Using Unmanned Aerial System (UAS) for Playa Wetland Monitoring and Assessment

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Goals & Tasks

“The overall goal is to develop a methodology for using small **Unmanned Aircraft System (UAS)** to conduct dynamic **monitoring and precise assessment for playa wetland habitat conditions** in the Rainwater Basin, Nebraska.”

Goals & Tasks

1 Multispectral Sensor

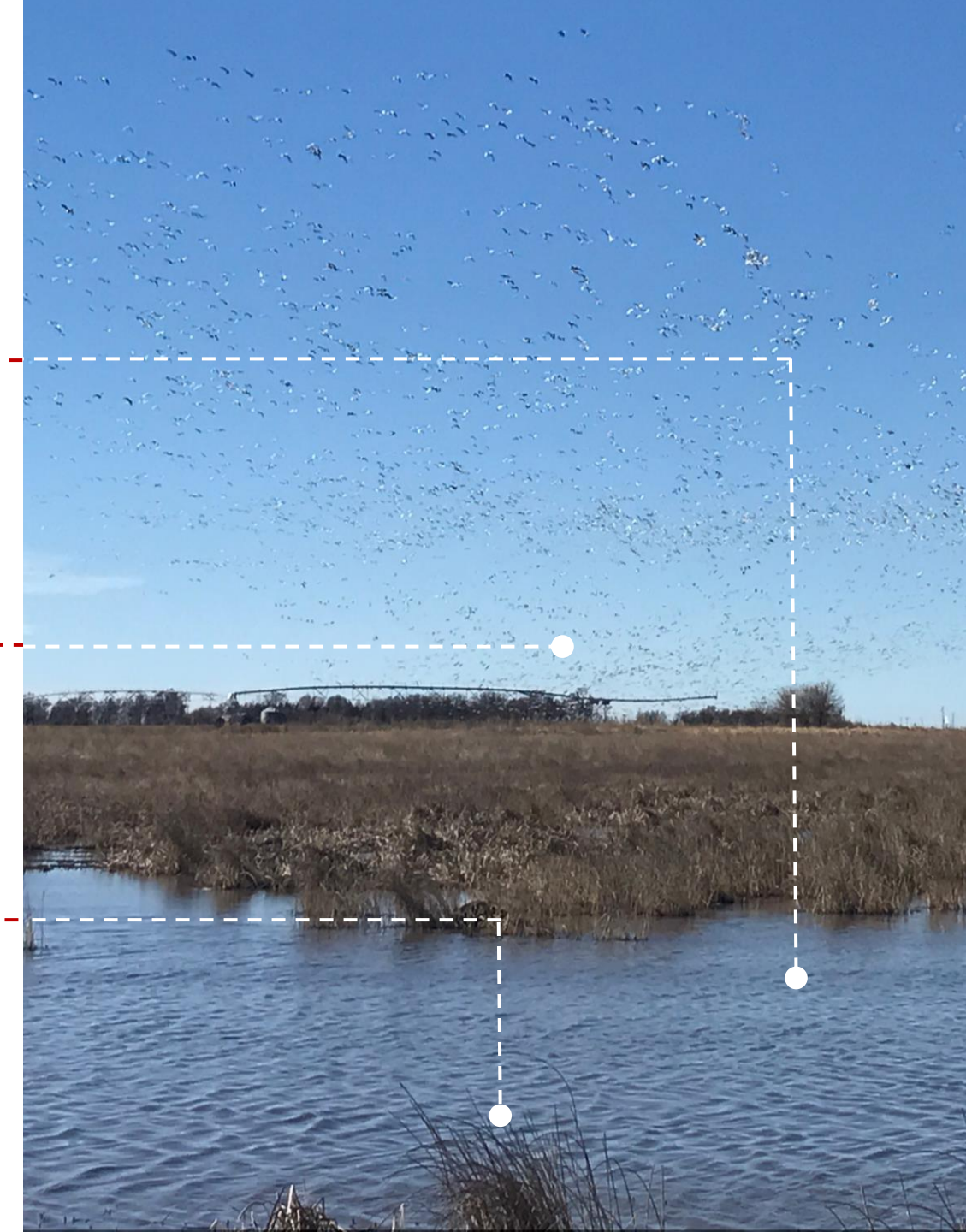
Detect **soil moisture** and map **wetland inundation dynamics** during spring migration season

2 Thermal Sensor

Use thermal technology to detect and evaluate **wildlife use and distribution** on playa wetlands

3 3-D Imagery System

Survey **vegetation community** conditions and estimate energetic availability and vegetation management effectiveness



What is UAV/UAS/sUAS ?

UAV

An unmanned aerial vehicle (UAV), commonly known as a drone, is an aircraft without a human pilot aboard.

UAS

UAVs are a piece of unmanned aircraft systems (UAS):

- an unmanned aerial vehicle
- a Ground-based controller
- a system of communications

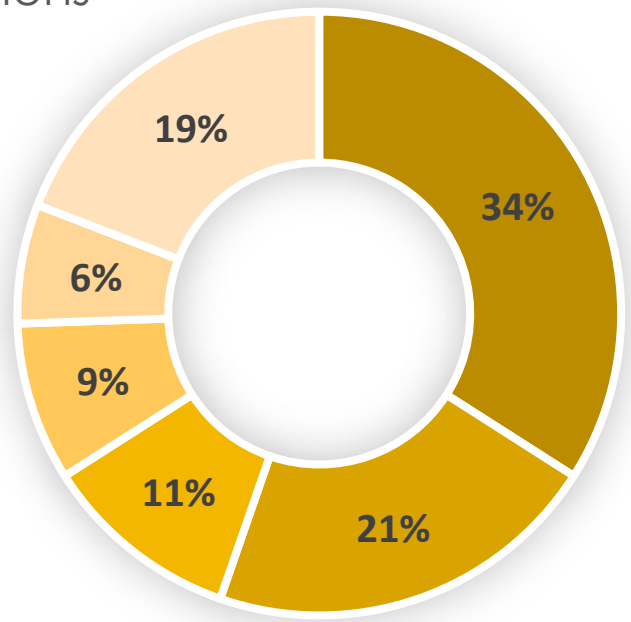
sUAS

An sUAS incudes the unmanned aircraft itself and its associated elements:

- **Less than 55 pounds (25kg)**

Literature Review: The Trend of UAV Application

Research Applications



16 Wetland

10 Wildlife

47 PAPERS

There is an obvious increase of applying UAV/UAS/sUAS on wetland and wildlife management. The topics arrange from wetland inundation & vegetation cover to biomass estimation & terrain delineation.

The Advantage of UAV/UAS/sUAS

Satellite

UAV/UAS/sUAS

- High spatial resolution
- High temporal resolution
- High accessibility
- High flexibility
- Low expense

Piloted Airborne

Ground Survey

Approvals for the UAV/UAS/sUAS flying

FAA Regulation

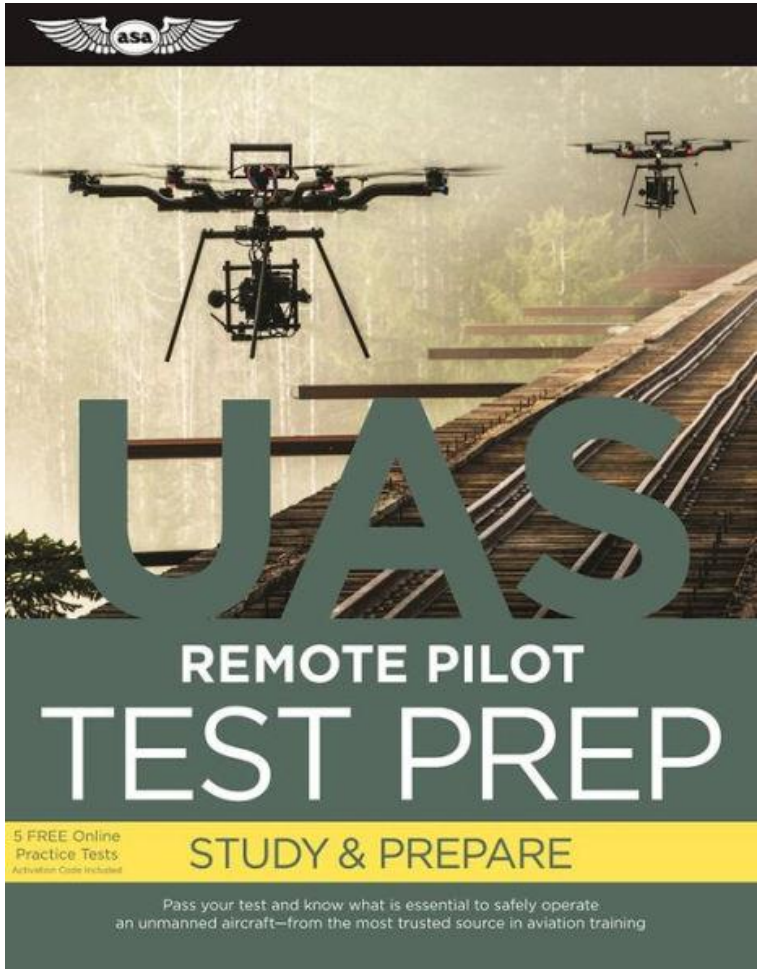
The **Federal Aviation Administration (FAA)** has adopted **Title 14 of the Code of Federal Regulation (14 CFR) Part 107** to allow the operation of civil small unmanned aircraft systems (sUAS) for purpose other than **hobby** and **recreation**.

Flight Certificate

A person acting as a remote PIC of an sUAS in the National Airspace System under Part 107 must obtain a **Remote Pilot certificate with an sUAS rating** issued by the FAA prior to sUAS operation.

UNL Regulation

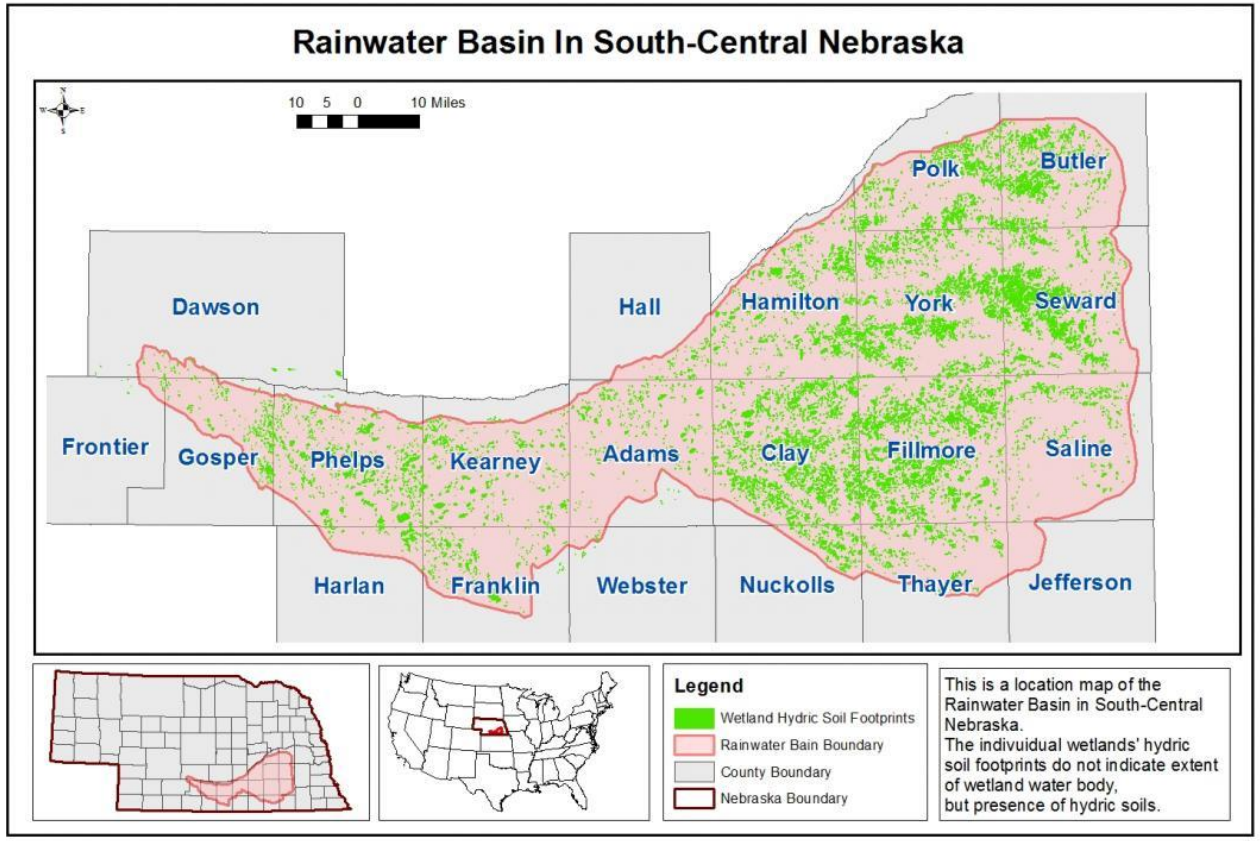
UNL has a strict approval procedure for UAS flying.



Study Area

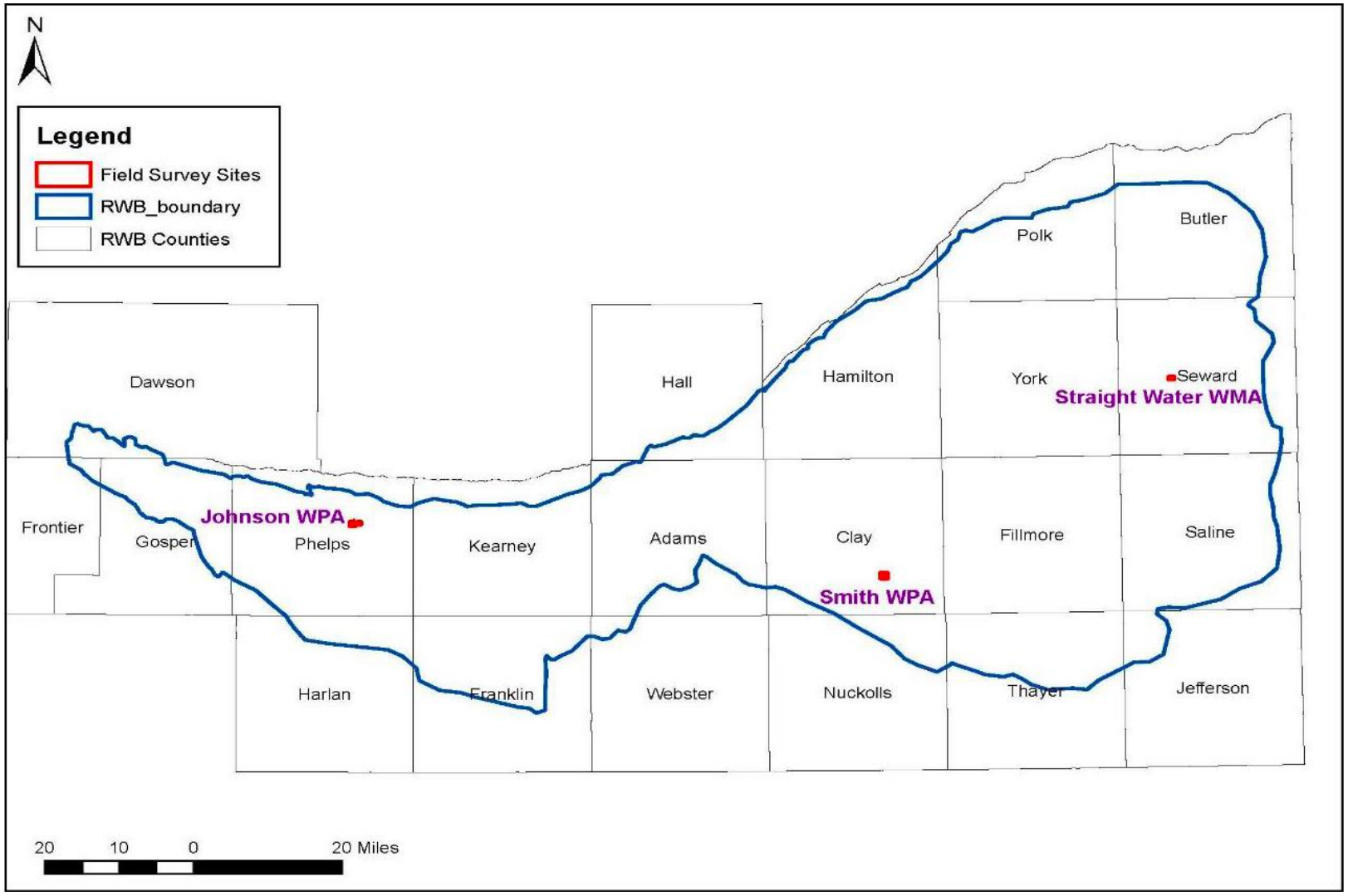
Publicly-managed wetland watersheds are the core of wetland habitat in the Rainwater Basin which contribute to approximately **half of the actual inundated areas** and the **foraging resources during each spring peak migration season**.

- *Nebraska Wetland Priority Plan*
- *Wetland Program Plan of Nebraska*
- *RWBJV Waterfowl Plan and Implementation Plan*



Sites Selection

- From east to west
- Area of wetland
- Distance
- Accessibility



Sites Description

Straight Water

Wetland Type: **WMA**

Location: **Seward County**

Total Area: **234.12 Acres**

Visible Water: **Yes**

Smith

Wetland Type: **WPA**

Location: **Clay County**

Total Area: **506.97 Acres**

Visible Water: **Yes**

Johnson

Wetland Type: **WPA**

Location: **Phelps County**

Total Area: **580.44 Acres**

Visible Water: **NO**

Considerations for the UAS flying

Wind Speed

Battery Limits

Operation Skills

Field Condition

Hunter in Wetland: No flying

If there are hunters, please do not do the fligh, as they are the ones who pay for the conservation work.

Wetland Program Manager

Whooping Crane: No flying

It is important that before you do any drone flying that you make sure that there are no whooping cranes and endangered species using the area.

Wetland Program Manager

Flights & Weather Condition

	Seward, NE Straight Water, MPA							Clay, NE Smith, WPA			Phelps, NE Johnson, WPA		
Date	**2/22**	**2/28**	**3/9**	**8/29**	**9/20**	**9/27**	**10/16**	**3/8**	**4/11**	**8/29**	**4/6**	**8/29**	
Time	10:45am	11:00am	1:30pm	2:00pm	10:00am	10:00am	10:00am	11:30am	12:00pm	1:00pm	10:30am	10:30am	
													
Temp	66.1 °F	44.1 °F	48.0 °F	78.1 °F	71.1 °F	55.0 °F	48.9 °F	53.1 °F	51.1 °F	75.0 °F	47.8 °F	69.3 °F	
Wind	3.5m/h	5.8m/h	**13.8m/h**	3.5m/h	**11.5m/h**	0.0m/h	6.9m/h	0.0mph	8.1mph	0.0mph	9.2mph	3.5mph	
	Test			**3D**	**3D**	**3D**	**3D**			**3D**		**3D**	
Task		**Rededge Thermal**	**Rededge Thermal**					**Rededge Thermal**	**Rededge Thermal**		**Rededge Thermal**		

12 Total Flights **10** Valid **2** Invalid

Hardware & Software

3 Software

Pix4D Mapper

ThermoViewer

ArcGIS

2 UAVs

Firefly 6 PRO

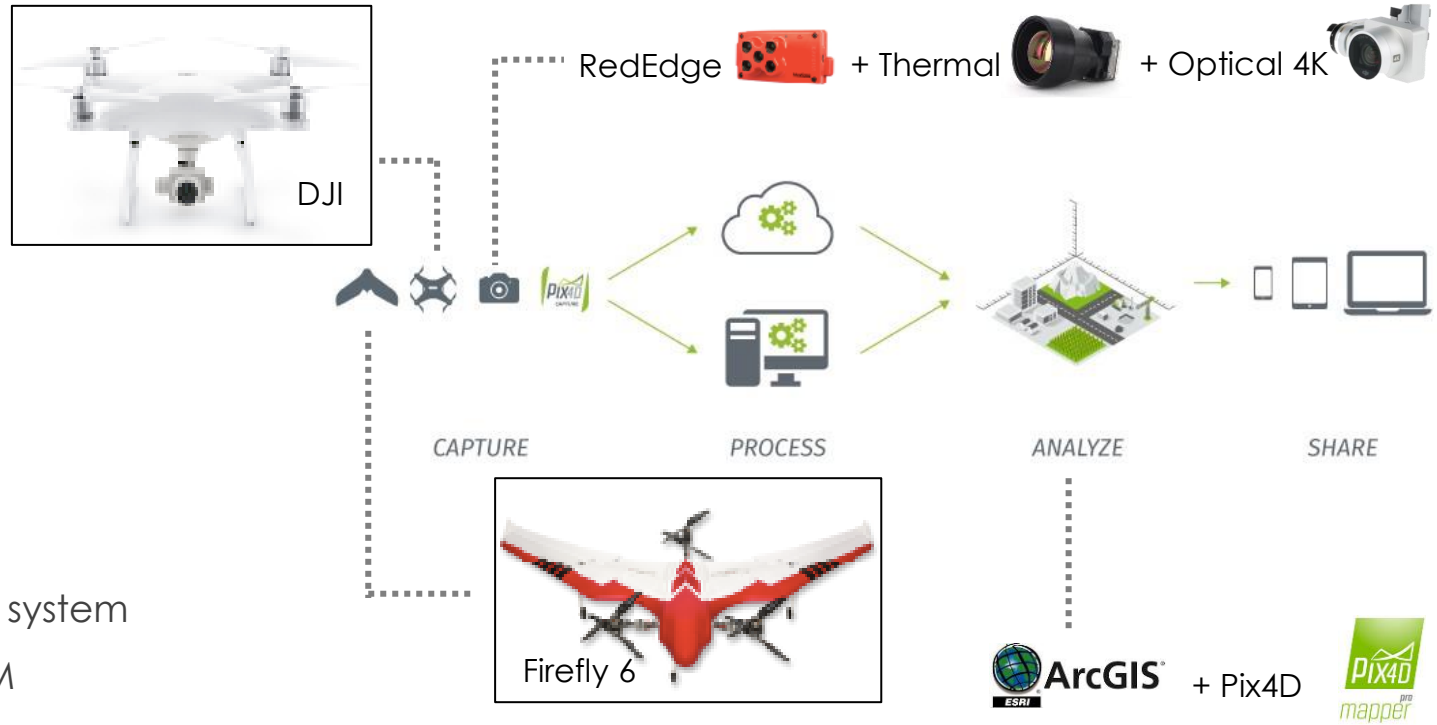
DJI PHANTOM 4 PRO

3 Sensors

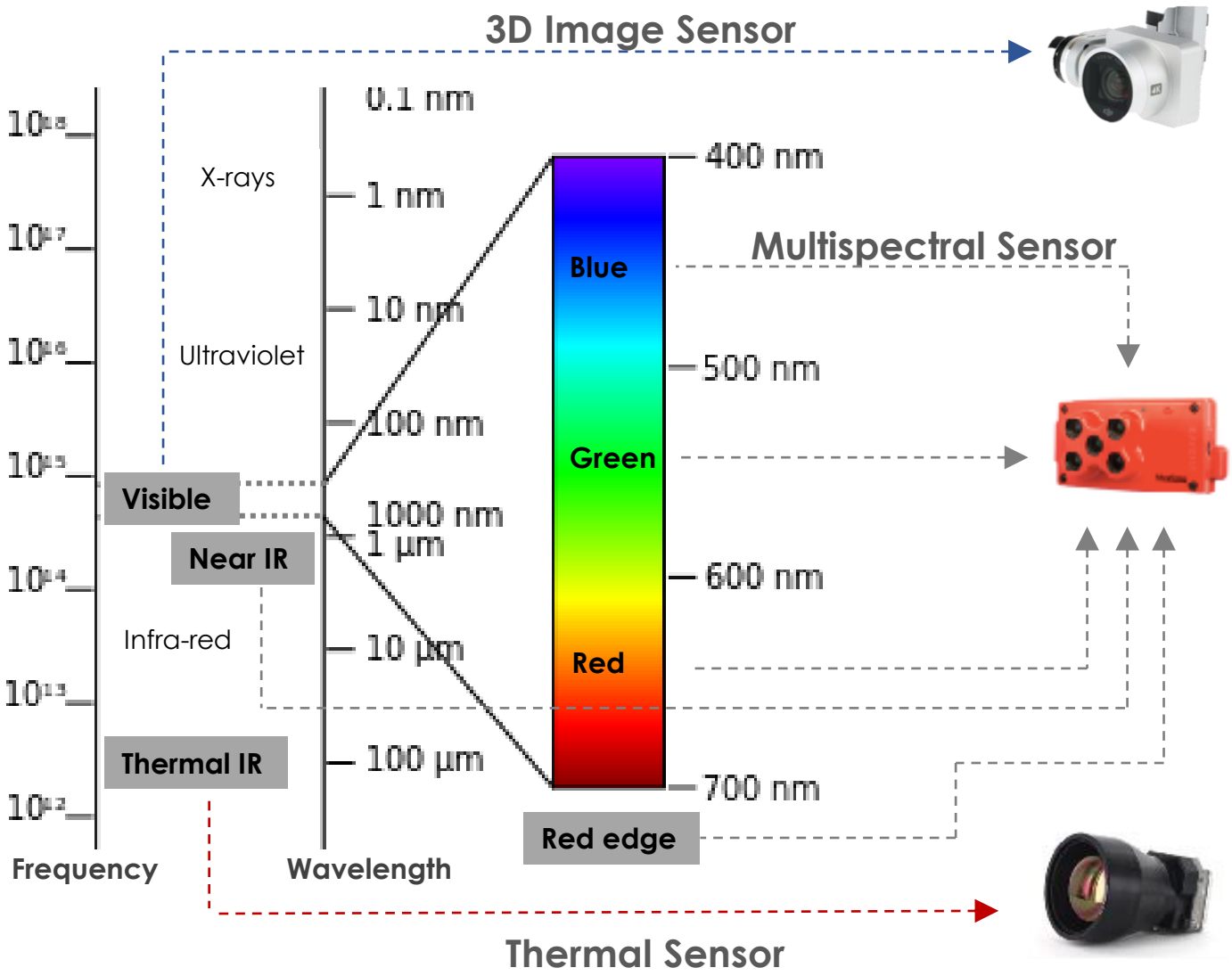
DJI optical 4K imaging system

MicaSense RedEdge-M

FLIR Tau2 640x512 thermal sensor with with TEAX add-on



Sensor & Data Collection



01

- 3D textured model
- Survey plant community
- Estimate biomass volume

02

- Index calculation (NDVI)
- Map wetland inundation
- Stimulate DSM & DTM (Terrain)

03

- Evaluate wildlife distribution
- Estimate wildlife population

The Process of Data Processing

Initial Processing

- Import Images
- Import Geographic Data
- Generate Routes
- Calibrate Images
- Generate Tie Points

01 2.5h — 4.0h (1.0GB)

Point Cloud & 3D Model

- Point cloud
- 3D textured model

02 4.0h — 7.0h (20 GB)

DSM, DTM & Orthomosaic

- Orthomosaic (Overview)
- DSM (Surface Model)
- DTM (Terrain Model)
- Contour Line
- Biomass Volume
- Index Map (NDVI)

03 2.5h — 3.0h (3 GB)

Export

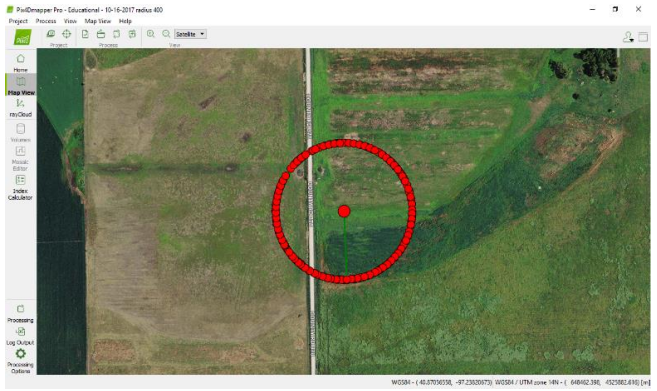
04

Data Processing : 01 Initial Processing

Single Route: Vertical

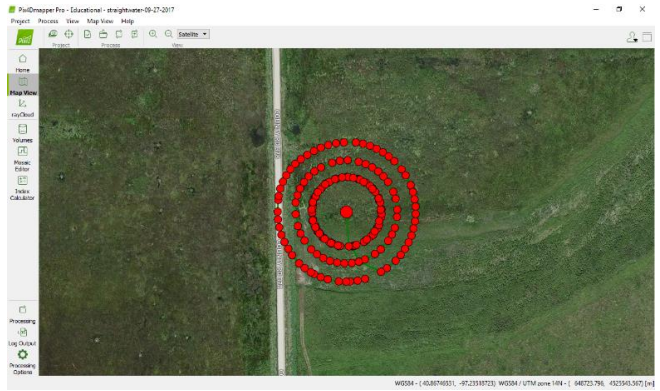
Smith -- 2017/03/08

Single Route: Oblique



Straight Water--2017/10/16 (400 radius)

Multi-routes: Oblique



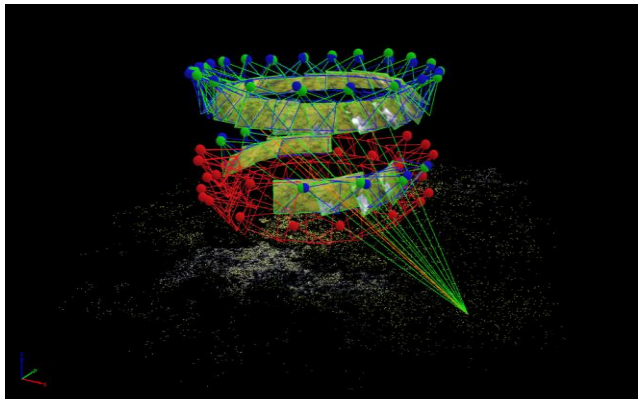
Straight Water--2017-09-27 (Multi-Radius)

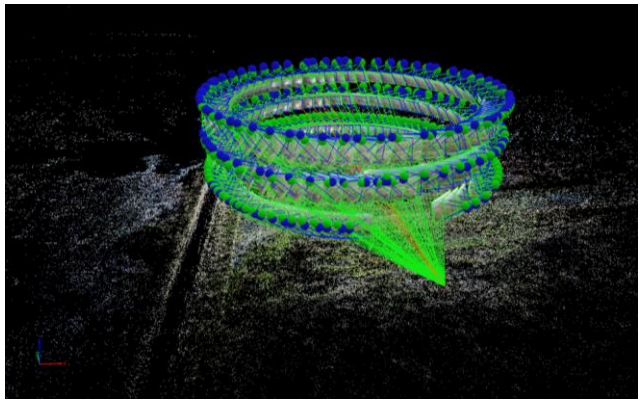
Vertical: when the camera's optical axis is ±3 degrees from perpendicular to the Earth's level surface (directly below).

Oblique: when the camera's optical axis is more than ±3 degrees from perpendicular to the Earth's level surface.

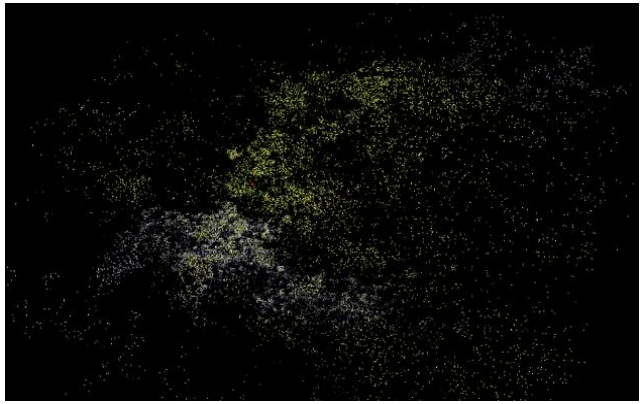
Data Processing : 01 Tie Points

Cameras Calibration

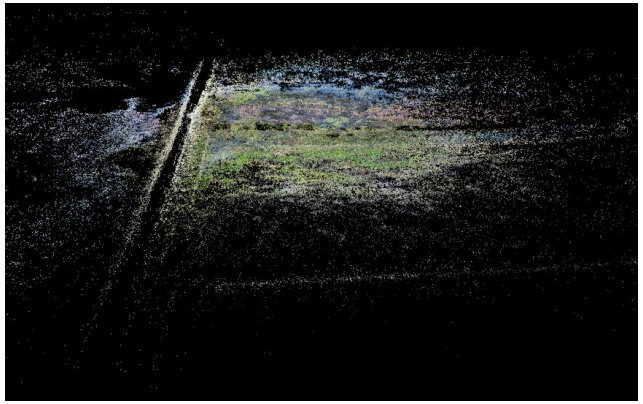




Tie Points



Straight Water--2017/08/29 (100 radius)



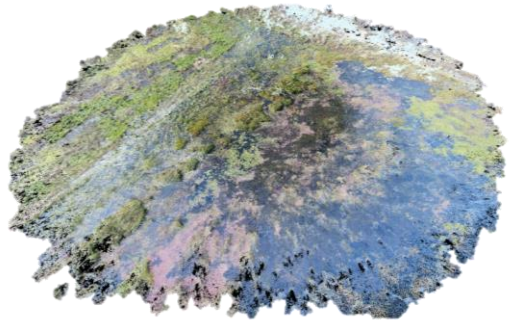
Straight Water--2017/10/16 (400 radius)

An **Automatic Tie point** and its corresponding 2D key points that were automatically detected in the images and used to compute its 3D position.

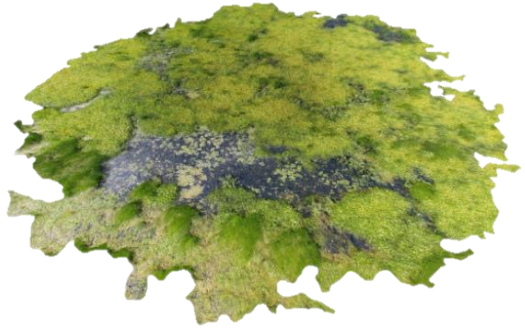
https://support.pix4d.com

Data Processing: 02 Point Cloud & 3D Model

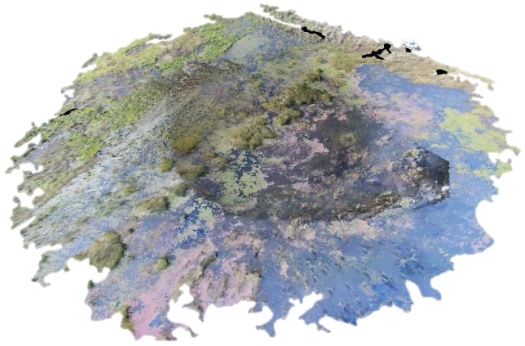
Point Cloud



3D Textured Model



Straight Water--2017/08/29



Straight Water--2017/10/16

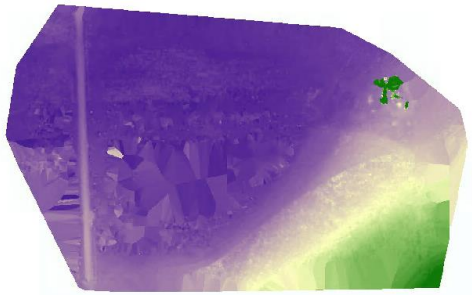
The **densified point cloud** is a set of 3D points that reconstructed the model. The X, Y, Z position and the color information is stored for each point of the densified point cloud. It is computed based on the **Automatic Tie Points**.

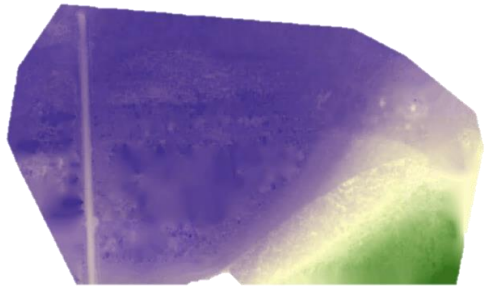
The **3D textured mesh** is a representation of the shape of the model that consists of vertices, edges, faces and the texture from the images that is projected on it. It is intended to look nice more than to be accurate.

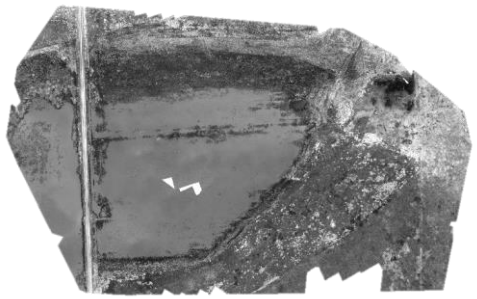
https://support.pix4d.com

Data Processing : 3.1-3.3 DSM, DTM & Orthomosaic

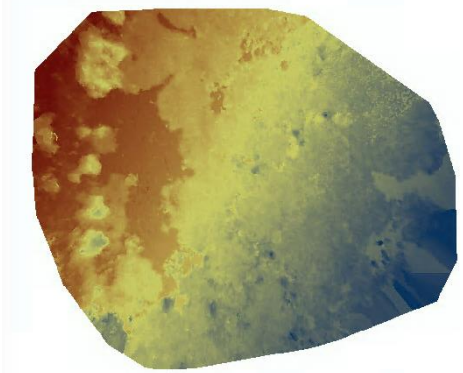
DSM(Surface) DTM(Terrain) Orthomosaic

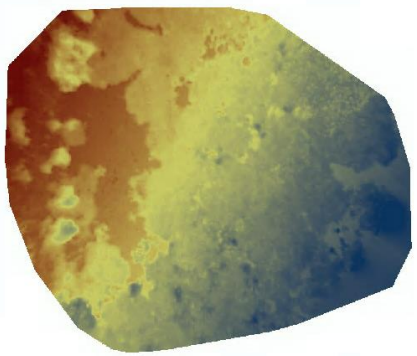


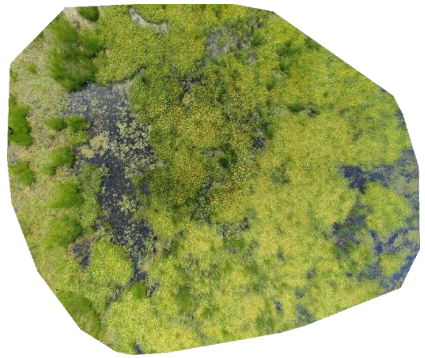




Straight Water--2017/02/28







Straight Water--2017/08/29

The **DSM (Digital Surface Model)** is a 2.5D model of the mapped area. Each point contains X, Y, Z data except color information.

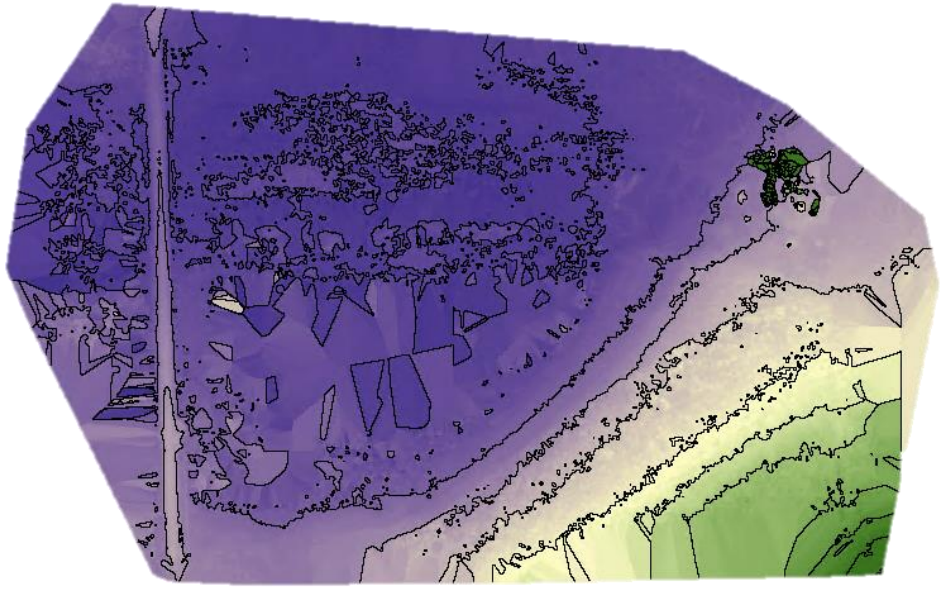
The **DTM (Digital Terrain Model)** is a 2.5 D model of the mapped areas after filtering out the objects. Each point contains X, Y, Z data except color information.

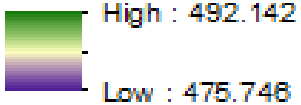
The **orthomosaic** is a 2D map. Each point contains X, Y and color information, and can be used for 2D measurements (distance, surface).

https://support.pix4d.com

Data Processing : 3.4 Terrain Contour Line

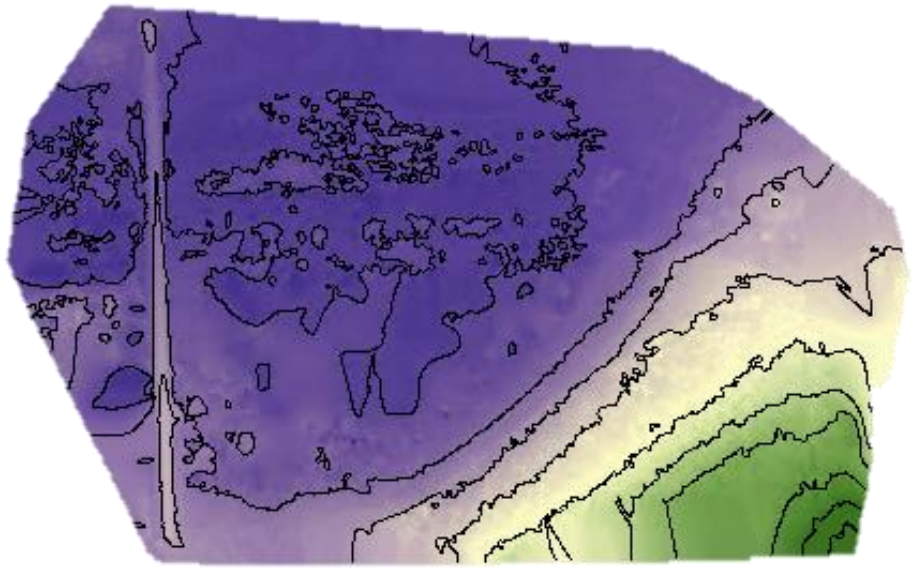
DSM(Surface Model)

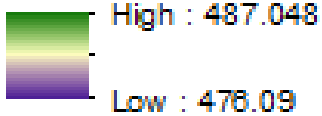




Straight Water--2017/02/28

DTM(Terrain Model)

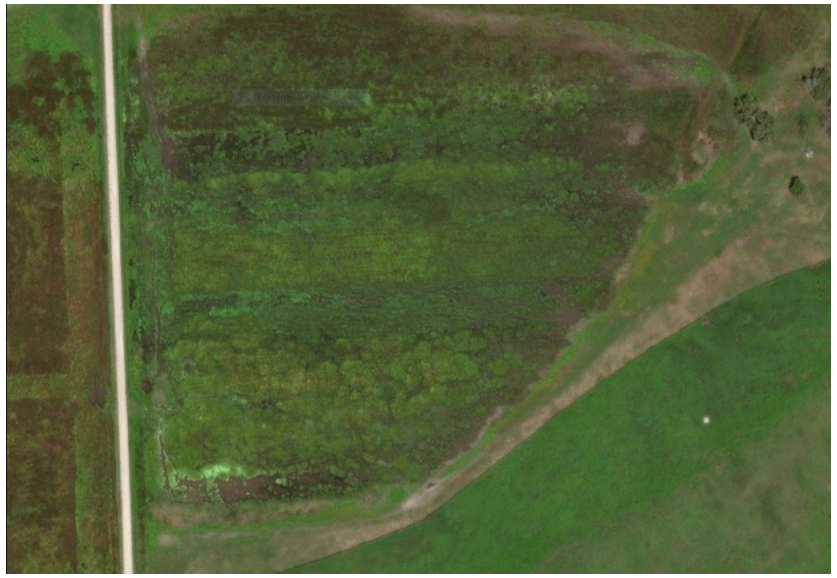




Straight Water--2017/02/28

Data Processing : 3.5 Index Map

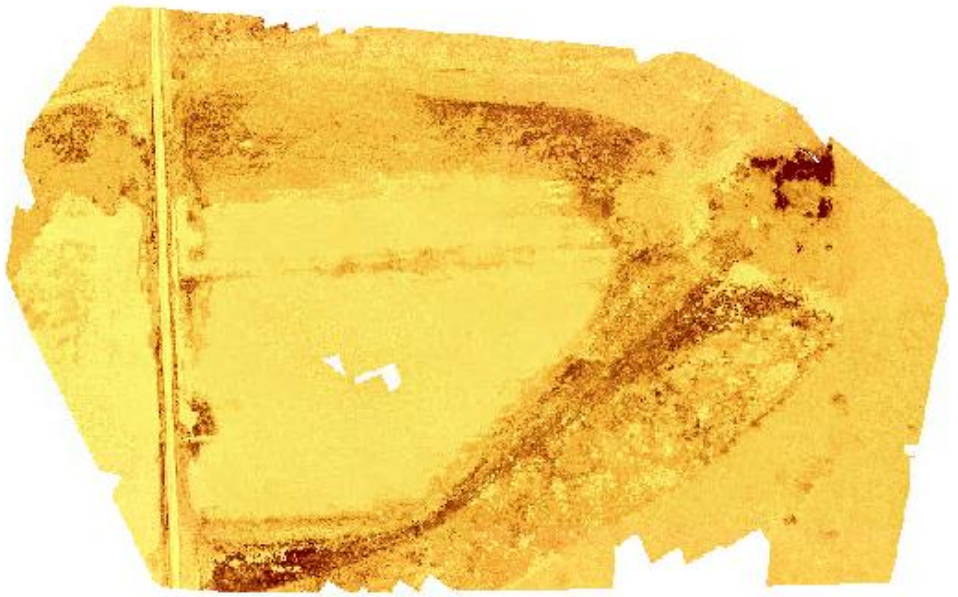
True Color Imagery



Google Earth

Straight Water

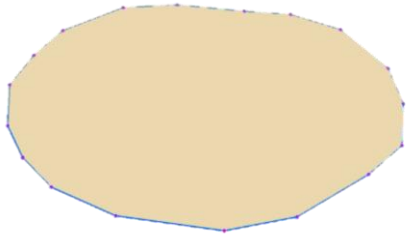
NDVI



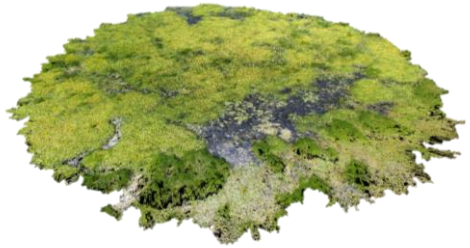
Straight Water--2017/02/28

Data Processing : 3.6 Vegetation Biomass Volume

01 BASE SURFACE

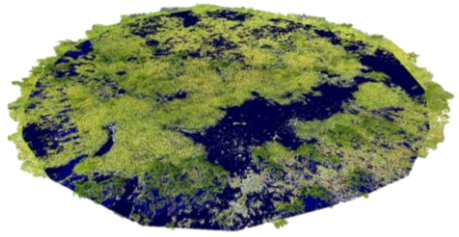


02 POINT CLOUD



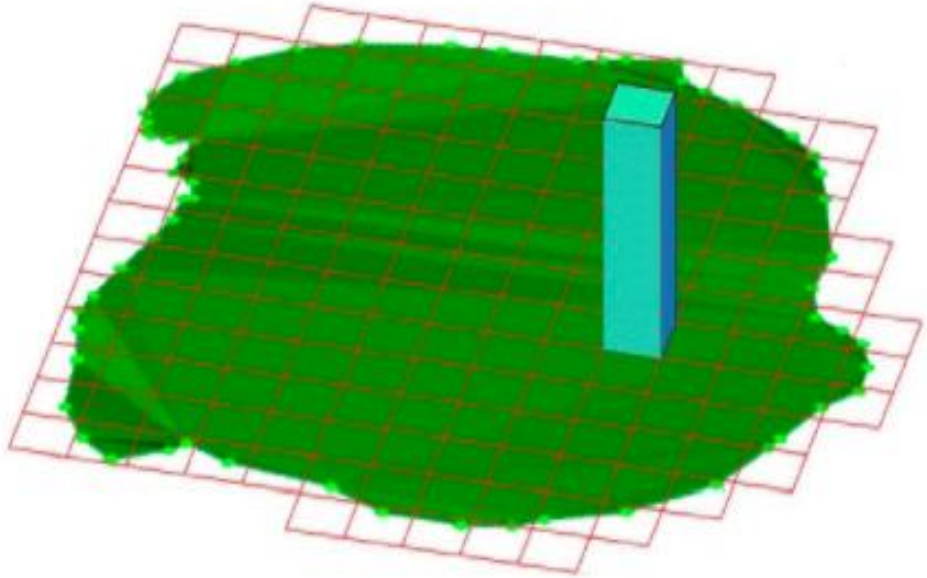
03 TERRAIN

04 VOLUME



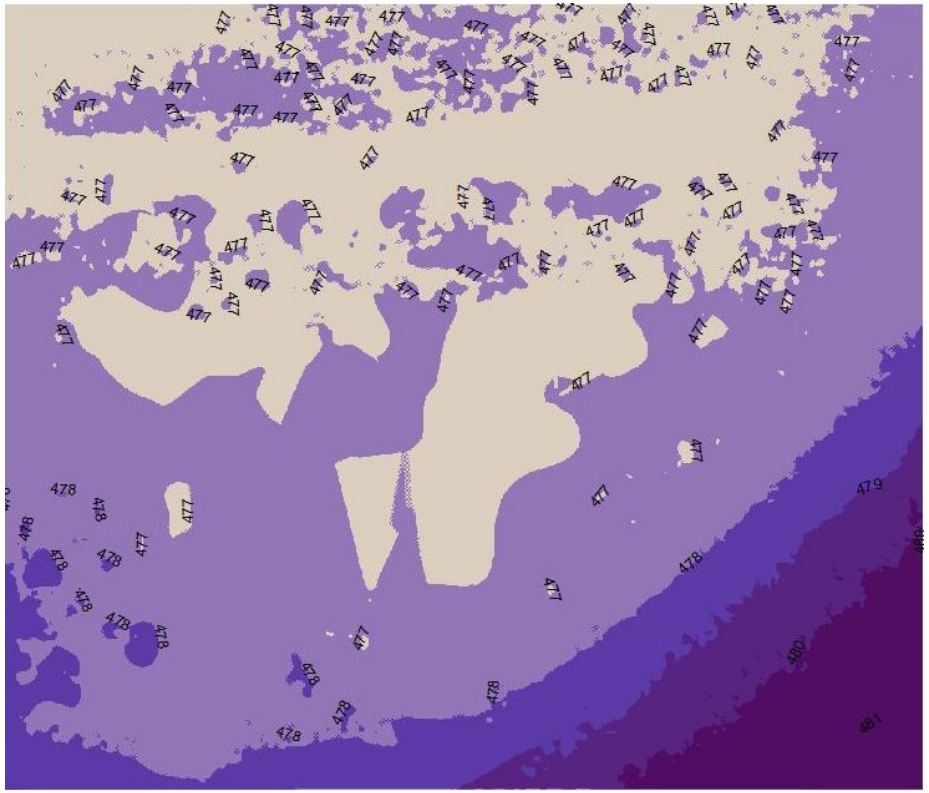
Straight Water--2017/08/29

Calculation Model

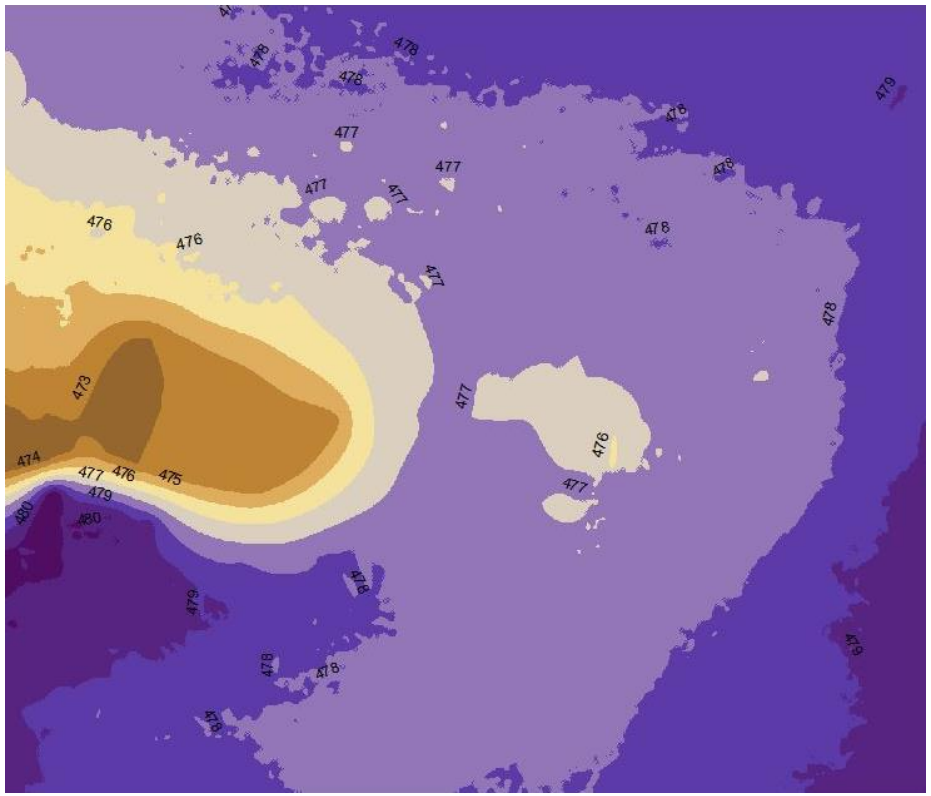


Results: Water Inundation Dynamics

DTM *Straight Water--2017/02/28*

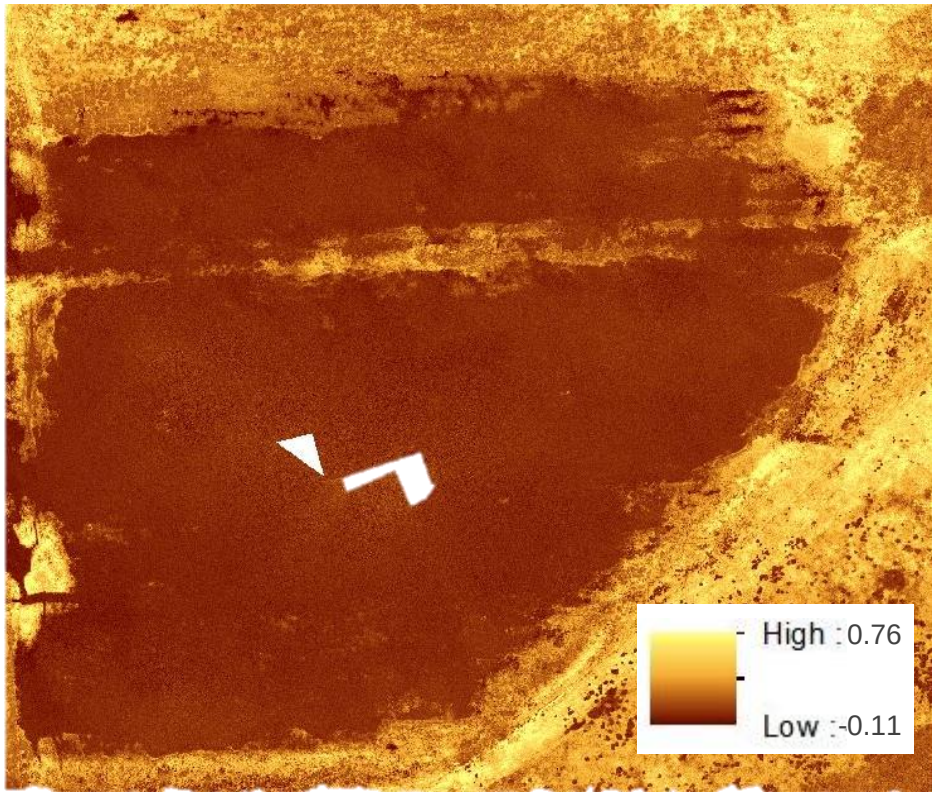


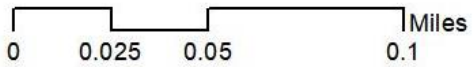
DTM *Straight Water--2017/03/09*



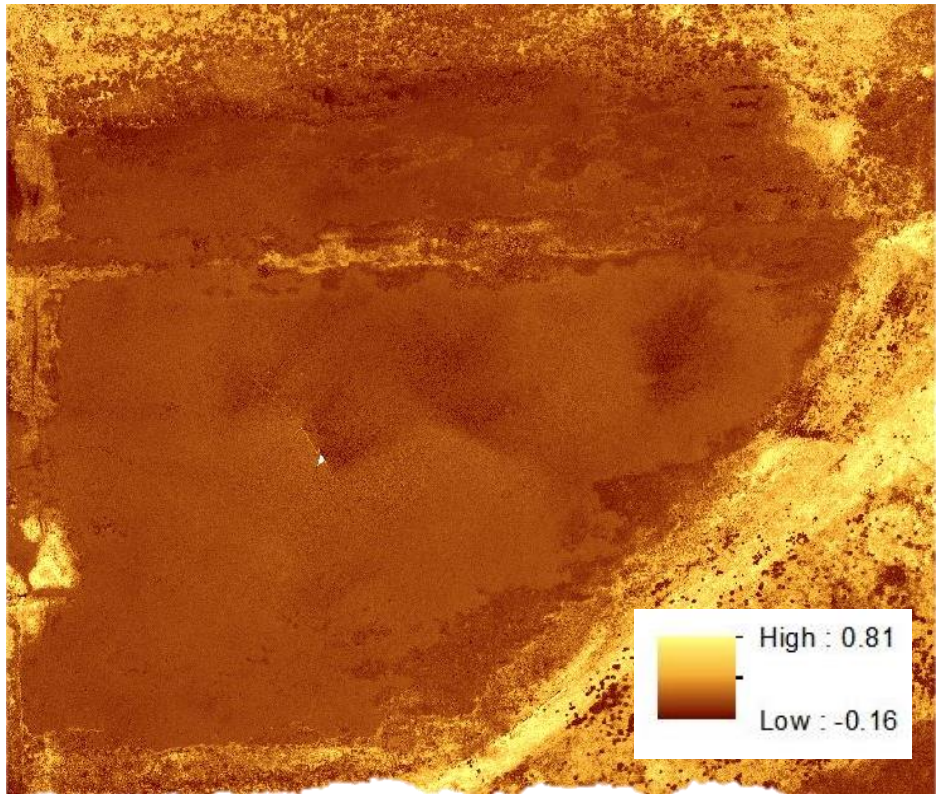
Results: Inundation & Vegetation Dynamics

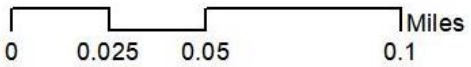
NDVI *Straight Water--2017/02/28*



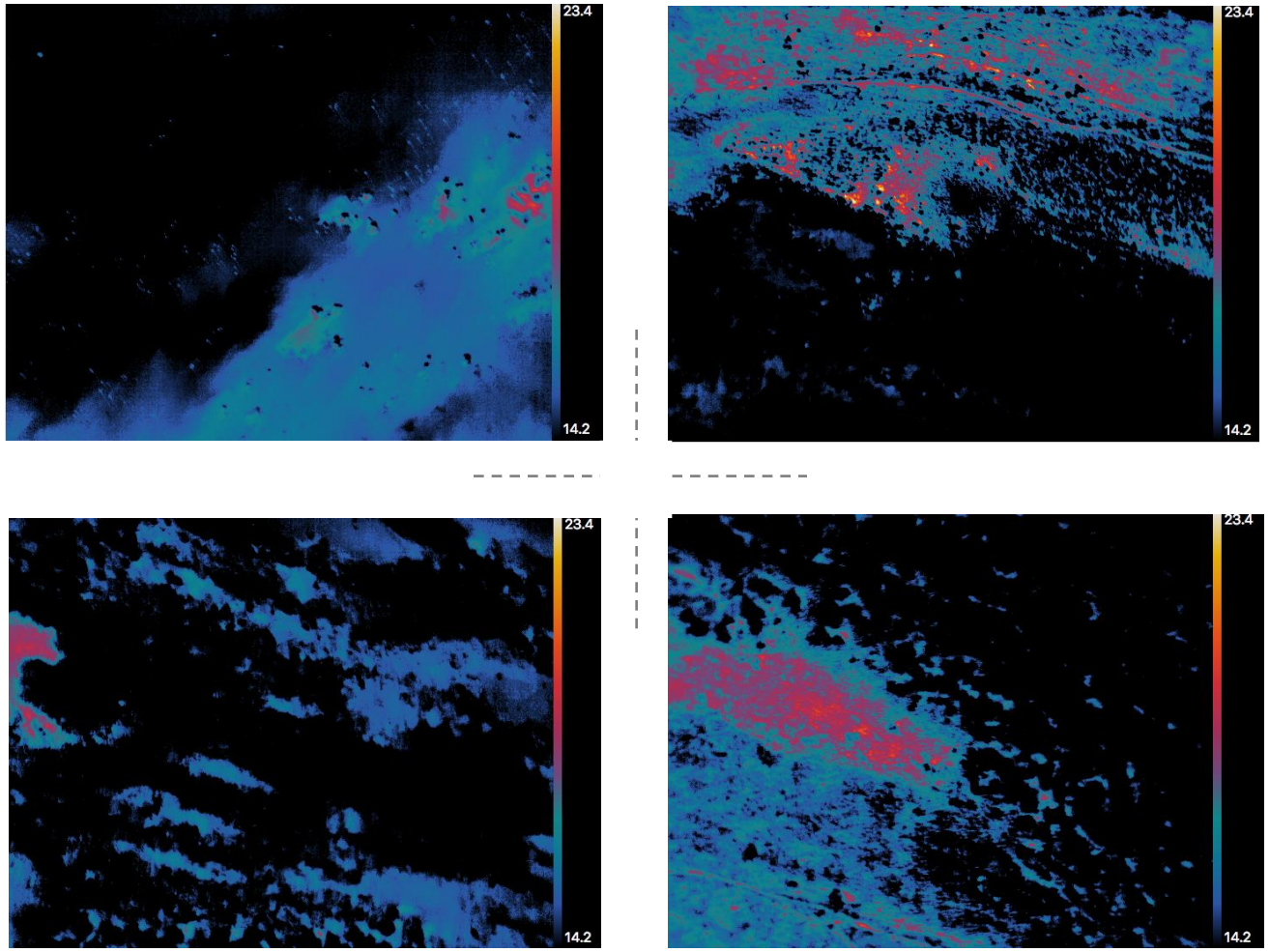


NDVI *Straight Water--2017/03/09*





Results: Thermal Image for Wildlife Detection



Findings

Thermal Image is hard to capture birds at 400 feet, as TIR always has long wavelength which requires larger area to produce enough signal.

Thermal image is an effective tool to identify water body, which can be considered as a potential usage.

Straight Water--2017/03/09

Results: Biomass Estimations

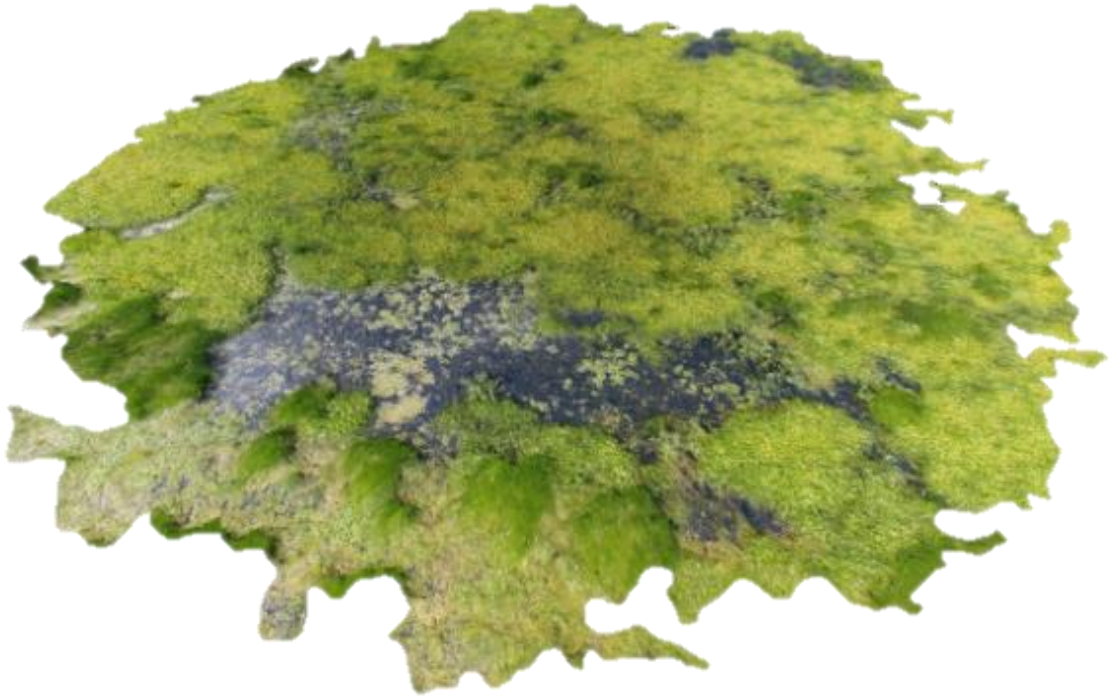
Straight Water--2017/08/29

Terrain 3D area: 4326 m^2

Cut Volume: 2073 m^3

Fill Volume: -181 m^3

Total Volume: 1892 m^{3}`



Results: Biomass Estimations

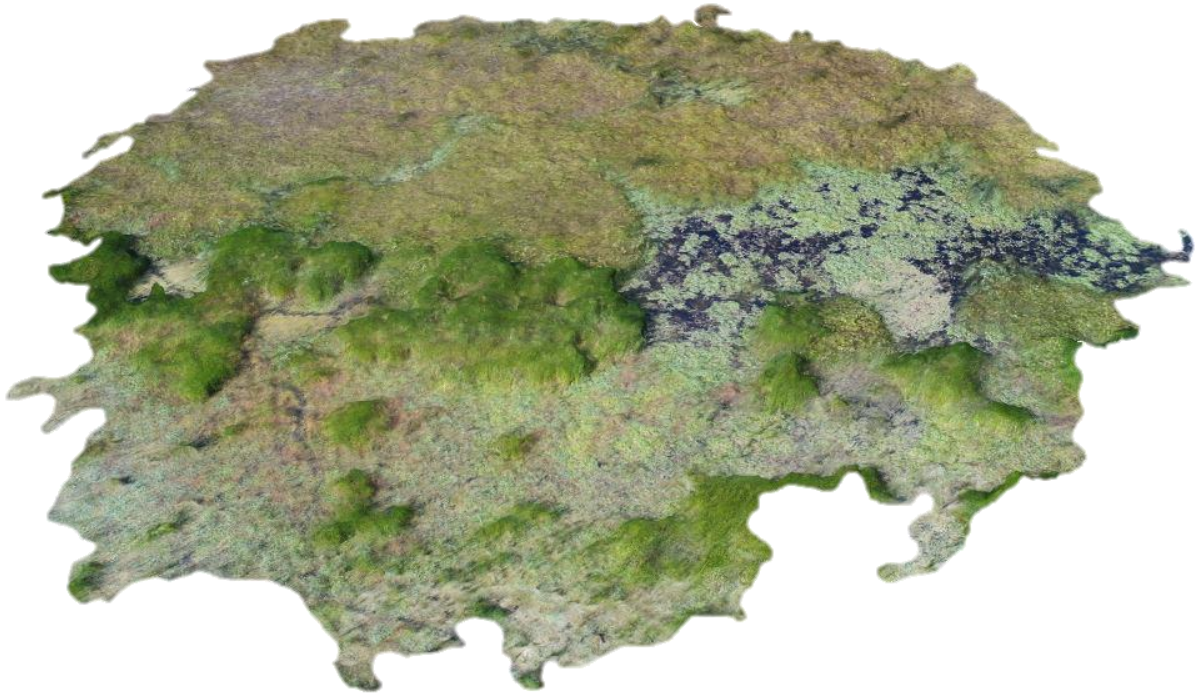
Straight Water--2017/09/20

Terrain 3D area: 2266 m^2

Cut Volume: 422 m^3

Fill Volume: -115 m^3

Total Volume: 307 m^3



Results: Biomass Estimations

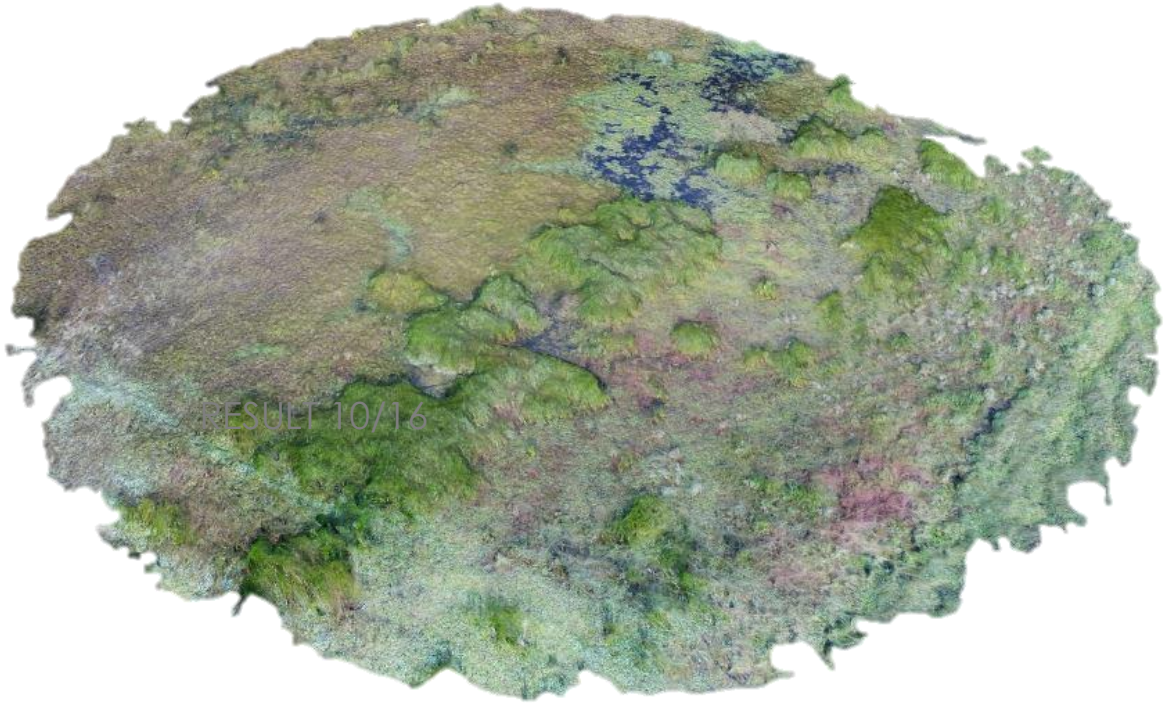
Straight Water--2017/09/27

Terrain 3D area: 4632 m^2

Cut Volume: 1111 m^3

Fill Volume: -122 m^3

Total Volume: 989 m^3



Results: Biomass Estimations

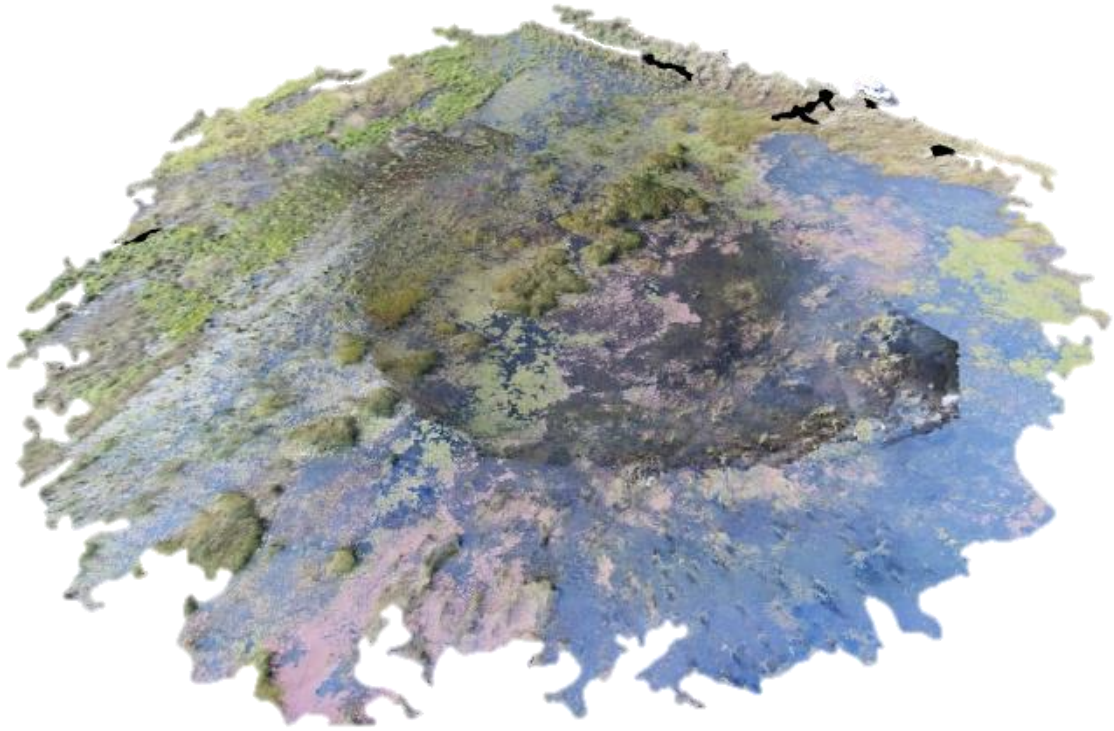
Straight Water--2017/10/16

Terrain 3D area: 223736 m^2

Cut Volume: 30498 m^3

Fill Volume: -60 m^3

Total Volume: 30438 m^3



Results: Time Series Normalized Biomass Density

Result 08/29

Terrain 3D area: 4325.67 m^2
Total Volume: 1891.53 m^3
Normalized Biomass Density: 0.437 m^3/m^2

Result 09/20

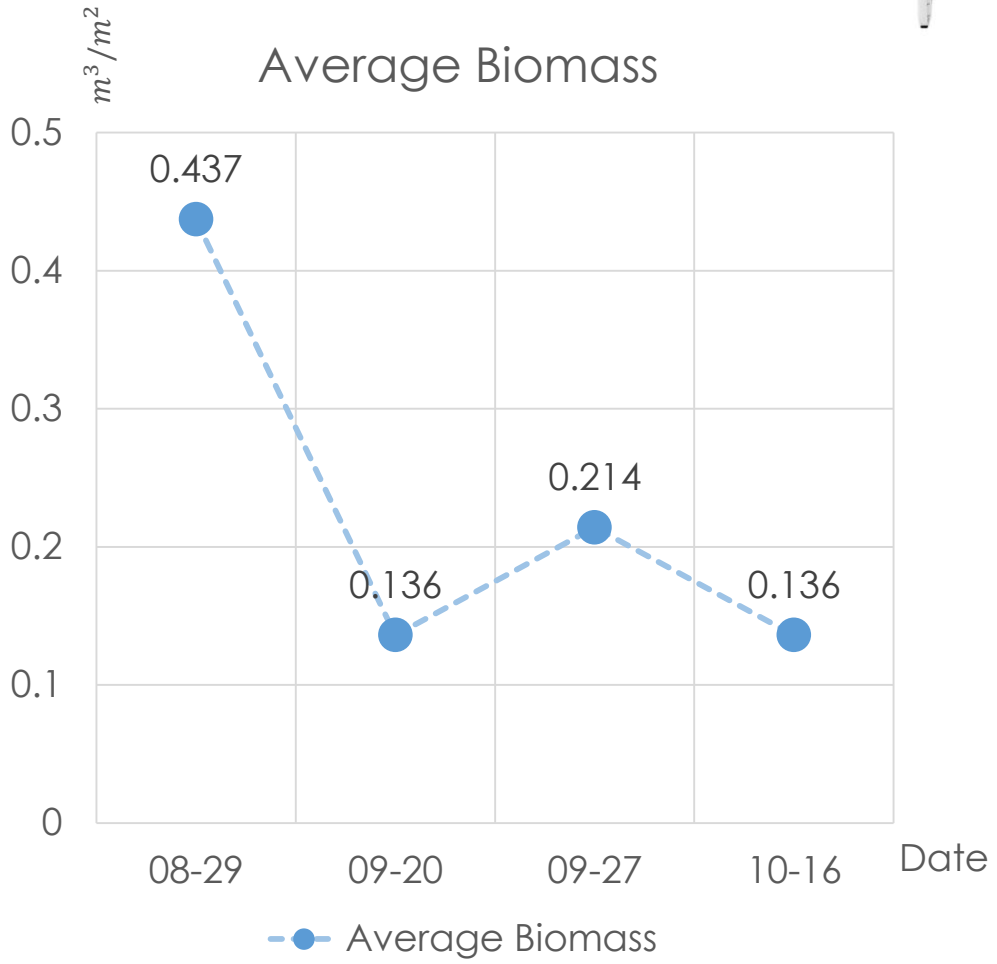
Terrain 3D area: 2265.94 m^2
Total Volume: 307.07 m^3
Normalized Biomass Density: 0.136 m^3/m^2

Result 09/27

Terrain 3D area: 4632.32 m^2
Total Volume: 989.31 m^3
Normalized Biomass Density: : 0.214 m^3/m^2

Result 10/16

Terrain 3D area: 223736.29 m^2
Total Volume: 30438.04 m^3
Normalized Biomass Density: : 0.136 m^3/m^2



Initial Conclusion for UAS Wetland Conservation

Wetland Inundation

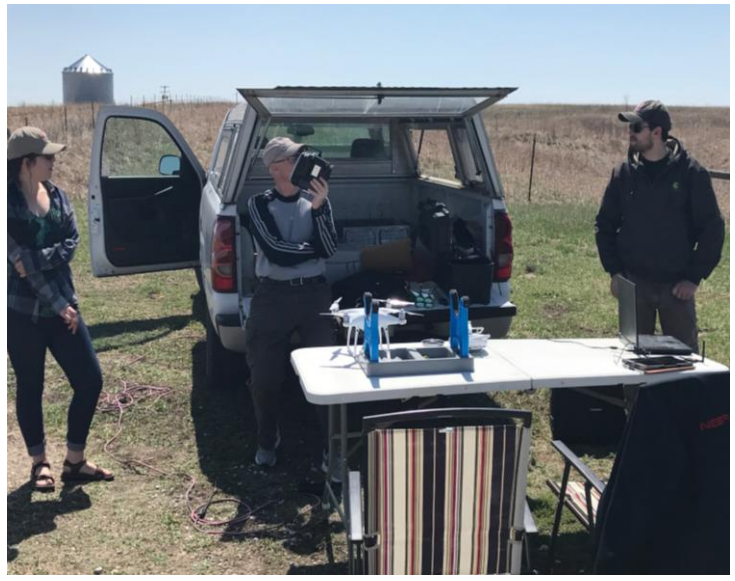
From February to March, the inundation volume has obvious variations.

Wildlife Monitoring

The flying altitude is critical to capture the wildlife in the wetland.

Vegetation Community

The average biomass volume vary from August to October gradually.



Acknowledgements

The View under the Camera of UAV

Recommendation & Future Research

Fixed Area & Altitude

The current flights are aiming to build a standard flight protocol. Fixed areas and altitudes will make the data more comparable and meaningful.

Regular Flights

Future flights will evenly distribute on three sites. This will give us deep insights of the spatial & time series differences in different wetlands.

Reference Model

Create a reference model about the wetland during the dry season can give us more quantitative comparison about the time series wetland dynamic change.