Cornell AgriTech
New York State Agricultural Experiment Station

EFFICIENT VINEYARD

The goal of Efficient Vineyard Project is to research, develop, and implement digital agriculture solutions for commercial U. S. grape production.

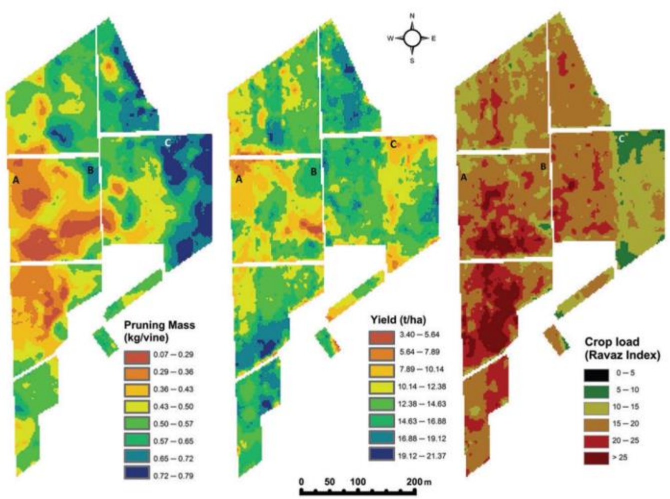
The multi-institutional and multi-disciplinary project was supported by the USDA-NIFA-Specialty Crop Research Initiative program from 2015-2020 and led by Dr. Terry Bates of the Cornell Lake Erie Research and Extension Laboratory.

The Efficient Vineyard theme will continue under a new SCRI project on precision nutrient management led by Washington State University.

The EfficientVineyard Project

The Measure, Model, Manage Theme

Spatial Data Driven, Variable-Rate, Mechanized Vineyard Crop Load Management



Measure	Model	Manage
Sense	Plan	Act
Data	Information	Decisions

Dr. Terry Bates, Cornell AgriTech, Lake Erie Research and Extension Laboratory

Establish your farm and goals

Management Outcomes need to drive Precision Viticulture

Locally determined, one size does not fit all

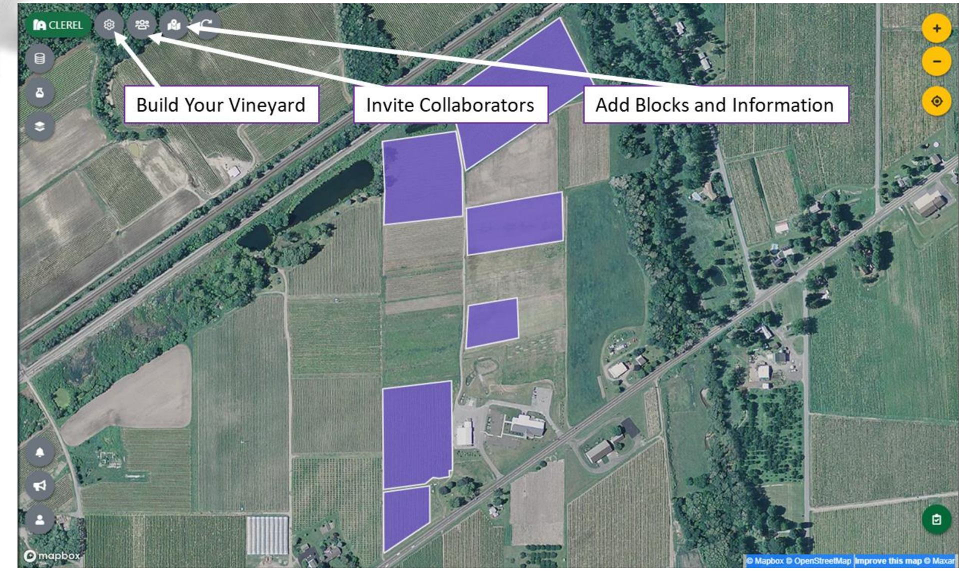
Lake Erie Concord Production

Lower Profit Margins
Ownrooted – Not Irrigated
Becoming more Mechanized
Focus on Crop Load Management
(Designed overcropping with VR vine balance)

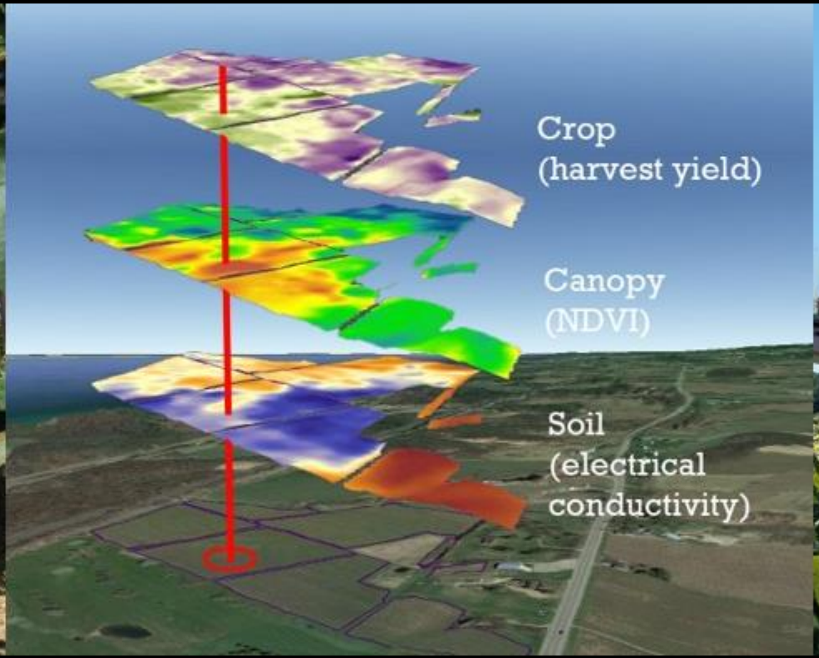
Lake Erie Riesling Production

Higher Profit Margins
Grafted on more vigorous rootstocks
Predominantly manual management
Focus on Canopy Management
(Canopy density, cluster exposure)

Build your farm in MyEV and import the data you want



The Efficient Vineyard Approach



Measure vineyard soil, canopy, and crop characteristics using mobile field sensors

Model multi-layer spatial data needed for perennial cropping systems

Manage vineyards by integrating spatial information with variable-rate technology

Sensors for collecting vineyard spatial information

Soil — DualEM

Canopy — CropCircle

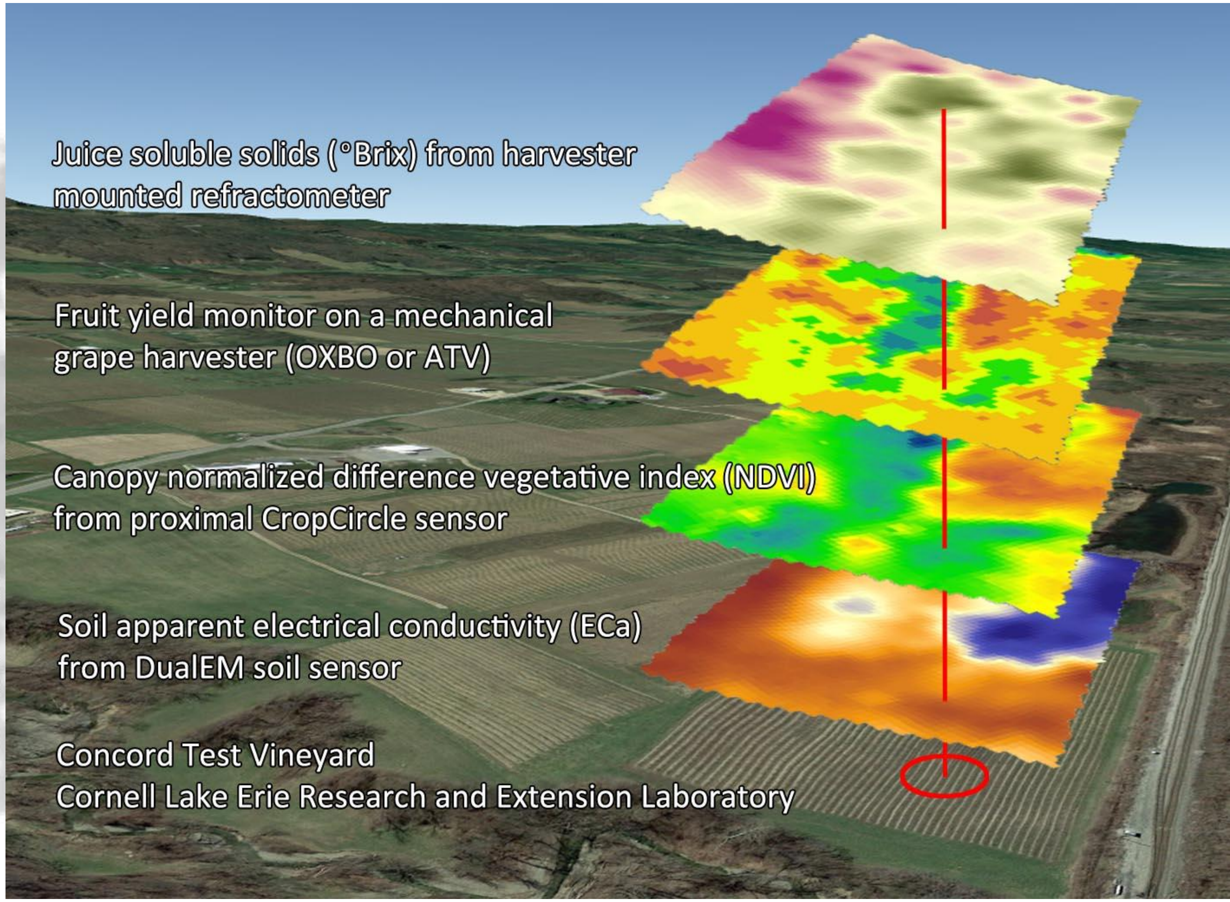
Crop — CMU, Bloomfield

Harvest Yield/Brix — OXBO

Vine Nutrients — RIT

Fruit Metrics — Felix Instruments

Anything — You + MyEV Data Collector



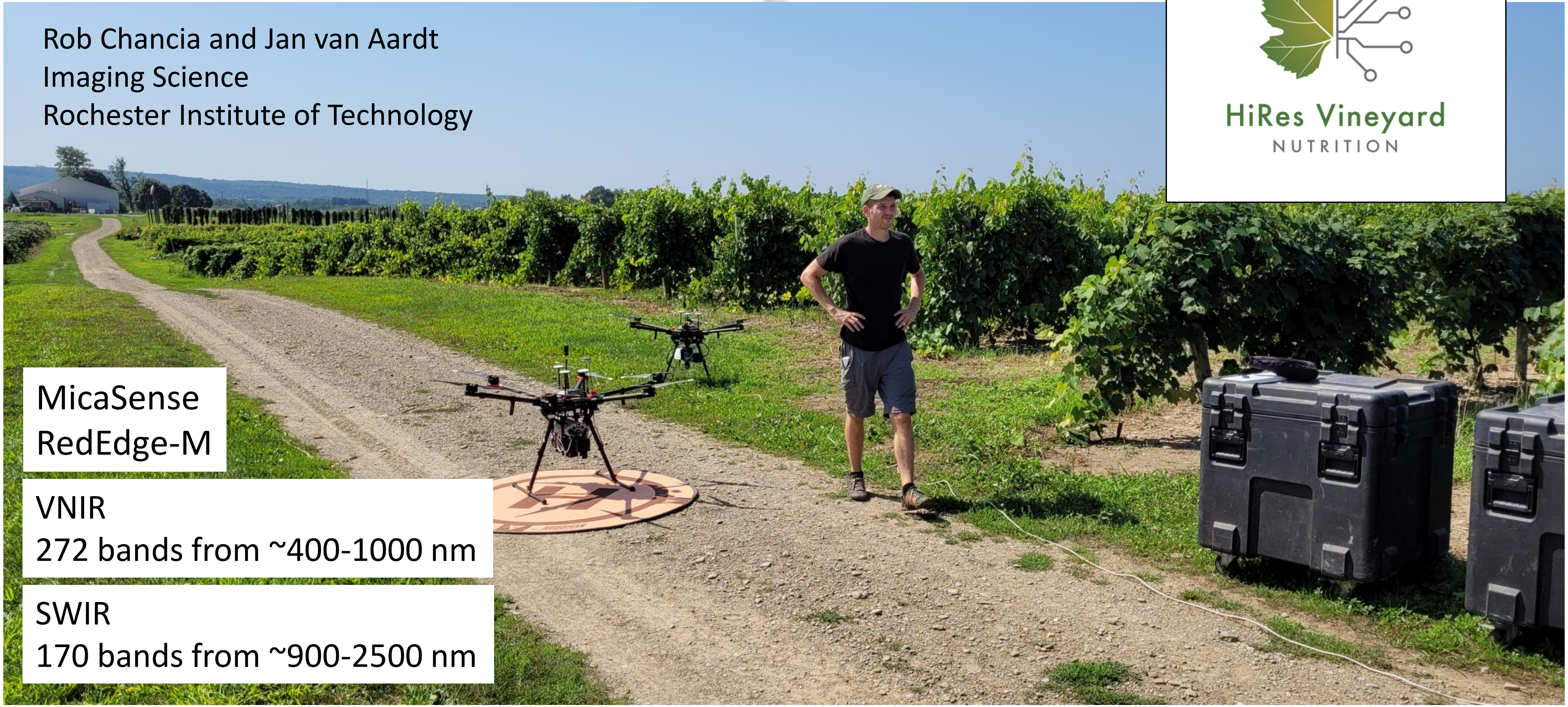
Import Spatial Data

Sensing Tools in the Toolbox

Collecting relevant spatial data…translating to viticulture information

Rob Chancia and Jan van Aardt
Imaging Science
Rochester Institute of Technology

HiRes Vineyard
NUTRITION

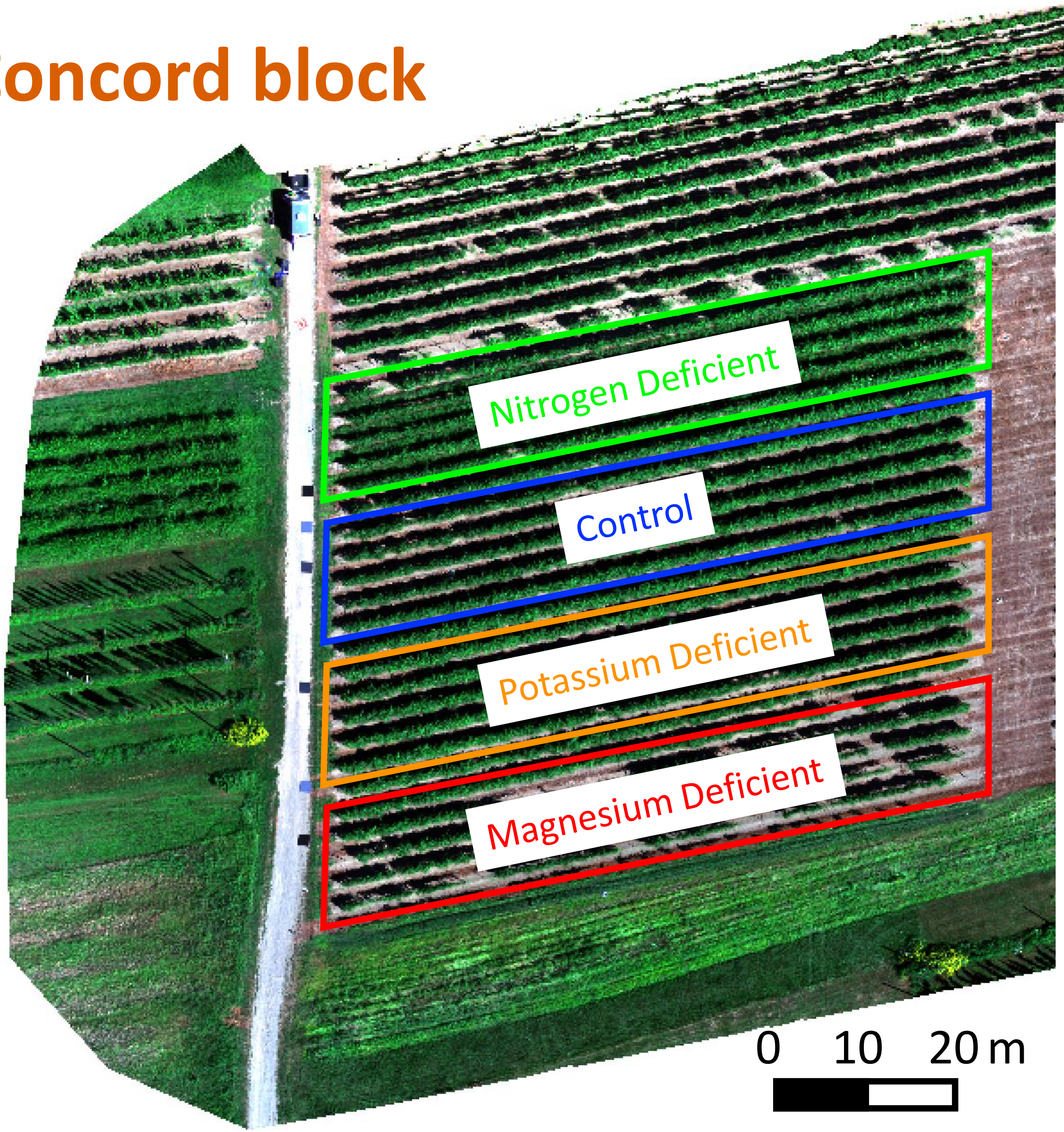


MicaSense RedEdge-M

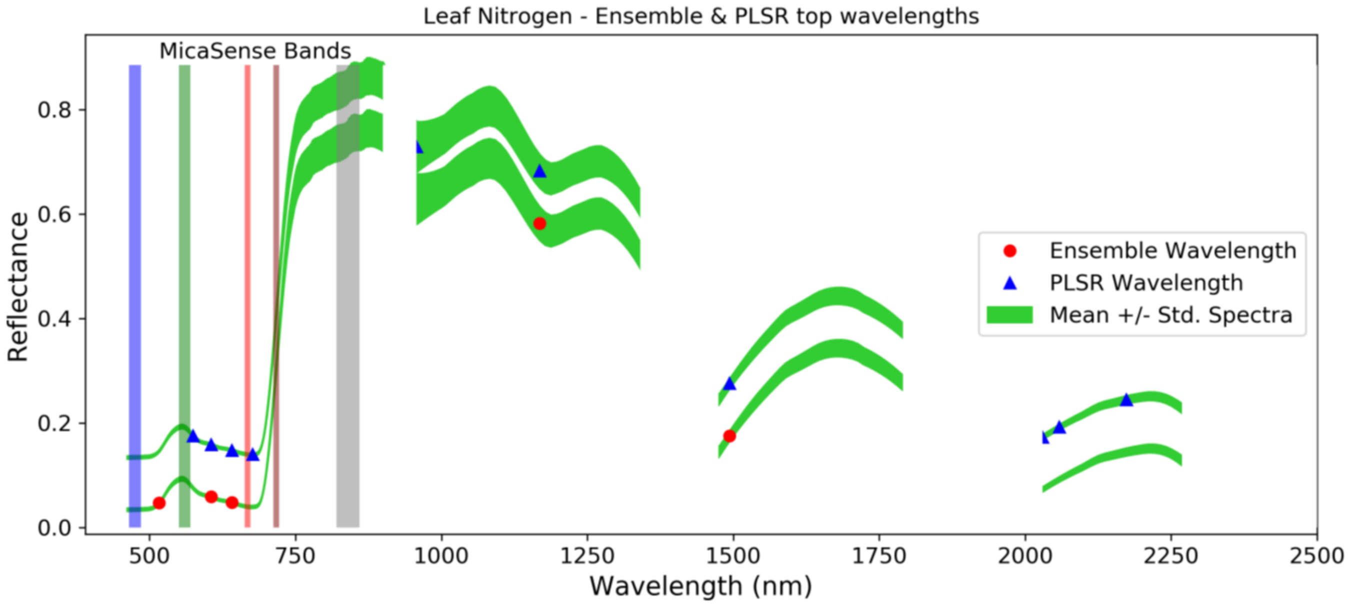
VNIR
272 bands from ~400-1000 nm

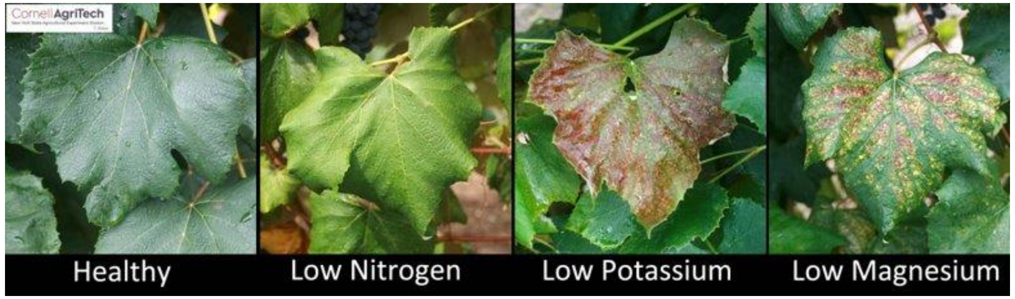
SWIR
170 bands from ~900-2500 nm

1-acre Concord block



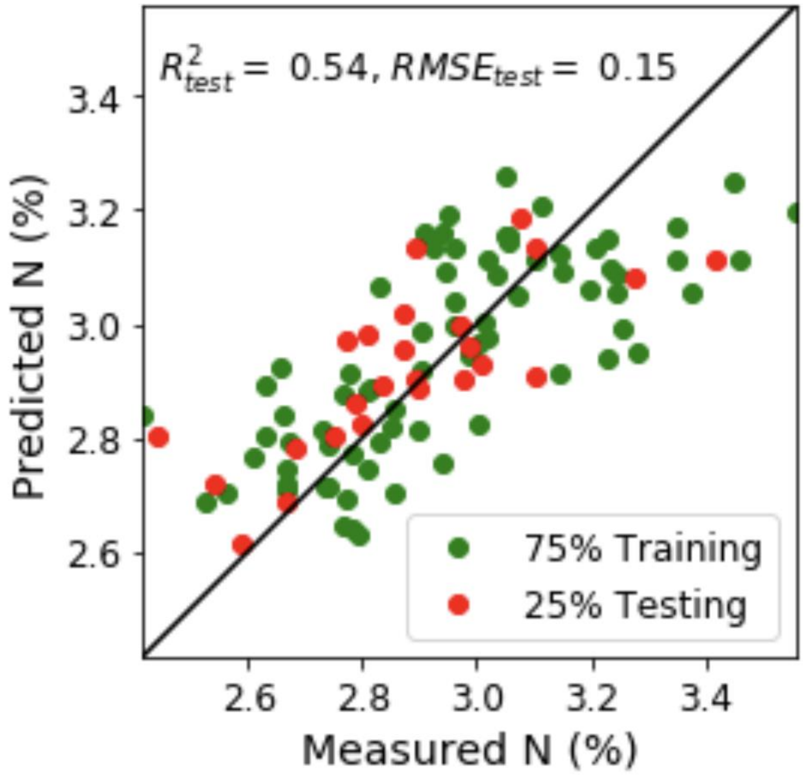
Leaf Nitrogen (%) wavelength selection



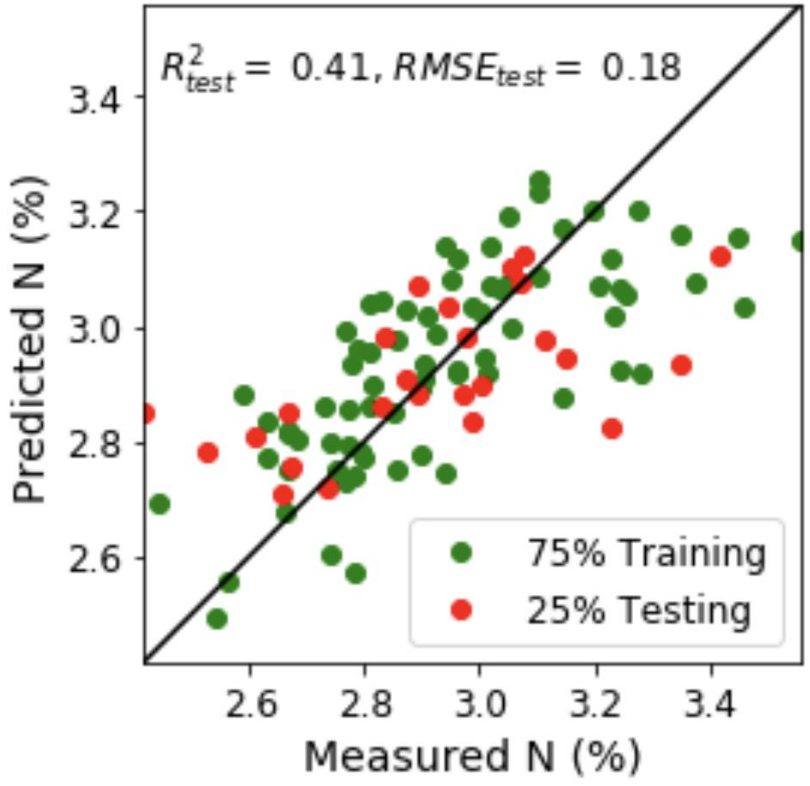


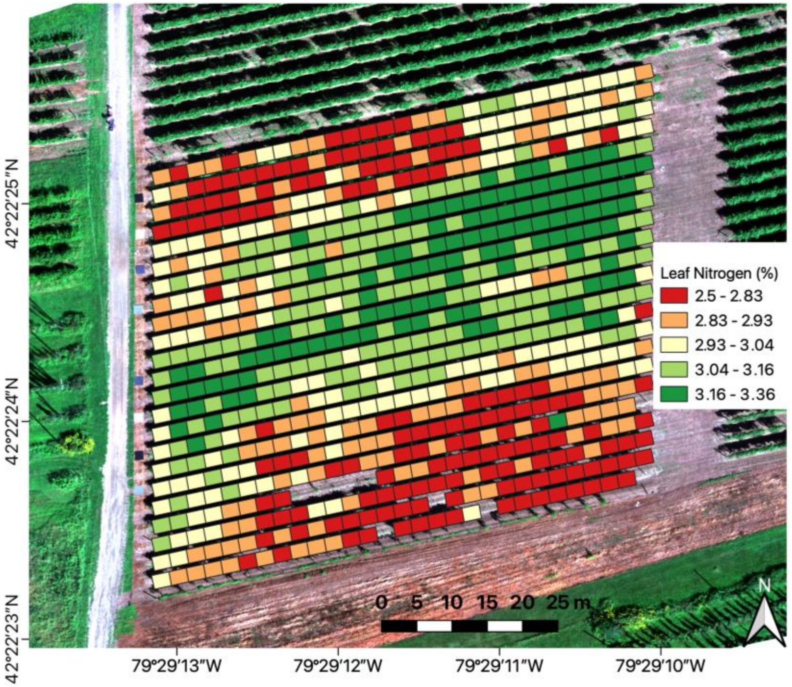
Leaf Nitrogen (%) regression results

VNIR+SWIR: 5 wavelength ensemble selection



MicaSense

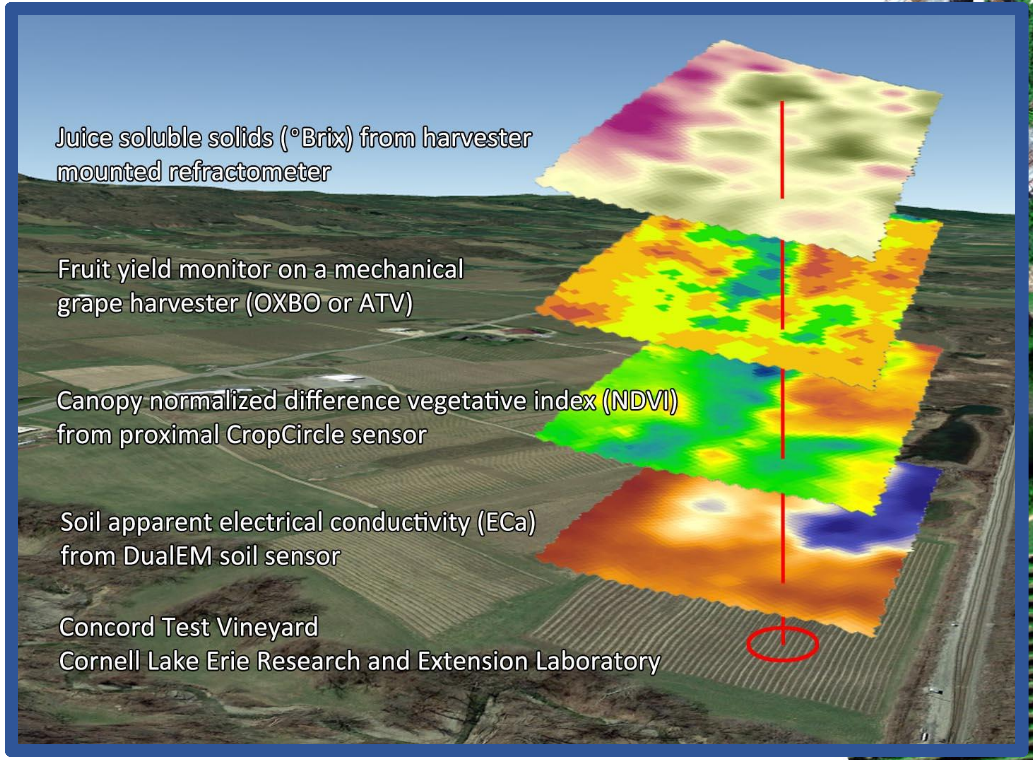


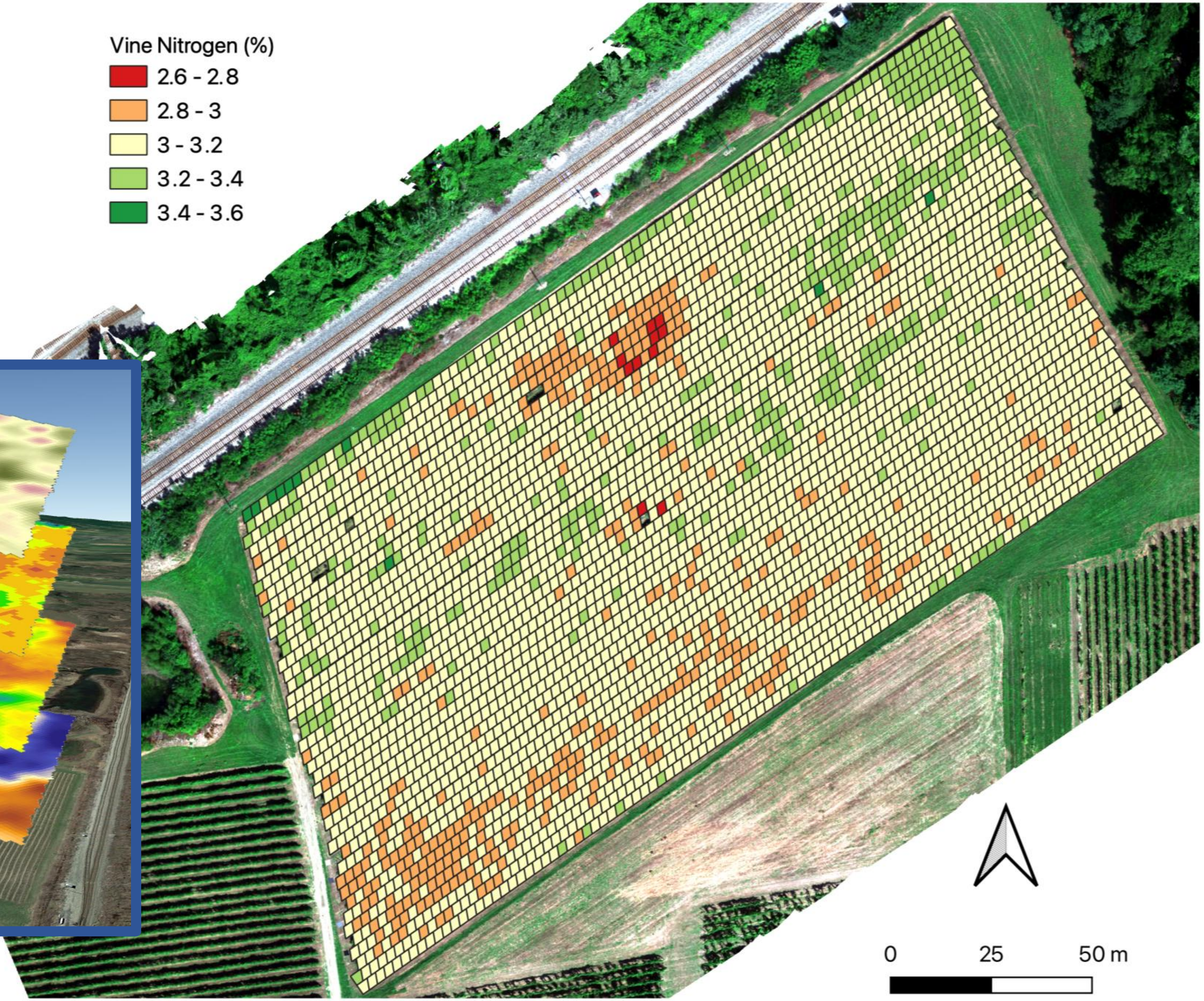


LOOCV: $R^2 = 0.44, RMSE = 0.17$

LOOCV: $R^2 = 0.41, RMSE = 0.18$

Railroad Block Nitrogen



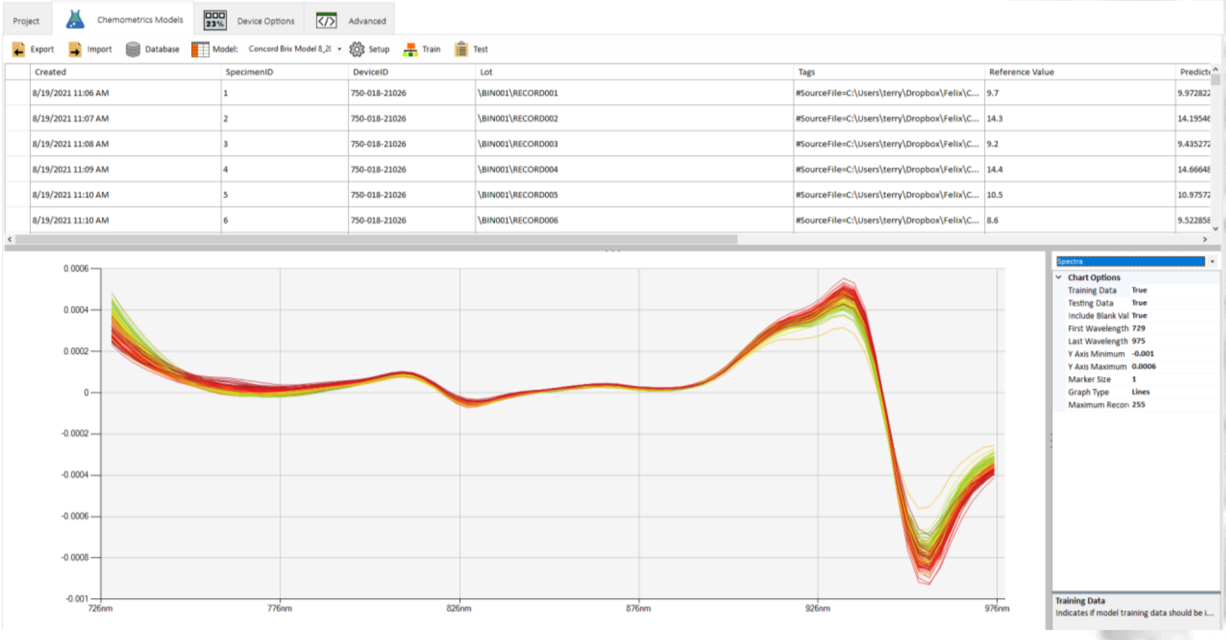


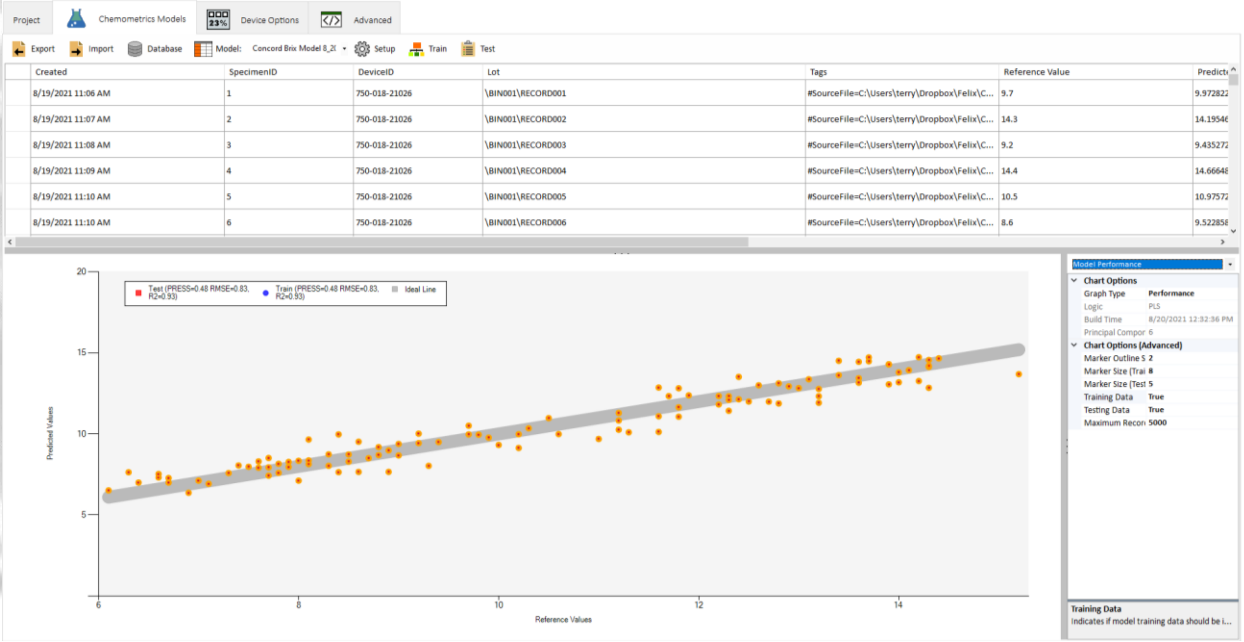
Sensing Tools in the Toolbox

Collecting relevant spatial data…translating to viticulture information

Import Spatial Data

Sensing Tools in the Toolbox





Dr. Terry Bates, Cornell AgriTech, Lake Erie Research and Extension Laboratory

Sensing Tools in the Toolbox

Collecting relevant spatial data…translating to viticulture information

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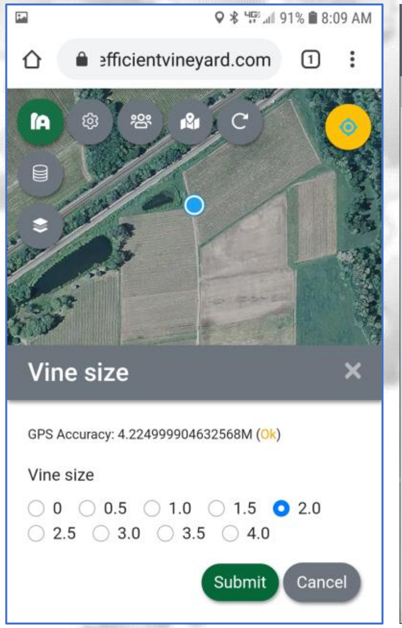
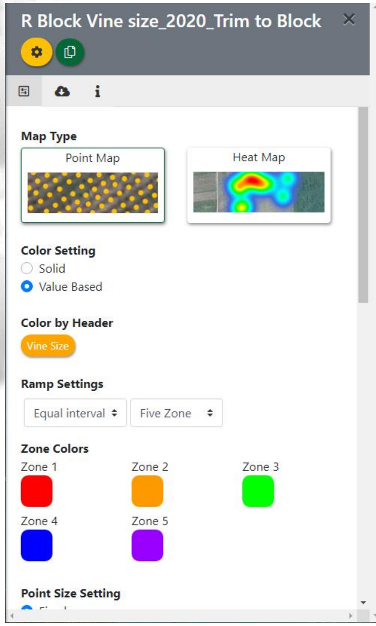
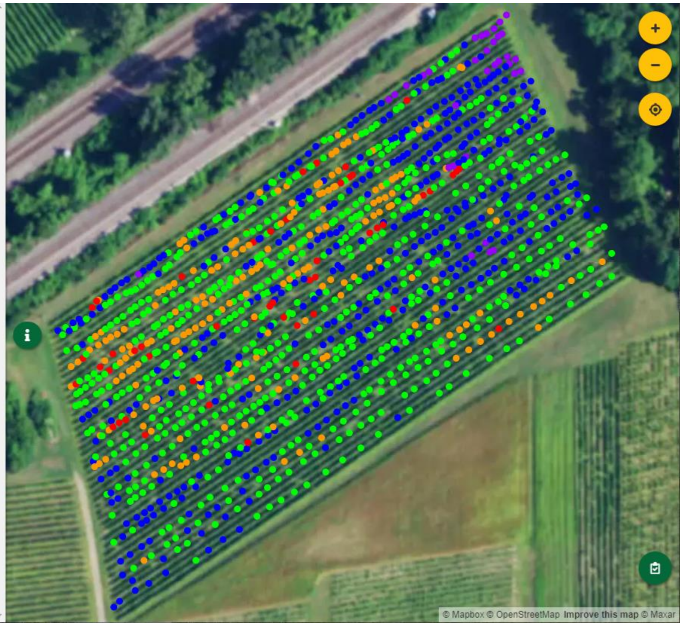
Sensing Tools in the Toolbox

Collecting relevant spatial data…translating to viticulture information

The MyEV Data Collector tool and the "Human" Sensor

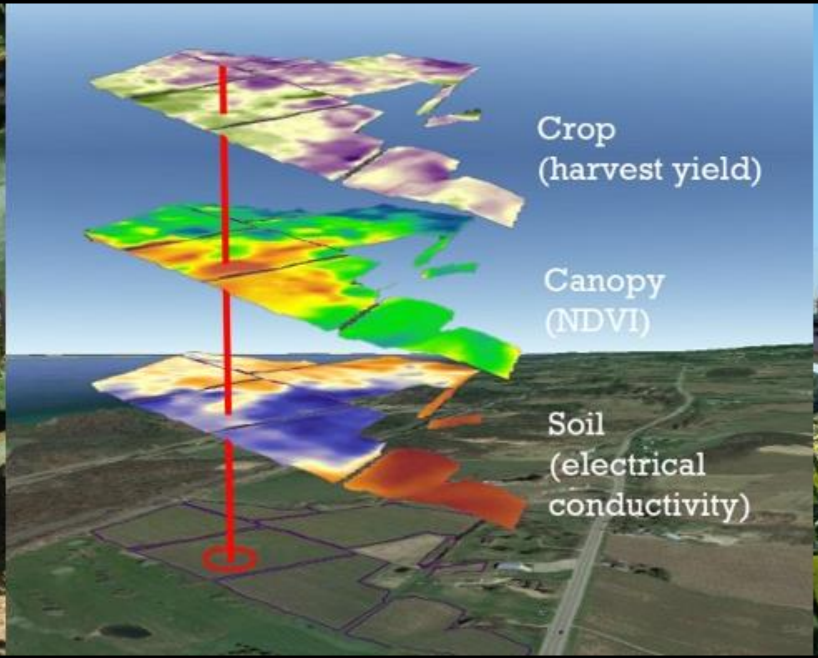






Dr. Terry Bates, Cornell AgriTech, Lake Erie Research and Extension Laboratory

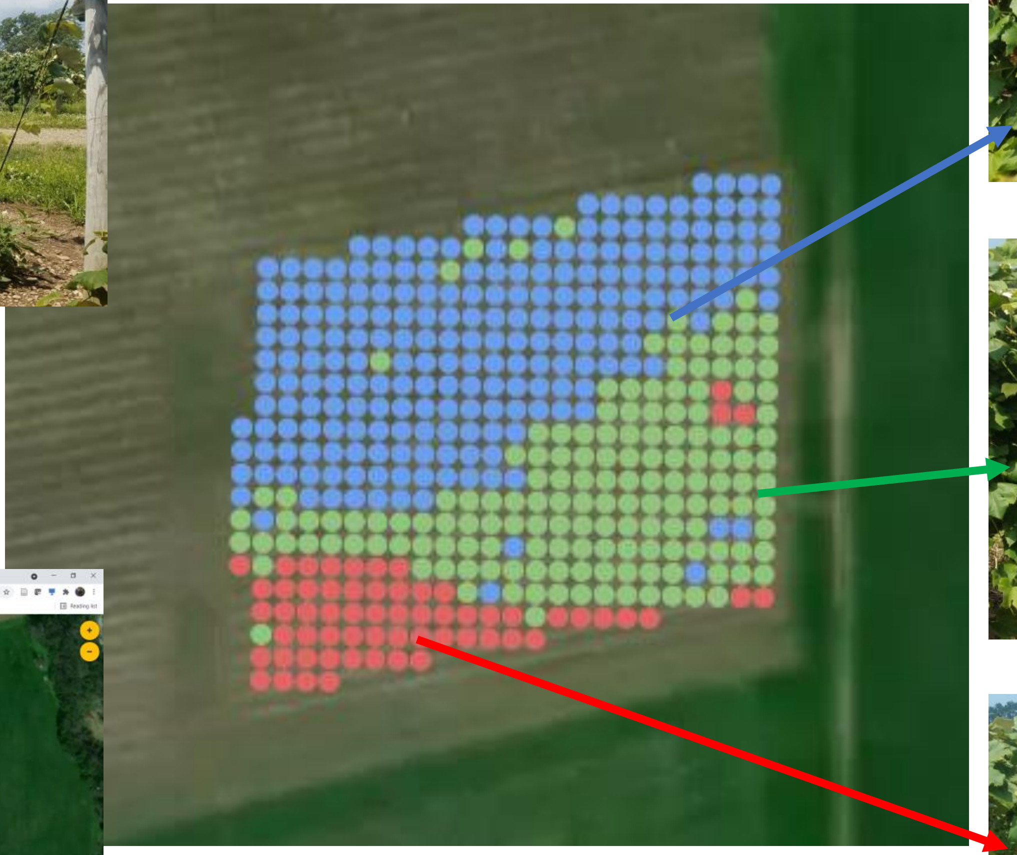
The Efficient Vineyard Approach

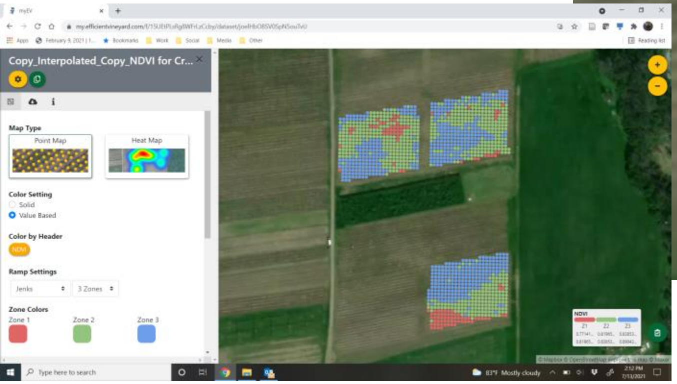


Measure vineyard soil, canopy, and crop characteristics using mobile field sensors

Model multi-layer spatial data needed for perennial cropping systems

Manage vineyards by integrating spatial information with variable-rate technology





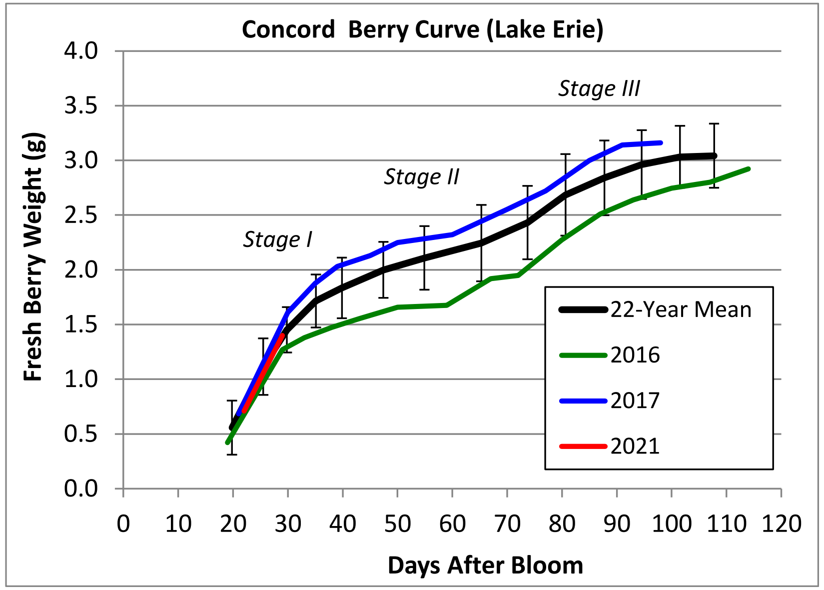
3 pound

2 pound

1 pound

Get Best Possible Sample

Use Concord Fresh Berry Curve



Dr. Terry Bates: Crop Estimation and Thinning Table: 7/16/2003

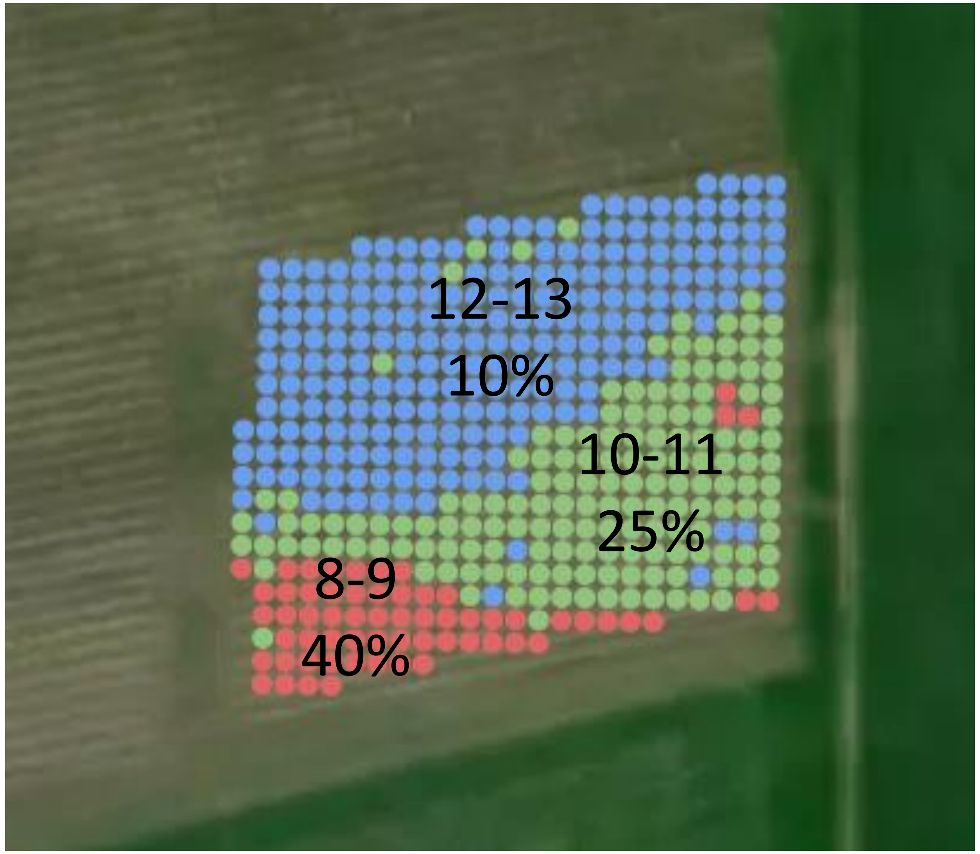
Pounds of Fruit Removed in 1/100th of an Acre	20	25	30	35	40	45	50	55	60	65	70	75	80	90	100
Time of Season		20DAB		25DAB			30DAB		40DAB	50DAB		Veraison			Harvest
% of Final Berry Weight															
10	2.5	2.0	1.7	1.4	1.3	1.1	1.0	0.9	0.8	0.8	0.7	0.7	0.6	0.6	0.5
20	5.0	4.0	3.3	2.9	2.5	2.2	2.0	1.8	1.7	1.5	1.4	1.3	1.3	1.1	1.0
30	7.5	6.0	5.0	4.3	3.8	3.3	3.0	2.7	2.5	2.3	2.1	2.0	1.9	1.7	1.5
40	10.0	8.0	6.7	5.7	5.0	4.4	4.0	3.6	3.3	3.1	2.9	2.7	2.5	2.2	2.0
50	12.5	10.0	8.3	7.1	6.3	5.6	5.0	4.5	4.2	3.8	3.6	3.3	3.1	2.8	2.5
60	15.0	12.0	10.0	8.6	7.5	6.7	6.0	5.5	5.0	4.6	4.3	4.0	3.8	3.3	3.0
70	17.5	14.0	11.7	10.0	8.8	7.8	7.0	6.4	5.8	5.4	5.0	4.7	4.4	3.9	3.5
80	20.0	16.0	13.3	11.4	10.0	8.9	8.0	7.3	6.7	6.2	5.7	5.3	5.0	4.4	4.0
90	22.5	18.0	15.0	12.9	11.3	10.0	9.0	8.2	7.5	6.9	6.4	6.0	5.6	5.0	4.5
100	25.0	20.0	16.7	14.3	12.5	11.1	10.0	9.1	8.3	7.7	7.1	6.7	6.3	5.6	5.0
110	27.5	22.0	18.3	15.7	13.8	12.2	11.0	10.0	9.2	8.5	7.9	7.3	6.9	6.1	5.5
120	30.0	24.0	20.0	17.1	15.0	13.3	12.0	10.9	10.0	9.2	8.6	8.0	7.5	6.7	6.0
130	32.5	26.0	21.7	18.6	16.3	14.4	13.0	11.8	10.8	10.0	9.3	8.7	8.1	7.2	6.5
140	35.0	28.0	23.3	20.0	17.5	15.6	14.0	12.7	11.7	10.8	10.0	9.3	8.8	7.8	7.0
150	37.5	30.0	25.0	21.4	18.8	16.7	15.0	13.6	12.5	11.5	10.7	10.0	9.4	8.3	7.5
160	40.0	32.0	26.7	22.9	20.0	17.8	16.0	14.5	13.3	12.3	11.4	10.7	10.0	8.9	8.0
170	42.5	34.0	28.3	24.3	21.3	18.9	17.0	15.5	14.2	13.1	12.1	11.3	10.6	9.4	8.5
180	45.0	36.0	30.0	25.7	22.5	20.0	18.0	16.4	15.0	13.8	12.9	12.0	11.3	10.0	9.0
190	47.5	38.0	31.7	27.1	23.8	21.1	19.0	17.3	15.8	14.6	13.6	12.7	11.9	10.6	9.5
200	50.0	40.0	33.3	28.6	25.0	22.2	20.0	18.2	16.7	15.4	14.3	13.3	12.5	11.1	10.0

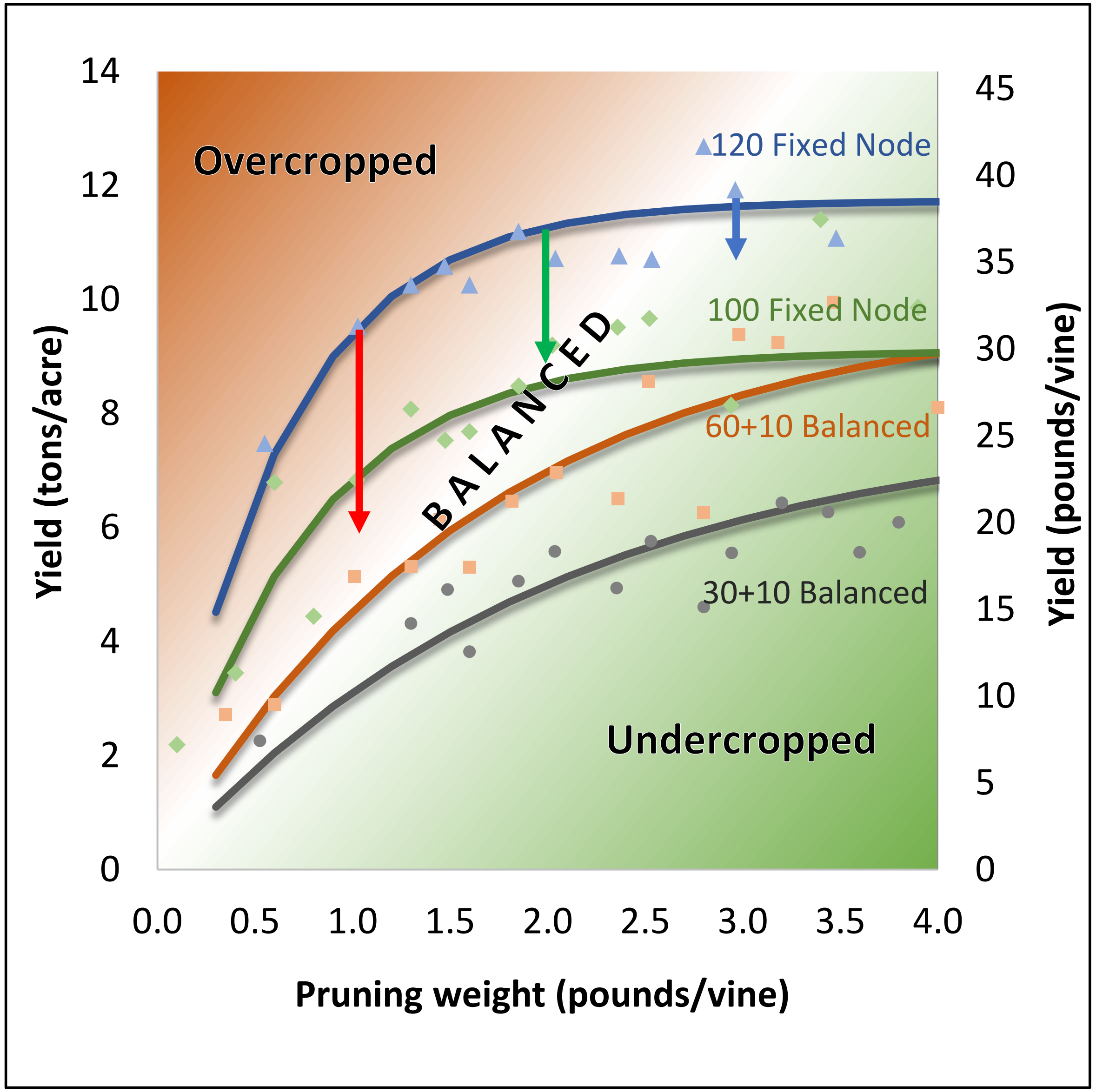
Row Spacing determines length of 1/100th of an acre
10.0 feet row spacing = 43.5 feet = 1/100th of an acre
9.5 feet = 45.9 feet = 1/100th of an acre
9.0 feet = 48.4 feet = 1/100th of an acre
8.5 feet = 51.2 feet = 1/100th of an acre
8.0 feet = 54.45 feet = 1/100th of an acre
7.5 feet = 58.1 feet = 1/100th of an acre

Calculation
43, 560 square feet per acre
Divide by row spacing and then
divide by 100 to get 1/100th of an acre

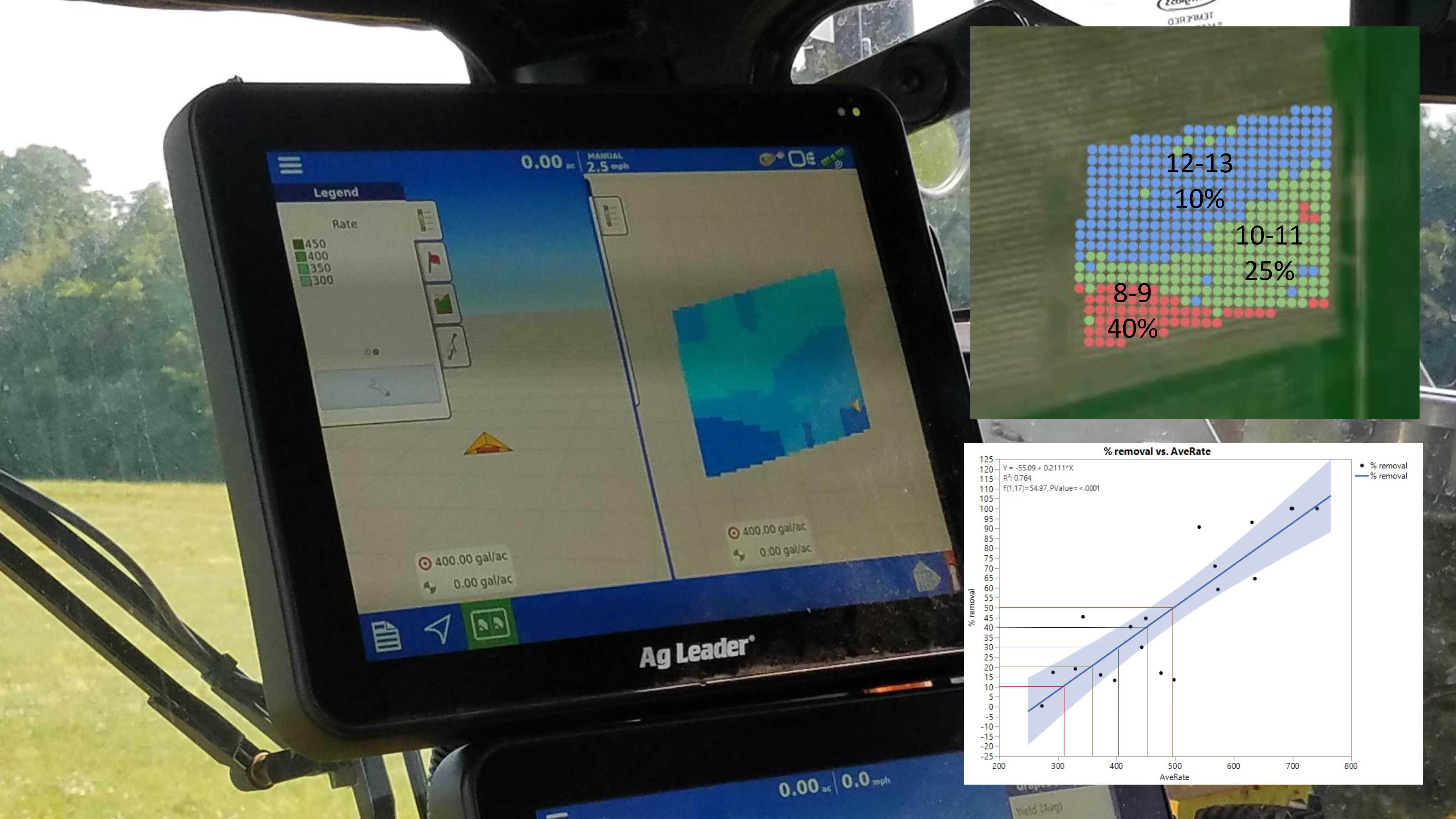
Example:
A grower has 9 foot row spacing and clean picks 48.4 feet at 25 days after bloom. The fruit weighs 80 pounds and the grower estimates that the berries are between 35% and 40% of final berry weight. According to the table, the crop estimate is between 10.0 and 11.4 tons per acre.

Disclaimer:
This table gives the relationship between time of season and % final berry weight on an average year. Year to year variability in weather related berry growth adds error to this table. Information on current year berry growth can be obtained from the Fredonia Vineyard Lab (or) it is strongly suggested that individual growers start collecting berry weight information from their own individual vineyard blocks.


12-13
10%
10-11
25%
8-9
40%


Overcropped
120 Fixed Node
100 Fixed Node
BALANCED
60+10 Balanced
30+10 Balanced
Undercropped
Yield (tons/acre)
Yield (pounds/vine)
Pruning weight (pounds/vine)
0
2
4
6
8
10
12
14
0
5
10
15
20
25
30
35
40
45
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0

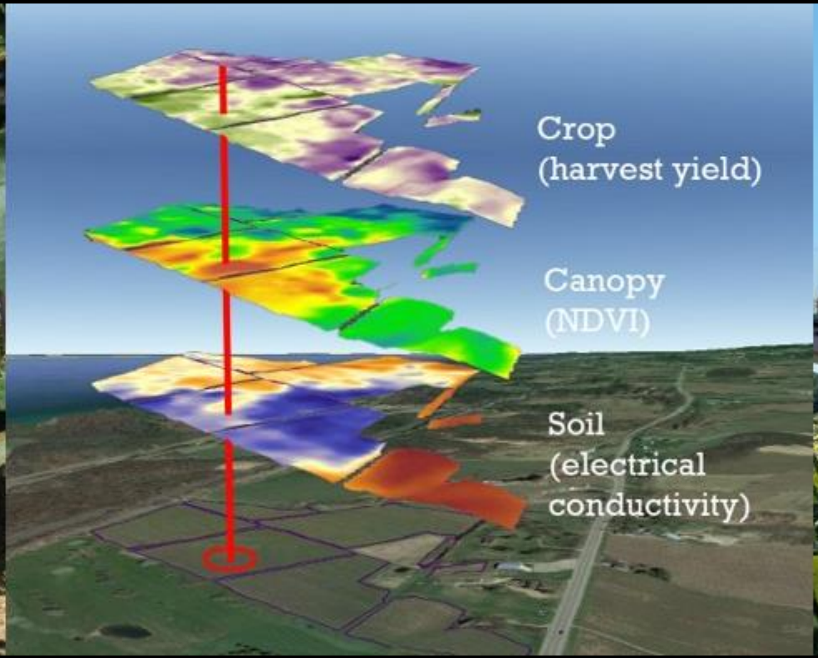

0.13
2.5 mph
Legend
Thinning
Rate
458 +
418 - 458
379 - 418
339 - 379
0 - 339
388.00 gal/ac
388.00 gal/ac
Ag Leader



0.00 ac
MANUAL
2.5 mph
Legend
Rate
450
400
350
300
400.00 gal/ac
0.00 gal/ac
400.00 gal/ac
0.00 gal/ac
Ag Leader
0.00 ac
0.0 mph
12-13
10%
10-11
25%
8-9
40%
% removal vs. AveRate
Y = -55.09 + 0.2111*X
R²: 0.764
F(1,17)=54.97, PValue= <.0001
% removal
% removal
% removal
AveRate
200
300
400
500
600
700
800
125
120
115
110
105
100
95
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0
-5
-10
-15
-20
-25


OXBO

The Efficient Vineyard Approach

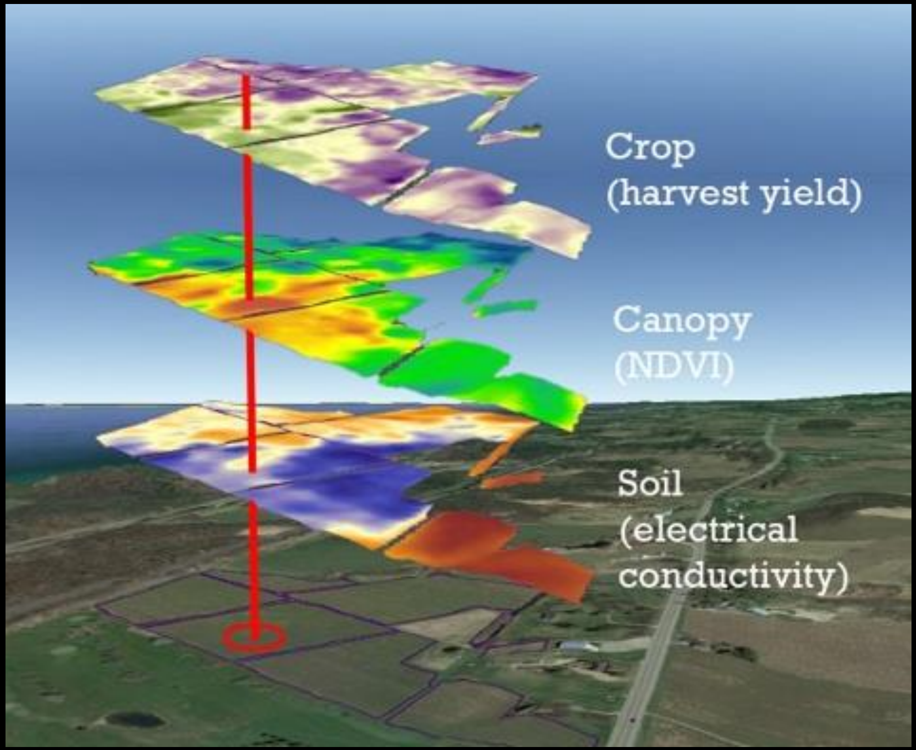


Measure vineyard soil, canopy, and crop characteristics using mobile field sensors

Model multi-layer spatial data needed for perennial cropping systems

Manage vineyards by integrating spatial information with variable-rate technology

Development of Efficient Vineyard Software (aka: The MyEV Tool)



Spatial Data Barrier

We found that processing and working with spatial information was a barrier for growers to adopt new precision viticulture management techniques.

Why not use existing platforms?

Powerful GIS software, such as ArcGIS and QGIS, provide many functions but have a substantial learning curve and are not agriculture specific.

The MyEV goal

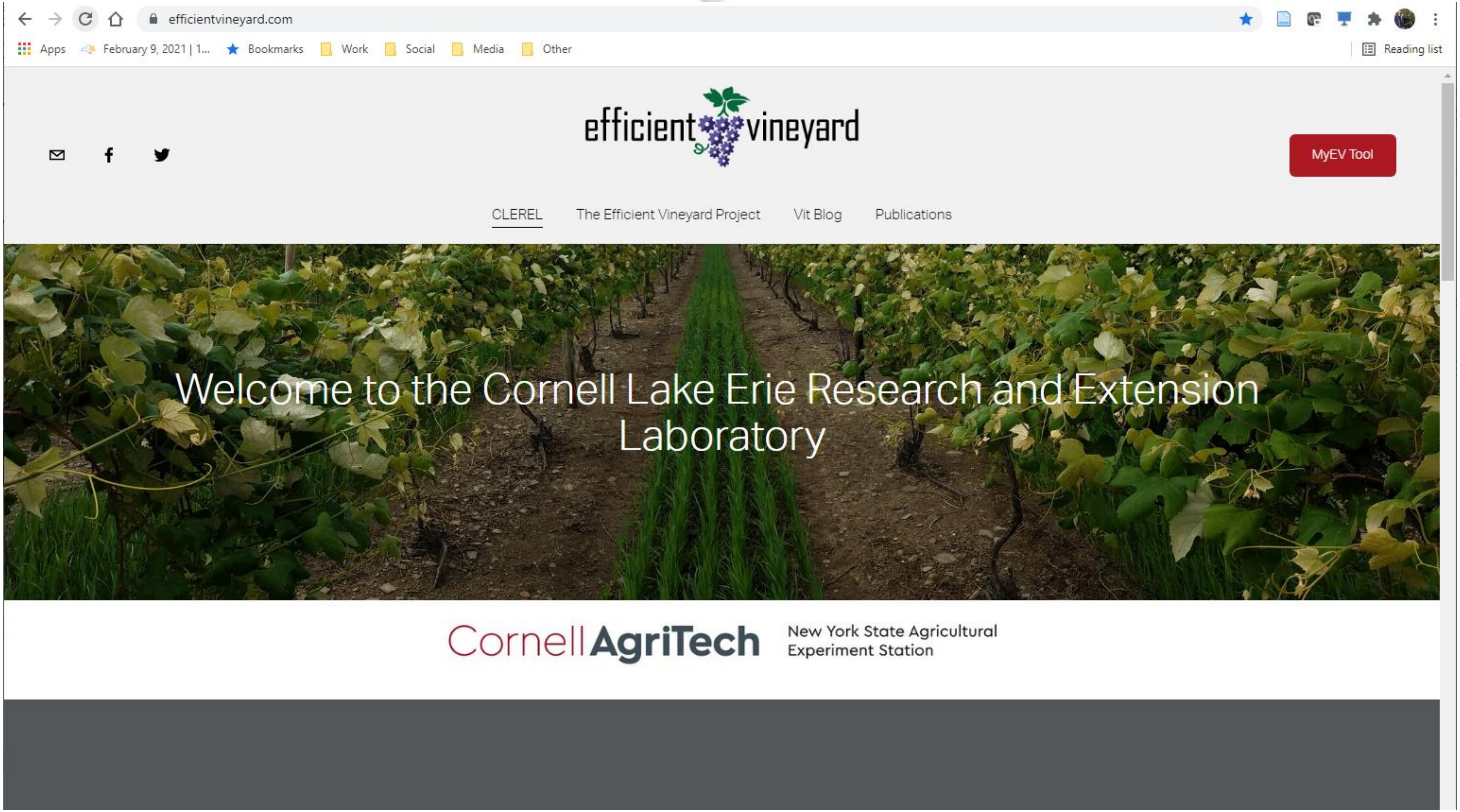
Our goal was to develop a simple, easy to use, web-based software tool for vineyard managers to upload, process, visualize, and download spatial data.

Who did this work

MyEV is a cooperative effort between Terry Bates (Cornell Viticulturist) and Nick Gunner (Software Developer and owner of Orbitist, https://orbitist.com/).

Establish Farm	Build farm and Establish block Information	Data sharing with collaborators	File Management	Block level record keeping?
Import Spatial Data	Import sensor spatial data as .txt, .csv, .geojson, or shapefile.zip	Generate user defined spatial data with "Data Collector"	Import point data from raster image (plug-in)	
Visualize/Process Raw Data	Visualize raw data with color and break options	Trim data with flexible filtering options	Clip data to blocks and save/export desired data sets	
Data Translation	Plug-in development	Identify validation sample locations (by zones or by distribution mimicking)	Collect, record, import in-field manual observations	Correlate spatial and manual data, Translate spatial map
Data Interpolation	Interpolation Plug-in	IDW to a Common grid	Save/Export data	
Multi-Layer Integration	Data-Joiner Plug-in	Save/Export data		
Management Maps	Cluster analysis Plug-in	GeoVit Fuzzy logic Plug-in	Assign management and Export to SMS or Smartphone	

ORBITIST



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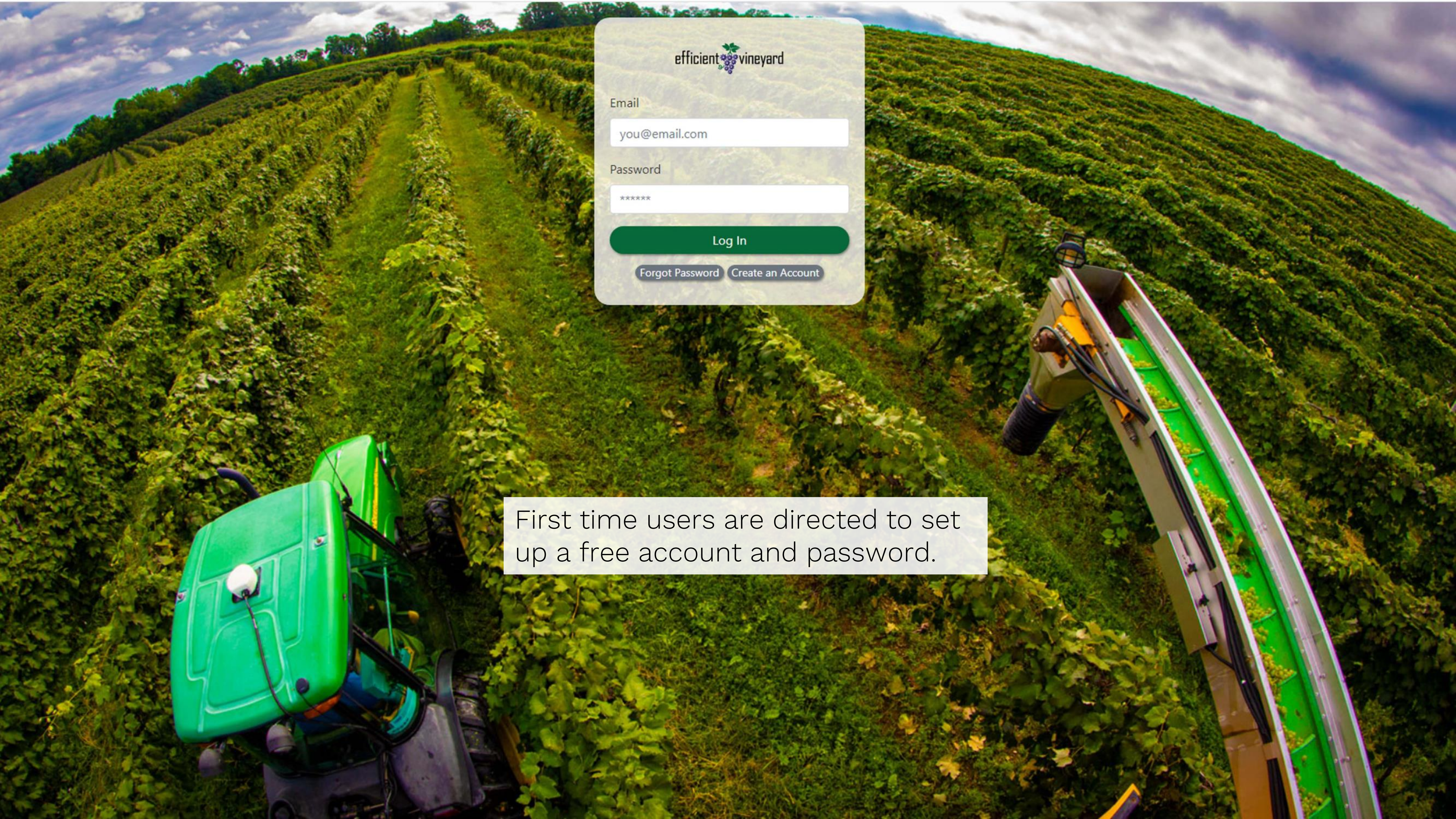
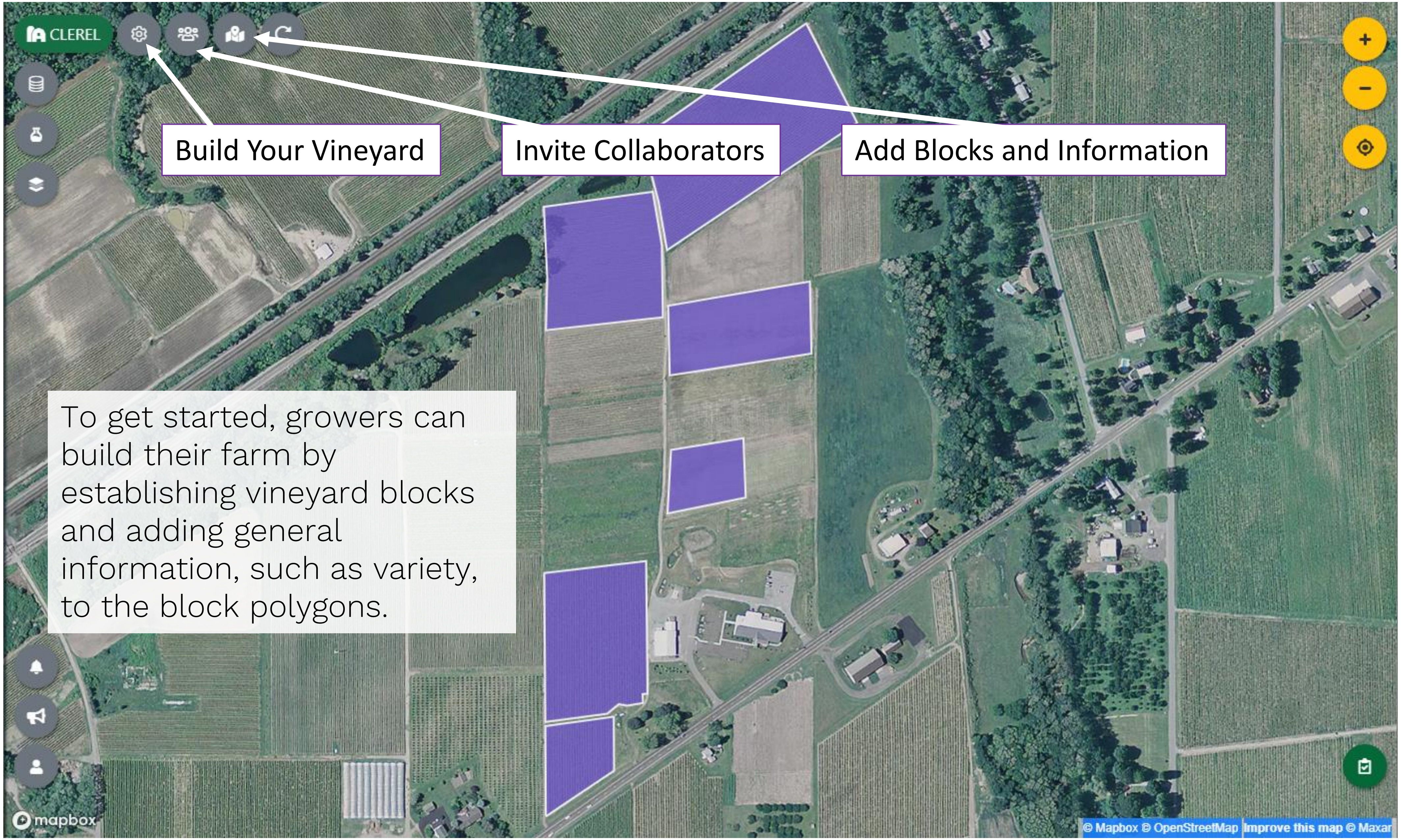
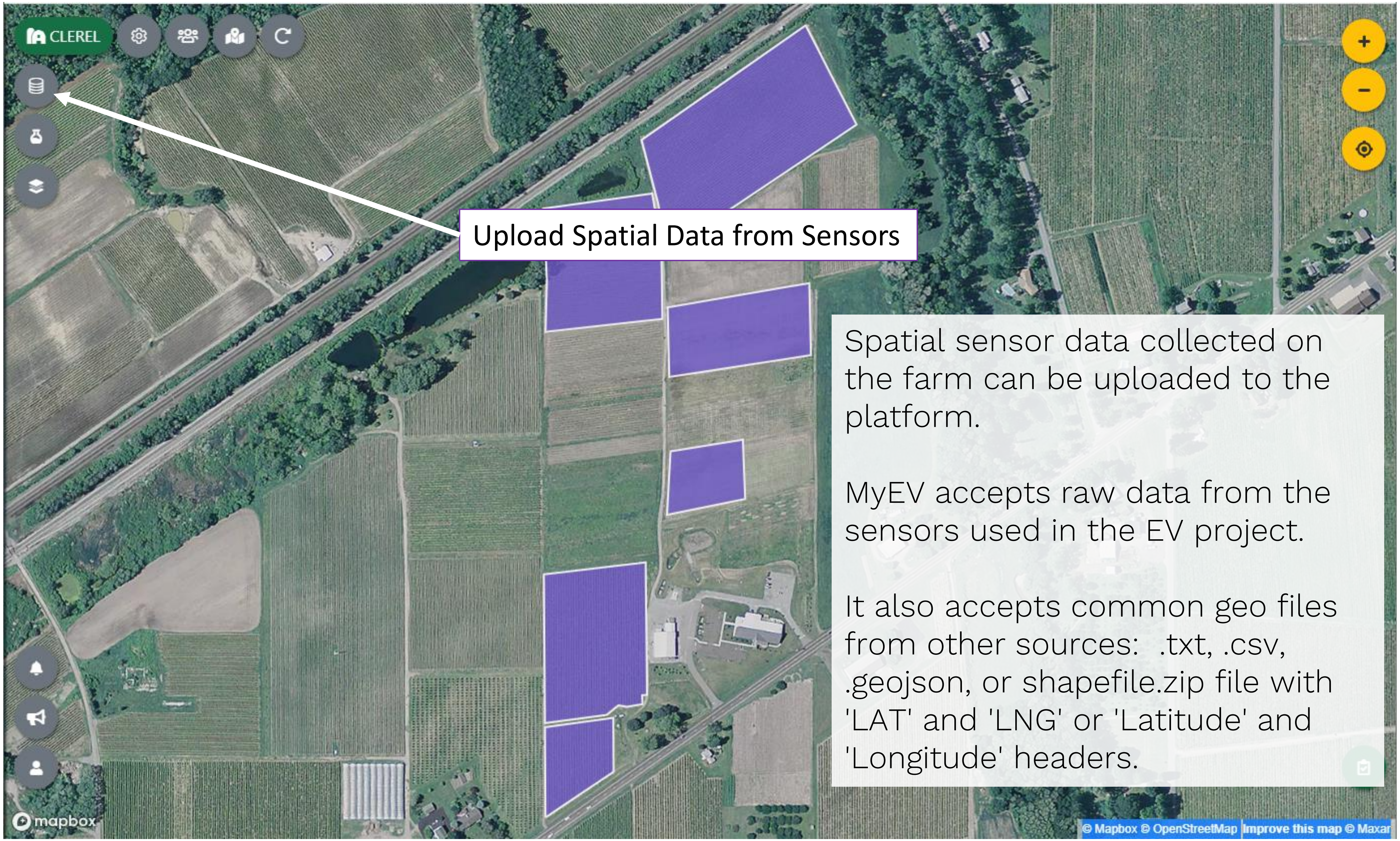
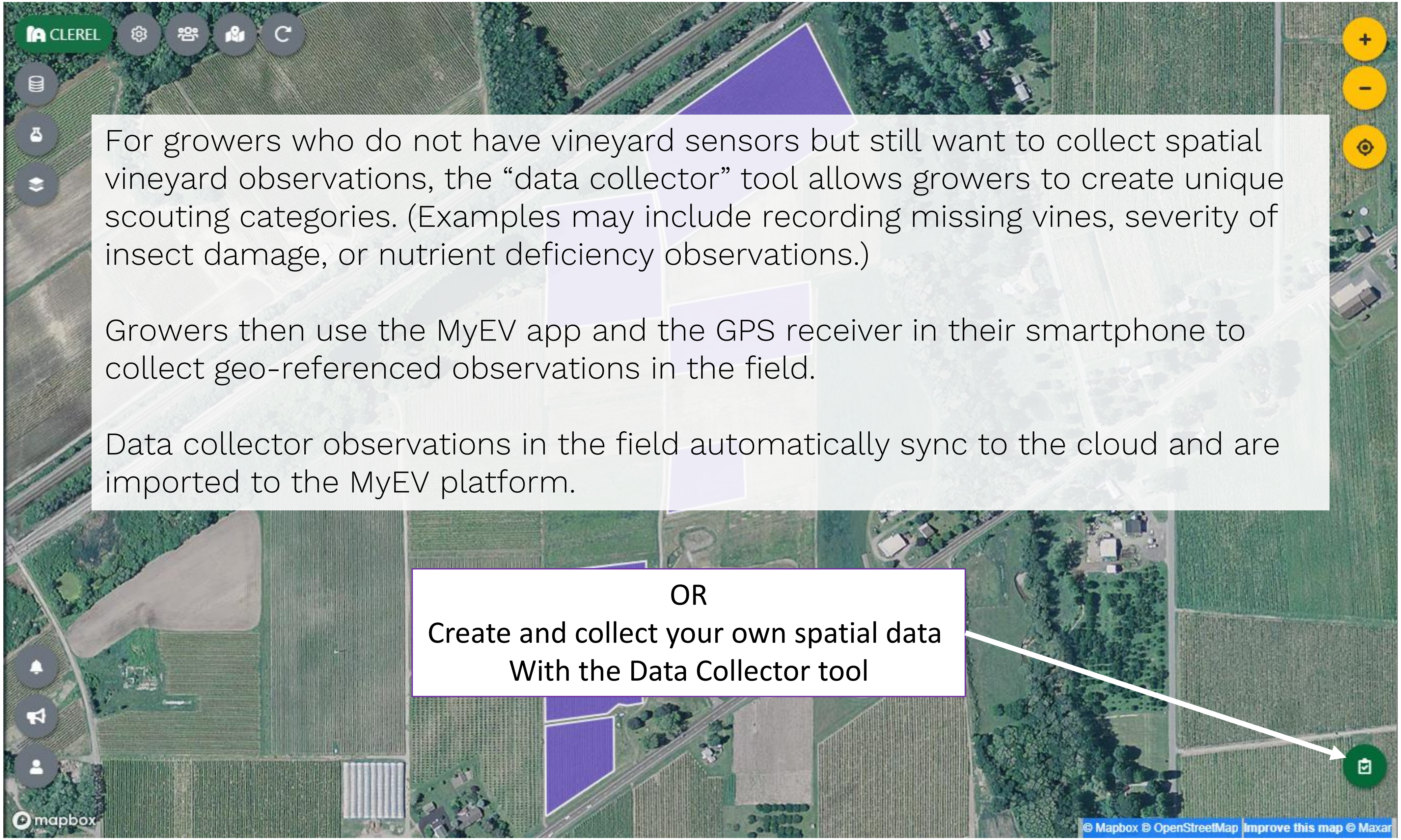
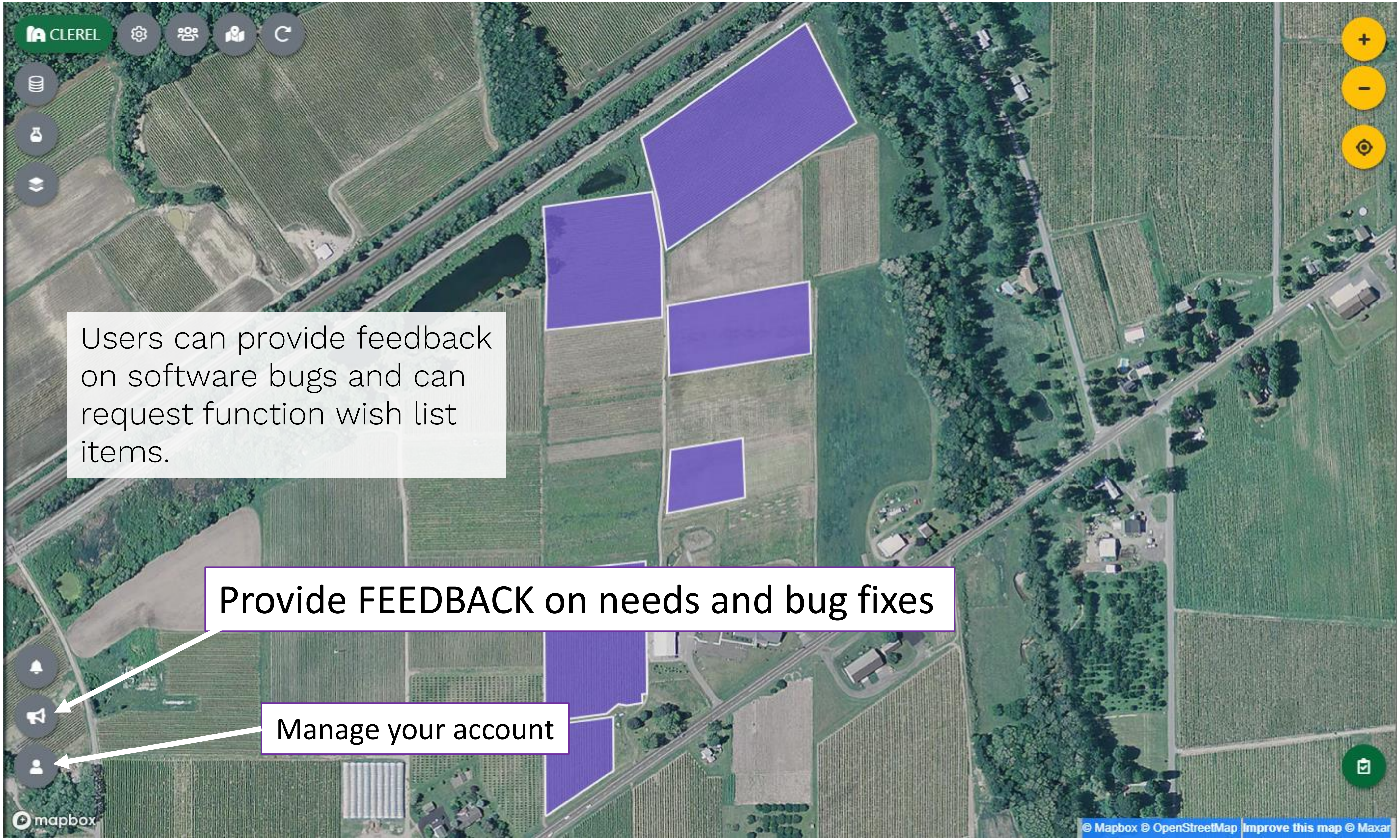

efficient vineyard
Email
you@email.com
Password
******
Log In
Forgot Password
Create an Account
First time users are directed to set up a free account and password.


CLEREL
Build Your Vineyard
Invite Collaborators
Add Blocks and Information
To get started, growers can build their farm by establishing vineyard blocks and adding general information, such as variety, to the block polygons.
mapbox
© Mapbox © OpenStreetMap Improve this map © Maxar


CLEREL
Upload Spatial Data from Sensors
Spatial sensor data collected on the farm can be uploaded to the platform.
MyEV accepts raw data from the sensors used in the EV project.
It also accepts common geo files from other sources: .txt, .csv, .geojson, or shapefile.zip file with 'LAT' and 'LNG' or 'Latitude' and 'Longitude' headers.
mapbox
© Mapbox © OpenStreetMap Improve this map © Maxar

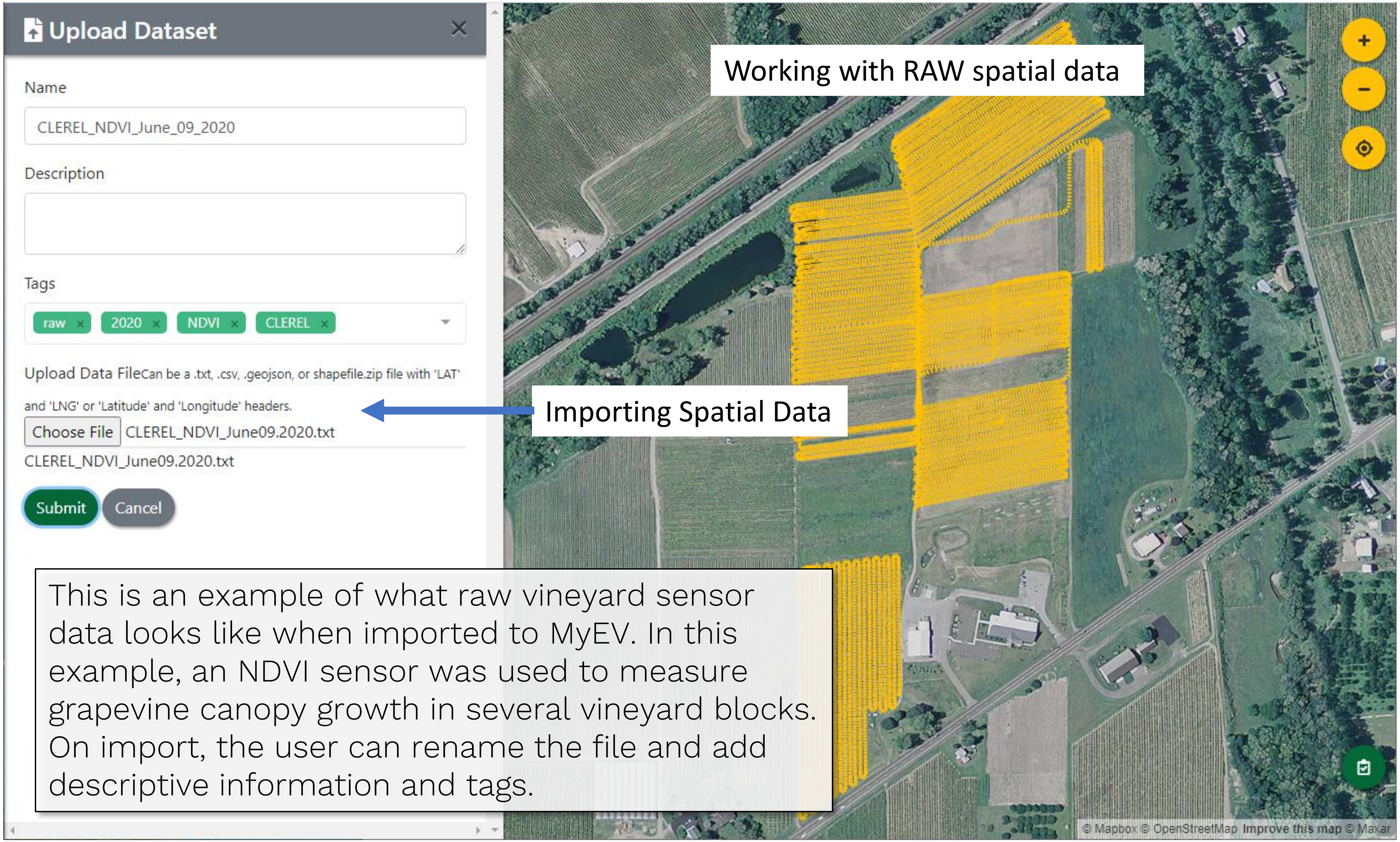

CLEREL
For growers who do not have vineyard sensors but still want to collect spatial vineyard observations, the “data collector” tool allows growers to create unique scouting categories. (Examples may include recording missing vines, severity of insect damage, or nutrient deficiency observations.)
Growers then use the MyEV app and the GPS receiver in their smartphone to collect geo-referenced observations in the field.
Data collector observations in the field automatically sync to the cloud and are imported to the MyEV platform.
OR
Create and collect your own spatial data
With the Data Collector tool
mapbox
© Mapbox © OpenStreetMap Improve this map © Maxar

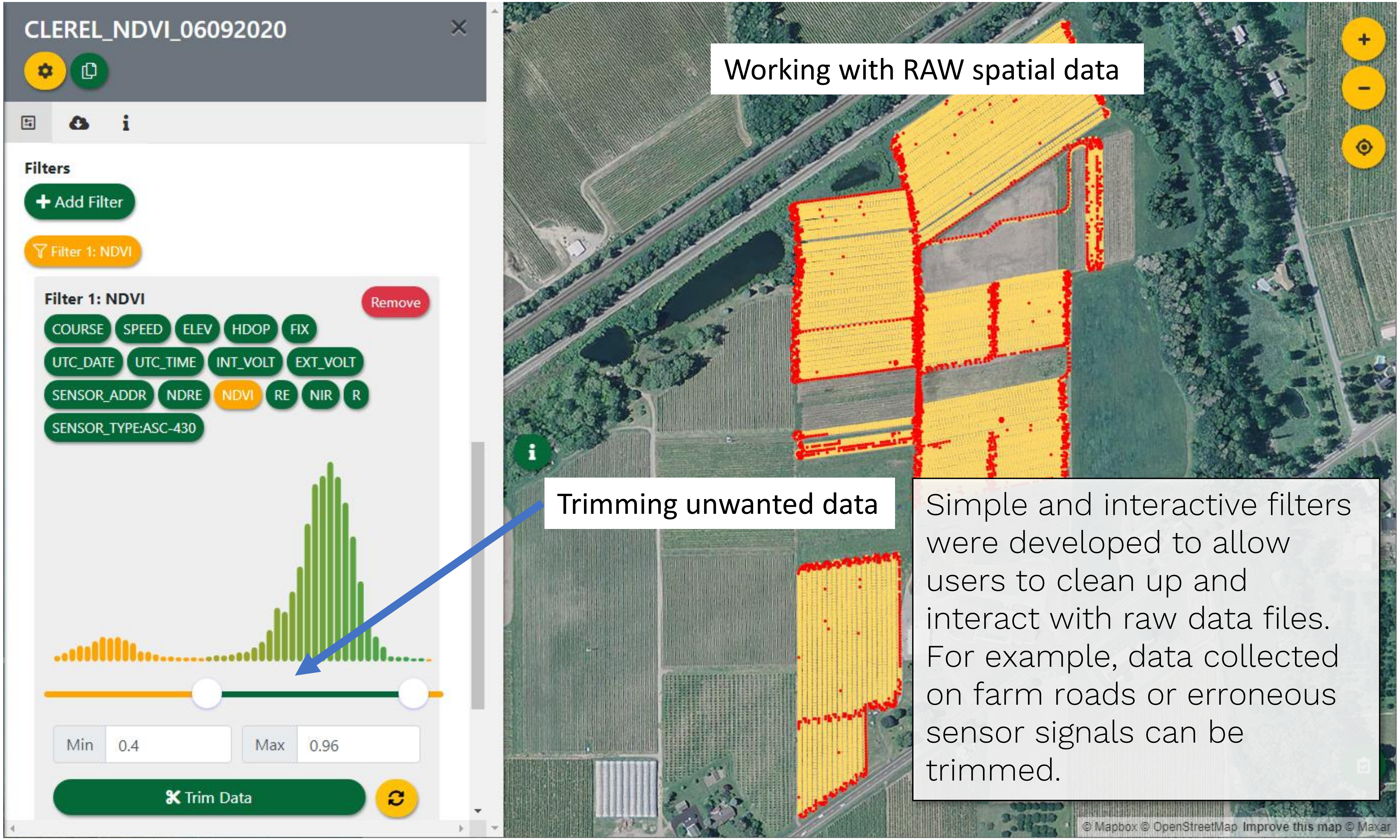


Users can provide feedback on software bugs and can request function wish list items.

Provide FEEDBACK on needs and bug fixes

Manage your account


Upload Dataset
Name
CLEREL_NDVI_June_09_2020
Description
Tags
raw
2020
NDVI
CLEREL
Upload Data FileCan be a .txt, .csv, .geojson, or shapefile.zip file with 'LAT' and 'LNG' or 'Latitude' and 'Longitude' headers.
Choose File CLEREL_NDVI_June09.2020.txt
CLEREL_NDVI_June09.2020.txt
Submit
Cancel
Working with RAW spatial data
Importing Spatial Data
This is an example of what raw vineyard sensor data looks like when imported to MyEV. In this example, an NDVI sensor was used to measure grapevine canopy growth in several vineyard blocks. On import, the user can rename the file and add descriptive information and tags.
© Mapbox © OpenStreetMap Improve this map © Maxar


CLEREL_NDVI_06092020
Filters
Add Filter
Filter 1: NDVI
Filter 1: NDVI
Remove
COURSE
SPEED
ELEV
HDOP
FIX
UTC_DATE
UTC_TIME
INT_VOLT
EXT_VOLT
SENSOR_ADDR
NDRE
NDVI
RE
NIR
R
SENSOR_TYPE:ASC-430
Min
0.4
Max
0.96
Trim Data
Working with RAW spatial data
Trimming unwanted data
Simple and interactive filters were developed to allow users to clean up and interact with raw data files. For example, data collected on farm roads or erroneous sensor signals can be trimmed.
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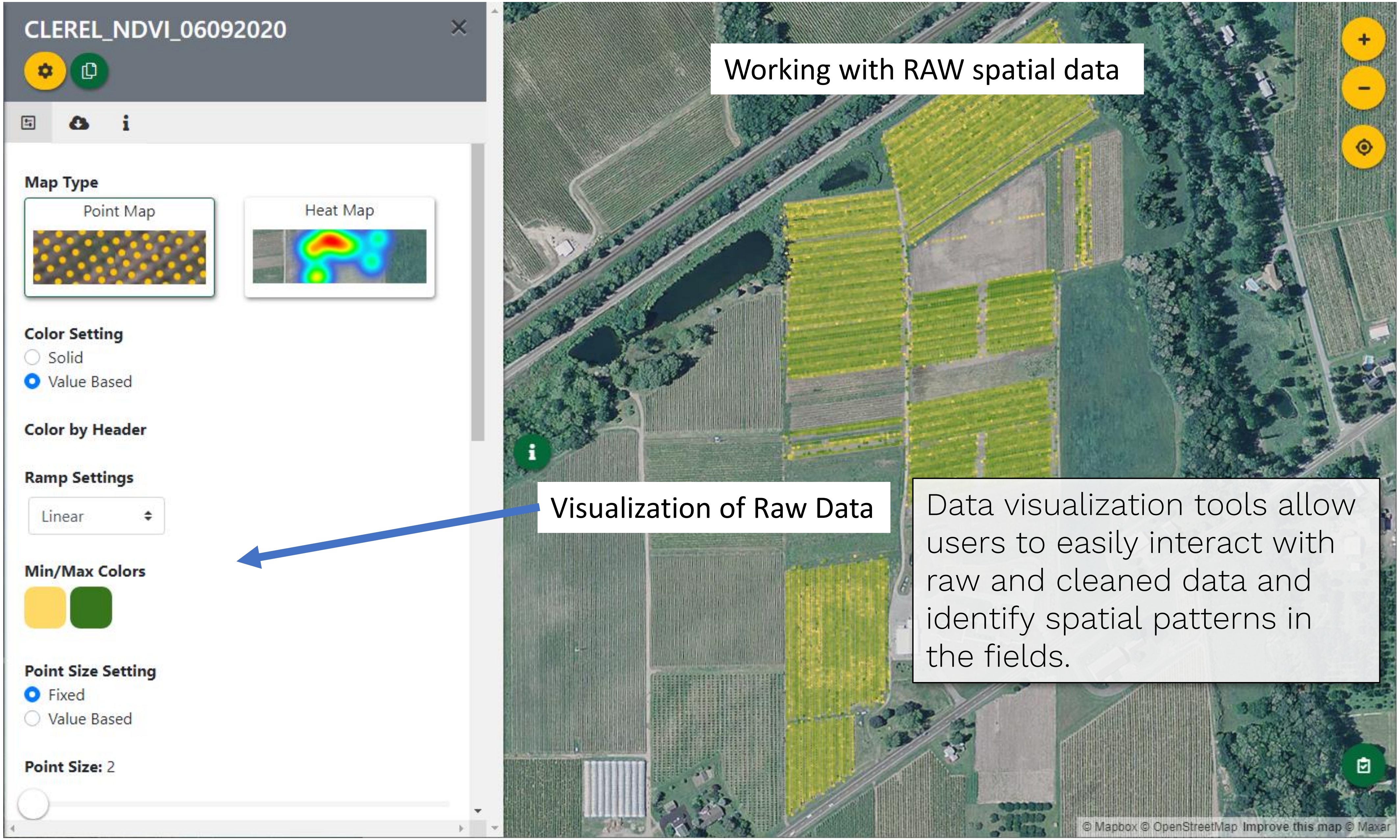
CLEREL_NDVI_06092020
Map Type
Point Map
Heat Map
Color Setting
Solid
Value Based
Color by Header
Ramp Settings
Linear
Min/Max Colors
Point Size Setting
Fixed
Value Based
Point Size: 2
Working with RAW spatial data
Visualization of Raw Data
Data visualization tools allow users to easily interact with raw and cleaned data and identify spatial patterns in the fields.
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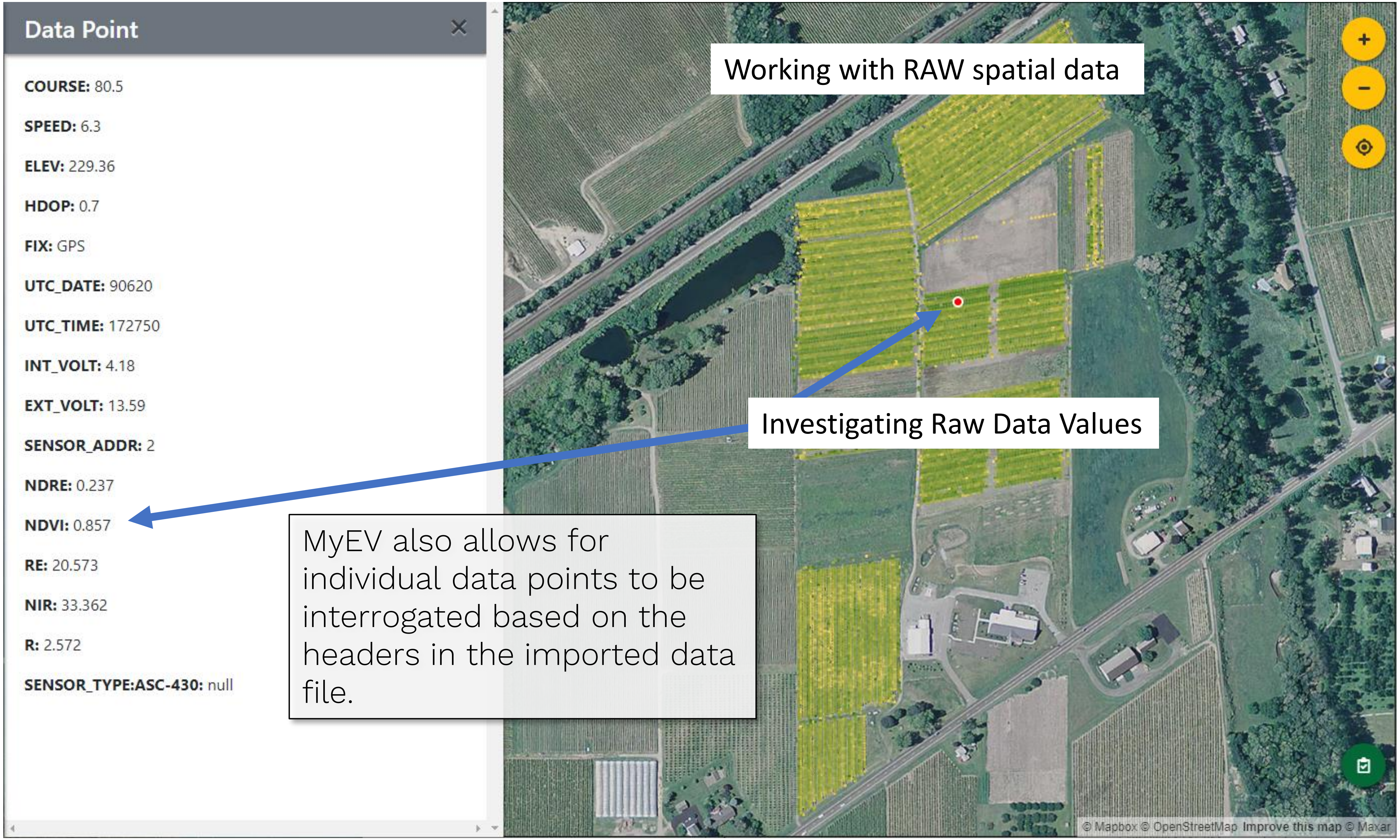
Data Point
COURSE: 80.5
SPEED: 6.3
ELEV: 229.36
HDOP: 0.7
FIX: GPS
UTC_DATE: 90620
UTC_TIME: 172750
INT_VOLT: 4.18
EXT_VOLT: 13.59
SENSOR_ADDR: 2
NDRE: 0.237
NDVI: 0.857
RE: 20.573
NIR: 33.362
R: 2.572
SENSOR_TYPE:ASC-430: null
Working with RAW spatial data
Investigating Raw Data Values
MyEV also allows for individual data points to be interrogated based on the headers in the imported data file.
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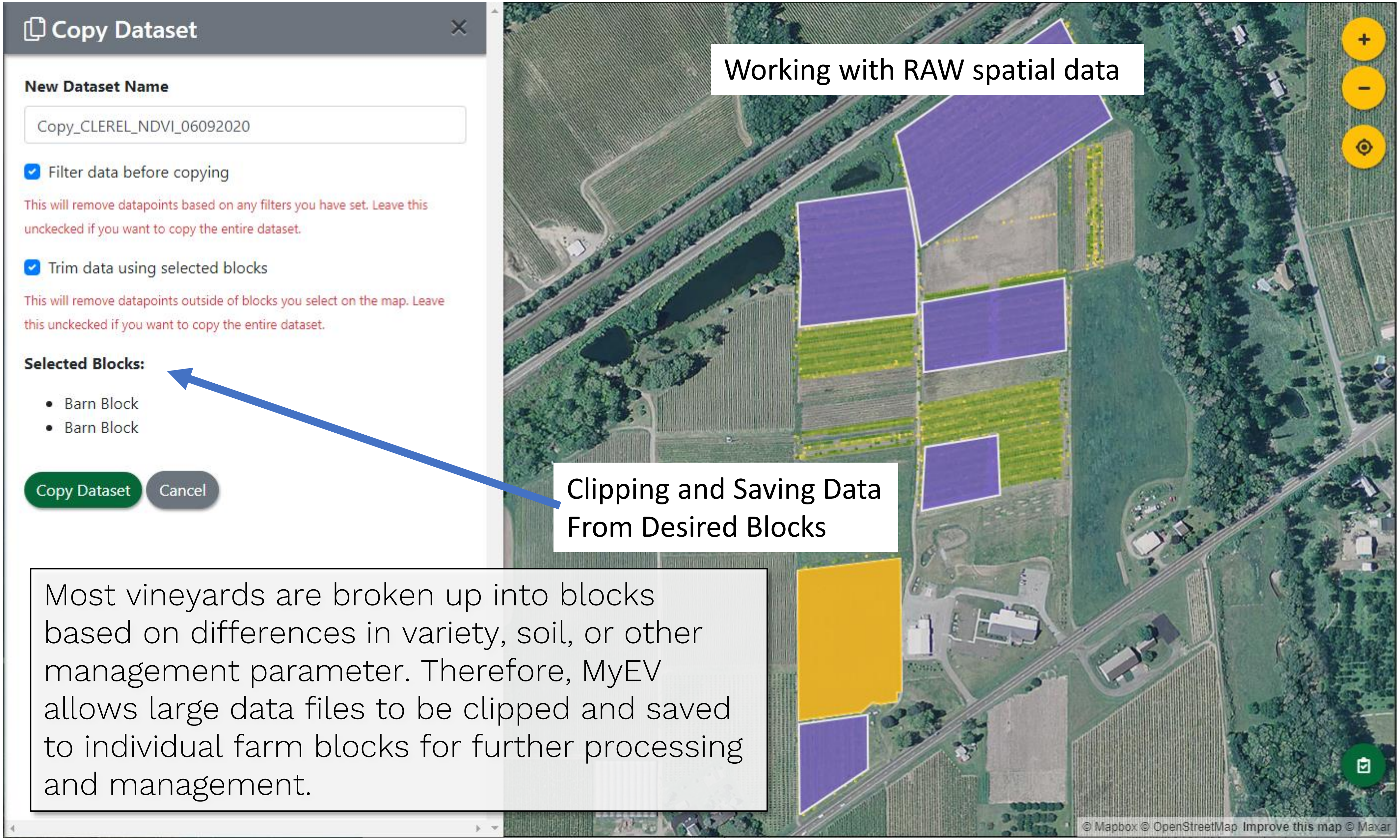
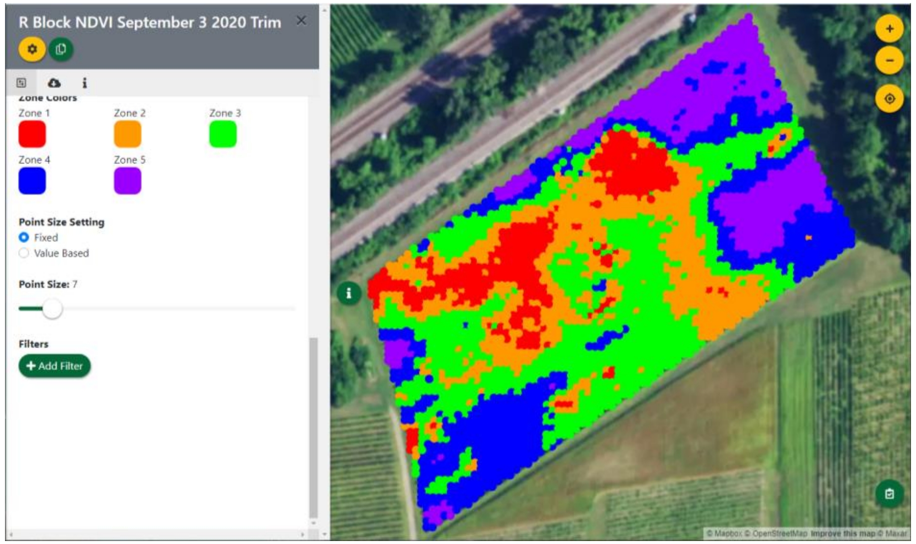


Most vineyards are broken up into blocks based on differences in variety, soil, or other management parameter. Therefore, MyEV allows large data files to be clipped and saved to individual farm blocks for further processing and management.

Proximal field sensors in the vineyard

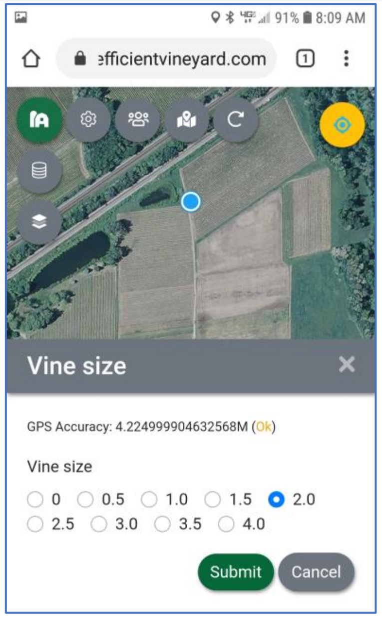
High End Investment

Vineyard Sensors
External GPS
Commercial Data Logger



High density spatial data from proximal field sensor

MyEV is flexible in accepting geo-referenced data from field sensors or the MyEV data collector



MyEV Smartphone app showing data collector

Low End Investment

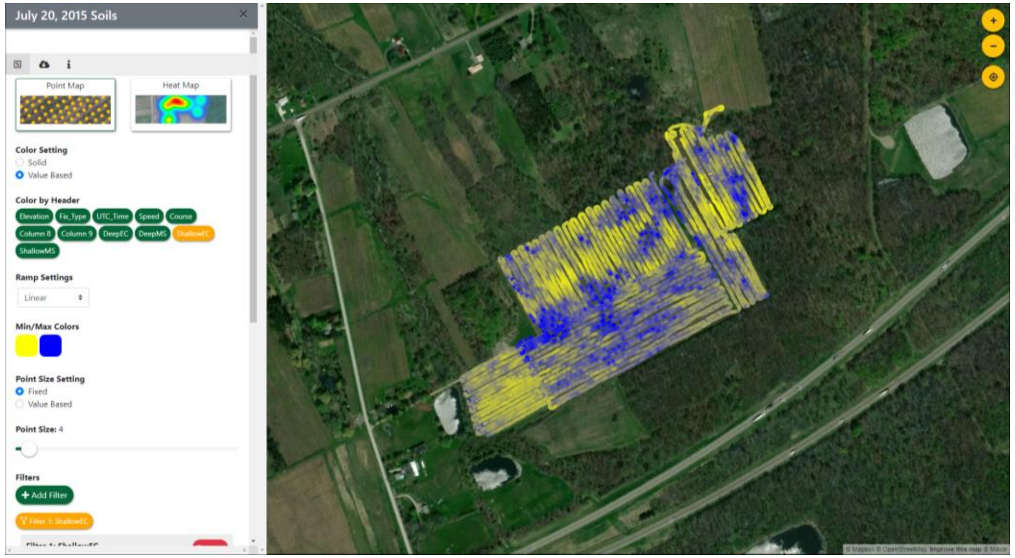
Human Observation
GPS enabled phone
“Data Collector” function

Moderate density spatial data from visual observations recorded on MyEV smartphone app

How and Where is MyEV being used by the Industry

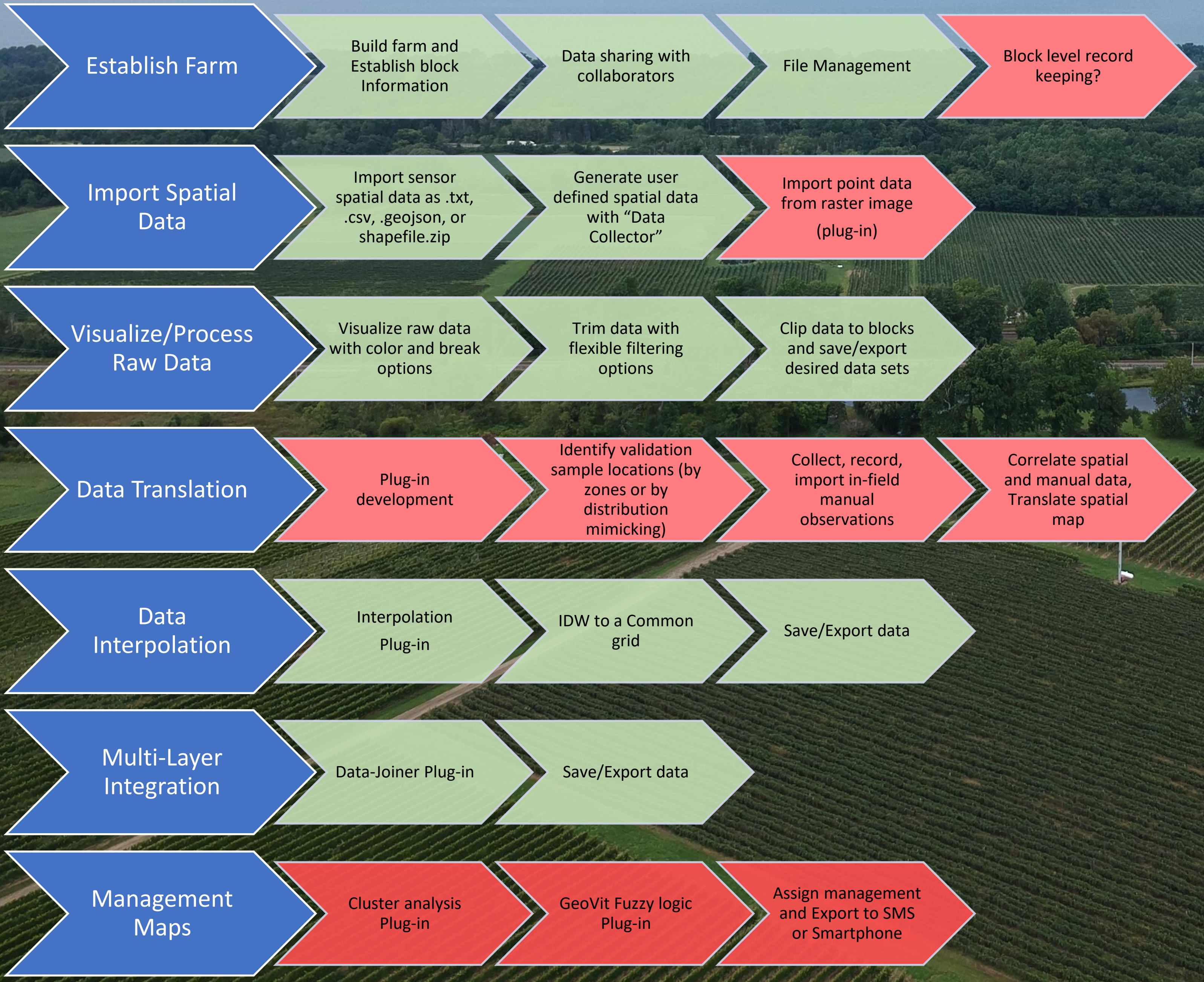
Where MyEV Accounts have been established in the U. S.

Where grapes are produced in the U. S.



Vineyard Soil mapping in New York

Scouting for virus infected vines in CA



Accomplishments and Planned Development for MyEV

The base MyEV platform for establishing user accounts and block maps, importing and visualizing raw data, and basic data interpolation and exporting has been developed and is currently live and accepting grower feedback.

Future development will focus on advanced plug-in development for data processing, in-field data validation, and generating spatial prescription management maps.