March 2017

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DATA-DRIVEN **INSIGHTS** FOR VINEYARDS

What do great wine, water on mars and drones have in common?

e Institute/AP/File | View Caption

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Today: Drone Technologies in Viticulture

AGENDA

Technology Context: big data, precision ag, drones

Background: SkySquirrel

Focus: vineyards

Closing

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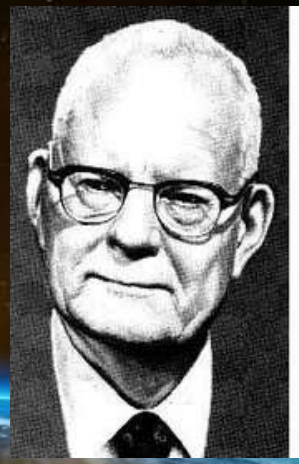
- Canadian Technology Co.
- Manufacture drones & sensors
- Cloud-based data analytics
- Joint venture with VineView (Napa Valley)

2017: The Information Age



"Without data you're just another person with an opinion"

- W. Edwards Deming

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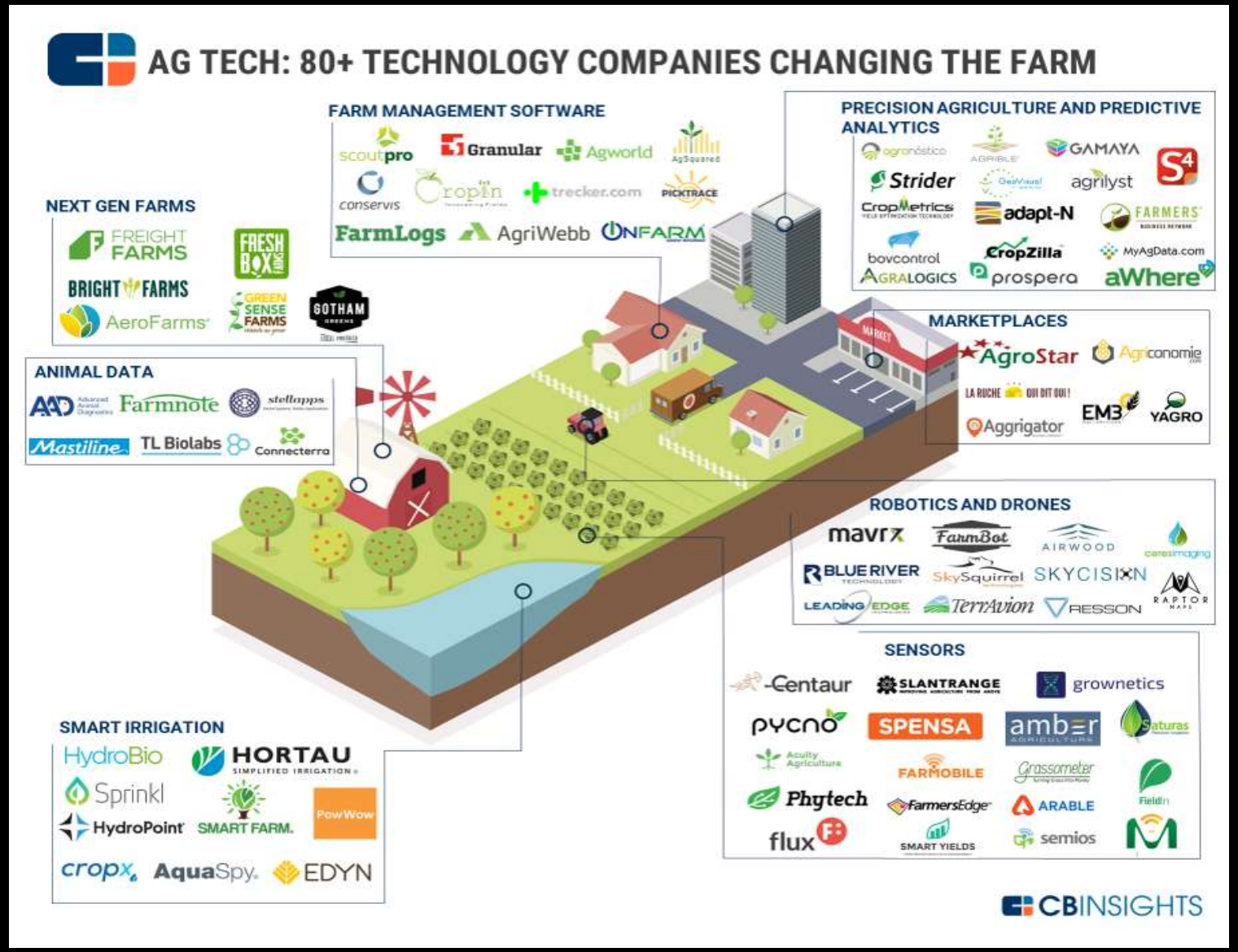
Precision Agriculture For a Sustainable Future

$4.6B AgTech funding in 2015



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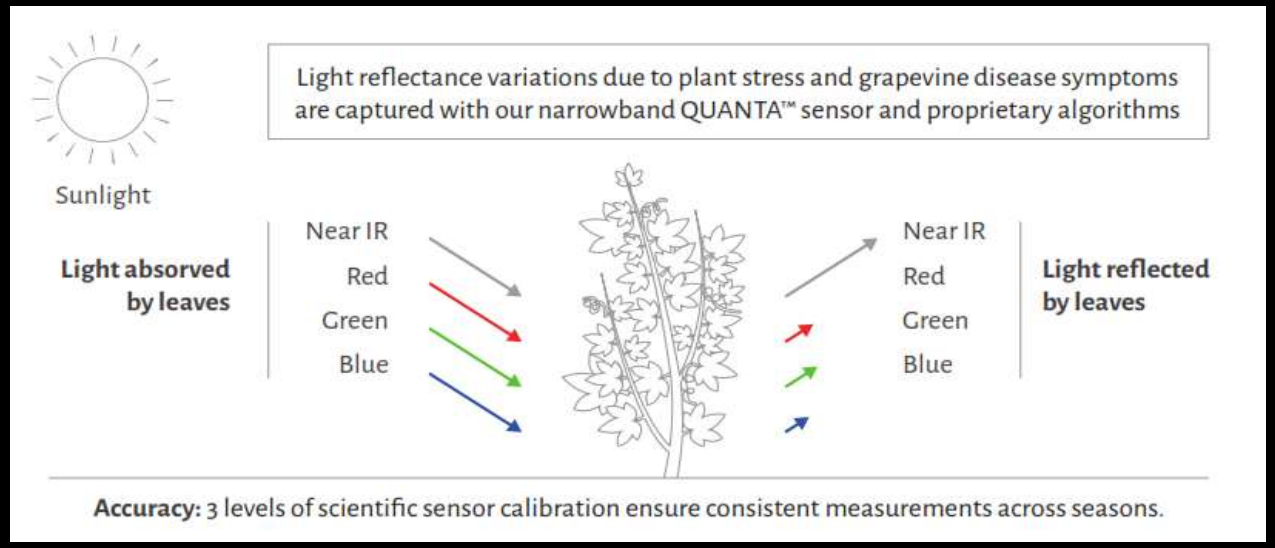
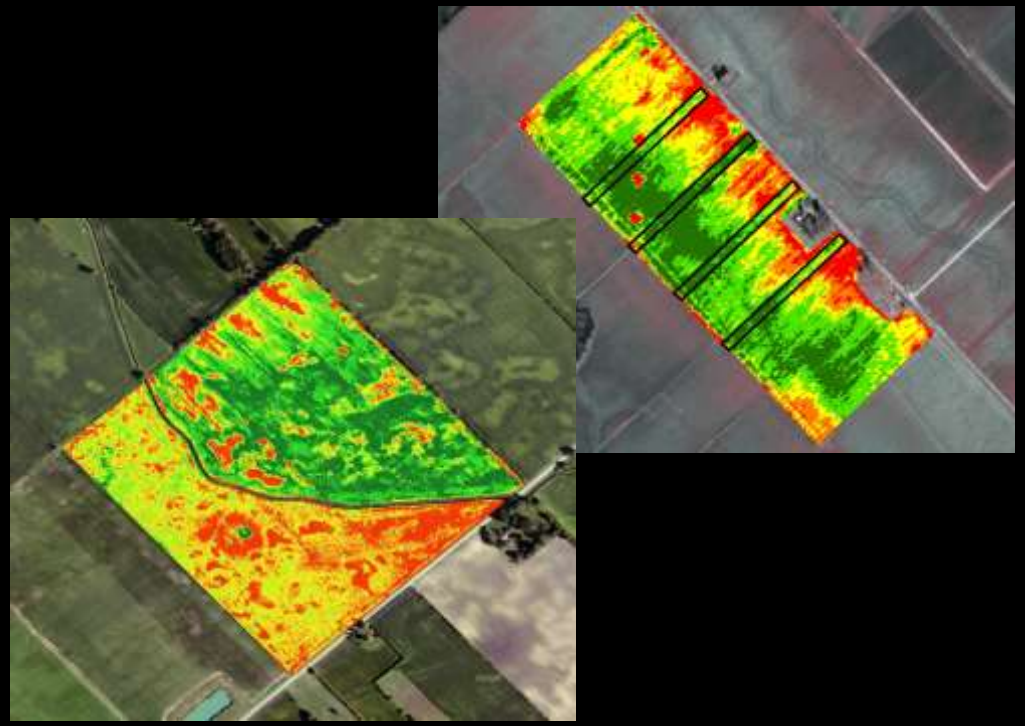
http://video.nationalgeographic.com/video/magazine/food-by-the-numbers/ngm-precision-agriculture

Plant Health Diagnostics: NDVI

- **NDVI** = **N**ormalized **D**ifference **V**egetation **I**ndex
- Also known as "vigor"
- Plants convert visible light into chlorophyll during photosynthesis
- Measure of light reflectance off the leaves as an indication of plant health
- Challenge: relative measure (not calibrated), results are variable





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Evolution: NDVI and Remote Sensing

1970s: NDVI first used by NASA (satellite)

1990s: NDVI in vineyards (airplanes, California)
Mondavi-NASA project: segmented harvest based on vigor; low vigor = high wine quality

2016: Drones make tech available to everyone, improved resolution, EVI

1970s: satellite

1990s: airplanes, grapes

2016: drones

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Rise of the drones

https://www.youtube.com/watch?v=wU2R_RCVD7c

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SPECIALIZED IN SOLUTIONS
FOR VINEYARDS
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technologies

The SkySquirrel **Solution**

A TURN-KEY IMAGING SOLUTION FOR VINEYARDS

AQWEO™ QR-200

Worry-free GPS autopilot

Multi rotor for easy take-off and landing between rows

Industrial grade components

QUANTA™ CAMERA

Patent-pending, multispectral camera

Customizable optical filters

Onboard, real-time calibration for data accuracy

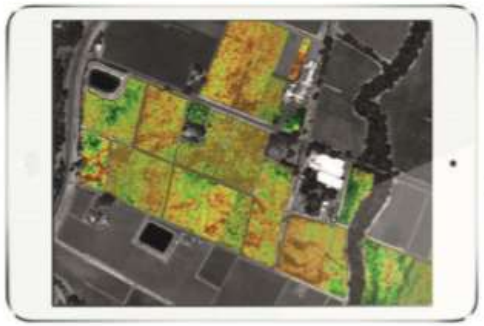
DRONEFUSE™ CLOUD ANALYTICS

Powerful, cloud-based image analysis service

Complex atmospheric calibrations

Scientific algorithms that do the work for you

Free data storage



THREE INTEGRATED TECHNOLOGIES

1. Autonomous Drone
2. Multi-Spectral Camera
3. Cloud Data Analytics

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Drones for higher resolution, more accurate data

Resolution

3-10 cm
Individual plants

1-10 m
Large areas

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Quanta: customized for vineyards

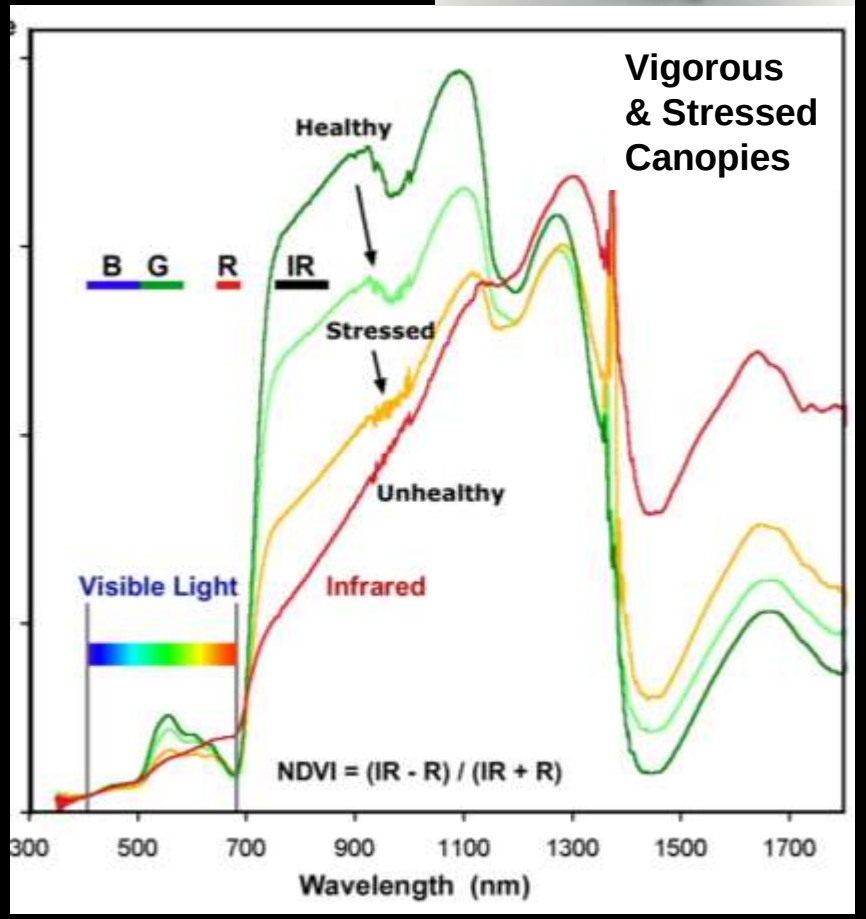
Four customizable optical filters

- ✓ RGB-NIR (Vigor)
- ✓ Narrow bands for disease detection, water content

Calibration, calibration, calibration

1. Radiometric calibration
2. Ground reference object
3. On-board, 8-channel calibration sensor
4. Algorithms for atmospheric calibration

Visible light is only fraction of plant information available by remote sensing



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VineView's Algorithms & Processes

Drs. Matthew Staid & Melissa Staid

- Ph.D. in geological sciences from Brown University
- 20 years experience in remote sensing applications including NASA Planetary Missions
- Co-founder & President of VineView
  - ✓ 15 years aerial imaging of vineyards
  - ✓ 40% of vineyards in Northern California
  - ✓ Recognized leaders in vineyard aerial data
- Winners of:
  - ✓ 2016 Innovation+Quality Award
  - ✓ 2015 Vintage Report Innovation Award
  - ✓ 2015 Vineyard Tech Award (North Bay Biz J.)

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VineView
Scientific Aerial Imaging, Inc.

NDVI* results are different, 2 hours later

11:59 am

2:09 pm

Shadows related to row direction can cause apparent changes in vigor at specific times of day (between morning and afternoon NDVI images)

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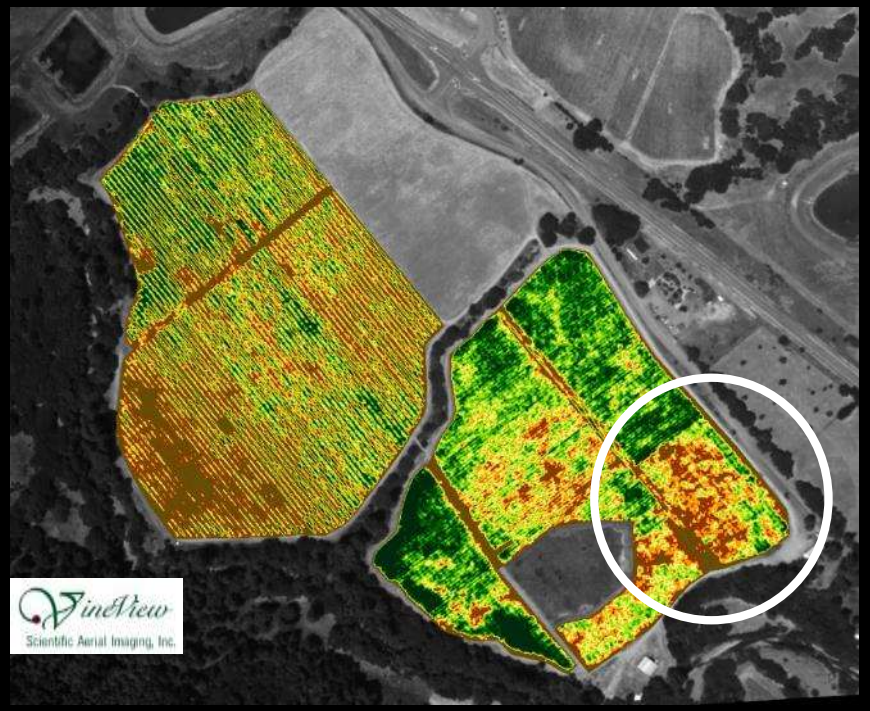
*NDVI = Normalized Difference Vegetation Index

Calibrated Enhanced Vegetation Index (EVI) provides consistent results

11:59 am



2:09 pm

EVI is much less sensitive to shadows & soil boundaries & more directly sensitive to Leaf Area Index

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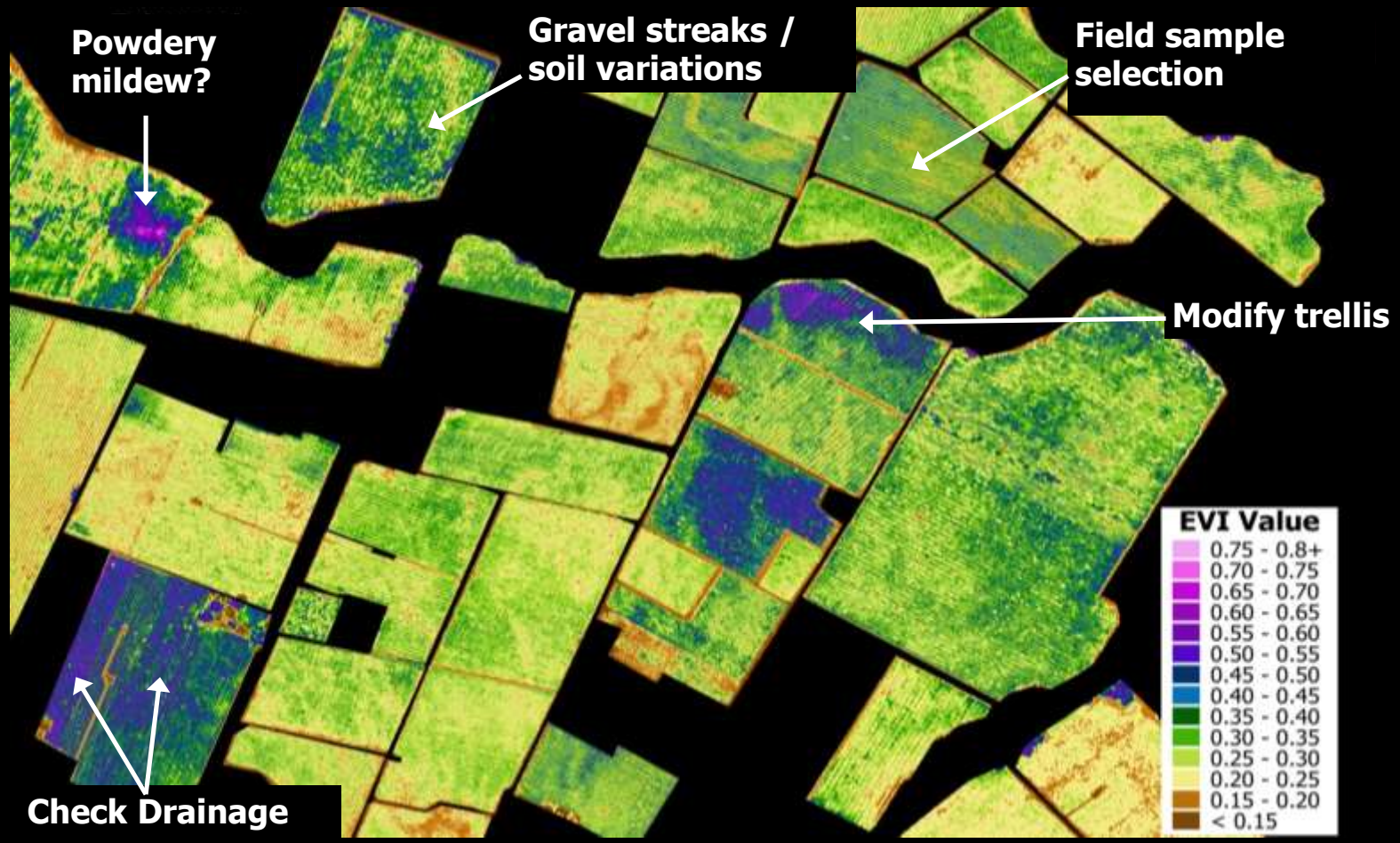
Calibrated EVI = Reliable Information

High Vigor Areas

- ✓ Segmentation of grape quality for higher pricing
- ✓ Ensure proper drainage & irrigation management
- ✓ Cover crop to control soil moisture
- ✓ Check for disease: Powdery Mildew?
- ✓ Adjust crop load
- ✓ Remove leaves
- ✓ Modify trellising
- ✓ Cultivation planning



Uniformity assessment → Segmented Harvest / Guide field measurements
Identify problems → Find solutions & monitor over time

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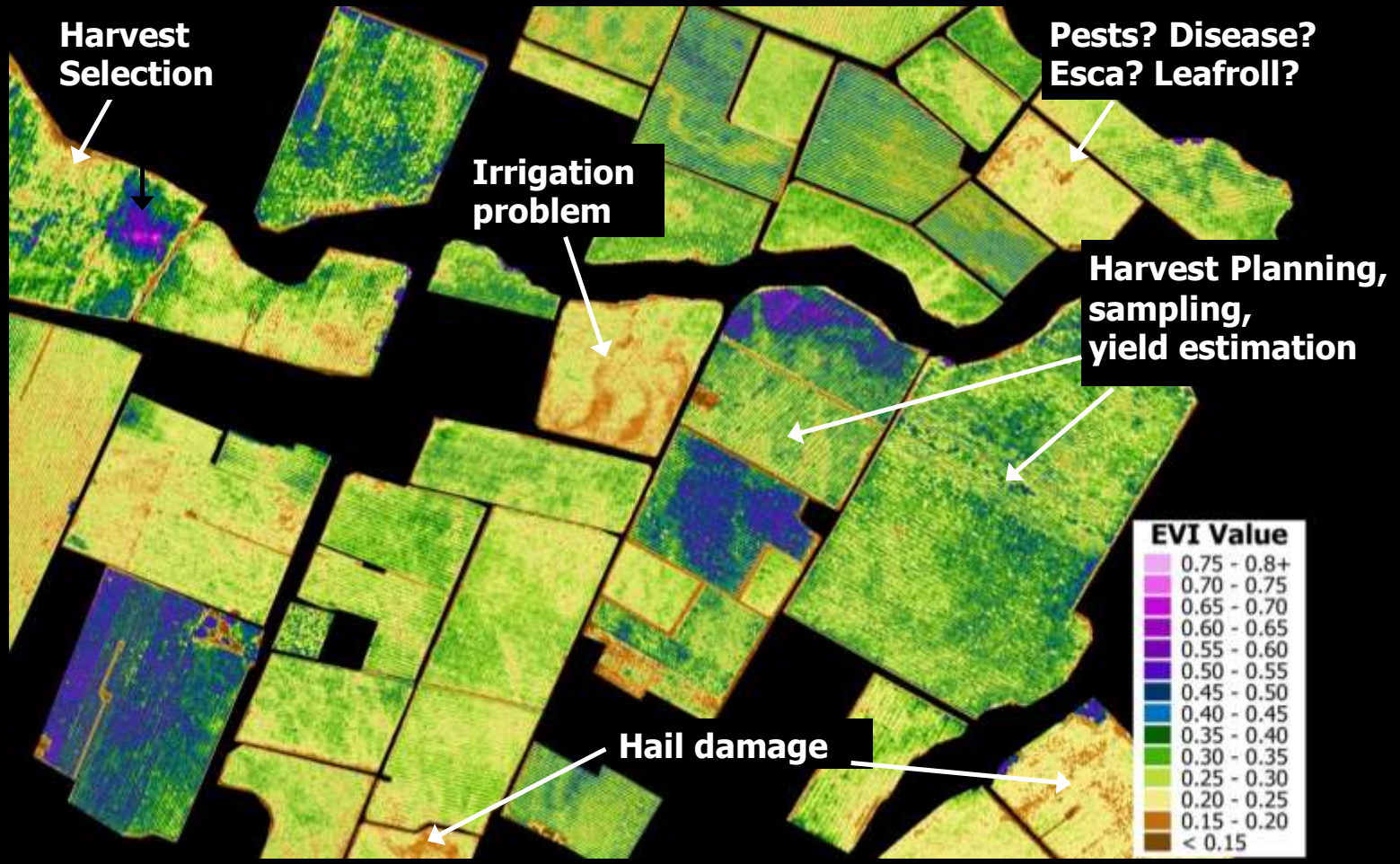
Calibrated EVI = Reliable Information

Low Vigor Areas

- ✓ Examine & modify irrigation
- ✓ Target fertilizer
- ✓ Check for disease
- ✓ Check for insects/apply pesticide
- ✓ Hail damage
- ✓ Harvest planning
  - Sampling
  - Yield estimation
  - Segmentation
  - Fruit dropping



Uniformity assessment → Segmented Harvest / Guide field measurements
Identify problems → Find solutions & monitor over time

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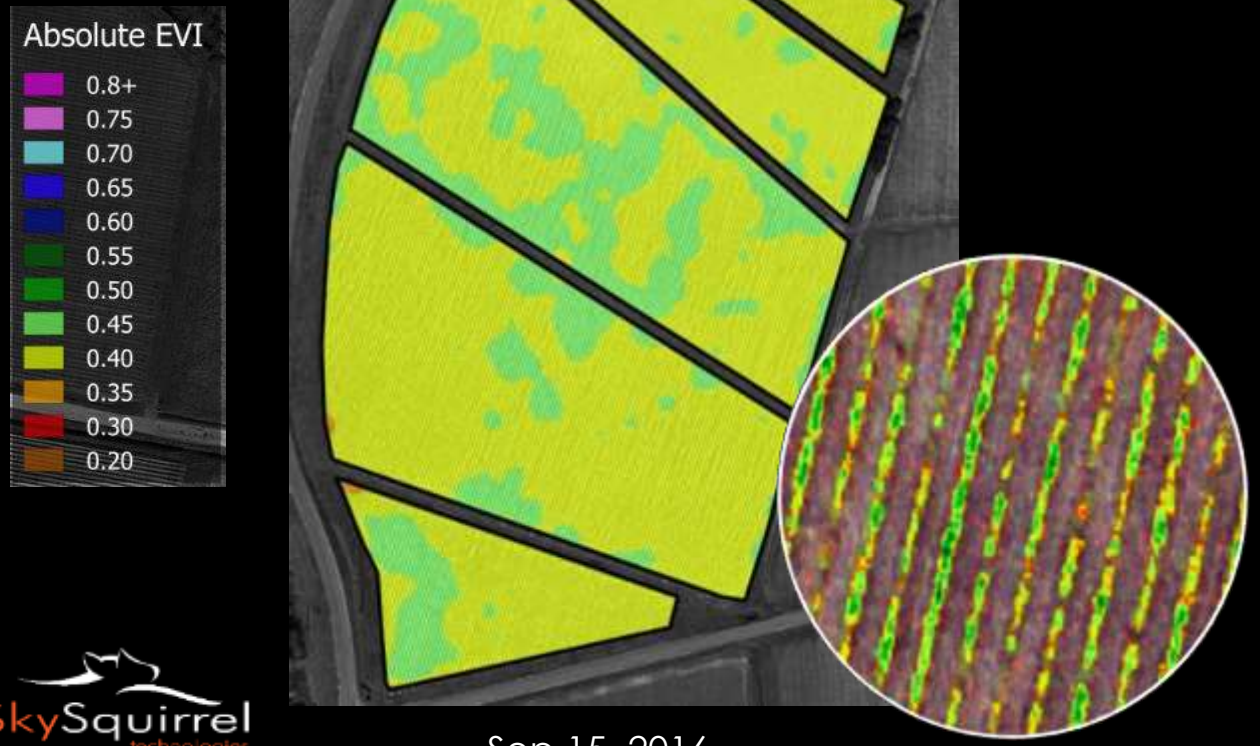
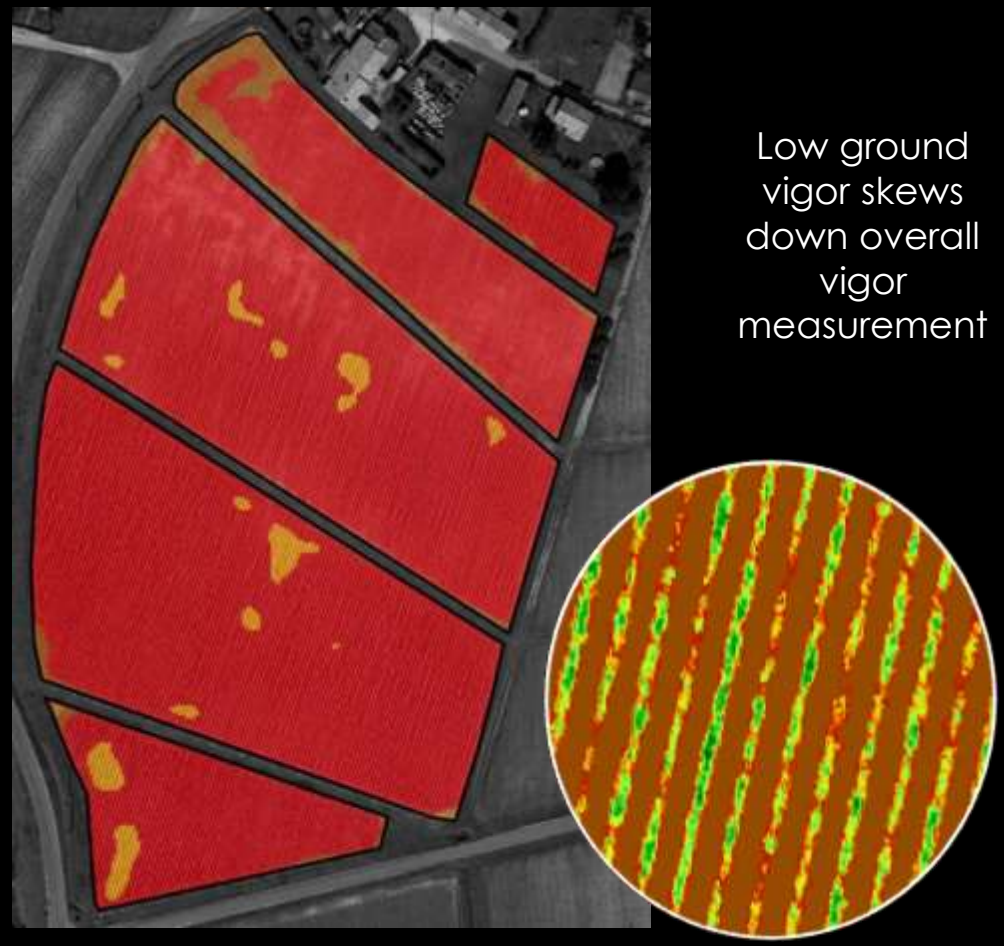
Filtering ground data provides accurate vine health information

Absolute EVI – VineCanopy



Sep 15, 2016

Absolute EVI – with ground cover



Low ground vigor skews down overall vigor measurement

Sep 15, 2016

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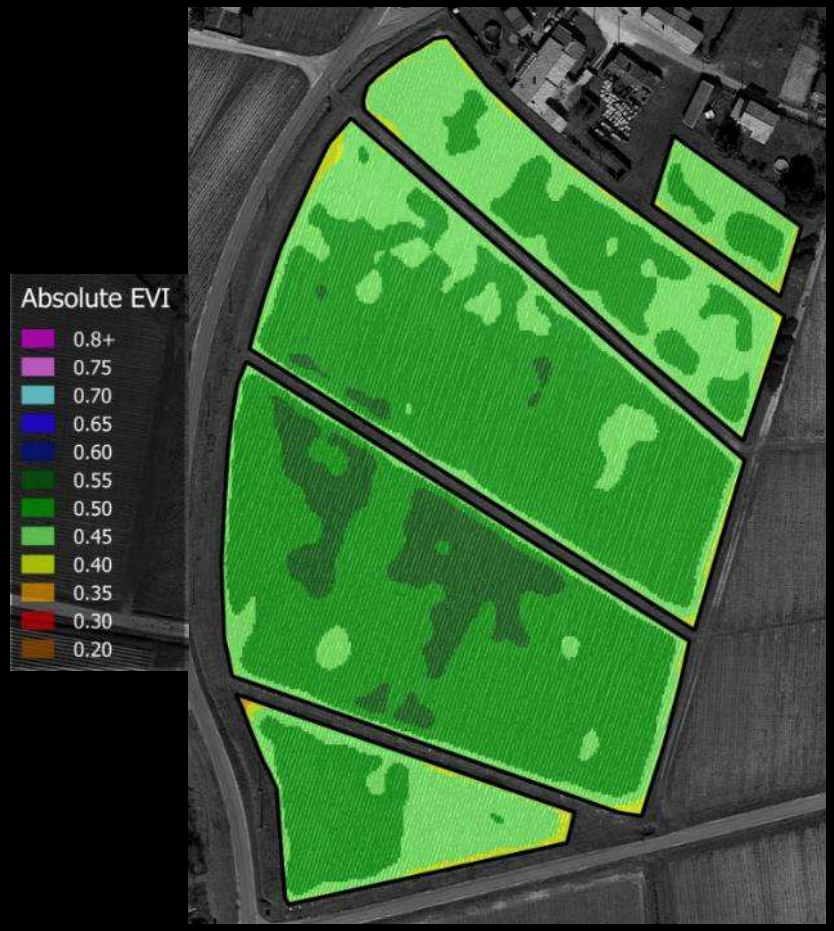
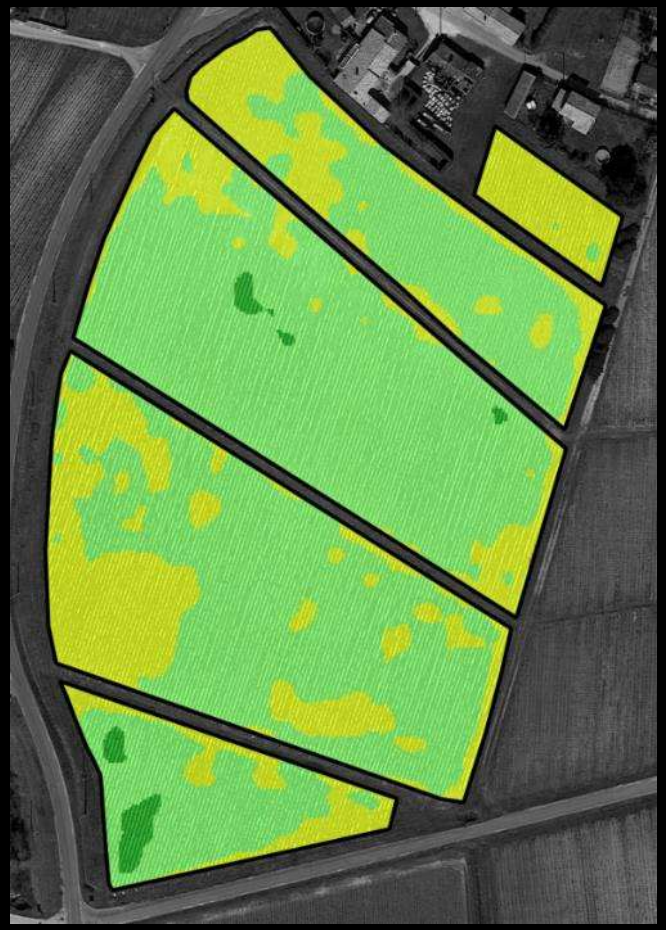
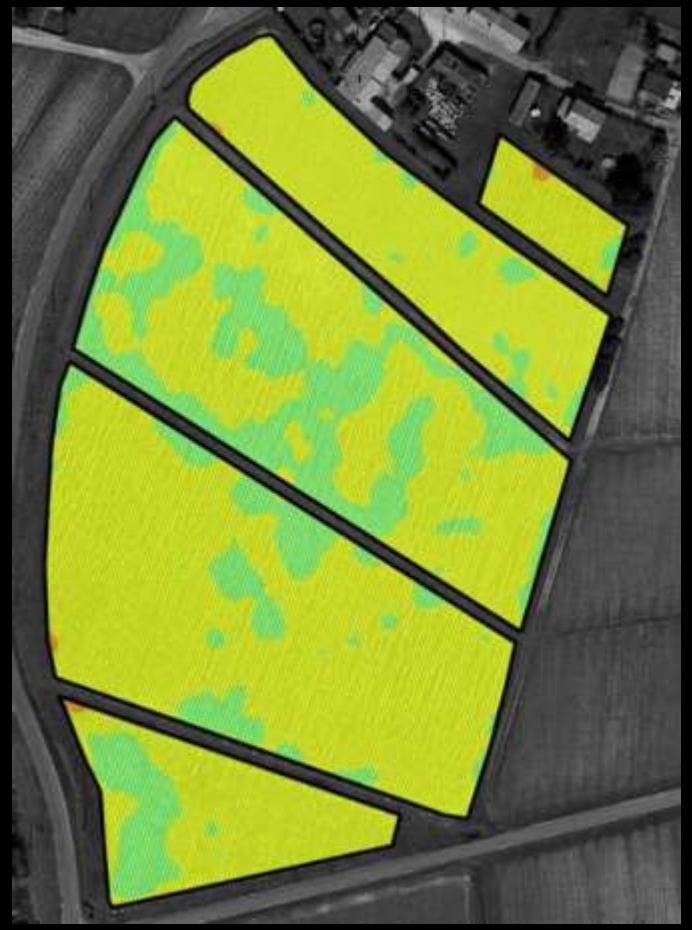
Compare results between fields and across time periods with Absolute EVI



Absolute EVI
July 24, 2016



Absolute EVI
Sep 1, 2016



Absolute EVI
Sep 15, 2016

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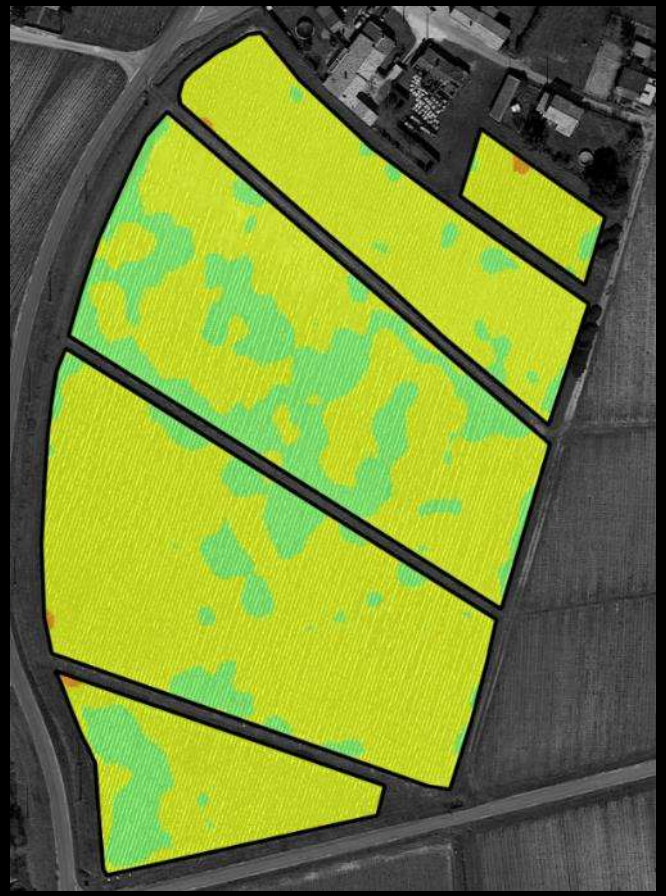
Zoom-in to view variability and details of each parcel with Parcel EVI

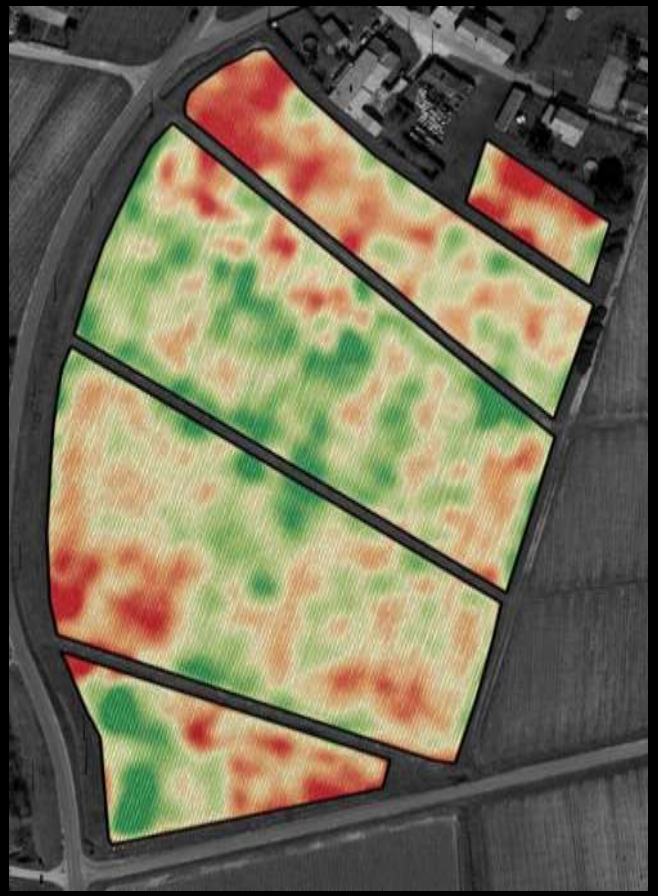
Absolute EVI



Sep 15, 2016

Zoom-in details

Parcel EVI



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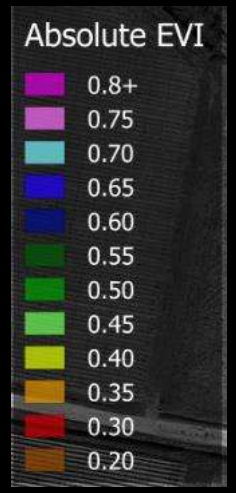

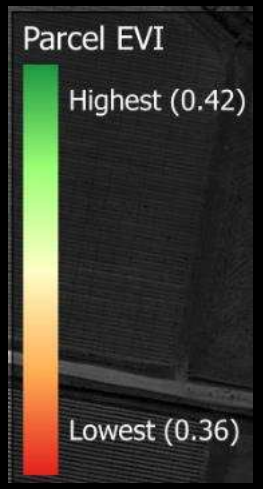

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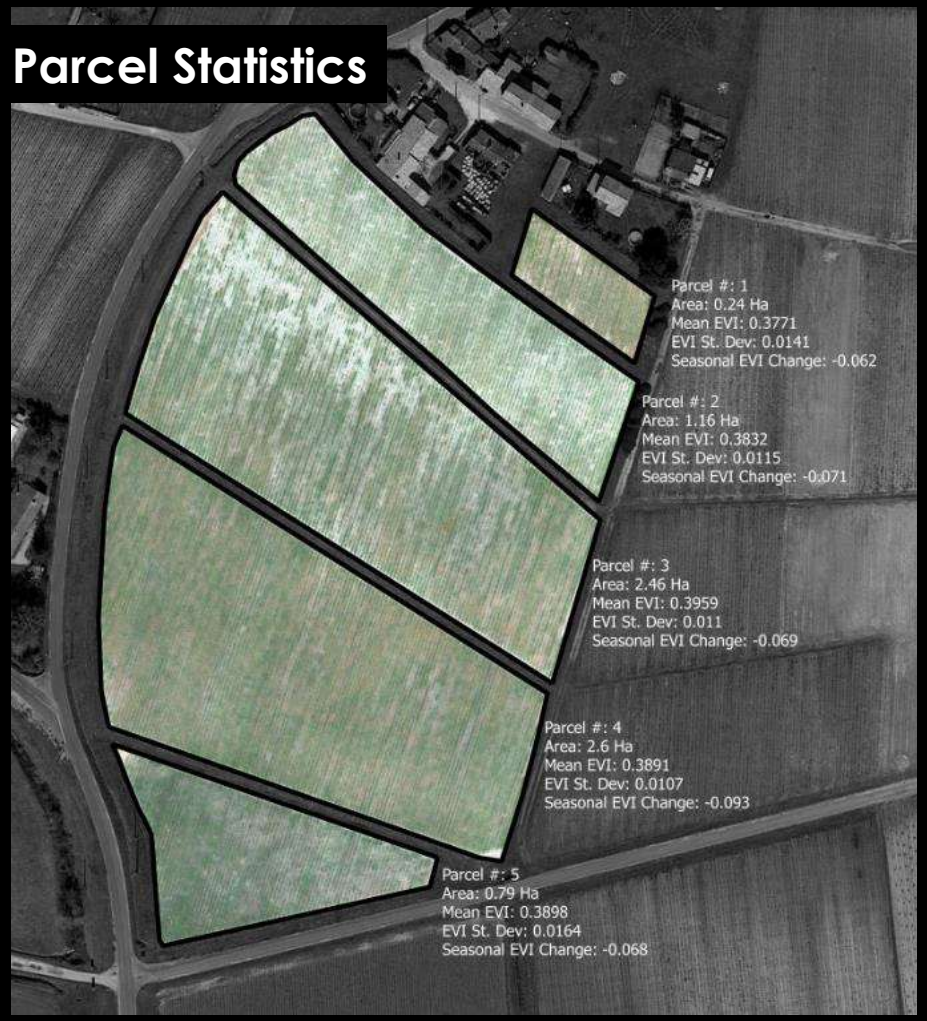
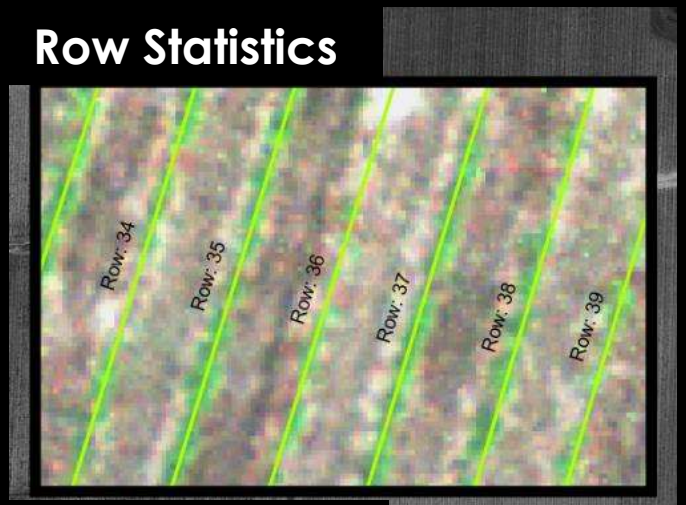
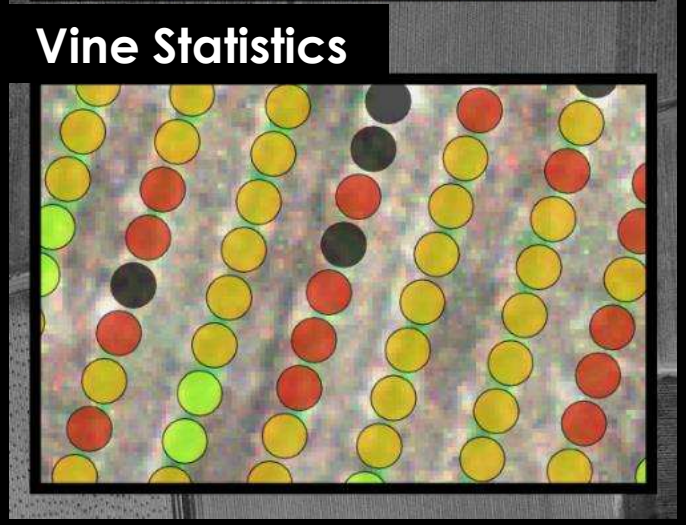
VineMetrics provides EVI vigor statistics for comparison between parcels, rows and vines







Vine by Vine Metrics
(Vine Statistics)
Coming May 2017

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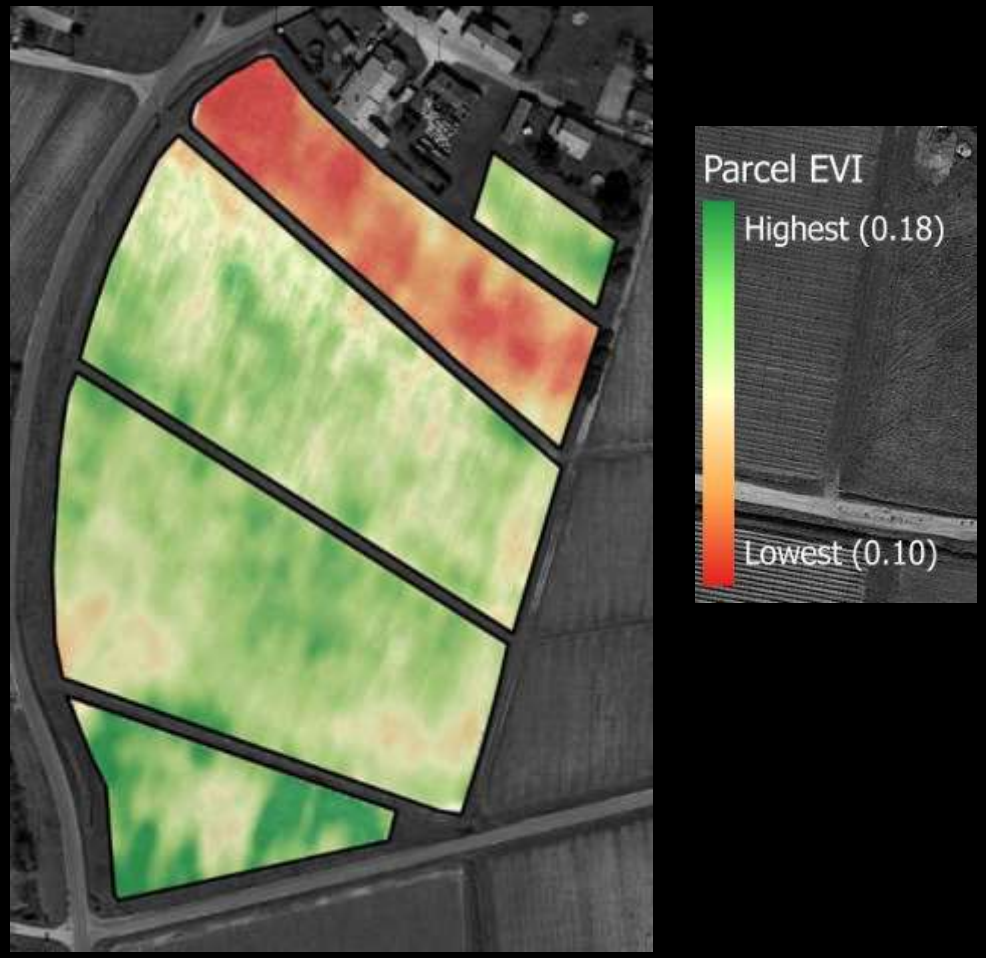
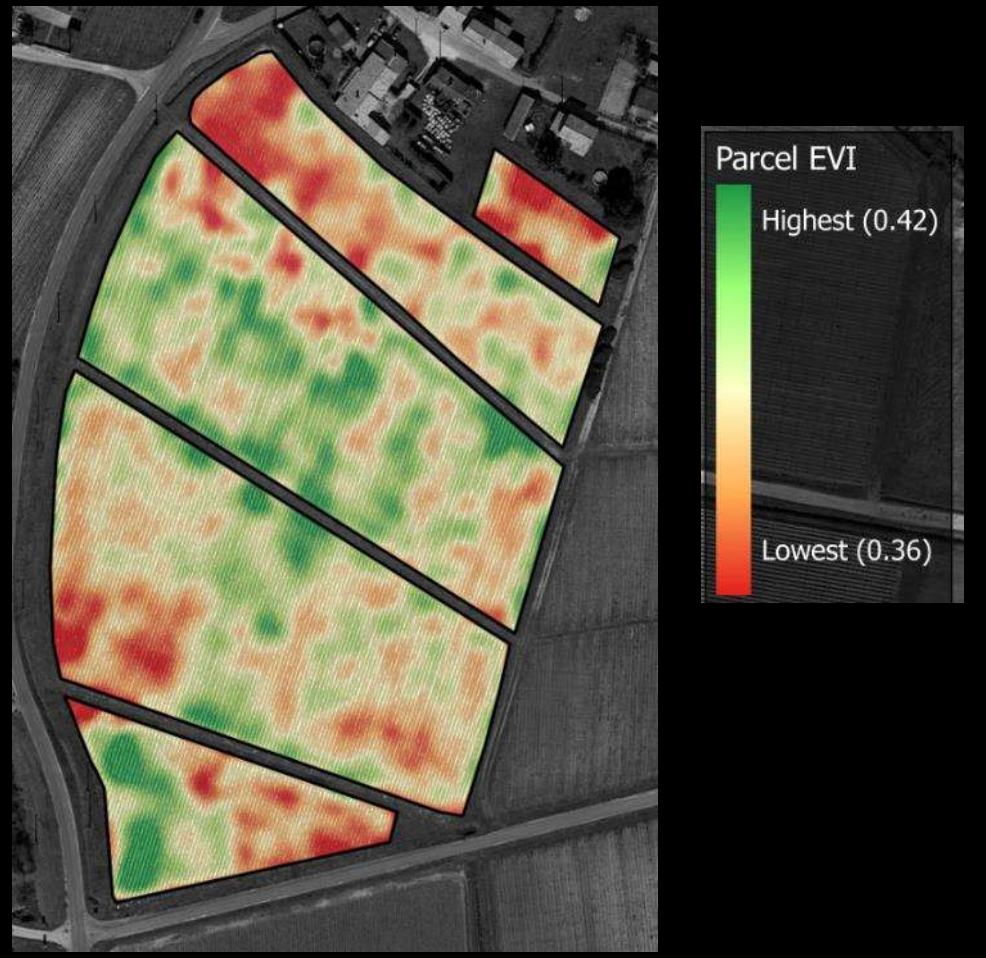
Compare EVI vigor results between VineCanopy and CoverCrop

Calibrated Parcel EVI – CoverCrop



Calibrated Parcel EVI – VineCanopy



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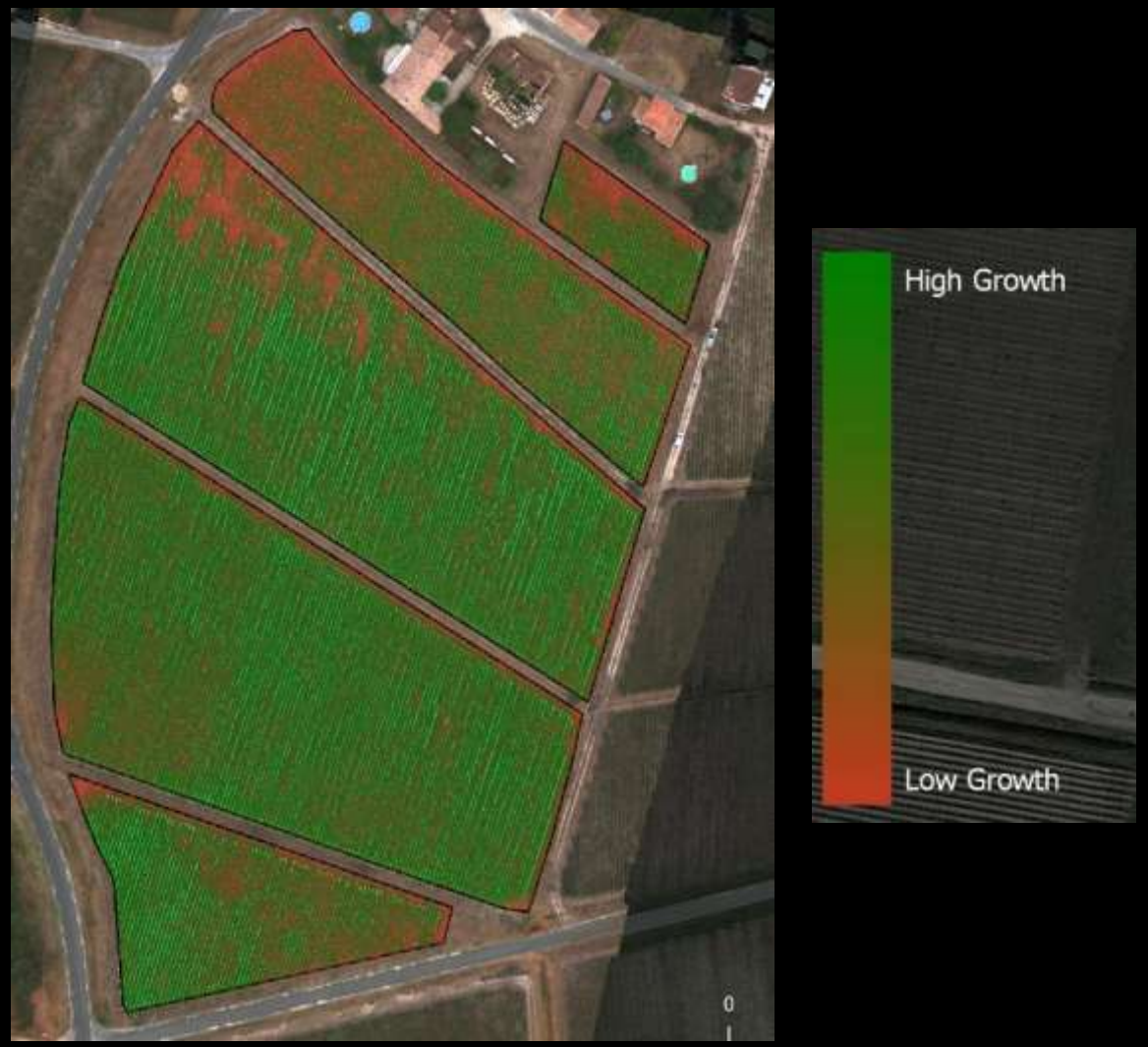
Identify locations for high probability of missing vines with CanopyCoverage



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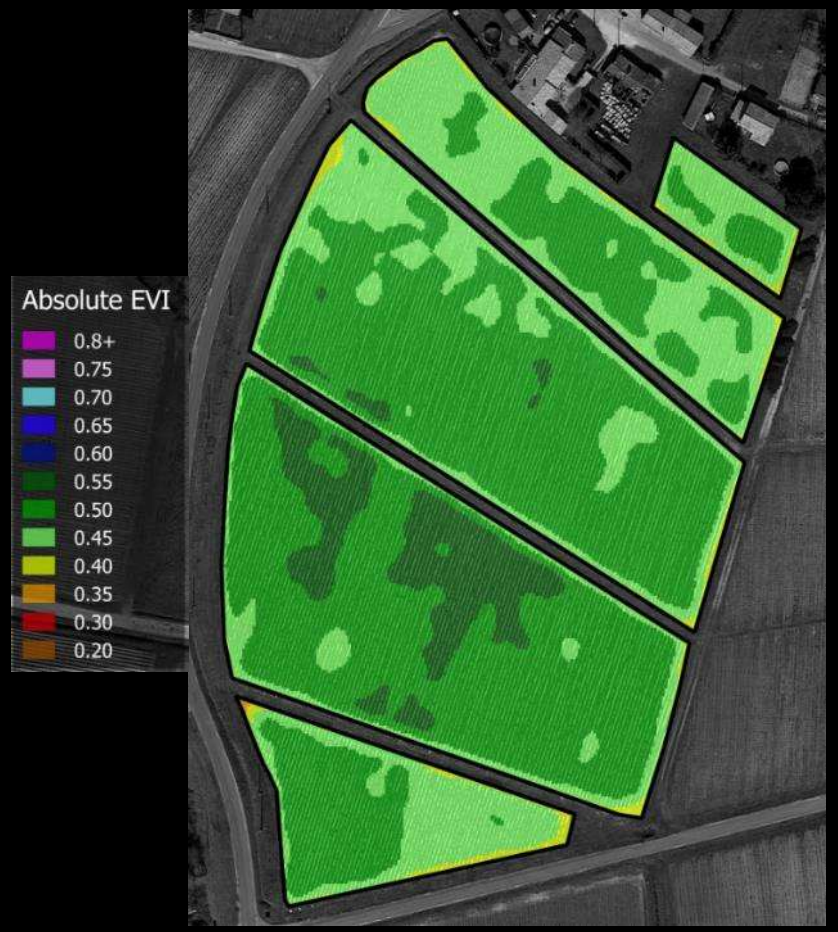
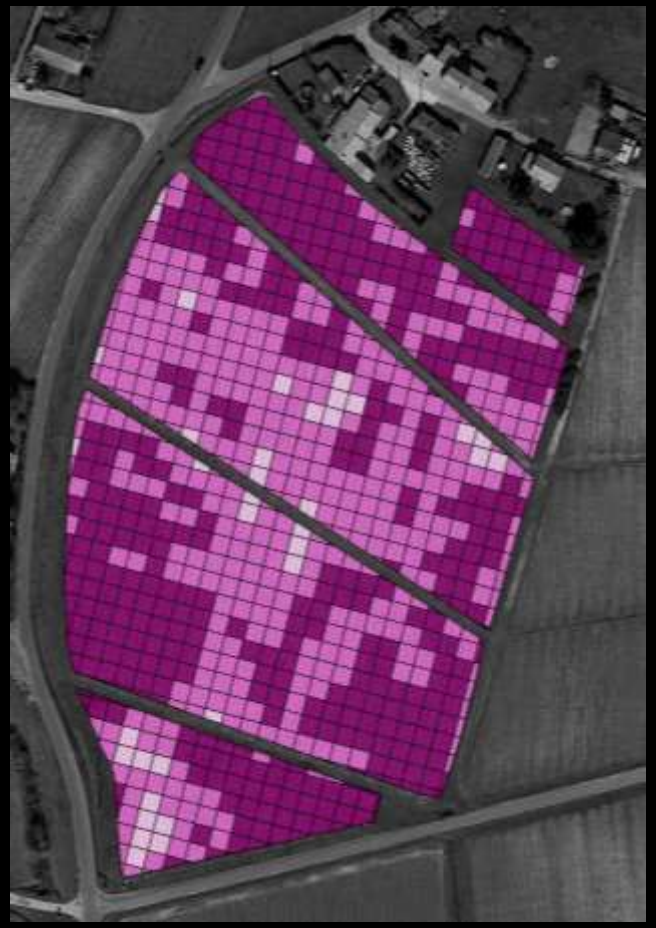
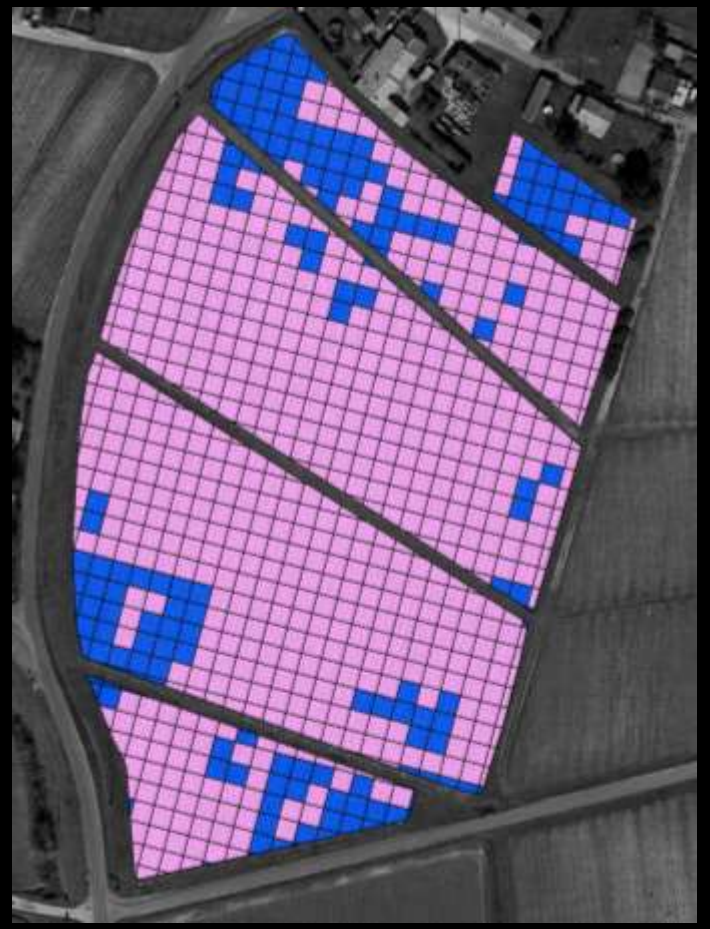
Translate EVI data into ZoneMaps for applications such as harvest segmentation or fertilizer optimization with ground data and client input



Absolute EVI
July 24, 2016





NextGen Remote Sensing

Based on 15 years of experience applying NASA technologies to Californian vineyards, SkySquirrel Technologies brings innovative new data products to commercial vineyards

Disease Detection

- Leafroll Disease
- Flavescence Doree

Water Index

Digital Elevation Model

Thermal Map

SkySquirrel technologies

The Problem

Disease is costing vineyards $15 Billion every year

Leafroll, Flavescence Doree, ESCA

- 30-50% of vineyards globally infected
- $10k-$16k loss per infected acre

Leafroll "…threatens the sustainability of the wine grape industry"
– American Vineyard Foundation

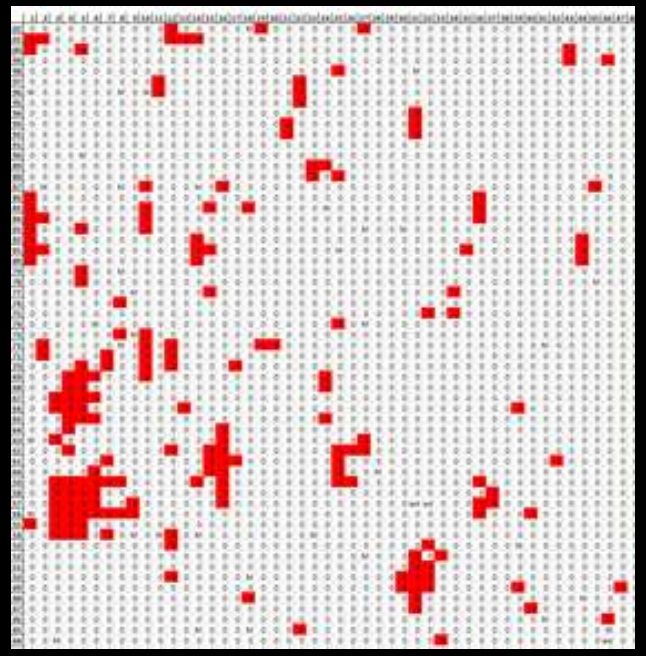
Flavescence Doree "…measures are polluting, costly, and run counter to wine industry moves to reduce pesticide use"
– French Institute for Ag Research

ESCA "…could become as devastating [to vineyards] as a 19th-century plague"
- French Chamber of Agriculture

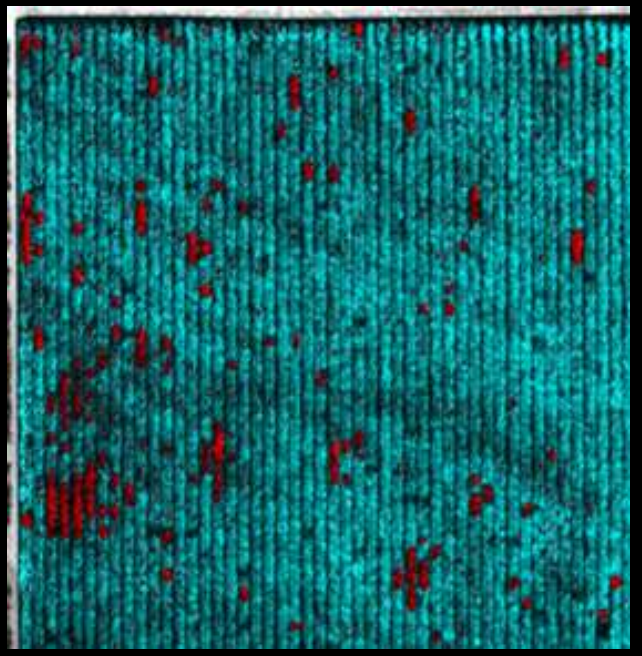
Leafroll Detection, Scientifically Proven (Napa)

VineView
Scientific Aerial Imaging, Inc.

Visible color image



Field scouting
(M. Cooper, UCCE data)



Aerial Leafroll Map:
Red = High Blue = Low

2013-2014 study between VineView & University of California

- ✓ Study conducted w/ UC Davis and Napa County scientists
- ✓ 5 vineyards blocks flown in 2013 & 2014
- ✓ Field scouting was done on all vines; some also lab tested

Rate of successful aerial detection was > 95%

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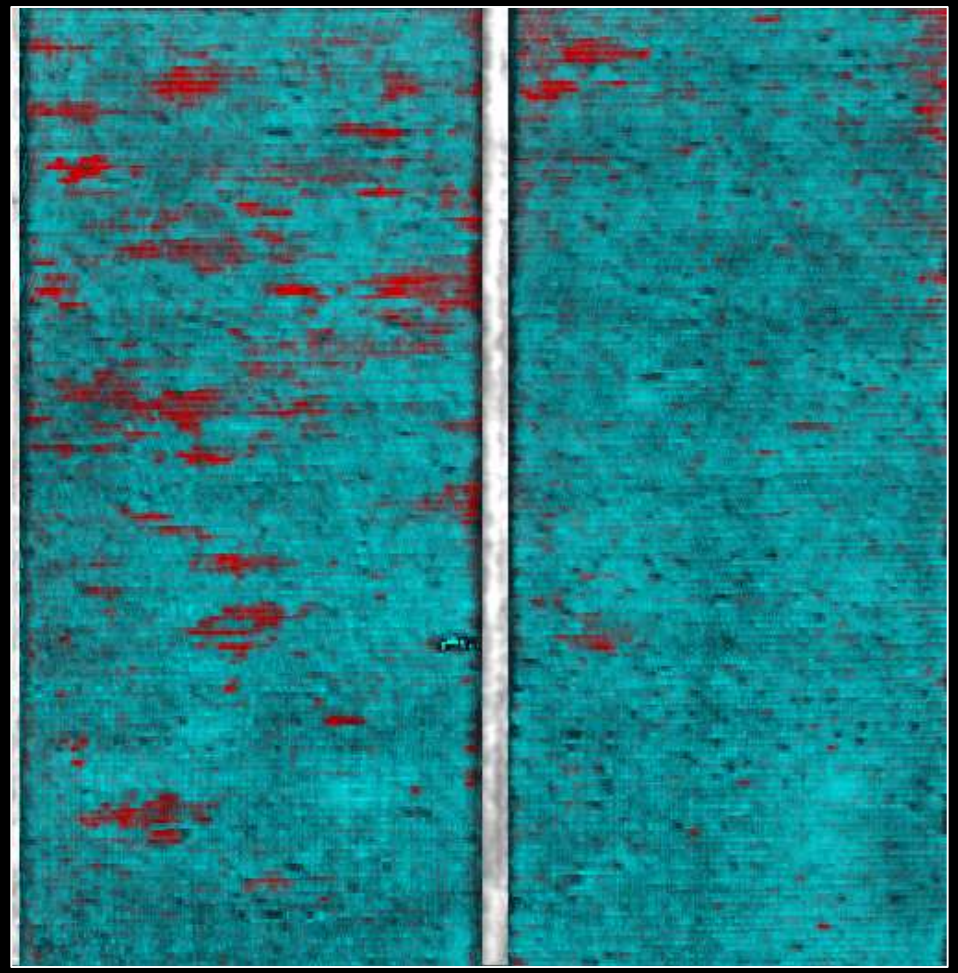
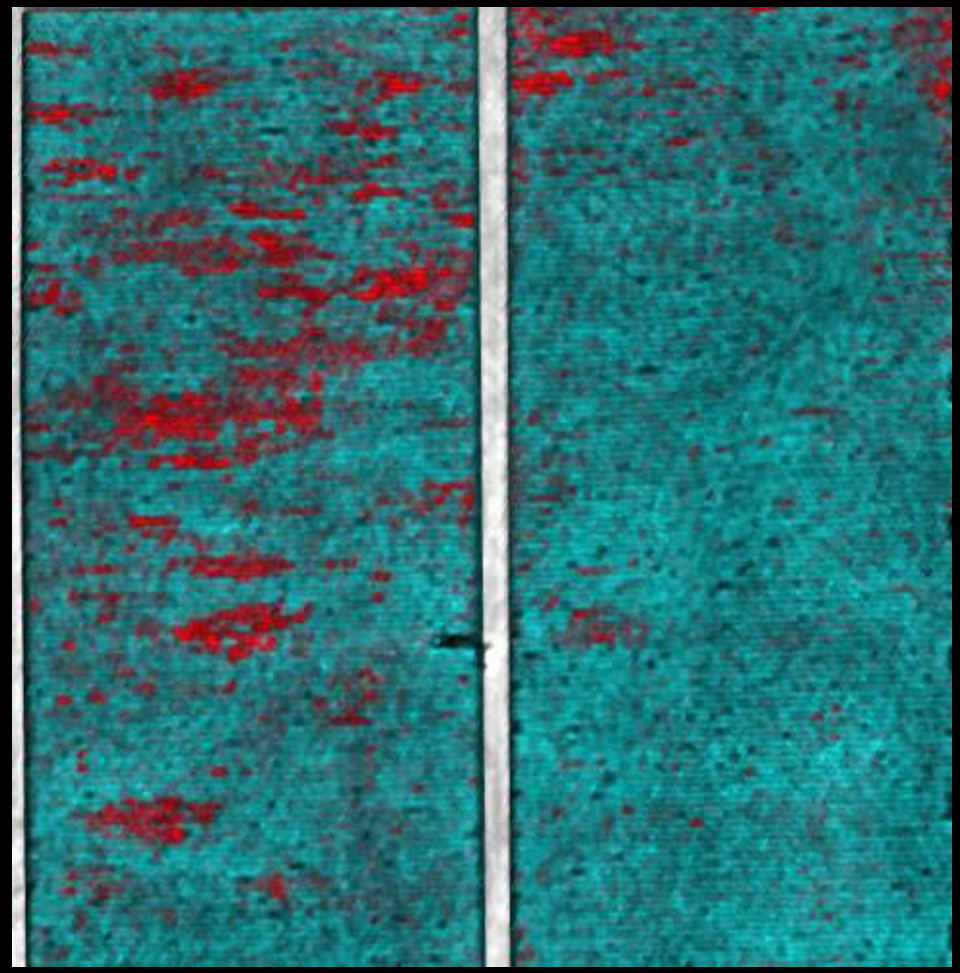
Leafroll progression, 1 year





High = Red Low = Blue

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Technology

A turn-key imaging solution for vineyards

Proprietary Camera Technology

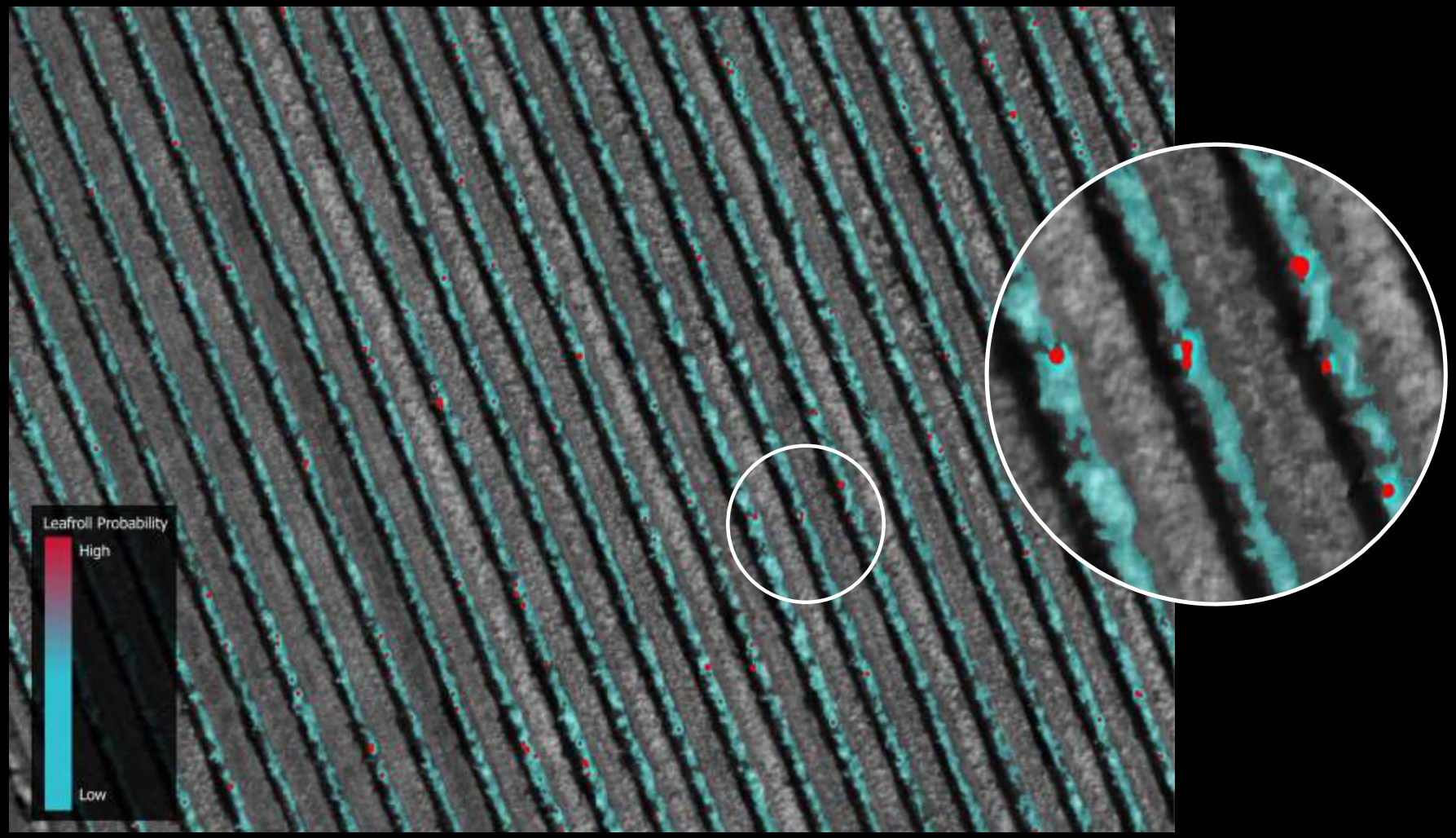
- Multi-spectral sensor designed to detect specific disease symptoms
- Adapted for UAV

Spectral Signature Analysis

- Based on NASA technology
- Database of symptoms based on over 12 years of imaging
- Proven accuracy of 95% for Leafroll Disease - Unique
- Applying methods to other problems

Leafroll Disease Detection (drone): Raw Data

Preliminary results, 2016



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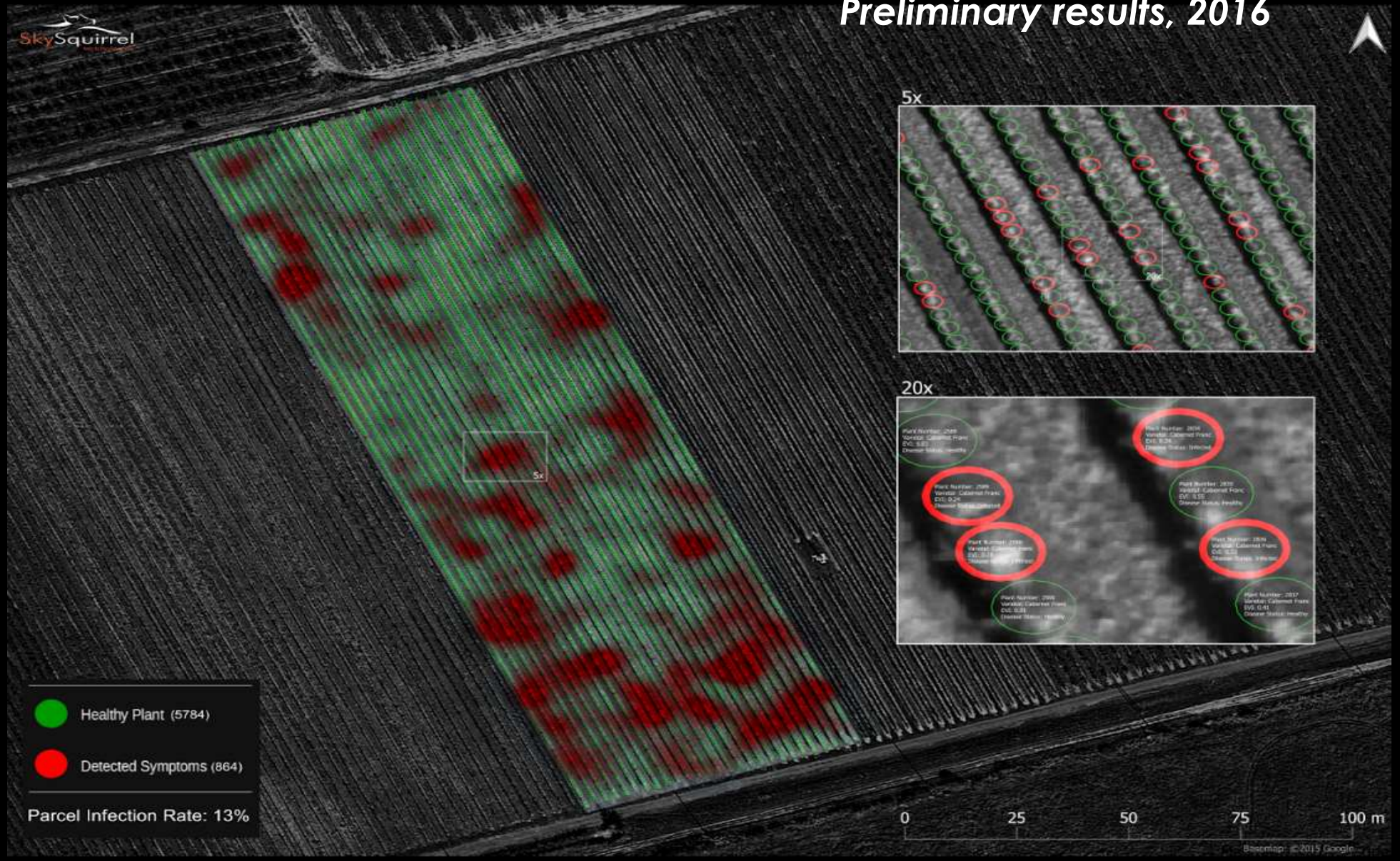
Leafroll Disease Detection (drone): Heat Map

Preliminary results, 2016



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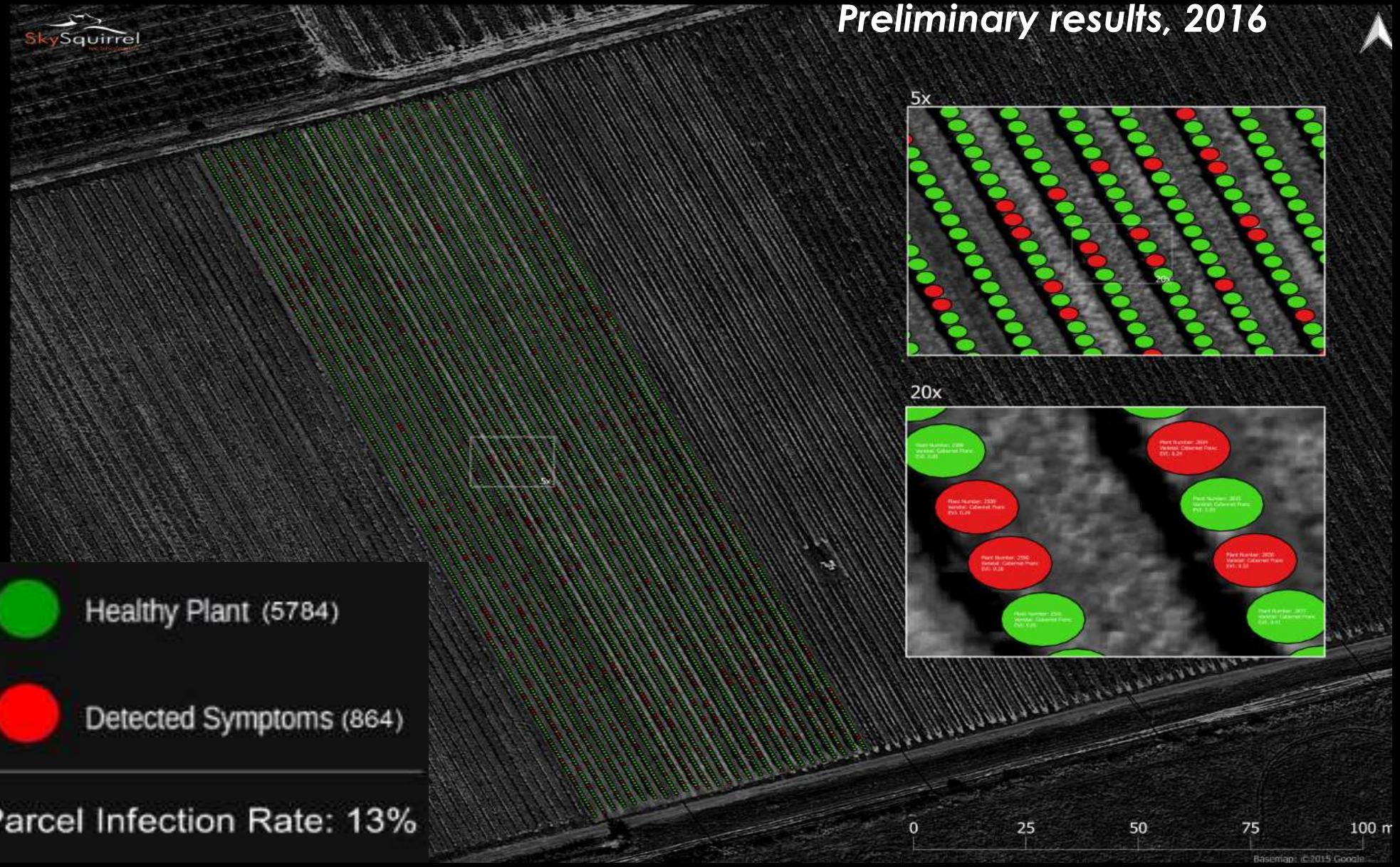
Leafroll Disease Detection (drone): VineMetrics

Preliminary results, 2016



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Flavescence Doree Detection (drone), France, 2016

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Directly measure water content in your vines with multispectral Water Index

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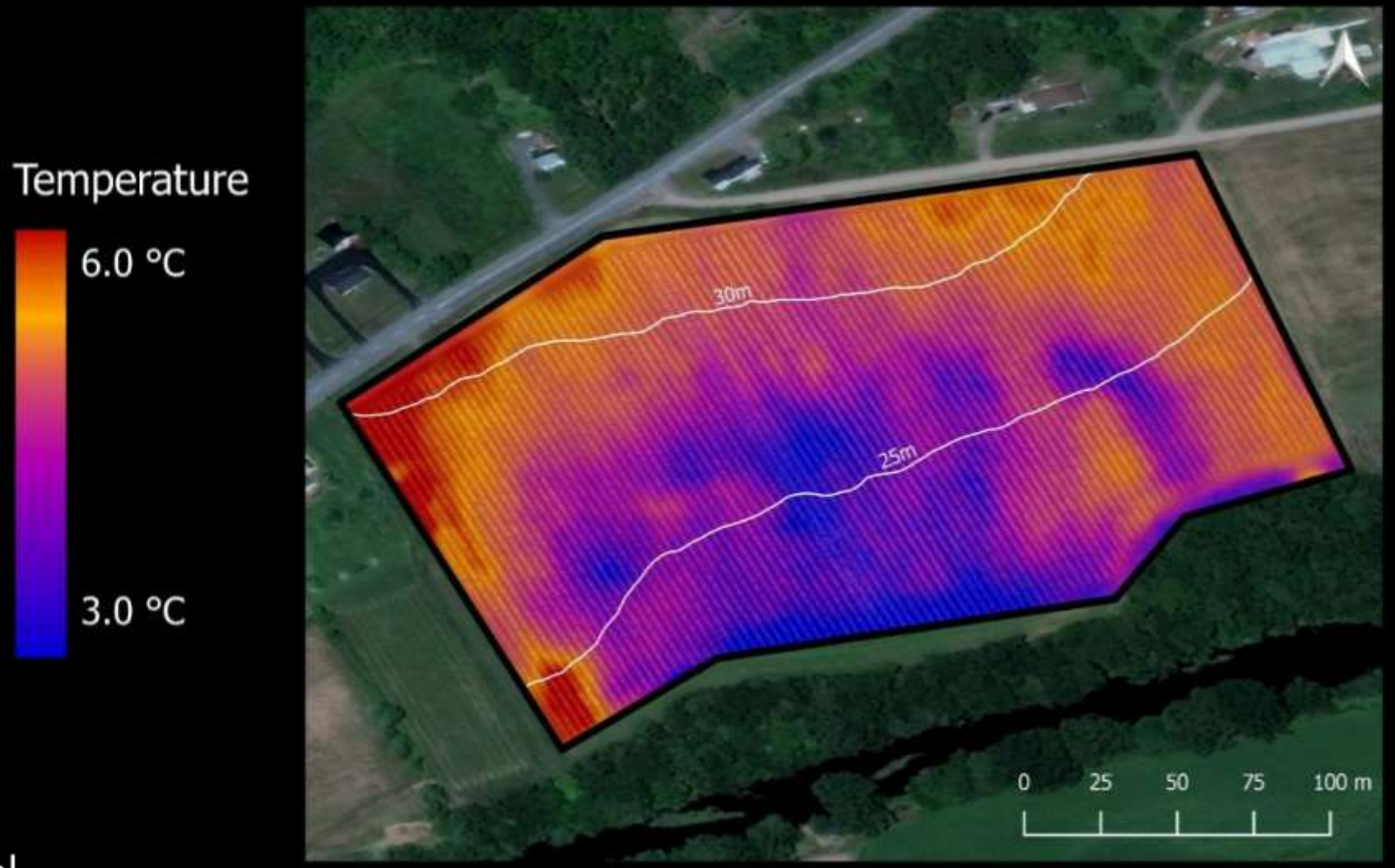
2017 Beta Product

Identify high risk areas for frost protection with accurate Thermal Maps



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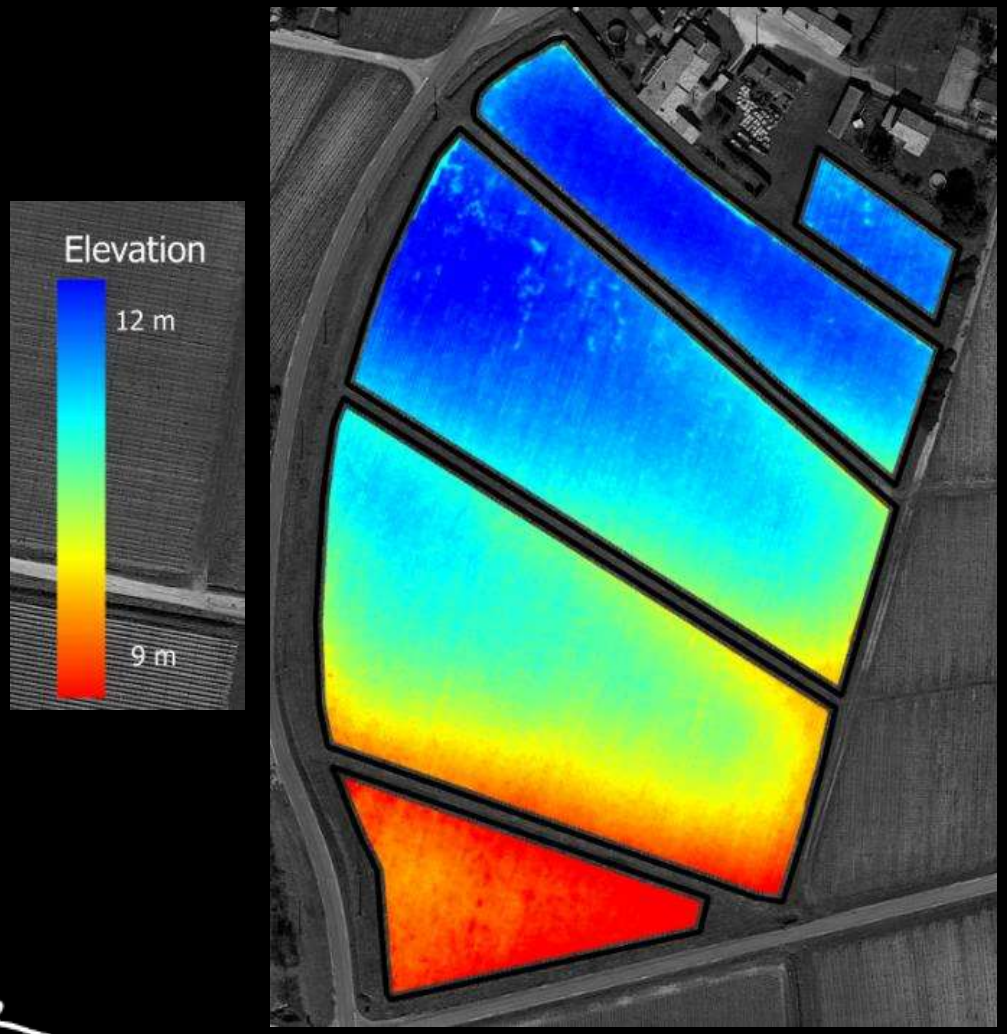
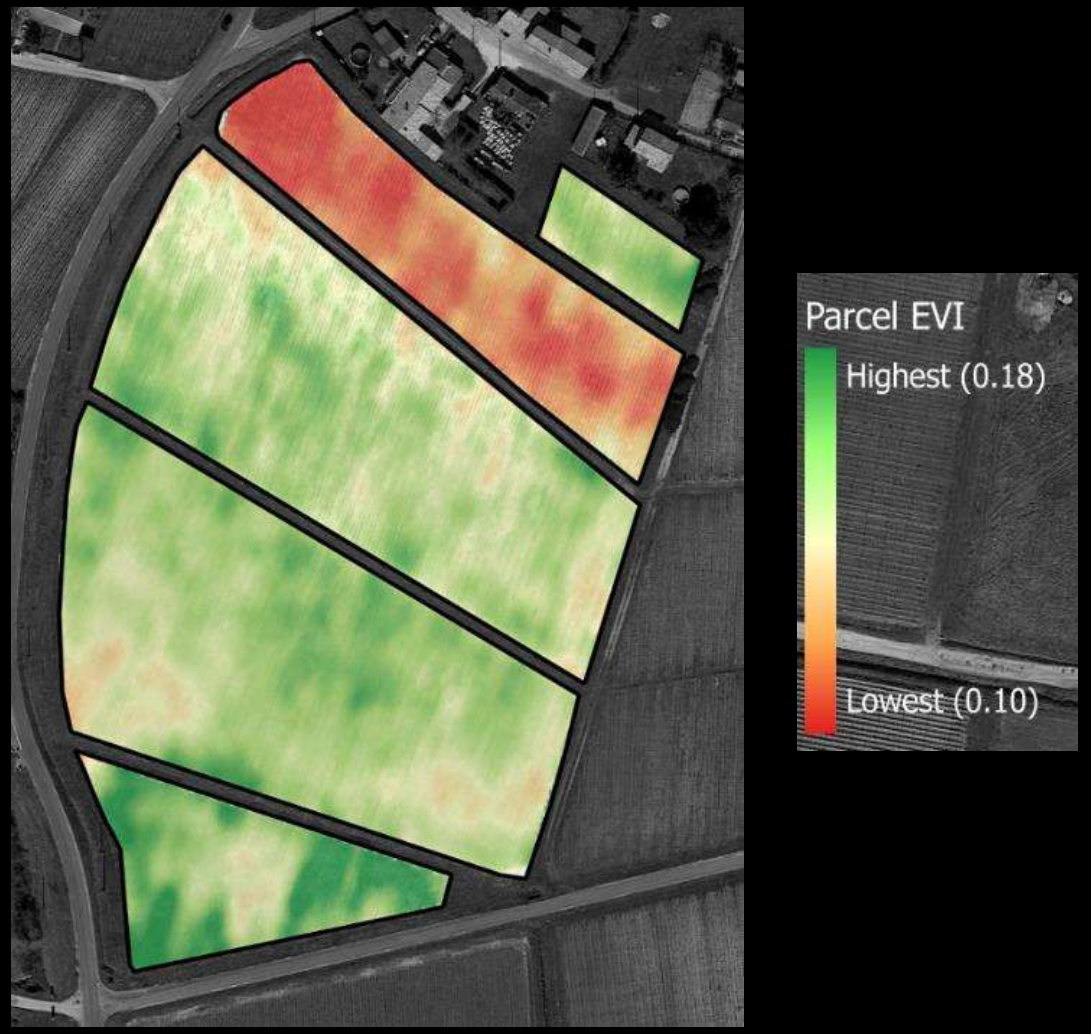
Evaluate ground contours and impact on vine growth with Digital Elevation Model





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DroneFuse Mobile Client Platform

Analyze your vineyard data from the palm of your hand, while standing in the field

You are here

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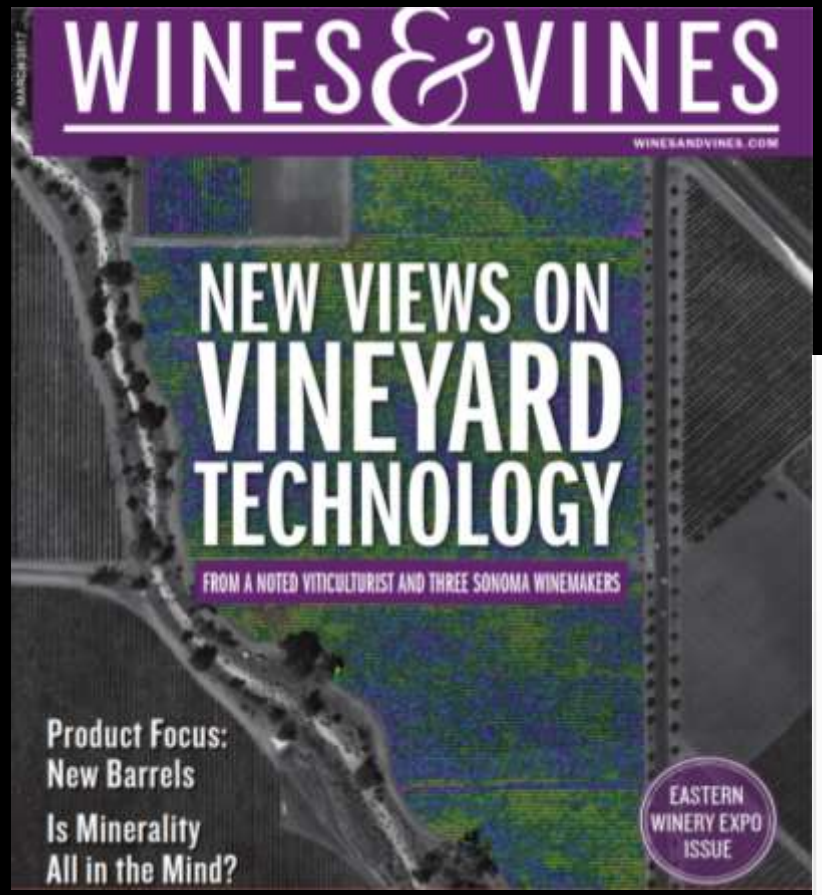
In the News…



"…the extensive use of VineView's aerial imaging and spectral mapping to identify areas of high and low vigor, which then directs their efforts to balance the vineyard."

- Wines & Vines, March 2017

Rodney Strong Vineyards

Since 1959, Rodney Strong Vineyards has been one of Sonoma County's premier wine operations, producing 850,000 cases annually under the Rodney Strong and Davis Bynum labels. The winery owns 1,200 acres of vineyards exclusively in Sonoma County. While Rodney Strong purchases two-thirds of its grapes, the grape contracts provide viticultural control. Both winemaker Justin Seidenfeld and winegrower Ryan Decker shared their approaches to growing and winemaking.

Crop level decisions: Seidenfeld and Decker stated that they no longer look at tons per acre, measuring pounds of fruit per vine instead. As Decker notes, while "yield per acre is easy to trace, pounds per vine speaks to what the vineyard is doing." They aim for a weight/vine target specific to the vineyard location and varietal; for example in a Sonoma County Pinot Noir block, the target is 4 to 6 pounds per vine, depending on the clone. They believe the old "tons per acre" method leads to under-cropping vigorous vines and over-cropping the weaker ones, leading to variable grape quality and a wide range in vine health within the vineyard.

Decker noted that targeting level fruit weight per vine makes the grower work to equalize vine vigor to achieve the weight when replanting.

Vineyard health measurements: Ryan stated that his team does petiole sampling at bloom and at *véraison* to measure the following nutrient levels: nitrogen, potassium, magnesium, calcium, boron and zinc. He added that they may also look at chlorides if the soil is known for high salinity.

Harvest decisions: Seidenfeld seeks "a physiologically ripe grape, so measuring pH and TA is almost as important as Brix." Ideally, all blocks and all vines would have the same physiological ripeness. He tries to avoid hard tannins from underripe fruit or chalky tannins from overripe fruit. If it's overripe, "It's just desiccating, so everything is out of whack."

Advanced technology: Seidenfeld believes that in striving to improve quality, "Technology is the helping hand." An example is his use of selective mechanical harvesting and field sorting. Machine harvesting allows him to pick at night and bring in cooler fruit, which improves wine quality and saves considerable energy in cooling warm grape must. In addition, it helps to avoid any labor-shortage issues. The Pellenc harvester then field sorts fruit, separating ideal berries from raisins. Decker stated that the sorter unit "has replaced six or seven people on an incline conveyor and does a better job."

Additional examples include the extensive use of VineView's aerial imaging and spectral mapping to identify areas of high and low vigor, which then directs their efforts to balance the vineyard. They also use advanced methods of monitoring vine water status via evapotranspiration and stomatal conductance measurements. Looking to the future, they will add continuous soil moisture monitoring to their vineyard weather stations and investigate other remote-sensing devices to be able to keep tabs on their vineyards 24 hours a day.

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Thank you

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