Latest Advancements in Technology as it Pertains to Agricultural Production

Ed Barnes

Ag & Env Research Division

Cotton Incorporated

Cary, NC

Opportunities for Robotic Systems and Automation in Cotton Production

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Acknowledgements

Overview

History of AgTech

Tools Here Today

- Google Earth + Prism
- Harvest Data
- Gin Data
- Machine Vision

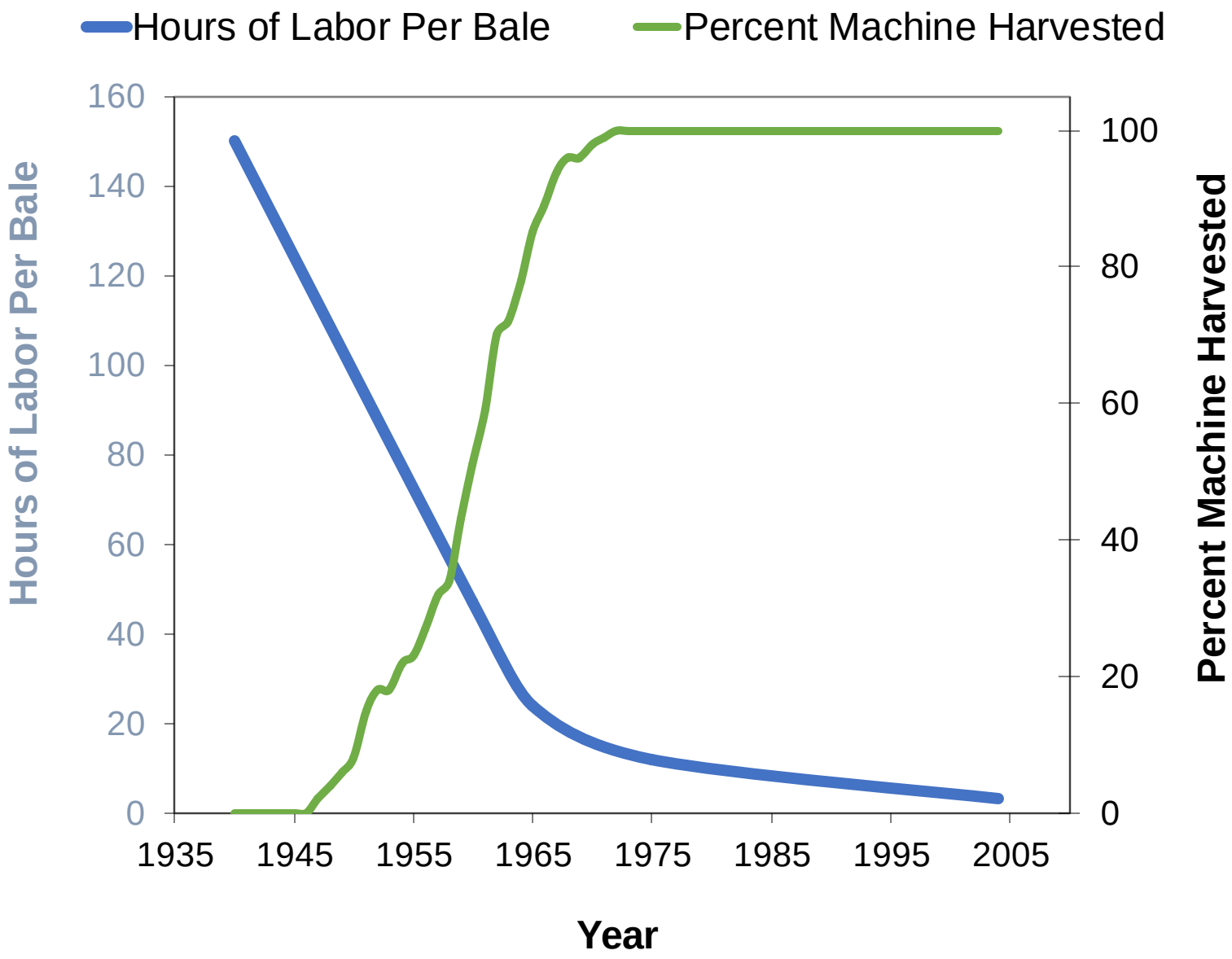
Tools Coming Tomorrow

- Automation
- Weed Control

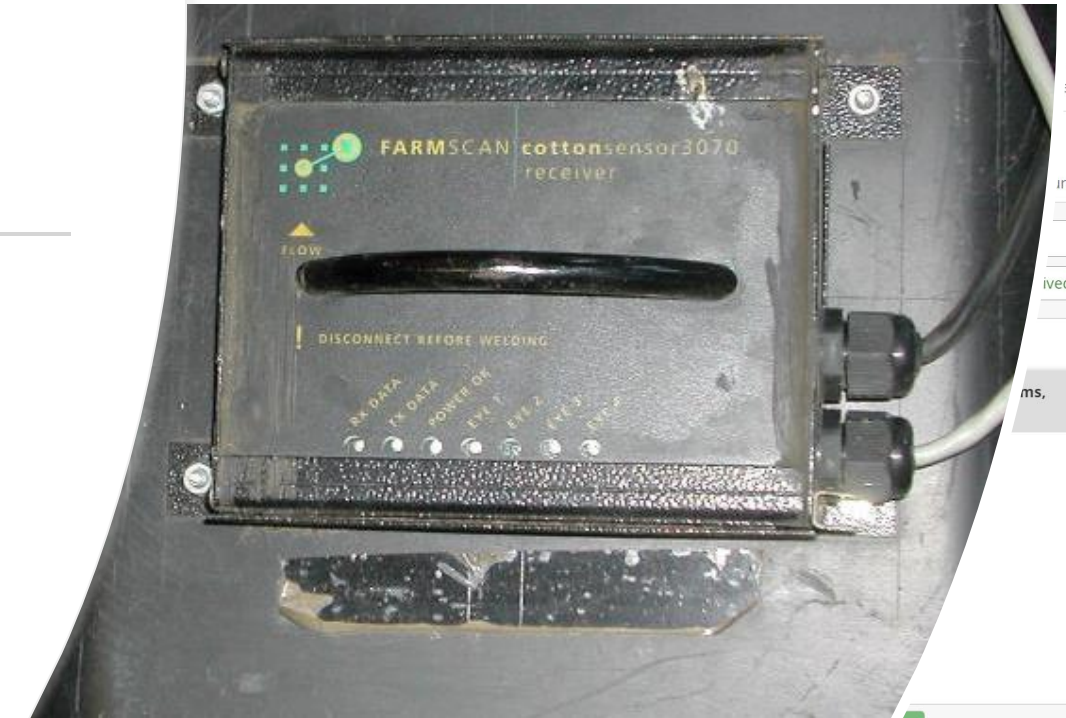

COTTON PICKER

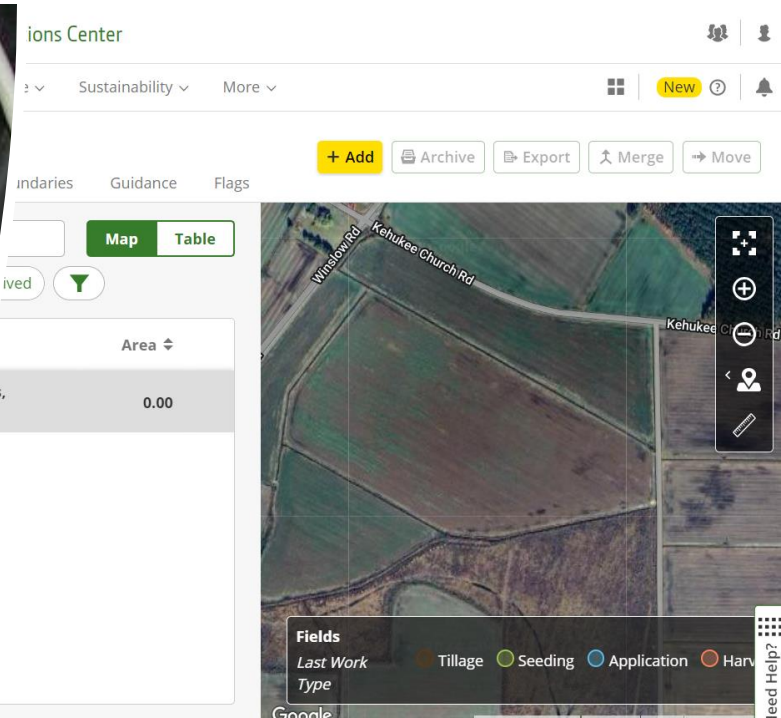

KBH

Impact of Mechanization on Labor

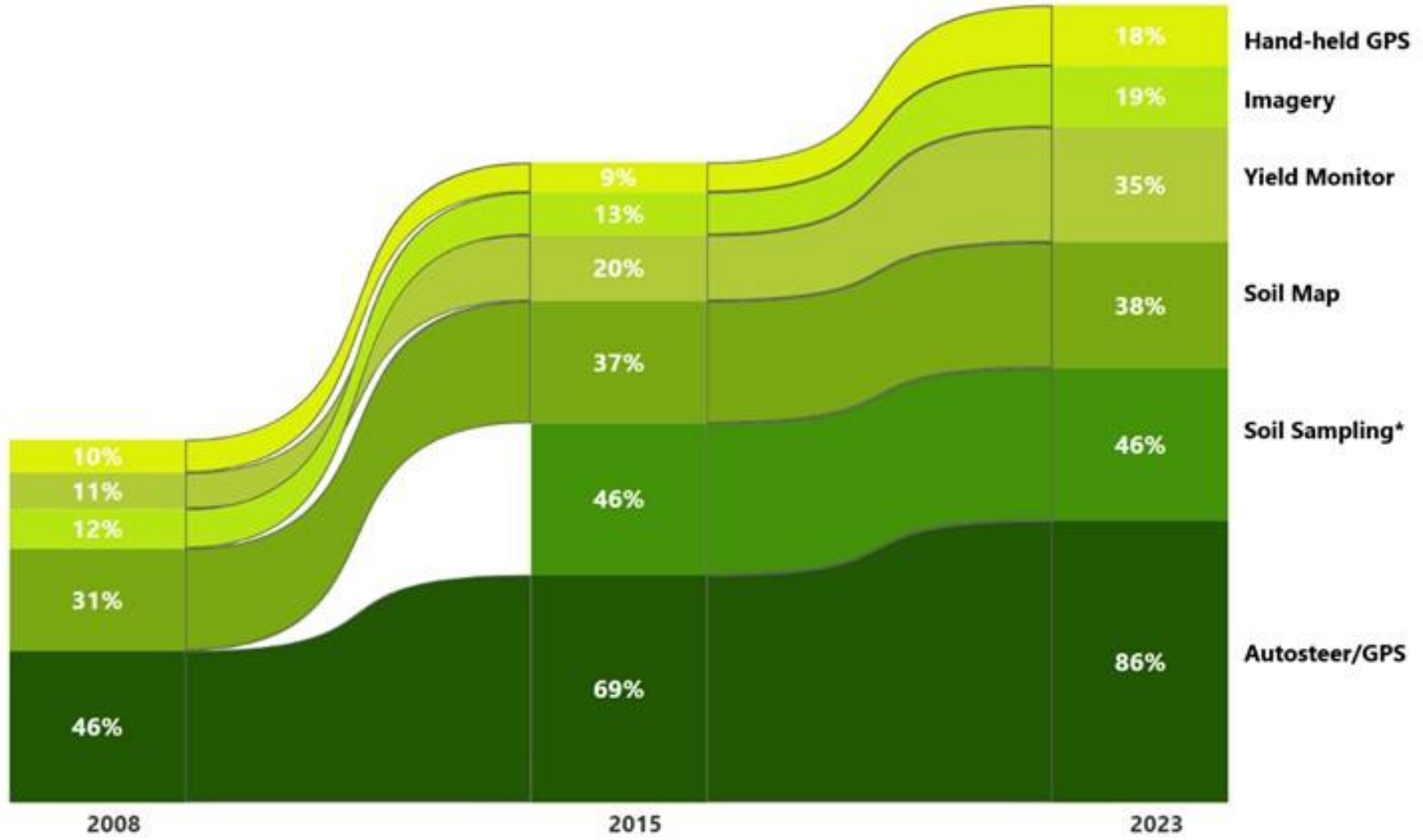


Technology Continues to Evolve





Technology Adoption by U.S. Cotton Farmers



DOI: 10.15376/biores.19.4.7279-7319

Google Earth

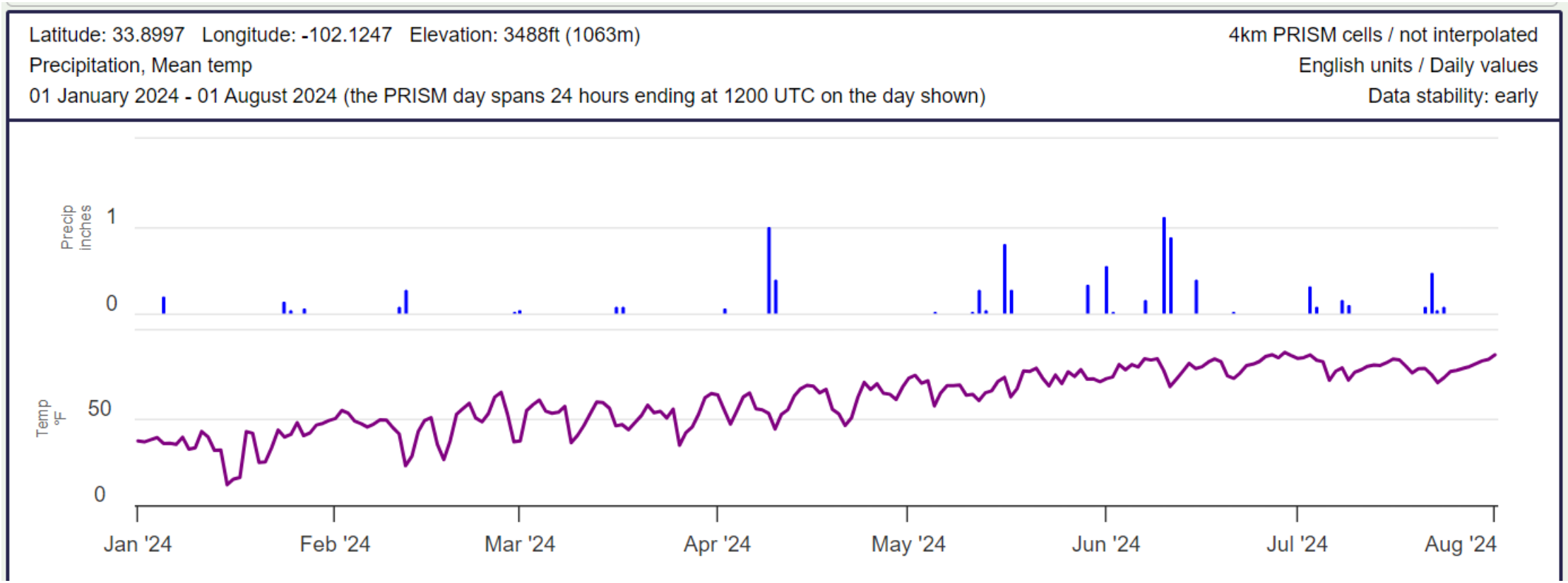
Google Earth Time Lapse

1989

1995

2024
(Full circle ~ 2000)

Prism



https://prism.oregonstate.edu/explorer/

Cotton Has a History of Capturing Value from Data

Data Flow at Harvest

Harvester → Gin → Bale → AMS → Warehouse → Merchant → Mill

Gin/Grower
- PBI + HVI Data

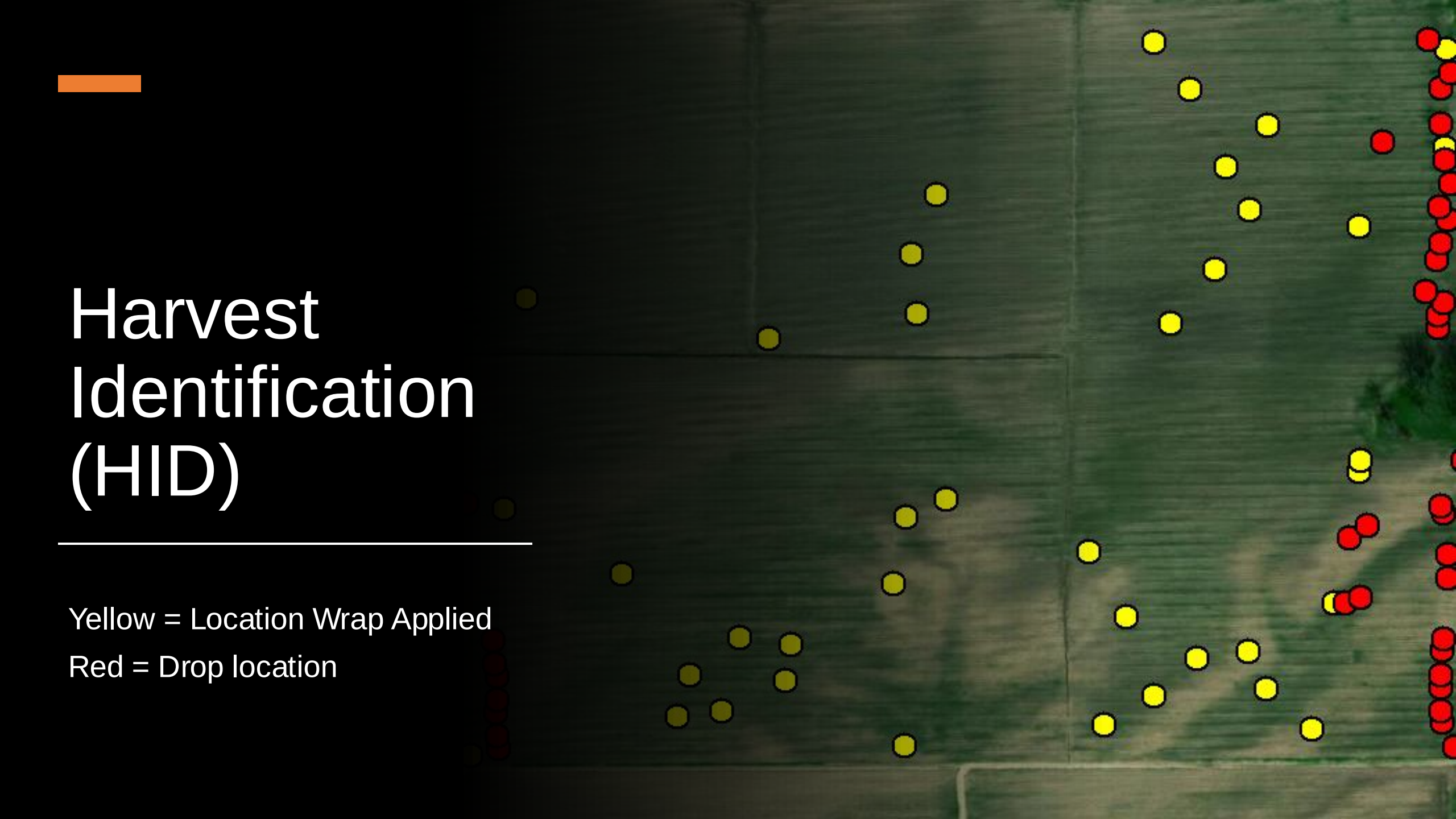
RFID
- Linked with PBI tags

Location
- Quality Map

Harvest Identification (HID)

Yellow = Location Wrap Applied

Red = Drop location



Information Documented by Harvest Identification (HID), Cotton Pro for Every Module

- **Client**
- **Farm**
- **Field**
- **Variety**
- Machine PIN
- Operator
- Module ID
- **Module SN**
- **Latitude**
- **Longitude**
- GMT Date/Time
- Tag Count

- Gin ID
- Producer ID
- Local Time
- Field Area
- Season Total
- **Diameter**

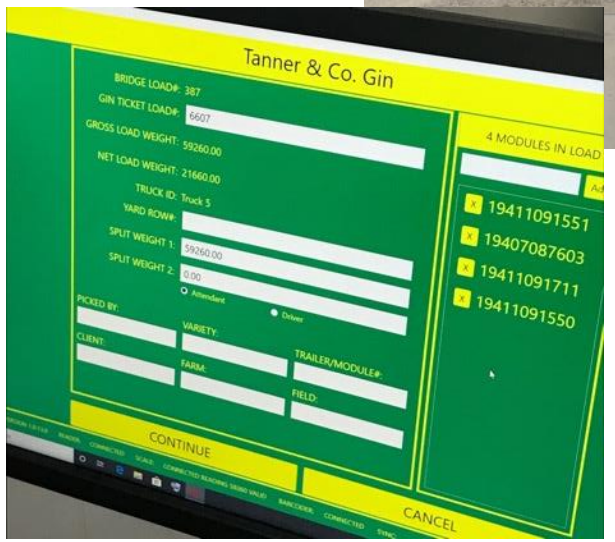
2017+ Models

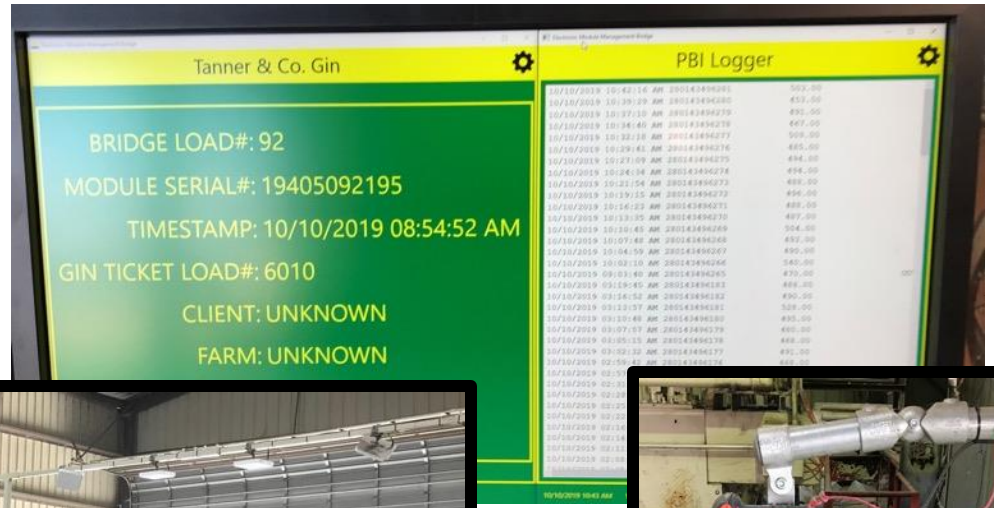
- **Moisture**
- **Weight**
  - Drop Latitude
  - Drop Longitude
  - Field Total
  - Incremental Area
  - Local Date
  - Comments

RFID Tags to Connect Bales to Field

Successful test of open-source software at LA gin. Can follow cotton from field to module feeder.

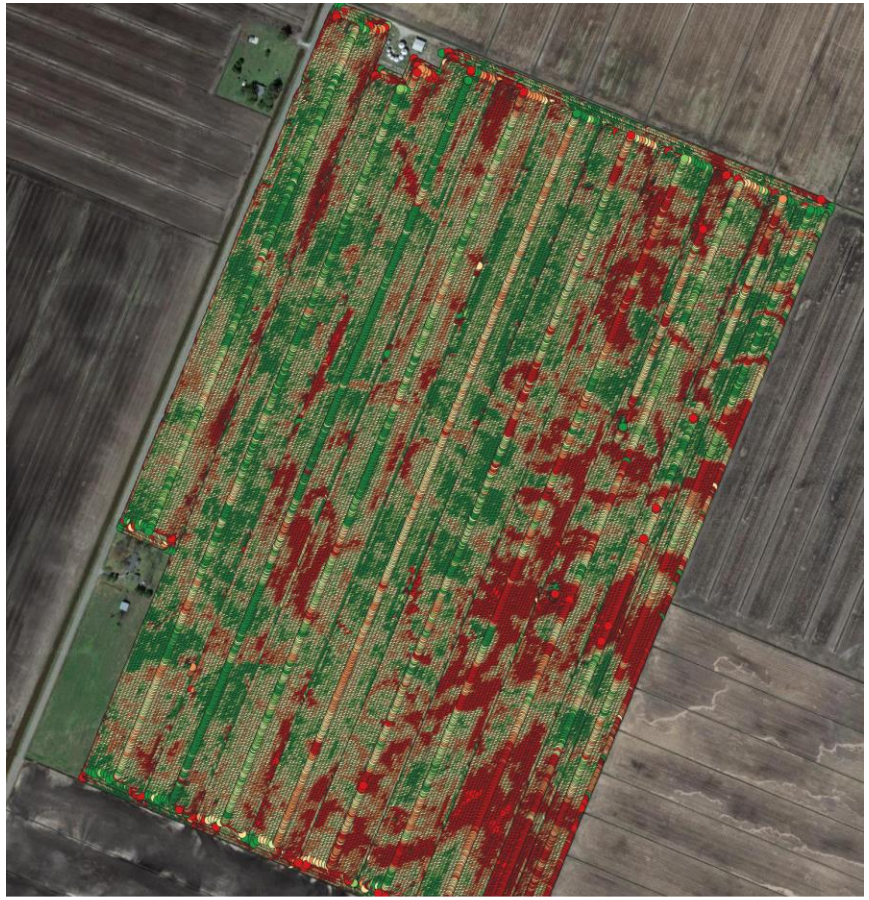
John Wanjura – USDA-ARS Lubbock Gin Lab



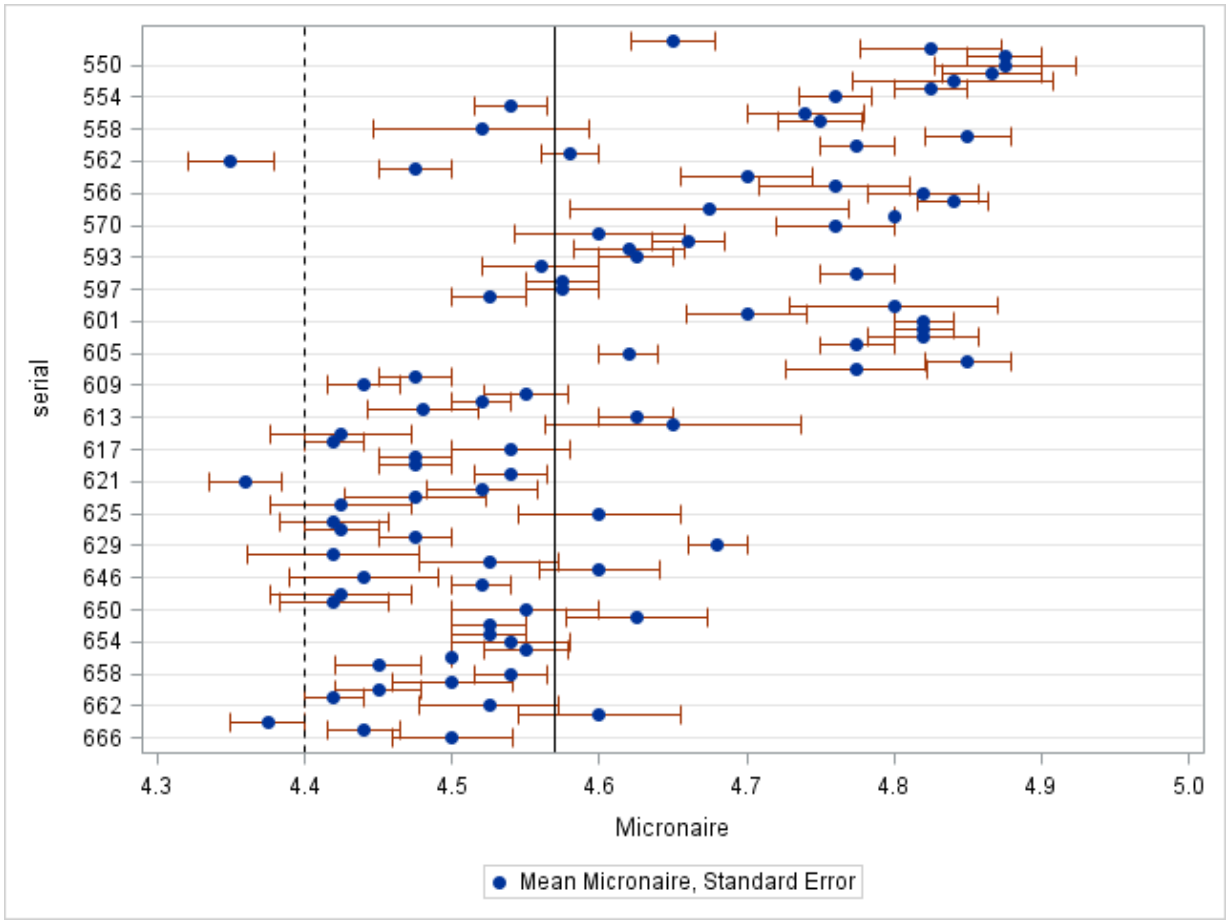


Mic Average and Range Per Round Module

Yield Map (red = low)



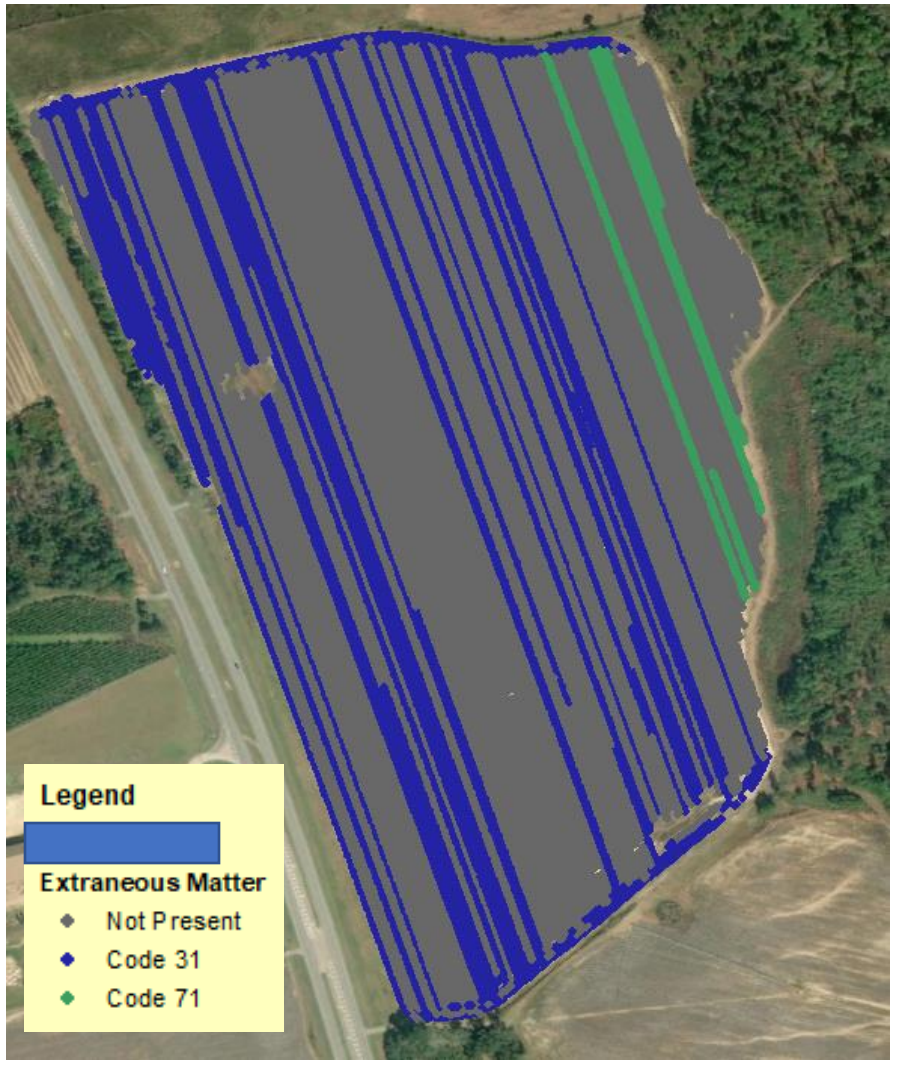
Micronaire Variation within Field

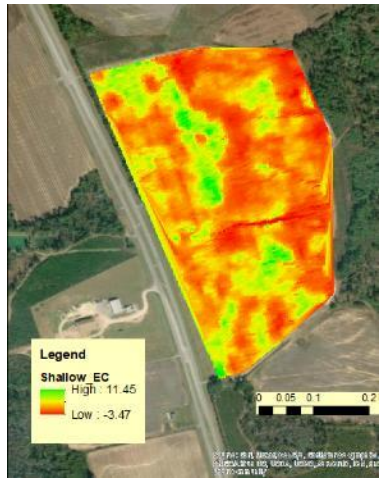


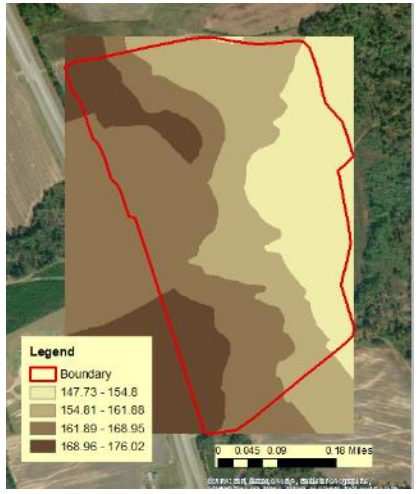
Jason Ward, NC State University

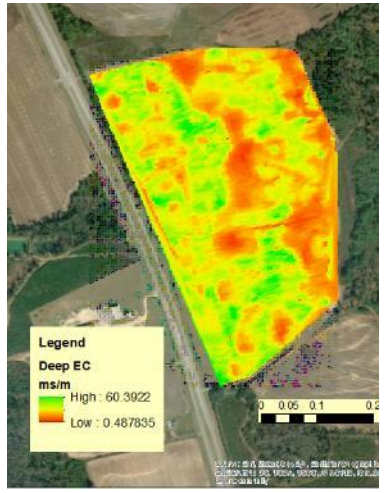
Mapping Extraneous Matter

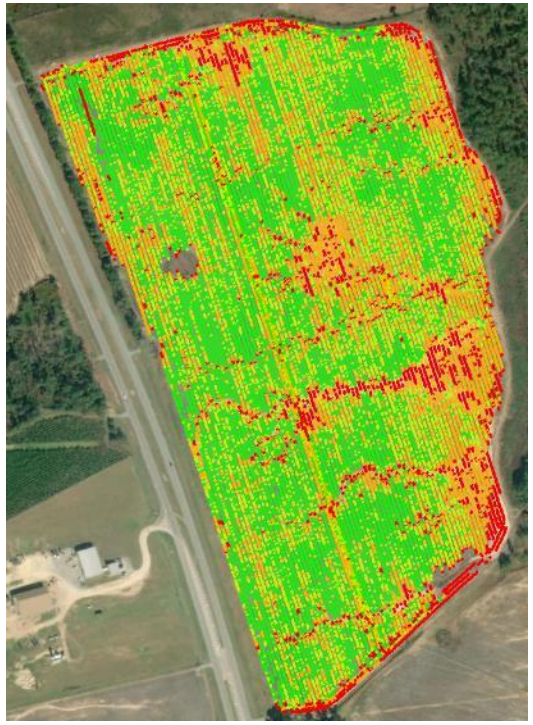
Luke Fuhrer & Wes Porter
University of Georgia

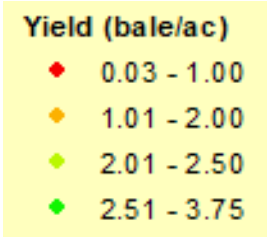












Loader Data Collection: Weight, Moisture, RFID + Module Rotation

Developed by Dr. John Wanjura – USDA-ARS, Lubbock

Recommend Using Approved Wrap

https://www.cotton.org/tech/quality/approved-rmw-products.cfm

Supplier	Manufacturer	Identifier	Type	RFID General Manager Number (digits 3-9 of the 24 character RFID string)
Tama USA Inc.	Tama RMW Agricultural Cooperative Society Ltd.	TamaWrap Yellow and Pink Premium	Standard, Arctic	"13B9880"
S and K Packaging	Shandong Longxing Plastic Film Technology Co., Ltd	SK COTTON WRAP Premium Blue	Standard	"1300004"
Langston Co.	TECHAGRO/AZUL PACK FILMES E EMBALAGENS LTDA	SAPPHIRE WRAP	Standard	"1300003"

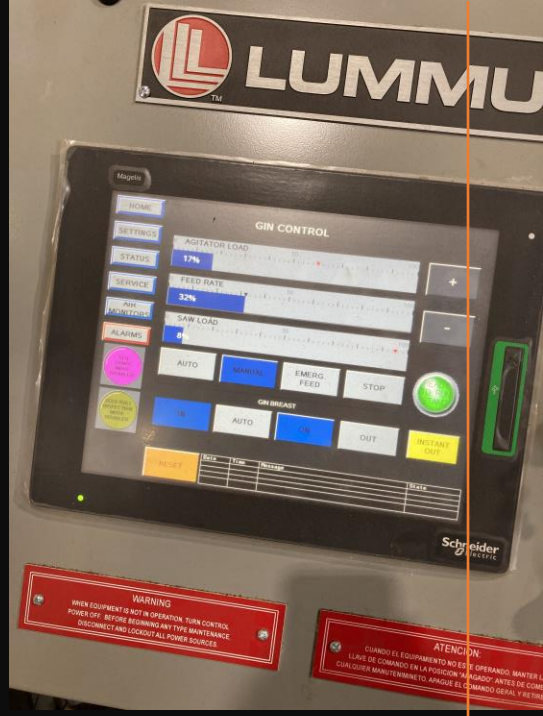
Approved wrap as of September 4, 2024

Gin Automation

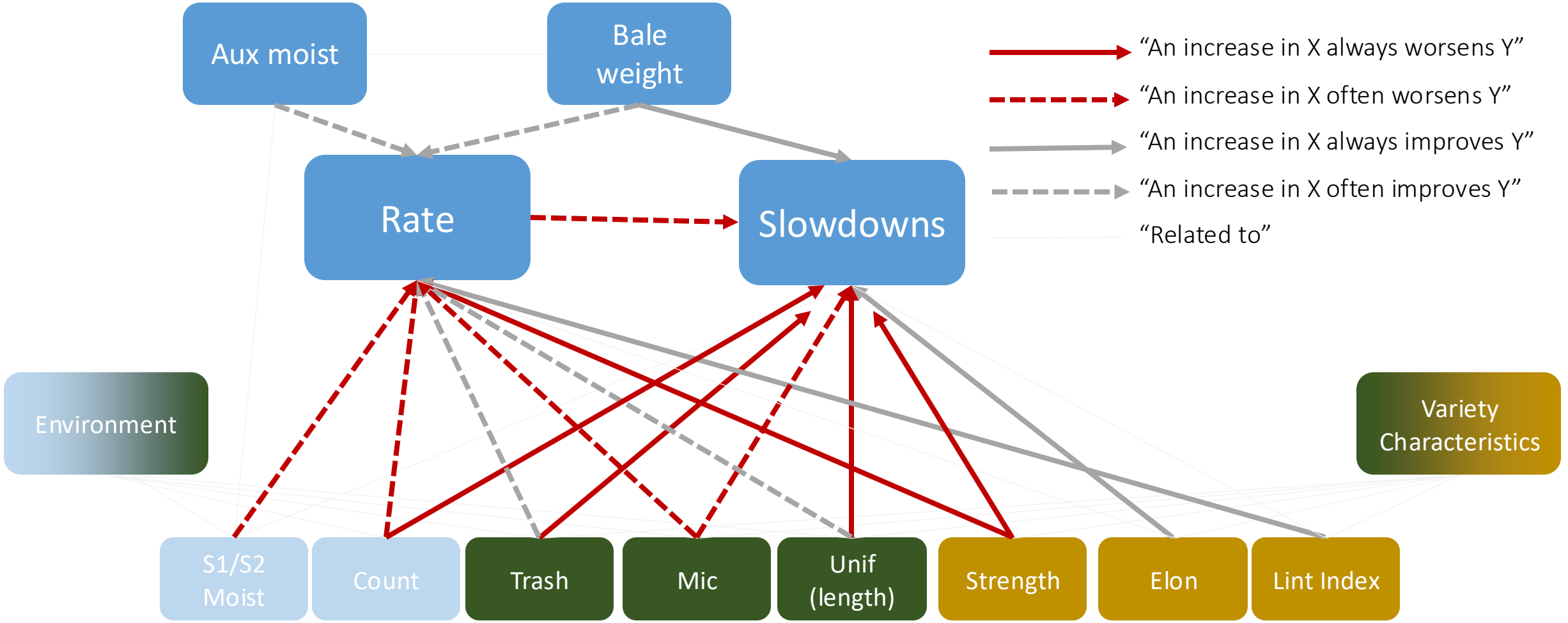
- Good progress with automatic:
  - Strapping systems
  - Bagging
  - Sampling
- Automating data flow (RFID)
- Data Collection:
  - Moisture
  - Motor loads
  - Trash Content Estimate

Ginning Data Project

- National Cotton Ginners Association (NCGA) - Harrison Ashley
- Cotton Incorporated - Ed Barnes
- USDA-ARS Gin Labs - Greg Holt, John Wanjura, Mathew Pelletier, Derek Whitelock, Paul Funk, Joe Thomas, Chris Delhom
- Texas A&M - Bobby Hardin
- NC State - Jason Ward
- University of Georgia - Wes Porter
- SAS Institute - John Gottula, Adam Hillman and Emily Kelly
- SW Gin Advisors:
  - Paul Wilson, United Cotton Growers, TX
  - Keith Mixon, Carson County Gin, TX
  - Curtis Stewart, Spade Coop Gin, TX
  - Clay Whitley / Jimmy Roppolo, UnitedAg Coop, TX
  - Daniel Luehrs / Sid Brough, Edcot Co-op Gin, TX



SAS, NCGA & Cotton Incorporated Gin Data: 2022 – 8 gins - >500,000 bales data



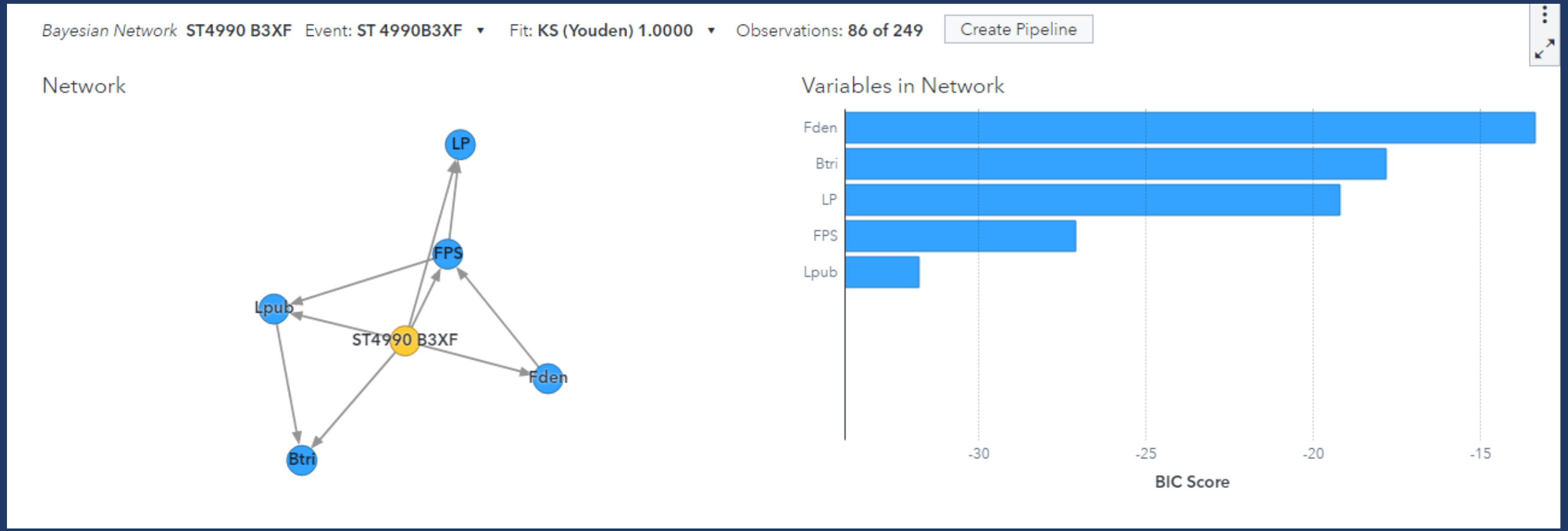
Machine learning used to identify key variables.

High Level Outcomes

- **Important to know what variety is coming to the gin.**
- Could help set ginning rate:
  - Wet, “tough” variety – decrease rate
  - Dry, “easy” variety – increase rate
- Help define prescriptive ginning charges
- Better defined variety characteristics that impact ginning.
- If we add more gins and data, there is potential to develop a robust ginning model.

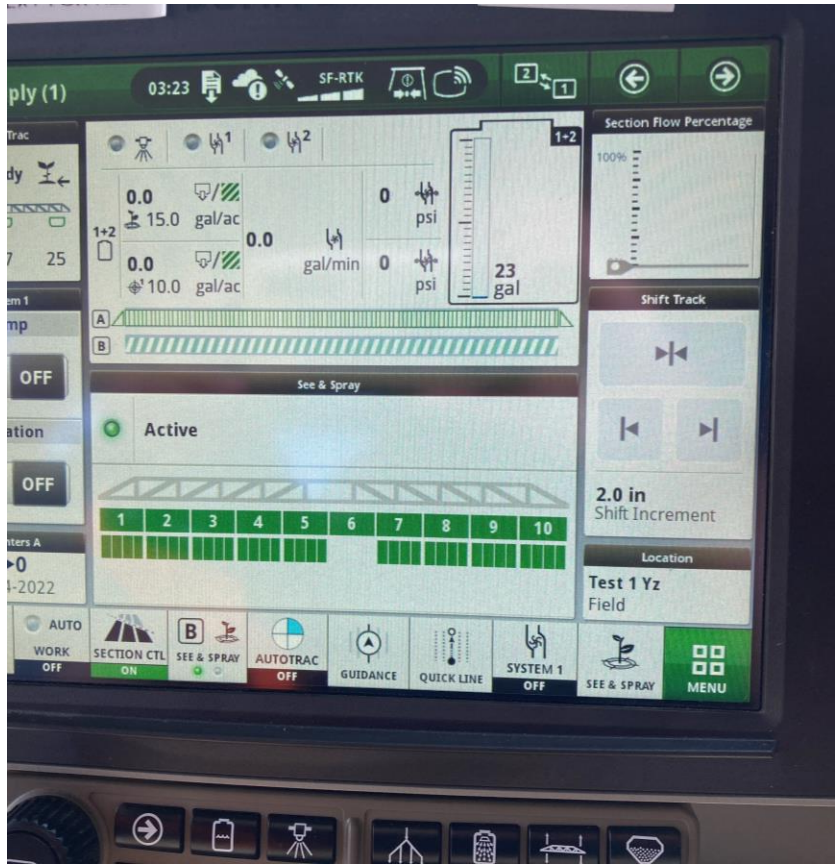
What variety characteristics reduces ginning rate?

- Lower Fiber Density → Fewer Fibers per Seed → Lower lint percent



The Need for Data Standardization

- Modeling the impact of different measures on gin performance:
  - Seed cotton and bale moisture
  - Dryer temperatures
  - When a bale is formed
  - Documenting downtimes
- Combining data sets from different sources / companies
  - EWR + Samuel Jackson
  - John Deere Ops Center
  - Sustainability Programs
- Ultimately will allow data to flow seamlessly behind the scenes so you can use it without thinking about it.



Machine Perception Systems

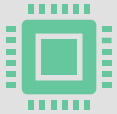
Low costs = increased used

Software is mainly open source:

Ubuntu – Open-source operating system optimized for “internet of things” (IoT) applications

OpenCV – open-source computer vision routines

ROS – Open-source robotics operating system

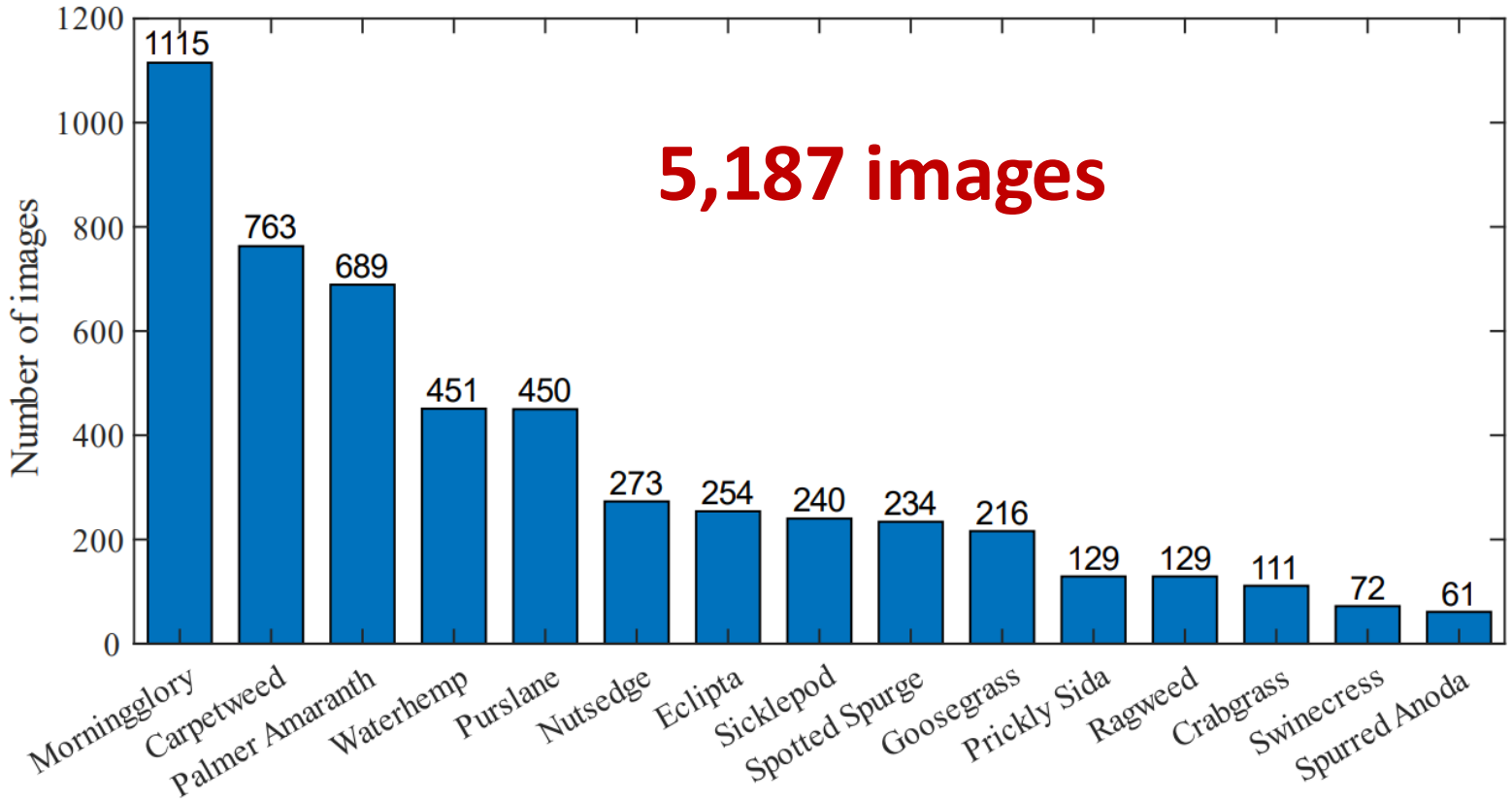


Computer systems for processing and control are about $400. For example, Jetson TX 2.

Stereo Cameras are also inexpensive. For example, ZED Stereo Camera sales for about $450.

Open-Source Machine Vision Libraries Important

- **Developing libraries of weeds (with USB) cotton diseases and bolls / flowers**
- **Allows companies to quickly adapt their machine vision-based technologies to cotton**



CottonWeedID15: Yuzhen Lu (Mississippi State)

See & Spray - Precision Application 2.0

More Detect & Treat Systems Coming:

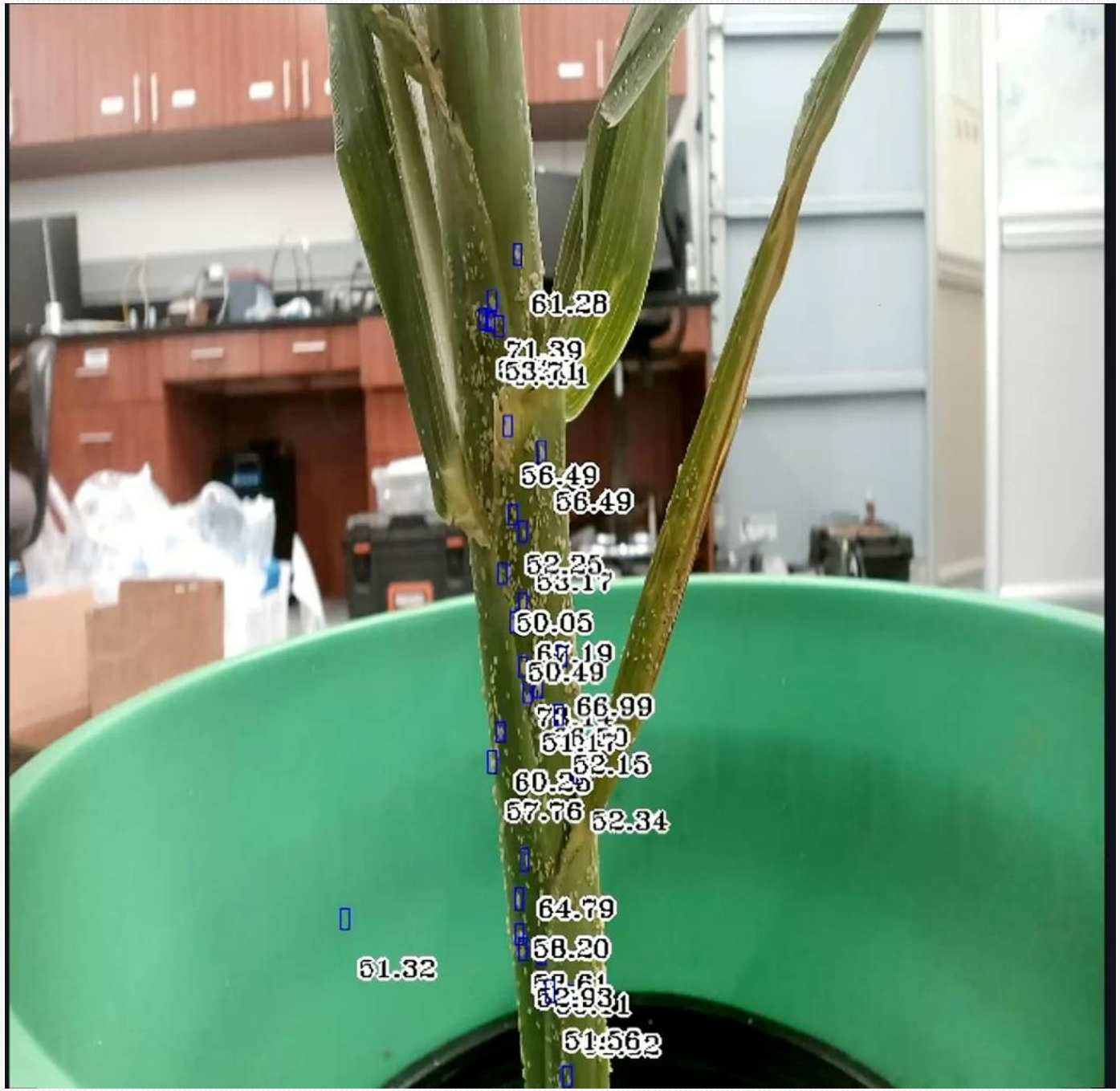
1. Agtech By Design: Australian focused, early stage RGB-based for GoB (future GoG). Viticulture/Horticulture focused.
2. Agtecnic Sensespray: Australian retrofit RGB-based system with Isobus integration for GoB.
3. Alterratech: Australian-focused early stage retrofit RGB + NIR system for GoB and potential GoG.
4. AutoWeed: Australian-focused, early stage retrofit RGB-based GoB/GoG for rangelands/sugarcane.
5. Bayer Magic Sprayer: Shrouded precision sprayer. stereo RGB + depth. *Prototype* that can spray a 4x4 cm area.
6. Bilberry (now part of PTx Trimble): RGB-based system for GoB/GoG use. In AUS, EU, CAN, ARG, USA and Brazil. Acquired by Trimble but not showing up on Trimble's site yet.
7. Carbon Bee SmartStriker: RGB + other bands for GoB/GoG use. Partnered with BBLeap for BeeLeap. U.S. dealer in the south: https://innovativeagsolutions.com/
8. DeepAgro sprAI: RGB-based retrofit option for GoG/GoB use. Based in Argentina currently. USA OFFICE: +1 864 650 3282
9. Dimensions Agri Technologies Ecopatch: Norwegian/EU focused retrofit RGB-based option for GoB/GoG. Inbuilt LED strobes, lens cleaning.
10. Ecorobotix ARA: Shrouded precision spraying. stereo RGB + depth. Only supporting vegetables and grassland at this time.
11. EXXACT Robotics 3S Spot Spray Sensor: Part of the Exel Group an RGB system for GoB/GoG. Inbuilt lighting.
12. Flux: Australian-focused system in high value crops, early stage, RGB-based detection for GoB/GoG. Looks to be very early prototype stage.
13. Greeneye Technology: RGB-based retrofit camera option for GoG/GoB. Focused in North America (corn/beans) with the Farmer Business Network. Appears available in the U.S. and **cotton** is listed as a crop option.
14. HORSCH: Identified the opportunity and tested RGB-based GoB/GoG prototype. Unclear when commercial.
15. John Deere See and Spray Select (Ultimate): RGB-based GoB (+GoG with Ultimate). Focused on North America - corn/beans/**cotton**. Cost calculator at https://www.deere.com/en/sprayers/see-spray-calculator/
16. MOVE ON AI: Turkish weed detection system with RGB-based detection.
17. Niqo Robotics RoboSpray: Indian-based company with RGB-cameras for GoB/GoG. Recently raised US$13M.
18. ONE SMART SPRAY, a Joint Venture of Bosch and BASF: RGB camera with IR/NIR filters (unclear which bands specifically) and inbuilt lighting. GoB and row-based GoG currently it seems. **Cotton is listed as one of the available crops.** Partially funded by the EU, so assuming it will be available there first.
19. OpenWeedLocator: open-source, RGB-based GOB. Components can be order to build your own control system.
20. PerPlant: Danish/EU-focused cab-mounted retrofit option. GoB/GoG and crop monitoring.
21. Precision Planting Vision: Retrofit system together with their Symphony nozzle body. GoB/GoG. Two imaging sensors, presumedly RGB+non-visual. Not shown on their website yet.
22. SaveFarm Pulverização Seletiva: Brazilian dual-sensor system for GoB/GoG and inbuilt lighting.
23. SoilEssentials Ltd SKAi: RGB-based retrofit system for GoG/GoB. Started in grasslands, now in arable crops.
24. Solinftec Solix: Autonomous platform for weeding-as-a-service. **Cotton listed as a crop**. In the US – based at Purdue so probably early in getting established here.
25. Verdant Robotics: Shrouded, precision sprayer with targeted jets. Made in the U.S. and available for demo and purchase. *Limited swath and speed* so more for vegetable crops currently. I saw this one at FIRA – slow but highly accurate.

Listed compiled by Guy Coleman

Open Weed Locator (OWL)

guycoleman@plen.ku.dk

Aphid Detection




Robots in the Sky
Photo credit: Simer Virk, UGA

Precision Application 4.0
New mode of action = LASER

Spraying and Cultivation

Scale: Still to be determined and could vary by application or preference.

Swarm – several small units per field.

Mid-size (~4 row) equipment.

Full size – just remove operators.

Automated Frequent Harvest?

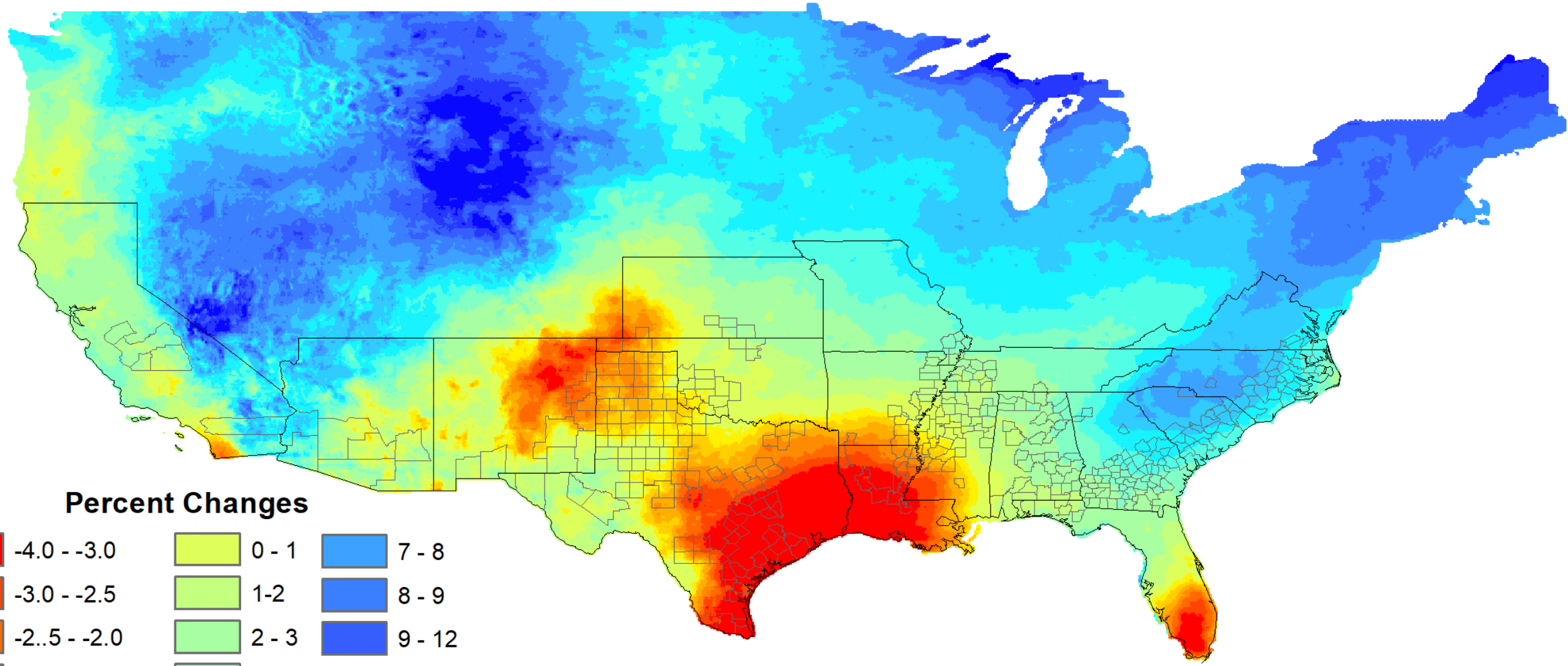
- Frequent cotton harvest (5-25 passes)
  - ✓Reduced risk of yield loss
  - ✓Prevents quality loss
  - ✓Less soil compaction
- Scalable – one robot per 10 to 50 acres?
- Multifunctional:
  - ✓Weeding
  - ✓pest scouting
  - ✓spot spraying
  - ✓spot replanting …

Texas A&M / MSU

Clemson

UGA

Projected Change in Precipitation, Annual
Higher Emissions (RCP 8.5) 2040-2069 vs. 1971-2000



Percent Changes

-4.0 - -3.0	0 - 1	7 - 8
-3.0 - -2.5	1-2	8 - 9
-2..5 - -2.0	2 - 3	9 - 12
-2.0 - -1.5	3 - 4	
-1.5 - -1.0	4 - 5	
-1.0 - -0.5	5 - 6	
-0.5 - 0	6 - 7	

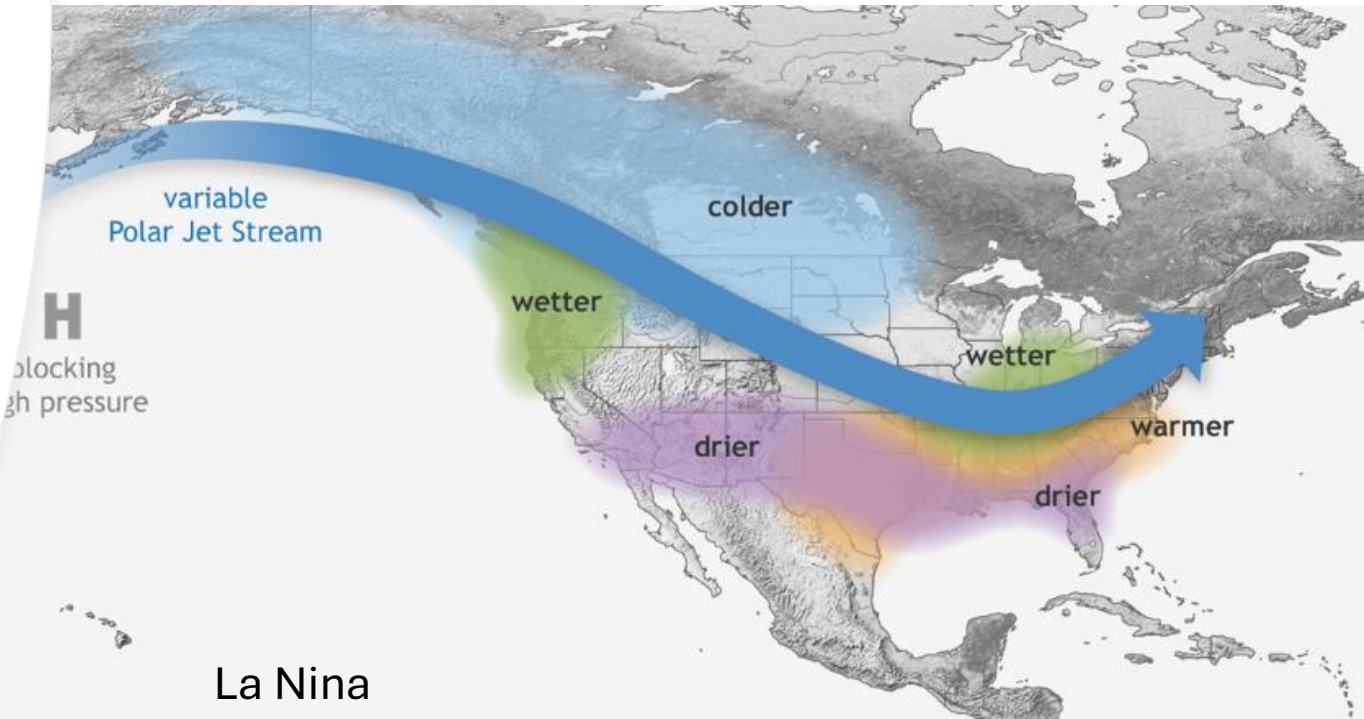
Cotton States

County with cotton 2016 to 2020

Data Source: Climate Toolbox
Data: MACAv2-METDATA

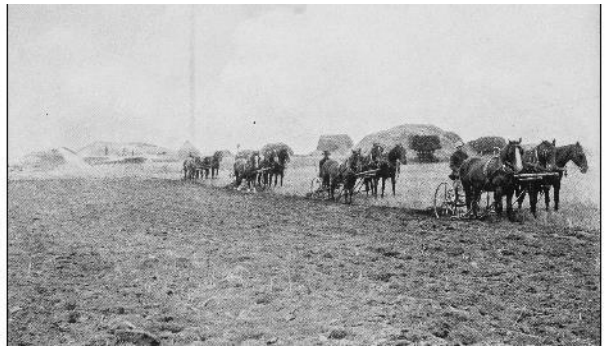
Possible Strategies for Income Stability

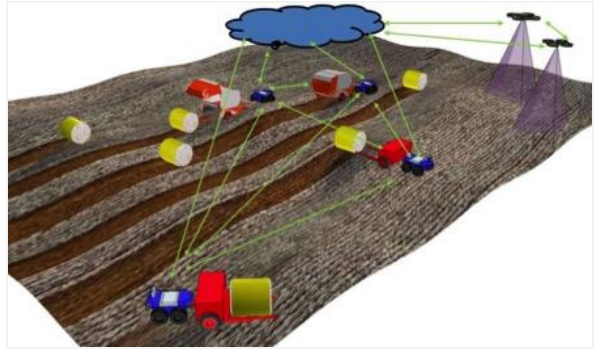
- Improving effective rainfall capture: Soil health, Furrow diking
- Models & climate forecast: Input management, planting date
- Holding soil moisture: Rotations, fallow periods, annual/perennial systems
- Increasing available water per plant: plant & row spacing
- Breeding: stomatal conductance, root architecture, genomics



La Nina

Summary





- Now
  - Labor reduction and efficiency improvement at the gin.
  - Increased data that can become information
  - UAV applications
- Soon
  - Detect and spray everything
  - New weed control options
- Future
  - Smaller equipment (less soil compaction and more scalable), autonomous, “intelligent”

All will reduce inputs (energy, chemicals & labor), and often improved yields.

Hope to provide more income stability.

Thanks!: ebarnes@cottoninc.com