Navigating the Digital Expanse:

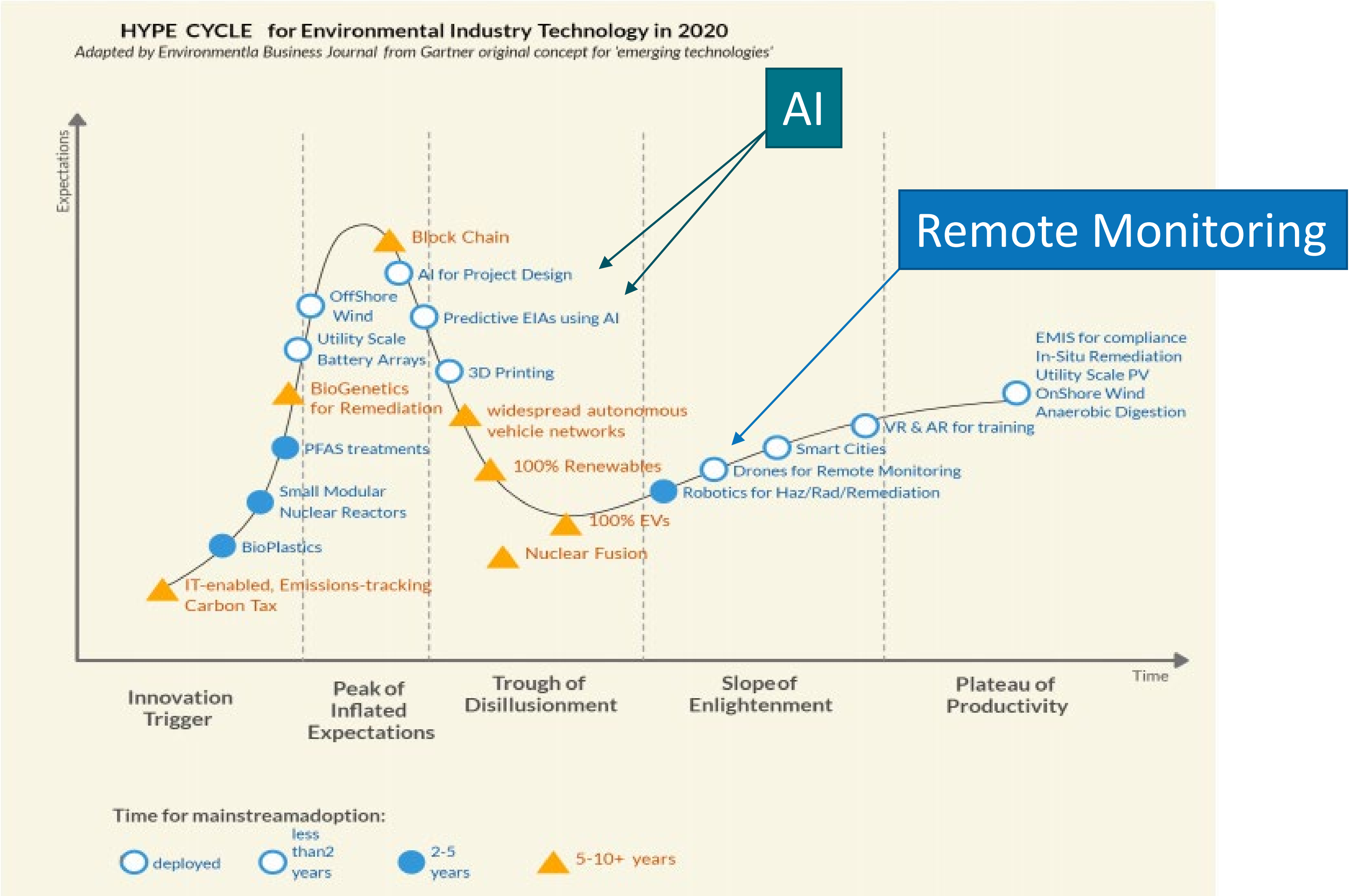
Empowering Environmental Decisions with Machine Learning and Remote Sensing

Devin Wilson, PWS

May 2024

sky wave™ at CDM Smith

AI and remote sensing will be vital to the environmental industry.

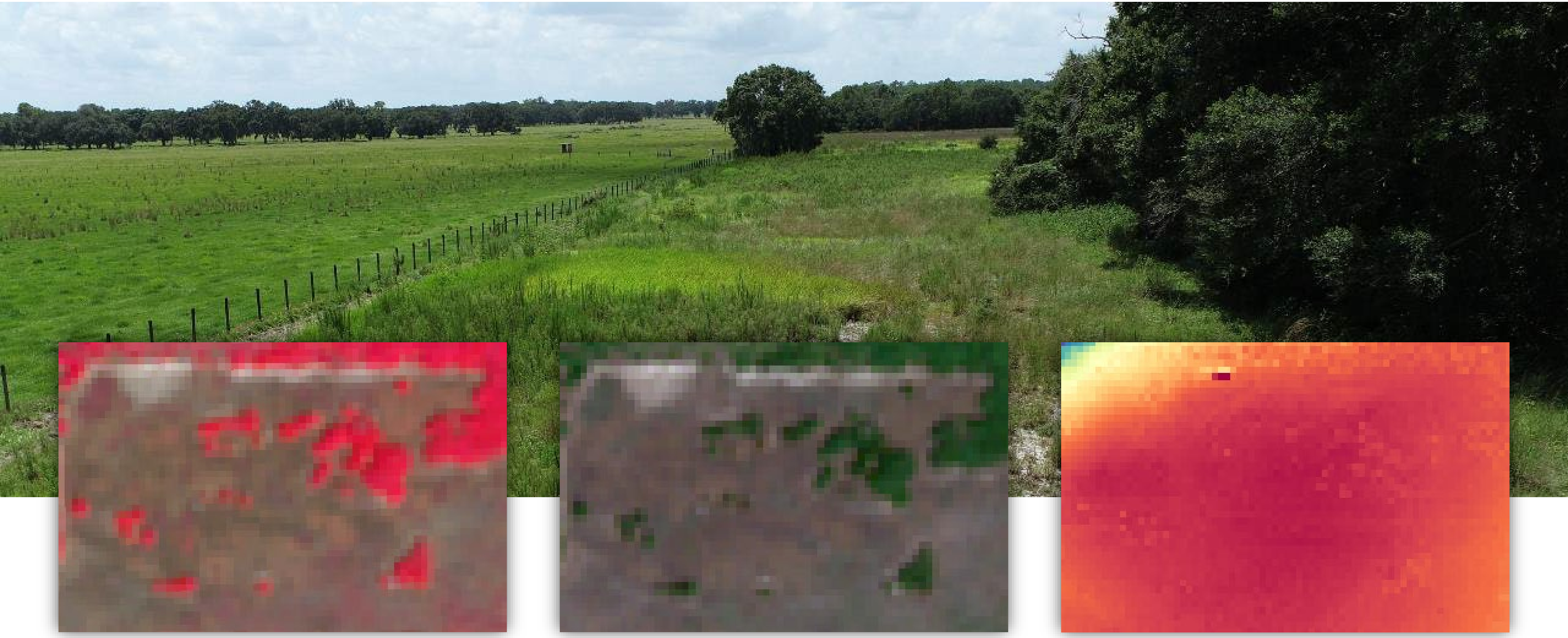


Field work is an invaluable but limiting factor.

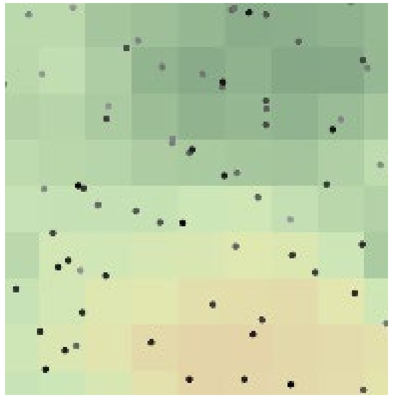
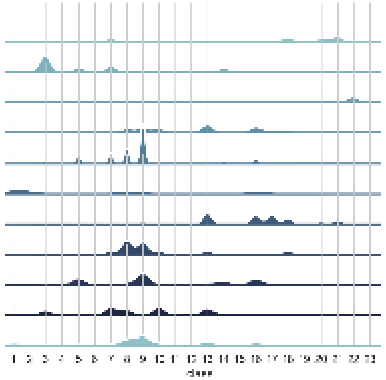
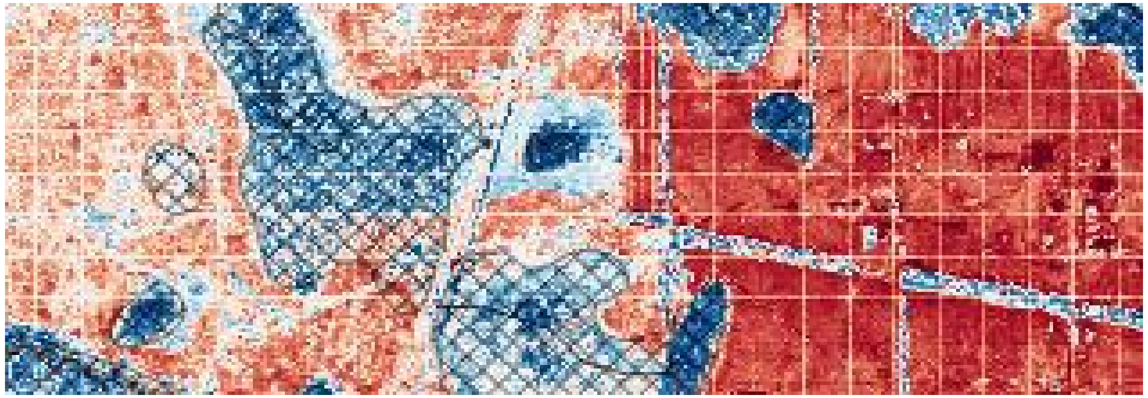
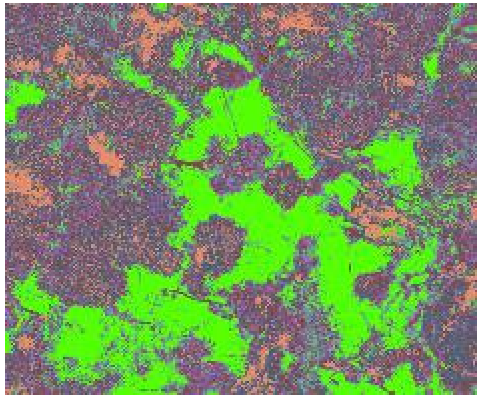
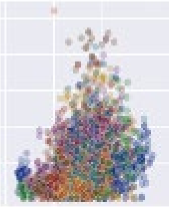
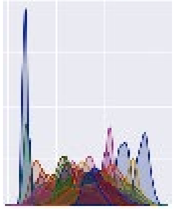
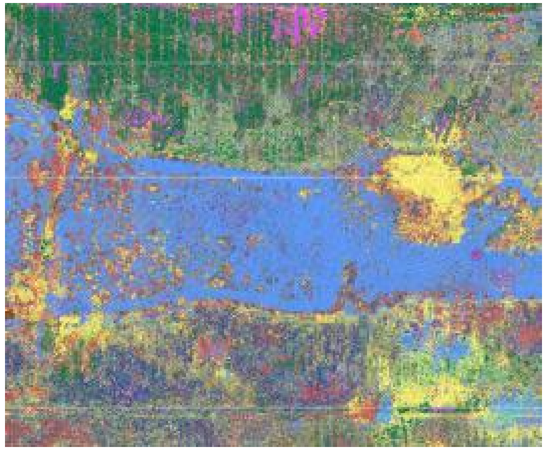
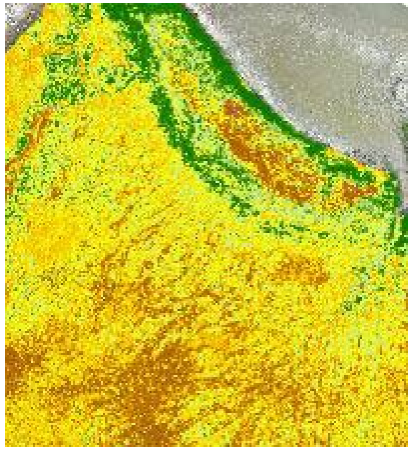
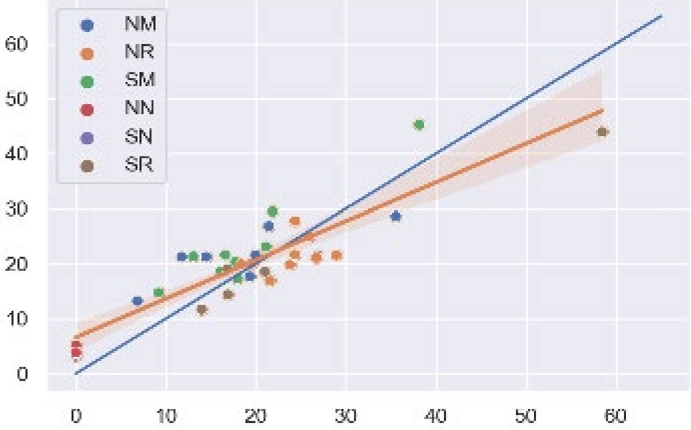


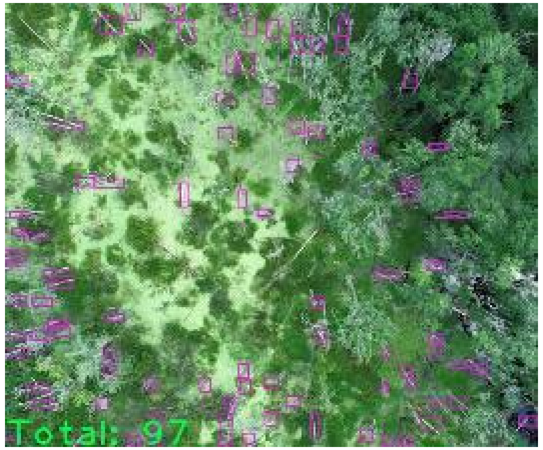


Satellite/plane data is widely available but low spatial or temporal resolution.

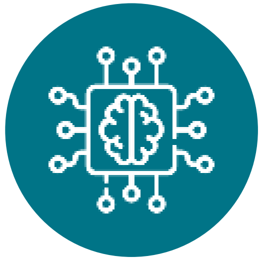


We are finally seeing the promise of machine learning being delivered, but environmental applications are lagging.



Modern day computer processing power has opened the door to widespread use of AI.

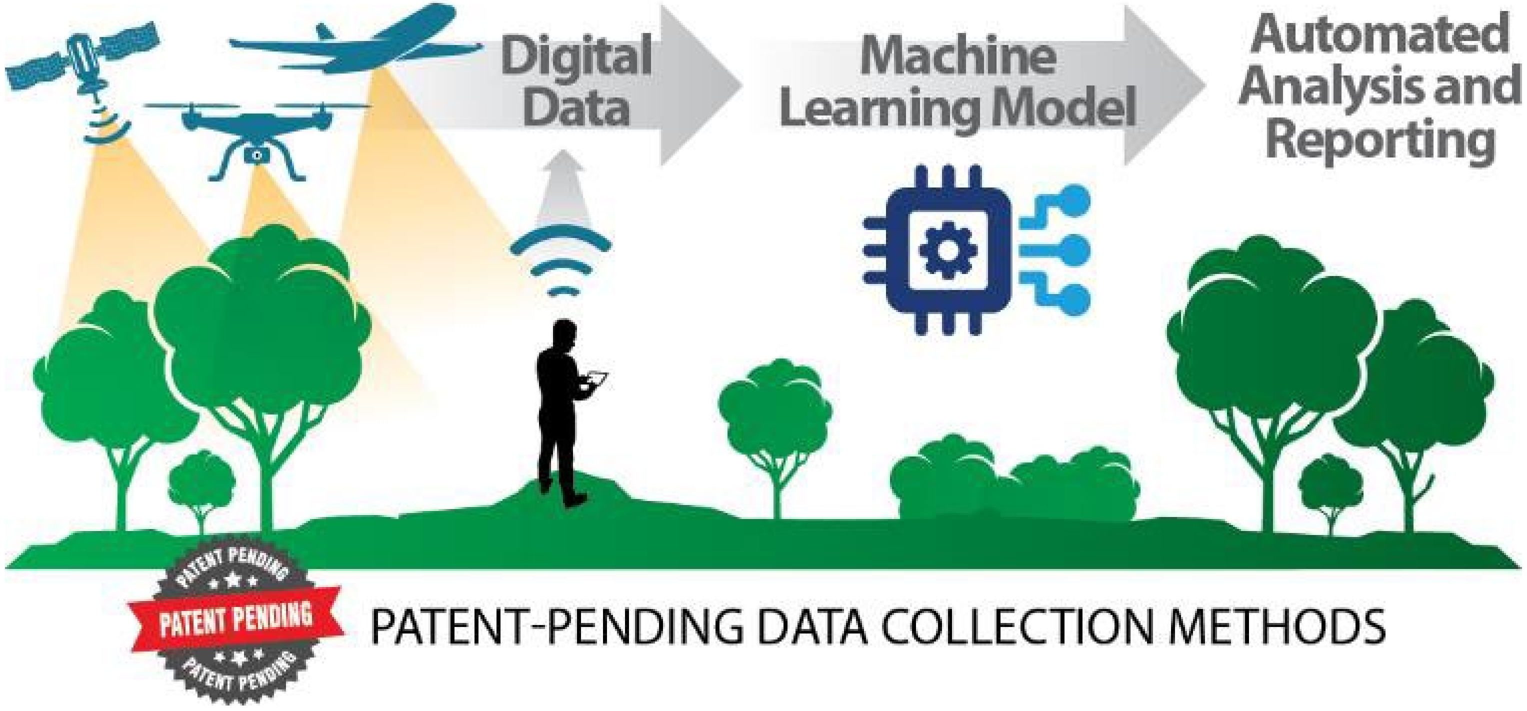


Modern day computer processing power has opened the door to widespread use of AI.

An expert-centered digital pipeline empowers better decisions.

- Surveyors
- Engineers
- Geologists
- Scientists
- FAA-certified drone pilots
- Remote sensing
- Machine learning

sky wave™

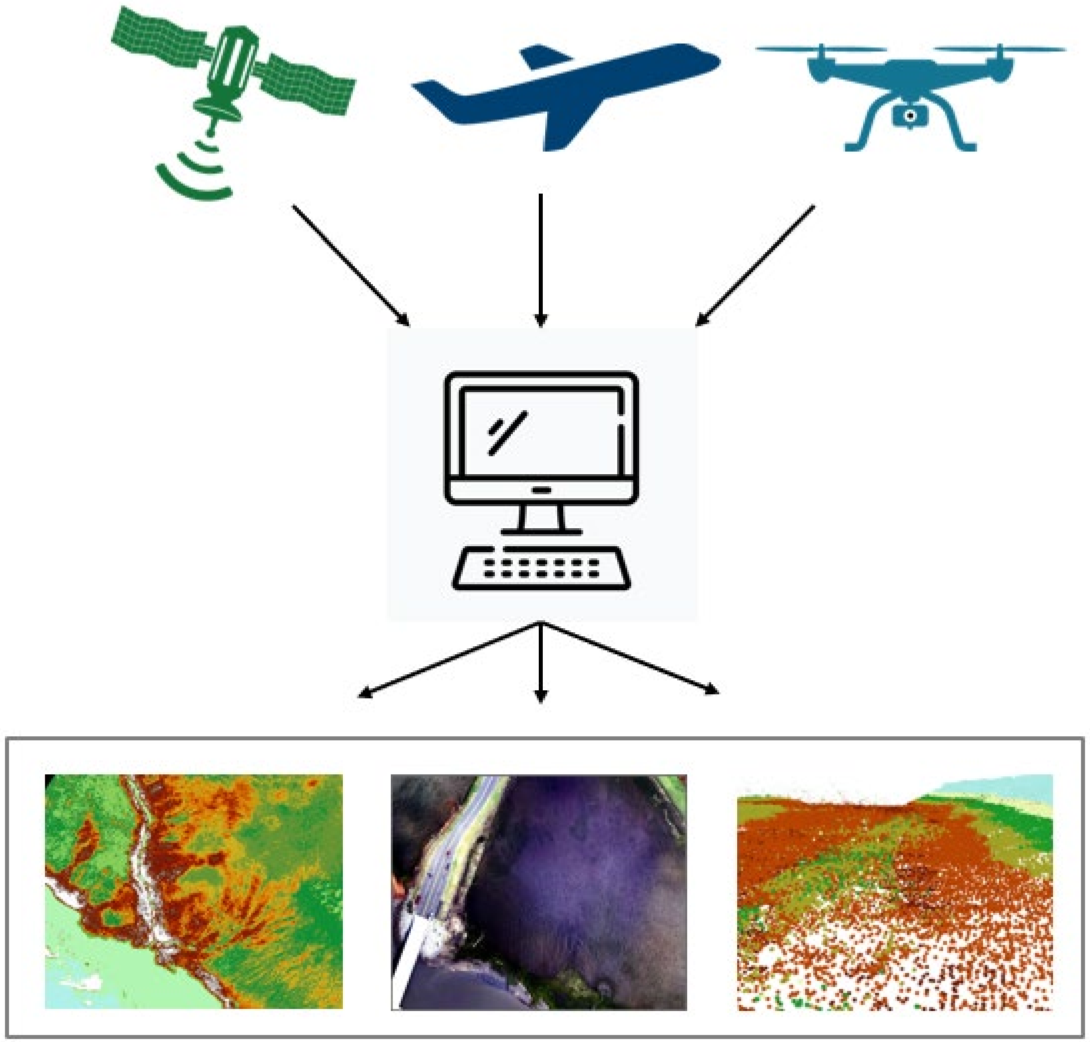


Agenda

- Remote Sensing Basics
- Machine Learning Basics
- Site Feasibility: Wetland delineation
- Land Management: Invasive species identification
- Remediation: Excavation and Capping/ Tree Monitoring

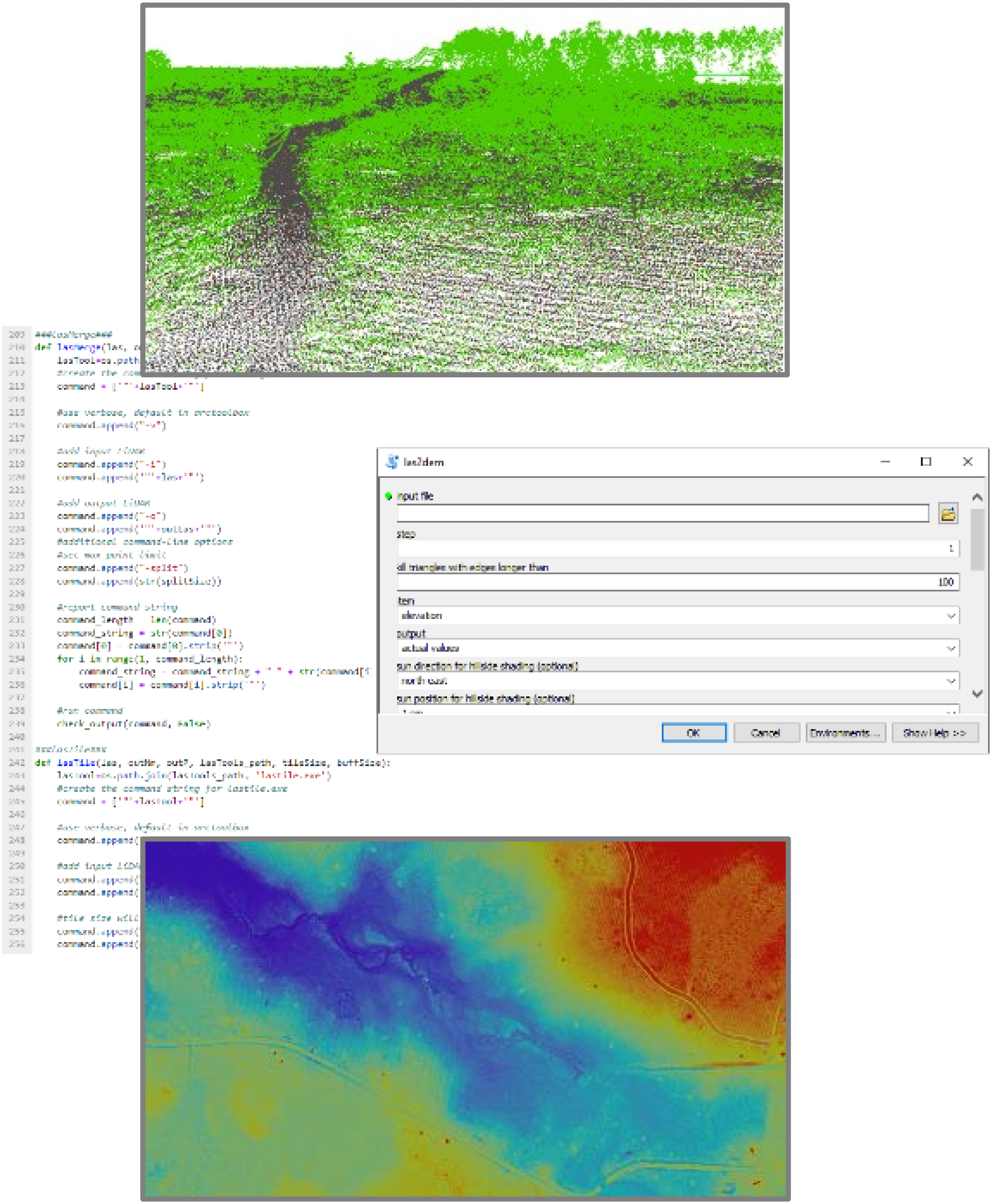
Remote Sensing

- Common collection platforms
  - Satellite, plane, UAVs/ drones
- Common sensors
  - camera, thermal, lidar
    multispectral, hyperspectral
- Common products
  - Imagery, elevation
- Choosing the right tools
  - Site size, project needs

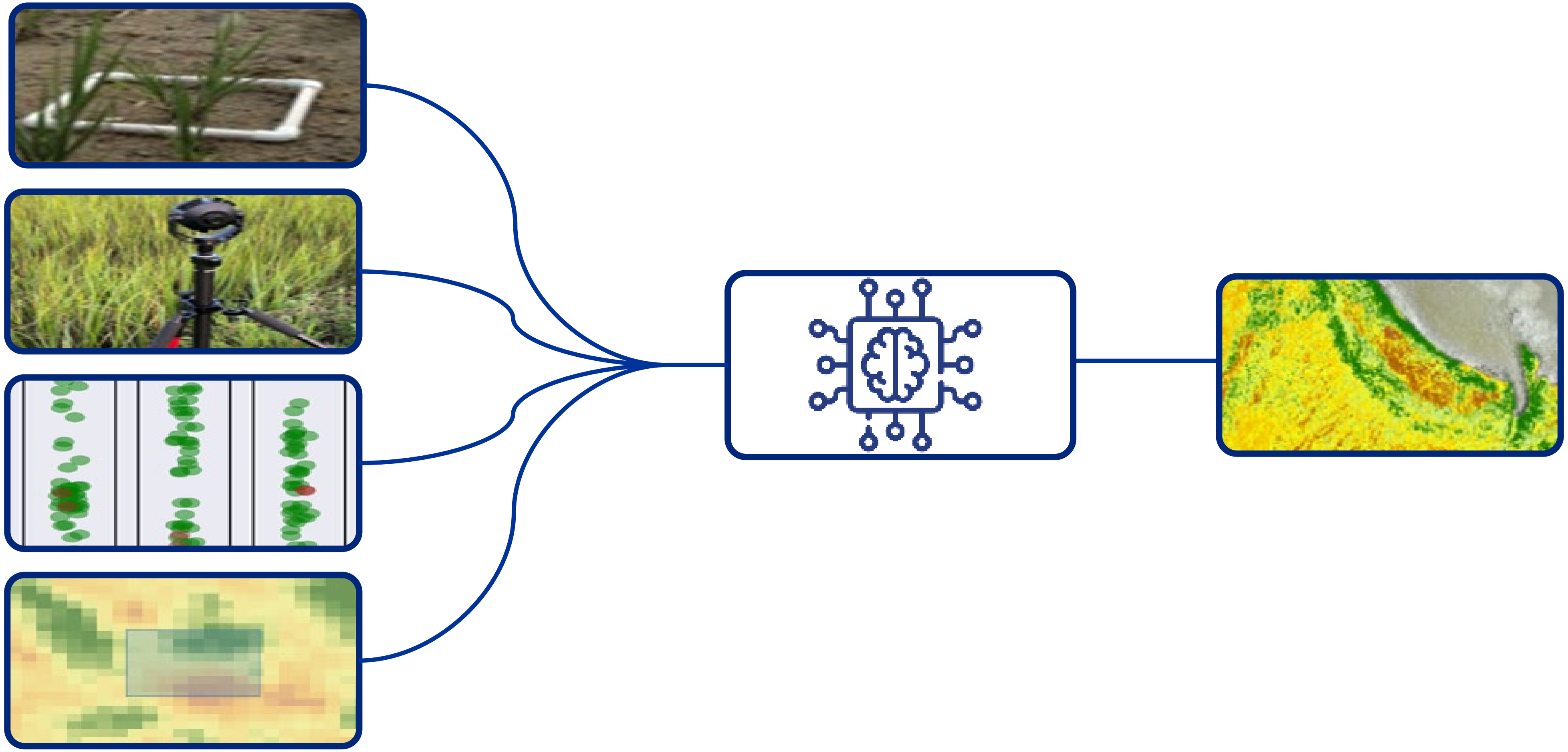


Automation

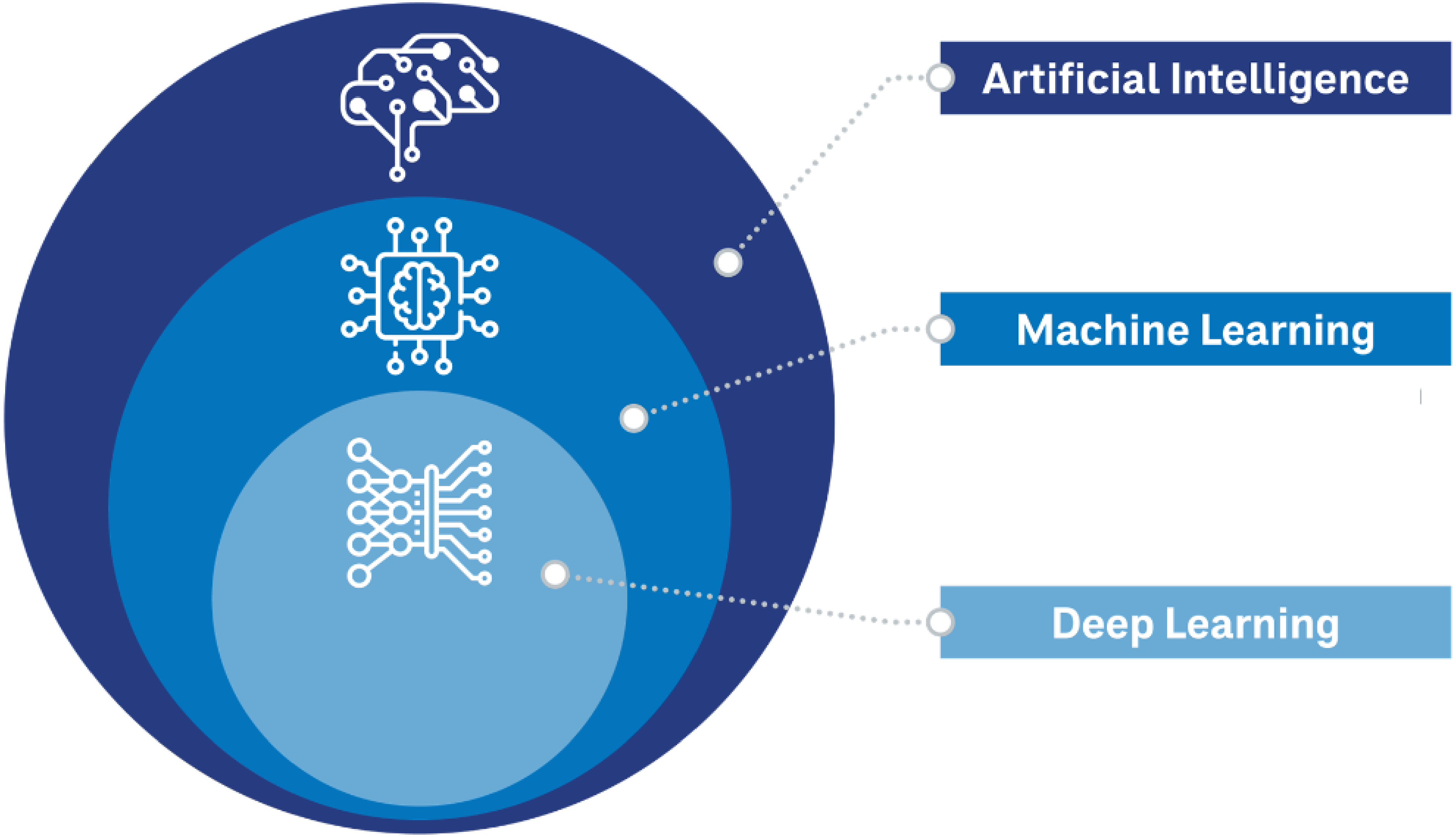
- Automation ≠ machine learning
- Automation is a pivotal part of the process
- How can we make things easier?
  - Automate it!



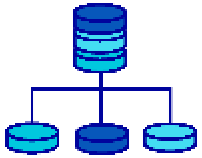
Automation's role in machine learning

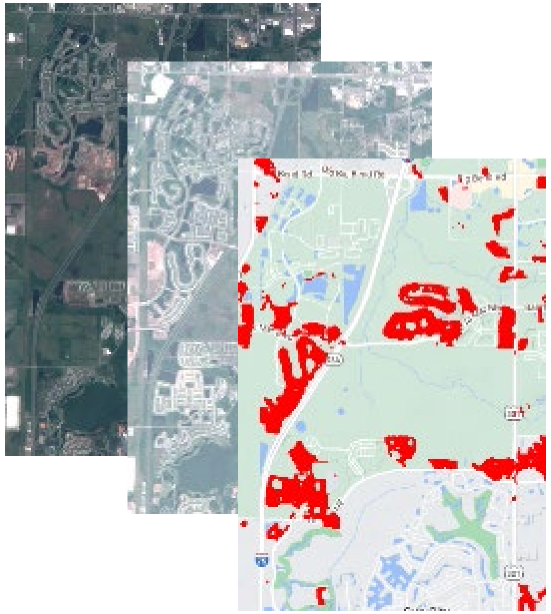


Machine Learning Basics

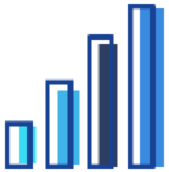


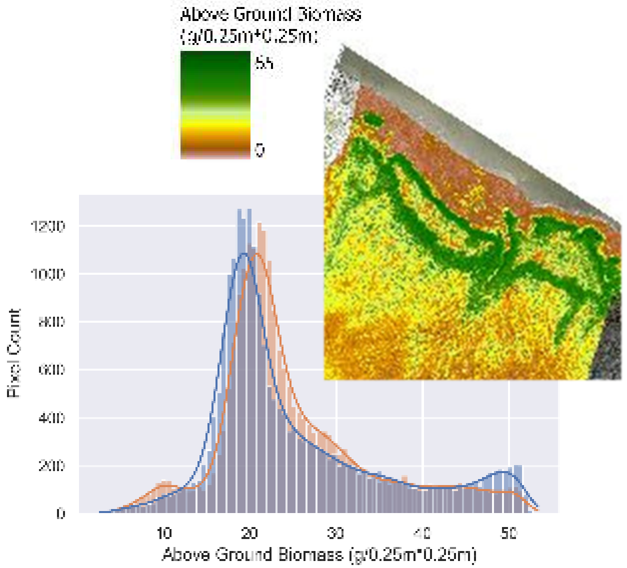
Classify/Locate



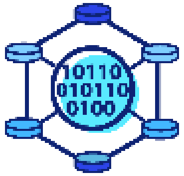


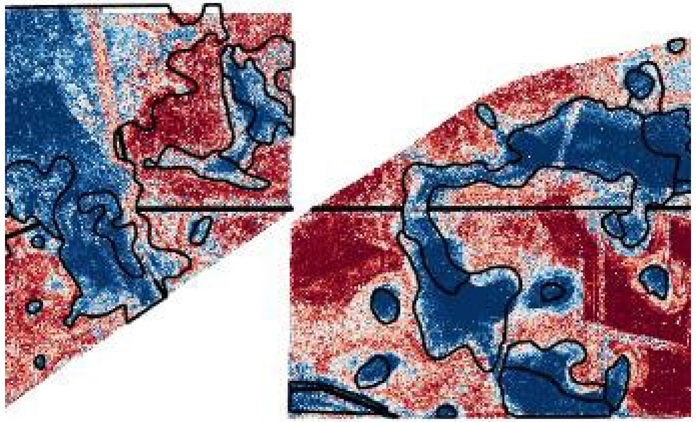
Quantify





Segment





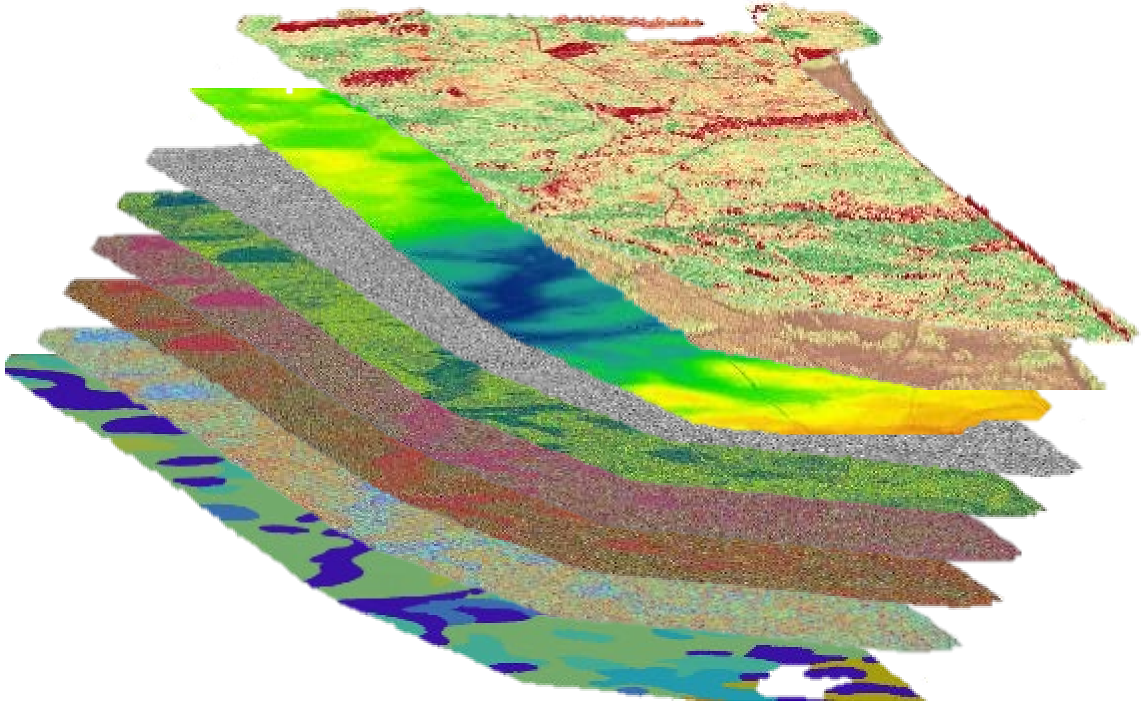
Machine Learning Basics

Multiple features

(easier/cheaper/faster to collect)

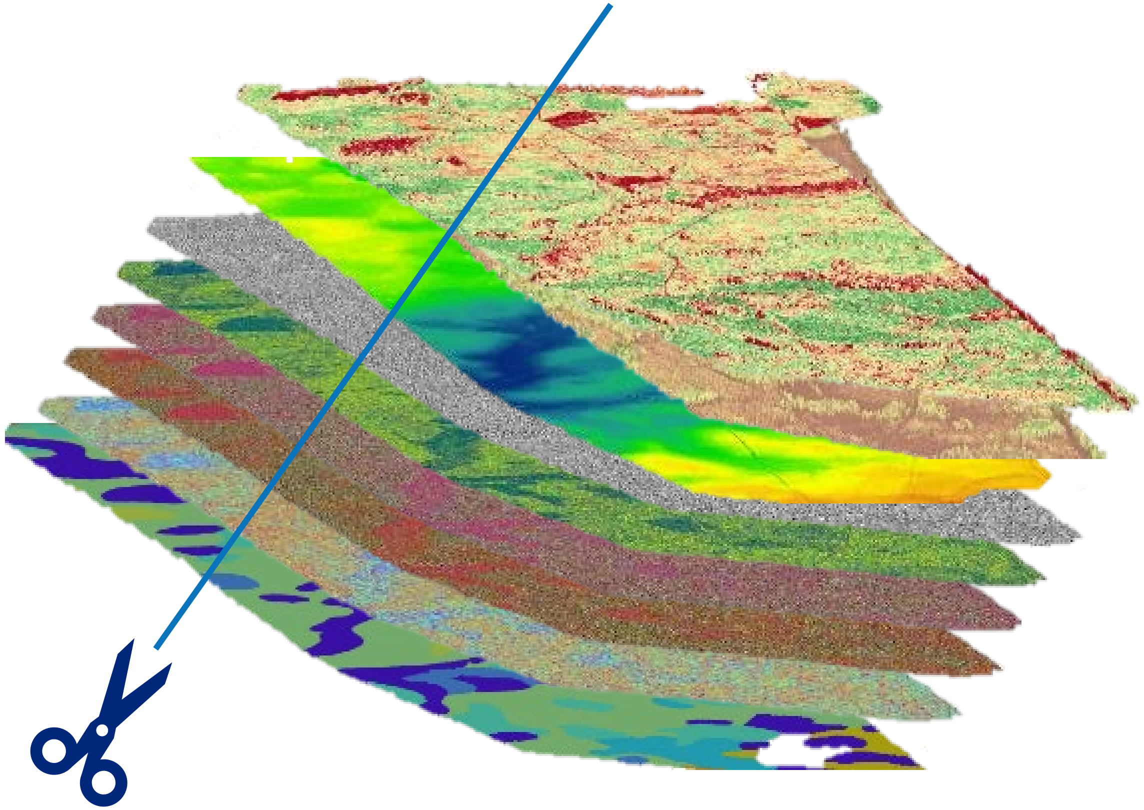
1 property to classify or quantify

(difficult /expensive/slower to collect)

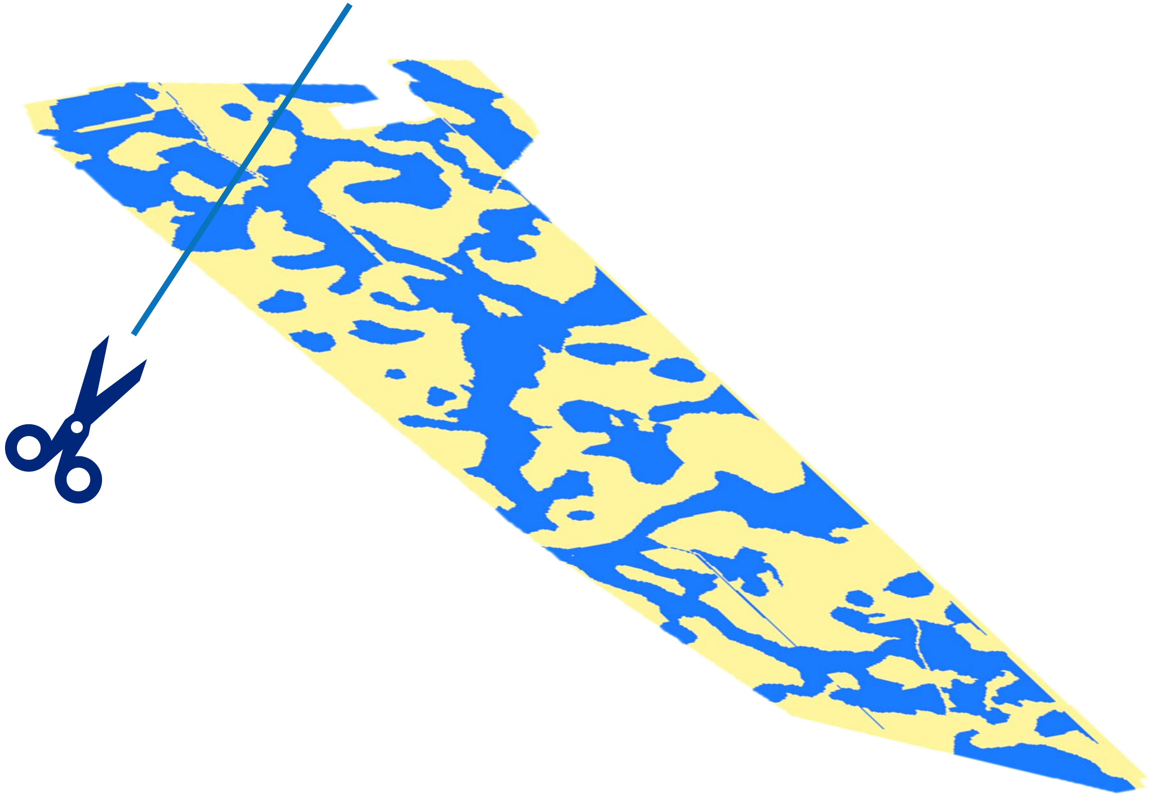


Machine Learning Basics

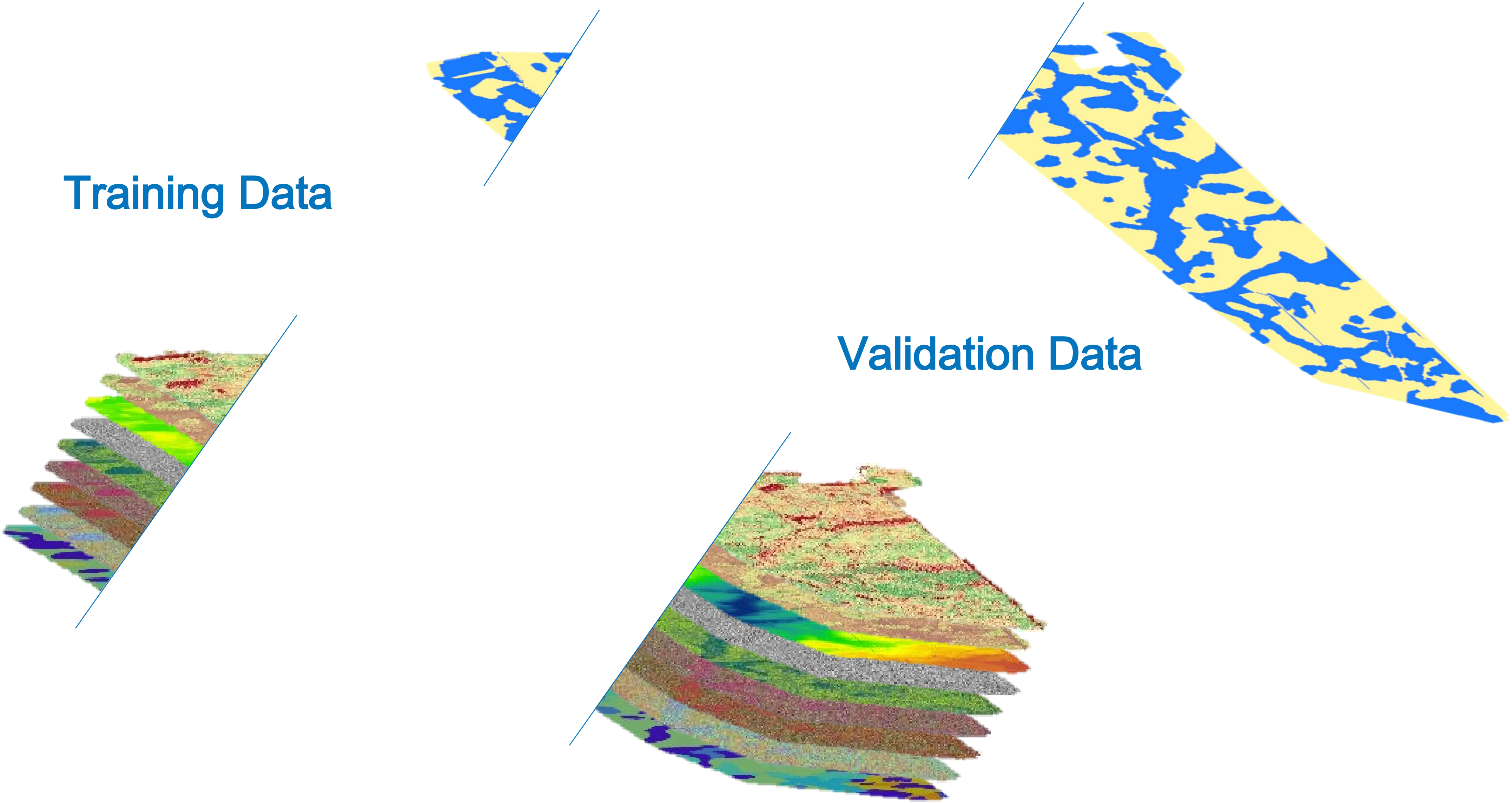
Model Variables



Target Class

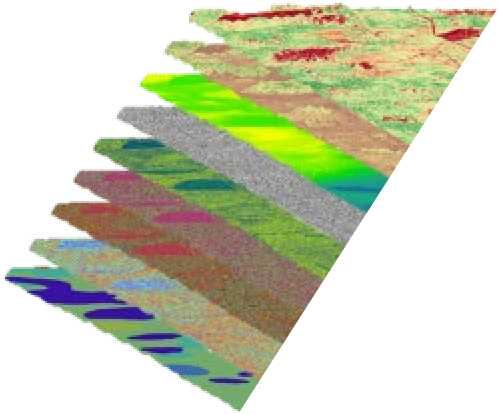


Machine Learning Basics



Train the Model

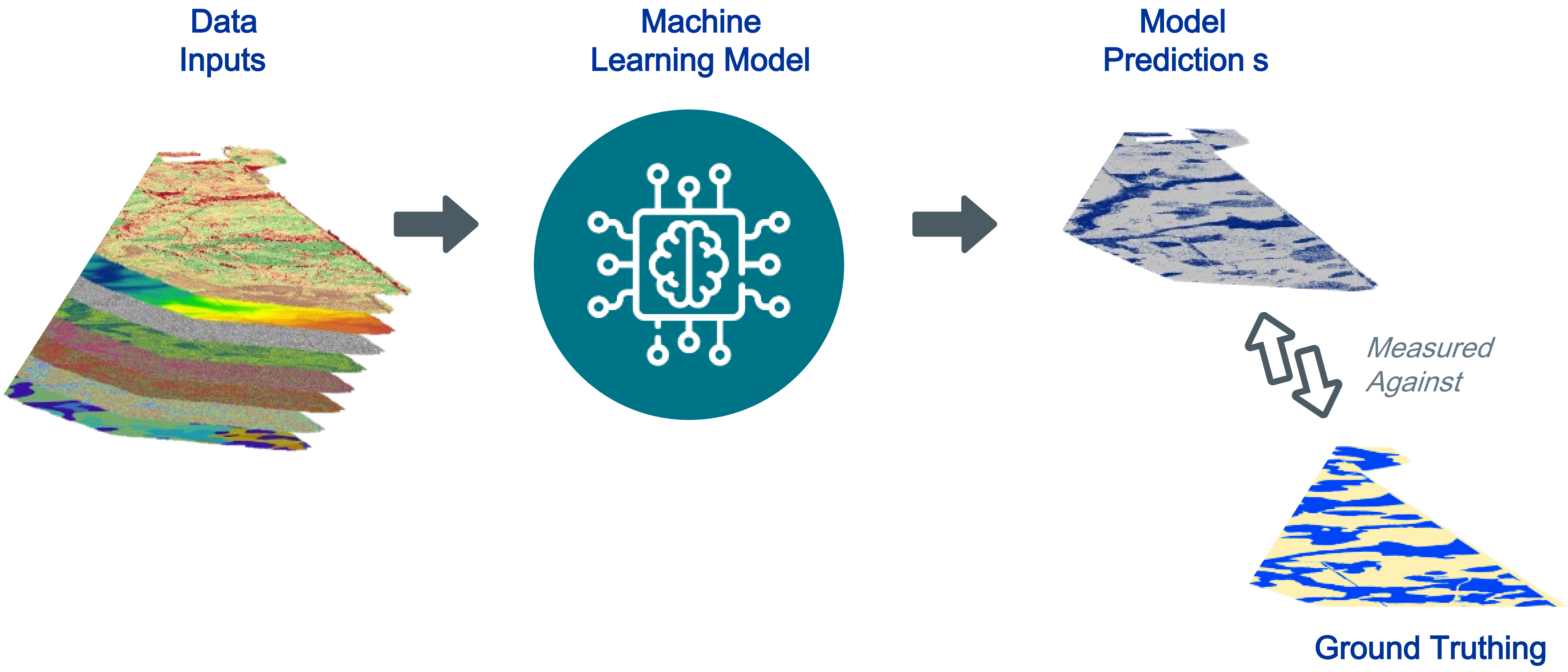
Data
Inputs



Ground
Truthing

Machine
Learning

Model Accuracy



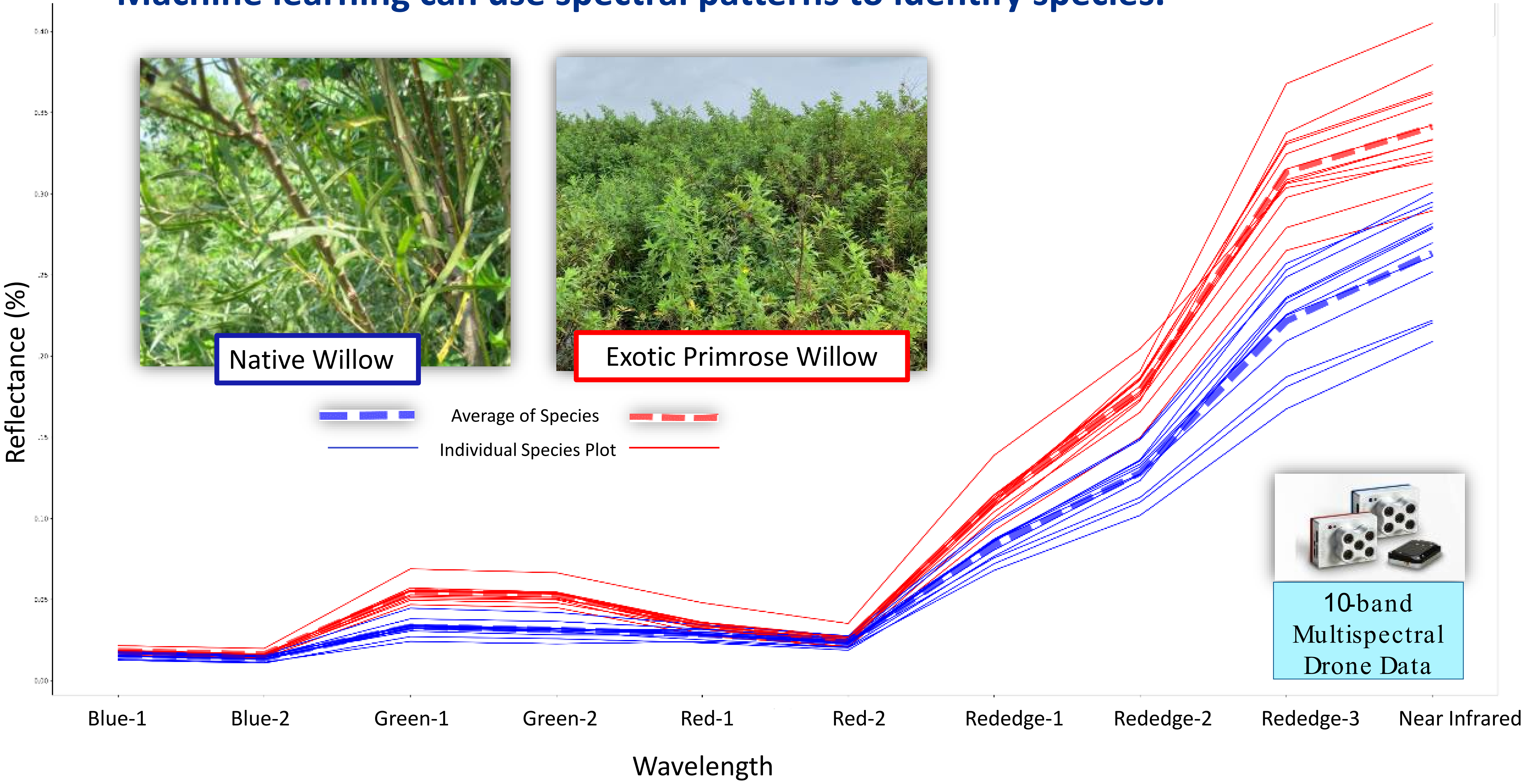
Land Management: Invasive & Native species identification

- How do we identify invasive species and assess the effectiveness of treatments to remove them?

Traditional approach for invasive species mapping.

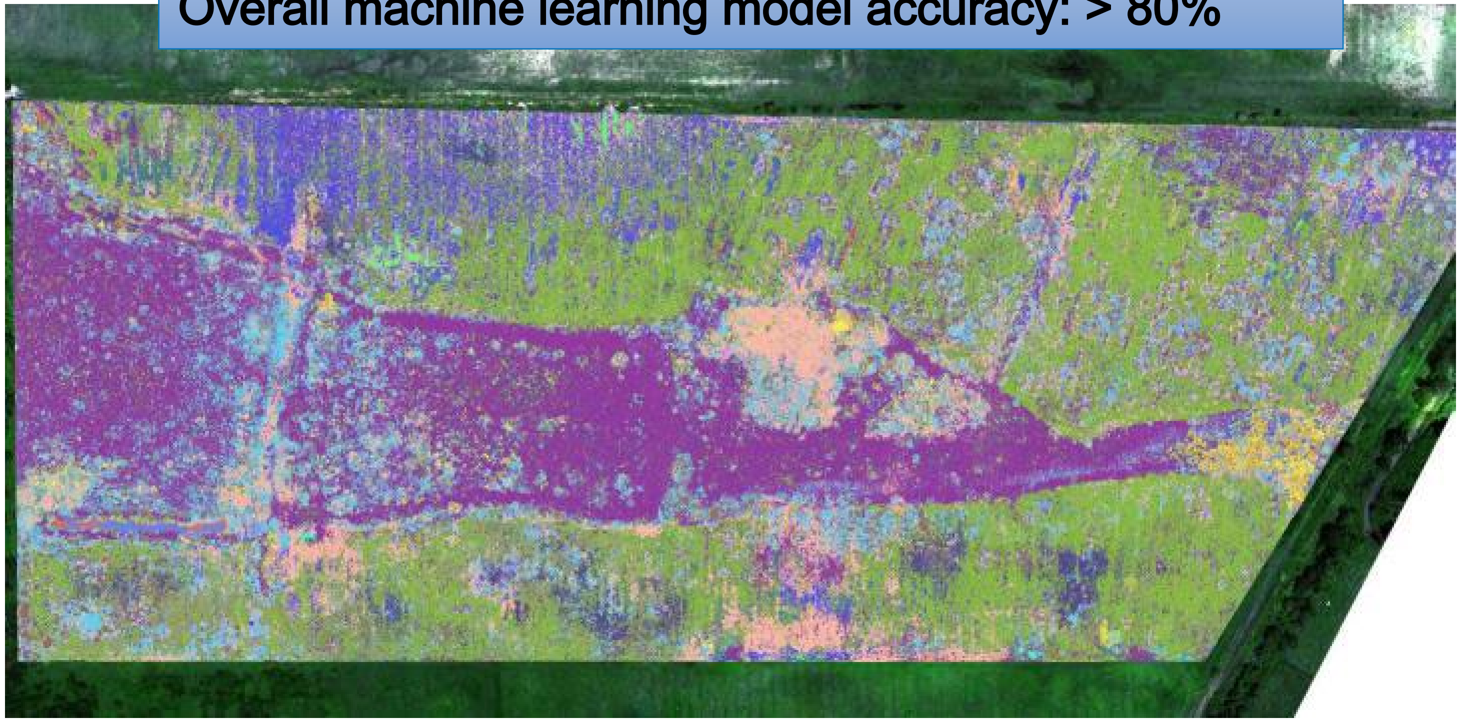
CDM Smith developed patent -pending data collection methods to increase efficiency and improve model accuracy.

Machine learning can use spectral patterns to identify species.



CDM Smith developed a high accuracy map of native and invasive species using machine learning.

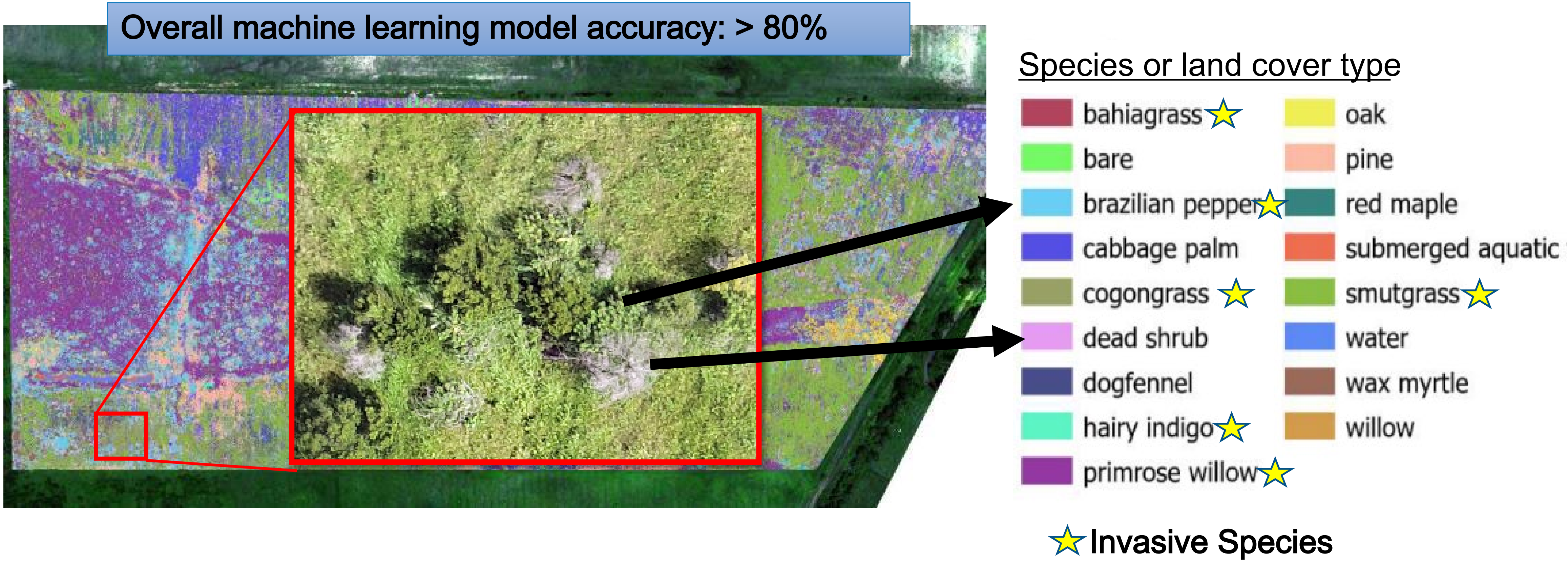
Overall machine learning model accuracy: > 80%



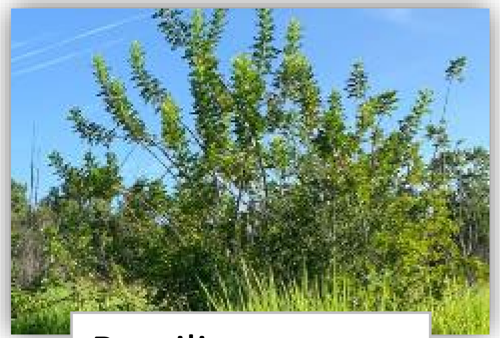
Species or land cover type

☆ Invasive Species

The machine learning model can identify and quantify living and dead Brazilian pepper.



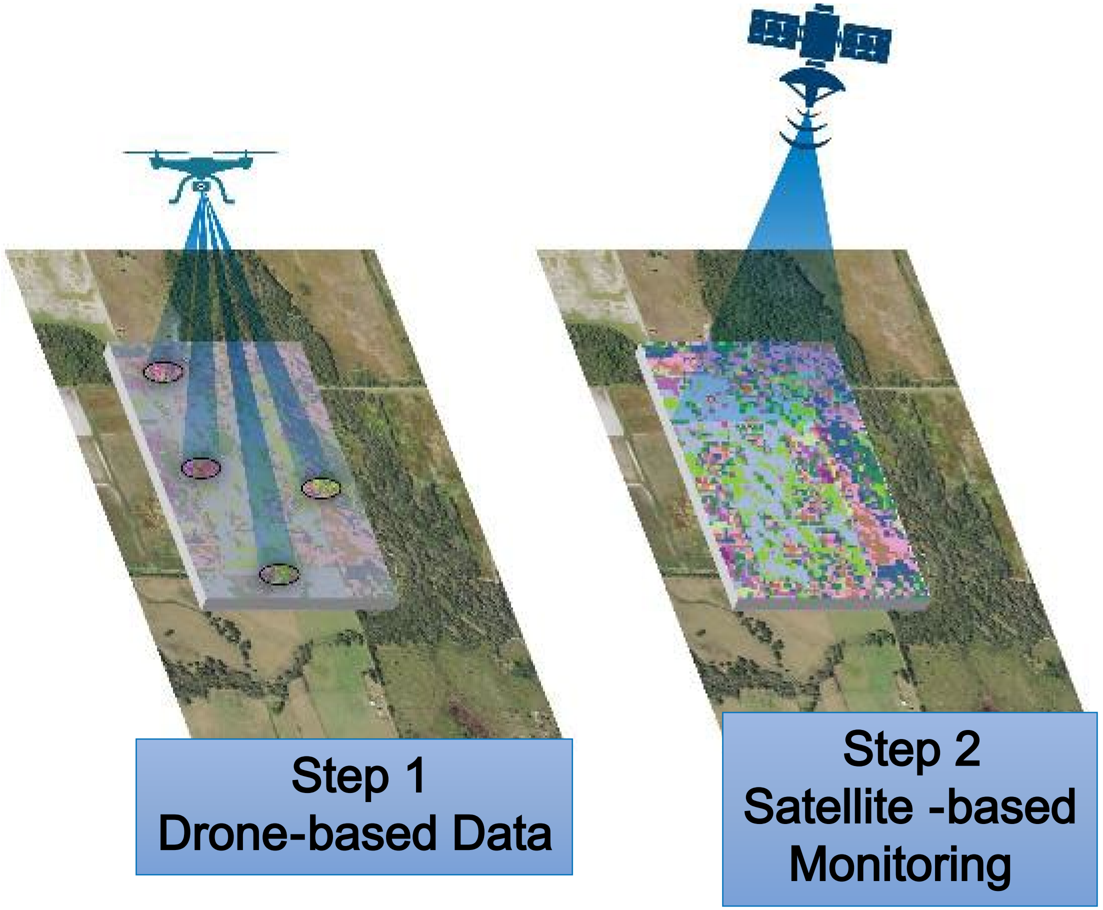
The machine learning model can identify and quantify dead Brazilian pepper.



Brazilian pepper

Dead Brazilian pepper

Looking forward: machine learning models using high resolution satellite data increases spatial and temporal tracking of invasives and biodiversity.

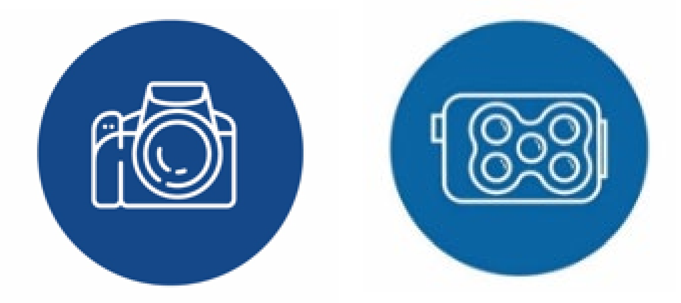


Case Study: Remedial Excavation and Capping – Jacksonville, FL

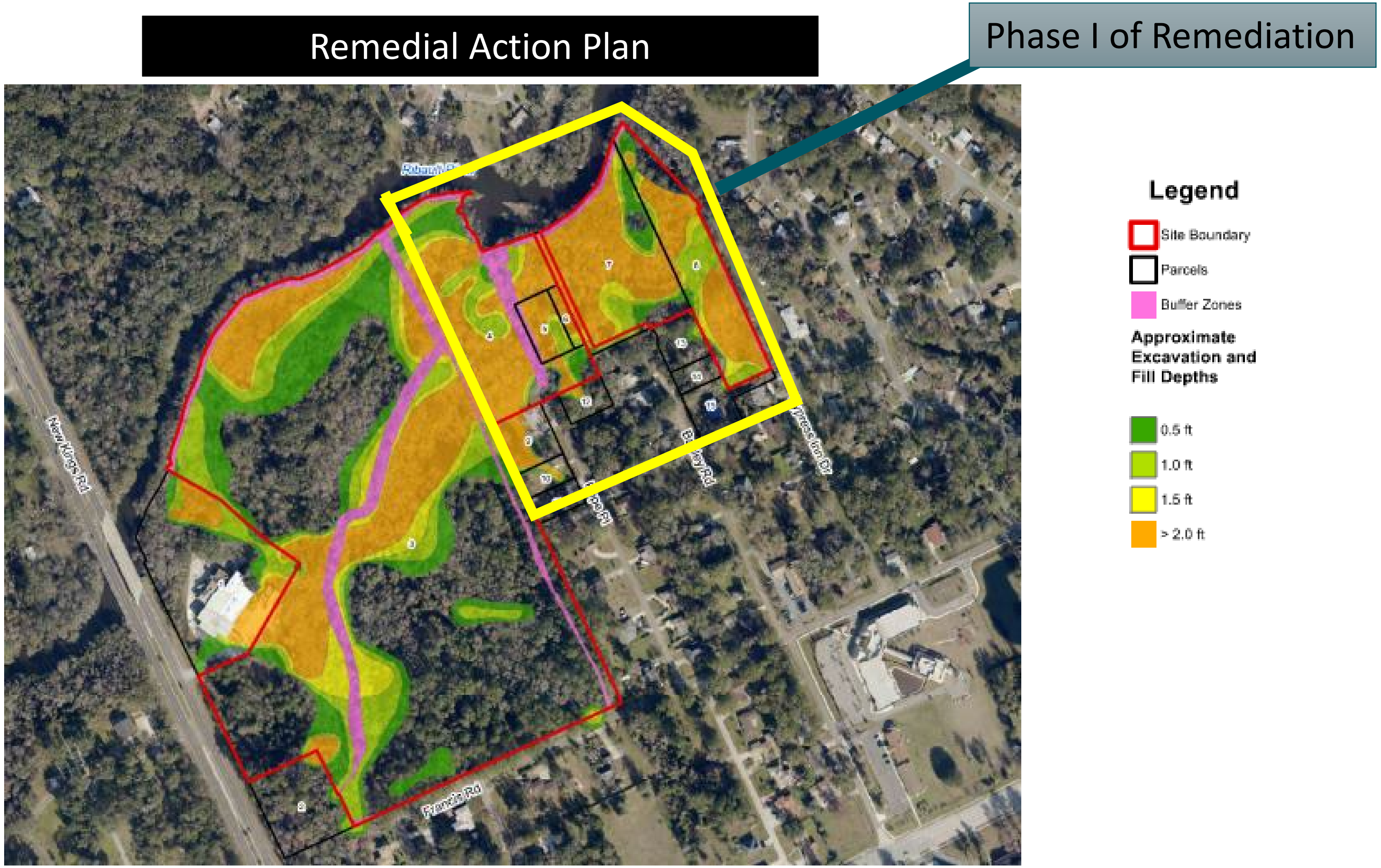
CDM Smith used automation and machine learning to monitor excavation and verify cap placement at a remediation site.

- Objectives
  - Track contractor performance
  - Earth volume measurement
  - Compliance
- Location
  - Ribault River, Jacksonville, FL

- Size
  - 50 acres
- Sensors

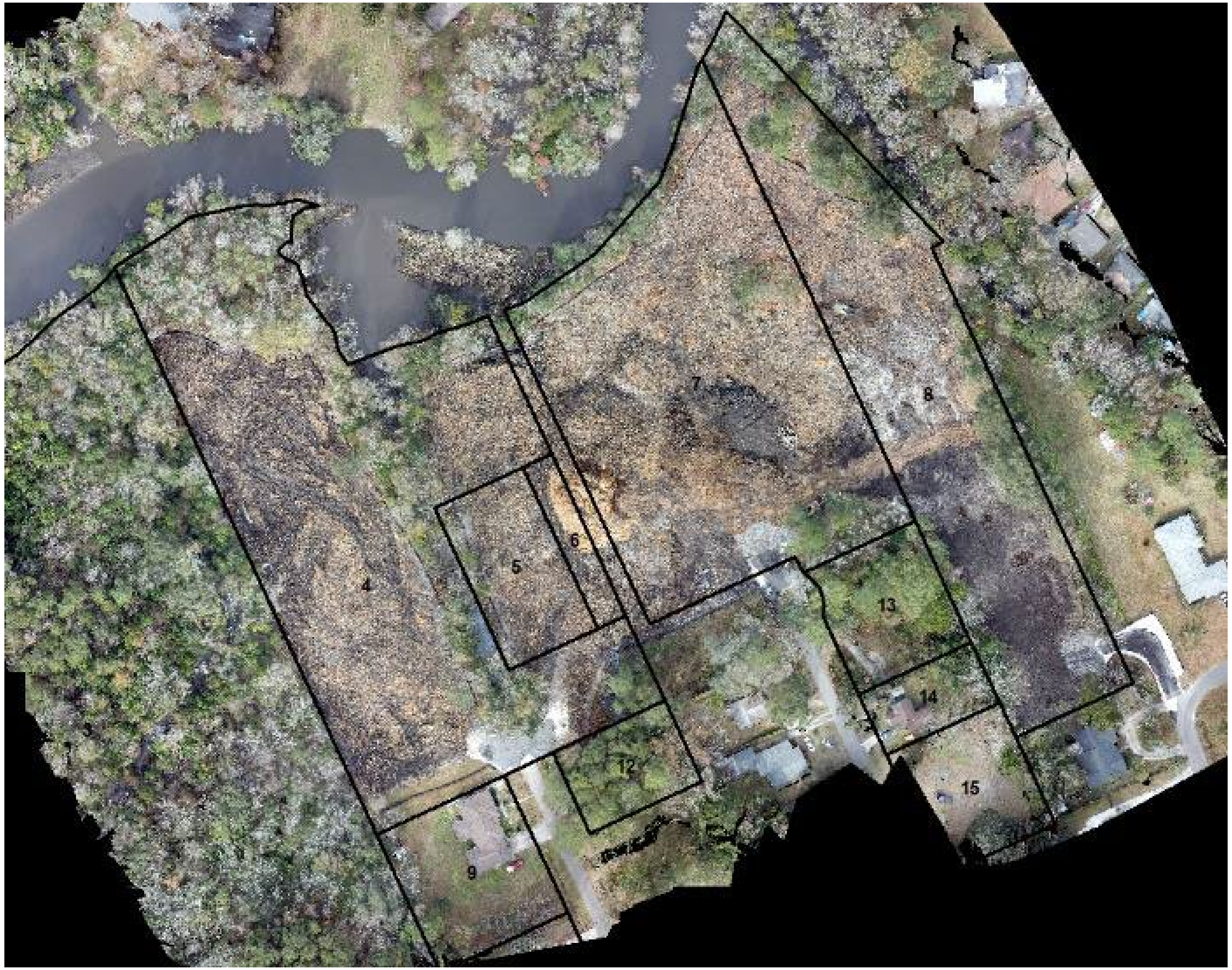


Phase I of the remediation included excavation of 2 feet and capping with clean fill.

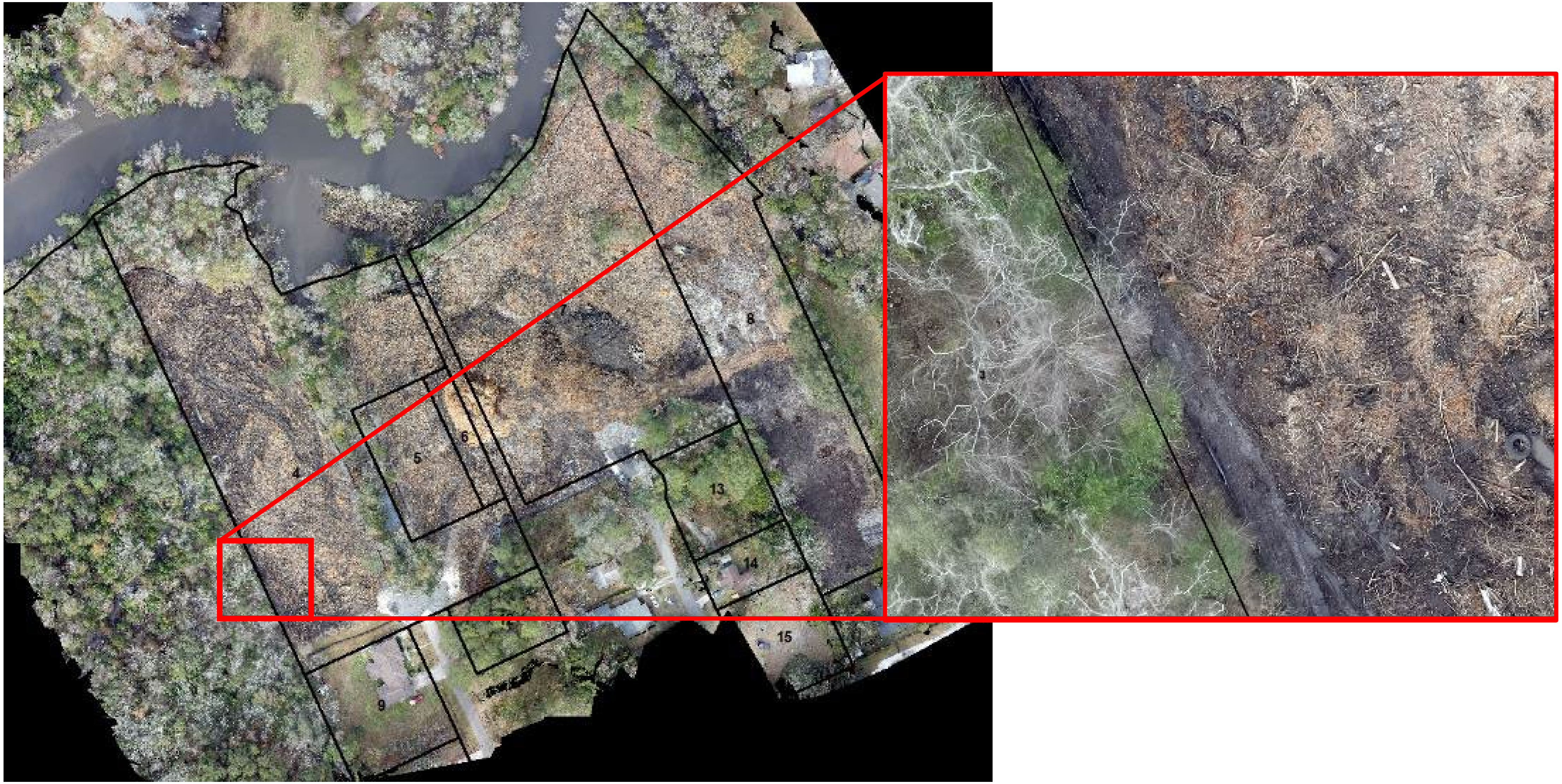


High resolution cameras are used to collect digital imagery of the site monthly.

High resolution aerial imagery documents site conditions.



Imagery can be used to assess contractor performance.

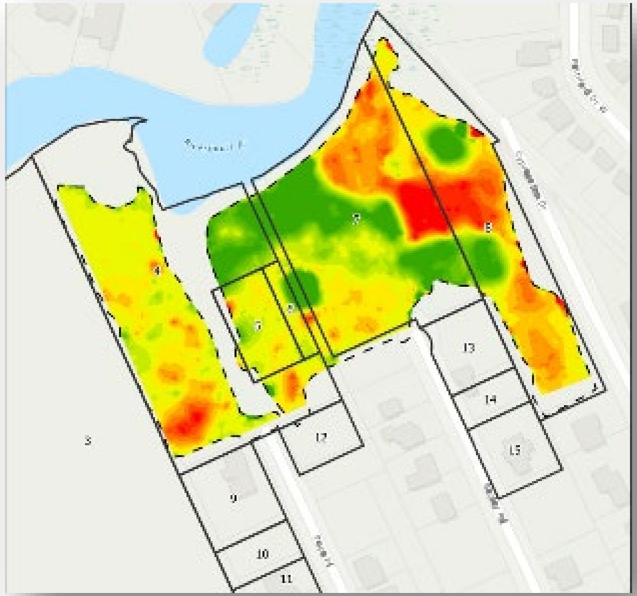


A 3D model is created for the site from each monthly drone flight.

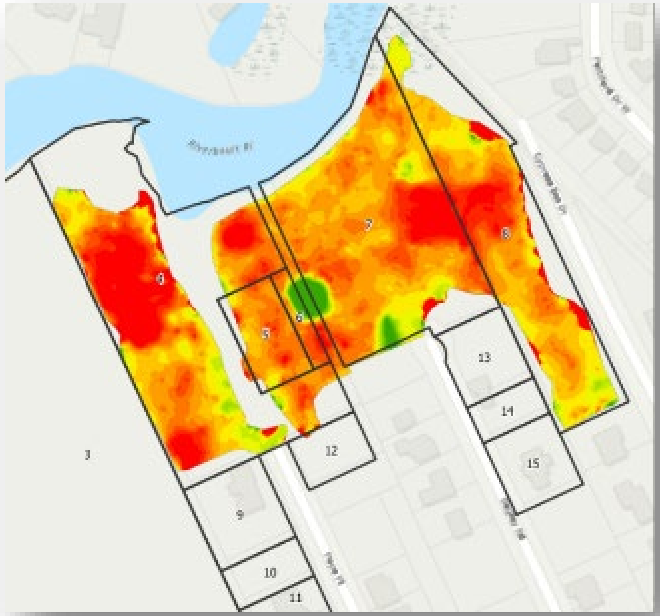
Drone-derived 3D Model

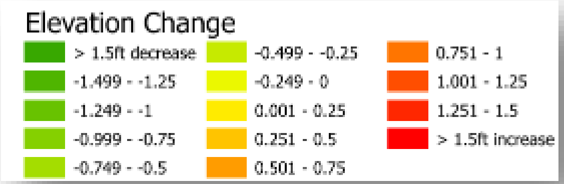
CDM Smith uses automation to track topographic changes over time.

February

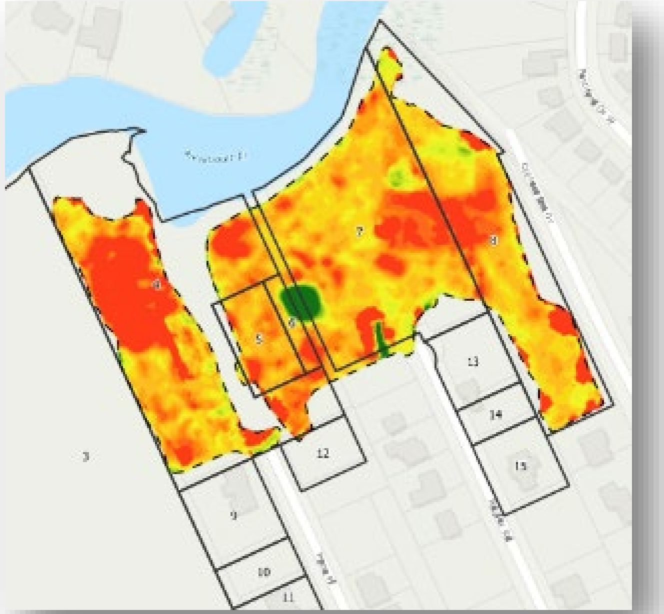


March





April



After capping wetland trees were planted in a portion of the site to comply with state and federal permit requirements.

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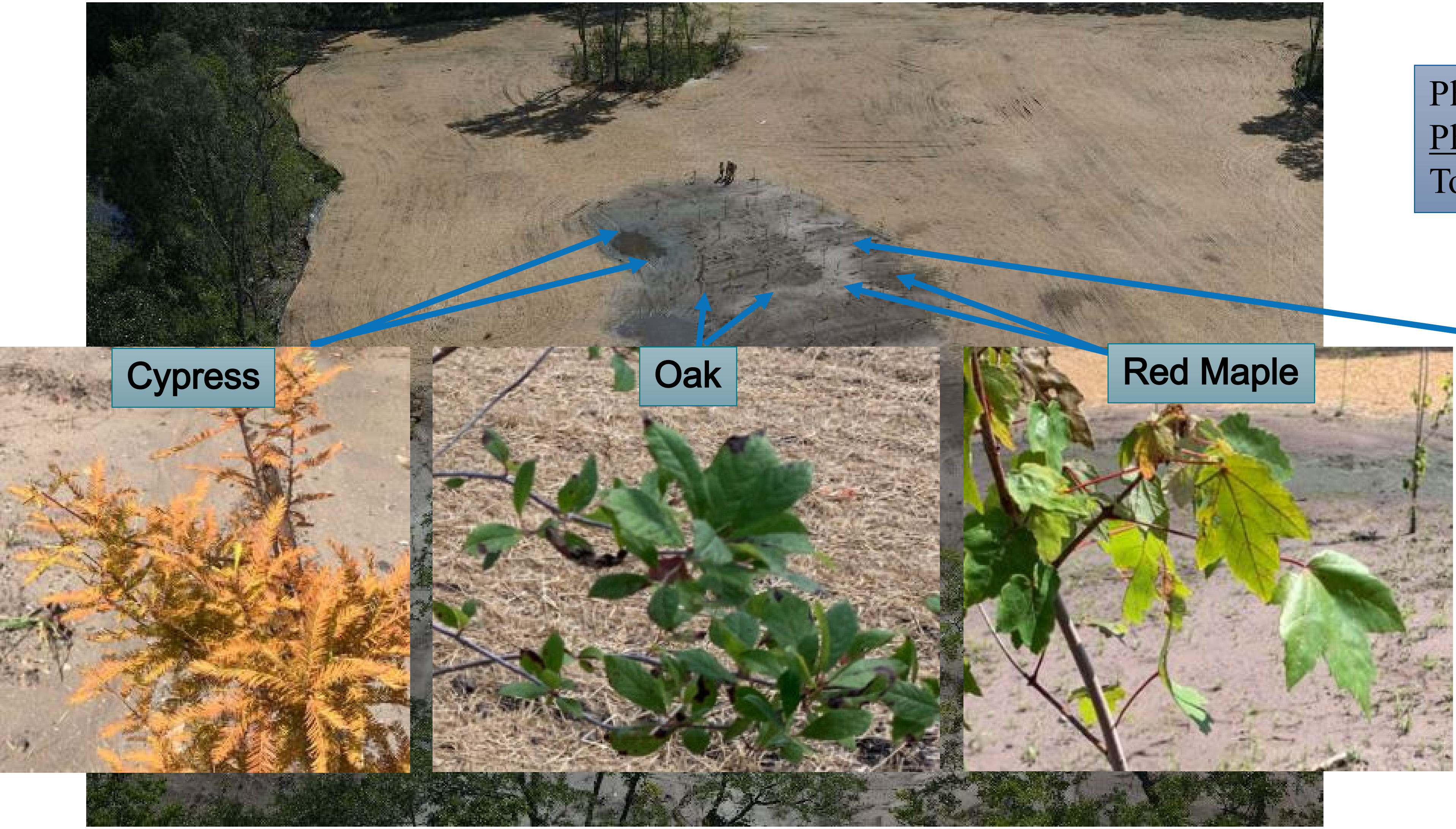
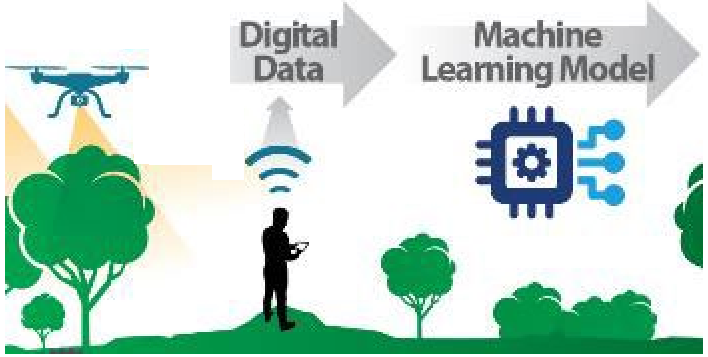
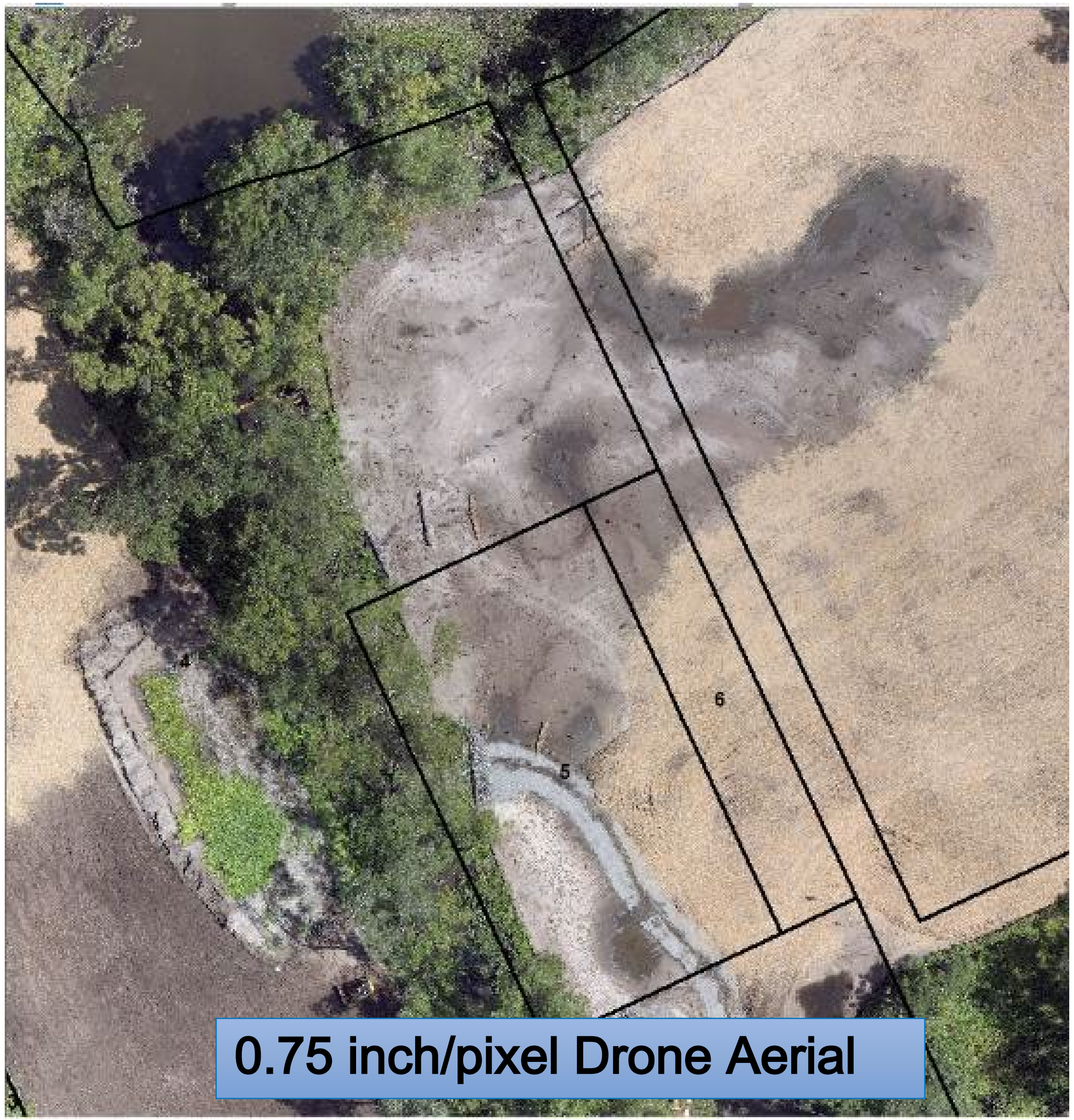


Phase I	=	470 trees
Phase II	=	1,370 trees
Total	=	1,840 trees

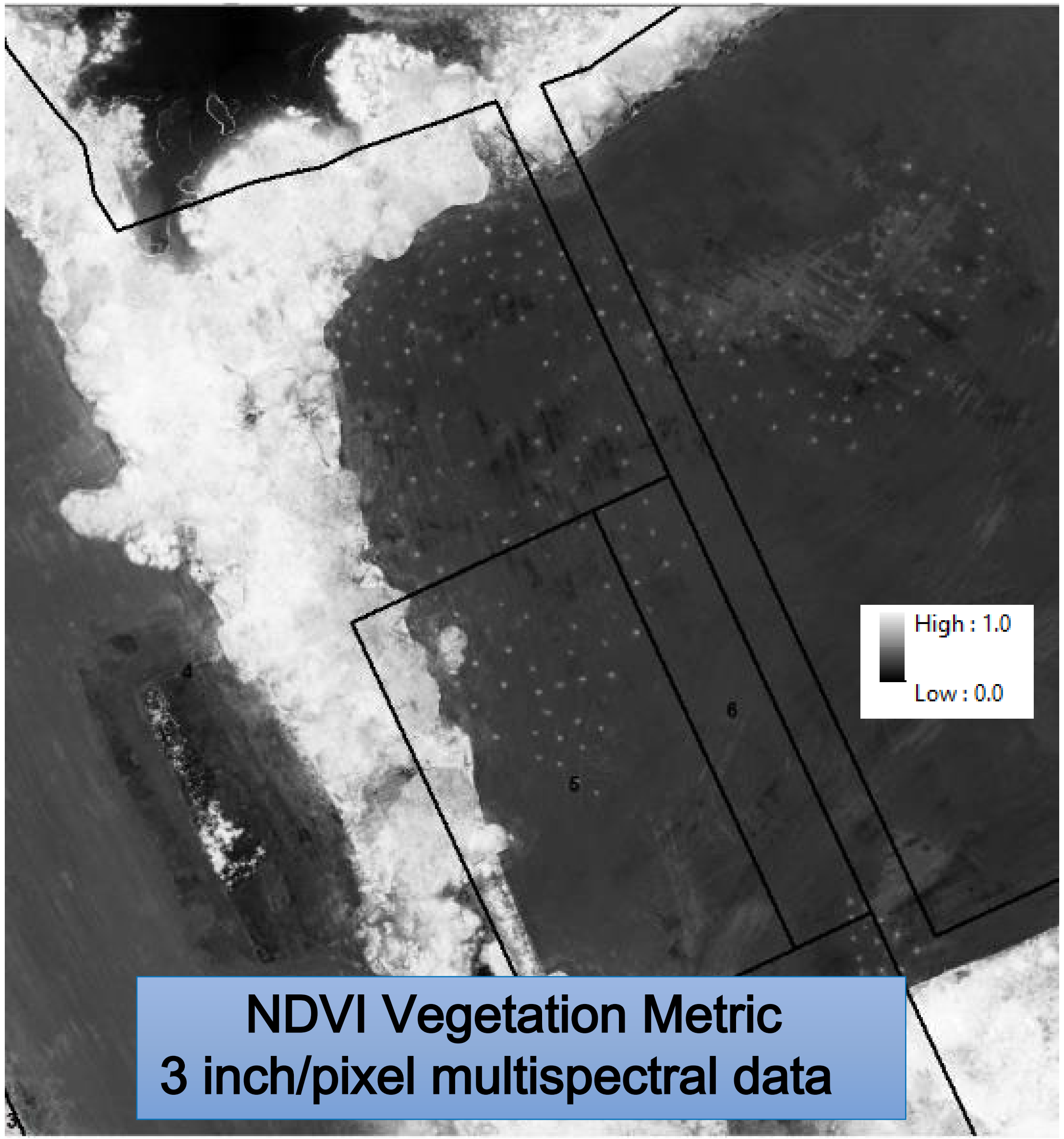
Ground truthing data was collected for use in a machine learning model.



Regular digital camera and multispectral sensor were used to monitor the wetland restoration area.



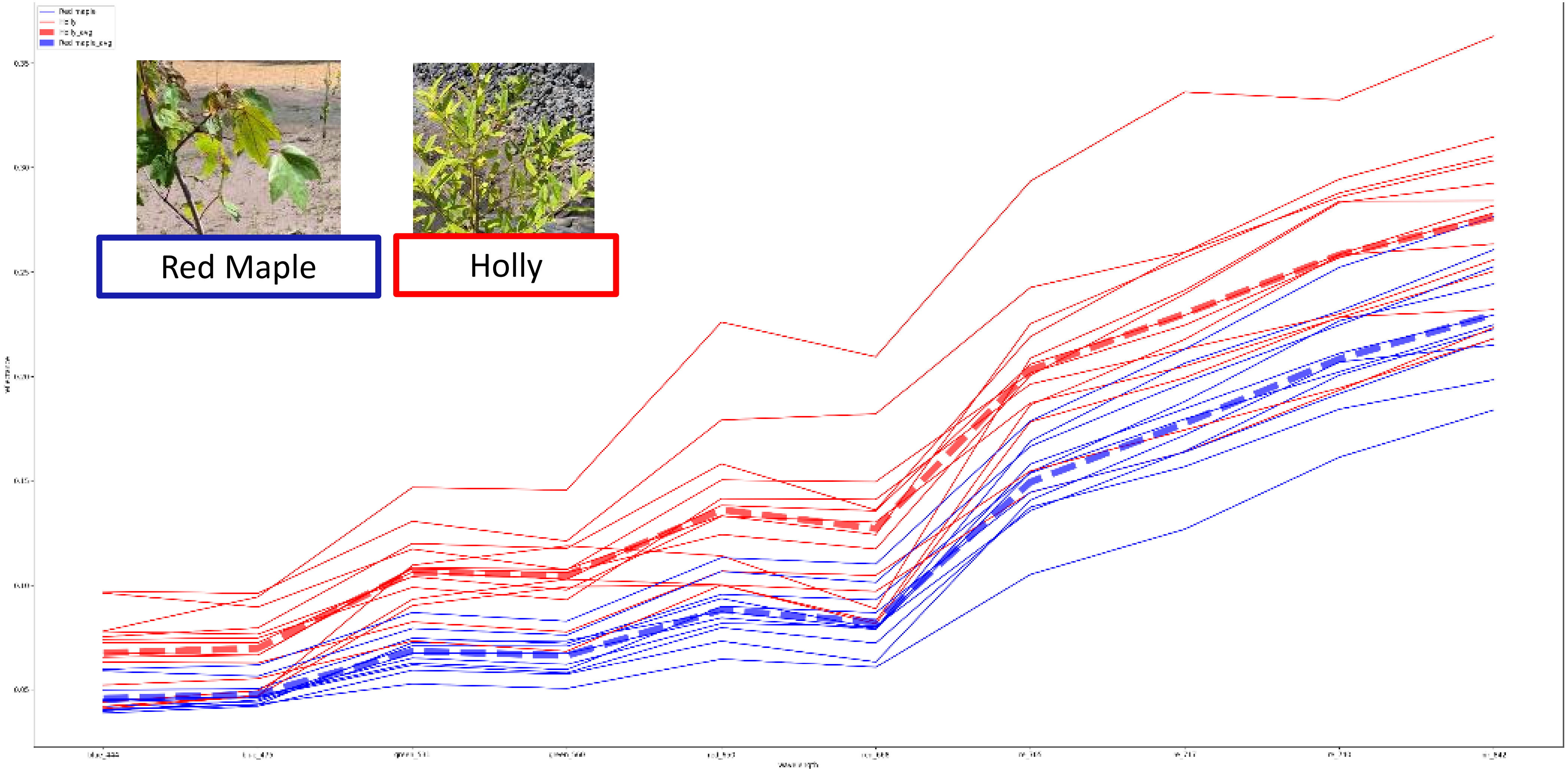
Multispectral sensor collects near-infrared and provides data on vegetation.



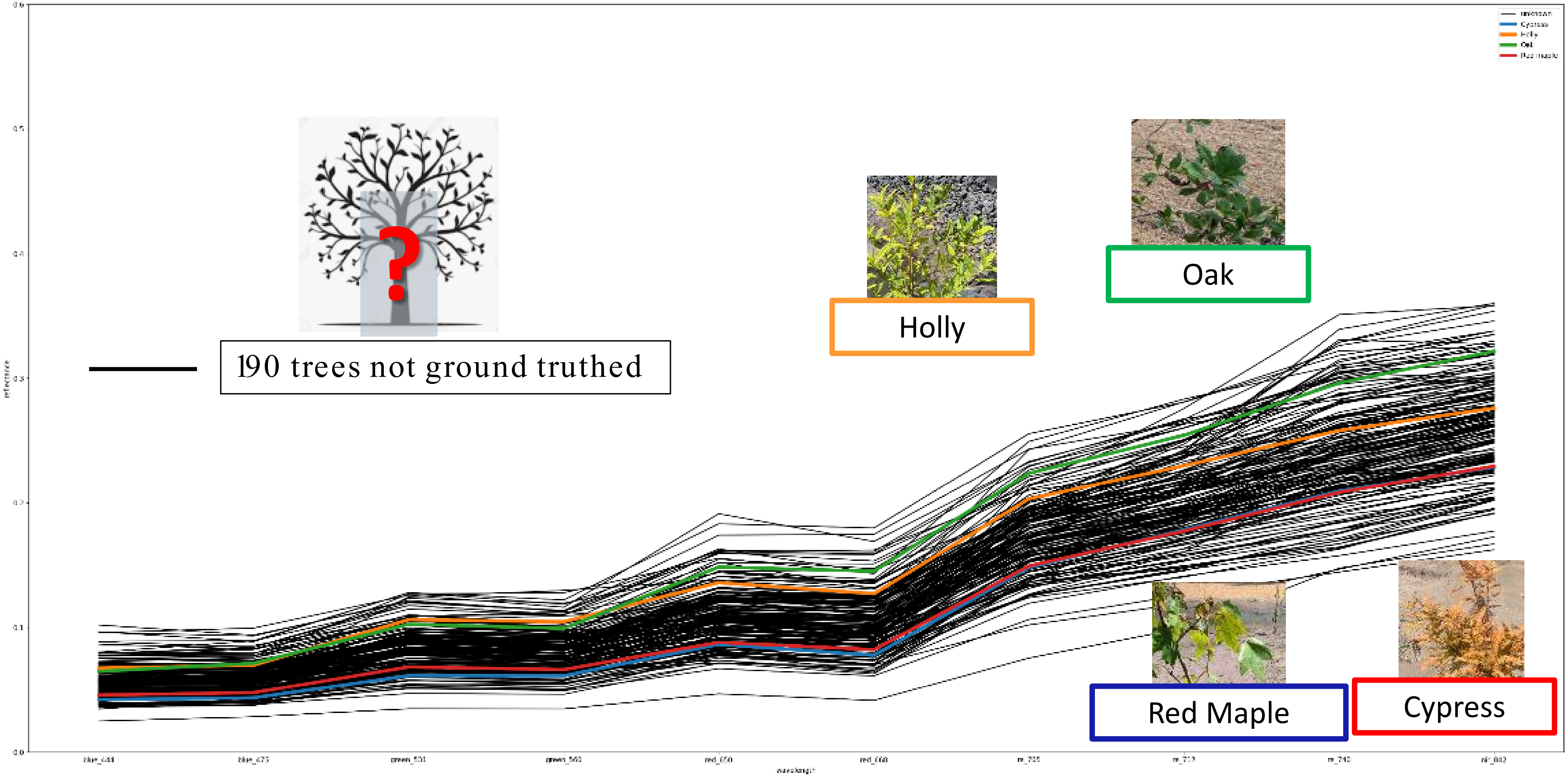
NDVI Vegetation Metric
3 inch/pixel multispectral data

10-band Multispectral Drone Data

The spectral signatures are often different between species.

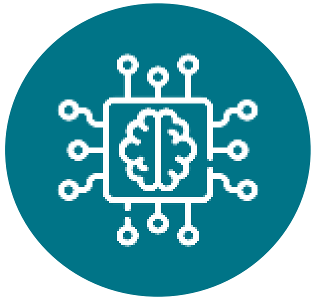


Machine learning is necessary to analyze the multifaceted high-volume dataset.

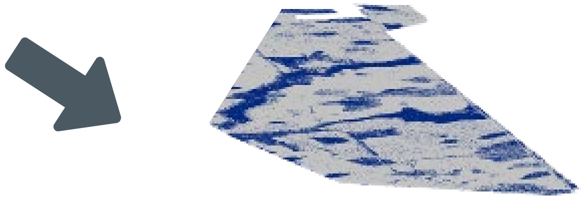


CDM Smith used a machine learning model to identify tree species in the restoration area.

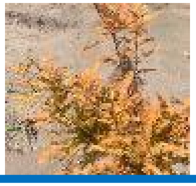
MACHINE LEARNING MODEL



MODEL PREDICTIONS

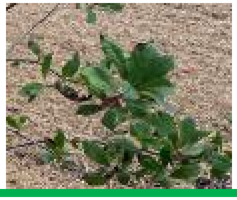


Holly



Cypress

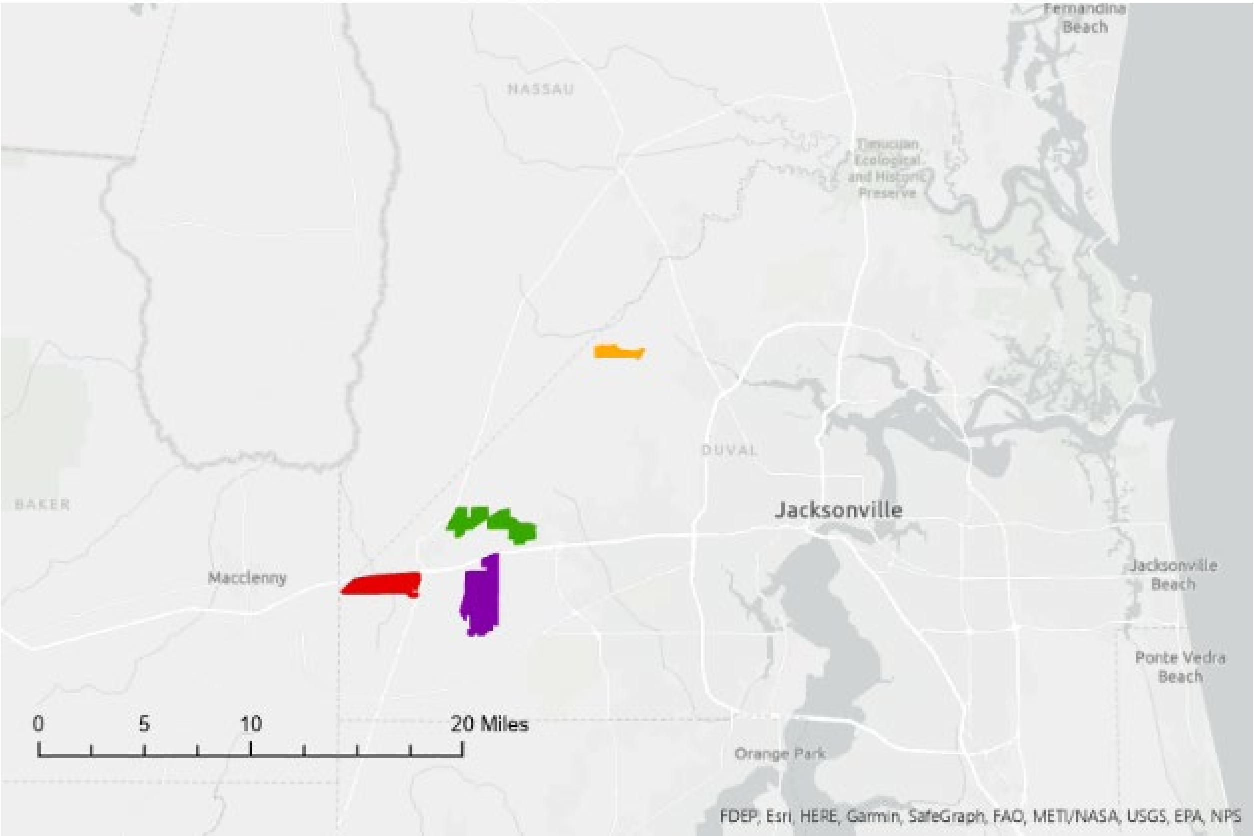
Red Maple

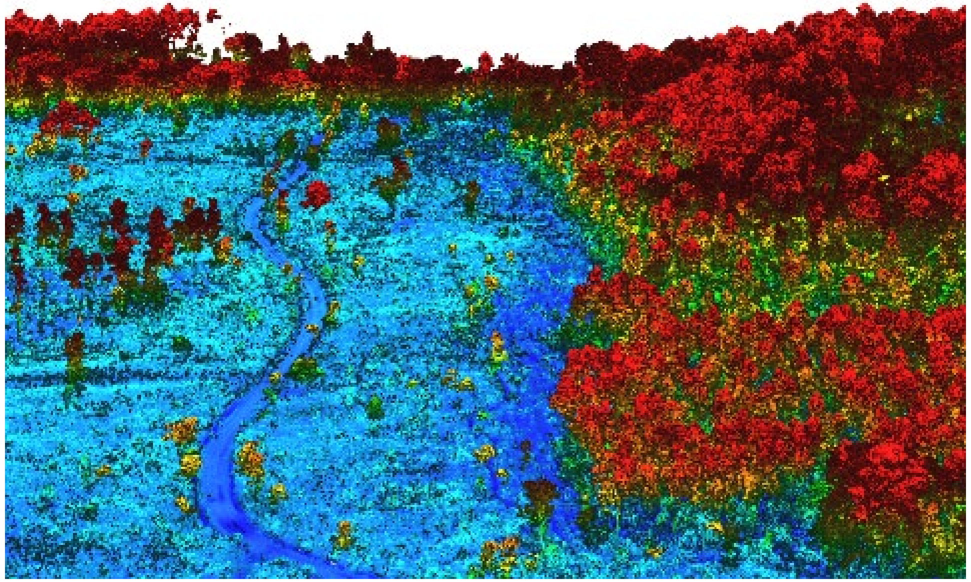


Oak

Site Feasibility: Wetland delineation

- How do we locate wetlands to quantify how much land is available for development?





Traditional approach for delineating wetlands.



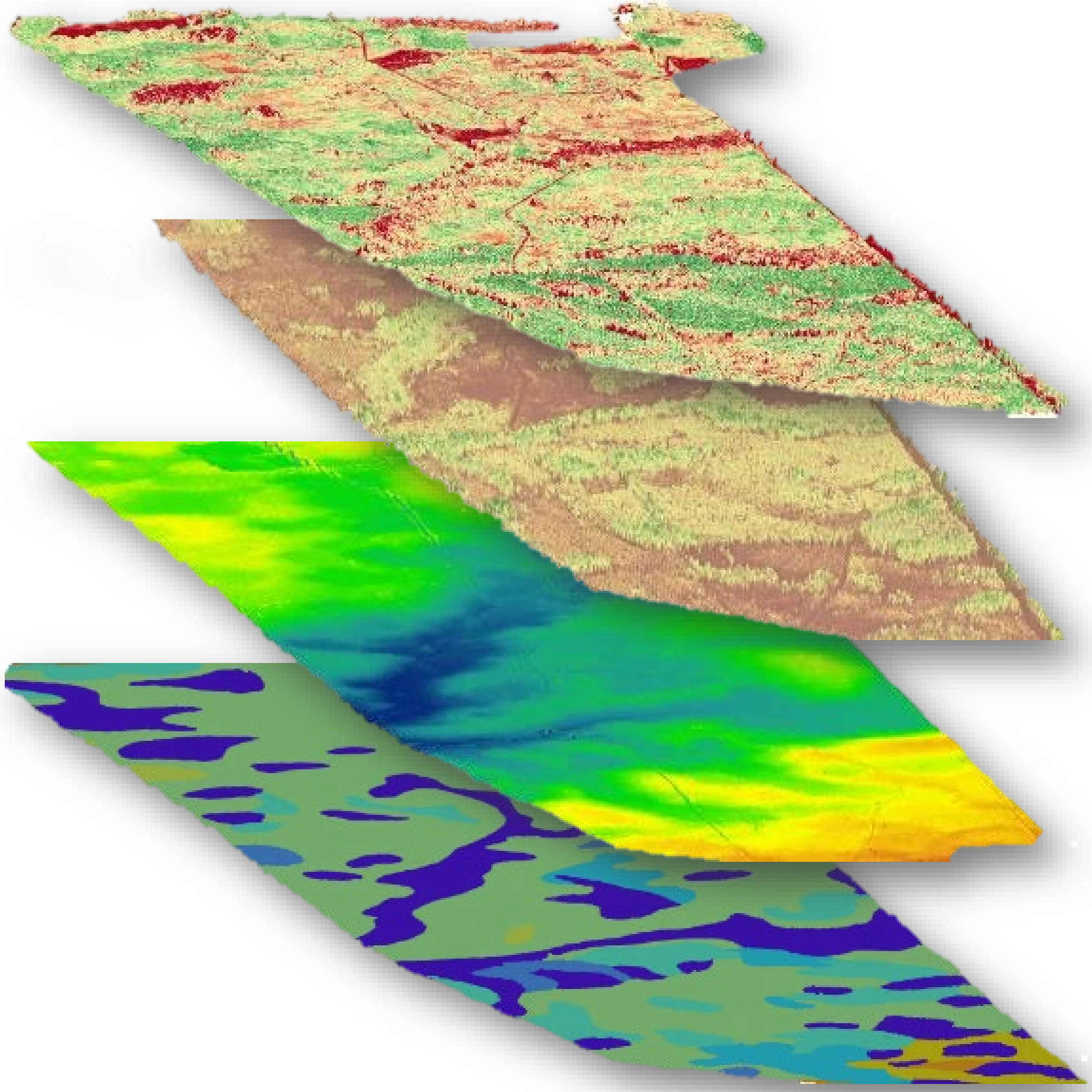



What defines a wetland and how can we predict their location?

NDVI from NAIP

LiDAR Products

SSURGO Soils Data



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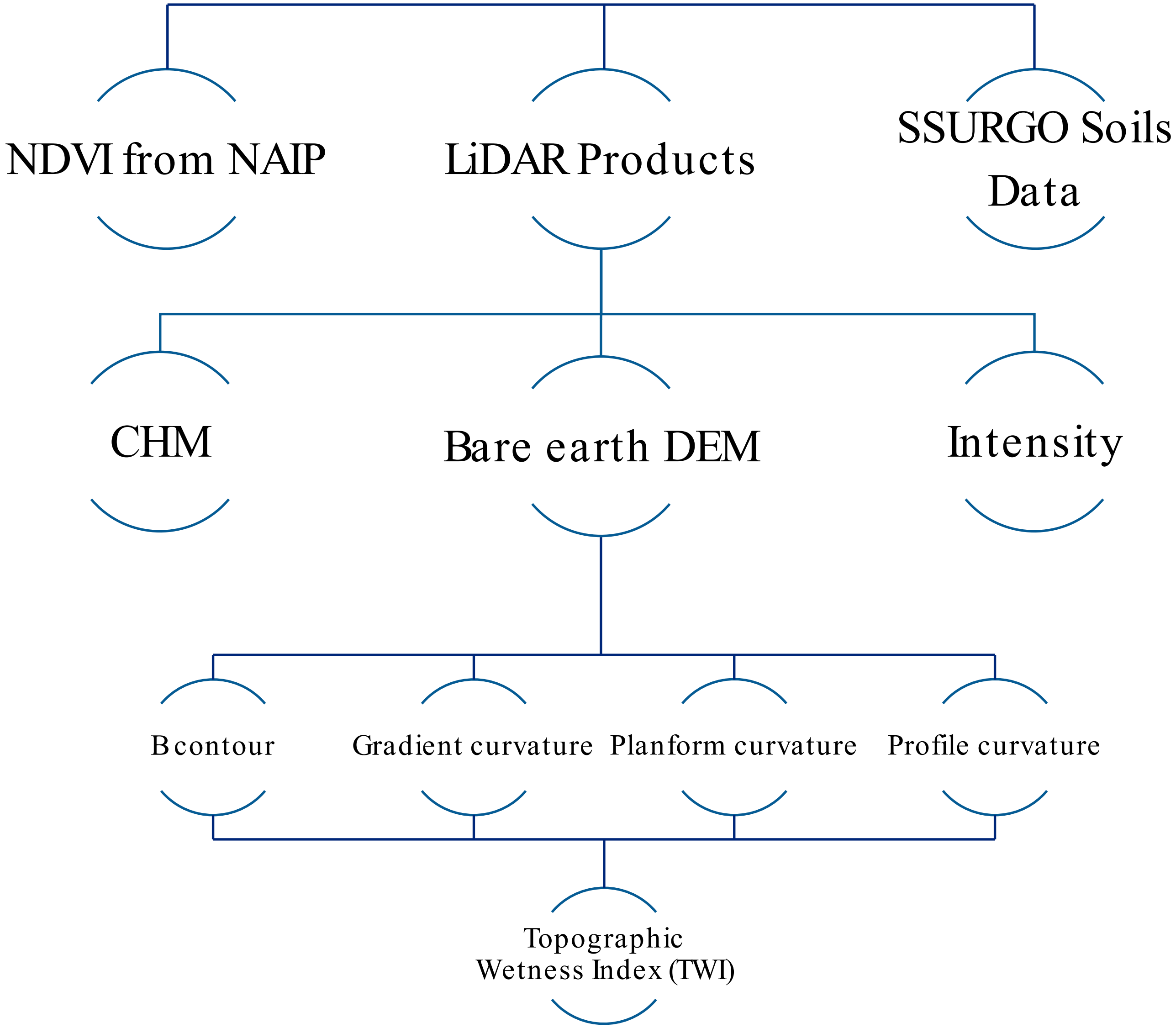
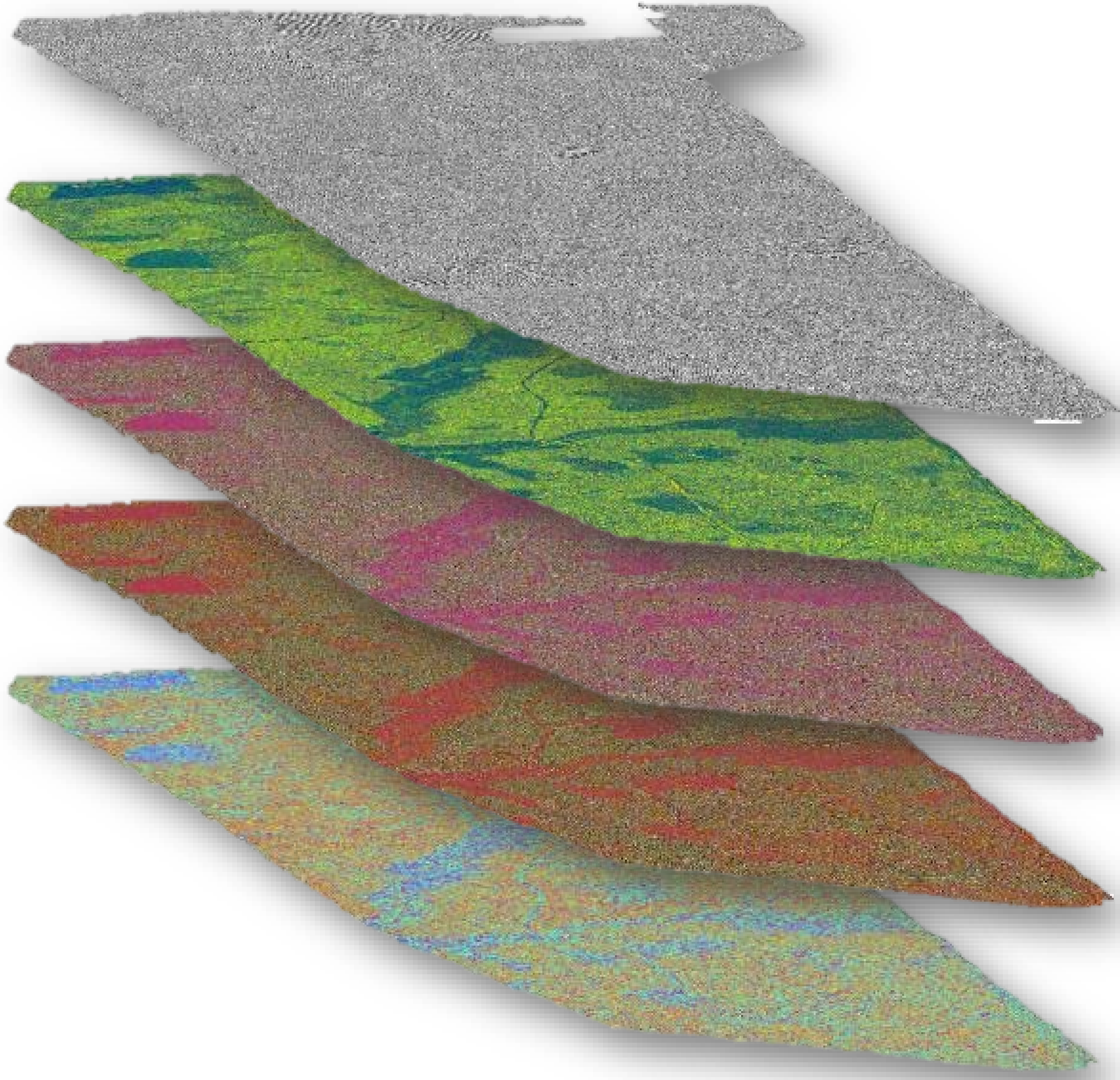
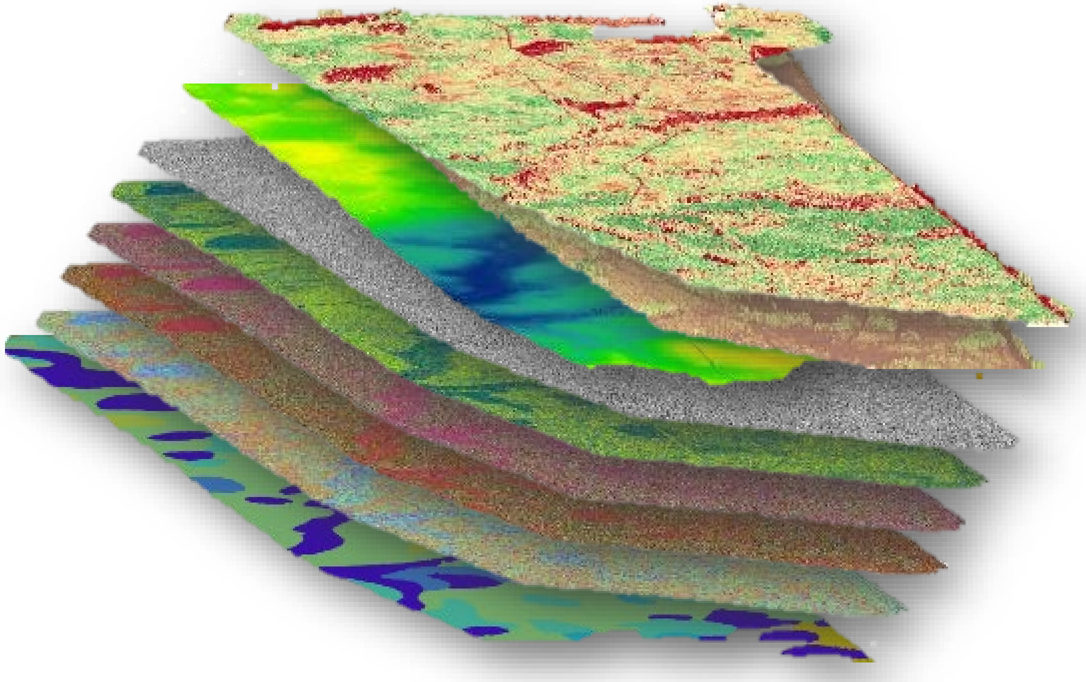


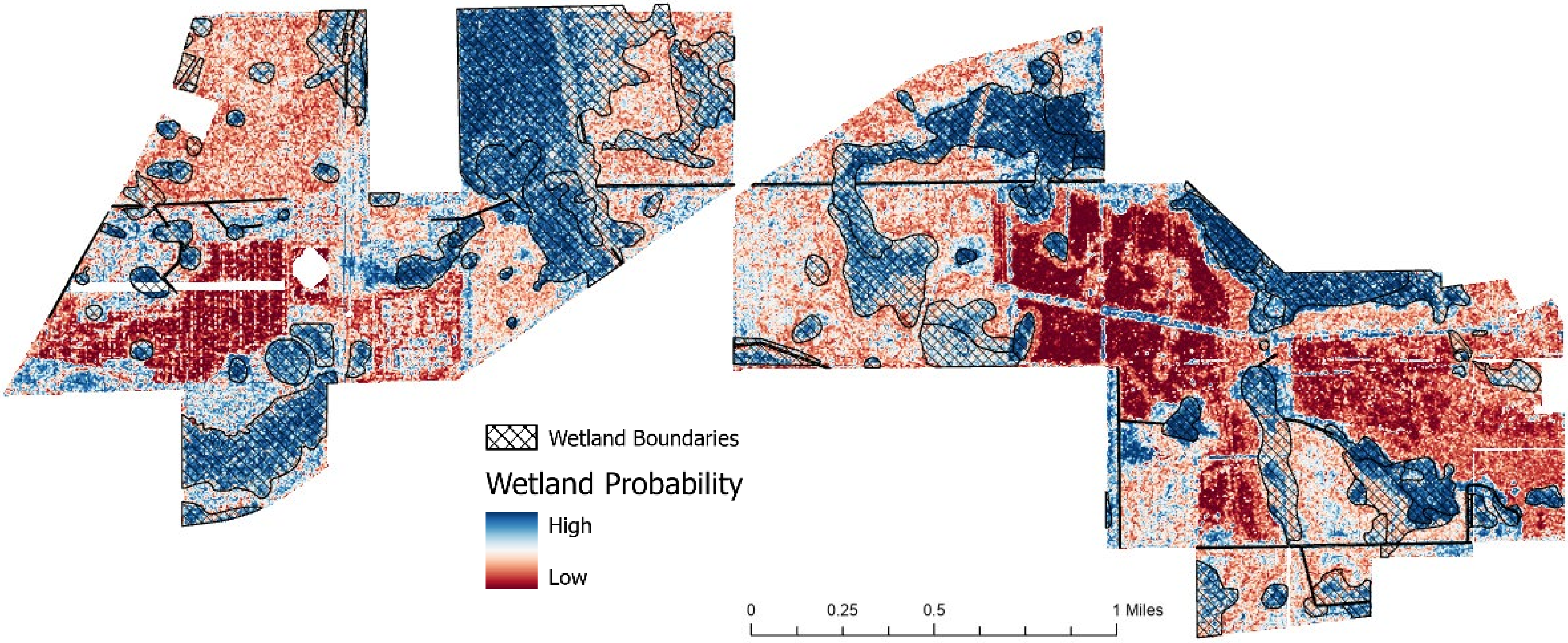


Machine learning models require data to be in certain formats.

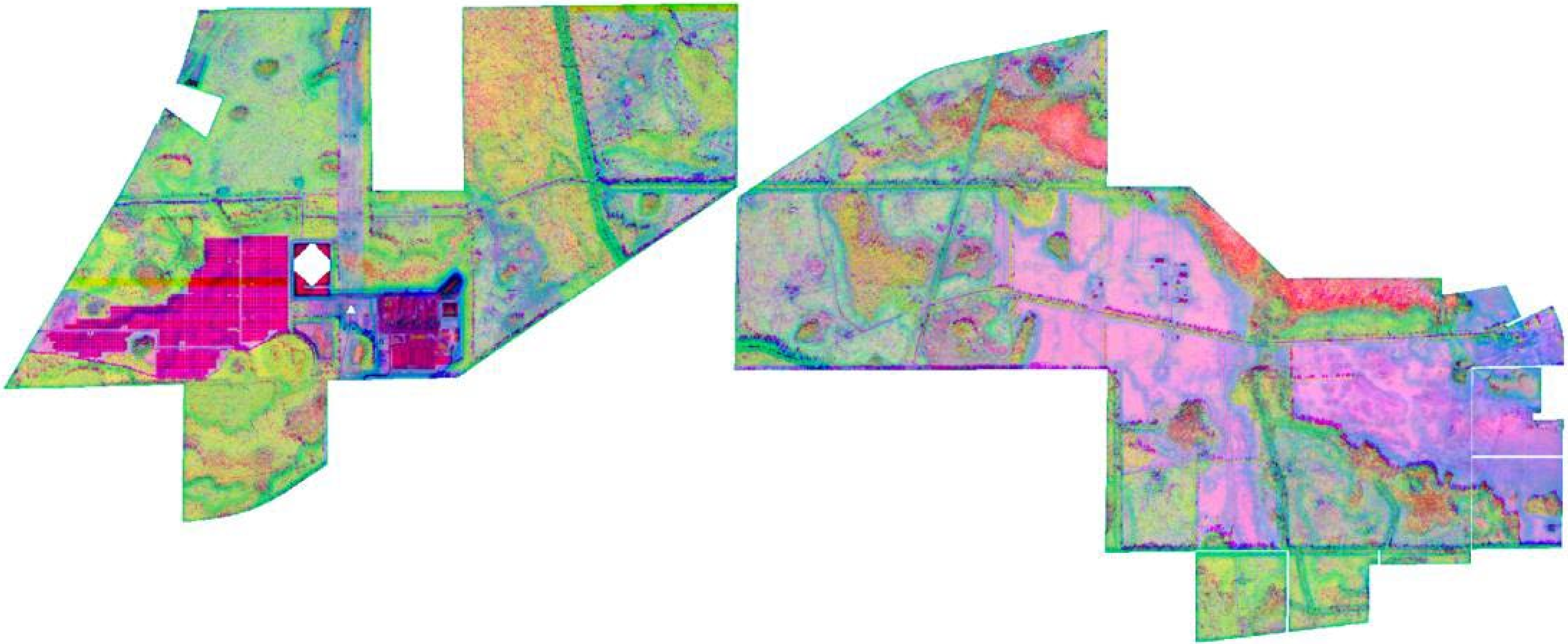


	grnd	bcon	chm	grad	plan	prof	twi	ndvi	soil
0	0.848292	1.168940	4.480000	0.155842	0.280000	0.039993	3.049424	0.349663	96.0
1	1.097692	0.433987	0.490000	0.087569	0.026195	-0.073811	2.948446	0.189539	5.0
2	-1.546986	1.550257	0.190000	0.162854	0.018937	0.058930	2.267665	0.194915	41.0
3	1.151135	1.346371	11.780000	0.045512	-0.032000	0.088011	3.089783	0.183789	5.0
4	0.525409	0.794799	0.620000	0.108565	-0.077797	0.002205	2.220407	0.148438	5.0
5	-1.654614	0.842667	1.070000	0.214368	-0.220559	0.299447	2.107459	0.170622	96.0
6	-1.059320	0.816192	0.040000	0.123974	0.399878	-0.060131	3.647214	0.160622	41.0
7	0.137206	2.055617	4.010000	0.013117	0.013995	-0.025983	4.333852	0.168724	3.0
8	-1.591522	1.809911	1.050000	0.145349	-0.031793	-0.071787	2.383315	0.324561	41.0
9	0.469739	0.000077	0.590000	0.050373	0.105280	-0.134711	6.356588	0.130081	5.0
10	0.472708	0.663679	23.139999	0.096262	-0.137603	0.142397	2.340686	0.279412	5.0
11	-1.060805	0.923987	1.160000	0.162201	0.119405	-0.060596	4.151978	0.188679	41.0
12	-1.365874	0.706800	14.959999	0.086919	-0.058871	-0.038875	3.184917	0.097893	100.0
13	-1.616017	1.505951	0.010000	0.017339	-0.181535	0.118461	4.054793	0.151515	41.0
14	0.814891	1.617866	17.760000	0.074437	-0.020164	-0.060157	2.597808	0.235669	5.0
15	-1.735521	1.540530	3.070000	0.136662	-0.044501	-0.404495	2.627947	0.178325	41.0
16	0.614480	0.916568	65.909996	0.115491	0.066427	-0.133555	3.257171	0.432836	5.0
17	-0.211657	3.033164	0.570000	0.051313	-0.314218	0.185753	2.969817	0.126984	3.0
18	0.965570	1.091349	19.504999	0.357448	-0.077501	0.082503	1.721911	0.358025	5.0
19	-1.080104	1.074648	12.910000	0.056568	-0.010010	0.029999	3.565446	0.254902	3.0

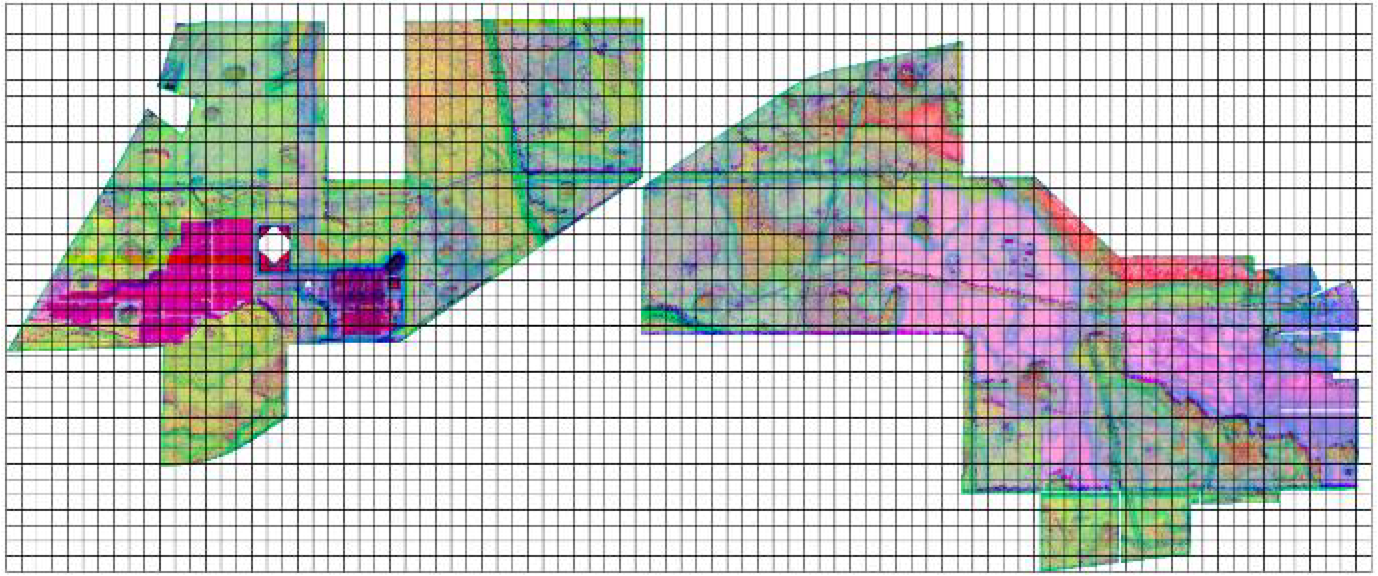
Machine learning models can provide nuanced evaluations of wetlands.

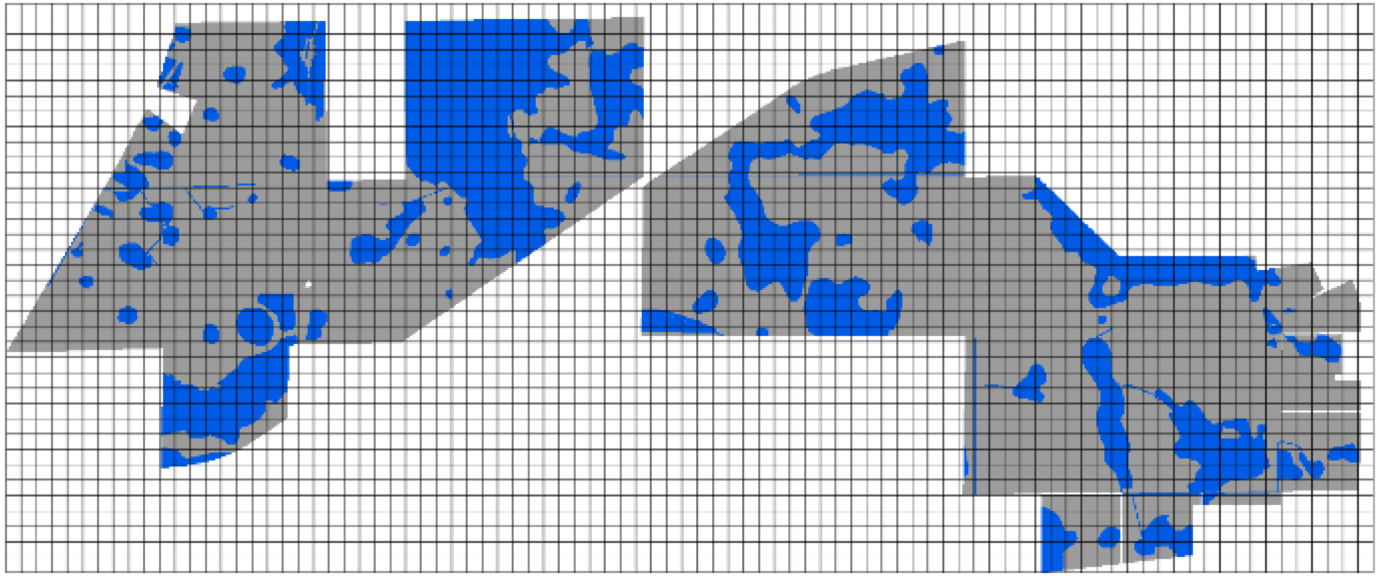


Complex environmental systems can require deep learning models.

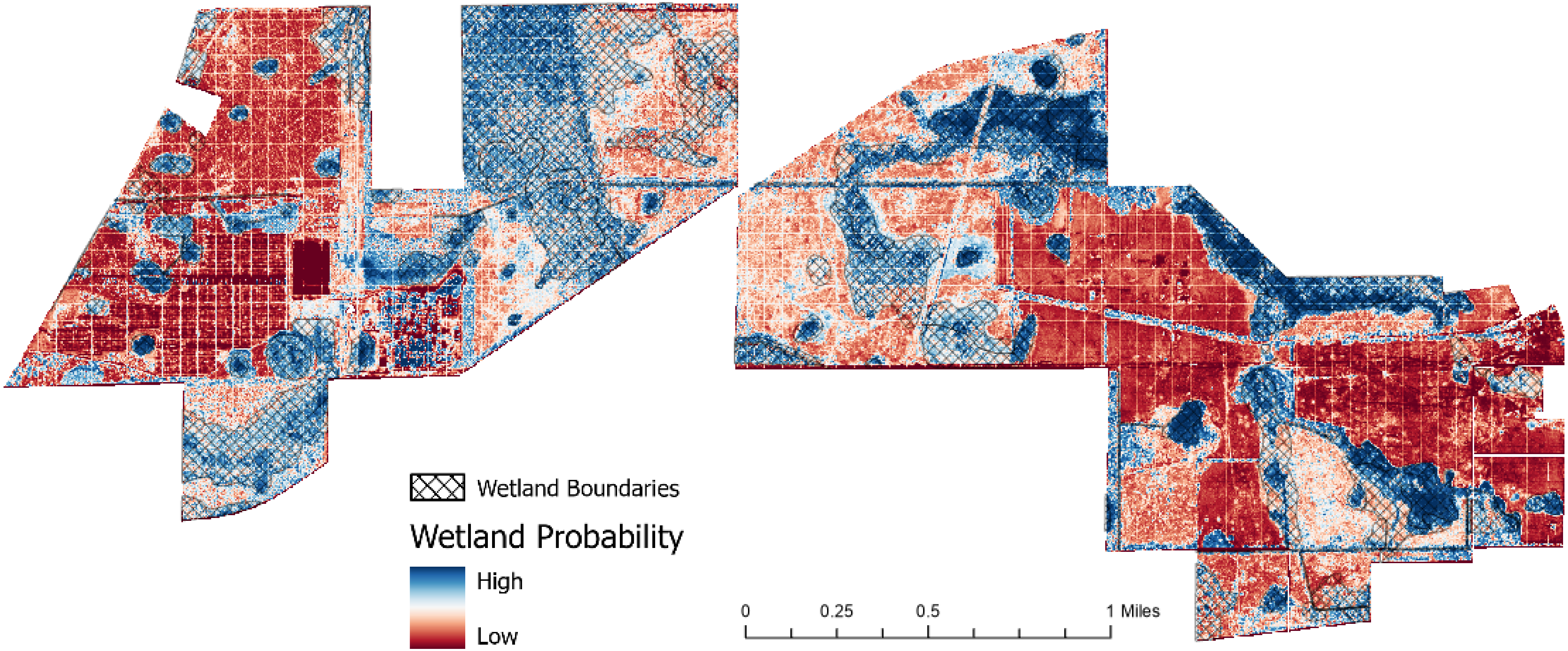


Deep Learning models often require data to be broken down.

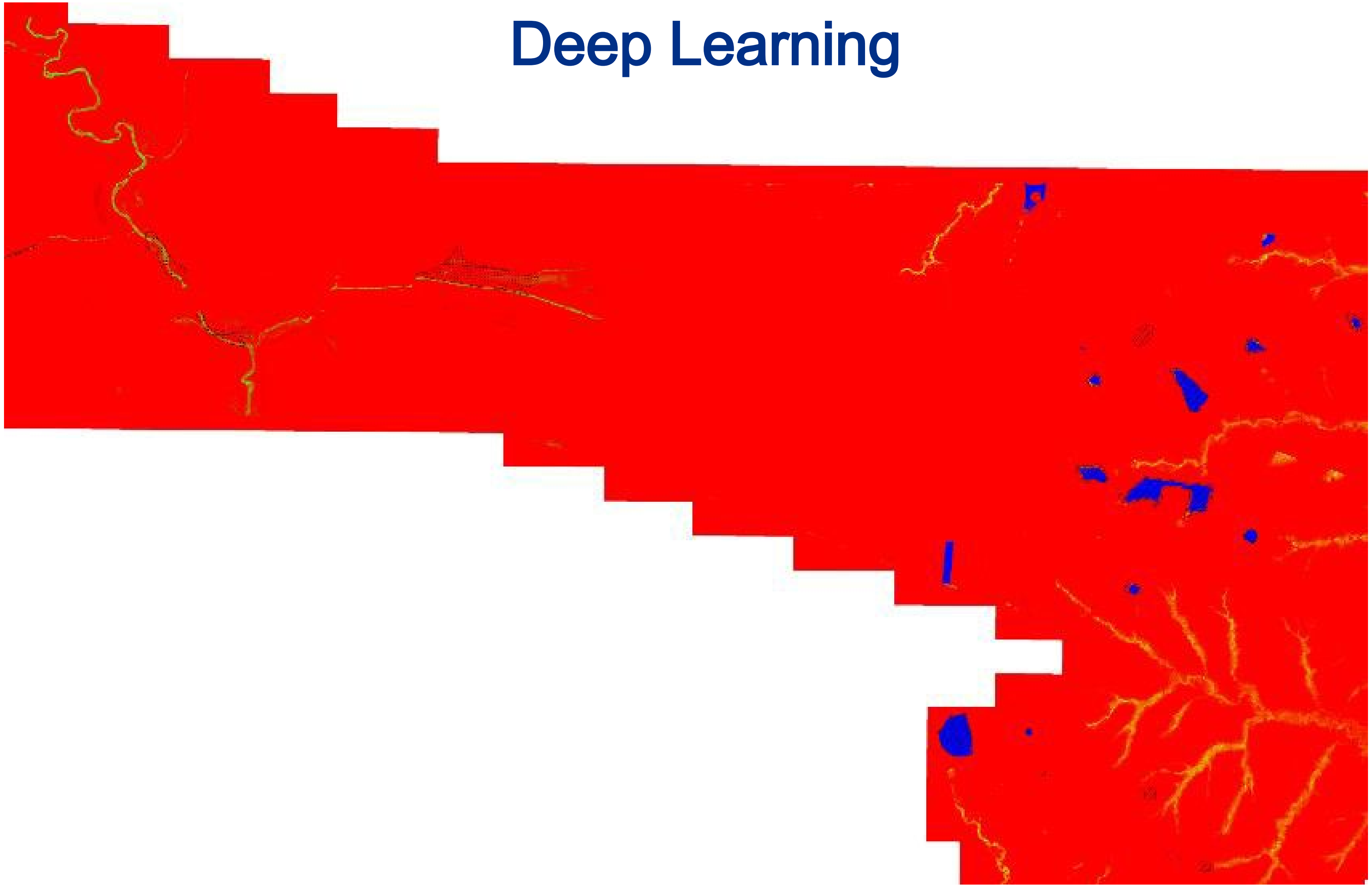




The deep learning model was better at evaluating “blind” sites.

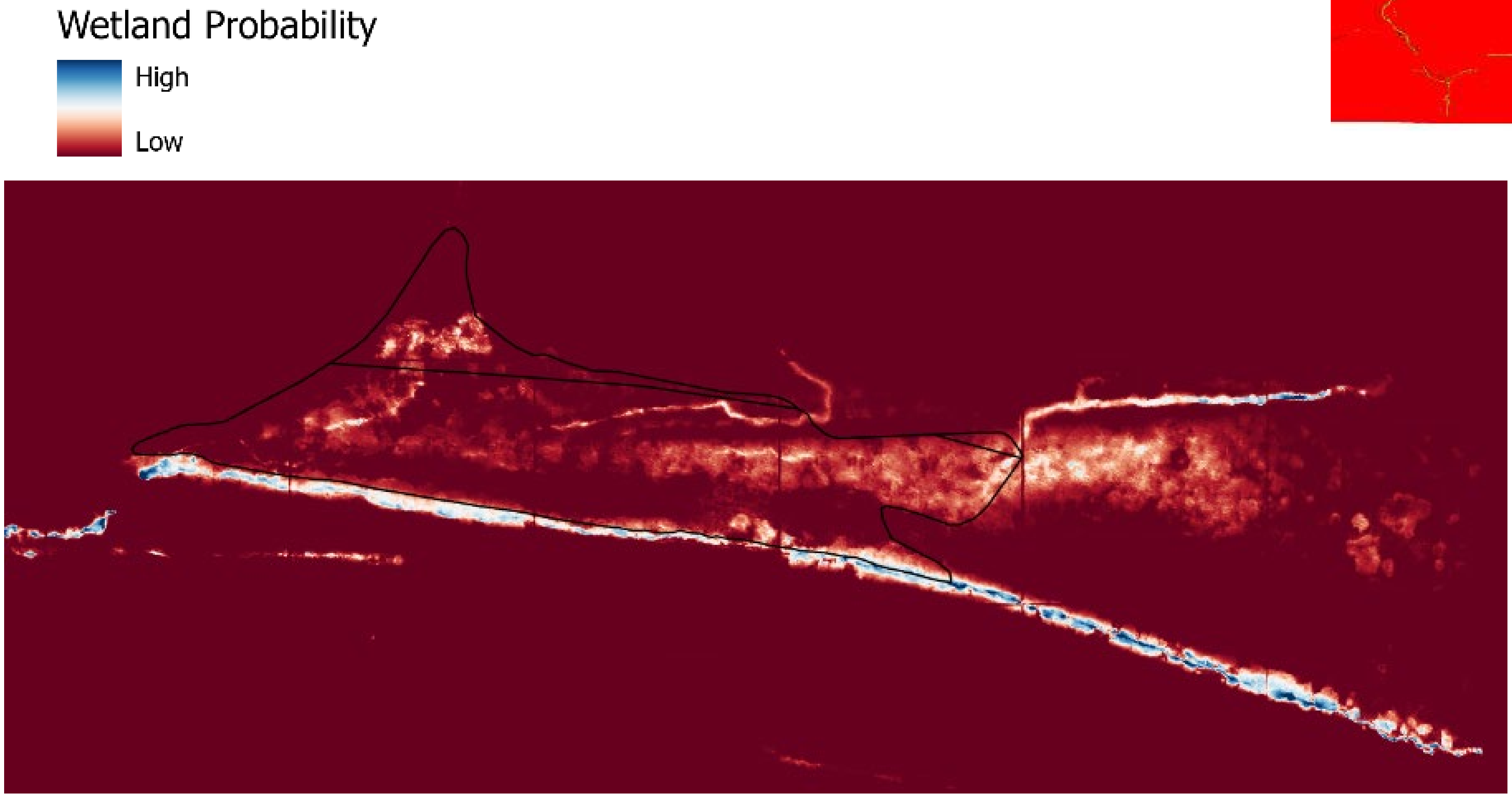


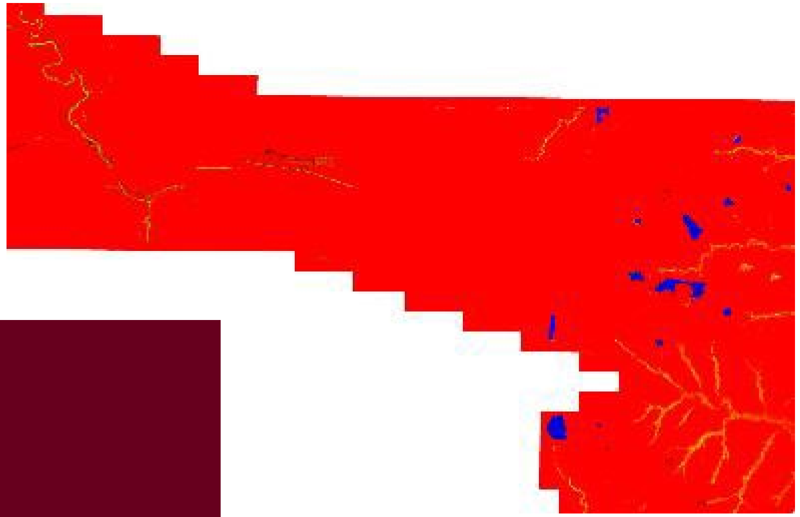
CDM Smith applied our deep learning model to a MoDOT corridor study.



Deep Learning

CDM Smith applied our deep learning model to a MoDOT corridor study.

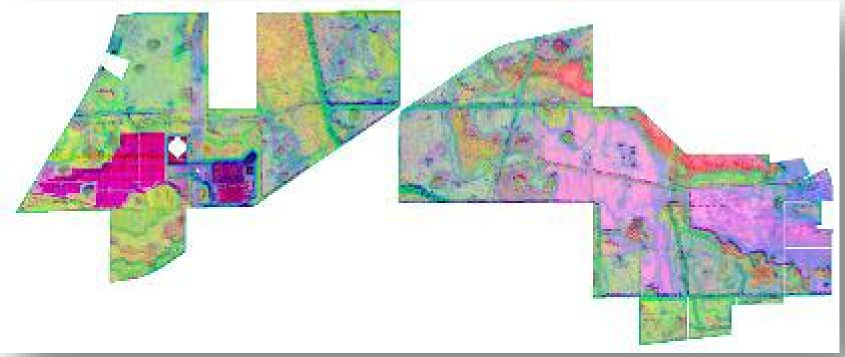




Looking forward: expanding capabilities for wetland delineation

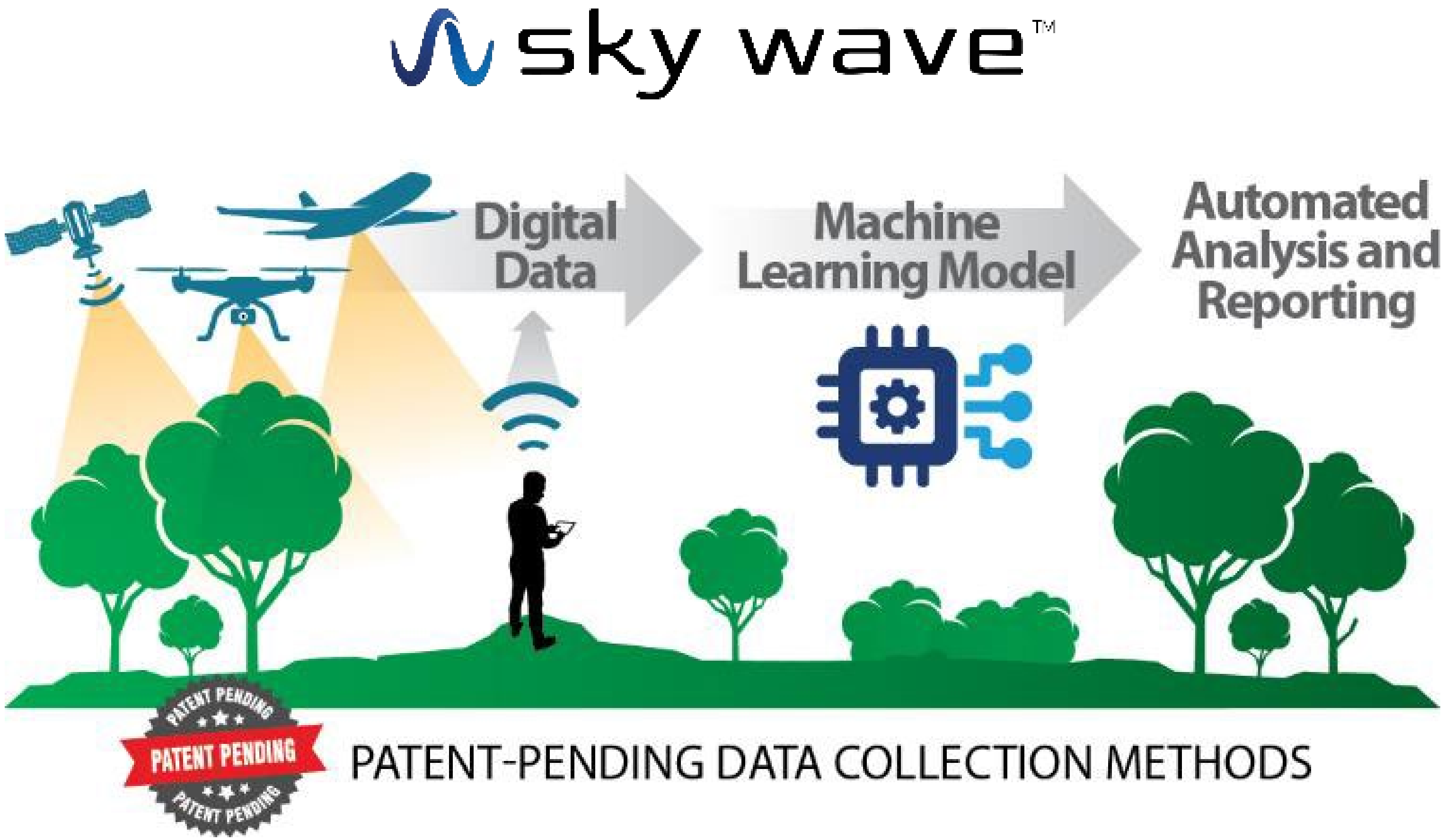
- Drive strategic field collection/verification design
- Support permitting
- Resiliency planning
- Access changes over time

Machine learning and advanced remote sensing can help develop environmental solutions for the future.



Sky Wave provides multiple benefits to environmental projects.

- Lower Cost
- Improved Understanding
- Reduced Risk/Uncertainty



Contact us: skywave@cdmsmith.com