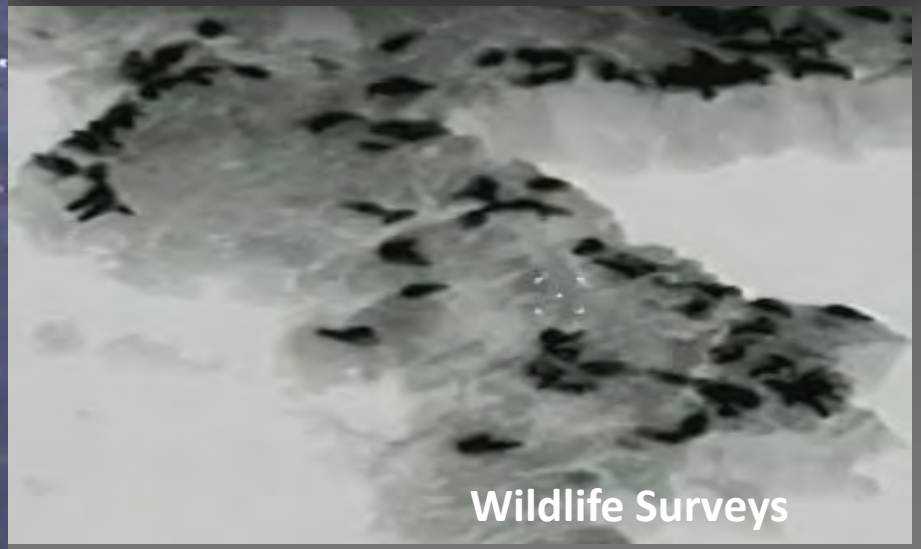
NOAA Collaboration



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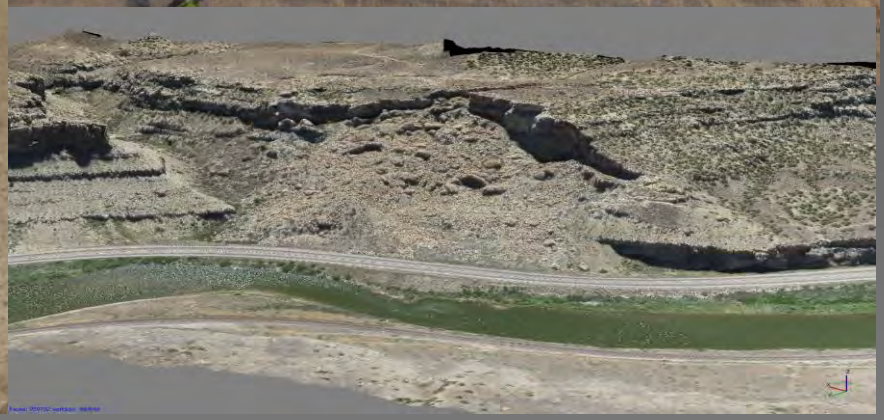
Mesa County Gravel Pit & Landslide



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Summary

- **Compared to traditional data acquisition methods, UAS data acquisition can be more-**

  Economical,
  Safer and
  Efficient

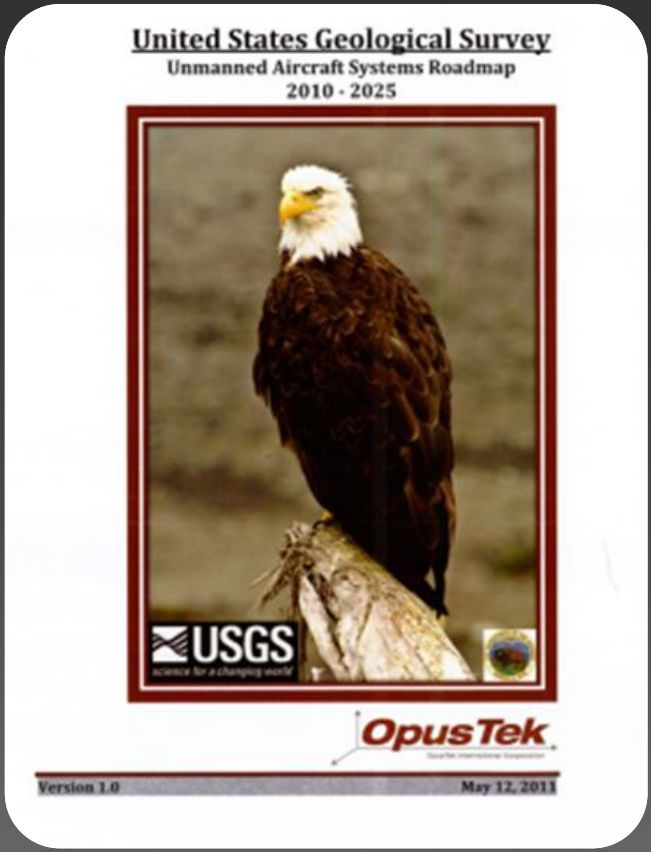
- **Allows us to do things we couldn't do before**

  Enhanced Observations,
  New Science,
  More Informed Decisions

- **Assessment of Technology-**

  Developing at an extraordinary rate,
  Viewed as a multipurpose tool,
  Plug and Play Sensors,
  Analysis Tools Lagging

- **Will not replace other observation techniques** ***Will emerge as the primary platform for DOI remote sensing applications***



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Website: http://uas.usgs.gov/