A Down to Earth Look at UAVs in Agriculture

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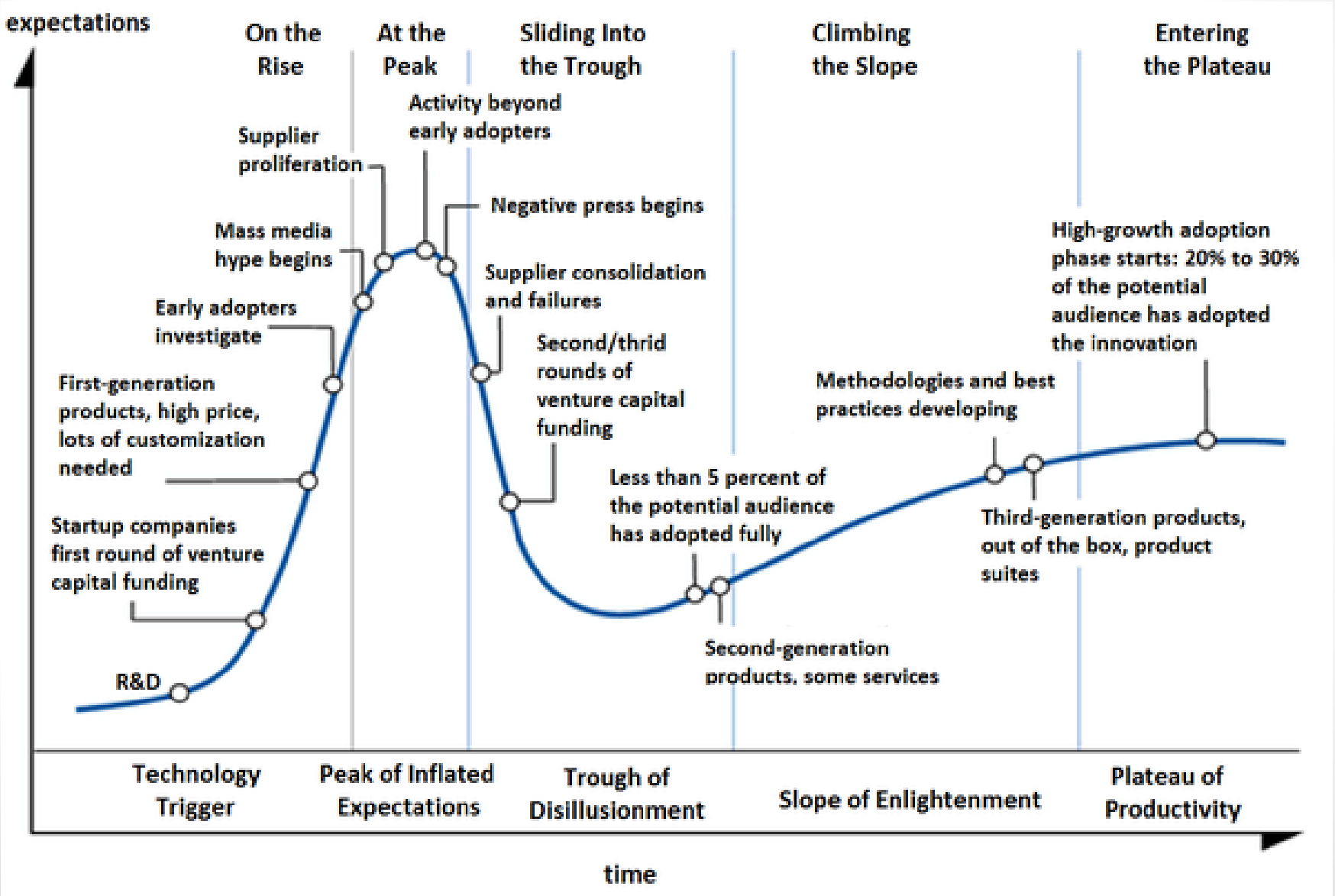
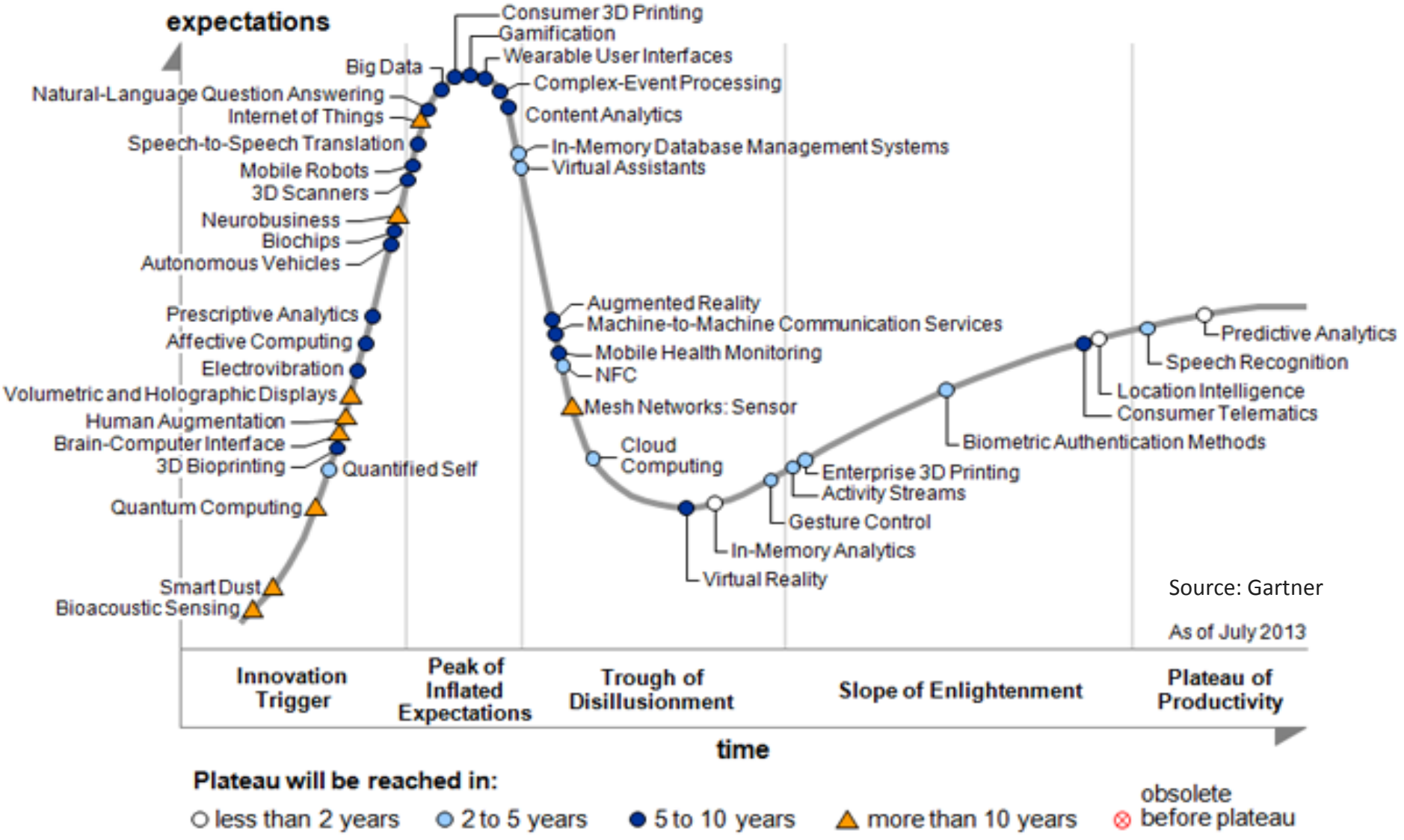
- Ok State has provided cease and desist.
- I have not flown one.
- I am very familiar with their data and use.
- UAV's and Teenagers
- Cow Art, Klingenberg Farms

- I want one…..


expectations
On the Rise
At the Peak
Sliding Into the Trough
Climbing the Slope
Entering the Plateau
Activity beyond early adopters
Supplier proliferation
Negative press begins
Mass media hype begins
Supplier consolidation and failures
Early adopters investigate
Second/thrid rounds of venture capital funding
First-generation products, high price, lots of customization needed
Methodologies and best practices developing
High-growth adoption phase starts: 20% to 30% of the potential audience has adopted the innovation
Less than 5 percent of the potential audience has adopted fully
Startup companies first round of venture capital funding
Third-generation products, out of the box, product suites
R&D
Second-generation products, some services
Technology Trigger
Peak of Inflated Expectations
Trough of Disillusionment
Slope of Enlightenment
Plateau of Productivity
time


expectations
Consumer 3D Printing
Gamification
Wearable User Interfaces
Big Data
Complex-Event Processing
Natural-Language Question Answering
Content Analytics
Internet of Things
In-Memory Database Management Systems
Speech-to-Speech Translation
Virtual Assistants
Mobile Robots
3D Scanners
Neurobusiness
Biochips
Autonomous Vehicles
Augmented Reality
Prescriptive Analytics
Machine-to-Machine Communication Services
Affective Computing
Mobile Health Monitoring
Electrovibration
NFC
Volumetric and Holographic Displays
Mesh Networks: Sensor
Human Augmentation
Brain-Computer Interface
Cloud Computing
3D Bioprinting
Quantified Self
Enterprise 3D Printing
Activity Streams
Quantum Computing
Gesture Control
In-Memory Analytics
Virtual Reality
Smart Dust
Bioacoustic Sensing
Predictive Analytics
Speech Recognition
Location Intelligence
Consumer Telematics
Biometric Authentication Methods
Source: Gartner
As of July 2013
Innovation Trigger
Peak of Inflated Expectations
Trough of Disillusionment
Slope of Enlightenment
Plateau of Productivity
time
Plateau will be reached in:
less than 2 years
2 to 5 years
5 to 10 years
more than 10 years
obsolete before plateau

FAA

- http://www.faa.gov/news/press_releases/

- **Press Release Results**
- 12/10/2014 FAA Grants Five More Commercial UAS Exemptions
- 11/18/2014 FAA Statement on NTSB Decision in Huerta v. Pirker
- 10/08/2014 FAA Statement on MITRE's Independent Assessment and Recommendations for NextGen
- 9/25/2014 U.S. Transportation Secretary Foxx Announces FAA Exemptions for Commercial UAS Movie and TV Production
- 9/10/2014 FAA Statement
- 8/13/2014 FAA Announces Virginia Tech UAS Test Site Now Operational
- 8/07/2014 FAA Announces New York UAS Test Site Now Operational

Agricultural pilots have a number of low-level obstacles to contend with that have cost ag aviators their lives. According to NAAA's statistics, between 2004 and 2013 there have been 39 fatalities as a result of ag aircraft collisions with obstructions, over 57 percent of all ag aircraft fatalities during that time period. This shows that unmarked, unlighted, low-level obstacles present a mortal hazard to ag aviators, and these obstacles are stationary. UAVs present similar risks but are highly mobile, thereby increasing, we believe, the likelihood of an incident. Fortunately, there are two clear technological solutions to mitigate the hazards presented by UAVs in the National Airspace utilizing technology that already exists for manned aircraft.

NAAA urges the FAA to require that UAVs be equipped with strobes so they are clearly visible both in the daytime and at night to low-level pilots. UAVs should also be equipped with technology similar to ADS-B Out technology, allowing nearby aircraft with the proper reading equipment to identify their exact location. This requirement, one which the FAA is going to require for all manned aircraft operating under Air Traffic Control in 2020, is feasible and cost-effective utilizing current technology. Furthermore, we believe the selection of the six test sites, especially, but not limited to,

Drone Sightings

- http://graphics.wsj.com/faa-drones/
- Published 11/26/14; records 2/22-11/11
  - Significant amount 1000-7000 ft.
- **Oklahoma City, Okla.**
- Oct. 12, 2014 CORRECTED INFO FROM FAA OPS: TINKER AFB, OK/UAS INCIDENT/1424C/OKLAHOMA CITY ATCT REPORTED AN ACFT REPORTED **TAKING EVASIVE ACTION TO AVOID A SMALL UAS AT 4,800 FEET, 2 FEET WIDE BLACK IN COLOR WITH A CAMERA ATTACHED ON THE BOTTOM.** PILOT REPORTED UAS CAME WITHIN 10 - 20 FEET OF ACFT 10 N TINKER. LEOS NOTIFIED
  - Not ag, but.

UAS/UAV/The D Word in Ag

dji.com

DJI soon to have NO FLY ZONE Capability

http://agmapsonline.com/

Trimble.com

Tetracam.com

Hints on Platform

- They will crash. Period.
  - Easier to get a replace pieces the better.
- Copters, Hover and stable
- Planes / Fixed Wing, Covers ground

Consulting

https://www.youtube.com/watch?v=Rh7KKO12Mj8

www.manitobacooperator.ca

Moving Beyond the GoPro

- We can collect data, and potentially a lot of it.
- To Get Quality

AREA COVERAGE TABLE

Height	GSD	Coverage/flight [km²] (1)			Coverage/day [km²] (2)		
		70%	80%	90%	70%	80%	90%
75 m (246 ft)	2.4 cm (0.94 in)	1.1 km² (0.43 mi²)	0.8 km² (0.31 mi²)	0.4 km² (0.15 mi²)	6.85 km² (2.63 mi²)	4.5 km² (7.74 mi²)	2.3 km² (0.88 mi²)
100 m (328 ft)	3.2 cm (1.26 in)	1.8 km² (0.7 mi²)	1.2 km² (0.64 mi²)	0.6 km² (0.23 mi²)	10.8 km² (4.17 mi²)	7.2 km² (2.78 mi²)	3.6 km² 1.39 mi²)
150 m (492 ft)	4.8 cm (1.89 in)	3.1 km² (1.2 mi²)	2.1 km² (0.81 mi²)	1.0 km² (0.39 mi²)	18.7 km² (7.22 mi²)	12.5 km² (4.83 mi²)	6.2 km² (2.39 mi²)
200 m (656 ft)	6.4 cm (2.52 in)	4.4 km² (1.7 mi²)	3.0 km² (1.16 mi²)	1.5 km² (0.58 mi²)	26.6 km² (10.27 mi²)	17.8 km² (6.87 mi²)	8.9 km² (3.44 mi²)
250 m (820 ft)	8 cm (3.15 in)	5.8 km² (2.24 mi²)	3.8 km² (1.47 mi²)	1.9 km² (0.73 mi²)	34.6 km² (13.36 mi²)	23.1 km² (8.92 mi²)	11.5 km² (4.44 mi²)
300 m	9.6 cm	7.1 km²	4.7 km²	2.4 km² (0.93 mi²)	42.5 km² (16.41 mi²)	28.3 km² (10.93 mi²)	14.2 km² (5.48 mi²)
				3.2 km² (1.24 mi²)	58.0 km² (22.40 mi²)	38.7 km² (14.94 mi²)	19.3 km² (7.45 mi²)
				4.1 km² (1.58 mi²)	74.2 km² (28.65 mi²)	49.5 km² (19.11 mi²)	24.7 km² (9.54 mi²)
				6.3 km² (2.43 mi²)	113.9 km² (43.98 mi²)	75.9 km² (29.31 mi²)	38.0 km² (14.67 mi²)

(1) For a 2:1 aspect ratio, which is a flight block with length equal to 2 times the width. This is a good approximation of the average flight block.
(2) Assuming on average 5 minutes pre-flight and 5 minutes post-flight setup and recovery time and operation between 10 am and 4 pm.

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150 m (492 ft)	4.8 cm (1.89 in)	3.1 km² (1.2 mi²)	2.1 km² (0.81 mi²)	1.0 km² (0.39 mi²)

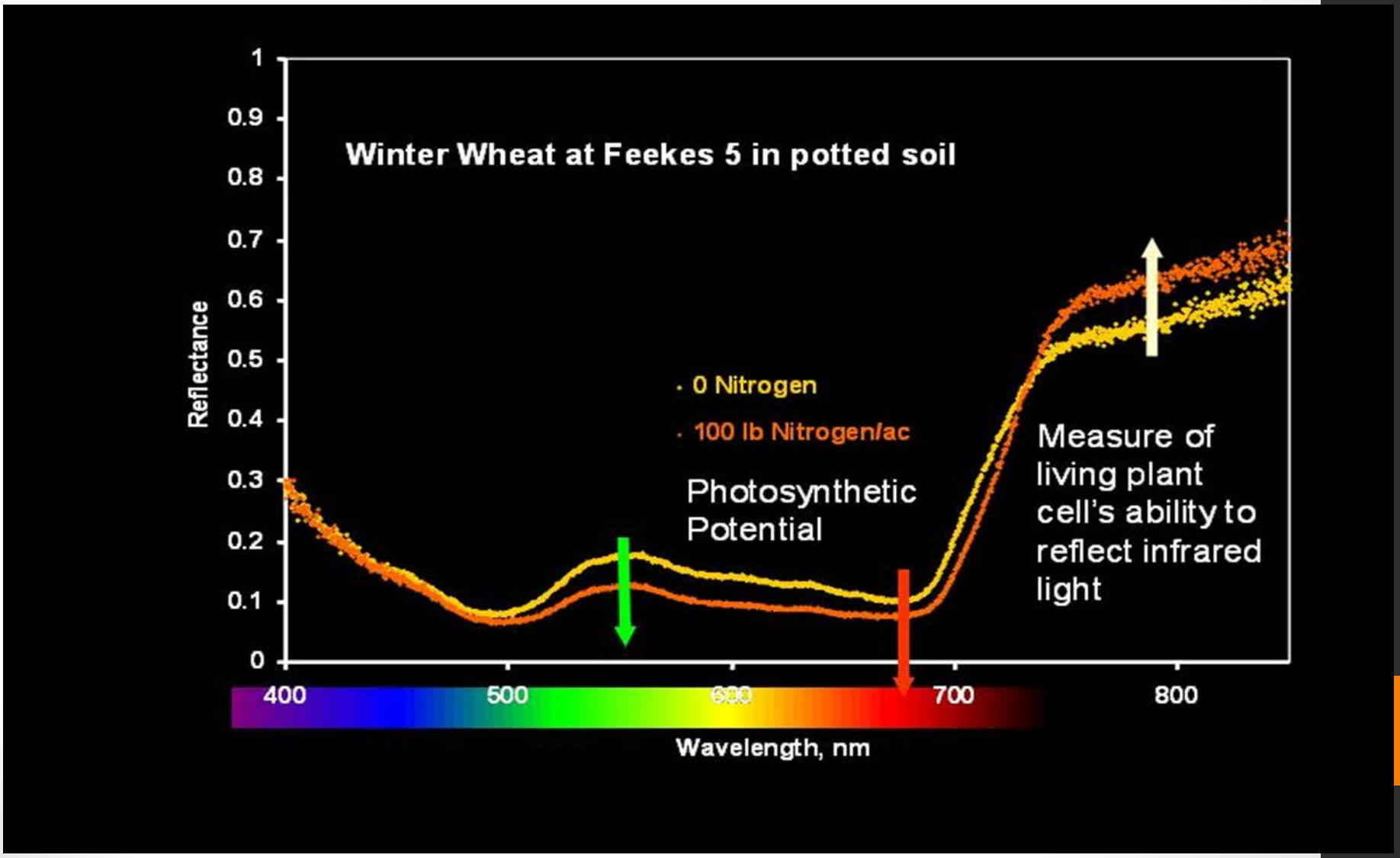
Imagery Stitching

- OrthoRectification
  - http://www.satimagingcorp.com/services/orthorectification/
    - open sources available
    - http://conservationdrones.org/post-processing/

Challenges

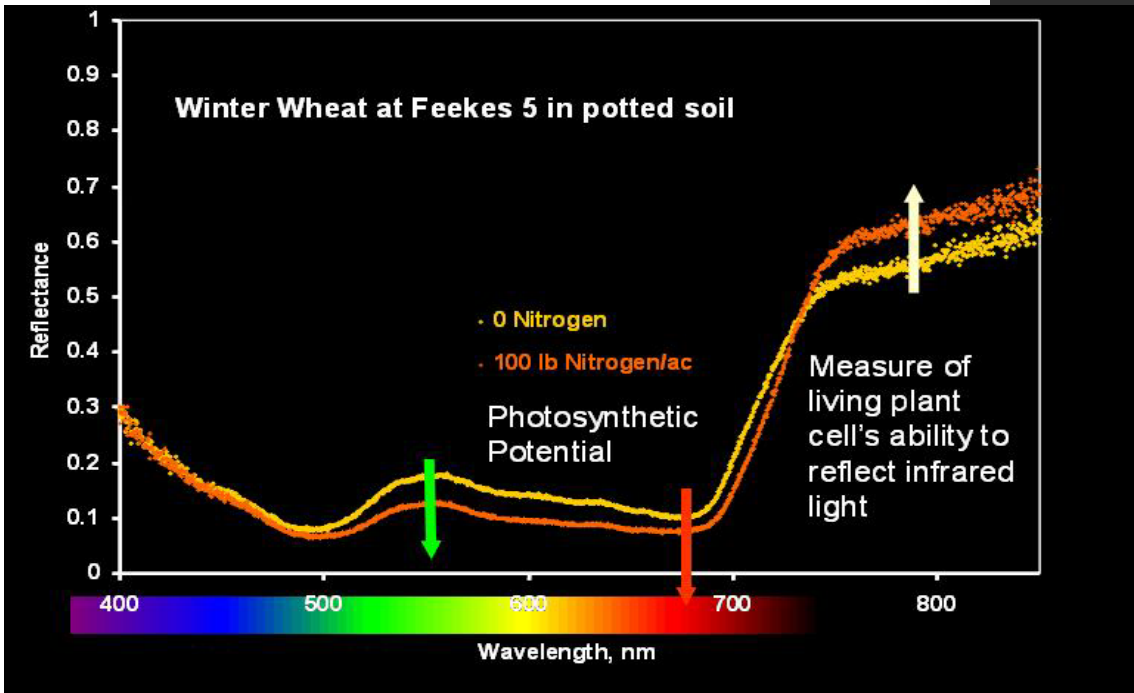
- Small footprint
- Image distortion
- Locating ground control points
- Relatively large errors in exterior orientation parameters (X, Y, Z, roll, pitch, heading)
  - Wind comes sweeping down the plains……..

Reflectance



Wavelengths & Indices

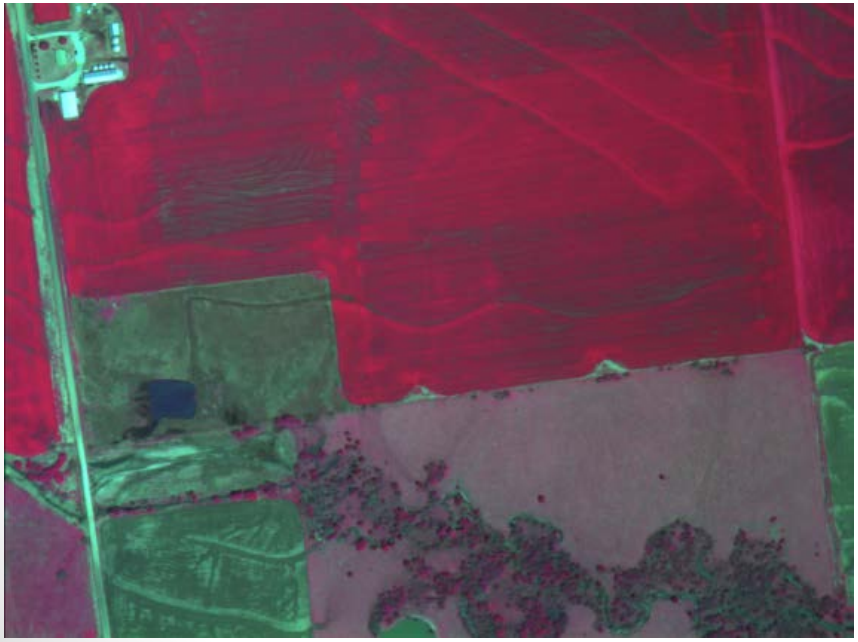
- NDVI and Simple Ratio
  - **Biomass**: Red and NIR (650, 780)
  - Green or Amber instead of Red (550, 590)
  - Growth Stage for Amber v Red
  - Red Edge 680
- Chlorophyll
  - SPAD (650 – 940)
- Protein
  - 710 , 810
    (Kelly et al 04)



Reflectance Data

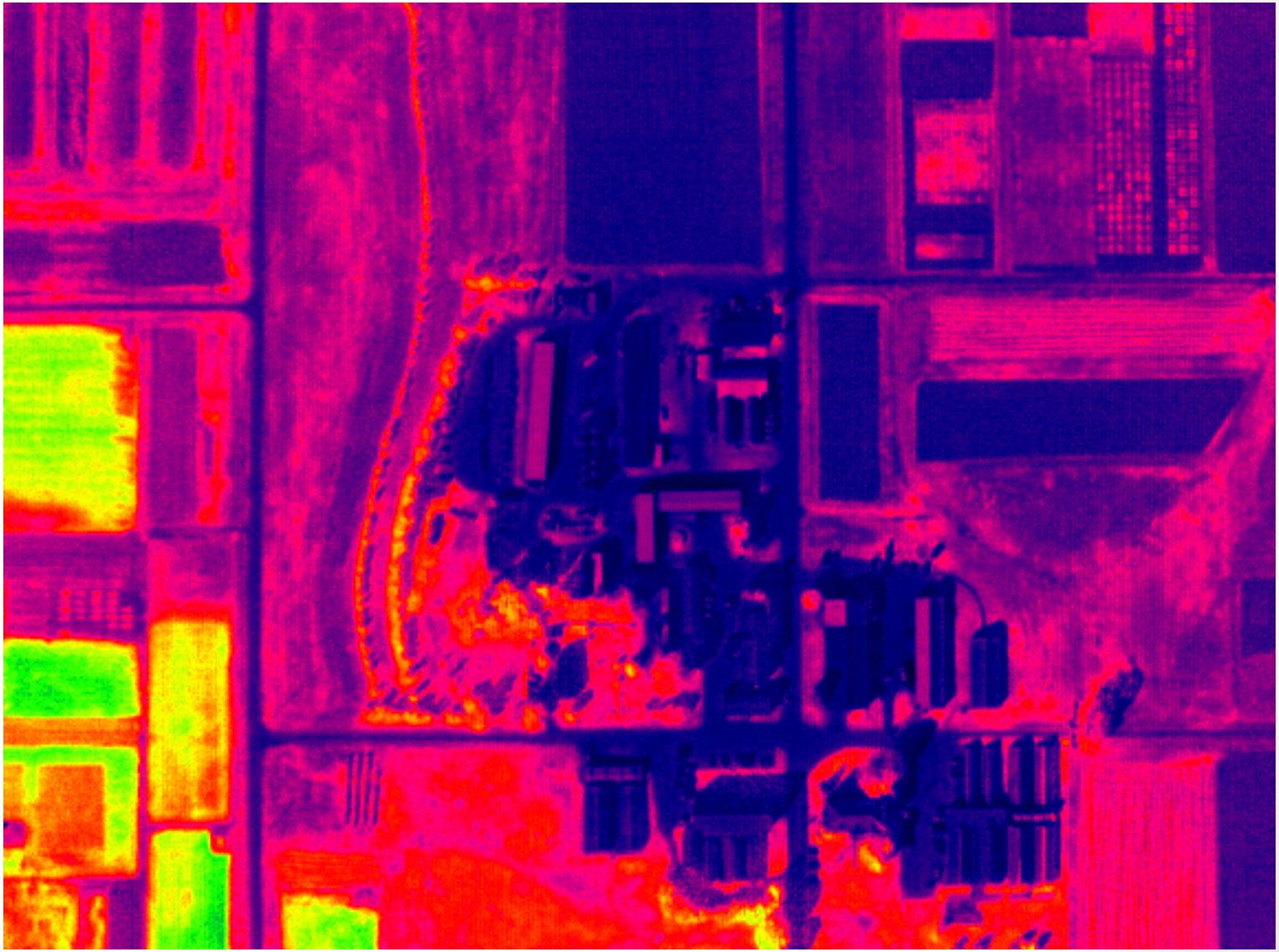
- Historically satellite and aerial imagery widely used.
- Ok State in the mid 90's started investigating VRT N work.
  - Evaluated Aerial and Satellite.

Precision Ag Research at OSU

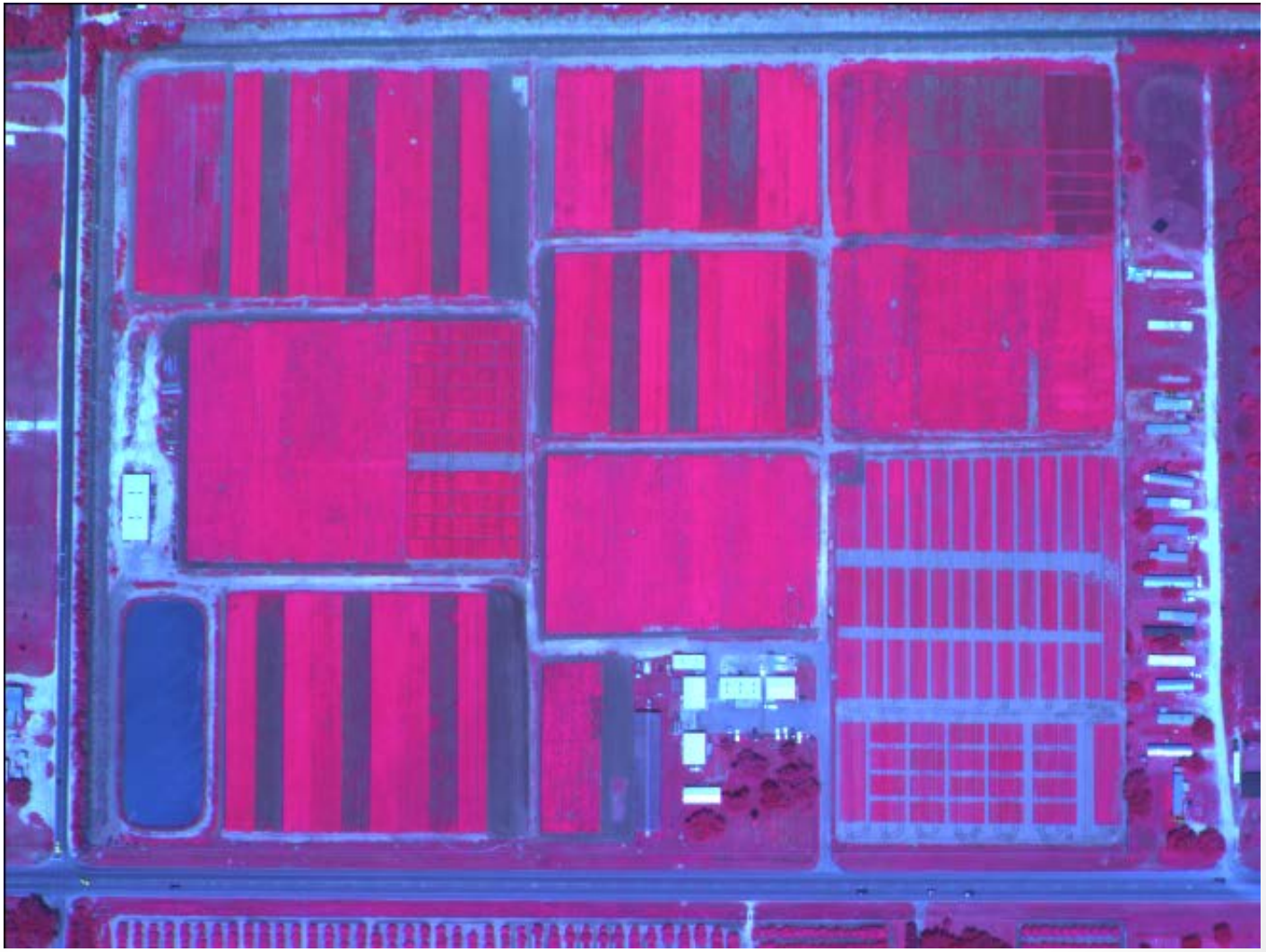


NDVI of OSU Experiment Station

1m Resolution



False Color (green, red, NIR) Image
< 1 m Resolution - Raw Radiometric Data
(Courtesy F. Schiebe, SST Software)



Passive vs Active

- Active Sensor emits light, typically via LED.
- Passive Sensor records reflectance of natural light.
  - Sun Angle, impacted by time of day and time of year.
  - Clouds
  - Atmospheric interference.

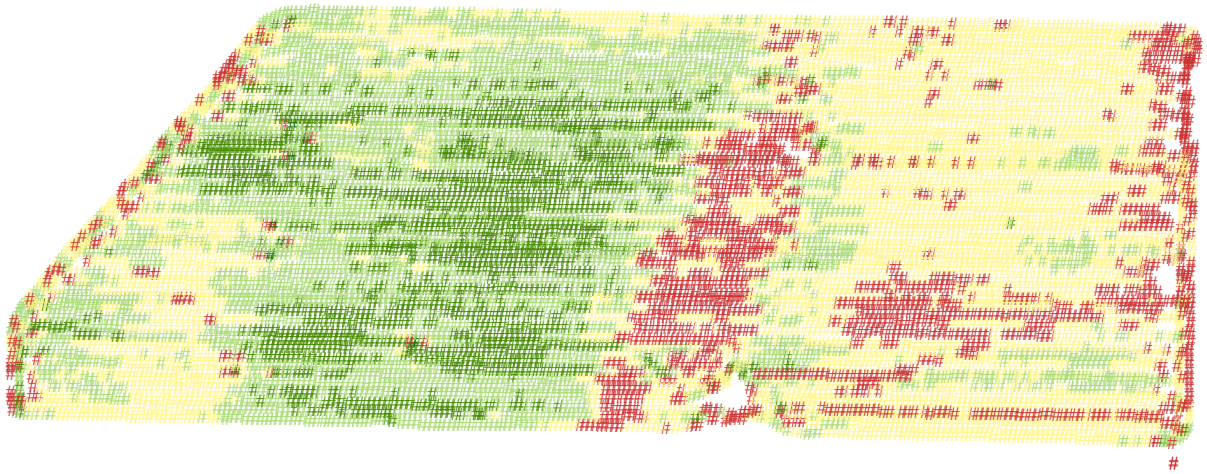
Use of relative values

*From Auto Copter

- Map segmented into NDVI values
  - Fertilizer into 150lb, 130lb, 110lb, 90lb, and 70lb
    - 150lb for the lowest NDVI value
    - 130lb for the middle-lowest NDVI value
    - 110lb for the middle NDVI value
    - 90lb for the middle-highest NDVI value
    - 70lb for the highest NDVI value

Aerial Imagery values w/o Cal

- Yield Monitor



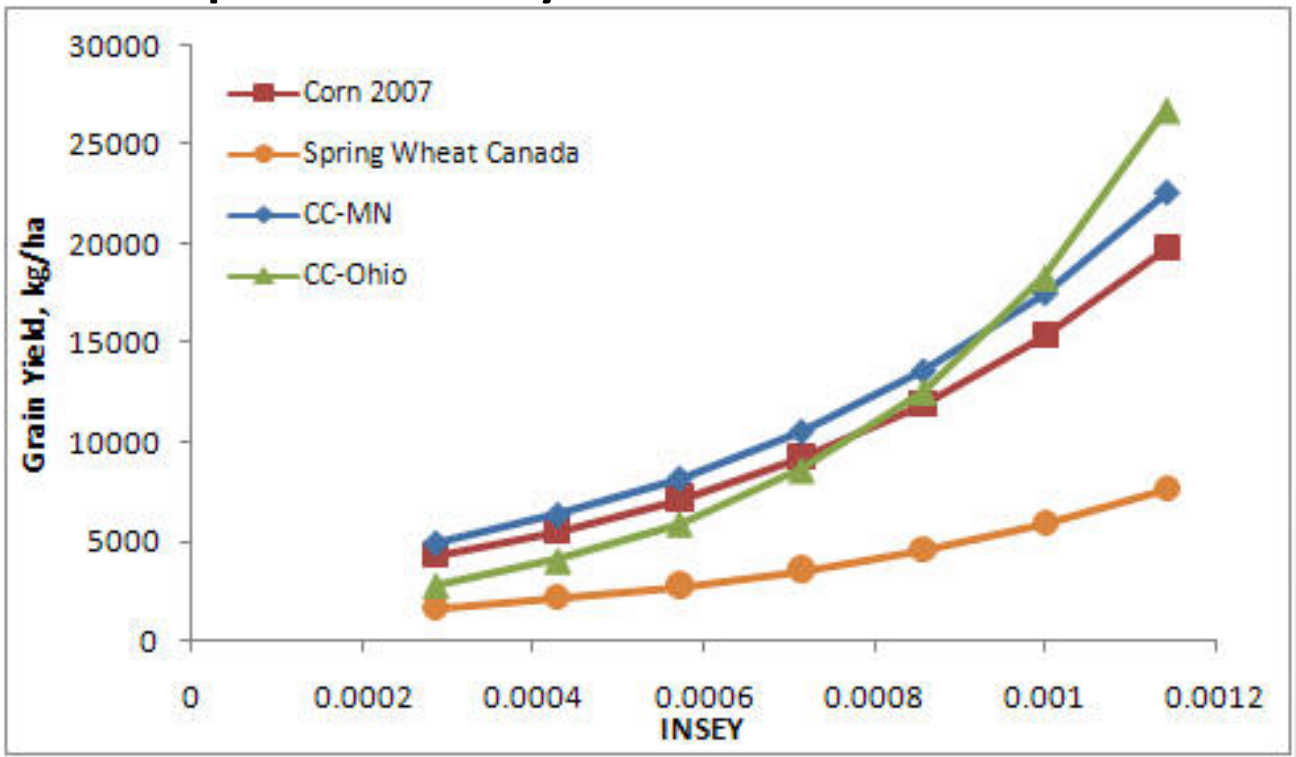
Rendel 2010 Harvest

To Calibrate

- With Spectrometer, use white plate.
- NUE Wheat project with 330+ plots.
  - 10 to 2
  - White plate
  - Incoming and reflectance
  - Reverse order

Replicated values

- OSU's use of active sensors
- Relate Specific values.
- Must have repeatability



Beyond reflectance

- Stand Count
  - Quite easy
- Canopy Temp
- Soil Moisture
- Soil OM
- DOCUMENTATION

http://agloop.com/how-to-produce-more-with-less-the-emergence-of-uav-technology/

Resolution

Satellites

- ***June 10-2014*** **Google Tuesday agreed to buy satellite startup Skybox Imaging Inc.** for $500 million in cash, the latest in a number of moves by the world's largest Internet search provider to collect and provide data from the sky. **Skybox has designed small, relatively cheap satellites that can collect daily photos and video of the Earth. Skybox satellites weigh roughly 260 pounds,** making them much cheaper to build and launch than traditional satellites that can weigh tons. Skybox planned to launch 24 such satellites that could shoot pictures of the Earth more often.
- ***Feb 3 2015*** **Wilbur-Ellis Co. has reached an agreement with Planet Labs** to bring satellite imagery to the AgVerdict software platform, Wilbur-Ellis' technology in agricultural data usage. This enhancement will significantly improve the delivery of satellite imagery to a grower, making the data available in a matter of minutes rather than days. This new feature will benefit **Wilbur-Ellis** customers by providing imagery using **"ultra-compact" satellites that will soon scan the planet every twenty-four hours.**

How many times are you on a field?

Today

- Consultants can be more efficient and make more money.
  - With low end UAV's
- Platforms available for high end imagery.
- Companies scrambling to find
  - Increase easy of data processing
  - Create decision aid tools.

Nothing

- I mean NOTHING takes the place of Scouting and good Agronomy.
- NOTHING..
- Get dirty walk the field, take samples.
- But there is always a degree of WRONG We are dealing with a living system. More so we are dealing with a Weather Dependent system.

- Have a Plan, Have a goal

Thank you!!!

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