Examining Current & Future Connectivity Demand for Precision Agriculture

Interim working group report

July 22, 2020

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Disclaimer

- This presentation is a work in progress and shouldn't be viewed as a final statement or set of recommendations from the working group
- The working groups initial official report by mandate will be submitted for review in the coming months

Working Group Mandate

- The current and future connectivity needs for precision agriculture in terms of coverage, speed, monthly usage, latency, and other factors; the technologies available to meet those needs; and the advantages and limitations of those technologies;

- Whether and how connectivity needs vary by agricultural product geography, and other factors;

- How and why demand for precision agriculture needs may change over time due to, for example, population increases and shifts, environmental challenges, changes in diets, and increased demand for knowing where food is sourced; and,

- Whether the amount or type of connectivity available is shifting or will shift the choices of agricultural producers, for instance from growing one particular crop or crop type to another

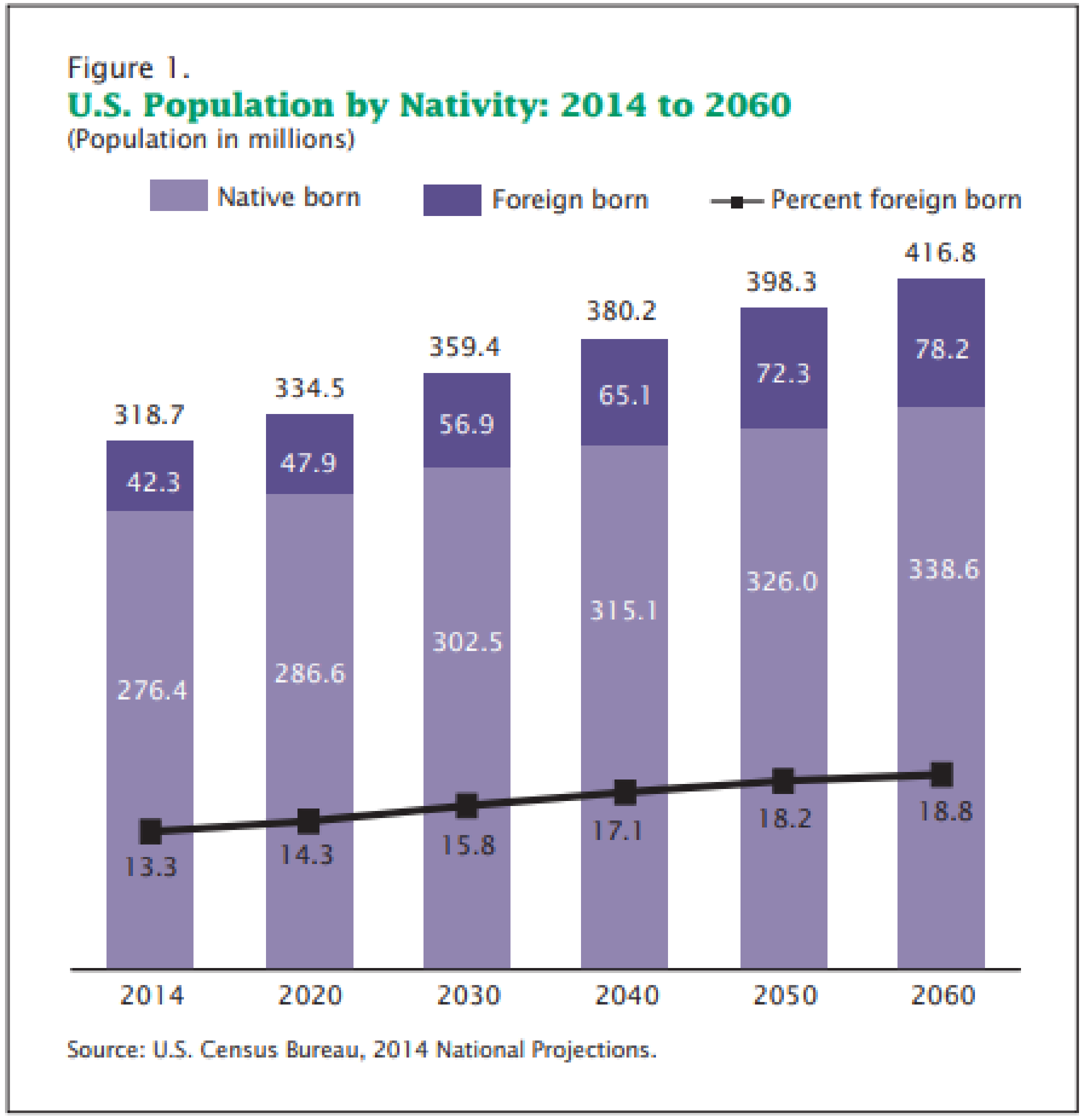
Executive Summary

The case for action is clear and compelling

Both current and future use cases require closing connectivity gap and improving connectivity performance

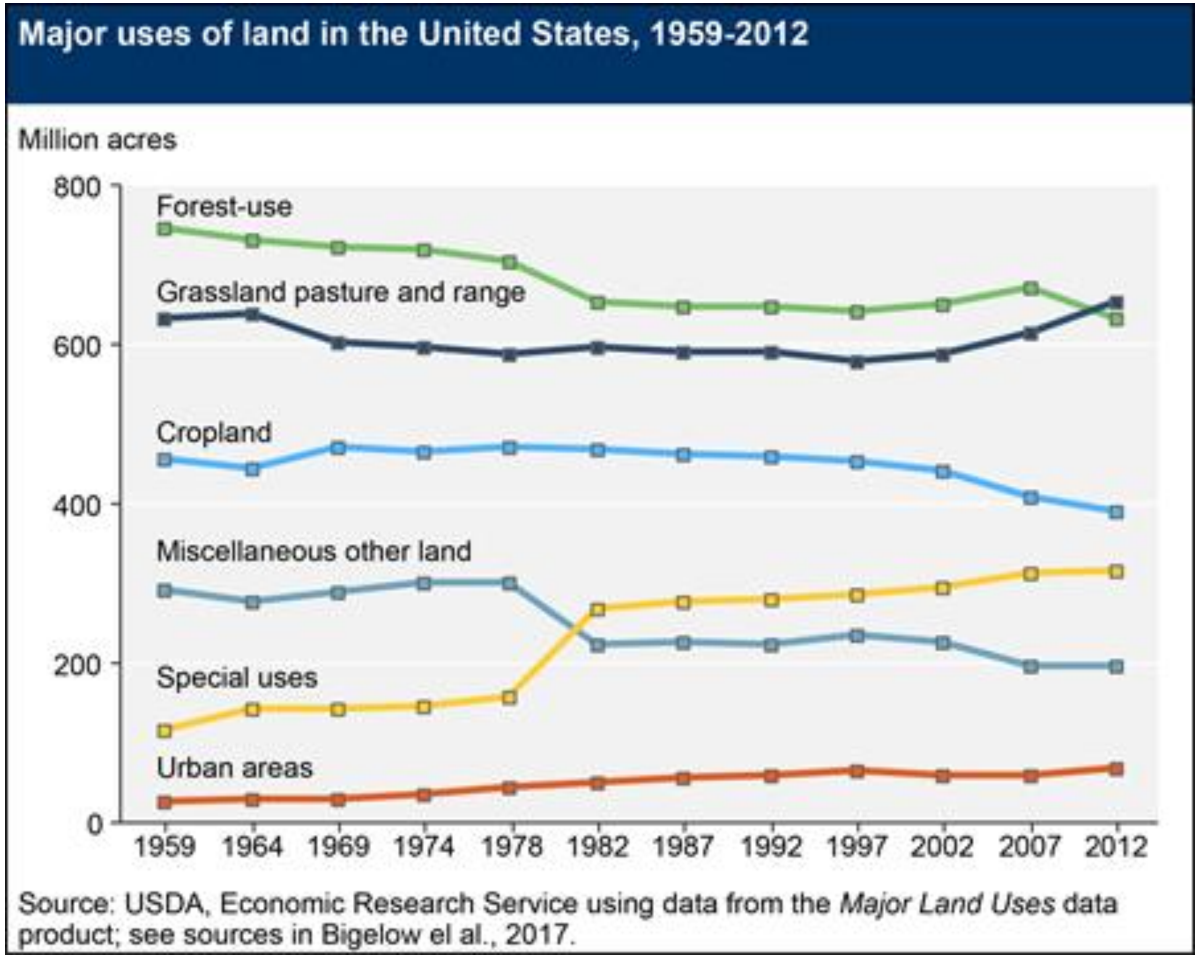
Team has made progress while more work in refining and aligning across working groups lies ahead

The US Census Bureau projects the U.S. population to increase by ~80 million from 2014 levels in the next 40 years.



https://www.census.gov/content/dam/Census/library/publications/2015/demo/p25-1143.pdf

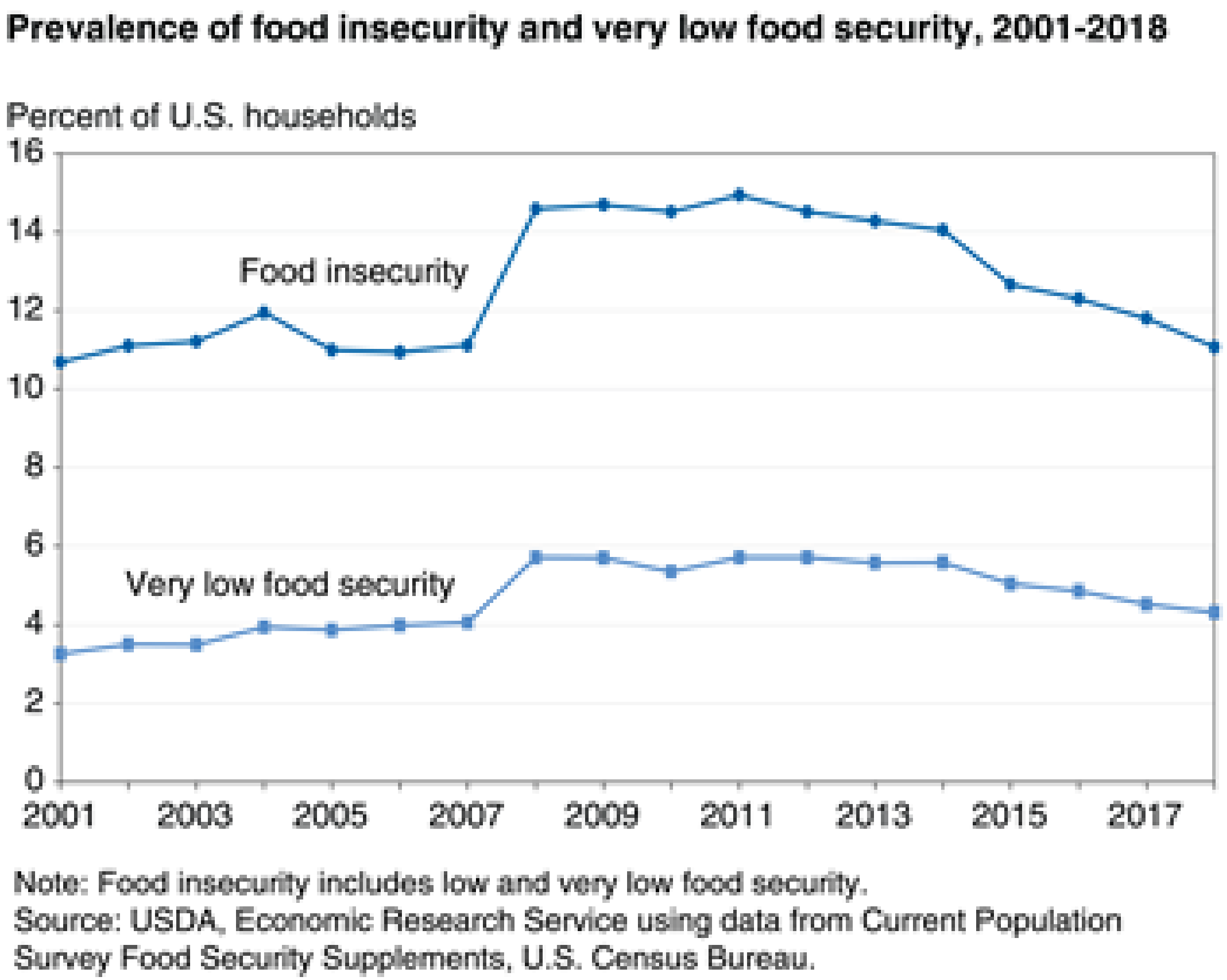
"About 52 percent of the 2012 U.S. land base (including Alaska and Hawaii) is used for agricultural purposes, including cropping, grazing (on pasture, range, and in forests), and farmsteads/farm roads." – USDA



The amount of land available to grow food isn't changing.

https://www.ers.usda.gov/topics/farm-economy/land-use-land-value-tenure/major-land-uses/

Food Security is a Growing Issue for the U.S.

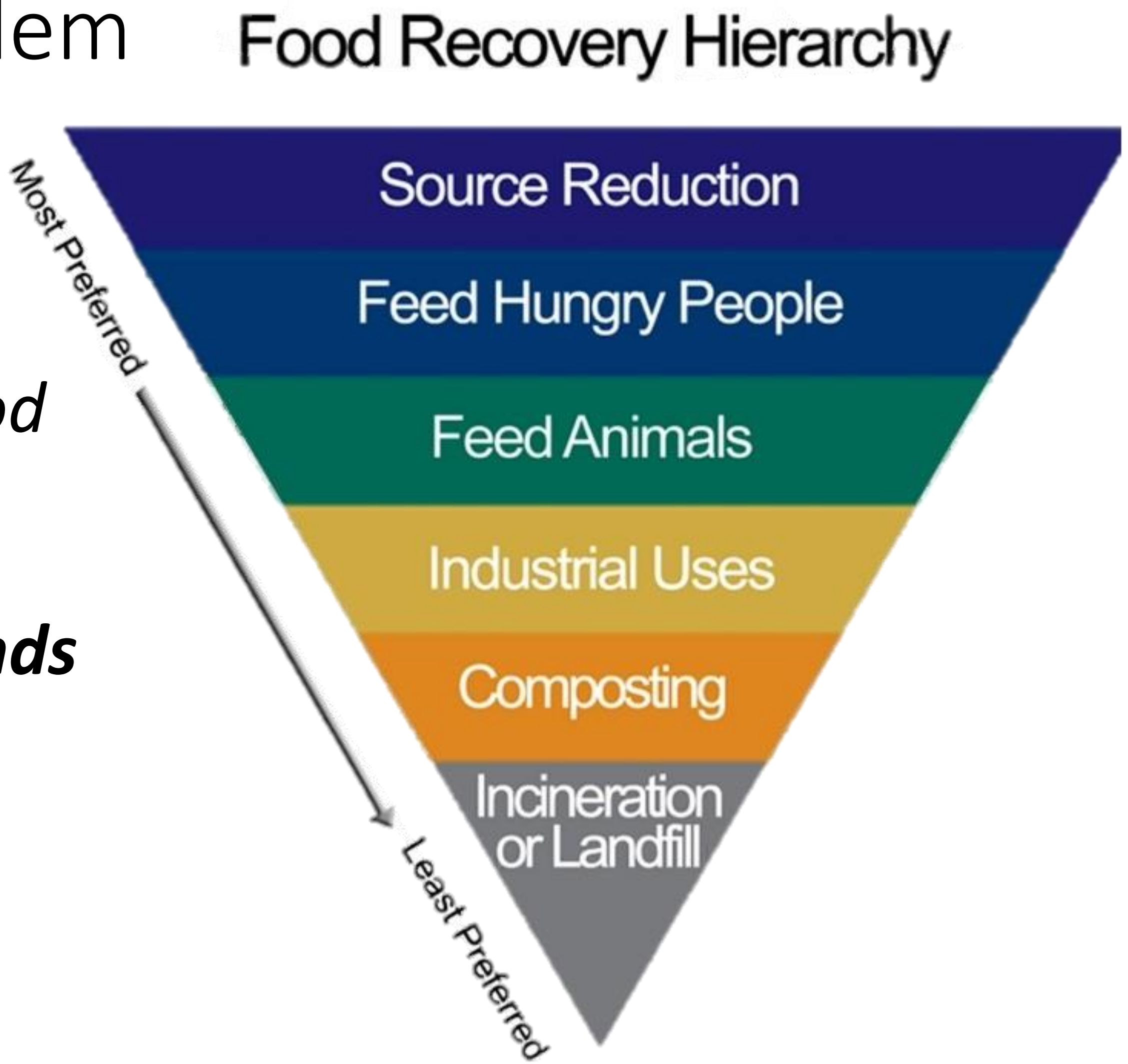


Food security is already a problem in the U.S. and it will only get worse as the population increases.

https://www.ers.usda.gov/data-products/ag-and-food-statistics-charting-the-essentials/food-security-and-nutrition-assistance/#:~:text=The%20prevalence%20of%20food%20insecurity,had%20very%20low%20food%20security.

Food Waste is a Growing Problem

USDA estimates: amount of food loss and waste from the food supply at the retail and consumer levels: *in 2010 food loss and waste at the retail and consumer levels was* ***31 percent of the food supply****, equaling* ***133 billion pounds*** *and almost* ***$162 billion***.



An Answer … Precision Agriculture

Precision Agriculture is the use of technology and data to make better decisions and automate practices to produce more and use less.

Why Precision Ag

- Reduce inputs
- Increase outputs
- Lower environmental impact
- Integrate into the supply chain

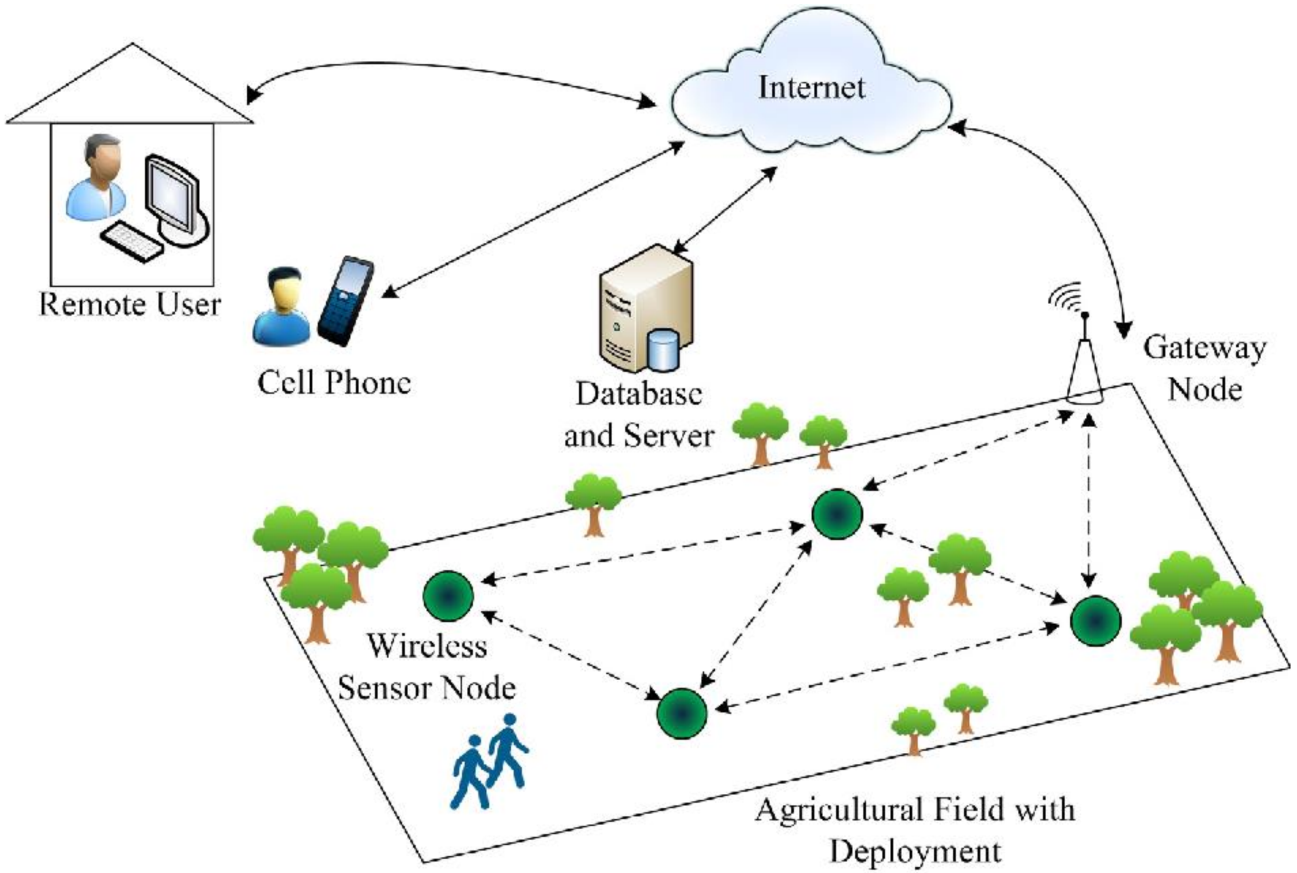
Precision Ag Results

- Feed the world
- Reduce environmental impact of agricultural practices
- Improve profitability of U.S. agriculture
- Increase skilled labor demand
- Food gets where it's needed
- International competitiveness
- Reduced food waste/spoilage

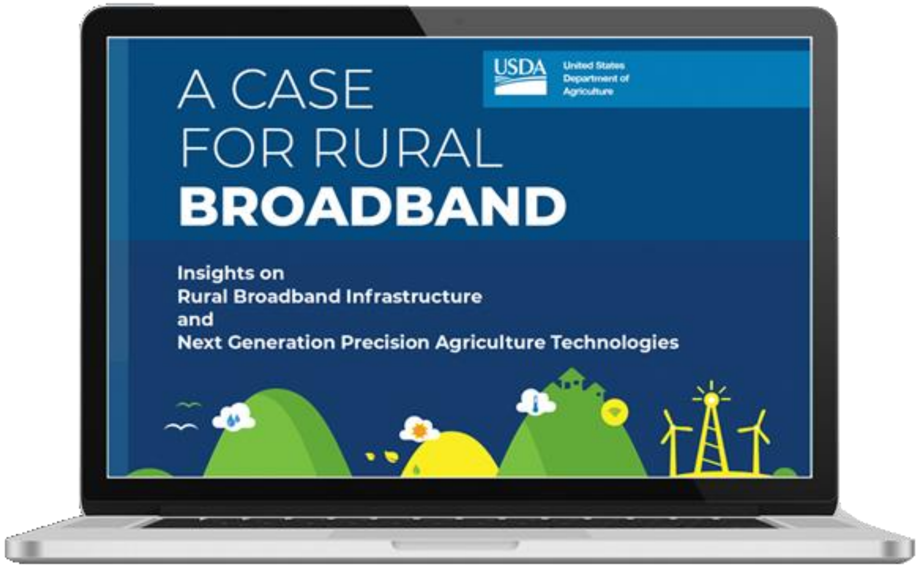
Connectivity is key to success

The value of technology in agriculture is amplified exponentially when connected, enabling data to flow.

Connectivity (Broadband and Narrowband) is the enabling fabric of Precision Agriculture



April, 2019 –
USDA Report on Rural Broadband and Benefits of Next Generation Precision Agriculture



*"**Reliable, High-Speed Broadband e-Connectivity is Essential to Enhanced Agricultural Production**"*

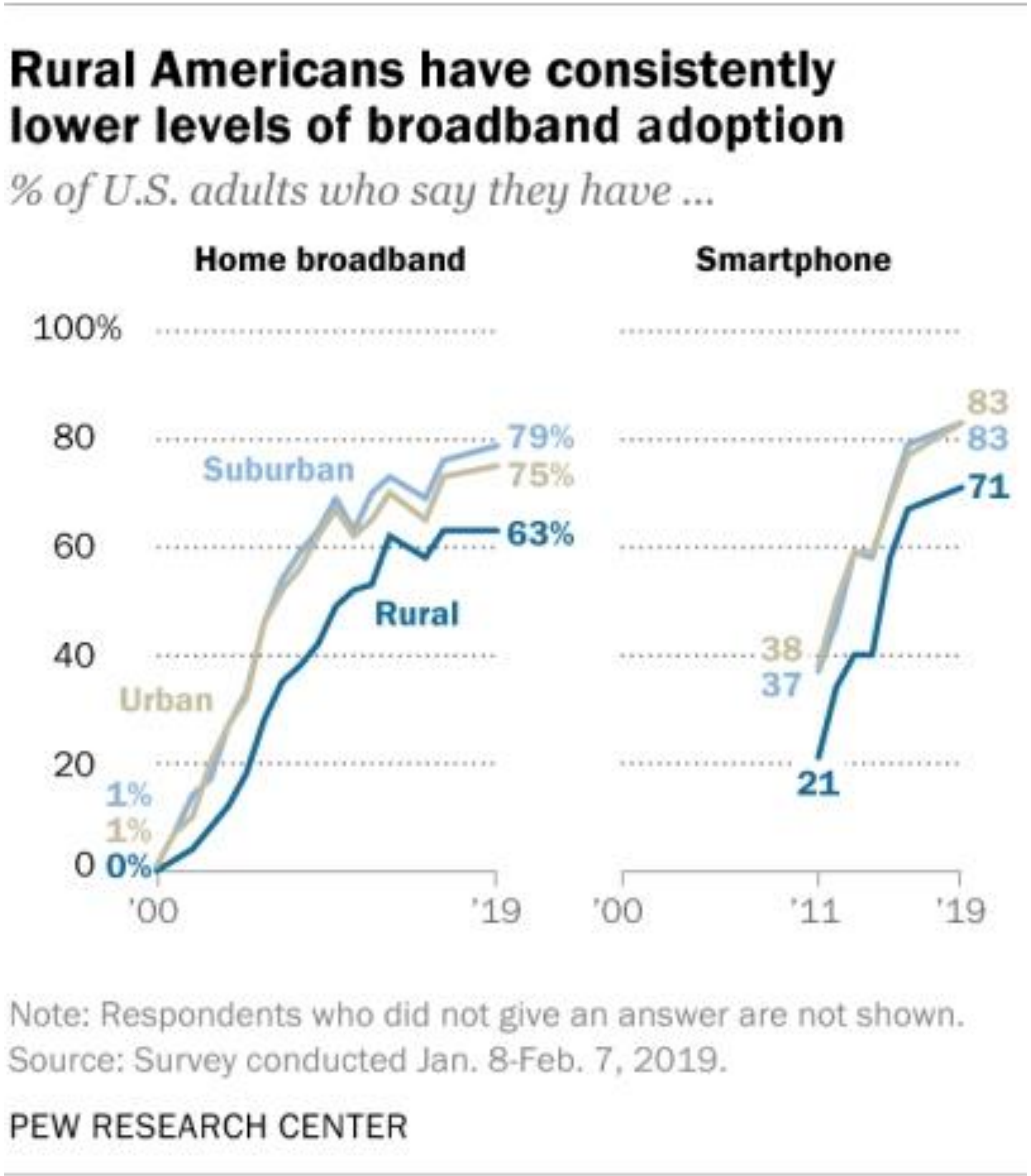
"When we are able to deploy broadband ubiquitously, think of all the things we will be able to design, harvest, and develop … Broadband in rural America will be as transformative in the 21st century as rural electrification was in the last century." - U.S. Secretary of Agriculture Sonny Perdue

https://www.usda.gov/media/press-releases/2019/04/30/usda-releases-report-rural-broadband-and-benefits-next-generation

Connectivity: The Current State Dilemma

If it were profitable to deploy broadband and faster connectivity options to rural communities and areas of high agricultural production, communications service providers would have already done it.

If we wish to ensure food security for the U.S. population, the government must enable the adoption of precision agriculture by expanding broadband connectivity across as much agricultural land as possible, and high-speed connectivity to as many farms as possible.



https://www.pewresearch.org/fact-tank/2019/05/31/digital-gap-between-rural-and-nonrural-america-persists/

Working Group Progress – To Date

- Demand Side
  - Development of current and future use cases by 3 agricultural sectors
    - *Row Crop (e.g. corn and soybeans)*
      & Broad Acre (e.g. wheat, rice)
    - *Livestock (e.g. cattle, dairy, poultry)*
    - *Specialty Crops (e.g. apples, vegetables)*

Technologies & Trends

Evaluate currently available tech & future trends for speed, latency, & cost

Technology	Bandwidth (peak)
Satellite broadband	100/10 Mbps
White spaces UHF	100 Mbps
Wi-Fi HaLow (802.11ah)	150 Kbps
Wi-Fi 802.11ac	210 Mbps
Bluetooth/BLE	2 Mbps
3G Cellular	7.2 Mbps
4G Cellular	150 Mbps
4G Advanced Cellular	1 Gbps
5G	10 Gbps
CBRS	790 Mbps
NB-IoT	250 Kbps
CAT-M1 (LTE-M)	1 Mbps
LoRaWAN	50 Kbps
Ingenu	624/156 Kbps
Sigfox	100 Bps
Weightless	200 Bps-100 Kbps
NFC	424 Kbps
RFID	4-8 Kbps
Zigbee	20-250 Kbps

Connectivity Working Group - General Assumptions
3 – 5 Years – 2022 to 2025

Common Connectivity	Bandwidth/ Speed	Latency	Cost
Fiber	H	M	H
Satellite – Geo	L	H	M
Satellite - LEO	M	M	H

Popular Wireless Technologies	Bandwidth/ Speed	Latency	Cost
4G	M	M	L
5G	H	L	M
LoRaWAN	L	M	L
TVWS	M	M	L

General Spectral Categories	Bandwidth/ Speed	Latency	Cost
Cellular – Low Band 600MHz – 2.5GHz	M	M	H
CBRS + 6G Band Mid 3.5G - 7GHz	M/H	L	M/L
Millimeter Wave High 24GHZ – 60GHz	H	L	L

Connectivity Working Group - General Assumptions
0 – 2 Years – 2020 to 2022

Local Networks				
Network	Range	Bandwidth/ Speed	Latency	Cost
Wi-Fi		L	M	L
TV Whitespace		H	M	H
Private LTE		L	H	M

Access Networks				
Network	Range	Bandwidth/ Speed	Latency	Cost
3G/4G		M	M	H
5G		H	L	M
Lo-Ra WAN		L	M	L
TVWS		M	M	L
Fiber		H	M	H
Satellite – Geo		L	H	M
Satellite - LEO		M	M	H

General Spectral Categories	Range	Bandwidth/ Speed	Latency	Cost
Cellular – Low Band 600MHz – 2.5GHz	10's of miles	M	M	H
CBRS + 6G Band Mid 3.5G - 7GHz	miles	M/H	L	M/L
Millimeter Wave High 24GHZ – 60GHz	100's of feet	H	L	L

Takeaways:

- No silver bullet for rural broadband in the next 5 years
- Need for Edge Compute on farms to accelerate broadband scenarios
- Policies & Grants needed for increased broadband coverage

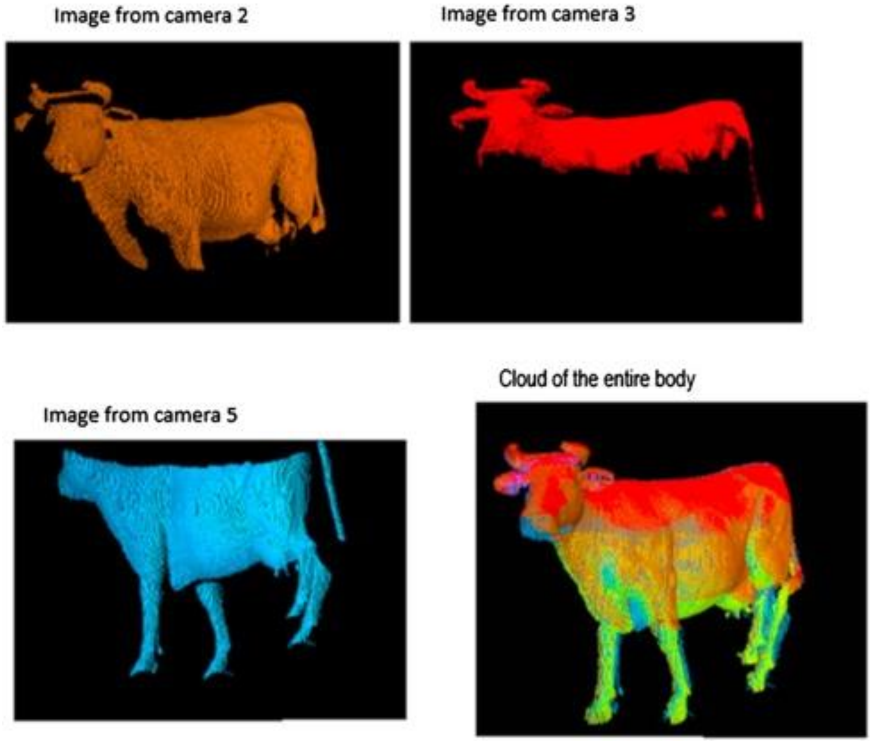
Matching Demand with Supply

Livestock

	Low (<100 kbps)	Med (< 5Mbps)	High (5 Mbps+)
Meat/Beef			
Free-range grazing	Estrus detection	Activity monitor Rumination/Grazing (research focused)	Body scanner
Feed lots	Activity monitor Movement monitoring (time & distance/proximity to feed bunk)		Automated BCS scores Feed intake
Dairy			
Replacement calves	ID Tags, birth weight, calving ease	Vet data, pedigree, records, automated calf feeding	
Production cows	Productivity (lbs of milk),	Robotic systems (fat/protein content), health, monitoring rumination (accelerometer, etc.) Carbon monitoring	Automated BCS scoring, monitoring eating & rumination using AI/ML, remote health/vets, remote nutritionists
Dry cows	Estrus monitoring		Feed monitoring

Livestock Demand with Supply

Cow Body Scanner



Activity Monitors

Estrus Detection

Use Case Example – Dairy Farm (Livestock)

- Commonly available Precision Agriculture Techniques
  - Robotic milking machines
  - Activity systems

- Developing Precision Agriculture Techniques
  - Phenotyping data collection

Use Case Example – Dairy Farm (Livestock)

Robotic Milking Machine

- Benefit – Efficiency / Data Collection
  - Cows are milked at will
  - Effort can be used elsewhere
  - Data automatically collected
- Requires Internet Connectivity
  - Software Updates
  - Remote Diagnostics
  - Herd Performance Upload

Lely Robotic Milking Machine @ Valley Wide Farm, Spring Mills, PA

Use Case Example – Dairy Farm (Livestock)

Activity Monitors

- Benefit – Data Collection / Care
  - Accelerometers measure vibrations and movement to determine cow activity
  - Some systems can monitor rumen function, temperature, eating time, and cow location and position
- Requires Internet Connectivity
  - Much like a Fitbit® or other smart devices for humans, downloads are facilitated by Broadband

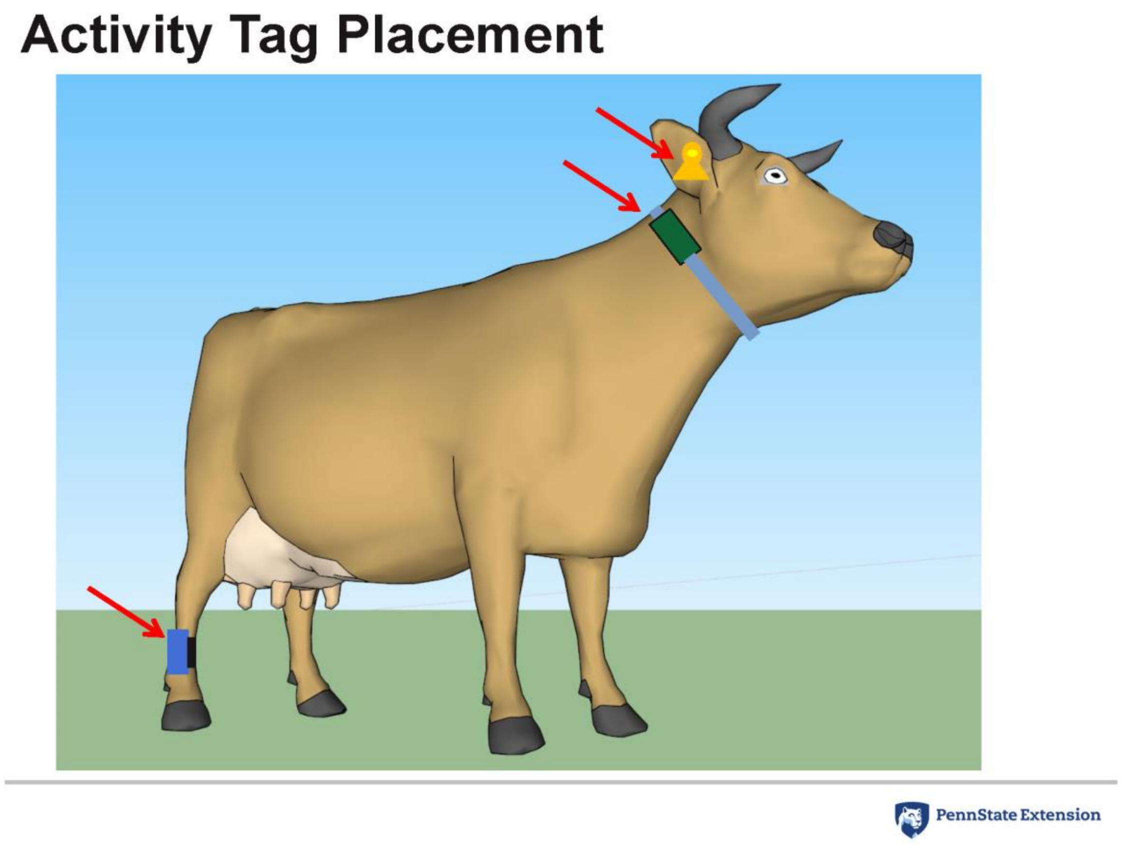
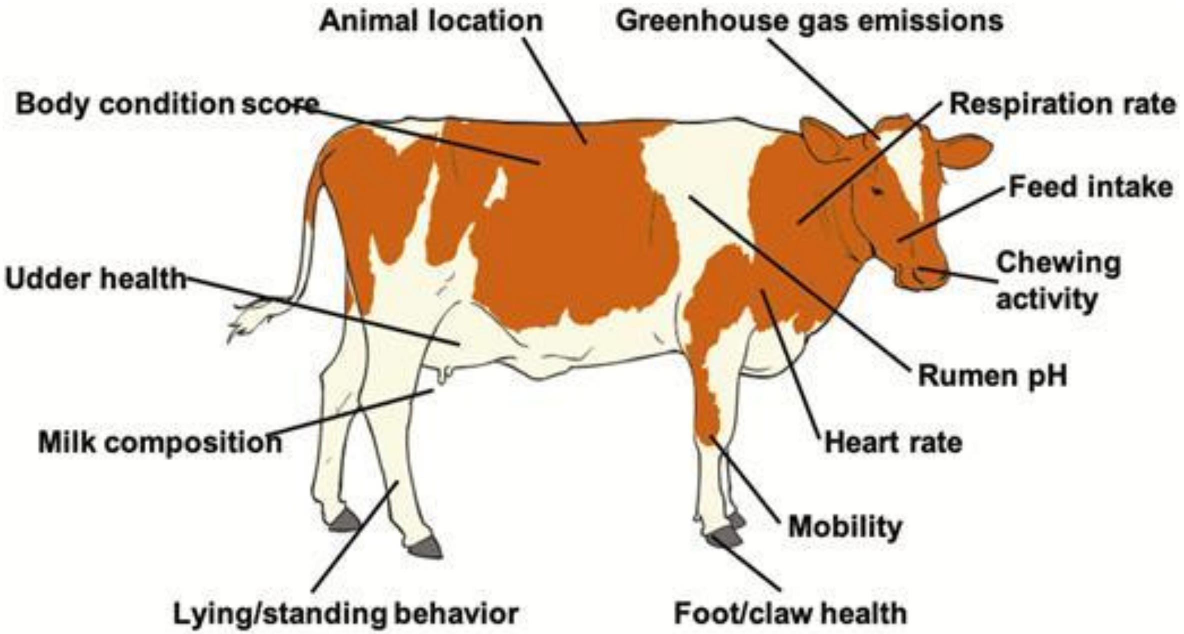


Image Courtesy Mat Haan Penn State Extension

Future Use Case Example – Dairy Farm (Livestock)

What we could do with Phenotyping

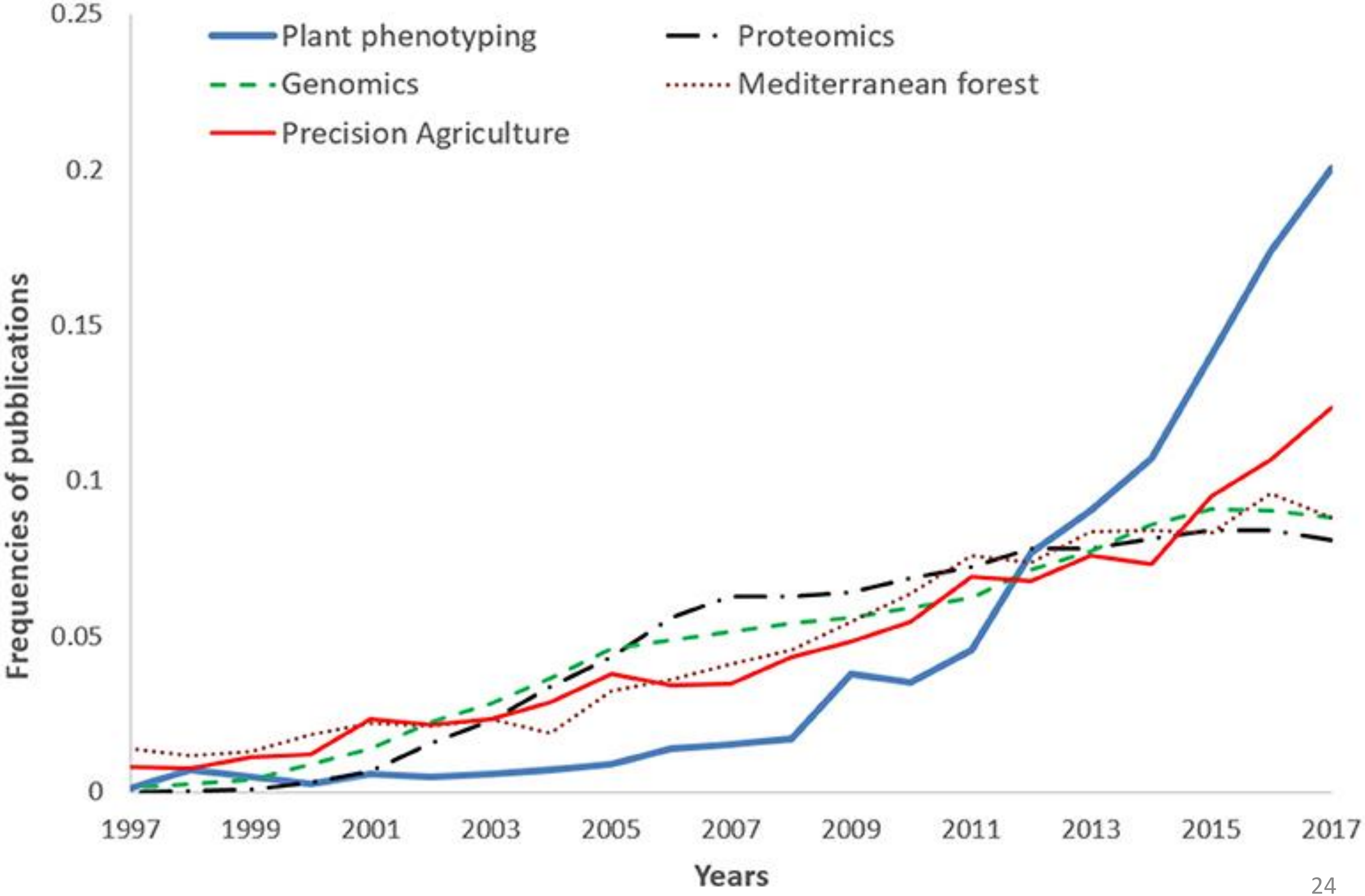
- Benefit – Data Collection - Breeding
  - High-frequency measurements of animal performance and environments provide data in real time or near real time
  - Advanced analysis assists with animal ranking and selection
- Requires Internet Connectivity
  - *"The lack of access to rural broadband internet is also a growing problem because of the need to transfer data to and from farms."*



The future of phenomics in dairy cattle breeding
Animal Frontiers, Volume 10, Issue 2, April 2020

Growth in Phenotyping & Precision Ag Research

"The application of plant phenotyping in the field is still under rapid development and this application has strong linkages with precision agriculture."



Plant Phenotyping Research Trends, a Science Mapping Approach
[Corrado Costa](#) et al
Plant Sci., 07 January 2019

Precision Agriculture - The Future Awaits

"AI (Artificial Intelligence) can improve predictions by taking advantage of large datasets from real-time sources (i.e., remote sensors, digital farm equipment, and satellites)."

"We need more observations of the phenomena we seek to predict in order to train better models"

"Observations from farms and ranches across landscapes and regions are needed, which can be facilitated by mobile technologies and collaborative networks involving farmers and ranchers."

Scaling Up Agricultural Research With Artificial Intelligence
Brandon T. Bestelmeyer USDA-ARS et al
IEEE IT Professional (Volume: 22 , Issue: 3 , May 2020)

Up Next

- Have begun drafting initial report for September 2020 delivery
- Continuing development of use cases
- Classifying activities by bandwidth and other needs
- Identifying the magnitude of benefits
- Development of initial recommendations

Collaboration Needs

- Cross-functional working group review of direction and Draft document
  - Eliminate redundancy and share knowledge
- Team desires to capture feedback from private and public sectors
  - OEMs (farm equipment to sensor devices) on connectivity roadmap for their products
  - Current/future Service Provider options for Ag sector
  - State and Local initiatives (independent of FCC) to improve rural community access
  - Quantify other rural broadband programs that may compliment Precision Ag
- Continue technical evaluation for report
  - Aggregate bandwidth drivers by farm type and size
  - Heatmap connectivity options
  - Impacts of premise networking and edge computing to public bandwidth consumption

Just the beginning!