Task Force for Reviewing the Connectivity and Technology Needs of Precision Agriculture in the United States

November 6, 2023

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EXECUTIVE SUMMARY

The Task Force for Reviewing the Connectivity and Technology Needs of Precision Agriculture in the United States (also known as the Precision Ag Connectivity Task Force) arose out of the Agriculture Improvement Act of 2018 (2018 Farm Bill). The Task Force's charge is to provide advice and recommendations to the Federal Communications Commission (FCC) and the United States Department of Agriculture (USDA) on how to assess and advance the deployment of broadband internet access service on unserved and underserved agricultural land and promote Precision Agriculture for both cropping and husbandry.

The Task Force has four working groups focused in greater detail on specific issues related to Precision Agriculture. These working groups are:

1. Mapping and Analyzing Connectivity on Agricultural Lands
2. Examining Current and Future Connectivity Demand
3. Accelerating Broadband Deployment on Unserved Agricultural Lands
4. Encouraging Adoption and Availability of High-Quality Jobs

Through the collective work of the Precision Ag Connectivity Task Force, the working groups, industry experts, technologists, economists, public officials, and conversations with farmers, ranchers, producers, and those living in rural communities, it is evident that digital infrastructure is tightly linked to the success of this nation.

Unfortunately, access to this infrastructure is not readily available in rural America, despite it having become a fundamental necessity. The challenges facing those without access to digital infrastructure are enormous. It can contribute to decreased agricultural productivity, lack of fresh food, education achievement gaps, declining rural communities and main streets, lower health care outcomes, hospital closures and lack of access to credit. It can also prevent adoption of conservation practices because farmers often use technology to enhance decision making and reduce their environmental footprint. The Task Force seeks to address these gaps with recommendations that advise the federal government on ways it can improve access to reliable, scalable, and low latency broadband access, specifically on rural and agricultural lands.

The recommendations fall largely within five primary categories with some additional key considerations: enhancing federal maps on agricultural lands, targeted incentives for a robust technology ecosystem, new technology considerations for agriculture, increasing agency collaborations, and developing specific education and training programs. Additional consideration should also be given to cyber and national security concerns.

Below, is a summary of the recommendations listed by Working Group. Each of these groups has done extensive research and developed recommendations that address current challenges.

Mapping and Analyzing Connectivity on Agricultural Lands

The agricultural sector is disconnected from the federal broadband mapping effort. The needs and geographic parameters are different from residential broadband serviceable locations but equally important. The following recommendations are intended to address deficiencies with the current broadband data and mapping efforts to ensure that all agricultural lands and use cases, as well as connectivity types are adequately represented in the national broadband mapping framework:

1. The FCC should enhance the Broadband Data Collection (BDC) map to improve the map's usability for precision agriculture:
    a. The current BDC map should include alternative lookup descriptors in addition to the ability to lookup a location based on service address. The group suggests including alternative lookup locations to help producers find their location of interest more effectively.

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b. Extend existing wireless coverage hexagon sizes used in the FCC map. The current zoom level is a good starting point for expressing coverage at higher zoom levels. In areas of greater data density, support a more granular zoom level presenting coverage layers in smaller hexagon sizes down to ~100 meters across, is needed to better identify coverage across specific locations including fabric locations and acreage.
c. Add agricultural structures (example, irrigation systems, grain bins, barns, water tanks, RTK towers, sheds, shops) to the BDC map.

2. The FCC should include a verification data layer(s) into the existing BDC interface showing where the existence and performance of connectivity has been independently verified, augmenting the existing data layers that show where connectivity is expected. Third party data sources to be included in this verification layer should adhere to a standard set of required key performance indicators (KPIs) interface.
3. The FCC, in partnership with USDA, should adopt a framework to determine and map unserved, also called negative space, and underserved agricultural lands and develop a visualization platform hosted by NASS to display the connectivity map over a base layer of cropland and pastureland data, with necessary funding, to support the broadband mapping needs of the agricultural community.
4. The USDA shall be directed to establish an inter-agency coordinating council focused on broadband connectivity data collection, verification, and mapping analysis of broadband coverage on agricultural lands as well as native farmlands to address the broadband connectivity challenges facing these communities and their stakeholders. The Council will include the USDA as well as the National Telecommunications and Information Administration (NTIA), the Bureau of Indian Affairs (BIA), the U.S. Census Bureau and the FCC. The Council should also consult with the National Association of Counties (NACo) and other state (for example, state departments of agriculture, state broadband offices and county officials), local and tribal governmental organizations to develop a comprehensive strategy towards mapping and expanding broadband access on agricultural lands. The Council will meet quarterly and provide a bi-annual report on its work to the House and Senate Agriculture appropriations and authorizing committees. Such reports will be provided until the next Farm Bill reauthorization in 2028.
5. Adopt connectivity use case driven standards for data & mapping purposes. Agriculture operations are primarily a mobile endeavor and the current BDC focuses on locations as opposed to mobile geographical areas.

Examining Current and Future Connectivity Demand

Precision Agriculture is the utilization of technology and data for generating insights that enhance decision-making in real time and automate farming practices. It plays a pivotal role in enhancing agricultural productivity, efficiency, and sustainability. Benefits include reducing inputs, increasing production, and minimizing environmental impacts.

Additionally, precision agriculture has the potential to contribute significantly to climate change mitigation efforts. The goal of the recommendations below is to help chart a path to achieving these benefits though government policy, incentives and by broadening funding opportunities to encourage farmers to build private networks on working lands, to meet the current and future needs for connectivity:

1. Prioritize deployment of wired, wireless, and satellite infrastructure in agricultural lands to achieve broadband connectivity to the last acre. Broadband connectivity has become a fundamental cornerstone of modern agriculture, driving efficiency, productivity, and sustainability. To ensure every farmer can harness the full power of digital tools and technologies, it’s vital to prioritize the deployment of diverse communication infrastructures across agricultural lands. By incorporating a mix of wired, wireless, and satellite systems, we can create a robust and redundant network that caters to the unique topographical and logistical challenges presented by expansive farming regions. The “last acre” in this context isn’t just a geographical point but represents the commitment to ensure that even the remotest and most isolated agricultural operations are not left behind in the digital revolution. Providing them with seamless broadband connectivity ensures that they benefit from real-time data, advanced analytics, and remote support, leveling the playing field and allowing every farmer to make informed and timely decisions for their crops and livestock.

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2. Farmers should be encouraged to band together to create private, on-farm networks as a self-sufficient solution to achieve last acre connectivity. Last acre focus can only increase with government policy and funding. The analogy is the success and importance of electrical cooperatives in the 1930s. Similar farmer alliances could build and deliver bespoke, carrier grade, highspeed wireless networks for the farmer members to help drive the adoption of precision agriculture applications.
3. Strong connectivity is foundational to the future of agriculture in the United States. The Task Force commends the FCC for recognizing the need to elevate current standards from 25 Mbps download/3 Mbps upload to 100 Mbps download/20 Mbps upload as seen in the latest FCC standards. However, as technology continues to advance, it is pivotal to incentivize innovation and increase the standards to meet future needs on a regular basis. In agriculture, download speeds are for “consumption”, upload speeds are for “production.” Therefore, the Task Force recommends the following:
    a. Significantly raise the standard on upload capacity over time to anticipate the needs of precision agriculture.
    b. Double or even triple the current standard for upload and download speeds to meet the needs of future technology such as autonomous tractors.
    c. In the next term, the Working Group should review a potential timeline for new standards based on research, examples, and testing to determine practical speeds.
4. Establish a national spectrum policy that makes available ample spectrum for agricultural use and that also helps lower costs by offering bidding credit for agriculture at spectrum auctions.
5. Amend the Reconnect Program (currently geared for households) to incentivize applications that benefit precision agriculture farm infrastructure. Private networks may be the best (though high cost) solution and must be part of the funding equation.
6. Improve Rural Utility Service (RUS) grants and loans for tower construction. Funding access to dark fiber could be an additional boon.
7. Consider the unique challenges of geography, profitability, operator aptitude, crop variety, labor, equipment, and support when implementing technology solutions. One size does not fit all.
   The complexity of the agricultural sector is often underappreciated, with numerous variables at play that can affect the successful integration of technology. Each agricultural operation, whether a sprawling commercial farm or a small family-owned plot, faces its unique set of challenges shaped by the geography of the land, from the inclines of terraced fields to the moisture levels of different soil types. Profitability also varies widely based on factors like market demand, crop yield, and external pressures like climate change. Furthermore, the aptitude of the operator, often influenced by generational practices and exposure to technology, can determine how swiftly and effectively new solutions are adopted.
   The diversity in crop varieties demands tailored technological approaches, as the needs of a vineyard vastly differ from those of a grain farm. Labor availability, the type and age of equipment in use, and the support infrastructure, both in terms of technology service providers and local knowledge bases, further add layers of considerations. This mosaic of variables underlines the fundamental truth: when it comes to agricultural technology solutions, a one-size-fits-all approach is not only ineffective but could also be detrimental. Tailored solutions that respect and respond to these nuances are imperative for the holistic progress of the sector.
8. Ensure seamless connectivity for precision agriculture by addressing cellular network limitations, roaming agreements, and antenna power level regulations.
9. Embrace emerging artificial intelligence (AI) techniques for multifactor analysis in agriculture and invest in training for accurate AI usage**.** Precision agriculture, with its reliance on real-time data and constant feedback loops, stands at the forefront of modern farming, promising optimized yields and resource management. However, the true potential of precision agriculture can only be unleashed when there’s uninterrupted connectivity. Cellular network limitations, often seen in the form of patchy coverages or signal drops, can significantly impede the efficient functioning of tech-driven farming tools.

Roaming agreements further compound the problem; when a machine transitions between carrier zones, a lapse in data transmission can occur, disrupting operations. Additionally, stringent regulations surrounding antenna power levels can sometimes curtail the effective range and reliability of signals. Addressing these challenges is paramount. By fortifying cellular networks, enhancing the interoperability through robust roaming agreements, and revisiting antenna power regulations, we can lay the groundwork for a digital agricultural revolution. Such efforts will not only drive productivity but also ensure that farmers, irrespective of their operation's scale or location, have the tools to make data-driven decisions, fostering a sustainable and prosperous future for agriculture.

10. Leverage edge compute technology and private 5G systems to extend cloud capabilities to remote farm locations. The fusion of edge compute technology and private 5G systems heralds a transformative era for modern agriculture. Farms, especially those located in remote areas, have historically grappled with challenges of connectivity and data processing. Edge compute technology addresses this by allowing data to be processed closer to where it's generated – right on the farm itself. This means real-time insights without the need for long round trips to central data centers, which can be especially valuable when immediate action is required based on the data received. Complementing this, private 5G systems offer high-speed, reliable, and low-latency communication, enhancing the ability of farms to handle massive data streams from IoT devices, sensors, and automated machinery. By melding these technologies, cloud capabilities, previously a distant luxury for many remote farms, can now be brought right to their doorstep. This localized approach not only boosts operational efficiency but also empowers farmers with the digital prowess to optimize resources, monitor conditions meticulously, and make informed decisions, all in real-time, paving the way for a more resilient and productive agricultural future.
11. Incentivize private cellular networks to meet high-speed connectivity requirements in agriculture, potentially using legislative vehicles like the Farm Bill. The burgeoning need for high-speed connectivity in the agricultural sector is unmistakable. As farming practices continue to embrace the digital age, the demand for seamless and robust connectivity grows. Private cellular networks can play a pivotal role in meeting this demand, offering tailored solutions that cater specifically to the unique challenges and requirements of agriculture. However, for these networks to flourish and serve the agrarian community effectively, there must be significant incentives. Herein lies the potential of legislative tools like the Farm Bill. By integrating provisions that promote and financially support the establishment and expansion of private cellular networks, the Farm Bill could act as a catalyst, spurring technological advancements in the field. Such a move would not only ensure that farmers have access to the digital tools they require but also foster an environment of innovation and competition among service providers. This, in turn, could lead to advancements in connectivity solutions, driving down costs, improving reliability, and ensuring that the digital revolution in agriculture leaves no farmer behind.
12. There are a number of policies that federal and state agencies can pursue to improve cellular connectivity.
    a. Require cellular companies to guarantee minimum download and upload speeds as part of the monthly contracted services purchased by consumers.
    b. Expand the mandate to provide service to everyone in a stated coverage area beyond cooperatives to national and regional carriers.
    c. Design policy for a farmer/rancher to seamlessly access multiple carriers or merge with satellite coverage – essential for maximizing efficiency and productivity in the fields.
    d. Incentivize modem and equipment development and articulation to capitalize on future dedicated ag spectrum.
    e. Ensure existing federal funds for infrastructure development and broadband can be used by states to create programs that help meet local needs. Ex. Cell Towers Grant program for local providers; restoring service where spectrum was sold to nationwide carriers who no longer provide reliable service.
    f. FCC continue developing and promoting consumer apps to ground truth provider service. Continue following up on speed test and connectivity challenges from cellular devices and from other connected devices.

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Accelerating Broadband Deployment on Unserved Agricultural Lands

This Working Group analyzed what is required to increase broadband deployment on unserved agriculture lands, focusing on meeting the needs of precision agriculture. The addition of the tens of billions of dollars being made available to increase broadband connectivity across the country is commendable; however, there is still concern whether this funding will reach the unserved lands that need it most, such as agricultural lands. Therefore, the following recommendations should be considered:

1. All U.S. federal agencies should use the same broadband definition and standards for funding decisions, and these definitions and standards should be updated on a bi-annual basis. A continuing major concern is that there is no single definition of broadband as our federal partners make broadband decisions (this gets even worse if one looks at the states and localities). To ensure that all agricultural lands have access to a baseline of broadband services, it is critical that federal agencies use the same threshold for establishing what, is the definition of "broadband service" and align all government support mechanisms and incentives.
2. Grant applications that include wide-area coverage to agricultural acreage, including the farm office or house, should be prioritized. Adding this criterion will ensure there is a robust broadband last mile network as well as wide area coverage to reach last acre agriculture lands, which require both wireline and wireless technologies.
3. The FCC, NTIA and USDA should require the use of interoperability standards as part of the funding process for precision agriculture and encourage the use of such standards through outreach, etc. As part of the funding process, the aforementioned agencies should require service providers receiving grants to utilize network equipment and devices that are compliant with industry-led interoperability standards, as seen with the evolution of the connected home and smart/connected devices.
4. The FCC and USDA should support rural broadband networks by including incentives for connectivity to rural agricultural land headquarters. The $42.5 billion NTIA's BEAD (Broadband Equity and Access Deployment) funding is an unprecedented amount for the build-out of broadband networks. We recommend an additional incentive for applicants that can and will build-out broadband networks to reach rural farm and ranch headquarters. Similarly, USDA can and should implement this criterion in selecting future ReConnect funding opportunities.
5. The FCC should make available dedicated terrestrial spectrum for precision agriculture at a low cost. The exclusive availability of spectrum will ensure that licensed spectrum is available in last-acre Private Wireless Networks, and having a low-cost provision will help ensure that the licensed spectrum costs can be managed by the FCC. This will also help with the establishment and manufacture of specific equipment and systems tied to specific spectrum metrics.
6. The USDA should provide funding for build-out and operation of last-acre networks to ensure the capability to use precision agriculture systems and devices. Any last-acre network option will be expensive, and this cost will be an obstacle for the small and mid-sized farm and ranch operations across the country. USDA has a long history of providing support to build last-mile telecom and broadband networks. These networks could be cost-prohibitive for many farming and ranching operations. Establishing a funding mechanism for last-acre networks for the individual farmer should include:
    a. Grant funding opportunities through local FSA or NRCS offices.
    b. Grant funding opportunities through qualified AG COOPS (qualified means those coops are willing and capable of administering grants).
    c. Providing flexibility for whichever option suits a particular farming community that USDA is trying to serve.
7. The FCC should continue to make incentives available to encourage precision agriculture deployment. In its Enhanced Competition docket, the FCC began to address ways to incentivize the use of spectrum on tribal and other unserved lands. However, as previously noted, there may be fewer spectrum auction opportunities in the future. It is too early to understand how a reduced number of auctions will impact deployment. However, we urge the FCC to continue to explore and examine methods in which

to incentivize further the use of spectrum to support unserved agricultural lands for all technologies. For example, the FCC should consider the use of bidding credits or other financial benefits for service providers who, as part of their auction bids, commit to the deployment of broadband to unserved agricultural lands within a set time period.

8. The FCC should revisit its broadband satellite service coverage requirements for NGSO (Non-Geostationary Orbit) satellite systems to the extent technically feasible. The FCC, in a recent docket, eliminated the requirement for country-wide coverage by NGSO broadband satellite systems. This means the broadband satellite systems that should be able to support the broadband needs of the most rural portions of the country, are no longer required to do so. The FCC should revisit this decision in light of the agricultural community's need to have access to competitive broadband services while balancing that technical requirement of the system.
9. The FCC should implement geographic build-out requirements for spectrum-based licenses, and the FCC, USDA, and NTIA should use this metric for funding to ensure the coverage of unserved agricultural lands on a timely basis. Today, the FCC uses population-based metrics for its build-out milestones for terrestrial wireless networks. However, these metrics have largely failed to result in the build-out of wireless networks to the most rural portions of the country. Accordingly, the FCC should implement geographic build-out requirements, rather than population-based requirements, tied to spectrum auctions with shorter build-out timelines. Funding guidelines for 5G broadband should require area-based coverage that includes verified device population, geographical, and usage data. Spectrum auctions should include a shorter and more aggressive build-out timeline as a positive consideration in winning bids.
10. The FCC should strengthen policies that require auction bidders to show the long-term sustainability and scalability of their proposed networks, recognizing the need to raise the bar significantly on upload and download speeds. All deployments of networks and the use of spectrum should be able to adapt to growing demands of the consumer. Precision agriculture needs will evolve and require networks to evolve to allow for the improved services offered by new technology.
11. The FCC and USDA should work with stakeholders to build a playbook for creating and operating rural community-based, nonprofit solutions (modeled after the NTIA playbook). An important key to the success of these types of solutions is for the entities involved to leverage the expertise of local, independent, existing operators to build these community-based high-speed networks. By providing direction, the FCC and USDA can establish guidelines that help public-private partnerships that are most likely necessary to accomplish successful builds in areas currently unserved by a local service provider.
12. The FCC, working with States and localities, should address zoning issues to ease regulatory and administrative burdens associated with deploying broadband networks, such as laying cable, setting towers, or establishing satellite base stations. The federal government should work with state governments and localities to ease permitting, zoning and other administrative burdens.
13. In tribal areas, states and localities should work with tribal authorities and the Bureau of Indian Affairs (BIA) to help speed deployment. To streamline the deployment of precision agriculture to tribal areas, it is important that the states work to avoid imposing duplicate or heavy burdens on the deployment of broadband to farms and ranches.

Encouraging Adoption and Availability of High-Quality Jobs

The United States agriculture industry faces a generational imperative to continue as a keystone on the national and international stage. Farmers are at the front lines of implementing solutions to address climate concerns and to contribute to geopolitical stability through the reduction of food insecurity that can prompt demographic uncertainties around the world. The continuing strength of the U.S. agriculture sector will be guided by sound public policy that encourages greater adoption of agriculture technology, as well as robust security and data privacy standards to secure one of the Nation's most vital industrial sectors. Meaningful funding and effort must be invested towards increasing on-farm connectivity, climate-smart agriculture and sustainable productivity, improving collaboration, research and innovation, assuring long-term continuity of U.S. agriculture systems, solidifying cyber-security and data-privacy requirements, and assuring multi-scale adaptability. With that in mind, the Working Group recommends the following:

1. The USDA and FCC should consider precision agriculture connectivity as a critical component of our Nation's food and homeland security.
2. USDA ReConnect should pivot to prioritizing on-farm connectivity as exemplified by Senate bill S.2542 (LAST ACRE Act of 2023) and companion House bill H.R.6142 (to amend the Rural Electrification Act of 1936 to establish a last acre program, and for other purposes).
3. The USDA should focus eligibility and awards on climate smart outcomes rather than specific practices or solutions.
4. The USDA should increase funding available to producers through the Environmental Quality Incentives Program (EQIP).
5. The USDA conservation programs should incentivize practices that have multiple environmental benefits (for example to improve water use efficiency may also improve water quality due to less runoff; optimally using nitrogen reduces life-cycle energy for crop production and can improve water quality).
6. The USDA should allow all new smart irrigation systems to be funded under EQIP (currently, only systems that have been deployed for two years apply are eligible for upgrades).
7. The USDA Risk Management Agency (RMA) should include in crop insurance "Precision Ag Premium Reduction." When farmers utilize precision agriculture equipment and data management, they lower their operational risk profile through automation in each cropping year and establish crop records that create sustainable long-term value of historical practice. Reductions in premiums to reflect those lower risks would encourage farmers to adopt precision agriculture technologies that often also conserve natural resources.
8. Crop Insurance, generally, should reflect the influence of improved accuracy of field size and climate/ conservation practices on actual production history (APH) needs careful consideration – particularly during transition years. The use of actual "as planted" maps can both reduce premiums and improve accuracy with improved measurement and reporting of active farmable area.
9. The USDA Farm Service Agency (FSA) "Precision Ag Loan Guarantee" should work with traditional farm lenders and with their own lending arm to guarantee loans for producers to purchase direct cost and labor reducing precision agriculture equipment and services, recognizing them as Best Management Practices (BMPs).
10. Using less energy through improved efficiency via better lighting, insulation, equipment maintenance, etc. should be rewarded similarly to generation of renewable energy. The agricultural landscape offers opportunities to generate renewable energy via digester, solar, wind, and geothermal systems and these can improve the economic resilience of farms.
11. USDA programs should empower farmers to use the hardware and software systems that improve machinery efficiencies or reduce passes over the field.
12. The USDA should continue the Regional Conservation Partnership Program (RCPP) program to enhance collaboration between university, stakeholder, and public/private partnerships. Greater clarity regarding use of the funds toward enabling technology could lead more to adoption as would lightening the match requirement.
13. Conservation Payment – The USDA FSA 'Precision Ag Environment Payment', NRCS 'Environmental Quality Incentives Program' (EQIP) and Regional Conservation Partnership Program (RCPP). As highlighted throughout the 2018 Farm Bill, precision agriculture and precision agriculture technologies are recognized as critical to conservation, production and profitability. Therefore, precision agriculture technologies and practices should be recognized as Best Management Practices and direct payments for its utilization should be established.
14. USDA should consider a voluntary program such as established in Growing Climate Solutions Act that includes carbon credits, nitrogen optimization, and water use efficiency.

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15. USDA or other relevant Federal agencies should dedicate increased funding to promote adoption of cover crops, reduced tillage, and other practices that promote soil organic matter that brings many benefits in utilization of all nutrients.
16. The USDA should lead increased marketing and education program across agencies to promote the value of precision agriculture technologies and agriculture benefits to the United States.
17. The NRCS should consider nationwide on-staff technologist and precision agriculture specialist.
18. USDA operating loans should be increased as a means to allow for ag tech adoption to mitigate operational risk and prepare for climate adaptability tools.
19. USDA should implement department and agency wide interoperability and symmetry of internal program formats to utilize operator driven data for future operator mandatory reporting, farm program creation and cohesive agency interaction of the data.
20. The state broadband coordinator, supported by NTIA, should partner with the land grant university system, extension service, non-land grant regional colleges and community colleges to develop digital literacy training to support the adoption of precision ag tools.
21. In partnership with DoD/DHS/NSF, the USDA should establish a biosecurity/cybersecurity research and innovation facility through the Land Grant University System.
22. USDA study on technology adoption benefits to productivity/profitability to ensure food and water security.
23. Land Grant University Extension Systems must be fully funded, and hiring qualifications must prioritize technology know-how and on-farm adoption assistance.
24. It increased national collaboration between USDA NRCS and Land Grant University System concerning as-applied research, technology use, and training.
25. CTE and community college precision agriculture curricula should be developed to support a system of systems approach. A developmental framework should be created with state NRCS offices, land grant universities/extensions, and local economic development agencies/county commissioners.
26. All systems need to contain the architectural element of a layered security strategy, as a means of defensible architecture.
27. Due to the sensitive nature of farm record data and the potential for vulnerability, all systems should have the requirement of multi-factor authentication.
28. Industry should adopt NIST800-53 presented herein.
29. States should adopt a guideline similar to Nebraska LB63, withholding state USF funding from any telco using equipment on FCC covered list.
30. Agricultural data privacy standards should be considered a matter of homeland security and as such, should be prioritized by state and federal agencies.
31. National focus supported by agricultural associations, land grant universities, industry and USDA should be placed on data privacy awareness, education and outreach.
32. Data privacy standards should include but not be limited to the following:
    a. Producer-owned (customer generated data) and producer-controlled data is a requirement.
    b. Data must be retrieved in its original form, without manipulation, in near real time.
    c. Right to access and delete personal or farm record data
    d. Right to opt out of sale or further use of data.
    e. Aggregate statistics utilizing producer generated data must not be shared or sold to third parties without written consent.
    f. All right, title and interest are owned by the producer/customer and may not be replicated, sold or manipulated.

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33. The FCC, NTIA and USDA should include consistent reporting metrics and surveys to identify broadband deployment and precision agriculture adoption.
34. USDA should leverage a consistent survey across departments regarding broadband use, affordability metrics, and precision agriculture use.
35. Data should be made public on National Broadband Map and the Deployment Locations Map created in the Infrastructure Investment and Jobs Act, (excerpt from LAST ACRE Act).
36. Congress should adopt Precision Ag Loan Act S.719 authorizing a department of USDA to administer low interest loans to producers and ranchers interested in precision agriculture.

Conclusion

The Precision Ag Connectivity Task Force seeks to address several gaps with these recommendations that will improve deployment and access to broadband in unserved and underserved rural communities and agricultural lands. Broadband is a fundamental necessity. We need access to it on our nation's ranch and farmland to better address critical challenges and build economic opportunity, competitiveness, and prosperity.

Given this, timely investment is critical. With the collective efforts of the FCC, USDA, NTIA and other relevant agencies, we remain encouraged that the United States government, working with states and localities can make broadband connectivity available to every corner of our great nation.

Detailed reports from each Working Group can be found in the remaining four sections of this document.

PART I: MAPPING AND ANALYZING CONNECTIVITY ON AGRITICULTURAL LANDS

Reliable broadband connectivity is crucial to the economic viability of each farm and ranch in the United States. Yet more must be done to inform growers and producers about the quality, performance, and availability of connectivity, and empower them with precision agriculture capabilities that this connectivity enables. As we learned from mapping experts, technology vendors, community stakeholders, federal agency mapping leaders and food producers, we realized how disconnected the agricultural sector is from the federal broadband mapping effort.

Our recommendations herein are intended to address deficiencies with the current broadband data and mapping efforts to ensure that all agricultural lands and use cases, as well as connectivity types are adequately represented in the national broadband mapping framework.

Interagency coordination between the Federal Communication Commission (FCC), United States Department of Agriculture (USDA) and other federal agencies with jurisdiction over rural areas and agricultural lands is crucial to ensure that they are part of the FCC's broadband mapping effort. Increasing the level of granularity of user data collected for the Agricultural Census and Farm Computer Usage and Ownership Survey will provide greater insights into the coverage challenges facing agriculturists. USDA National Agricultural Statistics Service (NASS) hosting the connectivity map overlaying crop and pasture data layers on a data visualization platform will ensure that agricultural communities have easy access to these maps. Highlighting unserved and underserved areas, and adding agriculture use cases to the FCC's broadband mapping layers, will add more value to the agricultural and rural communities.

Our working group identified several recommendations for the FCC focused on improving the existing broadband mapping program for rural and agricultural lands. These include user-interface enhancements, improved searchability in rural lands, better geospatial data granularity, and connectivity verification data layers utilizing federal, state, and private third-party data sources to delineate the areas where the performance and availability of connectivity has been verified by end users.

Going forward, the federal agencies that have responsibility for broadband connectivity must continue to support the interests of agricultural producers and their stakeholders. The voice of the food, fiber, and biofuel industry should be considered in all federal and state broadband mapping proceedings that result in funding decisions and policy outcomes. Their needs and geographic parameters are different from residential broadband serviceable locations but equally important.

Background

At the working group's first kick off meeting on March 10, 2022, its members decided to meet weekly to establish a regular cadence to learn and refine recommendations that address the challenges facing key stakeholders in the precision agriculture sector. The weekly meeting schedule also provided the group the opportunity to discuss recommendations, share new perspectives and to receive presentations from key experts in the precision agriculture, broadband mapping and technology sectors.

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The group also spent time reviewing the charge (Appendix A1) and work performed by the previous working group as a starting point for identifying the core focus areas of our current working group. Based on those discussions, the group identified four areas to explore further:

1. Resources and policies to aid data mapping & analyzing connectivity.
2. Mapping Negative Space – gap in connectivity: Unserved, underserved vs served.
3. Multi-agency collaboration on whole farm data collection, data sharing and maintaining public facing ag focused data platform.
4. What should be mapped – level of coverage, speed, signal strength, resolution, etc.

Four individual subgroups were formed to explore each area in more detail and provide substantive recommendations to the Task Force. Subject matter experts spoke to the working group and shared valuable insights that spurred a robust discussion about the merits and opportunities of data collection methodologies and connectivity mapping efforts by various federal, state and private third-party organizations. Appendix A2 lists the experts and topics of presentation.

Based on the group discussions, meetings and presentations since March, the group identified two overarching themes:

1. Coordination across all relevant federal agencies with some jurisdiction over broadband as well as agricultural and federal lands is critical.
2. Data collection methodologies vary widely across different agencies and are not accurately capturing the broadband user experience among agricultural producers (farmers and ranchers) as well as the level of service availability.

As a result, these disparities have created a fragmented data set that cannot accurately capture the challenges among farmers and producers who need reliable broadband access but cannot obtain it on their farm, ranch, pasture or farm office.

Recommendations and Considerations

From the information collected and discussed, the working group respectfully submit the following recommendations to the chair of the task force. These recommendations were developed to address the variety of data sets across federal agencies including the Federal Communications Commission (FCC), National Telecommunications and Information Administration (NTIA), and several key subagencies within United States Department of Agriculture (USDA) such as Rural Development's Rural Utilities Service (RUS), the National Agricultural Statistics Service (NASS), and the Agricultural Research Service (ARS).

Some of the data collected by the federal agencies listed above can benefit the national broadband mapping work performed by the FCC and should be integrated into the FCC's Broadband Data Collection (BDC) program. Ensuring that all relevant federal agencies with jurisdiction over broadband investments as well as agricultural lands coordinate more extensively on broadband mapping as it relates to agricultural, tribal, and federal lands.

Meaningful and dedicated coordination across these agencies is imperative and must be a top priority for policy makers interested in improving the level of connectivity on farmlands. Without this level of coordination, data sets will continue to remain fragmented and unhelpful to the precision agriculture sector.

Recommendation 1

BDC Usability Enhancements for Precision Agriculture

We recommend the FCC to add the following information to improve the usability of the current BDC map for precision agriculture:

1. The current BDC map should include alternative lookup descriptors in addition to the ability to lookup a location based on service address.
   a. The National Broadband Map has a few different alternative descriptors to use for a search (e.g., state, county, census place…). We suggest including alternative lookup locations to help producers find their location of interest more effectively including:
      - County/Parish/Borough.
      - Municipality/Township/Subdivision.
      - Postcode.
      - Geo Latitude/Longitude.
2. Wireless coverage mapping.
   a. Extend existing coverage hexagon sizes used in the FCC map. The current zoom level is a good starting point for expressing coverage at higher zoom levels. In areas of greater data density, support a more granular zoom level presenting coverage layers in smaller hexagon sizes down to ~100 meters across, is needed to better identify coverage across specific locations including fabric locations and acreage.
   b. Add agricultural structures (example, irrigation systems, grain bins, barns, water tanks, RTK towers, barns, sheds, shops) to the BDC map.

Recommendation 2

BDC Verification Data Layers

The FCC should include verification data layer(s) into the existing BDC interface showing where the existence and performance of connectivity has been independently verified, augmenting the existing data layers that show where connectivity is expected.

Third party data sources to be included in this verification layer should adhere to a standard set of required key performance indicators (KPIs) including:

1. Network performance data such as download and upload speeds, latency at idle and saturation, jitter, packet loss, active connection type, etc.
2. Provider network details (Internet Service Provider (ISP) name, advertised speed, etc.).
3. Test location (GPS, service address, etc.).
4. Active connection type (Wi-Fi, Ethernet, Long Term Evolution (LTE), etc.).
5. Wireless RF metrics (Reference Signal Received Power (RSRP), Reference Signal Received Quality (RSRQ), Signal to Noise Ratio (SNR), etc.) when available.
6. Data sources may include State broadband office data, federal connectivity data sets, tribal broadband data, and private third-party data sets.

(Refer to Appendix A3 for a complete set of recommended key performance indicators (KPIs))

Recommendation 3

Framework for Defining Served, Unserved, Underserved and Unverified Lands

The FCC, in partnership with USDA, should adopt a framework, as described here, to determine and map unserved, also called negative space, and underserved agricultural lands and develop a visualization platform hosted by NASS to display the connectivity map over a base layer of cropland and pastureland data, with necessary funding, to support the broadband mapping needs of the agricultural community.

1. The FCC BDC data would be used to create the current state of connectivity layer on agricultural lands as indicated by providers.
2. Following the framework to develop the map, we recommend that FCC and USDA adopt a methodology for classifying broadband availability on agricultural lands using a visual map classification, as explained in Table 1, that can be easily understood by public.
   a. **Unserved** – Providers do not indicate any connectivity available on the production land, or providers indicate connectivity availability, but verification data shows a clear lack of acceptable service.
   b. **Unverified** – FCC BDC data indicate that connectivity should exist on agricultural lands, but no verification data exists to validate acceptable service standards.
   c. **Underserved** – FCC BDC data indicate that connectivity should exist on agricultural lands, but verification data sets indicate available services do not meet the performance and reliability threshold required for agricultural broadband use cases.
   d. **Verified** – FCC BDC data indicate that connectivity should exist on agricultural lands, and third-party verification sources confirm that in fact users have demonstrated connectivity in that location.

Table 1. Suggested rubric for displaying connectivity map.

	Unserved	**Unverified**	**Underserved**	**Verified**	
Cultivated land					*a.*
Pasture/Grazing					*b.*
Ag Structures					*c.*
Homestead					*d.*

a. 25 acres parcels wired/or wireless (A minimal broadband definition needs to be defined for agricultural lands and structures not included in the FCC Broadband Data Collection definition).
b. 25 acres parcels wired/or wireless.
c. Ag Structures that are on the tax roles wired/ or wireless.
d. Main farm head/home location with connectivity meeting currently accepted federal minimum broadband definition (e.g., 100/20Mbps, 25/3Mbps).

(Refer to Appendix A4 for more details)

Recommendation 4

Interagency Cooperation

The Office of the Secretary for the US Department of Agriculture (USDA) shall be directed to establish an inter-agency coordinating council focused on broadband connectivity data collection, verification, and mapping analysis of broadband coverage on agricultural lands as well as native farmlands to address the broadband connectivity challenges facing these communities and their stakeholders.

The Council will include the USDA as well as the NTIA, the Bureau of Indian Affairs (BIA), the U.S. Census Bureau (Census Bureau) and the FCC. The Council should also consult with the National Association of Counties (NACo) and other state (for example, state departments of agriculture, state broadband offices and county officials), local and tribal governmental organizations to develop a comprehensive strategy towards mapping and expanding broadband access on agricultural lands. The Council will meet quarterly and provide a bi-annual report on its work to the House and Senate Agriculture appropriations and authorizing committees. Such reports will be provided until the next Farm Bill reauthorization in 2028.

The USDA should also coordinate internally to address the lack of connectivity on agricultural lands. Specifically, the USDA will be directed to:

1. Establish an intra-agency agricultural connectivity task force to coordinate broadband connectivity and mapping-related efforts across the following Mission Areas: Research, Education and Economics (REE), including ARS, Economic Research Service (ERS), NASS, and National Institute of Food and Agriculture (NIFA); Farm Production and Conservation (FPAC), including Farm Service Agency (FSA) and Natural Resources Conservation Service (NRCS); Rural Development (RD); and other sub-agencies within USDA as the Secretary and Congress deem appropriate. This USDA Task Force will consult with local, tribal, cooperatives, cooperative extension leaders and other agricultural stakeholders to increase agricultural producer participation in data collection efforts and validate coverage from broadband connectivity maps (per recommendation 2), and to develop strategies for broadband resource allocation to rural agricultural areas as well as those owned by native nations. The USDA intra agency Task Force will provide annual updates to the inter-agency council, which will be part of the updates from the council to the House and Senate Agriculture appropriations and authorizing committees in Congress.
2. Ensure that NASS and the FCC collaborate to enhance NASS' Farm Computer Usage and Ownership Survey and Agricultural Census for the purpose of examining the lack of broadband coverage on agricultural lands including farmlands owned by native nations. This will require engaging more agricultural producers and cooperative extension leaders in verification data collection and analysis.
3. The inclusion of language in the 2023 Farm Bill to authorize sufficient funds to USDA-NASS to collect and analyze a more comprehensive set of broadband coverage and usage data by increasing the granularity of data reporting from the state to county level via the Farm Computer Usage and Ownership Survey. Specific detailed questions regarding broadband coverage, usage, broadband enabled use cases on farms and the utilization of precision agriculture tools shall also be included. The survey results shall be analyzed and incorporated into the USDA visualization platform (per recommendation 2) to produce a new comprehensive USDA broadband coverage map illustrating the level of connectivity over agricultural lands to help the expansion and adoption of precision agriculture technologies.
4. The inclusion of language in the 2023 Farm Bill to authorize sufficient funds to USDA-NASS to expand the set of broadband coverage and usage questions asked via the Agricultural Census. Such questions can be collected and analyzed as part of the existing data published from the Agricultural Census. The census results shall be incorporated into the aforementioned comprehensive USDA broadband coverage map to illustrate the adoption and use of broadband connectivity for precision agriculture technology.
5. Authorize additional funds in the 2023 Farm Bill to establish a new grant program administered by USDA NIFA to fund outreach, education, broadband data collection and broadband mapping initiatives led by land-grant institutions through state Cooperative Extension Services and Experiment Stations in rural communities.

6. To work with, in conjunction with the FCC, the United States Census Bureau through a Memorandum of Understanding to utilize Census data or seek the necessary authority required to access that data.

(Refer to Appendix A5 and Appendix A6 for more details)

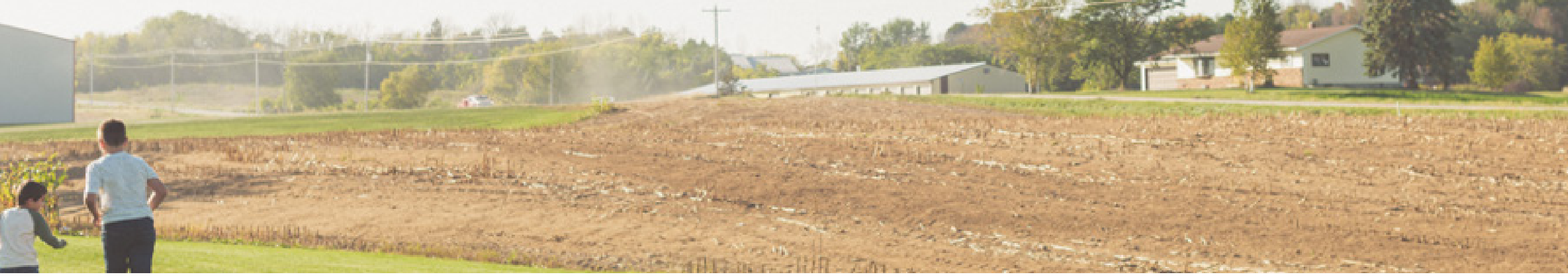
Recommendation 5

Adopt Connectivity Use Case Driven Standards for Data and Mapping Purposes

Agriculture operations are primarily a mobile endeavor and the current BDC focuses on locations as opposed to mobile geographical areas. Therefore, we recommend that precision agriculture connectivity profiles or use cases required to enable current and future precision agriculture adoption, on a geographical basis of less than 25 acres, based on “Connectivity Demand” working group recommendations, are incorporated into the map. The precision agriculture use cases may include:

1. Real-time heavy data processing use cases such as Artificial Intelligence (AI) and Autonomous and Robotic Agricultural Machines driven technology that require high bandwidth, low latency connection profile.
2. Realtime telematics data communication needs for farm machinery operational problems, livestock health and wellbeing, etc. Examples may include an irrigation system or machinery malfunction during operation, predation on livestock, etc.
3. Asynchronous bulk data transfer needs such as whole field mapping with drone or field robots that would help make decision for the next day or within a few days. Examples may include mapping soil fertility for future fertilizer applications, or crop senescence for harvesting decisions.

(Refer to Appendix A7 for full use case and required connection profile recommendation)



PART II: EXAMINING CURRENT AND FUTURE CONNECTIVITY DEMAND

Precision Ag is the utilization of technology and data for generating insights that enhance decision-making in real time by the farmer at the center of the action and automate fundamental farming practices. It plays a pivotal role in enhancing agricultural productivity, efficiency, and sustainability. Farmers want and need access to these tools on their phones, tablets, and equipment to be able to reduce inputs, increase production, enhance food and operator safety, and minimize environmental impacts. Appendix B2 provides more detail on components in Precision Ag.

The goal of this report is to help chart a path to achieving these benefits through government policy, incentives, and by directing funding opportunities to include public and private wireless coverage to the last acre. One of our prime examples is a pilot project in Helm, California in the Central Valley where Cal.net and Microsoft partnered to build a Private wireless network to automate irrigation of 80 acres of tomatoes on Terranova Ranch (Appendix B4). In just two months, the companies were able to make the network operable. In the first month of operation, the farm saw a 20% decrease in costs and a 10% decrease in water use. Though technically a private wireless network, this project is voluntarily shared with the local public. It shows how farmer-driven collaborative or consortium networks could also benefit surrounding communities. According to the August 2023 National Agricultural Statistics Service (NASS) report, 85 percent of farms reported having access to the internet. But "access to the internet" is a far cry from having the robust connectivity across working lands needed to unlock the full potential of Precision Ag.[1]

Achieving Precision Ag's full potential necessitates the widespread deployment of wired and wireless broadband connectivity to cover the last acre. Achieving last acre connectivity requires:

- Intentionally and simultaneously building deep fiber and interoperability to support satellite, wireless and cellular to the last acre.
- Significantly raise the standard on upload capacity over time to anticipate the needs of precision agriculture.
- Double or even triple the current standard for upload and download speeds to meet the needs of future technology such as autonomous tractors.
- In the next term, the Working Group should review a potential timeline for new standards based on research, examples, and testing to determine practical speeds.
- Vastly improving cellular reliability and accountability in rural areas.
- Allocating Spectrum for agriculture.
- Promoting and accelerating the deployment of edge compute, AI, and private wireless networks to enable data-driven farming practices.
- Future-proofing connectivity networks begins immediately with the Farm Bill, FCC, and NTIA policies.

1 United States Department of Agriculture, National Agricultural Statistics Service, Technology Use (Farm Computer Usage and Ownership) at 5 (August 2023): https://downloads.usda.library.cornell.edu/usda-esmis/files/h128nd689/4j03fg187/fj237k64f/fmpc0823.pdf

Theme 1

Last Acre

The first policy requirement for Precision Ag is connectivity to the last acre i.e., not just to the farmhouse or headquarters, but reliable, affordable, ubiquitous coverage that enables uploading and analyzing data in the field. Such focus requires harnessing leading-edge policy, promulgated by the FCC, and fast emerging technological advances to enable 5G-like, and future 6G-like, performance at the field/pasture level so farmers and ranchers can achieve the concurrent goals of increasing productivity and profitability while improving stewardship.

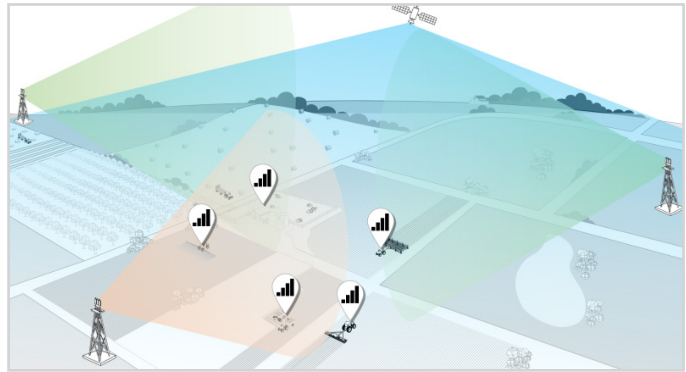


Image of Connected Farm Ecosystem provided by Deere and Company

Existing programs have been instrumental in supporting last mile broadband deployment, linking broadband networks to rural households or businesses. However, there is a gap in addressing last-acre connectivity, which is essential for farmers and ranchers to leverage Precision Ag technologies to the utmost. This working group's top priority is gaining connectivity in the field, to the last acre.

In her testimony to the House Energy and Commerce Subcommittee on Communications and Technology, Dr. Monisha Ghosh illustrated the limitations of current programs well:

"NTIA's Broadband, Equity, Access and Deployment (BEAD) program will oversee fiber deployments that will bring true broadband… to all "serviceable" locations as identified in FCC's National Broadband Map. However, this will not solve the problem of broadband availability to serve, for example, the needs of precision agriculture in farmland: a tractor or a field of corn is not a "serviceable" structure. While satellite services can address some of these needs, terrestrial services will still be required for many such rural applications: our research and measurements have shown that sensors in a field of full-grown corn are very difficult to reach even with cellular IoT due to the signal attenuation from the corn biomass. So, alternative architectures need to be explored, for example using satellite backhaul with local distribution over shared spectrum using a private network" (Ghosh).

"Last acre" connectivity refers to the extension of reliable broadband coverage to the entirety of agricultural properties. This is a multi-track process to deploy fiber as deeply as possible into rural areas while building wireless coverage – both terrestrial and satellite, for backhaul and ultimately for reliable, ubiquitous coverage in the field. Note the two connection points:

1. From the fiber network to the backhaul.
2. To the last acre, on-farm, wireless network.

Funding programs must be "technology neutral," incorporating all types of network infrastructure – fiber, wireless, satellite, space and open the door for creative, alternative architectures like satellite backhaul with local distribution over shared spectrum using a Private wireless network. There are myriad use cases and an array of technologies available to achieve a strong and integrated ecosystem with optimal network performance to support Precision Ag. All must be enabled.

Last Acre Use Cases Illustration the Importance of Connectivity for Precision Ag

Agricultural lands beyond the reach of symmetric-speed fiber must not be left behind. Instead they should be prioritized for immediate deployment of any available combination of wired, wireless, and satellite infrastructure. Achieving broadband speeds to the last acre must factor in the unique challenge of the land, size of the farm, economics of deployment and needs of the farmer. When considering the fast pace of innovation and wide range of operations in Precision Ag, it is important to keep in mind that policy must benefit a wide range of farmers and uses. The demographics of farmers, foresters, and ranchers to consider include:

- Geography – location of decision-making operations as well as topography.
- Profitability.
- Operator aptitude.
- Variety of crops and/or services.
- Laborers/managers.
- Equipment age and versatility, availability of support.

Applications within Precision Ag are described in the table below. Three detailed use cases follow to illustrate the range of data needs.

APPLICATION	DESCRIPTION
Automation and Control to Optimize Resource Management	Precision Ag technologies require comprehensive connectivity to enable precise resource management, including water, fertilizers, and pesticides. This optimization not only enhances crop yields but also reduces resource waste and environmental impact.
Sensors and Data Collection to Enhance Crop Monitoring	Real-time data from remote sensors and cameras are critical for monitoring crop health, pest infestations, and weather conditions. Every acre coverage ensures that no part of the farm or ranch is left unmonitored. Data can be managed on smart phones or computers which is especially valuable for geographically and agronomically diverse farms.
Enabling Autonomous Machinery	Autonomous farming equipment relies on continuous connectivity to operate efficiently and safely across expansive rural properties. This connectivity is essential for improving operational efficiency and reducing labor costs.
Data-Driven Decision-Making	Real-time access to data is paramount for making informed decisions about planting, harvesting, and resource allocation. Full-farm connectivity ensures that farmers have access to the data they need, when they need it, and where they need it – in the field.
Predictive Analytics	By analyzing historical and real-time data, farmers can develop predictive models for crop yields and disease outbreaks. This proactive approach helps optimize resource allocation and reduce losses.

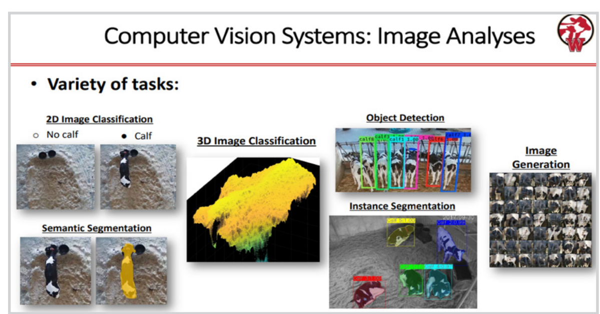
Supply Chain Efficiency	On-farm connectivity facilitates seamless communication with the agricultural supply chain. Data on crop quality, quantity, and harvest timing can be shared with buyers and distributors in real time, improving efficiency and reducing food waste.
Climate Smart Practices	Reduced resource footprint, lower emissions through fewer passes and more efficiency, enabling earlier cover cropping to increase carbon sequestration, smart irrigation to reduce water usage and energy consumption for pumping, weather data and analytics to adapt management practices, enhancing carbon farming in agroforestry and incorporating perennial crops, supply chain efficiencies to communicate optimal harvest dates and crop quality to lessen food waste.
Farm Safety	Last acre connectivity can enhance farm safety by monitoring equipment and providing alerts for maintenance or unsafe conditions. This helps prevent accidents and ensures the well-being of farm workers.

Use Case 1

Autonomous Agricultural Machinery

Autonomous tractors are a prime example of low speed, broad coverage requirements. Such autonomous agricultural machines are ushering in a new era of farming, functioning in rural landscapes where consistent connectivity is challenging. To ensure the safety and efficiency of these machines, when they detect a potential safety risk, they are programmed to halt operations immediately. Simultaneously, they send an alert accompanied by low-resolution images to a remote operator, providing an instantaneous, firsthand view of the issue which should allow for timely interventions. The necessity of relaying an image to a remote operator underscores the need for upload speeds. If the autonomous vehicle has made the determination to halt on its own, signaling and image transmission delays in data transmission to a distant operator will result in a lag in the time it takes of a potential restart. Some amount of latency is not a great issue. On the other hand, if the autonomous tractor were to sense an obstruction in part of a field where there was no data connectivity, no alerting message could be sent to the distant operator. The stopped autonomous tractor would be struck until a person can investigate. This situation makes a case for ubiquitous data coverage.

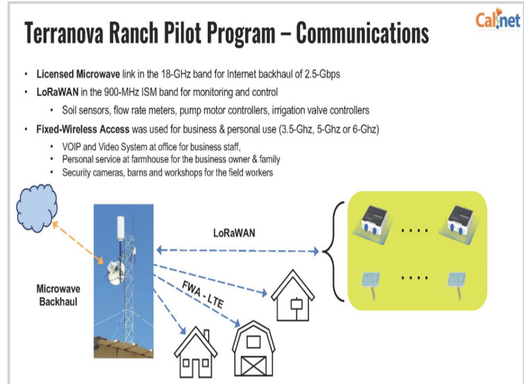
Given the connectivity challenges inherent in these rural areas, a viable solution lies in harnessing the potential of the low band spectrum. Drawing inspiration from FirstNet, leveraging this spectrum could significantly enhance the reliability and consistency of connections for autonomous operations. Such an approach would ensure that autonomous tractors, soon to become standard farm equipment, can function optimally even in areas where conventional connectivity solutions falter.



(Source: Cloud Farm & Connectivity: AI Applications in Ag Systems. Dr. Joao Dorea, Univ. of Wisconsin, Madison)

Use Case 2

Automated Applications



In California's Central Valley, Terranova Ranch and Cal.net have developed an automated water delivery solution for row crops that will enhance agricultural productivity and maximize water usage, while improving the tech skills of agricultural workers at all levels. Combining scalable, low-bandwidth radio technology and broadband infrastructure, growers can use in-ground sensors and solar-powered valve controllers to deliver water when and where it is needed. Precision automation of field irrigation results in:

- Increasing crop yields.
- Saving water.
- Improving run times, consistency and trackability.
- Providing data analytics to drive resource allocation.

The system uses Long Range Wide Area Network (LoRaWAN) in the 900-MHz ISM band, standards-based, off-the-shelf equipment. It is scalable, upgradeable, and applicable for many uses:

- Row crops as well as orchards, center-pivot.
- Animal husbandry.
- Livestock tracking & biometrics.
- Asset tracking.
- Machinery & other movable equipment.
- Tank fluid levels.
- Water, irrigation fertilizer, fuel.
- Greenhouse environmental controls.
- Weather monitoring.
- Stored grain conditions sensing.
- Pasture gate open/close sensing.
- Remote building security.

In the first month of operation, this system resulted in a 20% reduction in operating costs and a 10% reduction in water use. Costs for replicating this system over a variety of scales can be found in Appendix B4.

Use Case 3

Artificial Intelligence (AI)-Driven High Spectrum Usage in Agriculture

An evolving facet of dairy operations is computer vision, AI, edge and cloud computing for livestock monitoring and tele veterinary medicine. This use case illustrates the potential for high-speed, centralized transmission requirements to monitor animal behavior and performance, allowing for short-term management decisions like tracking weight gain, feed efficiency, and animal health, as well as long-term planning for breeding.

Low Bandwidth requirement applications are widely implemented today through usage of smart "Fitbit" like animal collars or Radio Frequency Identification (RFID) ear tags. Medium bandwidth applications can be found in robotic milking, feed pushing, and manure management systems. High bandwidth, centralized applications are needed for animal monitoring and phenotyping.

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3D images of cattle can generate as much as 130 TB of data daily for a commonly sized dairy herd of 200 animals. Even with edge computing compression, the data requirements result in approximately 300 GB per day. Edge computing can reduce the data requirements down to approximately 1 GB per day, still an over 20-minute upload on a typical 7 Mbps farm internet connection. Farmers consulted by this working group have been informed such an upload would take more than 10 hours if a connection could be maintained for that duration.

This example illustrates the magnitude of data that can be collected for one dairy animal herd. It also illustrates how edge computing/processing is an integral part of the data management path.

Policies To Connect the Last Acre

The U.S. Department of Agriculture (USDA) and National Telecommunications and Information Administration (NTIA) lack a dedicated program to extend broadband connectivity to the last acre. Such a program would be instrumental in bridging the digital divide, ensuring that farmers and ranchers across the country have equitable access to the tools and resources necessary for Precision Ag, bolstering existing first responder connectivity in rural areas, and enhancing techniques to deal with climate variability.

Another policy solution is found in a bipartisan proposal of 2023 known as the Linking Access to spur Technology for Agriculture Connectivity in Rural Environments (LAST ACRE) Act. It would allow eligible farmers and ranchers to work with internet providers to submit bid applications for projects. It is important that any proposal – by Congress or through administrative agencies – target resources as close to the ground as possible through local providers who have vested interest in a rural area's success. Appendix B3 includes testimonial statements from many members of Congress that cast more light on the factors contributing to the digital divide.

Policy should incentivize farmers cooperating to create private, on-farm networks as a self-sufficient solution to achieve last acre connectivity. The analogy is the success and importance of rural electrification in the 1930's. Alliances of farmers could build and deliver tailored, carrier grade, high speed wireless networks for the farmer members to help drive the adoption of Precision Ag applications. The economic and deployment challenges associated with farm operators building their own network can be overcome by engaging a third-party service provider or integrator to design, build, run and operate the network. Either way, government incentives are imperative. Countries like Australia have been pioneers in adopting private wireless networks in agriculture. By taking cues from their approach and leveraging tools like the USDA Farm Bill, the FCC Rural Development Opportunity Fund, and American Recovery and Reinvestment Act funds administered through NTIA and the Rural Utility Service (RUS), it becomes possible to channel the required incentives and investment into this vital sector.

Redundancy is an overlooked need in rural connectivity. Some farm locations may experience temporary or semi-permanent broadband service loss due to terrain and vegetation. System failures can occur due to natural disasters, vandalism, hacking. But agricultural operations cannot be delayed due to service disruptions. Current eligibility requirements that limit "overbuilding" are inappropriate in rural areas where it is rare to find one, let alone multiple, providers that can provide symmetrical, scalable service.

1. Establish a dedicated program and/or target funding of existing programs to deliver connectivity at the last acre.
2. Expand the pool of applicants to programs to include farmers and rural entities such as cooperatives and economic development coalitions.
3. Incentivize Private wireless networks.
4. Incentivize redundancy in rural areas to ensure that system outages will not be experienced.

Theme 2

High Speed Symmetrical Service – Keep Raising The Bar

A second key theme of this working group's findings is that government funding should drive a process for scalability by continually raising the bar of symmetrical upload and download speeds. While achieving symmetrical coverage is challenging in rural areas with today's technology, it is imperative to future proof U.S. agriculture's capacity to grow its production. Significantly raising the standard on upload capacity over time and doubling or even tripling the current standard for upload and download speeds is essential to anticipate the needs of precision agriculture. As noted by this working group in its first term, "Particular focus should be placed on increasing the upload speeds to meet the evolving demands of Precision Ag data creation and utilization for improved value. Both non-terrestrial and terrestrial technologies are important to include in this work." (2021 Report, p. 73)

In short, download speeds are for "consumption," and upload speeds are for "production." In this case, they are literally for producing the food, feed, fiber, and renewable fuels the United States and much of the world relies on in the most environmentally responsible methods that technology and management can deploy.

> ***Download speeds are for "consumption," and upload speeds are for "production."***

This working group recommends raising the bar to prepare for 6G like performance and future technologies. However, farmers and rural Americans find themselves in a connectivity conundrum. The working group has explored facets of this puzzle and conclude the final ecosystem will be pieced together by a variety of technologies such as interoperable fiber, fixed wireless, equipment modifications, and satellite to overcome topography and other physical barriers.

Understanding the Connectivity Conundrum

The core conundrum is the inevitable tradeoff between bandwidth and signal propagation. Low speeds can cover more ground. Higher speeds can deliver more data over short hauls which require more towers or supplemental connectivity.

	PROS	CONS
LOW-SPEED BROAD COVERAGE	Low-speed connectivity solutions, such as low band spectrum or narrowband networks, can cover larger geographic areas with fewer infrastructure investments. This approach is cost-effective for reaching remote and sparsely populated regions.	Low-speed connections may not meet the bandwidth requirements for data-intensive applications like high-definition video streaming, real-time data analytics, and Artificial Intelligence (AI). This can limit the potential for advanced Precision Ag practices.
HIGH-BANDWIDTH SOLUTIONS	High-bandwidth solutions, which often require the deployment of additional towers or satellite connectivity, provide the necessary bandwidth for data-intensive applications. This enables farmers to take full advantage of Precision Ag technologies, real-time analytics, and remote monitoring.	High-bandwidth solutions can be expensive to deploy and maintain, particularly in remote rural areas with challenging terrain. The cost of building and maintaining additional infrastructure can be a barrier to widespread adoption. Satellite connectivity needs to be included in the "toolbox."

Policies To Solve the Connectivity Conundrum

To address this connectivity conundrum effectively, a balanced approach is necessary:

1. **Heterogeneous Networks** – Consider implementing networks that combine low-speed, wide area coverage with high-speed, localized connectivity. This ecosystem of technologies approach allows for basic connectivity across the entire farming area while providing high bandwidth where it's needed most, such as at the farm headquarters or in areas with data-intensive operations.
2. **Prioritization** – Prioritize bandwidth allocation based on specific agricultural needs. For example, allocate higher bandwidth to areas where real-time data analytics or autonomous machinery operation is crucial, while using low-speed coverage for less data-intensive tasks.
3. **Interoperability** – Interoperability of technologies and equipment is imperative. Policies to allow greater wattage on machine antennas that are not near the farmer operator and policies that incentivize technology development to cooperate with dedicated spectrum are needed to realize full operability within the ecosystem of technologies.
4. **Scalability** – Infrastructure must be scalable, allowing for the gradual upgrade of connectivity as technology demands increase or as funding becomes available. Start with basic connectivity and expand as the needs and economic feasibility dictate. This is the only way to future proof Precision Ag capabilities.
5. **Technology Innovation** – Keep an eye on advancements in connectivity technology. New solutions, such as low earth orbit (LEO)satellites, may offer improved bandwidth and lower latency, potentially mitigating some of the tradeoffs between bandwidth and propagation.
6. **Cooperation and Private Ownership** – Widen the field of eligible applicants to include farmer-and rural-led alliances to build networks where existing internet service providers are unwilling or inadequate.

Ultimately, addressing the connectivity conundrum for agriculture requires a multi-track approach that accounts for the unique needs of each farming operation, the available technology, and the economic considerations. Balancing the tradeoff between bandwidth and propagation will be essential for ensuring that farmers can fully benefit from Precision Ag technologies while also optimizing infrastructure investments.

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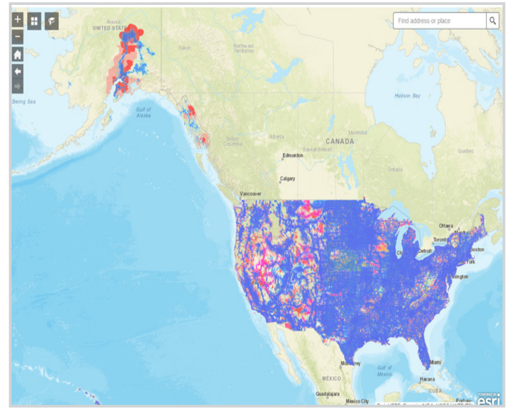
Theme 3

Cellular Reliability

The government, led by the FCC and Congress, must remedy cellular shortfalls in rural America. It is often the first tool farmers, foresters, and ranchers rely on to manage Precision Ag applications and data for decision making.

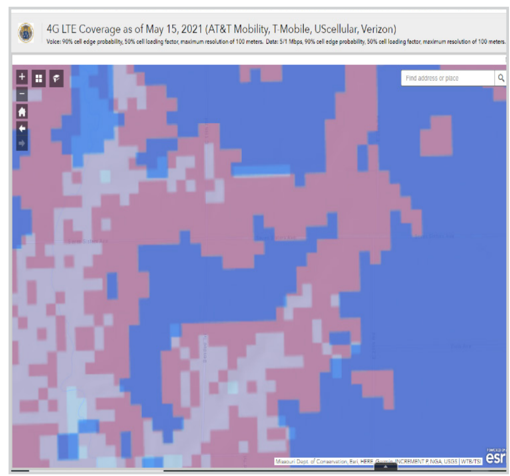


(Source: FCC LTE Coverage Map, May 15, 2021 – entire U.S.)

This working group recognizes that achieving ideal connectivity across agricultural lands poses certain challenges. For example, limited roaming agreements and limits on antenna power levels can significantly impede the full utilization of the network. To tackle these barriers, collaboration is key.

Engaging across intergovernmental agencies, the wireless industry, and electric and telecommunication cooperatives, which have a mandate to serve every individual within their territory, can significantly enhance connectivity in these remote areas.

Furthermore, it's essential to address issues of spectrum allocation, opening it up for smaller, localized projects, and ensuring that underserved agricultural areas aren't left behind in the technological revolution.



(Source: FCC LTE Coverage Map, May 15, 2021 – magnified to township section)

On closer inspection, much of rural America is like a screen door. There are millions of holes in the cellular coverage that farmers and ranchers need to reach the last acre. Even in locations that appear to have a provider, cellular carriers can claim they provide service by providing voice services that cannot sustain more than a minimum of 2 Mbps download of data with upload speeds that are negligible. This reality that applies to millions of acres of farm, forestry, and ranchland makes it impossible to reach the potential of Precision Ag.

Policies To Improve Cellular Reliability and Bandwidth

There are a number of policies that federal and state agencies can pursue to improve cellular connectivity:

1. Require cellular companies to guarantee minimum download and upload speeds as part of the monthly contracted services purchased by consumers.
2. Expand the mandate to provide service to everyone in a stated coverage area beyond cooperatives to national and regional carriers.
3. Design policy for a farmer/rancher to seamlessly access multiple carriers or merge with satellite coverage – essential for maximizing efficiency and productivity in the fields.
4. Incentivize modem and equipment development and articulation to capitalize on future dedicated ag spectrum.
5. Ensure existing federal funds for infrastructure development and broadband can be used by states to create programs that help meet local needs. Ex. Cell Towers Grant program for local providers; restoring service where spectrum was sold to nationwide carriers who no longer provide reliable service.
6. FCC continue developing and promoting consumer apps to ground truth provider service. Continue following up on speed test and connectivity challenges from cellular devices and from other connected devices.

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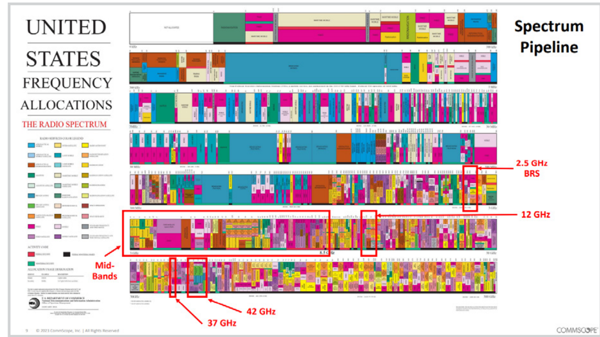
Theme 4

Spectrum Allocation

Proper planning and allocation of spectrum is critical to the future of the last acre communications and adoption of Precision Ag technologies. This requires greater commercial availability emphasizing agricultural use across a mix of frequency ranges to maximize performance and contiguous spectrum assignment to maximize efficiency.



The centerpiece to 5G use case adoption is mid-band spectrum, including Citizens Broadband Radio Service (CBRS), as connected devices command higher throughput and lower latency while increasing 100x in quantity from 4G. Networks deployed using mid-band also prove to be more energy-efficient than expanding 4G. Another potential benefit of 5G use case adoption across all business sectors, including agriculture, would be 20% reduction in emissions by 2025 according to a report published by Accenture. Nationally, 5G infrastructure deployment is far from complete. A diverse spectrum approach during network modernization is critical with data traffic expected to grow 25% annually through 2028 (Ericsson Mobility Report). While the U.S. leads globally in the 5G availability, this is achieved through low-band spectrum and a misleading indicator as the U.S. ranks outside the top 10 in downlink performance. Conversely, China allocates 3 times more commercially available mid-band spectrum and leads the U.S. in performance.

"...Precision Ag infrastructure should qualify as an eligible expense within state and federal broadband programs..."

From a practical standpoint farmer operators need to feel confident their fields are verifiably "Autonomous equipment ready" with reliable connectivity, proper throughput, and reasonable latency. The farm operator must have confidence that an autonomous solution will function in their operation prior to buying in. Coverage must be field-wide with no dropped signal. Even the low bandwidth needs of autonomous tractors require seamless connectivity. These vehicle systems are designed to stop at the first sign of an abnormality, for instance, a person walking in front of the tractor or a hitched implement not maintaining depth, then the machine sends an alert/image of the problem. Connectivity issues transmitting that picture would delay clearing the way to resume work. A lapse in connectivity could mean the tractor has to be physically driven or transported to a location where connectivity is present to be restarted.

As a 3-tier band, CBRS creates a unique opportunity for Precision Ag specifically through maximizing use of Priority Access Licenses (PAL) in rural areas. It delivers uplink and downlink throughput performance of commercially licensed lower mid-band. Activating CBRS requires greenfield deployments in many rural counties and lower power limits of CBRS require more capital construction costs for fronthaul, however, credits could accelerate deployment across unserved agricultural areas. Incentives could also be considered for farm operators willing to invest in a last acre CBRS Private wireless network assuming sufficient backhaul is available to the farm headquarters. Along with hardware and software costs, complexities exist with Spectrum Access System (SAS) activation and operating a CBRS Private wireless network. Farm operators are likely to require support services from a systems integrator.

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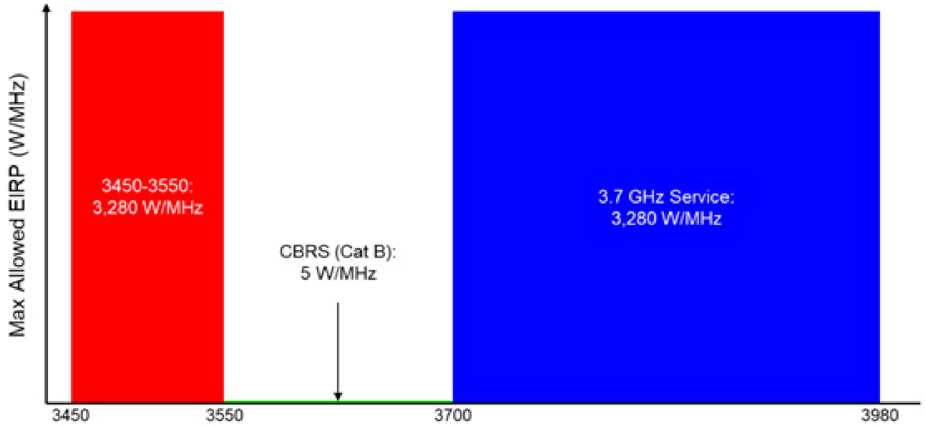

(Maximum Equivalent Isotropic Radiated Power (EIRP) chart comparing CBRS to other lower mid-bands.)

This report focuses on lower mid-band spectrum levers for licensed commercial use in agriculture, but multiple presenters to the working group cautioned against underestimating how connectivity needs are growing exponentially. The many sensors and robots in the field, for planting cover crops, or harvesting, may not require high bandwidth to operate, but bandwidth is needed for processing and evaluating the data, decision making in real time, and communicating across the farm. Computer vision uses, like indoor and outdoor monitoring of livestock, using imagery, requires high bandwidth.

Reallocating licensed commercial spectrum can realize milestone-based deployment timelines, harmonized global standards, quality of service, guaranteed capacity, enhanced security, contiguous blocks and auction revenues.

Policies To Allocate Spectrum

- The FCC and NTIA should make available dedicated spectrum for Precision Ag at a low cost. Establish a new, a national spectrum policy that makes available ample spectrum for agricultural use and helps lower costs by offering bidding credits for agriculture at spectrum auctions by modifying the current structure which awards spectrum to the highest bidder.
- The FCC should implement geographic build-out requirements for spectrum-based licenses and the FCC, USDA and NTIA should use this metric for funding to ensure the coverage of unserved agricultural lands on a timely basis.
- Incentivize CBRS PAL holders in rural counties to accelerate 5G service activation.
- Repurpose and auction lower mid-band spectrum (3.1-8.4 GHz range) to increase licensed commercial use emphasizing farm-centric band(s).
- Evaluate options to arrange contiguous mid-band spectrum blocks to drive performance efficiency and reduce environmental impact with less equipment. FCC develop a strategy to provide a range of licensed and unlicensed spectrum to agriculture for fixed wireless access and mobile broadband, rather than the spectrum be auctioned [looking at new spectrum between 7-24 GHz and the sub-THz bands].
- Develop comprehensive spectrum policy – Evaluate additional spectrum needed for 5G and 6G access to the farm decision headquarters and IoT device connectivity to the last sensor.
- FCC should consider opening up spectrum for space-to-earth communication for satellites via auction.
- Adopt policy in 3-5 years to accelerate 5G, 6G and like spectrum access, including shared spectrum, and deployment to farmlands in 2030 and beyond.
- Create incentives for service providers to mitigate coverage gaps created during decommissioning of older “G” technologies.

- The third term of the task force should be charged with working with the FCC and NTIA to build out a spectrum allocation blueprint.
- Appendix B5 highlights additional key findings pertaining to agricultural lands in each frequency range.

Theme 5

Future-Proofing Through The Farm Bill and Other Agency Policies

The United States has allocated an historic amount of funds for broadband connectivity and buildout. It is crucial these investments build a solid foundation for future network connectivity needs and opportunities. Future-proofing – supporting scalable connectivity at the field level – began with each grant award and continues today.

Establishing a funding mechanism for last acre networks within the upcoming Farm Bill is a crucial step to ensure that farming and ranching operations, regardless of their geographic location, can fully benefit from advanced connectivity as quickly as possible. Unlike traditional population-based requirements, focusing on geographic buildout requirements recognizes the unique needs of rural and agricultural areas. USDA is an experienced provider and overseer of rural development programs and telecommunications programs through its agencies of the Rural Utility Service (RUS) and Rural Development. The agency has a lead role in encouraging additional stewardship practices enabled by Precision Ag for sustaining our natural resources.

While this report emphasizes the Farm Bill as a timely vehicle to advance priorities and USDA has a capable agency to administer many programs, Precision Ag infrastructure should qualify as an eligible expense within state and federal broadband programs, encompassing all previously mentioned network components to support edge computing infrastructure and private 5G-like wireless systems.

Policies should be guided by the tenets of connecting the last acre by using an ecosystem of technologies as well as recognizing that unserved and underserved, sparsely populated areas are in greater need of funding to support connectivity buildout than more populated areas. Therefore, a geographic buildout requirement should be tied to infrastructure funds.

Policies To Future-Proof Through the Farm Bill

- Amend the Reconnect Program to incentivize applications that benefit farms by allowing Precision Ag enabling infrastructure such as Private wireless networks. Allow novel ownership strategies such as cooperatives, individuals and groups of farmers, ag. retailers, food hubs, communities and local service providers to apply.
- Amend RUS rules to allow grants for cell tower construction where it will benefit last acre connectivity.
- Reauthorize the Precision Ag Task Force to interact closely with the FCC and NTIA.
- Adopt technology-inclusive language to ensure deep fiber is delivered and to support a full ecosystem of wired, wireless, and satellite technologies to support Precision Ag.
- Grant authority for the USDA to closely advise or even act as a subcontractor in the delivery of federal and other rural broadband and connectivity programs. This collaboration would leverage USDA's expertise and resource to enhance rural connectivity and Precision Ag.
- Explore mechanisms to allocate funding for rural broadband and connectivity programs through proceeds generated from FCC auctions to provide a stable funding source for rural connectivity initiatives.
- Locate equipment and infrastructure needed to expand rural broadband access on existing USDA grounds and other federal-owned property. This approach will aid in reducing the cost of easements and acquisition that hinders buildout in many areas.

Future-proofing through the Farm Bill is a forward-thinking approach that accounts for agriculture's rapidly evolving technological landscape. By adopting inclusive policies, leveraging USDA resources, and ensuring adequate funding, policymakers will position agriculture to thrive in the digital age so it can further contribute to food security, environmental stewardship, and economic growth.

Summary of Conclusions Drawn by Current and Future Needs for Connectivity Working Group

ACTION NEEDED	ACTION DESCRIPTION
Enable Decisions and Action at the Last Acre	Ensure that technology and connectivity support decision-making and actions on every inch of agricultural land.
Support an Ecosystem of Interoperable Technologies	Promote the development and adoption of technologies and equipment that can seamlessly work together to enhance efficiency and productivity in agriculture.
Strong connectivity is foundational to the future of agriculture in the United States.	Significantly raise the standard on upload capacity over time to anticipate the needs of precision agriculture. Double or even triple the current standard for upload and download speeds to meet the needs of future technology such as autonomous tractors. In the next term, the Working Group should review a potential timeline for new standards based on research, examples, and testing to determine practical speeds.
Technology-Neutral Funding Programs	Develop funding programs that do not favor specific technologies, ensuring a level playing field for various solutions.
Concurrently Support Fiber Deployment into Rural Areas and On-Farm Wireless Networks	Facilitate the expansion of fiber-optic infrastructure as deep into rural areas as possible, while also ensuring reliable, ubiquitous 5G-equivalent speeds on working lands, bearing in mind there are two connection points to consider: the backhaul and the second to support the on-farm eco-system of technologies needed to create site specific Private wireless networks.
Incentivize Ecosystem Partnerships for Farm Operator Investment	Encourage farm operators to invest in private wireless networks through incentives and partnerships within the technology ecosystem.
Promote Satellite-Based Broadband Connectivity	Encourage the use of satellite-based broadband as a solution for areas with no coverage, ensuring connectivity even in remote locations and where there are physical barriers like hills, trees, and even crop canopy.
Establish Connectivity Standards for Autonomous Equipment	Develop and enforce connectivity standards to ensure that agricultural equipment is ready for autonomous operations through wireless connectivity.

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Amend the Reconnect Program to Cover Working Lands	Modify existing programs, such as the Reconnect Program, to incentivize applications and initiatives that directly benefit farms and agricultural operations, as opposed to households.
Improve RUS Grant/Loan Programs for Cell Tower Construction	Enhance funding programs that support the construction of cell towers in rural areas to improve network coverage, as an option to support backhaul to the "last acre" to then connect to the "last mile."
Establish Spectrum Policies for Agricultural Use	Create spectrum policies that allocate ample spectrum for agricultural purposes and offer bidding credits to agriculture to reduce costs. Consider both short-term solutions like CBRS and long-term spectrum planning. (see p. 16 for comprehensive recommendations)
Consider a Dedicated Farm Band	Explore the possibility of dedicating a specific spectrum band for farm use, like First Net.
Increase Incentives for Infrastructure Development	Provide additional incentives to encourage the development of a robust telecommunications infrastructure in agricultural areas for redundancy and competition.
Improve Collaboration and Remove Regulatory Impediments	Enhance cooperation and communication between federal agencies involved in agriculture and technology development, while streamlining regulations that may hinder progress.
Increase Digital Access to Education and Training	Expand access to digital education and training programs for individuals engaged in farming, ensuring they can effectively leverage new technologies for improved agricultural practices.
Improve Cellular Connectivity	Require minimum download and upload speeds, mandate to provide service to everyone in a stated coverage area beyond cooperatives to national and regional carriers, design policies for seamless integration of coverage, incentivize modem and equipment development and articulation to capitalize on future dedicated ag spectrum, ensure existing federal funds for infrastructure development and broadband can be used by states to create programs that help meet local needs.

PART III: ACCELERATING BROADBAND DEPLOYMENT ON UNSERVED AGRICULTURAL LANDS

The Accelerating Broadband Deployment on Unserved Agricultural Lands (Deployment WG) has analyzed what is required to increase broadband deployment on unserved agriculture lands, focusing on meeting the needs of precision agriculture (PA), including reviewing the recommendations from the earlier Task Force and considering technology inxnovations, funding additions, and other changes. Based on this analysis, we have developed the following recommendations associated with how to accelerate broadband deployment on unserved agricultural lands, which is critical to having PA become a reality on farms across the country, no matter where they are located.

We started our efforts by examining the benefits of PA advancement to the farms and ranches, as well as the entire country. We then reviewed the recommendations made by the previous Deployment WG to see which recommendations have been implemented and which remain outstanding. We did this while keeping in mind four core principles that guided our work. Those principles are discussed in Section II.

In addition to new recommendations, we have included and updated the outstanding previous recommendations based on changes that have occurred since releasing the 2021 PA Report. In addition, we have included policy, funding, and related recommendations based on our analysis of what is required to successfully address the lack of broadband deployment required to meet the needs of farms and ranches for PA. With the U.S. Congress recently making over $65 billion available for broadband deployment, the United States Government and each of the states have a unique opportunity to ensure broadband service is fully available on unserved agricultural lands by 2025. However, as discussed below, this requires funders to impose conditions to ensure the funding is used sustainably to support broadband deployment to farms and ranches. In addition, we urge Congress and federal, state, and local policymakers to consider the role of private wireless networks for last-acre purposes as another method to accelerate broadband to unserved agricultural lands. We also urge policymakers to make policy and spectrum decisions, which will help to ensure that our agricultural lands do not suffer from a lack of broadband and other required communications connectivity now or in the future. This can be done by creating incentives for build-out and ensuring that required operational funds are available for the long-term sustainability of broadband and other communications networks in the most rural parts of the country.

Our Report does not stop there. We also make recommendations in numerous other areas, including changes to FCC rules and ways to help enable deployment of PA on tribal lands.

We urge the FCC, USDA, Congress, and other interested government agencies to act now on our recommendations to ensure that by 2025 our agricultural lands no longer suffer from a lack of broadband services that are so necessary to address critical issues, including food security, health, and education.

Guiding Principles of Our Recommendation

Throughout our discussions, we focused on four guiding principles which we consider critical to ensuring the deployment of broadband to unserved agriculture lands. These principles are the following:

1. **All Technologies** – All technologies (terrestrial fixed, mobile wireless, wireline, and satellite) have a role to play in the deployment of broadband/Precision Agriculture to the farm/ranch.
2. **Funding Priority** – Broadband deployment funding and licensing decisions must prioritize deployment to under and unserved agriculture lands and rural populations living on farms, ranches, or other isolated areas.

3. **Adequate Resources** – Adequate resources (funding, expertise, etc.) must be allocated to achieve the US goal of providing broadband to under and unserved agriculture lands by 2025.
4. **Complete Coverage** – Not only do broadband networks have to support the last mile for PA, but last-acre coverage is critical.

We urge the FCC, Congress and relevant agencies in federal, state, and local governments to keep these four principles in mind as they review our recommendations as they work to solve the critical issue of ensuring America's farms and ranches having access to the broadband services they require.

The Advancement of Precision Agriculture Brings Significant Benefits to the Farm, the U.S., and the World

While the American people make up less than 5% of the world's population, American row-crop farms produce about 30% of the world's corn, 30% of soybeans, 13% of cotton, 12% of sorghum, and 8% of wheat.[2] The U.S. exports tremendous amounts of these commodities to feed and clothe the world's population, and world consumption is expected to increase by 35% or more in the next few decades.[3] Furthermore, rising living standards worldwide raise the demand for animal protein, which adds an additional requirement for grains as feed. With the recent war in Ukraine, we have seen the fragility of the world's food system, so U.S. farms must maintain a high level of productivity to help meet the world's demand for food and related agriculture products. On top of these worldwide demand pressures, expectations for environmental risk mitigation and sustainability are increasing, requiring that crop inputs be reduced.[4] Moreover, a changing climate adds uncertainty to future yield capabilities, and high-quality farmland is being lost to urbanization and road construction. Farm labor shortages are an exacerbating factor. Aside from the aging of farmers, rising living standards are reducing the desirability of farm work among the world's youth. The average age of immigrant farmworkers in the U.S. rose by five years between 2008 and 2018.[5] Moreover, immigration issues worldwide are reducing the flow of migrant farmworkers, making it critical that U.S. farms increase their operational efficiency.[6] This changing workforce on agricultural lands mandates that our farming and ranching must become more efficient to survive in the future, where obtaining qualified workers becomes increasingly difficult.

PA provides vast opportunities to feed the country and the world while helping to restore and preserve the earth's biodiversity. It does this by accounting for variability across a field regarding topography, soil type and condition, plant health, etc. For example, in a corn crop, different portions of a field have the potential to produce different amounts of corn, so it is desirable to apply the right amount of fertilizer at each location to maximize economic return while preventing pollution caused by over-application of fertilizer. PA reduces chemical inputs into the soil that can leach into ground water or run off into rivers, uses less petroleum-based fuel, and increases the economic productivity of the land. PA is a technology with the potential to address multiple agricultural issues in the United States and globally, including a reduction in available farm labor, a decrease in the number of farms, climate change, drought and declining aquifers, and the need to increase production to feed the estimated additional 2 billion people that will inhabit the earth by 2050 (9.7 billion inhabitants).

PA can involve both crop/livestock farming and ranching. In both cases, PA incorporates advanced technologies to monitor and optimize the conditions of plants or animals and their surrounding environments. With livestock, monitoring may include weather, barn conditions, food consumption, health, and well-being for every animal. With both crops and livestock, PA is benefitting from major technological trends, including positioning technologies, sensors, big-data, artificial intelligence, and advances in computing and communications.

2 https://www.investopedia.com/articles/markets-economy/090316/6-countries-produce-most-corn.asp. Accessed on 23 OCT 2022.
[https://beef2live.com/story-world-soybean-production-ranking-country-0-164836. Accessed on 23 OCT 2022.]
[https://worldpopulationreview.com/country-rankings/cotton-production-by-country. Accessed on 23 OCT 2022.]
[https://www.indexmundi.com/agriculture/?commodity=sorghum&graph=production. Accessed on 23 OCT 2022.]
[https://www.visualcapitalist.com/cp/visualizing-global-wheat-production-by-country/. Accessed on 23 OCT 2022.]
3 van Dijk, M., Morley, T., Rau, M. L., & Saghai, Y. (2021). A meta-analysis of projected global food demand and population at risk of hunger for the period 2010–2050. Nature Food, 2(7), 494-501.
4 Canavari, M., & Coderoni, S. (2020). Consumer stated preferences for dairy products with carbon footprint labels in Italy. Agricultural and Food Economics, 8(1), 1-16.
5 Economic Research Service, U.S. DEPARTMENT OF AGRICULTURE. U.S. Farm Employers Respond to Labor Market Changes With Higher Wages, Use of Visa Program, and More Women Workers. https://www.ers.usda.gov/amber-waves/2020/october/us-farm-employers-respond-to-labor-market-changes-with-higher-wages-use-of-visa-program-and-more-women-workers/. October 5, 2020. [Zahniser, S., Taylor, J. E., Hertz, T., & Charlton, D. (2018). Farm labor markets in the United States and Mexico pose challenges for US agriculture.]
6 Milbourne, P., & Coulson, H. (2021). Migrant labour in the UK's post-Brexit agri-food system: Ambiguities, contradictions and precarities. Journal of Rural Studies, 86, 430-439.

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Tractor guidance is a PA technology that relies on GPS/GNSS for positioning and can result in accuracy within one centimeter when planting, spraying herbicide, or applying fertilizer. Thus, a farmer can know the position of every one of the millions of seeds planted in a field. The increased precision can result in fewer overlaps (areas with double application) and gaps (skipped areas) as well as overall improved economic and environmental efficiencies.

The future of farming includes collecting images with remote sensing, which may involve satellites or Unmanned Aerial Systems (UAS), such as drones, as well as both stationary or mobile sensors for efficient mapping, spraying, etc. For example, UAS can map a property of interest, report on crop health, monitor livestock and irrigation systems, and more. The ability to collect and analyze this type of image data in real time has tangible outcomes for farmers, such as better crop yield, fewer resources expended on pesticides and herbicides, and overall improved management decisions.

Drones are beginning to be used to spray crops more precisely than a traditional tractor. Whether fertilizers or pesticides are being used, a spraying plan designates the right amount of product at each location to maximize crop health and economic return while preventing pollution or wasting chemicals by over-application. Some UAS do not only apply materials to a crop, but some can also adjust the application rate using variable-rate technology (VRT) based on a prescription map. UAS potentially offer farmers major cost savings, enhanced efficiency, and more profitability.

Autonomous vehicles can potentially operate day and night to maximize productive time. Both large and small farms can potentially see significant economic and environmental savings as reductions in costs and changes in business models—e.g., robotics as a service (RAAS)—often lead to increases in profits. The precise guidance on autonomous machines offers more precise operations, which lead to reduced operator fatigue, higher yield, and the ability to work longer workdays during inclement conditions. These changes may significantly reduce fuel, labor, repair, and maintenance costs.

Responsible use of water as a resource is of critical importance for sustainable agricultural development, food security, and overall economic growth. The added impact of climate change, drought, and wildfires, and the competing demand for water from other economic sectors clearly demonstrate why water management is critical. The efficient and effective management of irrigation water is another benefit of PA technology. Precision irrigation allows applying a precise amount of water to crops at a precise time.

During planting and growing seasons, sensor data provides farmers with farm-level information that enables them to manage risk more optimally and more precisely apply fertilizer, seed, and herbicides. Additionally, at harvest, yield monitoring systems provide data on the results. All this information can be applied to planning future crops.

The implementation of PA involves the integration of smart technologies in both farming and livestock, allowing the farmer to manage variability and to monitor plant or animal performance with a focus on maximizing both efficiency and the cost-benefit ratio. Animal and plant health is key to the food and agriculture sector and industry, as livelihoods are based on milk, egg, meat, vegetable, fruit, and grain production. The collecting, processing, and analyzing of a growing volume of data are key to PA, and the seamless movement of this data is vital. Remote farm fields with mobile farm machines must have wireless networks that enable broadband data transmission across the farm in order to derive the necessary benefits from PA. The network, last mile, and last acre allow for the connectivity of smart technologies to be realized and integrated. Without the investment for a robust broadband network, PA will not evolve to achieve the goals for improved production and cost savings.

The key purpose of PA is optimization—to maximize productivity and efficiency while minimizing environmental risks and costs at as high a level of detail as possible, even to the level of small portions of a field or individual animals. Gathering, processing, and analyzing data are essential to PA as the volumes of data grow with advances in sensing capability and the deployment of more sensors in the fields and mounted on equipment. The movement of data on-farm and exchange with remote computers is a critical requirement for the advancement of PA. Farm fields are typically remote, and farm machines are typically mobile; therefore, wireless networks that enable broadband data transmission across the farm's last acre are essential to modern agriculture. The successful implementation of PA depends upon a robust last mile broadband network connecting the farm/ranch headquarters to the Internet cloud, as well as a last acre network that reaches across the area supported by the PA technology. The last acre network is almost always going to need wireless connectivity to support the needs of PA. Many farms and ranches in the United States cover thousands of acres, and PA devices will vary in use, in deployment style, and in data requirements. We refer to the network used to connect these PA devices across the farm or ranch footprint as the last acre network. As shown in the appendix on the private network options, PA devices will not generally connect physically to the last acre network, but as the PA data requirements move towards higher data, lower latency activities, the last acre wireless network will need to be backhauled to an edge computing device at the farm or ranch headquarters which is connected to the last mile broadband network.

It is critical that we prioritize and work to solve the lack of broadband to support PA and other critical needs on unserved agricultural lands by no later than 2025. The recommendations below must be acted upon if the United States is going to be able to meet this important challenge now and in the future.

The Status of the 2021 PA Recommendations on Accelerating Broadband Deployment

The 2021 PA Task Force Report made several recommendations on accelerating broadband deployment on unserved agricultural lands. We have updated and incorporated many of the yet-to-be implemented recommendations into our recommendations below to encourage action by the identified government agencies to ensure broadband is deployed as quickly as possible to unserved agricultural lands. We would be remiss if we did not highlight several actions that have been taken that are helping to meet the 2025 goal of broadband to all unserved agricultural lands:

- Congress allocated over $65 billion in federal funding for broadband deployment and this funding is beginning to be made available.
- The FCC's efforts at improving broadband mapping to determine how to best use scarce resources to deploy broadband where it is needed most.
- The FCC established incentives for small businesses and tribal areas to be able to gain access to more spectrum.
- The FCC released additional spectrum for wireless build-out.
- The FCC working to ease administrative burdens to enable tower deployment.

Even though there are some efforts already under way, we urge further action be taken on our earlier recommendations as follows:

- Consideration of a single broadband definition for funding and other purposes across all the Federal agencies and states.
- Increased incentives in the spectrum auction process to encourage broadband build-out to unserved agricultural lands.
- To define standards for broadband deployment.

Several recommendations have not been addressed. It is crucial that the Federal government continue to take important steps to enable and encourage the deployment of broadband to support PA on farms and ranches. These unresolved recommendations, which are key to the successful deployment of broadband to unserved lands by 2025, include the following:

- The FCC implementing geographic spectrum build-out requirements rather than just population coverage requirements to enable build-out of agricultural lands for auctioned spectrum.
- The FCC should require spectrum auction bidders to demonstrate the long-term sustainability (both commercial and technological) and scalability of their proposed networks.

Several unresolved recommendations from the 2021 Precision Ag Task Force Report, listed below, are key to the successful deployment of broadband to unserved lands by 2025.

The Impact of Current Federal and State Infrastructure Funding on the Acceleration of Broadband Deployment to Unserved Agricultural Lands

Significant federal and state funding has flowed into broadband deployment since the conclusion of the 2021 Report. A significant amount of this funding, $65 billion, was earmarked for broadband deployment through the 2021 Infrastructure Investment and Jobs Act (the Act), signed into law by President Biden on November 15, 2021.[7] This funding falls into the following programs that are most relevant for PA:

1. The Broadband Equity, Access, and Deployment Program (BEAD) ($42.45 billion)
2. Digital Equity Planning, Capacity, and Competitive Grants ($2.75 billion)
3. The Tribal Broadband Connectivity Program ($2 billion)
4. Rural Broadband Programs at the Department of Agriculture ($2 billion)
5. The Middle Mile Grant Program ($1 billion)
6. Private Activity Bonds (~$600 million)

In addition, the FCC's Rural Digital Opportunity Fund (RDOF) is in the process of disbursing up to $20.4 billion over a 10-year period to bring fixed broadband and voice service to millions of unserved homes and small businesses in rural America. As discussed below these programs have the potential to impact the acceleration of broadband deployment to unserved agricultural lands.

1. The BEAD Program

Title I of the BEAD is a formula-based grant program for U.S. states and territories—designed to close the access gap for unserved and underserved areas of the country. In the Bead, $42.45 billion was administered by NTIA in conjunction with State Broadband Authorities or Commissions to utilize for broadband deployment, mapping, and adoption projects. Each state, the District of Columbia, and Puerto Rico are guaranteed a grant of at least $100 million. An additional $100 million will be divided equally among the United States Virgin Islands, Guam, American Samoa, and the Commonwealth of the Northern Mariana Islands. To gain access to these funds, the United States and its territories had to submit five-year plans by the end of August 2022. These plans are now under review and funding disbursement could begin as early as the fourth quarter of 2023 for some states.

The remaining funding under BEAD is being distributed based on a formula that considers the number of unserved and high-cost locations in the state utilizing maps published by the FCC in November 2022. The funding priority is to provide broadband to unserved areas (those below 25/3 Mbps), followed by underserved areas (those below 100/20 Mbps), and then serving community anchor institutions (1/1 Gbps) (e.g., schools, libraries, and medical facilities).

Under the BEAD program, states are required to prioritize projects based on deployment to counties with persistent poverty or high poverty areas, speeds of service, expediency of completion, and demonstrated record of compliance with federal labor and employment laws. As with all the funding, states are required to award subgrants with the following prioritization:

1. Unserved Projects.
2. Underserved Projects deploying to at least 80% of locations with 100/20 Mbps service, low latency (100 milliseconds or less), and scalable to gigabit speeds.
3. Eligible Community Anchor Institutions.

7 In addition, other funds have been made available through other funding programs. See e.g., https://www.whitehouse.gov/bipartisan-infrastructure-law/#internetaccess.

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In many cases, the state and/or territory or its collaborating local entities will allocate funds to subgrantees who will deploy broadband services in the required areas. Competitive selection of subgrantees must safeguard against collusion, bias, conflicts of interest, etc. Subgrantee solicitations may begin upon approval of Initial Proposal and continue for up to one year. Subgrantees will be selected based on the set criteria including:

- Most affordable gigabit service offer.
- Priority to subgrantees with a demonstrated record of fair labor practices.
- Speed to deployment (required to deploy within four years of grant issuance).
- Workforce equity and job quality.
- Open access on fair/neutral terms to wholesale last-mile service for the life of network subsidy.
- Local and tribal coordination.

NTIA has determined that "Priority Broadband Projects" are those that use end-to-end fiber-optic architecture. NTIA decided that only end-to-end fiber will "ensure that the network built by the project can easily scale speeds over time to meet the evolving connectivity needs of households and businesses" and "support the deployment of 5G, successor wireless technologies, and other advanced services." As discussed below, this determination has raised concerns within the Deployment WG since, in some cases, it may not be possible to connect farms with end-to-end fiber because of difficult geography and extremely high cost.

2. Tribal Lands

Our review of the deployment of broadband for PA on tribal lands led to the following conclusions.

First, addressing long-term operational funding to offset the cost of construction for networks helps greatly, but the long-term feasibility of operating the network is also still a challenge without additional funding. Network operators are required to cover a large geographic area with few subscribers contributing to the profitability of an operation. This is part of the reason why private operators have not invested in these areas which remain unserved. Operators must pay for all the upkeep on the network, plus plan for the eventual capital investment to replace aging or out of service equipment. It becomes very difficult to offer affordable services and even break even to operate. Compound this with higher poverty rates in many of these areas and even affordable services need subsidy. Currently programs like ACP exist but this funding is projected to be exhausted in early 2024.

Second, construction costs are very high. Terrain and large geographic areas contribute to high network construction costs. Many tribal areas have a lot of rocky/hilly areas where blasting is required to install fiber and, in some places, it can cost upwards of $75K per mile to install fiber. These areas are also very hilly and covered with forest so wireless deployment is more expensive. More towers are required to cover these areas because of the hills and trees blocking wireless signal. Since there aren't a large number of homes or anchor institutions to service, the construction cost per site is very high which makes the case for funding look less attractive.

Finally, there is the issue of the speed to build. All of the right of way and permitting processes are lengthy and difficult. In some tribal areas, the tribes do not have co-right of way with the state, so they have to follow the same processes as any company wanting to do construction. It can take months to get an approval to perform any construction on their own reservation while the Tribe believes they should have equal right of way. The processes for approval on environmental reviews are similar with the funding agencies. The delay leads to additional costs for deployment.

3. Enabling Middle Mile Broadband Infrastructure

The Middle Mile Broadband Infrastructure Grant (MMG) Program provides $1 billion in funding for the construction, improvement, or acquisition of middle-mile infrastructure. The grant program's purpose is to expand and extend middle-mile infrastructure to reduce the cost of connecting areas that are unserved or underserved to the Internet backbone. The MMG was open to states, political subdivisions of a state, Tribal governments, technology companies, electric utilities, utility cooperatives, public utility districts, telecommunications companies, telecommunications cooperatives, nonprofit foundations, nonprofit corporations, nonprofit institutions, nonprofit associations, regional planning councils, Native entities, economic development authorities, or any partnerships of two or more of these entities. These grants have been made.

4. USDA Rural Utilities Service

The Act allocated $2 billion to the United States Department of Agriculture Rural Utilities Service for the ReConnect Program. The ReConnect Program offers loans, grants, and loan-grant combinations to facilitate broadband deployment in areas of rural America that currently do not have sufficient access to broadband. In facilitating the expansion of broadband services and infrastructure, the program will fuel long-term rural economic development and opportunities in rural America. Corporations, Limited Liability Companies and Limited Liability Partnerships, Cooperatives or mutual organizations, States or local governments (including any agency, subdivision, instrumentality of political subdivision thereof), United States territories or possessions, and Indian Tribes are eligible to apply.

5. Other Funding Opportunities

Through its Rural Digital Opportunity Fund (RDOF), the FCC has provided more than $6 billion in broadband deployment to 47 states. RDOF will eventually disburse up to $20.4 billion over 10 years to bring fixed broadband and voice service to millions of unserved homes and small businesses in rural America. RDOF participants must offer stand-alone voice service and broadband service at speeds consistent with their winning bids, which must be at least 25 Mbps downstream and 3 Mbps upstream (25/3 Mbps), at rates reasonably comparable to those available in urban areas to all locations within an awarded area over eight years of the 10-year program. Initial interim deployment milestones are based on those adopted for the CAF Phase II Auction program. Carriers must complete a competitive application process with the FCC to be awarded RDOF grants. The most recent round of funding supported projects using a range of network technologies, including gigabit service hybrid fiber/fixed wireless deployments that will provide end user locations with either fiber or fixed wireless network service using licensed spectrum.

Funding Requirements

While the Deployment WG welcomes the addition of the tens of billions of dollars being made available to increase broadband connectivity across the country, we remain concerned about whether this funding will reach the unserved lands that need it most; therefore, we offer the following recommendations:

Recommendation 1

All U.S. Federal Agencies Should Use the Same Broadband Definition and Standards for Funding Decisions, and These Definitions and Standards Should Be Updated on a Bi-Annual Basis

A continuing major concern is that there is no single definition of broadband as our federal partners make broadband decisions (this gets even worse if one looks at the states and localities). To ensure that all agricultural lands have access to a baseline of broadband services, it is critical that federal agencies use the same threshold for establishing what, exactly, is considered to be “broadband service” (greater network capacity with a better balance between upload and download speeds) and align all support mechanisms and incentives. We further urge that this definition be reviewed, and if appropriate, updated on a reasonable basis, such as every two years. The Working Group and the Task Force are pleased to see steps taken by the FCC, NTIA, and USDA to coordinate better and share information. We encourage continued efforts in these inter-agency activities and collaboration, including with States and localities.

Recommendation 2

We Recommend Prioritizing Grant Applications That Include Wide-Area Coverage to Agricultural Acreage, Including the Farm Office or House

Adding this criterion will ensure there is a robust broadband last mile network as well as wide area coverage to reach last acre agriculture lands, which require both wireline and wireless technologies. If not given priority for funding, we will continue to see resources going to networks that do not facilitate the advancement and evolution of PA across our nation, especially considering the high-cost nature of serving these sparsely populated areas.

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Recommendation 3

The FCC, NTIA and USDA Should Require the Use of Interoperability Standards as Part of the Funding Process for Precision Agriculture and Encourage the Use of Such Standards Through Outreach, etc.

As part of the funding process, the FCC, NTIA and USDA should require service providers receiving grants to utilize network equipment and devices that are compliant with industry-led interoperability standards, as seen with the evolution of the connected home and smart/connected devices. A process similar to the one used to develop the interoperability standards required to allow the smart home and device ecosystem to grow and evolve should be considered. The government must ensure ISO 11783 standards, as well as standards related to IP-enabled devices, ensuring interoperability across manufacturers and platforms to allow this same type of evolution to achieve the goals of PA.

Recommendation 4

Additional Incentives Should be Provided to Build Out Precision Agriculture to Rural Land Headquarters

The FCC and USDA should support rural broadband networks by including incentives for connectivity to rural agricultural land headquarters. NTIA's BEAD funding allocations to the States have recently been determined. This $42.5 billion is an unprecedented amount of funding for the build-out of broadband networks. We recommend an additional incentive for applicants that can and will build-out broadband networks to reach rural farm and ranch headquarters. Similarly, USDA can and should implement this criterion in selecting future ReConnect funding opportunities.

Private Wireless Networks

Federal and state funding is a primary element necessary to build-out last mile broadband networks to reach the farm or ranch. In addition to the last mile network, it is important to consider deployment to the last acre of a farm or ranch. PA needs both a last-mile network and a last-acre network to achieve the best possible results promised by PA technology. Private Wireless Networks have been considered a candidate for the last acre networks. Commercial networks would be a good solution for rural lands; however, because of the lack of users and other financial incentives, it is very unlikely commercial networks will be built-out and economically sustainable. This is where private networks may be the best solution[8]. We make the following recommendations:

Recommendation 5

The FCC Should Make Available Dedicated Terrestrial Spectrum for PA at a Low Cost

As recommended by the 2021 Task Force, the FCC should provide a carve-out of Low-band, Mid-Band and High-Band spectrum, specifically for PA usage at a low cost. The exclusive availability of spectrum for PA will ensure that licensed spectrum is available in last-acre Private Wireless Networks, and having a low-cost provision will help ensure that the licensed spectrum costs can be managed by the FCC. This will also help with the establishment and manufacture of PA-specific equipment and systems tied to specific spectrum metrics.

Recommendation 6

The USDA Should Provide Funding for Build-Out and Operation of Last-Acre Networks to Ensure the Capability to Use PA Systems and Devices

As recommended by the 2021 Task Force, the USDA should make funding available to the specific build-out and operation of last-acre networks. Any last-acre network option will be expensive, and this cost will be an obstacle for the small and mid-sized farm and ranch operations across the country. USDA has a long history of providing support to build last-mile telecom and broadband networks. These networks could be cost-prohibitive for many farming and ranching operations.

8 For a further discussion, including use cases, see Appendix C3.

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Establishing a funding mechanism for last-acre networks for the individual farmer should include:

1. Grant funding opportunities through local FSA or NRCS offices.
2. Grant funding opportunities through qualified AG CO-OPS (qualified means those co-ops are willing and capable of administering grants).
3. Providing flexibility for whichever option suits a particular farming community that USDA is trying to serve.

Spectrum Efficiency

Based on the need for broadband connectivity to unserved areas, it is critical that the FCC and other government agencies continue to work to improve spectrum efficiency and encourage network deployment. The following recommendations build on these requirements:

Recommendation 7

The FCC Should Continue to Make Incentives Available to Encourage Precision Agriculture Deployment

In its Enhanced Competition docket, the FCC began to address ways to incentivize the use of spectrum on tribal and other unserved lands. However, as previously noted, there may be fewer spectrum auction opportunities in the future. It is too early to understand how a reduced number of auctions will impact deployment. However, we urge the FCC to continue to explore and examine methods in which to incentivize further the use of spectrum to support unserved agricultural lands for all technologies. For example, the FCC should consider the use of bidding credits or other financial benefits for service providers who, as part of their auction bids, commit to the deployment of broadband to unserved agricultural lands within a set time period.

Recommendation 8

The FCC Should Revisit its Broadband Satellite Service Coverage Requirements for NGSO Satellite Systems to the Extent Technically Feasible

The FCC, in a recent docket, eliminated the requirement for country-wide coverage by NGSO broadband satellite systems. This means the broadband satellite systems that should be able to support the broadband needs of the most rural portions of the country, are no longer required to do so. The FCC should revisit this decision in light of the agricultural community's need to have access to competitive broadband services while balancing that technical requirement of the system.

Recommendation 9

The FCC Should Implement Geographic Build-Out Requirements for Spectrum-Based Licenses, and the FCC, USDA, and NTIA Should Use This Metric for Funding to Ensure the Coverage of Unserved Agricultural Lands on a Timely Basis

Today, the FCC uses population-based metrics for its build-out milestones for terrestrial wireless networks. However, these metrics have largely failed to result in the build-out of wireless networks to the most rural portions of the country. Accordingly, the FCC should implement geographic build-out requirements, rather than population-based requirements, tied to spectrum auctions with shorter build-out timelines. Funding guidelines for 5G broadband should require area-based coverage that includes verified device population, geographical, and usage data. Precision agriculture, by its very nature, will require the use of geographical-based build-out instead of the more traditional approach based on population. Spectrum auctions should include a shorter and more aggressive build-out timeline as a positive consideration in winning bids. Although the available spectrum for future auctions may be limited, we believe this is necessary for last mile, and even more so, for last acre implementation of PA. These same types of milestones should be included as part of funding received from NTIA, USDA, and the FCC.

Recommendation 10

The FCC Should Strengthen Policies That Require Auction Bidders to Show the Long-Term Sustainability and Scalability of Their Proposed Networks, Recognizing the Need to Raise the Bar Significantly on Both Upload and Download Speeds

All deployments of networks and the use of spectrum should be able to adapt to growing demands of the consumer. PA needs will evolve and require networks to evolve to allow for the improved services offered by new technology. Accordingly, it is critical that in order to participate in auctions, as part of the application process, bidders are required to demonstrate the long-term sustainability of their networks.

Stakeholder Incentives

Recommendation 11

The FCC and USDA Should Work with Stakeholders to Build a Playbook for Creating and Operating Rural Community-Based, Nonprofit Solutions (Modeled After the NTIA Playbook)

An important key to the success of these types of solutions is for the entities involved to leverage the expertise of local, independent, existing operators to build these community-based high-speed networks. By providing direction, the FCC and USDA can establish guidelines that help public-private partnerships that are most likely necessary to accomplish successful builds in areas currently unserved by a local service provider.

Recommendation 12

The FCC, Working with States and Localities, Should Address Zoning Issues to Ease Regulatory and Administrative Burdens Associated with Deploying Broadband Networks, Such as Laying Cable, Setting Towers, or Establishing Satellite Base Stations

We urge the federal government to work with state governments and localities to ease permitting, zoning and other administrative burdens. While the FCC has taken some important initial steps, more needs to be done at all levels of government.

Recommendation 13

In Tribal Areas, States and Localities Should Work with Tribal Authorities to Help Speed Deployment

To streamline the deployment of PA to tribal areas, it is important that states work to avoid imposing duplicate or heavy burdens on the deployment of broadband to farms and ranches. We urge states and localities to work with tribal authorities to find ways to minimize burdens on the deployment of broadband in tribal areas.

Conclusion

The Deployment WG applauds the 2019 Task Force and is pleased to build on their recommendations to advance the deployment of broadband for unserved agricultural lands. We urge Congress, the FCC, and USDA to fully consider these recommendations, both those carried forward and the new recommendations, to ensure that broadband is available to all agricultural lands no later than 2025. To fully realize the benefits of Precision Agriculture, a robust IP network must be deployed to allow for the tools of Precision Ag to deliver data and function at the optimum efficiency. Failure to adopt these recommendations increases risk to the climate and the lives of people across the country and the world who depend on farms and ranches across the United States for food and other agricultural products. We respectfully request your adoption and action to implement these recommendations.

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PART IV: ENCOURAGING ADOPTION AND AVAILABILITY OF HIGH-QUALITY JOBS

The United States agriculture industry faces a generational imperative to continue as a keystone on the national and international stage. Farmers are at the front lines of implementing solutions to address climate concerns and to contribute to geopolitical stability through the reduction of food insecurity that can prompt demographic uncertainties around the world. The continuing strength of the U.S. agriculture sector will be guided by sound public policy that encourages greater adoption of agriculture technology, as well as robust security and data privacy standards to secure one of the Nation's most vital industrial sectors.

Farmers, and the multi-domain systems they operate that ensure the future of food, are fundamental to national security and geopolitical stability. Agriculture is at a multi-point intersection of increased responsibility; the pressure to grow more with less; and the rising challenge of satisfying stakeholder, trade partner, investor, and consumer demand for food, fuel, and fiber to be produced in a sustainable, traceable, and humane ways. The proper broadband-enabled tools, relying on connectivity and data-empowered technology, will be necessary to better meet growing domestic and international demands.

Long before the COVID-19 pandemic, health issues and supply shortages among certain products demonstrated how even seemingly minor disruptions to the Nation's food system could cause serious problems. And the war in Ukraine, the world's fourth largest exporter of wheat, is additional evidence of how a disrupted agricultural system can have deep and global impacts. It is clear that ensuring that the security of the Nation's food system demands attention that is commensurate to that paid to transportation and cybersecurity. Humanity, for all its advances through time, still requires food, clothing and shelter for survival. Agriculture provides those needs and technology is the mechanism that increases the efficient management needed for sustainable production.

Meaningful funding and effort must be invested towards:

- Increasing on-farm connectivity.
- Climate-smart agriculture and sustainable productivity.
- Improving collaboration, research, and innovation.
- Assuring long-term continuity of U.S. agriculture systems.
- Solidifying cyber-security and data-privacy requirements.
- Assuring multi-scale adaptability.

Connectivity

Connectivity plays a critical role in securing and improving the future of food. Connectivity is necessary not only for meeting current agricultural needs, but also for providing new frameworks on which to build innovation. These include but are not limited to data gathering and modeling; increased granularity for understanding and affecting the food production process; increased market leverage for growers; greater ability for global insight for farmers at all scales; and collective effects for national security. These will enable a vast range of innovative technology and practices to empower farmers to increase productivity, decrease inputs, and become more efficient and profitable.

U.S. policy regarding connectivity will be critical to meet those future needs of production demands as well as transparent and informative data. Moreover, increased and higher-capacity connectivity will strengthen both traceability and transparency, leading in turn to increased consumer confidence. Consumers who purchase domestically grown food, fiber, and biofuel products strengthen local economies and resilience. Connectivity enables transparency and traceability throughout the entire supply chain. Ubiquitous connectivity across farmland is critical to ensuring equal access for precision agriculture adoption.

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The disparity caused by connectivity gaps will only be more pronounced as technology continues to evolve and market adoption becomes the standard.

Recommendations

- The USDA and FCC should consider precision agriculture connectivity as a critical component of our Nation's food and homeland security.
- USDA ReConnect should pivot to prioritizing on-farm connectivity as exemplified by Senate bill S.2542 LAST ACRE Act of 2023 and fully adopt the bill.

Climate Smart Agriculture

While responsible for producing safe, healthy, and sustainable food and bio-based products, farmers and producers are dealing with the effects of climate impacts every day. The attention paid to production methods and management of inputs such as fertilizer and water is more difficult than ever given the dynamic and often unpredictable changes in weather. Moreover, farmers contemplate adjustments to crop and product mix, which can introduce significant impacts on equipment and infrastructure.

The agricultural sector is already a major environmental player. Its impact on water resources, air quality, and carbon sequestration can be dramatically adjusted with agriculture technology. It is imperative that policy not only meet producers where they are today but build with them for their and the Nation's future. Farmers have engaged careful stewardship and sustainable practices for decades and proper policy can provide the tools and resources needed to capture climate-smart practices moving forward.

Climate smart agriculture focuses on three things:

- Increasing sustainable productivity (efficiency).
- Increasing resilience (adaptation).
- Decreasing Net Greenhouse Gas Emissions (mitigation).

Ag tech can contribute toward each of the above-stated goals. Although many solutions to support these aims have been developed and are implemented today, adoption is not widespread due to challenges in connectivity, interoperability, and education. Those challenges moreover affect the types and numbers of jobs in precision agriculture.

Academic literature on healthy soils indicates several regenerative agriculture opportunities that address climate smart ideals that require precision agriculture technologies for fullest impact *(refer to Appendix D3)*.

Sustainable Productivity

The achievement of maximum improvements in efficiency and productivity requires a holistic analysis of the ag production system. However, integration of public data (weather, topography, market prices) and private data (sampling (as applied inputs), yield, equipment, treatments, operations) is difficult. Resultant decisions generally fall into two categories: strategic and tactical. Strategic decisions, such as determining which crop should be planted in which field, or nutrient application regime, are less frequent but invoke significant outcomes. Tactical decisions, in contrast, address logistics, such as which field to plant or harvest first and in-season pest treatments. Those decisions require a deep level of information synthesis that can be supported with data and models.

Many farmers are now paying increased and careful attention in cropping systems to the role of the "4Rs" (source, rate, time, place) of nutrient management, which directly influence efficiency, effectiveness, and utilization *(refer to Appendix D3)*.

In a similar vein, “4Rs” of data have also been identified *(refer to Appendix D3)*:

- Right data (appropriate data points).
- Right data infrastructure (stored appropriately – Findability, Accessibility, Interoperability, and Reuse).
- Right data pipelines (system architecture for data acquisition, flow, security).
- Right talent (data interoperability requires people interoperability, with data transforming from mere numbers to insight).

These 4Rs of data are critical to the adoption of ag tech practices. The right data includes an appropriate level of resolution in both time, space, and precision. Accurate data is critical when assessing probabilities of outcomes in analyses and decisions. Nevertheless, acceptance of applicable decision aids or tools, even when validated, requires trust. Some of that trust comes from experience which includes more explicit expression of uncertainty and some will come from training. This type and quality of training and experience can be supported by policies and programs that promote adoption of applicable technologies that sustain productivity.

Recommendations

- The USDA should focus eligibility and awards on climate smart outcomes rather than specific practices or solutions.
- The USDA should increase funding available to producers through the Environmental Quality Incentives Program (EQIP).
- The USDA conservation programs should incentivize practices that have multiple environmental benefits (for example to improve water use efficiency may also improve water quality due to less runoff; optimally using nitrogen reduces life-cycle energy for crop production and can improve water quality).

Resilient Agriculture and Adaptation

Changes in weather patterns (rainfall per event, durations of rain-free periods, localization of weather events) can dramatically affect production and the condition of planting locations. Conventional best practices can still result in poor yields, excessive nutrient loss, and crop damage or loss. In turn, these can affect significantly the energy, water, and environmental footprint of operations within a growing season. Adoption of technological solutions that enable in-season adjustments, however, can improve the resilience of our production systems.

Data-driven insights, perhaps through biophysical or artificial intelligence models that project likelihoods of outcome for the relatively near-term future, can lend counsel that includes risk assessment. The title of Annie Duke’s 2018 best seller book, “Thinking in Bets – Making Decisions When You Don’t Have All the Facts” suggests that almost all decisions are made with uncertainty. Managing that uncertainty can be improved with precision technologies, but adoption of those connected technologies must be facilitated.

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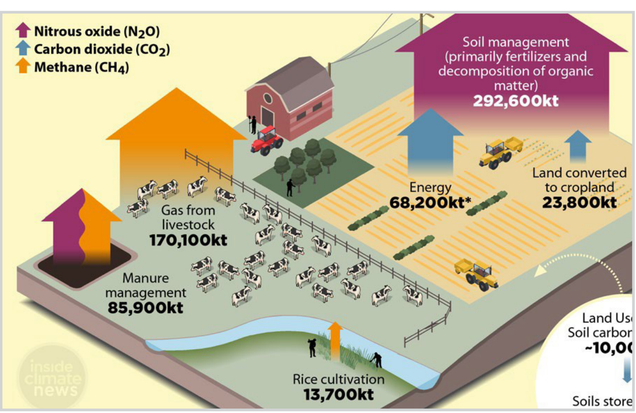
Recommendations

- The USDA should allow all new smart irrigation systems to be funded under EQIP (currently, only systems that have been deployed for two years apply are eligible for upgrades).
- The USDA Risk Management Agency (RMA) should include in crop insurance "Precision Ag Premium Reduction." When farmers utilize precision agriculture equipment and data management, they lower their operational risk profile through automation in each cropping year and establish crop records that create sustainable long-term value of historical practice. Reductions in premiums to reflect those lower risks would encourage farmers to adopt precision agriculture technologies that often also conserve natural resources. This recommendation was previously submitted in the 2021 Report.
- Crop Insurance, generally, should reflect the influence of improved accuracy of field size and climate/ conservation practices on actual production history (APH) needs careful consideration – particularly during transition years. The use of actual "as planted" maps can both reduce premiums and improve accuracy with improved measurement and reporting of active farmable area.
- The USDA Farm Service Agency (FSA) "Precision Ag Loan Guarantee" should work with traditional farm lenders and with their own lending arm to guarantee loans for producers to purchase direct cost and labor reducing precision agriculture equipment and services, recognizing them as Best Management Practices (BMPs). This recommendation was previously submitted in the 2021 Report.
- Using less energy through improved efficiency via better lighting, insulation, equipment maintenance, etc. should be rewarded similarly to generation of renewable energy. The agricultural landscape offers opportunities to generate renewable energy via digester, solar, wind, and geothermal systems and these can improve the economic resilience of farms.

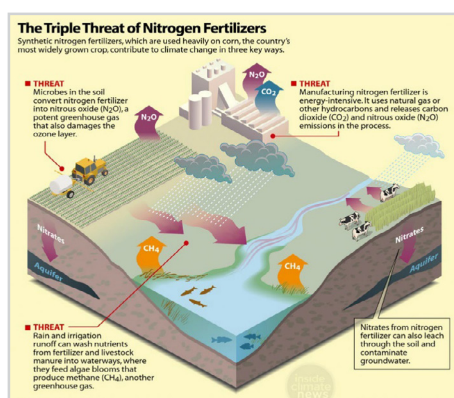
Fewer Net Greenhouse Gasses

Increased adoption of precision agriculture can contribute to net greenhouse gas reductions. These potential contributions include improved productivity on the land in current and active production, as well as prospective gains from conversion of land not yet actively being farmed. More optimal use of nitrogen in production systems can be obtained through improved timing in the crop growth cycle; active or passive sensing and accurate application control based on current need rather than average or benchmark recommendations (resulting in less N2O and less energy for fertilizer manufacturing); and improved efficiencies in field operations (directly reducing fuel and associated emissions).

Each of these require data driven insights stemming from precision technology adoption and the ability to collect data and act upon it in a timely fashion, enabled by wireless connectivity that itself is undergirded with sufficient wired bandwidth capabilities. Most pertinent is the fact that it is management practices on agricultural lands that account for just over half of the agricultural GHG emissions *(refer to Appendix D3)*. Climate smart agriculture needs to target this specifically and sensors, predictive modeling, and accurate controls are key precision technologies that can enable better nutrient management while sustaining production.



Farm contributions to climate change
(Source: P. Horn, 2018)



Triple threat of nitrogen fertilizers
(Source: P. Horn, 2018)

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Opportunities for carbon offset programs are growing, but payment level, liability of non-compliance, and skepticism lead the reasons stalling adoption *(refer to Appendix D3)*. Even when those factors are addressed, the data supporting honest brokering must be addressed. The Illinois Soybean Association identifies the data essential to capitalizing on the carbon market *(refer to Appendix D3)*. Fortunately, with regard to adoption, many of these same data elements can also inform strategic and logistics decisions on the farm. The challenge is generally that this information is rarely digital, rarely interoperable when it is digital, and unfortunately, not conveniently tied to government programs or industry incentives.

- Confirm master field boundaries
- Pre-populate all monitors with same set-up files
- Set clear data expectations with your drivers and team members

FARM RECORDS – "Data" to Capture	What About Electronic Field Records?
Soil Tests	• Request from your lab if available. (MODUS is an emerging soil test standard, but the variety of fil formats for tests remains a weak link in the data chain.)
Fall and Spring Tillage Date Type of Tillage Equipment Used Disk or Coulter Angle (if applicable) % Row Width Cultivated	• Tillage passes are equipment dependent but generally not auto-generated in a useful form, maki non-EFR records important! • Programs like FieldView are developing tools to create after-the-fact tillage maps
Fertility Date Type / Product Application Method Time-Release Injection Depth Rates N, P, K Inhibitor Used Manure: Rate, C:N Ratio, N %, Moisture %	• Make receipt of variable rate prescriptions and as-applied files a requirement of your ag retail and custom application relationships • Remember variable rate prescriptions may be easier to collect than actual as-applied
Planting Date Crop Variety Population Row Spacing	• Planter data should be considered a must-have with today's equipment
Crop Protection Date Type / Product Application Method Application Rate	• Equipment and ag retailer dependent • Be aware of the complexity of multi-product tank mixes and the need to keep non-EFR detailed records
Harvest Date Yield Moisture Residue Removal	• Yield data is a must-have with today's equipment
Cover Crops Planting Date Crop Variety Seeding Rate Termination Date Termination Method	• Planter data may be available • Use a smartphone camera with GPS-tagging enabled to document planting, seed tags, and termination

Post-Season Activities
- Organize and complete back-up records
- Pull original raw data files from monitors
- Review data for holes and inconsistencies
- Document or create EFRs for unrecorded passes
- Post-calibrate yields

Farm data checklist (Source: Illinois Soybean Association, 2022)

Farm types and sizes vary tremendously across the country and programs that encourage a net reduction in greenhouse gasses should lend equity across farm types, size, and locales. The merit of adopting practices must be science based, i.e., to tie back to benchmarks and data, but tied to actual additionality.

Recommendations

- USDA programs should empower farmers to use the hardware and software systems that improve machinery efficiencies or reduce passes over the field.
- The USDA should continue the Regional Conservation Partnership Program (RCPP) program to enhance collaboration between university, stakeholder, and public/private partnerships. Greater clarity regarding use of the funds toward enabling technology could lead more to adoption as would lightening the match requirement.
- Conservation Payment – The USDA FSA 'Precision Ag Environment Payment', NRCS 'Environmental Quality Incentives Program' (EQIP) and Regional Conservation Partnership Program (RCPP). As highlighted throughout the 2018 Farm Bill, precision agriculture and precision agriculture technologies are recognized as critical to conservation, production and profitability. Therefore, precision agriculture technologies and practices should be recognized as Best Management Practices and direct payments for its utilization should be established. This recommendation was previously submitted in the 2021 Report.

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- USDA should consider a voluntary program such as established in Growing Climate Solutions Act that includes carbon credits, nitrogen optimization, and water use efficiency.
- USDA or other relevant Federal agencies should dedicate increased funding to promote adoption of cover crops, reduced tillage, and other practices that promote soil organic matter that brings many benefits in utilization of all nutrients.

Continuity of Agriculture Systems

Producer methods, practical knowledge, culture, and the ability to innovate are intergenerational assets that support our Nation's stable food system. It is critical to our security that those qualities continue to be supported for long-term continuity. National agriculture policy that fosters partnerships between farmers and ranchers, universities, and the government have resulted in our Nation's ability to be one of a few countries in the world that has staved off famine for its population. Effective continuity over time will require farmers to leverage active insight and power in their relationships with trade partners and consumers; a broader social recognition of the role of ag and ag technologies; and the investment in long-term development of agriculture workforce.

Farmers empowered by greater technological reach and innovation will enjoy stronger market positions for effective trade that supports their needs, rural economic viability, and consumer interests. U.S agriculture's economic and social strengths are fundamental to our Nation's standing on geopolitical stage. Food traceability is but one asset that farmers can deploy.

For more than a decade, consumers have become increasingly aware of their food and food systems. They are interested in its origin, how it was grown or raised, and its level of processing. Consumers are often willing to pay a premium for products they trust. Agriculture technology enables farmers and producers to not only cut costs and increase productivity, but to increase traceability and to assure consumers of the practices they value such as food safety, sustainability, and organics, creating greater margin for producers and confidence for consumers.

The greater incorporation of technology in agricultural production, whether to support traceability or more efficient production and farming, will demand a skilled workforce that masters both farming and technology. Dedicated investments for agriculture tech workforce development will require focused attention to technology, culture, and infrastructure in ag-based communities. These investments, however, will support the ongoing revitalization of rural communities by growing high-quality talent that can drive economic growth in the areas of the country that are often among those in most need. These strategies will keep the next generation farming and ensure an ag tech future that is attractive, profitable, and a beneficial career path.

Recommendation

- The USDA should lead increased marketing and education program across agencies to promote the value of precision agriculture technologies and agriculture benefits to the United States.

Multi-Scale Adaptability

The full scale of farming systems needs to be supported in order to provide all farmers a variety of continually innovative means to adapt to the volatility of the future. Continual support for innovation across scales of farm sizes will grow integrated competencies and lend optionality to solve the problems necessary to secure a more resilient food system.

Technology across these scales will increase production through the more efficient use of input resources, the efficient increase of caloric production harvest and effective storage savings. Barriers to the adoption of precision agriculture across farm sizes and types must be acknowledged and addressed. Efforts to provide support for continued innovation must include assistance or cooperative models for mid/small producers, lending programs, and supporting domain know–how.

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Recommendations

- The NRCS should consider nationwide on-staff technologist and precision agriculture specialist.
- USDA operating loans should be increased as a means to allow for ag tech adoption to mitigate operational risk and prepare for climate adaptability tools.
- USDA should implement department and agency wide interoperability and symmetry of internal program formats to utilize operator driven data for future operator mandatory reporting, farm program creation and cohesive agency interaction of the data.
- Congress should adopt Precision Ag Loan Act S.719 establishing a department of USDA to administer low interest loans to producers and ranchers interested in precision agriculture.

Collaboration, Research and Innovation

Addressing the volatility of the future will require not only solving foreseeable problems but actively developing optionality to solve unforeseeable problems. National security, climate solutions, and global stability all rest on the ability for agriculture to be adaptive. To do that, ample education and technical assistance must be leveraged to drive precision agriculture adoption in a manner that recognizes the complex nature of agricultural systems.

The ultimate goal of every good management practice is to put the informed and technical research findings in the hands of the producer. Education and pragmatic information related to precision farming will be critical in the future. This is not only for current researchers, but for students at colleges and universities across the United States. It will be essential that students and researchers alike have cutting edge research and recommendations for management to be the most efficient and cost-effective farmers to feed the world. Funding should be aimed toward research, innovation and securing national security.

Recommendations

- The state broadband coordinator, supported by NTIA, should partner with the land grant university system, extension service, non-land grant regional colleges and community colleges to develop digital literacy training to support the adoption of precision ag tools.
- In partnership with DoD/DHS/NSF, the USDA should establish a biosecurity/cybersecurity research and innovation facility through the Land Grant University System.
- USDA study on technology adoption benefits to productivity/profitability to ensure food and water security.
- Land Grant University Extension Systems must be fully funded, and hiring qualifications must prioritize technology know-how and on-farm adoption assistance.
- It increased national collaboration between USDA NRCS and Land Grant University System concerning as-applied research, technology use, and training.
- CTE and community college precision agriculture curricula should be developed to support a system of systems approach. A developmental framework should be created with state NRCS offices, land grant universities/extensions, and local economic development agencies/county commissioners.

Cyber-Security and Data Privacy

With increased technology adoption and accessibility enabled by wireless connectivity, comes the increased need and responsibility for consideration of Cybersecurity. Through the most recent pandemic, our country has recognized both essential industries and supply chains, as well as become increasingly exposed to threats of cybersecurity and activity by “threat actors” upon both public and private institutions. Examples of these strategic vulnerabilities have been identified and leveraged in both the food supply chains with the active cyberattack on JBS, a major U.S. meat supplier, as well as an increase in individual attacks on hospitals and rural cooperatives, private businesses and other stakeholders located in rural America that are potentially active within the local economies and delivery of services to the public.

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As a working group, we focused on both vulnerabilities and lines of defensibility. Vulnerabilities can be classified into two categories: (1) single point vulnerability with the disruption of operations to an individual business and (2) system vulnerability or the potential infiltration of an individual link within the supply chain resulting in a disruption or stoppage of the entire supply chain.

Individual farms and agribusinesses are most vulnerable as they frequently have these characteristics.

With alignment and use of cloud-based platforms comes many hallmarks and cybersecurity defense mechanisms inherently designed into the architecture, representing a viable mitigation strategy. Examples of these include 128+ bit encryption, various firewall and monitoring techniques, etc.

It should be recognized that migration from desktop and individual server systems to cloud-based architecture, comes with it an inherent follow-on dependency for both bandwidth frequency and readily available connectivity, both wired and wireless.

As Rural America engages the challenges of improving cybersecurity, the corresponding dependency upon high bandwidth connectivity also becomes a requirement of necessary infrastructure. Individual farms represent single-point vulnerability as individual businesses that are susceptible to interruption. The more significant vulnerability is that of systemic vulnerability for disruption of larger scale stoppages within the supply chain.

That being said, farms and agribusinesses rely on strong cybersecurity and data privacy measures, which offer advantages to both consumers and the general public. Stringent data privacy protocols should allow producers to securely access their own raw data, providing the foundational piece for continuous improvement, and the validation of additionality for climate smart initiatives.

Agriculture, by its very nature, is subject to seasonality and seasonal changes local to specific geographies. When weather conditions and soil temperatures are ideal for planting, there is a natural tendency for many farms in a common local geography to begin planting at the same time, as environmental conditions are optimal for planting. It should also be recognized that this is high demand time.

A second aspect of systemic vulnerability can be characterized by the upstream and downstream infrastructure that serves individual farms within those localized geographies. The supply chain of inputs (fertilizer and fuel) or the downstream custody of on and off farm storage of grains or other agricultural commodities, off farm transportation and eventual downstream processing capacities all represent an additional potential threat of systemic vulnerability.

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In that interest, rural businesses such as electrical cooperatives, agricultural cooperatives, telco's, internet service providers and other providers of necessary rural infrastructure need to be equally protected from the potential threats represented by threat actors seeking to impact the supply chain.

Exhibit A

NIST Recommendations

Control Identifier	Control Name	Control	Discussion	Related Controls	Adopt	Time to Implement
AC-1	Policy and Procedures	a. Develop, document, and disseminate to [Assignment: organization-defined personnel or roles]: 1. [Selection (one or more): Organization-level; Mission/business process-level; System-level] access control policy that: (a) Addresses purpose, scope, roles, responsibilities, management commitment, coordination among organizational entities, and compliance; and (b) Is consistent with applicable laws, executive orders, directives, regulations, policies, standards, and guidelines; and 2. Procedures to facilitate the implementation of the access control policy and the associated access controls; b. Designate an [Assignment: organization-defined official] to manage the development, documentation, and dissemination of the access control policy and procedures; and c. Review and update the current access control: 1. Policy [Assignment: organization-defined frequency] and following [Assignment: organization-defined events]; and 2. Procedures [Assignment: organization-defined frequency] and following [Assignment: organization-defined events].	Access control policy and procedures address the controls in the AC family that are implemented within systems and organizations. The risk management strategy is an important factor in establishing such policies and procedures. Policies and procedures contribute to security and privacy assurance. Therefore, it is important that security and privacy programs collaborate on the development of access control policy and procedures. Security and privacy program policies and procedures at the organization level are preferable, in general, and may obviate the need for mission- or system-specific policies and procedures. The policy can be included as part of the general security and privacy policy or be represented by multiple policies reflecting the complex nature of organizations. Procedures can be established for security and privacy programs, for mission or business processes, and for systems, if needed. Procedures describe how the policies or controls are implemented and can be directed at the individual or role that is the object of the procedure. Procedures can be documented in system security and privacy plans or in one or more separate documents. Events that may precipitate an update to access control policy and procedures include assessment or audit findings, security incidents or breaches, or changes in laws, executive orders, directives, regulations, policies, standards, and guidelines. Simply restating controls does not constitute an organizational policy or procedure.	IA-1, PM-9, PM-24, PS-8, SI-12	Yes	60 Days

Control Identifier	Control Name	Control	Discussion	Related Controls	Adopt	Time to Implement
AC-2	Account Management	a. Define and document the types of accounts allowed and specifically prohibited for use within the system; b. Assign account managers; c. Require [Assignment: organization-defined prerequisites and criteria] for group and role membership; d. Specify: 1. Authorized users of the system; 2. Group and role membership; and 3. Access authorizations (i.e., privileges) and [Assignment: organization-defined attributes (as required)] for each account; e. Require approvals by [Assignment: organization-defined personnel or roles] for requests to create accounts; f. Create, enable, modify, disable, and remove accounts in accordance with [Assignment: organization-defined policy, procedures, prerequisites, and criteria]; g. Monitor the use of accounts; h. Notify account managers and [Assignment: organization-defined personnel or roles] within: 1. [Assignment: organization-defined time period] when accounts are no longer required; 2. [Assignment: organization-defined time period] when users are terminated or transferred; and 3. [Assignment: organization-defined time period] when system usage or need-to-know changes for an individual; i. Authorize access to the system based on: 1. A valid access authorization; 2. Intended system usage; and 3. [Assignment: organization-defined attributes (as required)]; j. Review accounts for compliance with account management requirements [Assignment: organization-defined frequency]; k. Establish and implement a process for changing shared or group account authenticators (if deployed) when individuals are removed from the group; and l. Align account management processes with personnel termination and transfer processes.	Examples of system account types include individual, shared, group, system, guest, anonymous, emergency, developer, temporary, and service. Identification of authorized system users and the specification of access privileges reflect the requirements in other controls in the security plan. Users requiring administrative privileges on system accounts receive additional scrutiny by organizational personnel responsible for approving such accounts and privileged access, including system owner, mission or business owner, senior agency information security officer, or senior agency official for privacy. Types of accounts that organizations may wish to prohibit due to increased risk include shared, group, emergency, anonymous, temporary, and guest accounts. Where access involves personally identifiable information, security programs collaborate with the senior agency official for privacy to establish the specific conditions for group and role membership; specify authorized users, group and role membership, and access authorizations for each account; and create, adjust, or remove system accounts in accordance with organizational policies. Policies can include such information as account expiration dates or other factors that trigger the disabling of accounts. Organizations may choose to define access privileges or other attributes by account, type of account, or a combination of the two. Examples of other attributes required for authorizing access include restrictions on time of day, day of week, and point of origin. In defining other system account attributes, organizations consider system-related requirements and mission/business requirements. Failure to consider these factors could affect system availability. (cont. next page)	AC-3, AC-5, AC-6, AC-17, AC-18, AC-20, AC-24, AU-2, AU-12, CM-5, IA-2, IA-4, IA-5, IA-8, MA-3, MA-5, PE-2, PL-4, PS-2, PS-4, PS-5, PS-7, PT-2, PT-3, SC-7, SC-12, SC-13, SC-37.	Yes	30 Days

Control Identifier	Control Name	Control	Discussion	Related Controls	Adopt	Time to Implement
AC-2	Account Management	a. Define and document the types of accounts allowed and specifically prohibited for use within the system; b. Assign account managers; c. Require [Assignment: organization-defined prerequisites and criteria] for group and role membership; d. Specify: 1. Authorized users of the system; 2. Group and role membership; and 3. Access authorizations (i.e., privileges) and [Assignment: organization-defined attributes (as required)] for each account; e. Require approvals by [Assignment: organization-defined personnel or roles] for requests to create accounts; f. Create, enable, modify, disable, and remove accounts in accordance with [Assignment: organization-defined policy, procedures, prerequisites, and criteria]; g. Monitor the use of accounts; h. Notify account managers and [Assignment: organization-defined personnel or roles] within: 1. [Assignment: organization-defined time period] when accounts are no longer required; 2. [Assignment: organization-defined time period] when users are terminated or transferred; and 3. [Assignment: organization-defined time period] when system usage or need-to-know changes for an individual; i. Authorize access to the system based on: 1. A valid access authorization; 2. Intended system usage; and 3. [Assignment: organization-defined attributes (as required)]; j. Review accounts for compliance with account management requirements [Assignment: organization-defined frequency]; k. Establish and implement a process for changing shared or group account authenticators (if deployed) when individuals are removed from the group; and l. Align account management processes with personnel termination and transfer processes.	(Cont. from previous page) Temporary and emergency accounts are intended for short-term use. Organizations establish temporary accounts as part of normal account activation procedures when there is a need for short-term accounts without the demand for immediacy in account activation. Organizations establish emergency accounts in response to crisis situations and with the need for rapid account activation. Therefore, emergency account activation may bypass normal account authorization processes. Emergency and temporary accounts are not to be confused with infrequently used accounts, including local logon accounts used for special tasks or when network resources are unavailable (may also be known as accounts of last resort). Such accounts remain available and are not subject to automatic disabling or removal dates. Conditions for disabling or deactivating accounts include when shared/group, emergency, or temporary accounts are no longer required and when individuals are transferred or terminated. Changing shared/group authenticators when members leave the group is intended to ensure that former group members do not retain access to the shared or group account. Some types of system accounts may require specialized training.	AC-3, AC-5, AC-6, AC-17, AC-18, AC-20, AC-24, AU-2, AU-12, CM-5, IA-2, IA-4, IA-5, IA-8, MA-3, MA-5, PE-2, PL-4, PS-2, PS-4, PS-5, PS-7, PT-2, PT-3, SC-7, SC-12, SC-13, SC-37.	Yes	30 Days

Control Identifier	Control Name	Control	Discussion	Related Controls	Adopt	Time to Implement
AC-2(1)	Account Management | Automated System Account Management	Support the management of system accounts using [Assignment: organization-defined automated mechanisms].	Automated system account management includes using automated mechanisms to create, enable, modify, disable, and remove accounts; notify account managers when an account is created, enabled, modified, disabled, or removed, or when users are terminated or transferred; monitor system account usage; and report atypical system account usage. Automated mechanisms can include internal system functions and email, telephonic, and text messaging notifications.	[None]	Yes	30 Days
AC-2(2)	Account Management | Automated Temporary & Emergency Account Management	Automatically [Selection: remove; disable] temporary and emergency accounts after [Assignment: organization-defined time period for each type of account].	Management of temporary and emergency accounts includes the removal or disabling of such accounts automatically after a predefined time period rather than at the convenience of the system administrator. Automatic removal or disabling of accounts provides a more consistent implementation.	[None]	Yes	30 Days
AC-2(3)	Account Management | Disable Accounts	Disable accounts within [Assignment: organization-defined time period] when the accounts: (a) Have expired; (b) Are no longer associated with a user or individual; (c) Are in violation of organizational policy; or (d) Have been inactive for [Assignment: organization-defined time period].	Disabling expired, inactive, or otherwise anomalous accounts supports the concepts of least privilege and least functionality, which reduce the attack surface of the system.	[None]	Yes	30 Days

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Control Identifier	Control Name	Control	Discussion	Related Controls	Adopt	Time to Implement
AC-2(4)	Account Management | Automated Audit Actions	Automatically audit account creation, modification, enabling, disabling, and removal actions.	Account management audit records are defined in accordance with AU-2 and reviewed, analyzed, and reported in accordance with AU-6.	AU-2, AU-6.	Yes	30 Days
AC-2(5)	Account Management | Inactivity Logout	Require that users log out when [Assignment: organization-defined time period of expected inactivity or description of when to log out].	Inactivity logout is behavior- or policy-based and requires users to take physical action to log out when they are expecting inactivity longer than the defined period. Automatic enforcement of inactivity logout is addressed by AC-11.	AC-11.	Yes	30 Days
AC-19	Access Control for Mobile Devices	a. Establish configuration requirements, connection requirements, and implementation guidance for organization-controlled mobile devices, to include when such devices are outside of controlled areas; and b. Authorize the connection of mobile devices to organizational systems.	A mobile device is a computing device that has a small form factor such that it can easily be carried by a single individual; is designed to operate without a physical connection; possesses local, non-removable or removable data storage; and includes a self-contained power source. Mobile device functionality may also include voice communication capabilities, on-board sensors that allow the device to capture information, and/or built-in features for synchronizing local data with remote locations. Examples include smart phones and tablets. Mobile devices are typically associated with a single individual. The processing, storage, and transmission capability of the mobile device may be comparable to or merely a subset of notebook/desktop systems, depending on the nature and intended purpose of the device. Protection and control of mobile devices is behavior or policy-based and requires users to take physical action to protect and control such devices when outside of controlled areas. (cont. next page)	AC-3, AC-4, AC-7, AC-11, AC-17, AC-18, AC-20, CA-9, CM-2, CM-6, IA-2, IA-3, MP-2, MP-4, MP-5, MP-7, PL-4, SC-7, SC-34, SC-43, SI-3, SI-4.	Yes	90 Days

Control Identifier	Control Name	Control	Discussion	Related Controls	Adopt	Time to Implement
AC-19	Access Control for Mobile Devices	a. Establish configuration requirements, connection requirements, and implementation guidance for organization-controlled mobile devices, to include when such devices are outside of controlled areas; and b. Authorize the connection of mobile devices to organizational systems.	(cont. from previous page) Controlled areas are spaces for which organizations provide physical or procedural controls to meet the requirements established for protecting information and systems. Due to the large variety of mobile devices with different characteristics and capabilities, organizational restrictions may vary for the different classes or types of such devices. Usage restrictions and specific implementation guidance for mobile devices include configuration management, device identification and authentication, implementation of mandatory protective software, scanning devices for malicious code, updating virus protection software, scanning for critical software updates and patches, conducting primary operating system (and possibly other resident software) integrity checks, and disabling unnecessary hardware. Usage restrictions and authorization to connect may vary among organizational systems. For example, the organization may authorize the connection of mobile devices to its network and impose a set of usage restrictions, while a system owner may withhold authorization for mobile device connection to specific applications or impose additional usage restrictions before allowing mobile device connections to a system. Adequate security for mobile devices goes beyond the requirements specified in AC-19. Many safeguards for mobile devices are reflected in other controls. AC-20 addresses mobile devices that are not organization-controlled.	AC-3, AC-4, AC-7, AC-11, AC-17, AC-18, AC-20, CA-9, CM-2, CM-6, IA-2, IA-3, MP-2, MP-4, MP-5, MP-7, PL-4, SC-7, SC-34, SC-43, SI-3, SI-4.	Yes	90 Days

Control Identifier	Control Name	Control	Discussion	Related Controls	Adopt	Time to Implement
CP-9(1)	System Backup | Testing for Reliability and Integrity	Test backup information [Assignment: organization-defined frequency] to verify media reliability and information integrity.	Organizations need assurance that backup information can be reliably retrieved. Reliability pertains to the systems and system components where the backup information is stored, the operations used to retrieve the information, and the integrity of the information being retrieved. Independent and specialized tests can be used for each of the aspects of reliability. For example, decrypting and transporting (or transmitting) a random sample of backup files from the alternate storage or backup site and comparing the information to the same information at the primary processing site can provide such assurance.	CP-4.	Yes	30 Days
CP-9(2)	System Backup | Test Restoration Using Sampling	Use a sample of backup information in the restoration of selected system functions as part of contingency plan testing.	Organizations need assurance that system functions can be restored correctly and can support established organizational missions. To ensure that the selected system functions are thoroughly exercised during contingency plan testing, a sample of backup information is retrieved to determine whether the functions are operating as intended. Organizations can determine the sample size for the functions and backup information based on the level of assurance needed.	CP-4.	Yes	30 Days
MA-3	Maintenance Tools	a. Approve, control, and monitor the use of system maintenance tools; and b. Review previously approved system maintenance tools [Assignment: organization-defined frequency].	Approving, controlling, monitoring, and reviewing maintenance tools address security-related issues associated with maintenance tools that are not within system authorization boundaries and are used specifically for diagnostic and repair actions on organizational systems. Organizations have flexibility in determining roles for the approval of maintenance tools and how that approval is documented. (cont. next page)	MA-2, PE-16.	Yes	90 Days

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Control Identifier	Control Name	Control	Discussion	Related Controls	Adopt	Time to Implement
MA-3	Maintenance Tools	a. Approve, control, and monitor the use of system maintenance tools; and b. Review previously approved system maintenance tools [Assignment: organization-defined frequency].	(cont. from previous page) A periodic review of maintenance tools facilitates the withdrawal of approval for outdated, unsupported, irrelevant, or no-longer-used tools. Maintenance tools can include hardware, software, and firmware items and may be pre-installed, brought in with maintenance personnel on media, cloud-based, or downloaded from a website. Such tools can be vehicles for transporting malicious code, either intentionally or unintentionally, into a facility and subsequently into systems. Maintenance tools can include hardware and software diagnostic test equipment and packet sniffers. The hardware and software components that support maintenance and are a part of the system (including the software implementing utilities such as ping, ls, ipconfig, or the hardware and software implementing the monitoring port of an Ethernet switch) are not addressed by maintenance tools.	MA-2, PE-16.	Yes	90 Days
SA-15(10)	Development Process, Standards, and Tools | Incident Response Plan	Require the developer of the system, system component, or system service to provide, implement, and test an incident response plan.	The incident response plan provided by developers may provide information not readily available to organizations and be incorporated into organizational incident response plans. Developer information may also be extremely helpful, such as when organizations respond to vulnerabilities in commercial off-the-shelf products.	IR-8.	Yes	90 Days

Control Identifier	Control Name	Control	Discussion	Related Controls	Adopt	Time to Implement
SA-15(12)	Development Process, Standards, and Tools | Minimize Personally Identifiable Information	Require the developer of the system or system component to minimize the use of personally identifiable information in development and test environments.	Organizations can minimize the risk to an individual's privacy by using techniques such as de-identification or synthetic data. Limiting the use of personally identifiable information in development and test environments helps reduce the level of privacy risk created by a system.	PM-25, SA-3, SA-8.	Yes	90 Days
SR-3	Supply Chain Controls and Processes	a. Establish a process or processes to identify and address weaknesses or deficiencies in the supply chain elements and processes of [Assignment: organization-defined system or system component] in coordination with [Assignment: organization-defined supply chain personnel]; b. Employ the following controls to protect against supply chain risks to the system, system component, or system service and to limit the harm or consequences from supply chain-related events: [Assignment: organization-defined supply chain controls]; and c. Document the selected and implemented supply chain processes and controls in [Selection: security and privacy plans; supply chain risk management plan; [Assignment: organization-defined document]].	Supply chain elements include organizations, entities, or tools employed for the research and development, design, manufacturing, acquisition, delivery, integration, operations and maintenance, and disposal of systems and system components. Supply chain processes include hardware, software, and firmware development processes; shipping and handling procedures; personnel security and physical security programs; configuration management tools, techniques, and measures to maintain provenance; or other programs, processes, or procedures associated with the development, acquisition, maintenance and disposal of systems and system components. Supply chain elements and processes may be provided by organizations, system integrators, or external providers. Weaknesses or deficiencies in supply chain elements or processes represent potential vulnerabilities that can be exploited by adversaries to cause harm to the organization and affect its ability to carry out its core missions or business functions. Supply chain personnel are individuals with roles and responsibilities in the supply chain.	CA-2, MA-2, MA-6, PE-3, PE-16, PL-8, PM-30, SA-2, SA-3, SA-4, SA-5, SA-8, SA-9, A-10, SA-15, SC-7, SC-29, SC-30, SC-38, SI-7, SR-6, SR-9, SR-11.	Yes	90 Days

Control Identifier	Control Name	Control	Discussion	Related Controls	Adopt	Time to Implement
SR-5(1)	Acquisition Strategies, Tools, and Methods | Adequate Supply	Employ the following controls to ensure an adequate supply of [Assignment: organization-defined critical system components]: [Assignment: organization-defined controls].	Adversaries can attempt to impede organizational operations by disrupting the supply of critical system components or corrupting supplier operations. Organizations may track systems and component mean time to failure to mitigate the loss of temporary or permanent system function. Controls to ensure that adequate supplies of critical system components include the use of multiple suppliers throughout the supply chain for the identified critical components, stockpiling spare components to ensure operation during mission-critical times, and the identification of functionally identical or similar components that may be used, if necessary.	RA-9.	Yes	180 Days

Note to Users

Note that NIST Special Publication (SP) 800-53, Revision 5 contains additional background, scoping, and implementation guidance in addition to the controls and control enhancements.

This PDF is produced from OSCAL Source data and represents a derivative format of controls defined in NIST SP 800-53, Revision 5, Security and Privacy Controls for Information Systems and Organization. This version contains only the controls and control enhancements.

If there are any discrepancies noted in the content between this NIST SP 800-53, Revision 5 derivative data format and the latest published NIST SP 800-53, Revision 5 (normative), please contact sec-cert@nist.gov and refer to the official published documents.

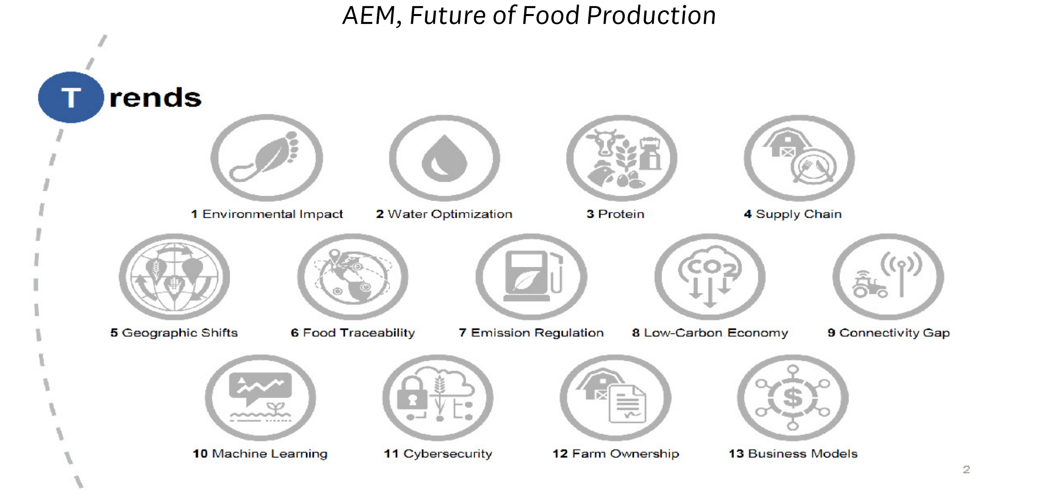
Recommendations

- All systems need to contain the architectural element of a layered security strategy, as a means of defensible architecture.
- Due to the sensitive nature of farm record data and the potential for vulnerability, all systems should have the requirement of multi-factor authentication.
- Adopt subset of NIST 800-53 presented herein.
- States should adopt a guideline similar to Nebraska LB63, withholding state USF funding from any telco using equipment on FCC covered list.
- Agricultural data privacy standards should be considered a matter of homeland security and as such, should be prioritized by state and federal agencies.
- National focus supported by agricultural associations, land grant universities, industry and USDA should be placed on data privacy awareness, education and outreach.

Data privacy standards should include but not be limited to the following:

- Producer-owned data (customer generated data) is a requirement.
- Data must be retrievable in its raw form, without manipulation, in real-time.
- Right to access and delete personal or farm record data.
- Right to opt out of sale or further use of data.
- Aggregate statistics utilizing producer generated data must not be shared or sold to third parties without written consent.
- All right, title and interest are owned by the producer/customer and may not be replicated, sold or manipulated.

AEM, Future of Food Production



The evolution of agriculture and the future of food is being driven not only by technology but also by changing consumer preferences, social trends, overall increasing global demand for food and, of course, climate change. How and which foods are produced where has economic, demographic, political and environmental impact. Precision agriculture can address many of the challenges and opportunities the future presents.

Innovation is at the heart of American agriculture. Connectivity-enabled ag tech will provide a range of resources for farmers to continue to rise to the challenges of the 21st century globalized food, fuel and fiber systems.

In order to expeditiously and effectively support the deployment of broadband on farms while increasing the adoption of precision agriculture, consistent and verified reporting must be implemented.

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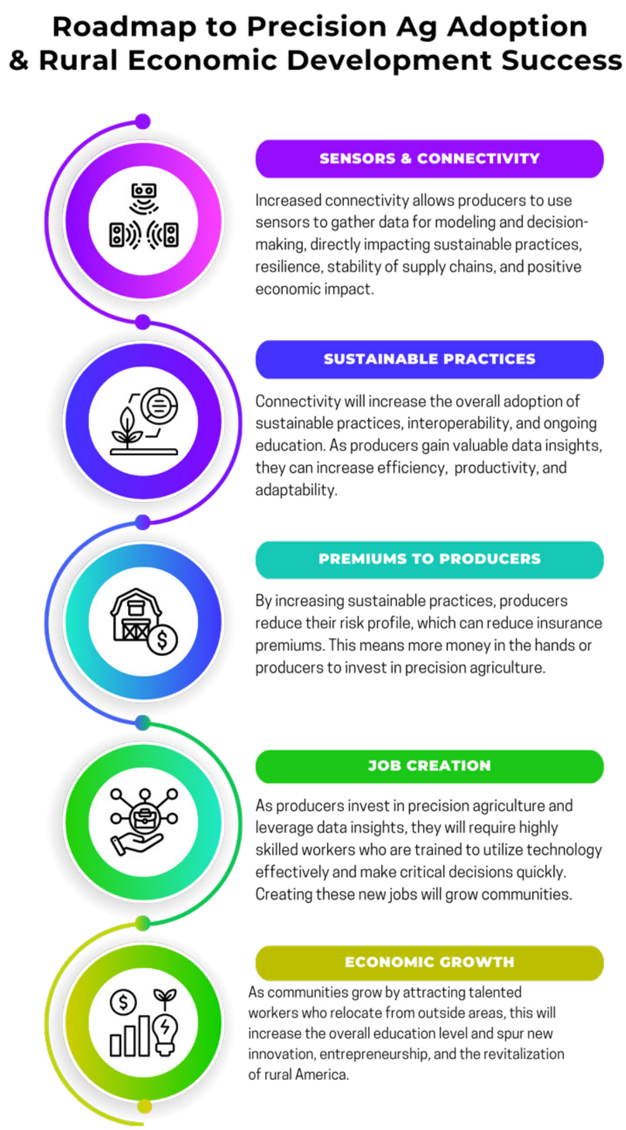
Recommendations

- The FCC, NTIA and USDA should include consistent reporting metrics and surveys to identify broadband deployment and precision agriculture adoption.
- USDA should leverage a consistent survey across departments regarding broadband use, affordability metrics, and precision agriculture use.
- Data should be made public on National Broadband Map and the Deployment Locations Map created in the Infrastructure Investment and Jobs Act, (excerpt from LAST ACRE Act).



Appendix A: Connectivity Mapping & Analysis

Appendix A1: FCC Charge to Working Group

The working group has been tasked with the following charges:

- Identify and measure current gaps in the availability of broadband internet access.
- Recommend specific steps the FCC should take to obtain reliable and standardized data measurements.
- Recommend specific steps that the FCC should consider ensuring that the expertise of the secretary and available farm data are reflected in future programs on broadband.

To carry out these charges, evaluate:

- FCC broadband deployment data and department data to identify broadband coverage on ag lands.
- With Accelerate Broadband Deployment Working Group, evaluate specific steps the FCC should take to ensure the expertise of the secretary and available land data and precision ag technology data are accounted for in policy making.
- The suitability of the Commission's and Department's data to appropriately identify and measure current gaps in the availability of broadband Internet access service on agricultural lands for precision agriculture purposes, and any limitations of the data.
- Specific steps the Commission and Department should take to improve and/or merge their data to better evaluate and facilitate broadband deployment for precision agriculture.

Appendix A2: Expert Speakers Invited by the Working Group

Thus far our Working Group has heard from the following speakers:

1. NACo Mapping of Broadband – Tarryl Clark & Seamus Dowdall, National Association of Counties (NACo) (03/24/2022): Information on NACo broadband task force and efforts to map broadband at county level, including the mobile app for mapping connectivity called NACo TestIt.
2. Ookla's Speedtest Ecosystem – Luke Deryckx, Ookla (04/07/2022): Ookla's platform for speed testing records middle mile connectivity and end-user experience and has coverage across the country.
3. Digitization in Agriculture – Use of Data in Modern Farming – Seth Crawford, AGCO (05/12/2022): Current machine systems employing precision agriculture and the connectivity demand to accomplish the goal of increasing farm income.
4. TV White Space: Data-Driven Agriculture (Ranveer Chandra, Microsoft) & Connectivity, Data and AI in the Farm (Andrew Nelson, Nelson Farms) (05/19/2022): Microsoft's FarmBeats program for data driven agriculture and the role of TV White Space for connectivity on agricultural lands for AI driven digital agriculture through Azure IoT Edge. A farm use case scenario of TVWS and AI at Nelson Farms for micro-climate forecasting, precision seeding, and precision spraying.
5. Distance vs Data Rate – Joe Carey, Trimble (06/09/2022): High data rate transmissions through mobile broadband require closely placed towers.
6. USDA-ARS Visualization Platform for Agriculture & Connectivity Data – Patrick Ryan, ESRI (06/16/2022): An update on the USDA-ARS platform for sharing connectivity data over agricultural lands with agricultural communities.
7. National Land Cover Data (NLCD) Products – Suming Jin and Jon Dewitz, United States Geological Survey (USGS) (06/23/22): The NLCD program serves as the authoritative source of national land cover data at 30 meters resolution or 0.22 acres/pixel that is updated every three years, with last update in 2019. The program publishes the National Land Cover Dataset, Forest Canopy, and Impervious Surface layers. They have developed protocols for assembling spectral, spatial, and temporal-consistent training data. Modeling and mapping efforts provide adequate land cover accuracies over land cover classes including

grass/pasture/range areas. There are data harmonization efforts between USGS NLCD and NASS Crop Data Layer program.

8. Presentation on Satellite Coverage and Connectivity – Sampath Ramaswami, Hughes Network (08/11/2022): The high-orbit satellite system for broadband connectivity, and how they may serve the precision ag needs.
9. Presentation from the American Farm Bureau by Philip Powell with Arkansas Farm Bureau Federation, Assistant Director of Local Affairs & Rural Development (08/18/2022): Arkansas Farm Bureau Federation is working with the state broadband division in mapping and connectivity to agricultural operations.
10. Broadband Resources for Extension, Kenneth Sherin, Broadband Access and Education Coordinator, County Extension Director, NC Cooperative Extension, Randolph County Center (08/25/2022): North Carolina Cooperative Extension works with Extension Committee on Organization and Policy (ECOP) and state government in their efforts to map connectivity and digital literacy.
11. Connectivity Mapping at John Deere – Mark N. Lewellen, John Deere & Company (10/6/2022): John Deere has developed a national map that combines crop data layer with tiger data (road miles from US Census Bureau) and 4G/5G LTE mobile broadband coverage data from FCC.
12. FCC Broadband Data Collection – Sean Spivey, Kirk Burgee and Kimia Nikseresht, Federal Communications Commission (10/13/2022): Speakers shared the details of BDC efforts including the processes and data flow, timelines, challenge process for fixed and mobility, and data mapping plans.
13. Broadband Program Update from USDA RUS – Administrator Andrew Berke and Telecom Assistant Administrator Laurel Leverrier, USDA Rural Development (02/23/2023): Speakers educated the working group on USDA RD programs focused on broadband.
14. What Makes a Good Map? Robert Watrel, South Dakota State University (03/16/2023).
15. Broadband Connectivity Mapping and Education at Penn State – Harry Crissy, Geospatial Intelligence Analyst, Penn State University Extension (03/23/2023).
16. Rural Consumer Internet Visualizations by Dr. Angela Hollman, University of Nebraska Kearney, and USDA ARS National Center for Resilient and Regenerative Precision Agriculture & UNL Ag-Tech Innovation Accelerator by Vice President Mike Boehm, University of Nebraska Lincoln (03/30/2023).
17. Airband Initiative Connecting the Unconnected – Jasmine Thomas, Allen Kim & Ranvir Chandra, Microsoft (04/06/2023).
18. PCTEL Scanning Receiver, Chintan Fafadia (04/13/2023).
19. Precision Agriculture in the Digital Era: Trends, Drivers, and Relationship to Connectivity – Jonathan McFadden and Eric Njuki, USDA-REE Economic Research Service (04/27/2023).

Appendix A3: Recommended Broadband Measurement Key Performance Indicators (KPIs) Standards for Participating Data Sources

1. Broadband Performance KPIs.
   a. Download speed, in Mbps.
      i. Maximum sustained throughout measurement for download speed.
   b. Upload speed, in Mbps.
      i. Maximum sustained throughout measurement for upload speed.
   c. Latency at idle, in milliseconds.
      i. The time it takes for a given packet to make a round trip during an idle network condition.
   d. Latency under load (saturated network condition), in milliseconds.
      i. The time it takes for a given packet to make a round trip during a loaded/saturated network condition.

   e. Jitter, in milliseconds.
      i. The delta between low and high latency measurements for a given test.
   f. Packet loss (if available).
      i. Percentage of network packets that are lost in transmission between the client and server.
2. Active connection type.
   a. Physical connection type in use by the measurement client, if available.
      i. (e.g., Ethernet, Wi-Fi, LTE).
3. Wireless RF signal data, if available.
   a. Band/Channel (e.g., LTD/5G band, Wi-Fi Channel).
   b. Signal strength (RSRP).
   c. Signal quality (RSRQ).
   d. Signal to Noise Ratio (SNR).
   e. Etc.
4. Location where measurement was conducted.
   a. Precise GPS location, if available.
      i. ~10-meter precision.
   b. Generalized GeoIP derived location.
5. Network details.
   a. Internet Service Provider (ISP) Name.
   b. Mobile MNC/MCC code, if available.
   c. IP address (truncated).
   d. Autonomous Systems Number (ASN).

Appendix A4: Recommendation of Subgroup on Mapping Negative Connectivity Space on Agricultural Lands

We propose the following:

Base map would be derived from the NASS Cropland Cultivated Data and the USGS MRLC/NLCD Grass/Pastureland data set. The map would be housed on and created by ARS for agriculturists with a link to the FCC site for connectivity providers.

1. Best available authoritative cropland and pastureland cover will be used over US territories.
2. The FCC 477 or BDC data would be used to create the current state of connectivity layer on agricultural lands as indicated by providers.
3. Additional data layers will incorporate service areas of connectivity providers and technology types not currently represented in 477 or BDC data.
4. Verification data layers will be incorporated from third party measurement data sets to verify coverage and performance of connectivity layers:
   - (e.g., State broadband, Ookla Speedtest, FCC Speed test, NACo TestIT, NTIA data, Tribal land data, etc.)
5. Further layers could be considered for additional context including:
6. Existing non-commercial private networks, where known.
   - Consider including data from the DOI Broadband Infrastructure Map like existing federal assets and right-of-way.
   - HIFLD Cellular Tower Data.
   - Availability of unused spectrum for private network deployment (e.g., TV White Space, CBRS).

Some underlying assumptions:

1. The map would be a point in time best effort with current data available.
2. The map would be updated and versioned quality as new source data updates are made available.
3. Third party verification data sets would need to conform to a standard set of parameters that measure the performance and reliability of connectivity, ensuring that multiple data sets from multiple sources can be combined.
   a. Median download speed, median upload speed, latency, jitter, packet loss.
   b. See A3 for complete set of recommended key performance indicators (KPIs).
4. Many base layer and verification layer data sets are available. Some are known to the writers of this recommendation, many are not. As such, the scope of recommended data sets will expand.
5. No consideration given to types of ag production just is there some type of production as indicated by the NASS and USGS data.
6. Negative space (unserved and underserved lands) map is to be based on a measured lack of coverage from verification datasets, and/or a lack of coverage from any/all reported coverage data sets, such as the BDC data. We will draw a clear distinction between an area where we've used data to confirm there is no service provided, and an area where we have no reliable data to make those inferences.
7. Acceptable performance thresholds to be based on federally defined broadband definitions, and specific agricultural use case thresholds as defined by the use case working group.

	Unserved	**Unverified**	**Underserved**	**Verified**	
Cultivated land					*a.*
Pasture/Grazing					*b.*
Ag Structures					*c.*
Homestead					*d.*

a. 25 acres parcels wired/or wireless.
b. 25 acres parcels wired/or wireless.
c. Ag Structures that are on the tax rolls wired/ or wireless.
d. Main farm/head home location with connectivity meeting currently accepted federal minimum broadband definition (e.g., 100/20Mbps, 25/3Mbps).

A categorization system with corresponding map colors will be used to indicate the following:

Unserved

Providers do not indicate any connectivity available on the production land, or providers indicate connectivity availability, but verification data shows a clear lack of acceptable service.

Unverified

Providers indicate that connectivity is available based on 477 or BDC data provided for that agricultural land, but no verification data exists to validate acceptable service standards.

Underserved

Providers indicate that connectivity is available based on 477 or BDC data, but verification data sets indicate available services do not meet the performance and reliability threshold required for agricultural broadband use cases.

Verified

Providers indicate that connectivity is available and third-party verification sources confirm that in fact users have demonstrated connectivity to that piece of agricultural land.

We suggest the following draft recommendations:

1. FCC adopt the framework as a base to determine unserved and underserved ag lands in low 48 states.
2. FCC adopt the underlying assumption to the framework as the supporting clarification to framework.
3. FCC adopt the rubric that lays out the steps that could be taken when adopting the framework.

Appendix A5: Recommendation of Subgroup on Policies, Resources and Cultural Awareness to Aid Broadband Data Mapping

Objectives

- To establish a coordinated approach to broadband mapping on agricultural lands across multiple USDA agencies and led by the National Agricultural Statistics Service (NASS) in coordination with numerous USDA agencies that fund projects on or near agricultural lands or who support conservation efforts and educational initiatives on agricultural areas.
- To integrate the expertise as well as the financial and technical resources of various USDA agencies with jurisdiction over broadband infrastructure deployment, agricultural lands, conservation districts and survey analysis. These agencies include:
  - Rural Development (RD-RUS), Natural Resources and Conversation Service (NRCS).
  - National Institute of Food and Agriculture (NIFA).
  - Farm Services Agency (FSA).
  - The National Agricultural Statistics Service (NASS).
- To ensure federal funds dedicated to collecting, measuring and analyzing coverage data and the level of fixed and mobile broadband coverage on farms and agricultural lands are executed in the most cost-effective manner to provide the most comprehensive view of broadband coverage on rural agricultural lands and farm.
- To allocate sufficient federal funding to support a USDA wide initiative that leverages existing USDA staff from the agencies listed above to build a comprehensive broadband map that illustrates the location of unserved and underserved farmlands.
- To ensure the FCC and NTIA utilize the USDA broadband mapping information for all federal grant and subsidy determinations starting in Q1, 2023.

Purpose and Scope

Several USDA agencies that work directly with and for rural communities, native nations and agricultural producers in rural unserved are maintain valuable expertise and familiarity with lack of connectivity on agricultural lands and its corresponding impact on the expansion and adoption of precision technologies to reduce input costs and increase efficiencies.

Rural Development (RD-RUS), Natural Resources and Conversation Service (NRCS), National Institute of Food and Agriculture (NIFA) and the Farm Services Agency (FSA) each have a wealth of insight to contribute toward the survey analysis conducted by the National Agricultural Statistics Service (NASS), which is the primary statistical USDA agency and an official source of comprehensive information. NASS data are used to support research, education, and advocacy for the future of agriculture.[9]

Given its role in overseeing statistical analysis and data collection on farming activity in the U.S., expanding NASS' responsibility to maintain farm field broadband data will complement its primary role in managing and conducting the biannual Farm Computer Usage and Ownership Survey and quinquennial Agricultural Census. Enhanced broadband data collection also helps USDA support further research on precision agriculture uses and trends.

9 https://www.nass.usda.gov/About_NASS/pdf/NASS_TalkingAboutNASS_ExternalGuide_2022_V01.pdf.

Broadband usage data collected by NASS is used widely by the precision agriculture sector as well as academic institutions, nonprofit organizations, regional federal reserve banks and many internal USDA agencies such as ERS and Rural Development.

Recommendation 1

To improve its broadband usage survey that examines the level of broadband coverage on agricultural lands, NASS be provided with the necessary funding to:

- Support broadband mapping at the same frequency as crop production data.
- Convert farm field mapping data into publicly accessible farm field broadband maps within the NASS agriculture database.
- Share data with relevant USDA farmer assistance agencies such as FSA, NRCS, NIFA as well as other federal agencies such as the NTIA, FCC, EDA.

NASS stakeholders and staff can benefit from improved and more precise coverage data as well as other inputs collected by other USDA agencies to increase the value of its mapping and surveying of broadband over farm fields which is a natural addition to crop production surveys and the Agricultural Census. Through NASS as the record keeper of farm field broadband mapping, the aggregate of US farm data will be enhanced for better research and service to farmers.

Recommendation 2

To ensure the necessary funds allocated to each USDA agency are used to facilitate the appropriate level of broadband mapping on farmlands, we urge Congressional Agriculture committee leaders in the House and Senate to adopt the following:

1. Include language in the 2023 Farm bill that allocates funds to each USDA agency listed above to contribute staffing, travel and operational funds toward a department wide intra-agency broadband mapping and data analysis task force.
2. Require the internal USDA task force to create an action plan that draws upon the core competencies of the relevant mission areas and agencies to develop an interactive broadband coverage map across agricultural lands.
3. The task force will be directed to meet weekly to develop a stakeholder engagement strategy to conduct outreach and field analysis of broadband coverage on farmlands including those held in trust or on reservation lands.
4. The USDA Internal Broadband Mapping task force will utilize the geospatial tools of each assigned agency to identify areas where coverage is insufficient for growers and producers to access and effectively operate precision technologies consistently.
5. The task force will also consult with local, regional, tribal and federal and agricultural stakeholders about their coverage needs and experiences. Input received from consultations will be incorporated to provide the following:
    a. A comprehensive rural broadband coverage map on farm and agricultural lands using existing data from the RUS ReConnect broadband program map, NRCS and conservation easement mapping data and NASS mapping data.
    b. Allocate at least $1.5 million to each agency listed above to support intra-agency coordination involving broadband adoption, research and education, network deployment and technology expansion involving precision technologies and tools. The expansion and adoption of precision technologies across the proposed funded service areas ("PFSA") will also be included in each grant and loan program administered by RUS in all future broadband loan and grant programs.

Recommendation 3

- Direct NIFA to establish a new competitive grant program to support rural field coordination and outreach to local and tribal producers on farms and agricultural lands.
- Land grant universities may apply for funds to build programs that support cooperative extension involvement in the education and collection of broadband usage and adoption data on farms and agricultural lands.
- Cooperative extension divisions of each land grant college and or university is uniquely qualified and best suited to support education, outreach and training performed by its cooperative extension agents to assist farmers and ranchers understand NASS surveys and complete them correctly to illicit the best data responses.
- Direct the NIFA to allocate funds to support the USDA's broadband mapping platform and goals.
- NIFA and RD shall distribute grant funds to local and regional organizations like the National Grange, to support the local survey and field analysis performed by Cooperative extension agents.
- USDA broadband mapping portal will be publicly launched in 3 years from the date of enactment of these provisions.

Appendix A6: Recommendation of Subgroup on Multi-agency Collaboration on Data Collection and Sharing and Maintaining Public Facing Ag-Focused Data Platform

1. Direct and fund agencies to collaborate on common goals around data collection and/or analysis.
   a. Who we want and what we want (the agencies, what are the goals)
   b. Funding will be required for this to work (Farm Agency, NASS)
      i. Farm bill – 2023
      ii. Annual appropriations – 2023
      iii. Joint USDA/FCC appropriated funding

2. Combine efforts to create or utilize third-party software collect connectivity verification data.
   a. Multi-agency adage, combining efforts of USDA NASS (survey) + Ookla, state broadband office speed tests, FCC speed test, NACo TestIT, other apps meeting data requirements as outlined in Appendix C.
   b. Instructing farmers/residents to check their connectivity around the farmland, instruction on testing connection and methods.

3. Collect samples from various locations around rural and tribal areas, utilize Land Grant Universities personnel, extension agents, rural mail carriers, delivery drivers, drones to achieve this goal with autonomous methods.
   a. Autonomous meaning background testing ability.
   b. Drone addition could capture pastureland, could have privacy issues (FAA issues).

Appendix A7: Recommendation of Subgroup on What Should Be Mapped – Level of Coverage and Resolution of Maps

The subgroup was tasked with determining the "level of coverage" needed for precision agriculture purposes. Understanding that there is at least one other working group in the Precision Ag Task Force that is working on this topic, the subgroup tried to focus on how the "level of coverage" necessary for precision ag purposes could be mapped.

We have learned that there are three main categories of use cases for broadband service in precision ag based on current and projected future industry needs:

1. Real-time heavy data processing use cases such as Artificial Intelligence (AI) driven technology that require high bandwidth, low latency connection profiles.
   a. Data transfers for this use case may include real time streaming if HD video, exceptionally large image transfers for near-real time processing, and other high-definition sensor data.
   b. Strong connectivity is foundational to the future of agriculture in the United States.

        i. Significantly raise the standard on upload capacity over time to anticipate the needs of precision agriculture.
        ii. Double or even triple the current standard for upload and download speeds to meet the needs of future technology such as autonomous tractors.
        iii. In the next term, the Working Group should review a potential timeline for new standards based on research, examples, and testing to determine practical speeds.
    c. Connectivity technologies best able to serve this connection profile would include as fiber or fixed wireless to farm with high performance on-site Wi-Fi, 5G or other high quality connection technologies

2. Asynchronous bulk data transfer needs such as whole field mapping with drone or field robots that would help make decision for the next day or within a few days.
    a. Examples may include mapping soil fertility for future fertilizer applications, or crop senescence for harvesting decisions.
    b. Data transfers for this use case may include image and video data which is not needed in real time and can be downloaded after the farm equipment is parked for the night. Sometimes this type of transfer can be a cache of a week's worth of data. For example, this data provides a farmer with information about how many bushels per acre they are harvesting the field. It provides the information for a farmer to know what land is producing the most. Farmers may use that data to obtain support from the government and make determinations such as whether to change what is planted in a particular area.
    c. This large download includes large files and needs to be at least a 25 Mbps download with a 3 Mbps upload ("25/3") connection.
    d. The best type of broadband for this task is last mile fixed service or a hybrid of fixed and mobile service (Wi-Fi, 5G, LTE) in combination.

3. Realtime telematics data communication needs for farm machinery operational problems, livestock health and wellbeing, etc.
    a. Examples may include an irrigation system or machinery malfunction during operation, predation on livestock, etc.
    b. It helps a farmer know for example, if one of the rows is plugged (on the planter). Most equipment provides an alarm to the farmer so he can fix this problem quickly because if not rectified it may impact your whole season.
    c. This use case can be served by connection profiles similar to CAT 1 LTE, at around 10 Mbps download with a 5 Mbps upload ("10/5") speed at 200 milliseconds latency.
        i. For reference, a typical cell phone is CAT 12 – 16 LTE which talks to multiple towers more frequently. That kind of service is unnecessary and not likely possible in rural areas due to lack of density.

Recommendation 1

Broadband data maps of agricultural lands should include layers that reflect the availability of fixed or mobile connectivity that is able to serve each category of agricultural use case. For example, a map of precision ag areas should show where mobile service of 10/5 Mbps or above is available and what the radius is. This would be a useful map for a farmer who needs to support telemetry/telematics and correction services and remote work orders. Additionally, it should show what the reliability of that link based on the topography of the area (e.g., down in the valley versus up the hill), in other words what is the probability the service will consistently perform above or below CAT 1 LTE speeds at 200 milliseconds latency, with additional layers representing connectivity able to serve the bulk data transfer and real-time AI driven use cases as outlined above.

Recommendation 2

A map of precision ag areas should show where there is fixed broadband service capable of meeting the minimum federally accepted definition of broadband. This enables farmers wishing to do large data transfers know where they can reliably make those transfers using fixed connectivity.

In so much as we make specific speed recommendations herein, we defer to the other working groups in the FCC's Precision Task Force that may be making specific speed recommendations for the same or equivalent purposes as described above.

To make both recommendations as beneficial as possible we note this Working Group's prior recommendation that there be a designation in the Broadband Data Collection Fabric for agriculture lands so that the overlaid service availability is shown on top of where agriculture lands and farms exist.

Appendix A8: Working Group Members and Guest Speakers

Chair: Sreekala Bajwa, Vice President for Agriculture, Dean of the College of Agriculture and Director of Montana Agricultural Experiment Station, Montana State University

Vice Chair: Lynn Follansbee, VP-Strategic Initiatives & Partnerships, USTelecom – The Broadband Association

Members:

- Michael Adelaine, CIO Emeritus and Special Advisor to President, South Dakota State University
- Dan Barcus, Farmer & Rancher, Blackfeet Nation
- Brent Birth, President of Stone Corner Resources, and member of National Society of Professional Surveyors
- Joe Carey, former Director for Wireless Strategy, Natural Resources Sector, Trimble (member till September 2023)
- Tarryl Clark, Chair of National Association of Counties (NACo) Rural Action Caucus and NACo board member
- Seamus Dowdall, NACo Alternate & Associate Legislative Director of Telecommunication and Technology, NACo
- Luke Deryckx, former Chief Technology Officer, Ookla (member till August 2023)
- Todd Harpest, External Affairs & Regulatory Director, MetaLINK Technologies
- Miles Kuschel, Farmer and member of Minnesota Farm Bureau Federation
- Todd Myers, Past Chairman of Power and Communications Contractors Association & President of Kenneth G. Myers Construction
- Matt Splitter, Farmer and Member of National Corn Growers Association
- Jessica Zufolo, Vice President for Rural Broadband Strategy, Magellan Advisors
- Rick Mueller, USDA Liaison & Section Head – Spatial Analysis Research Section, Research and Development division, USDA-NASS
- John Emmett, FCC Liaison & DDFO, Geospatial Data Specialist, FCC
- Ying Ke, FCC Laison & DDFO, Geospatial Data Specialist, FCC

Guest Speakers

1. Seth Crawford, AGCO: Digitization in Agriculture – Use of Data in Modern Farming
2. Ranveer Chandra, Microsoft & Andrew Nelson, Nelson Farms: TV White Space: Data-driven agriculture& Connectivity, Data and AI in the Farm
3. John Emmet, FCC: FCC Tracker
4. Patrick Ryan, ESRI: USDA-ARS Visualization Platform for agriculture & connectivity data
5. Suming Jin & Jon Dewitz, USGS: National Land Cover Data Products
6. Sampath Ramaswami, Hughes Network: Geostationary Satellite coverage and connectivity
7. Philip Powell, Arkansas Farm Bureau Federation: American Farm Bureau Efforts
8. Kenneth Sherin, NC Cooperative Extension: Role of Cooperative Extension

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9. Mark N. Lewellen, John Deere: Connectivity Mapping at John Deere
10. Sean Spivey, Kirk Burgee & Kimia Nikseresht, FCC: FCC BDC
11. Andrew Berke & Laurel Leverrier, USDA-Rural Development: Broadband Program Update from USDA-RUS
12. Robert Watrel, South Dakota State Univ.: What makes a good map?
13. Harry Crissy, Penn State University Extension: Broadband connectivity mapping and education at Penn State
14. Angela Hollman & Mike Boehm, Univ of Nebraska: Rural Consumer Internet Visualizations & Resilient and Regenerative Precision Agriculture
15. Ranvir Chandra, Jasmine Thomas & Allen Kim, Microsoft: Airband initiative connecting the unconnected
16. Chintan Fafadia, PCTEL: PCTEL Scanner Receiver
17. Jonathan McFadden & Eric Njuki, USDA-ERS: Precision Ag in Digital Era: Recent adoption on US Farms

Appendix B: Current & Future Needs

Appendix B1: FCC Charge to Working Group

The working group has been tasked with the following charges:

- Develop recommendations to weigh and prioritize connectivity needs of agricultural operations, farmers, and ranchers.
- Prepare a report on an annual basis that details the projected future connectivity needs.

Appendix B2: Buildout Requirements

Precision Ag is powered by a combination of key technologies and components that enable connected devices and objects to collect, transmit, and exchange data – the same fundamental elements that power the Internet of Things (IoT).

Sensors and Actuators

These are the physical devices that collect data from the field. Sensors can measure soil moisture. Actuators, on the other hand, can perform actions based on data received, like turning on/off a switch or adjusting a valve.

Data and Processing and Analytics

Collected data is processed and analyzed to derive meaningful insights. This can occur on a device (edge computing), in the cloud, or in edge data centers. Machine learning and AI techniques are often used for data analysis and predictive modeling.

Cloud Computing

Many Precision Ag applications leverage cloud platforms for data storage, processing, and management. Cloud computing provides scalability, redundancy, and accessibility for data.

Edge Compute

Edge compute involves processing data locally on IoT devices or in nearby data centers rather than transmitting it to a distant cloud server. This reduces latency and enables real-time decision-making in applicants like autonomous vehicles and industrial automation.

Security

Cyber security is crucial to protect data, devices, and networks from unauthorized access and cyberattacks. Security measures include encryption, authentication, access control, and regular software updates. Data privacy between farmers and other stakeholders remains of the utmost importance.

Protocols and Standards

Standardized communication protocols are needed to ensure interoperability between devices and systems.

Power Management

Sensors often operate on battery power, so efficient power management is essential for prolonging device lifespans. Low-power processors and sleep modes help conserve energy.

Data Visualization and User Interfaces

Farmers will want to see their data on their phones or tablets, in the field, throughout interfaces that present the data as graphs or dashboards, which could be web-based or part of mobile applications.

Geolocation Technologies

Automated tractors rely on geolocation data, such as GPS.

Scalability and Interoperability

Last acre solutions must be designed to scale to accommodate a growing number of devices and ensure compatibility with various device types and manufacturers. As the number of multi-functioning sensors and interacting "smart" machines increases, so do the bandwidth needs. Think back to what happened during COVID when everyone in the house was on their devices at once.

Appendix B3: Last Acre Act Text and Testimonials

s. 2542 LAST ACRE Act of 2023 – An important aspect that was not drafted into the original text of the bill, was to direct funds to be invested as close to the field as possible with local providers who have a vested interest in serving rural areas and their long-term viability.

The text of the bill can be found HERE at Congress.gov.

"It's time for us to connect the last mile to the last acre. Producers looking to adopt precision agriculture technologies need network connectivity that extends far past their residences. They need to be able to make real-time decisions that increase yields and employ resources more efficiently. Our LAST ACRE Act will ensure that USDA has the strategy and resources needed to support last acre connectivity." – Senator Fischer

"Small farms in remote zip codes should not preclude folks from access to high-speed internet. With nearly one-fourth of zip codes in New Mexico classified as 'remote,' the LAST ACRE Act will help farms and ranches in remote areas connect to broadband to provide Precision Ag and next generation farming technology. That's why I'm proud to join Senator Fischer in this effort to close the digital divide in all communities, regardless of zip code." – Senator Luján

Appendix B4: Cal.Net Terranova Ranch Automated Irrigation

Link to Terranova Ranch Presentation

Terranova Ranch farms over 6,000 acres of 25 organic and conventional crops in the central San Joaquin Valley, CA, headed by Don Cameron, president of the California Food & Ag Board.

Cal.net is a rural last mile Internet provider, who received a $50 million Connect America grant and is an active partner with Microsoft on many projects, including one with Land O Lakes in Tulare County, CA.

This project brought connectivity to 80 acres of tomatoes, leveraging Cal.net's $50 million Connect America grant to get microwave backhaul to Terranova.

They used Connect America dollars as a springboard to build an on-farm network automating water pumps through low bandwidth radio technology. The system is now set up to change watering by time, but in the future will be tied to soil moisture sensors.

The ability to automate crops that change seasonally with effective technology opens the door for multiple other components that could perform a wide range of other data collection and functional capabilities.

The network itself was built using all standards based, off the shelf technologies, so it is scalable and upgradable. For now – broadband for Ag Tech and rural unserved communities in CA is critical for water conservation, sustainable ag, environmental protection, economic growth, equity, workforce training, education, and health.

For Precision Ag

Off the shelf components, local vendors, non-proprietary technology, and local 24/7 maintenance/repair provide the flexibility that growers need.

For the Future

The ability to automate crops that change seasonally with effective technology opens the door for multiple other components that could perform a wide range of other data collection and functional capabilities.

Concerns about costs to the farmers of design and build of the Private wireless network underscores the need for grant programs to get connectivity to the last acre.

Potential FCC Support – Case Study in Row Crops

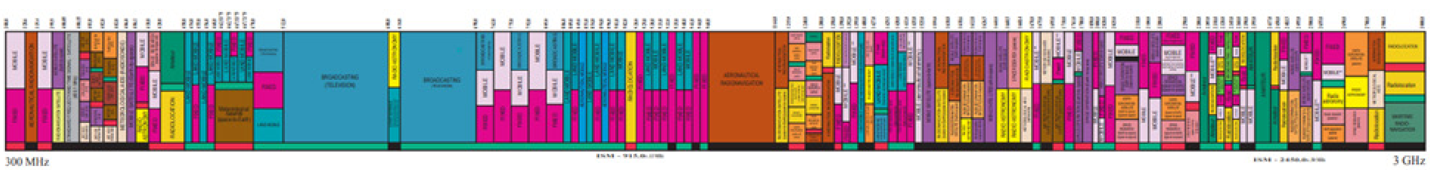
Calnet

- 100-Acre Pilot
- Scale at 1000 acres
- Federal grants and small grower co-ops to reach scale
- Initial Build Costs:
  - Field Equipment
  - Technology Components
  - Internet Installation
- Maintenance & NOC monitoring
- Includes service 24x7
- Extended warranty options on hardware

ASPECT Per acre - buildout	100 Acres $1,463.44	250 Acres $718.44	500 Acres $498.44	1,000 Acres $393.44	5,000 Acres $303.44	10,000 Acres $291.94
Field Equipment Valves & Installation	$19,344	$48,360	$96,720	$193,440	$967,200	$1,934,400
Controllers, Sensors & Installation	$27,000	$31,250	$52,500	$95,000	$435,000	$860,000
Internet Installation Buildout Charges	$100,000	$100,000	$100,000	$105,000	$115,000	$125,000
Annual Maintenance & Service	$12,000	$21,000	$30,000	$48,000	$180,000	$300,000
Annual Internet Connectivity	$6,000	$6,000	$6,000	$6,200	$6,600	$7,000

Appendix B5: Spectrum Allocation

Low-band (0.3-3 GHz)



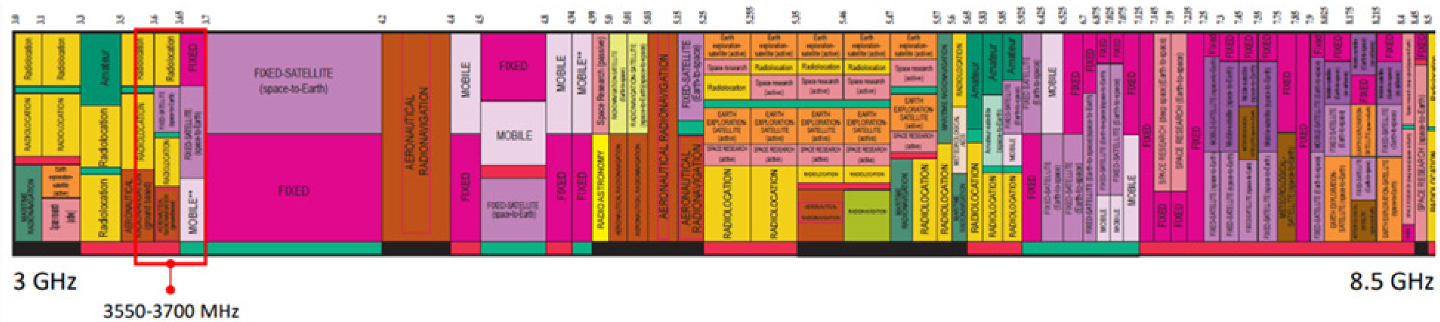
As previously discussed, low-band is imperative as the coverage layer (5G and previous generations) and this does not stop short of the last acre.

Service Providers, including Tier 1 Mobile Network Operators ("MNOs"), provide Fixed Wireless Access ("FWA") to connect areas not economically viable for terrestrial networks.

For example, T-Mobile leads other Tier 1 MNOs (AT&T and Verizon) in FWA subscriber projections through 2025 with 7-8 million forecasted using a combination of frequencies including 2.5 GHz.[10] Commercial use of low-band spectrum accounts for 29% of the overall low-band and recent auctions (such as 2.5 GHz on 10-year terms) will leave little room for further 5G expansion across new low-band frequency ranges.[11]

Moreover, low-band alone will not support exponential 5G device growth and capacity needs of Precision Ag.

Mid-band CBRS (3.5-3.7 GHz)



CBRS is a 3 tier band, but we will highlight benefits of PAL (2nd tier, lower 70 MHz of band) as this creates a unique opportunity for Precision Ag with fewer performance unknowns than the General Authorized Access ("GAA") tier.

In total there are 228 license holders and over 20,000 licenses nationwide.[12]

Although the device ecosystem is still maturing, CBRS delivers uplink and downlink throughput performance of commercially licensed lower mid-band.

County-specific PAL licensees create an opportunity to target unserved agricultural lands.

CBRS 5G NR Uplink and Downlink Performance Scenarios follow on the next page with an accompanying glossary related to Appendix 4.

3GPP

3rd Generation Partnership Project, standards organization for mobile communications.

4x4 MIMO

Multiple Input, Multiple Output with 4 antennas and 4 simultaneous data streams.

CSI-RS

Channel State Information Reference Signal is used in NR downlink direction for the purpose of channel sounding and used to measure the characteristics of a radio channel for correct modulation, code rate, beam forming etc.

DFTS

Discrete Fourier Transform relates to waveform and transmission power.

DoD

Department of Defense.

eMBB

Enhanced mobile broadband is a feature of 5G.

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10 "T-Mobile CFO says FWA churn is coming down (fiercewireless.com)", Fierce Wireless (June 2023).

11 "5G Connectivity: A Key to Enabling Technology to meet America's Climate Change Goals." CTIA commissioned study by Accenture (January 2022) https://api.ctia.org/p-content/uploads/2022/01/5G-Connectivity-A-Key-Enabling-Technology-to-meet-Americas-Climate-Change-Goals-2022-01-25.pdf.

12 Source Auction 105: 3.5 GHz Band, FCC (July-August 2020).

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FWA

Fixed Wireless Access.

GAA

General Authorized Access, Tier 3 CBRS.

LTE

Long-term Evolution, 4G wireless standard.

mMTC

Massive Machine-type Communications is a feature of 5G.

mmWave

Millimeter Wave is 24-40 GHz spectrum.

Modulation

Converts data in radio waves.

NR

New Radio, 5G wireless standard.

OEM

Original Equipment Manufacturer.

PAL

Priority Access Licenses, Tier 2 CBRS.

PRACH

Physical Random Access Channel.

PUCCH PRB Pairs

Physical Uplink Control Channel, information sent uses one RB in each of the two consecutive slots in a subframe and two RB used for PUCCH is here after called resource block pair (RB-pair).

QAM

Quadrature Amplitude Modulation combines modulation signals into a single channel.

RS

Resource Block consist of 12 consecutive subcarriers in a frequency domain.

SCS

Sub Carrier Spacing, only NR standalone with 30 kHz SCS is supported.

Service Provider

Companies offering a variety of communications services to the public leveraging network infrastructure as a functional platform.

SIB1

System Information Block present in signaling, the NR-capable UE can receive and decode configuration information from an NR cell.

Special Slot Pattern

Defines downlink, guard, and uplink symbols within special slot or slots.

SSB Periodicity

Secondary synchronization block periodicity.

SSF

Spec Subframes for switching downlink and uplink transmission.

TDD

Time Division Duplex allows for the transmission of both upstream and downstream data on the same frequency channel using different time slots.

TDD Pattern

Defines TDD pattern in terms of downlink, uplink and special slots.

UE

User Equipment is any mobile device used directly by an end user.

URLLC

Ultra Reliable Low Latency communications is a feature of 5G.

CBRS NR expected throughput – 4408

NR DL Parameters	
Inputs	Value
SCS	30kHz
TDD Pattern	DDDSUUDDDD (Pattern 1)
Special Slot	6:4:4 (SS Pattern_03)
CSI-RS Ports	4
SSB Periodicity	20ms
SIB1	disabled
SSB Position	minimum throughput impact

NR UL Parameters	
PRACH Format	Format 0
PUCCH PRB Pairs	1
UL Layers	2 (max)
DFTS	No

LTE Parms	
SSF	7
Frame Config	2

NR UE Peak Throughput L1 (Mbps)							
					DL L1 T'Put (Mbps)		
BW	Conditions	Modulation	DL MCS	Layers	Max	75%	55%
20	Ideal	256 QAM	27	4	288.2	216.2	158.5
20	Moderate	256 QAM	27	2	144.1	108.1	79.2
20	Poor	64QAM	18	1	26.8	20.1	14.7
40	Ideal	256 QAM	27	4	603.6	452.7	332.0
40	Moderate	256 QAM	27	2	304	228.0	167.2
40	Poor	64QAM	18	1	55.4	41.6	30.5
					UL L1 T'Put (Mbps)		
BW	Conditions	Modulation	UL MCS	Layers	Max	25%	45%
20	Ideal		28	2	40.6	10.2	18.3
20	Moderate		24	2	24.6	6.2	11.1
20	Poor		18	1	7.5	1.9	3.4
40	Ideal		28	2	65.6	16.4	29.5
40	Moderate		24	2	53.3	13.3	24.0
40	Poor		18	1	16.2	4.1	7.3

For comparison		
LTE UE Peak T'Put (DL - Mbps)		
Max	75%	55%
286.38	214.8	157.5
143.0	107.2	78.6
NA	NA	NA
NA	NA	NA
NA	NA	NA
NA	NA	NA

On the basis of BW, NR T'put is only marginally greater than LTE. Add'l BWs provide greater T'put / capacity

(Source: Ericsson, 3GPP standard, 4x4 MIMO, 4x5W output power)

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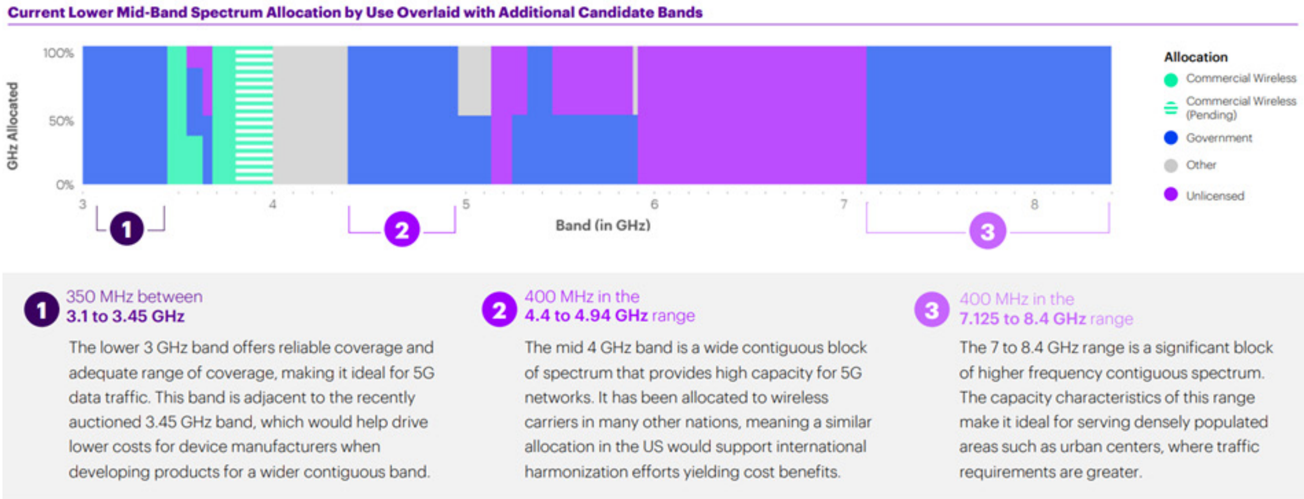
Lower mid-band (3.1-8.4 GHz)



(Source: Accenture, Commissioned by CTIA, Spectrum Allocation in the United States at 4 (Sept. 2022), https://api.ctia.org/wp-content/uploads/2022/09/Spectrum-Allocation-in-the-United-States-2022.09.pdf.)

Lower mid-band spectrum provides the greatest potential to meet 5G performance and capacity needs to support wide-area use cases from farming equipment to connect livestock. Lower mid-band should be prioritized over high-bands, such as mmWave, due to economically viable deployment models in rural communities.

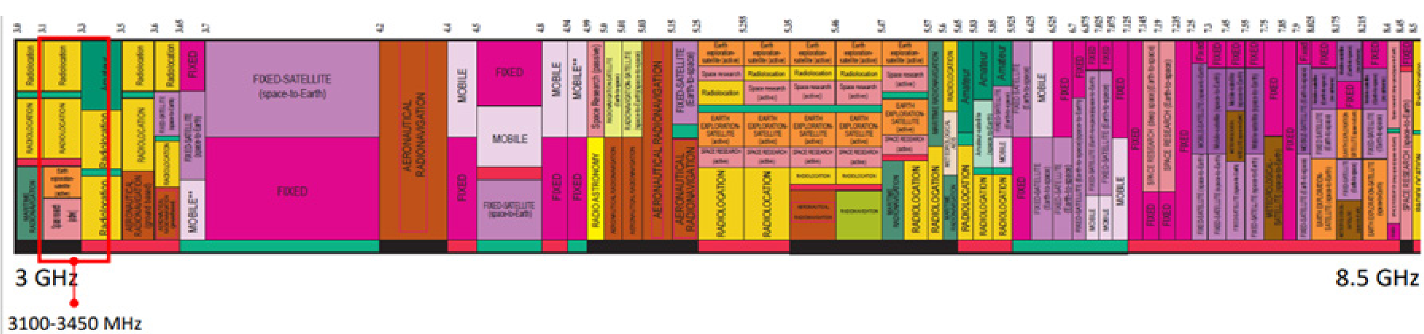
Unfortunately, lower mid-band spectrum in commercial use is disproportionately low (5% total) when compared to government and unlicensed allocations.

Following the second C-band tranche, commercial use will only account for 450 MHz of the available spectrum. Reallocating a significant portion of the 3 frequency ranges highlighted above could create more 5G parity with low-band and harmonize standards with Original Equipment Manufacturers (“OEMs”). Delivering environmental benefits and performance efficiency would be achieved by assigning contiguous spectrum blocks.

To support the future state of Precision Ag, mid-band is needed for an increasing number of low-energy devices via massive machine type communications as well as upload and Enhanced Mobile Broadband (“eMBB”) to connect critical farm applications.

Below are brief insights into the 3 frequency ranges listed above:

- **The 3.1-3.45 GHz** provides bandwidth and RF propagation ideal for 5G FWA and supporting device growth in Precision Ag. Additional benefits include international harmonization, hardware standardization and lower costs to deploy. These bands are currently licensed for government use with DoD cautioning on 3.1 GHz commercial availability, and 3.45 GHz only available for cooperative and periodic commercial use when authorized by DoD. We recommend accelerating feasibility studies and prospective auction(s) in 2025.



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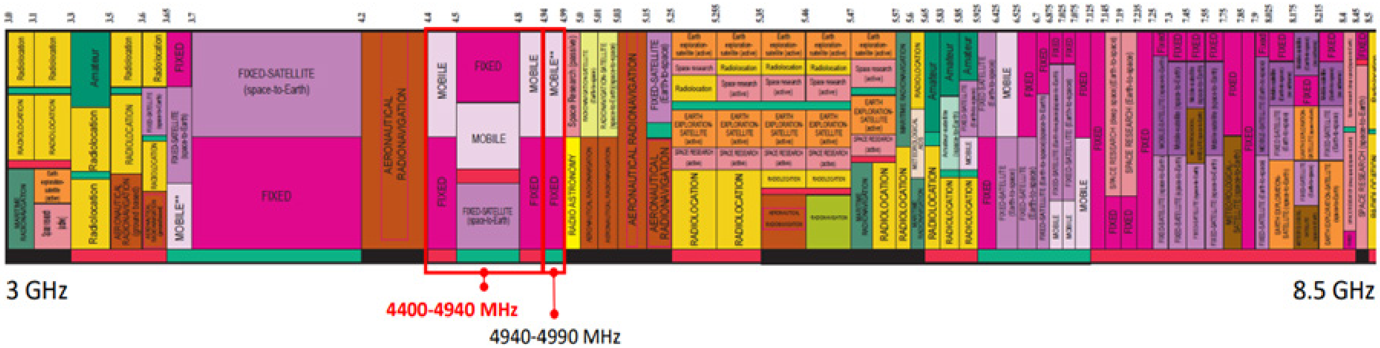
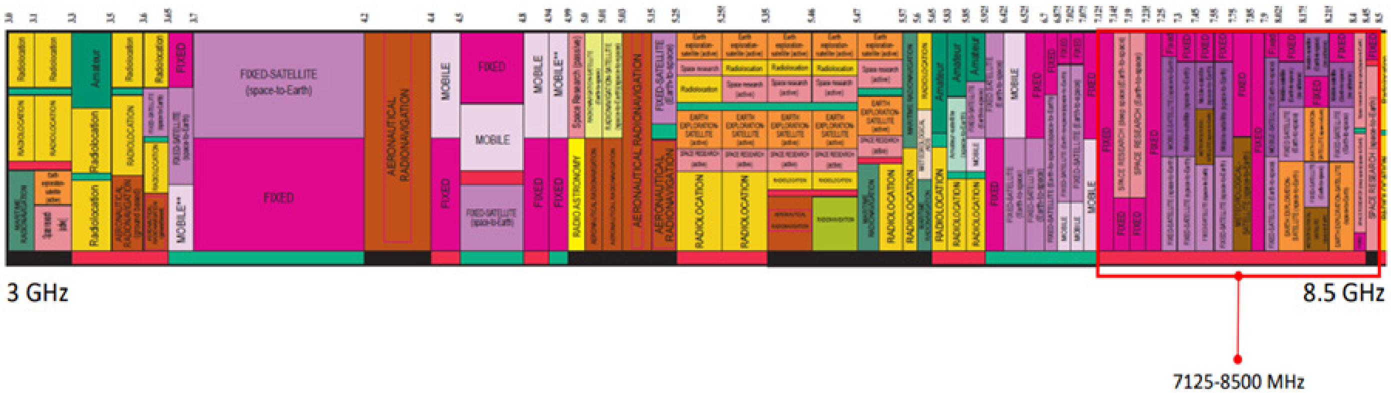
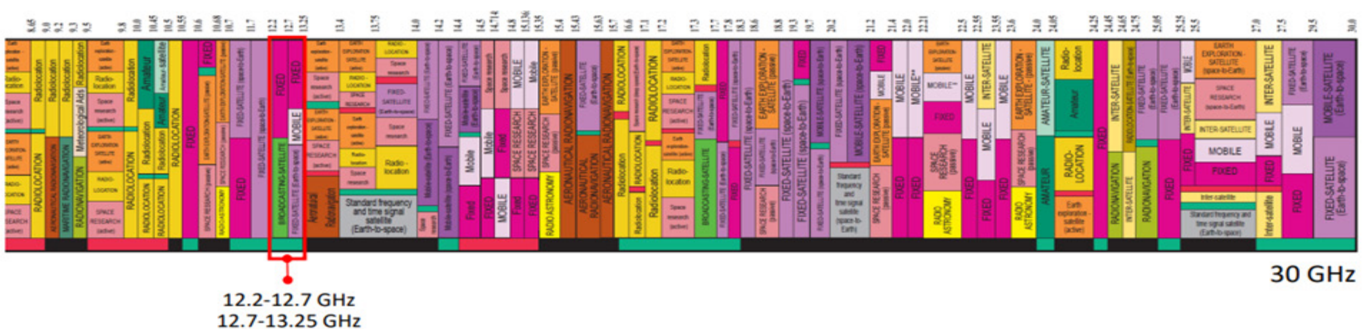
- **The 4.4-4.9 GHz** provides a unique balance of coverage and capacity. This band would support a multitude of future 5G use cases in Precision Ag ranging from autonomous operations to video applications while providing backhaul as alternate to higher cost fiber deployment. Although spectrum reassignment would require a complex rulemaking process, this band could open over 3,500 licenses and enable high-throughput 5G connectivity.



- **The 7.125-8.4 GHz** is primarily in government use today and likely to take several years to reassign for shared commercial use, however, Congress has shown support for shared commercial use with FCC and NTIA studying. High capacity attributes of this band would make a strong candidate for emerging 5G use cases, however, RF propagation would limit access mostly to farms located in densely populate areas. Additionally, the use this band for FWA connections to farm headquarters could prove more economical when compared to cost of terrestrial networks.



- **The upper mid-band (8.4-24 GHz)** are restrictive in rural areas due to RF propagation and deployment costs. Spectrum in the upper mid-band range could serve future 6G use cases in Precision Ag if economics are feasible for Service Providers, otherwise, spectrum could be made available for private wireless networks. This spectrum could enable future use cases requiring Ultra Reliable Low Latency Communications ("URLLC") if last acre connectivity options are limited and farm operator is able to invest in a private wireless network. This spectrum is under review by several rulemaking bodies and could be made commercially available in the coming years. Over 80% current use of this spectrum is held for government and FWA backhaul.



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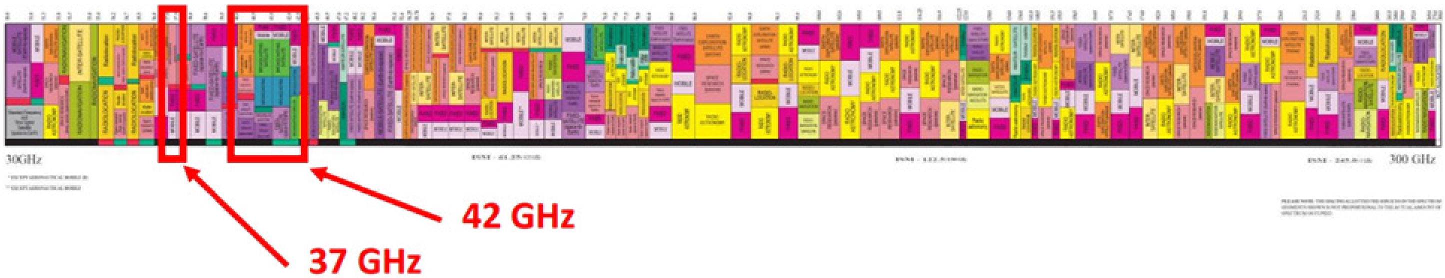
- **The high bands (above 24 GHz)** have gained traction through recent auctions of mmWave bands followed by deployments in public venues and dense urban centers. Today 19% of high-band spectrum is assigned for commercial use with room for further allocation. With limited to no incumbent use and ongoing assessment in the rulemaking process, opportunities exist with 600 MHz available in 37 GHz and 500 MHz available in 42 GHz. Although high-band access is unlikely for most rural areas, these bands could further enable Precision Ag test beds and emerging 6G use cases.



Appendix B6: The Crucial Role of Broadband in Empowering Ai-Driven Agriculture (by Andy Bater and Ranveer Chandra)

The agriculture industry is experiencing a significant transformation, driven by the rapid adoption of Artificial Intelligence (AI) and other advanced technologies. These innovations have the potential to improve productivity, minimize losses, promote sustainable agriculture practices, and streamline supply chains. However, the efficacy of these AI-driven solutions relies heavily on the availability and quality of data. In this annex, we will discuss the urgent need for broadband connectivity in the farm for AI, focusing on five main themes: data collection on the farm, data collection among farmers, off farm data collection and multifactor analysis, creation of "Digital Twin" models, and the role of edge computing and data privacy.

Theme 1

Data Collection in the Heart of the Farm

The first step in leveraging AI in agriculture is the collection of vast amounts of data from various sources such as sensors, drones, cameras, and more. For example, drones equipped with multispectral cameras can monitor crop health and detect early signs of pests or diseases. Broadband connectivity is essential in this process, as it enables the seamless transmission of data from the middle of the farm to the cloud or local servers for processing.

Theme 2

Multifactor Data Collection Among Farmers

Data collection may also involve collection from multiple farmers. Farmer A captures visual health images of plants perhaps providing early detection of disease, Farmer B collects local weather data enabling more accurate spraying operations, Farmer C tracks livestock prices at the local sale barn, and so on. Currently, this data might be shared informally over a cup of coffee, but in the future, these diverse data sources may be directly input into multifactor AI models. Subscribing[13] farmers could then access these collective insights. Again, high broadband capability across all farms is necessary.

[13] Non-governmental organizations (NGOs) or cooperatives can potentially serve as useful means of coordinating these disparate data sources.

Theme 3

Off Farm Data Collection and Multimodal AI

Many decisions in agriculture rely on complex multifactor analyses. “Multimodal” AI applications can combine multifactor insights with other models derived from satellite image analysis, historical crop yield data, examination of current and projected fertilizer prices, commodity futures prices, and more. These are the calculations farmers sometimes perform in their head given their on and off farm experience. “Multimodal” Artificial Intelligence can simulate similar “what if” scenarios.

Theme 4

Digital Twin Full Agricultural System Models

AI enables the creation of full system models, sometimes referred to as “Digital Twins”. Digital Twin model representations have become common in other industries[14]. Digital Twins can be virtual model representations of the entire farming operation. Digital Twins can also help farmers conduct what-if analyses, ultimately leading to more informed decisions and improved outcomes. By simulating various scenarios and analyzing their potential impacts, farmers can optimize their resource allocation, minimize risks, and enhance overall farm performance.

Theme 5

Edge Computing and Data Privacy

As illustrated elsewhere in the 12/2/22 Examining Current and Future Connectivity Demand for Precision Agriculture Interim Report[15], sending all the collected data to the cloud for AI processing can be time-consuming and resource-intensive. Moreover, data privacy concerns arise when transmitting sensitive information to remote servers. Edge computing, where data is processed on the farm using local servers or devices, potentially at the same time removing individually identifying information, offers a solution to these challenges. To enable edge computing in agriculture, farmers need access to robust broadband infrastructure that can support the high-speed data transmission required for real-time processing and analysis.

Integrative Artificial Intelligence Insights to the Farmer

These themes are all necessary steps along the road towards transformational AI derived information. The true value of AI in agriculture lies in its ability to provide actionable insights and recommendations to farmers in real-time. Examples include generative AI models that can predict crop yield, detect pests or diseases, and suggest optimal irrigation practices. With tools like Microsoft’s FarmBeats. AI and others announced by Amazon and Google[16], farmers can access soil and yield maps, conduct what-if analyses, and plan strategies to optimize their operations. Broadband connectivity is crucial for conveying these insights effectively, as it enables the rapid transmission of information from AI models to the farmer in the middle of the farm.

The future of agriculture is undeniably intertwined with AI and advanced technologies. However, to unlock the full potential of AI-driven solutions in the farm, there is a pressing need for reliable and high-speed broadband connectivity across all farms and agricultural infrastructure. Investing in broadband infrastructure is not only essential for data collection, edge computing, and AI insights dissemination, but also a critical step in empowering farmers and revolutionizing the agricultural industry as a whole. As we move forward, it is vital to prioritize the expansion of broadband access in rural areas, ensuring that farmers can harness the power of AI to address the challenges they face and secure a sustainable future for agriculture.

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14 “Digital twins, what are they and how are they enabling future networks?,” Ericsson (July 20, 2023), https://www.ericsson.com/en/blog/2022/3/what-are-digital-twins-three-real-world-examples

15 FCC, Precision Agriculture Task Force, Examining Current and Future Connectivity Demand for Precision Agriculture Interim Report at 19-21 (Dec 2, 2022), https://www.fcc.gov/sites/default/files/connectivity-needs-anticipating-demand-interim-12022022.pdf.

16 Belle Lin, America’s Farmers are Bogged Down by Data (Aug. 22, 2023), https://www.wsj.com/articles/americas-farmers-are-bogged-down-by-data-524f0a4d.

Appendix B7: Working Group Membership, Subgroups & Presenters

Heather Hampton+Knodle, WG Chairman, Vice President and Secretary of Knodle, Ltd. Farms

Joy Sterling, WG Vice Chairman, Chief Executive Officer of Iron Horse Vineyards

Seth Arndorfer, Chief Executive Officer of Dakota Carrier Network

Andy Bater, Farmer with Fifth Estate Growers, LLC

Dr. Ranveer Chandra, CTO Agri-Food, Managing Director, Research for Industry at Microsoft

Chris Chinn, Director of the Missouri Department of Agriculture, National Association of State Departments of Agriculture

Cassandra Heyne, Regulatory Compliance Analyst of SpaceX

Ryan Krogh, Manager, Production System Program Management of John Deere

Dan Maycock, Principal, Data Engineering of Loftus Labs (until August 2023)

Jason Miller, Safety Manager of Tillman Infrastructure, NATE: the Communications Infrastructure Contractors Association

Brian Scarpelli, Senior Global Policy Counsel of the App Association (ACT)

Steven Strickland, Director Partnerships and Channels of Ericsson

Mark Suggs, Executive Vice President & General Manager of Pitt and Greene Electric Membership Corporation, National Rural Electric Cooperative Association

George Woodward, President and CEO of Trilogy Networks, Inc., Rural Wireless Association

Subgroups within the Working Group

Policy/Current Needs – Heather, Joy, Chris C., Jason, Mark, Brian, Ryan

Use Cases – Andy, Ryan, Dan, Cassandra

Network Infrastructure – Steven, Cassandra, Mark

Edge Compute – George, Ranveer, Seth

Presenters

John Visclosky, FCC on Paperwork Reduction Act (4/28/22)

Zhang Hongwei, Iowa State University ARA: Wireless Living Lab for Smart and Connected Rural Communities with Christopher Yaw of Ericsson (5/12/22)

Andrew Nelson, Nelson Farms (5/26/22)

Vikram Adve, Director of AIFARMS with Deepak Vasisht (7/28/22)

Brent Kemp, President and CEO of Ag Gateway; Jeremy Wilson, Farmer, EVP/COO North American Director of Ag Gateway (8/25/22)

Robert Tse Senior Policy Advisor at USDA – Telecommunications Program, Rural Utilities Service (6/9/22)

Dr. Joao Dorea, University of Wisconsin Madison (2/9/23)

Christopher Ali, PhD, Pioneers Chair in Telecommunications, Professor of Telecommunications, Penn State University (5/9/23)

Outlook for 6G by Ericcson Marie Hogan 6G Portfolio Strategy, Rydin Ulf in Sweden, Mike Woodley and Stephanie Rollis (9/22/22)

Subrata Kumar Mitra, Ericsson, India (3/7/23)

Scott Waller, Open Innovation Labs (3/9/23)

SWARM Technologies Inc. (3/27/23)

Carrie Johnson, Director External Affairs & Policy/ Joe MarxAVP – Federal Regulatory Relations FirstNet Program at AT&T

Joe Carey, Director of Wireless Strategy for Trimble (5/4/23)

Tiffany Ingersoll, Sr. Product Manager for Application Automation with John Deere joined by Aaron Ticknor (6/1/23)

Caroline Chan, Mobile Edge Lead with Intel

Olfat Masoud, VP Technology and Ecosystem Development at Federated Wireless (7/20/23)

Megan Kwamme, CEO of Ohio Transparent Telcomm joined by Kyle Yoder, Steve Stone (8/10/23)

Don Cameron Terranova Ranch & Craig Rich Cal.Net joined by Linda Thomas, Ken Garrett, Craig Stein (8/24/23)

Mark Gibson, Sr. Director, Spectrum Policy at CommScope (9/7/23)

Sources

"5G Connectivity: A Key to Enabling Technology to meet America's Climate Change Goals." CTIA commissioned study by Accenture (January 2022). https://api.ctia.org/wp-content/uploads/2022/01/5G-Connectivity-A-Key-Enabling-Technology-to-meet-Americas-Climate-Change-Goals-2022-01-25.pdf

"A Case for Rural Broadband: Insights on Rural Broadband Infrastructure and Next Generation Precision Ag Technologies. USDA (April 2019)."

Besen Group Total Cost Ownership tools for private LTE networks.

"Broadband National Strategy Needed to Guide Federal Efforts to Reduce Digital Divide." U.S. Government Accountability Office (May 2022).

Cellco Partnership vs. FCC U.S. Court of Appeals District of Columbia Circuit Ruling No. 11-1135 Consolidated with 11-1136 (December 2012).

"Cybersecurity and Precision Ag." Cybersecurity and Infrastructure Security Agency (July 2022).

"Ericsson Mobility Report" (June 2023). https://www.ericsson.com/49dd9d/assets/local/reports-papers/mobility-report/documents/2023/ericsson-mobility-report-june-2023.pdf

FCC Broadband Serviceable Location Fabric Methods Manual. Costquest Associates, Inc. (December 2022).

FCC 2022 Communications Marketplace Report (December 2022).

FCC Notice of Inquiry Promoting the Deployment of 5G Open Radio Access Networks. GN Docket No. 21-63 (March 2021).

FCC Third Report and Order on Establishing the Digital Opportunity Data Collection. WC Docket No. 19-195. and Modernizing the FCC Form 477 Data Program. WC Docket No. 11-10 (January 2021).

"The Future of Food Production: An Analysis of 13 Trends That Could Reshape the Way Food is Produced." Association of Equipment Manufacturers (2022).

"Impact of Broadband Penetration on U.S. Farm Productivity." LoPiccalo, K. FCC Office of Economics and Analytics (Updated February 2021).

"IPv4 vs IPv6: what are they and what's the difference?" Hiley, Catherine. *Cybernews* (March 2023).

Memorandum of Understanding Regarding Information Sharing between FCC, USDA, NTIA, US Dept. of Commerce and US Dept. of Treasury (May 2022).

Public Law 112-96 Title VI – Public Safety Communications and Electromagnetic Spectrum Auctions (February 2012).

"Public-Safety Broadband Network: Congressional Action Required to Ensure Network Continuity." U.S. Government Accountability Office (February 2022).

"Responsible artificial intelligence in agriculture requires system understanding of risks and externalities." Tzachor, A; Devare, M; King, B; Avin, S; OhEigeartaigh, S. *Nature Machine Intelligence*. Vol. 4. (February 2022). https://www.nature.com/articles/s42256-022-00440-4

State of Missouri Cell Tower Grant Program Summary. Chinn, C. (September 2022).

Testimony to House Energy and Commerce Committee, Subcommittee on Communications and Technology Hearing on the Future of Spectrum Management Entitled "Defending America's Wireless Leadership" Ghosh, Monisha (March 2023).

"Zero-Energy Devices – a New Opportunity in 6G." Parkvall, S. Ericsson (September 2021).

Glossary

AI = Artificial Intelligence
CBRS = Citizens Broadband Radio Service (2.55 to 3.7 GHz, in "Band 48")
Cloud = Cloud computing
CTIA = Cellular Telephone Industries Association
Edge = Edge compute
eMBB = Enhanced Mobile Broadband
EPC = Evolved Packet Core
FCC = Federal Communications Commission
FDD = Frequency Division Duplexing
IoT = Internet of Things
LEO = Low Earth Orbit
LoRaWAN = Long Range Wide Area Network
M2M = Machine to Machine
ML = Machine Learning
MSC = Mobile Switching Center
NIST = National Institute of Standards and Technology
NTIA = National Telecommunications and Information Administration
PAL = Priority Access License
Precision Ag = Precision Ag
RAN = Radio Access Network
RF = Radio Frequency
TDD = Time Division Duplexing
UAV = Unmanned Aerial Vehicle
USDA = United States Department of Agriculture

Precision Ag = Managing, tracking, or reducing crop or livestock production inputs, including seed, feed, fertilizer, chemicals, water, and time, at a heightened level of spatial and temporal granularity to improve efficiencies, reduce waste, and maintain environmental quality.

Precision Ag Equipment = Any equipment or technology that directly contributes to a reduction in, or improved efficiency of, inputs used in crop or livestock production, including:

- Global Positioning System-based or geospatial mapping.
- Satellite or aerial imagery.
- Yield monitors.
- Soil mapping.
- Sensors for gathering data on crop, soil, or livestock conditions.
- Internet of things and technologies which are reliant upon edge and cloud computing.
- Data management software and advanced analytics.
- Network connectivity products and solutions including public and private wireless networks.
- Global Positioning System guidance, auto-steer systems, autonomous fleeting and other machine to machine operations.
- Variable rate technology for applying inputs, such as section control.
- Any other technology that leads to a reduction in, or improves efficiency of, crop and livestock production inputs, which may include seed, feed, fertilizer, chemicals, water, and time.

Appendix C: Accelerating Broadband Deployment

Appendix C1: FCC Charge to Working Group

The working group has been tasked with the following charges:

- Develop recommendations that will allow the Task Force to encourage adoption of broadband and precision agriculture on farms and ranches and thereby address labor supply challenges and promote the availability of high-quality job opportunities
- Promote effective policy and regulatory solutions that encourage the adoption of broadband Internet access service on farms and ranches and promote precision agriculture.

Appendix C2: Accelerating Broadband Deployment on Unserved Agricultural Lands Working Group

Chair

Jennifer Manner
Senior Vice President, Regulatory Affairs, *Hughes Network Systems, LLC*

Vice Chair

Jimmy Todd
Chief Executive Officer and General Manager, *Nex-Tech*

Members

Renee Bivens
Analyst and Manager, State Government Affairs, *DISH*

Garrett Hawkins
President, *Missouri Farm Bureau*

Anthony Dillard
Tribal Councilman, *Choctaw Nation of Oklahoma*

Betsy Huber
President, *The National Grange*

Zach Hunnicutt
Farmer, *Nebraska Farm Bureau Federation*

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Senior Manager for Precision Ag Sales for Americas, *AGCO Corp*

Richard Monaghan
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Carolyn Price
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Dr. Alex Thomasson
Professor, Department Head, Department of Agricultural and Biological Engineering, *Mississippi State University*

Dominic Walkes
Director of Strategic Initiatives, *Raven Applied Technology*

The Honorable Dan Watermeier
Commissioner, *Nebraska Public Service Commission*

Brandon Wipf
Farmer and Board of Directors Member, *American Soybean Association*

Mike Watson
Vice President and Deputy General Counsel, *Extenet*

Appendix C3: Private Wireless Networks

Like last-mile networks, one of the primary challenges to the deployment and adoption of private wireless networks (PWN) is their high cost. Accordingly, as part of funding decisions being made by the Federal, State, and local governments, it is critical that PWNs are included in that equation.

Access to licensed spectrum is another significant challenge for these networks. Licensed spectrum is preferred because it is not subject to the same potential for interference that unlicensed spectrum can be. For example, suppose the last acre unlicensed spectrum network is far from any densely populated community. In that case, there is a possibility that unlicensed spectrum may be sufficient to support the needs of the PWN. However, the quality of communication using unlicensed spectrum in more populated rural areas may degrade significantly due to interference from other users and devices.

Other considerations are both the technology used for PA activities and the use of the spectrum itself may dictate the type of spectrum needed. For example, the low-band spectrum will reach further distances and is more able to handle terrain and vegetation obstacles. Still, the data throughput capacity is limited by the low-band spectrum. Conversely, the high-band spectrum has greater data throughput capacity but generally has a shorter range and is impacted to a greater degree by terrain, vegetation, and weather.

The following scenarios demonstrate how a last acre PWN may be deployed for PA use. These examples are based on information gathered and confirmed by meeting with network engineers from a wireless communication company that designs, implements (or installs), and operates mobile wireless and fixed wireless networks.

The four scenarios described include a pure private wireless LTE network, hybrid/managed wireless LTE network, "private like" wireless LTE network, and WiFi-6/LoRa wireless network options. Each scenario uses a consistent set of details:

- The network for the first three scenarios will be based on LTE (4G or 5G) technology.
- The farm/ranch is 1,000 contiguous acres that are rectangular, almost square-like, in shape.
- The farm/ranch headquarters is connected to a low latency (>15 milliseconds) 1 Gbps fiber broadband connection. Eventually, latency requirements will need to be lower as PA technology evolves with real-time applications.

Scenario 1

Pure Private LTE Network

A pure private network in many ways will look like a smaller version of a fixed or mobile network. For the first example, this network will have five radiators (receivers/transmitters on a "tower"), and power will be required at each location. A full suite of PA devices will require two spectrum bands consisting of approximately 100 MHz of high band and about 50 MHz of low band. The high band spectrum (up to 10 GHz frequency) will allow for point-to-point communication between all the radiators, and the lower band (1-2 GHz frequency) will be used for data transmission to and from the PA devices.

Two of the challenges arising from licensed spectrum are that generally the cost of spectrum is high and the geography of a spectrum license—whether it be a PEA or county boundary—does not match the footprint of a farm/ranch. Therefore, the 2021 Task Force recommendation to have spectrum carve-outs, specifically for PA, is very applicable to deploying a PWN. Another important 2021 Our recommendation is to have a requirement for PA device standards and network standards. Without required standards, real-time PA implementation will be limited.

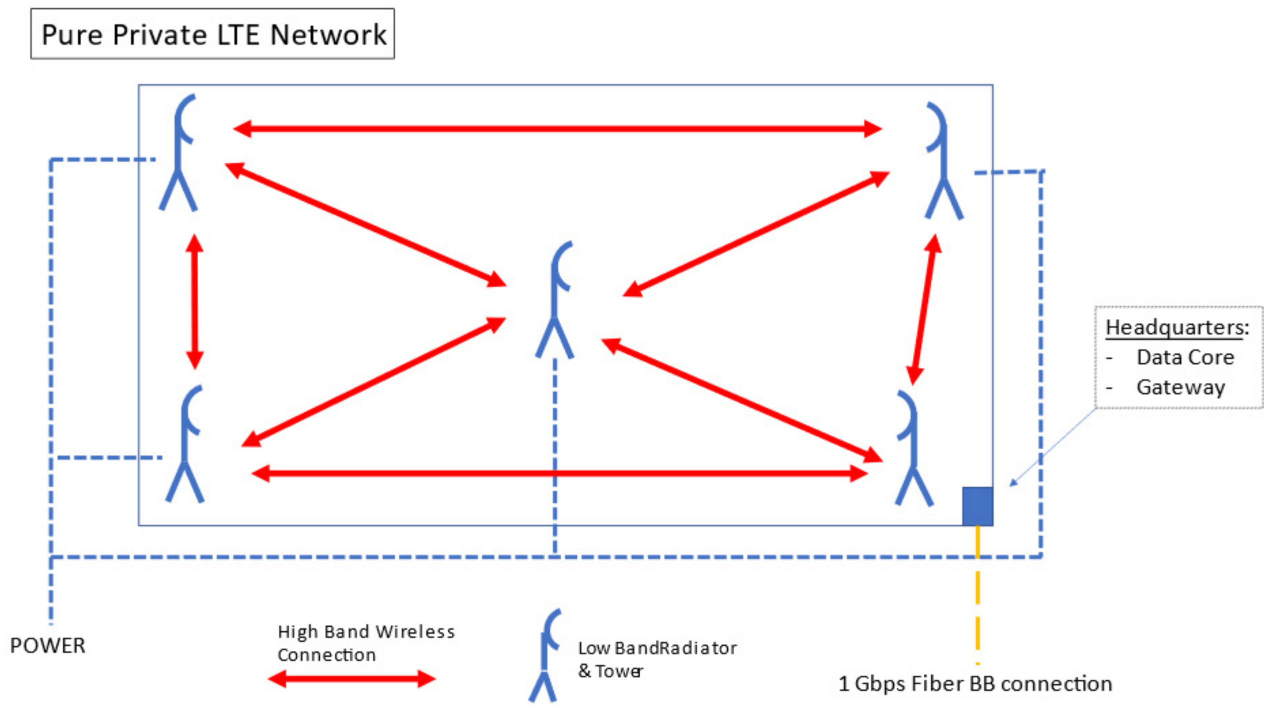
Infrastructure at the farm/ranch headquarters will require a data core to facilitate and aggregate the LTE data and provide ubiquitous band support and security. Additionally, the headquarters requires a gateway that connects the farm/ranch network to the Internet cloud via the local ISP. To design, implement, operate, and maintain the private network, the following individuals will be needed:

- An RF Engineer to design and deploy the private network.
- A core engineer to manage the core and the gateway.
- A technician to work on the towers and related equipment.

The approximate costs associated with designing, building, operating, and maintaining this type of network are the following:

- Staffing = $200-250,000 + benefits.
- Equipment = $300,000.
- Spectrum = Spectrum for this purpose in an isolated footprint is not currently available.
- Deployment Costs = $100,000.

Ongoing operational costs will generally include an annual fee of approximately 12% of the initial hardware costs in addition to the wages for the technician and engineer.



Scenario 2

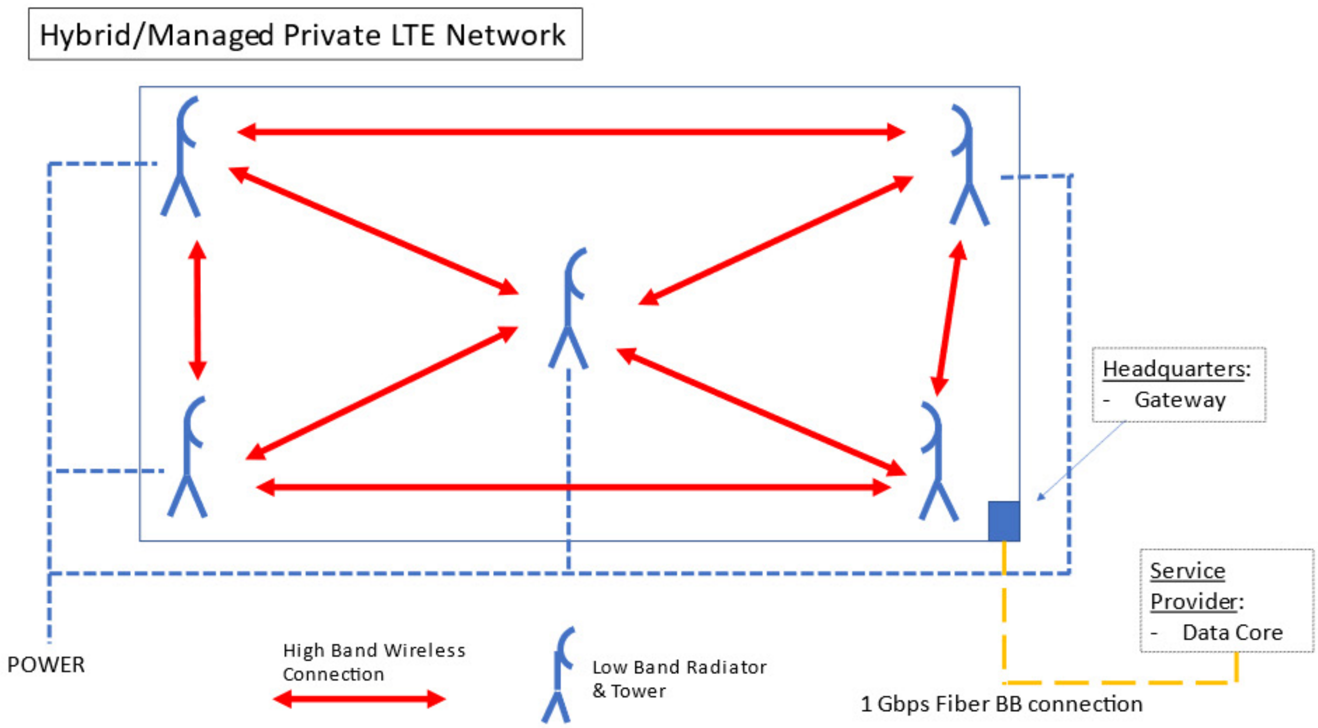
Hybrid/Managed Private Network

A Hybrid, or Managed, Private Network combines a private network and a wireless service provider's public network. In this example, the farm/ranch cannot manage the data core and decides to work with a local wireless service provider to manage the network. The farm headquarters will still need a server/gateway and connectivity to be established directly with the wireless service provider. Standards for PA are necessary for the devices and the network. This deployment will need to have the five radiators/towers with power to each one. Staffing requirements change due to the outsourced arrangement with the wireless service provider.

The RF Engineering and Core Engineer functions are now handled by the wireless service provider and become an outsourced operational cost. However, the onsite technician will still be recommended for maintaining the network. The cost of this type of deployment looks different from the pure private network:

- Staffing = $80,000 + benefits.
- Equipment = $200,000.
- Spectrum = Spectrum for this purpose in an isolated footprint is not currently available.
- Deployment Costs = $100,000.

Additionally, ongoing operational costs with the service provider will average approximately $1,200 per week for ongoing operations specific to this network, plus approximately $10,000 per month for management of the core and ongoing staff technician costs.



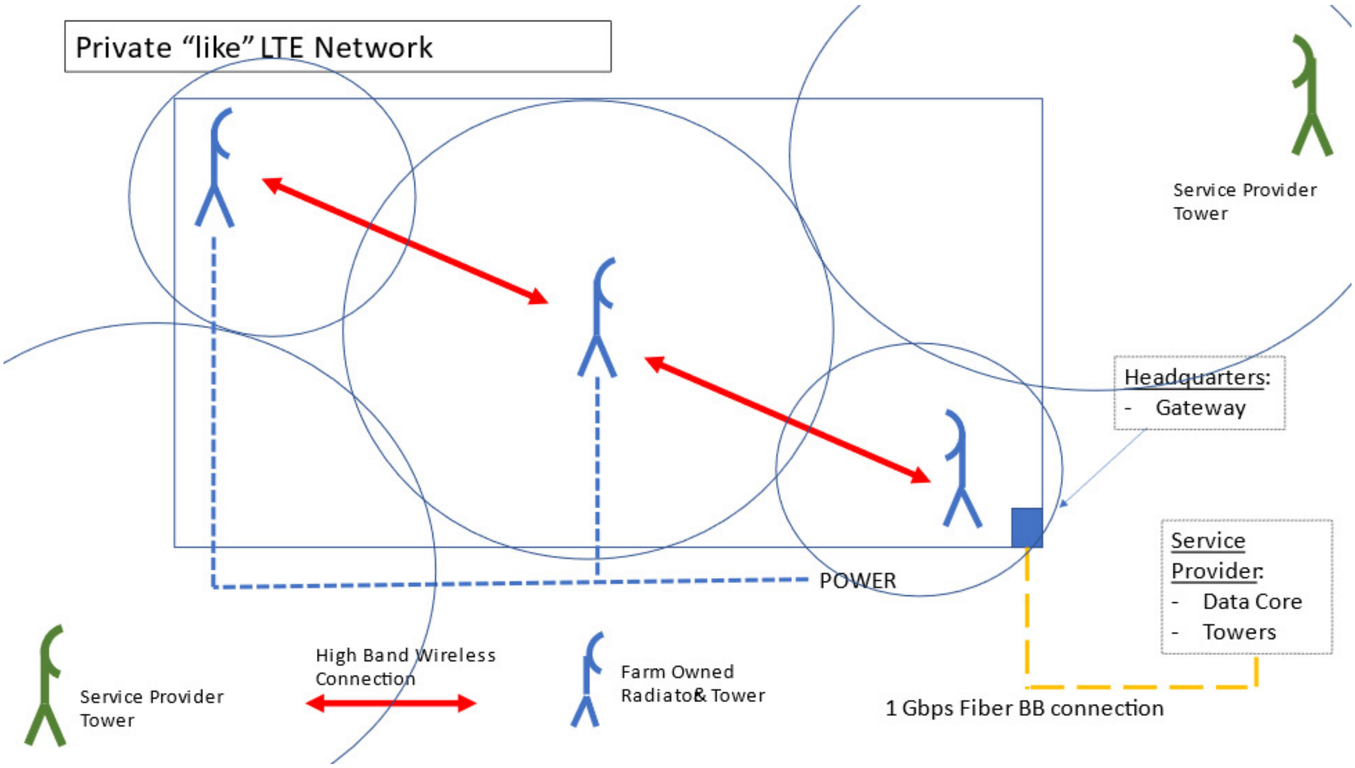
Scenario 3

"Private-like" Network

A "Private-like" Network is an option if a local service provider with strong wireless service at the edge of the farm/ranch is available. In this type of network deployment, the farm/ranch deploys less infrastructure and makes greater use of the service provider's network. In this scenario, if the farm/ranch cannot acquire spectrum, the wireless service provider may allow the farm/ranch to use licensed spectrum that they own. The data core is managed by the service provider—some of the radiators have been transitioned to the service provider's tower and network. The service provider's towers would need fiber backhaul to mitigate negative effects of latency. The farm/ranch may need a radiator near the center of the farm/ranch where the service provider's signal does not reach; or as shown in this example, three small cells fill in the coverage gaps. The headquarters still need a gateway, provided by the service provider, to facilitate the transfer of data into the network from the service provider and back out to the internet cloud. Technician staff is no longer necessary since the farm/ranch is outsourcing these tasks to the service provider. The cost of this type of deployment looks different from the other networks:

- Staffing = $0.
- Equipment = $75,000.
- Spectrum = Spectrum for this purpose in an isolated footprint is not currently available.
- Deployment Costs = $10,000.

Ongoing operational costs with the service provider will average approximately $25,000 per month for ongoing operations of the core, gateway, technical expertise and person-hours, and engineering design, as well as ongoing maintenance and upgrades, device sourcing, authentication, and security.



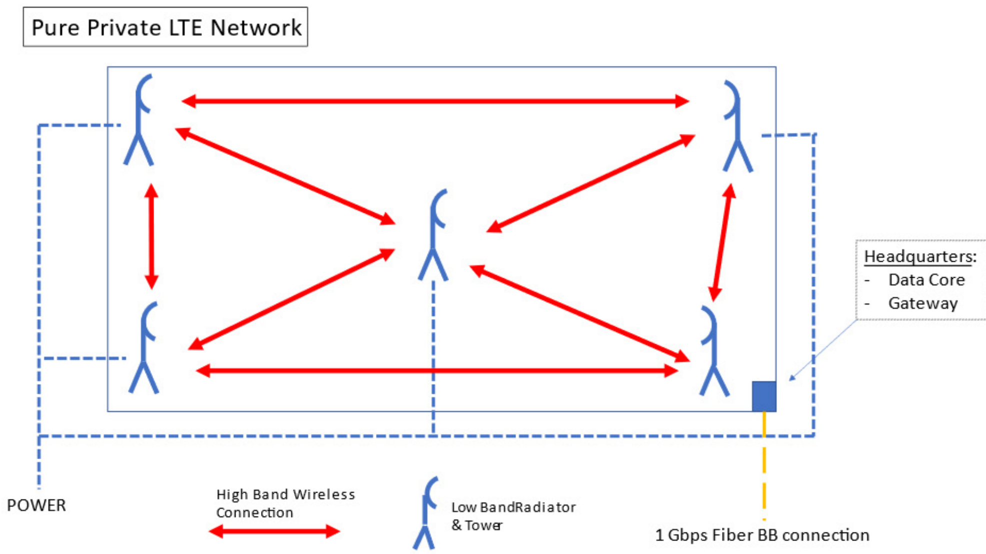
Scenario 4

Wi-Fi-6/LoRa Network

The Wi-Fi-6/LoRa “network” is something at the low end of the technical and secure range, but it is workable. In this scenario, this network is a hybrid Wi-Fi and LoRa network, which is based on a 1,000-acre farm with a low latency 1 Gbps fiber connection. For this kind of deployment, we do not consider the use of licensed spectrum; therefore, the need to be in an isolated rural area helps to mitigate the potential for spectrum noise, which could keep it from working optimally. Using 2.4 GHz spectrum, place radios around the property to allow for coverage across the farm/ranch. Eventually, 6 GHz could be added when dual-mode capability becomes available. High band spectrum can allow for communication between these radios. Power will be needed for these radios. Interconnect these radios with 5.8 GHz spectrum. Place LoRa repeaters for filling gaps and reaching subsoil sensors. These can be battery, solar, or wind-powered. The headquarters will need a LoRa gateway and a data aggregator for the 2.4 GHz network. There will need to be a device that aggregates the data from each of these to compile and synchronize the data received; however, PA standardization is still required. To make this work, you would need one technician, either on staff or outsourced, to manage the network and devices. The cost of this type of network is low, but this is a Do-It-Yourself option using equipment currently available. Costs include the following:

- Technician = $80,000 (on-staff or outsourced).
- Equipment = $40,000.

Deployment would be done primarily by the technician, but there will be a cost to extend power to the remote radios. Spectrum used for this example is unlicensed. If the farm/ranch is located near any significant population, it most likely will not work due to RF noise.



Summary

The above examples demonstrate how a last-acre private wireless network may be achieved. However, there are challenges for each of these examples, primarily with costs and spectrum. The average lifespan for the equipment in most of these examples is limited to no more than ten years. Still storms and other weather challenges will likely reduce this timeline for many of the outdoor devices. Some of these options could be scaled, and costs could be shared through some type of cooperative effort. However, this would lead to more complex and costly network deployments. The low-latency fiber connection to the headquarters is recommended because any real-time PA activities will require extremely low latency, and when incorporating high data packages, a higher-speed connection is preferable.

Appendix D: Connectivity & Technology Needs

Appendix D1: FCC Charge to Working Group

The working group has been tasked with the following charges:

- Develop policy recommendations to promote the rapid, expanded deployment of broadband Internet access service on unserved agricultural lands, with a goal of achieving reliable capabilities on 95 percent of agricultural lands in the US by 2025.
- Recommend specific new rules or amendments to existing rules of the Commission that the Commission should issue to achieve the goals and purposes of the policy recommendations described in the bullet above.
- Recommend specific steps that the Commission should consider ensuring that the expertise of the Secretary and available farm data are reflected in future programs of the Commission dedicated to the infrastructure deployment of broadband Internet access service and to direct available funding to unserved agricultural lands where needed.

Appendix D2: Encouraging Adoption of Precision Agriculture and Availability of High-Quality Jobs on Connected Farms

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Appendix D3: References

Thompson, N.M., M.N. Hughes, E.K.M. Nuworsu, C.J. Reeling, S.D. Armstrong, J.R. Mintert, M.R. Langemeieir, N.D. Delay, and K.A. Foster (2021). Opportunities and challenges associated with "carbon farming" for U.S. row-crop producers. Purdue Center for Commercial Agriculture: https://ag.purdue.edu/commercialag/home/resource/2021/06/opportunities-and-challenges-associated-with-carbon-farming-for-u-s-row-crop-producers/

Indiana State Climate Office (2019): https://ag.purdue.edu/indiana-state-climate/research/farming- for-a-better-climate/

Kowalowski, M. (2022). Four rights of data science: https://www.linkedin.com/posts/outcastdatascientist_datascience-programming-technology-activity-6989570161129226241-5t4d/?utm_source=share&utm_medium=member_android

Carbon and Data Guidebook (2022). Illinois Soybean Association: https://www.ilsoyadvisor.com/carbon-data-guidebook/

EPA (2022). Sources of Greenhouse Gas Emissions: https://www.epa.gov/ghgemissions/sources-greenhouse-gas-emissions

Wilder, C. and N. Lederer (2021). Healthy Soils and the Climate Connection. E2 (Environmental Entrepreneurs): https://e2.org/reports/healthy-soils-climate-connection-2021/

AEM (2021). Environmental benefits of precision agriculture in the United States: https://newsroom.aem.org/download/977839/environmentalbenefitsofprecisionagriculture-2.pdf

AEM (2022). Future of Food Production: https://www.aem.org/future-of-food-production

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