

# THE FUTURE OF AMERICAN FARMING



## BROADBAND SOLUTIONS FOR THE FARM OFFICE, FIELD, AND COMMUNITY

By Jordan Arnold

Published by the Benton Institute for Broadband & Society

# The Future of American Farming: Broadband Solutions for the Farm Office, Field, and Community

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Broadband Delivers Opportunities  
and Strengthens Communities

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# Executive Summary

Today, broadband is a necessary tool to innovate farming practices, allowing for more targeted and efficient resource use. Farmers need connectivity in the farmhouse and farm office, in the field, and in the community to enable sustainable, data-driven agriculture and meet the world's rising demand for food. How can we deliver the broadband that farmers need?

## The Farm Office

The farm operations center, often an office within the farmhouse itself, is used for administrative tasks, as well as making production and input decisions. Many farm office tasks, such as uploading raw sensor data and participating in remote training sessions, require significant upload speeds. Farmers can benefit from build-out of high-performance fiber-based networks deep into rural America. How do we ensure that farmers get reliable, symmetrical broadband service?

- **Establish future-proof performance standards:** To meet the growing demand among farmers for both upstream and downstream speeds, networks must be capable of 100/100 Mbps service.
- **Clarify rules around easements and rights of way:** State governments can address legal uncertainty around easements and rights of way, which can slow deployment and increase costs, particularly for electric cooperatives.
- **Incentivize build-out to the operations center:** Broadband funding programs can reward applicants that deploy broadband to the operations center of the farm and other critical farm buildings.
- **Support open-access, middle-mile networks:** Middle-mile deployment can pack a powerful punch by bringing scalable, fiber-based connections deep into rural communities while also lowering the cost of last-mile deployment for private providers.

## The Field

In the field, farmers rely on wireless connectivity—such as cellular, satellite, and fixed wireless—to make real-time strategic and logistical decisions about their land, crops, animals, equipment, and farm facilities. Experts agree that farmers may require multiple, complementary technologies to meet their connectivity needs in the field. How can we address the special connectivity demands of farms?

- **Adopt high-performance standards:** Performance standards for upload speeds and latency should reflect the changing needs of farmers for precision agriculture.
- **Encourage deep fiber build-out:** Fiber build-out in rural America, even if not directly to the farm, will be needed to support capable wireless connections for higher-bandwidth applications in the field.

- **Address gaps in mapping on farmland:** Broadband maps should include mobile coverage on agricultural lands. The underlying data that informs these maps must be available to the public.
- **Advocate for interoperability and privacy standards:** Without better coordination about interoperability and privacy standards, farmers may be less willing to adopt precision agriculture technologies.
- **Adjust spectrum award mechanisms to reward farmland coverage:** Spectrum auctions can adopt geographic coverage requirements in some rural agricultural areas to encourage deployment on farmland.

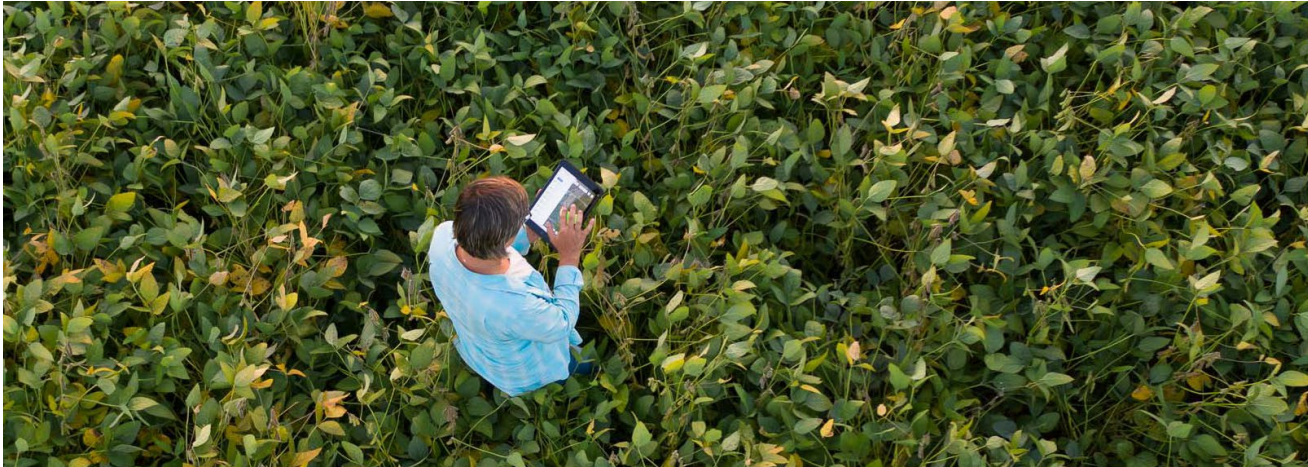
## The Community

Farms depend on rural communities, and rural communities depend on farms. Broadband can enable new opportunities in agricultural communities, such as remote education, telework, and telehealth. Rural communities can work with local organizations, including nonprofits, cooperatives, and community-oriented private providers, to find solutions that meet their access and adoption needs. How do we connect the communities that farms rely upon?

- **Adopt comprehensive state broadband plans:** State plans that encompass all aspects of a broadband strategy—including deployment, competition, and digital equity—are best suited to meeting states’ regional economic development and other goals.
- **Support digital equity programs at the state and local levels:** Digital equity programs led by state and local governments and backed by federal funding can work with communities to help people make full use of broadband connections.
- **Encourage local planning and capacity building:** Federal and state funding can encourage local planning and capacity building, which may include developing local or regional broadband strategies and applying for federal broadband grants.
- **Implement accountability measures:** Federal funding programs for broadband deployment that include strong accountability measures ensure that providers hit their deployment goals.
- **Encourage local, community-oriented providers:** Federal programs that support broadband can encourage entry from more broadband providers, including cooperative and community-based solutions.
- **Facilitate federal, tribal, state, and local coordination:** All levels of government should work together as partners to create opportunities for collaboration.
- **Coordinate efforts of federal agencies:** A coordinated effort between federal agencies will allow those agencies to synergize their respective expertise and meet the distinct needs of farmers.

Meeting tomorrow’s challenges means finally acknowledging that high-performance broadband is a must-have technology for modern agriculture. It’s time to deploy the broadband networks and adoption strategies farmers require to continue to innovate and feed the world.

# Introduction



Innovation has long been a hallmark of American agriculture. In the past 90 years, new inventions and practices have allowed yield to increase by 400 percent while inputs have stayed relatively flat.<sup>1</sup> From mechanical innovations like the steel plow and robotic milking machines to biological innovations like the creation of hybrid seed, American farmers have continuously adapted their operations to meet new demand and stay competitive in an increasingly globalized economy.

Now broadband is a necessary tool to innovate farming practices, allowing for more targeted and efficient resource use. But evidence shows that a majority of American farmers lack the connectivity required for sustainable, data-driven agricultural practices.

The United Soybean Board is a checkoff organization, funded entirely by soybean farmers themselves, for research, education, and promotion, with the aim of increasing sustainability for all U.S. soy farmers.<sup>2</sup> In 2019, the United Soybean Board interviewed thousands of farm operators across a wide range of

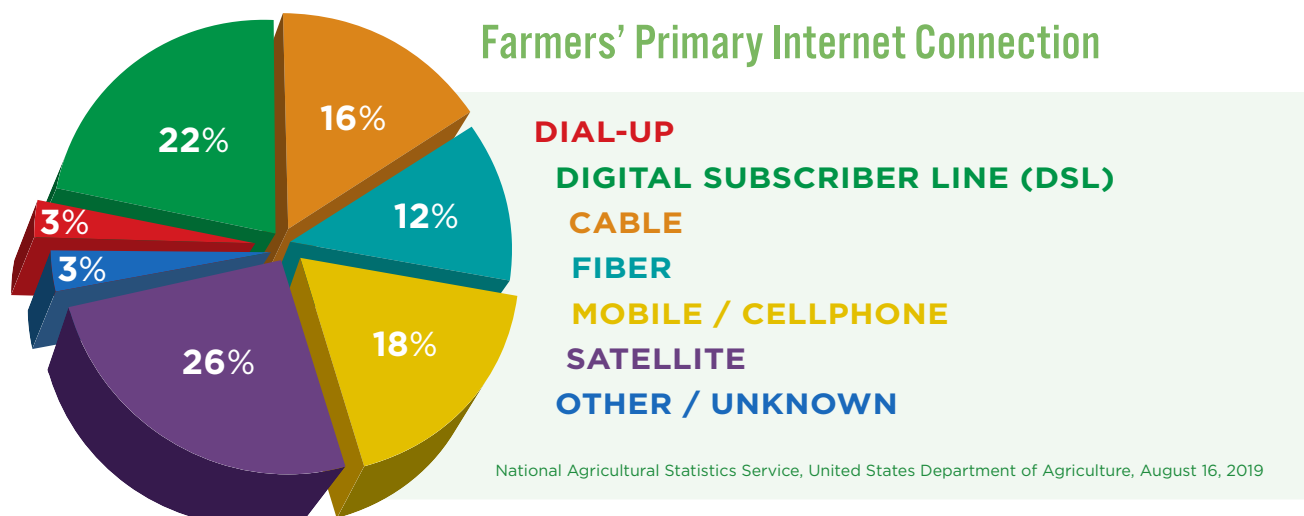
**Nearly 60 percent of U.S. farmers and ranchers do not believe they have adequate internet connectivity to run their businesses.**

agricultural sectors for its study [Rural Broadband and the American Farmer: Connectivity Challenges Limit Agriculture's Economic Impact and Sustainability](#), finding that nearly 60 percent of U.S. farmers and ranchers do not believe they have adequate internet connectivity to run their businesses.<sup>3</sup>

Most farmers (87 percent) plan on or are considering incorporating more data into day-to-day decisions, supporting their economic and environmental sustainability. However, they face internet-related barriers, including slow internet speeds (21 percent), high costs (20 percent), and unreliable service (16 percent). Nearly one third said internet connectivity has impacted purchase decisions to upgrade farm equipment in the past 18 months.

Biennial United States Department of Agriculture (USDA) studies on internet access and use among farmers show that many farmers are stuck using subpar connections, which limit their ability to conduct business online.<sup>4</sup> Data from 2019 shows that 16 percent of farms are using cable-based internet and another 12 percent have fiber. Twenty-six percent of farms use satellite as their primary

internet connection, and 22 percent of farms use a Digital Subscriber Line, or DSL, an increasingly antiquated internet service offered over old telephone networks. Another 3 percent are still using dial-up. Eighteen percent are stuck using their cellphones, whose service plans are often constrained by data caps or limits; overages can add hundreds if not thousands of dollars to monthly bills.



Slow, expensive connections are not good enough for modern e-commerce—only 29 percent of farms purchase agricultural inputs (such as seed, fertilizer, machinery, or replacement parts) over the internet, only 21 percent have online marketing, and only 47 percent of farms end up conducting any other business online.<sup>5</sup>

Broadband access poses a challenge for farmers across demographic groups, though minority-operated farms face lower rates of connectivity. Only 82 percent of farms have internet service in any form.<sup>6</sup> On average, 70 percent of Hispanic-operated farms,<sup>7</sup> 66 percent of American Indian– or Alaska Native–owned farms,<sup>8</sup> and 62 percent of Black-owned farms have internet access.<sup>9</sup>

While access is one problem, market competition is another. Despite widespread dissatisfaction with the speed, cost, or reliability of their current service, 78 percent of farmers do not have another viable option to change service providers.<sup>10</sup> Of those rural households that can connect, at least 38 percent of them face a monopoly at the basic broadband speed, which the Federal Communications Commission (FCC) currently defines as 25 megabits per second (Mbps) download and 3 Mbps upload, or 25/3 Mbps.<sup>11</sup> That definition, adopted in 2015, is no longer adequate to meet the needs of many Americans, especially those who are operating businesses.<sup>12</sup> At higher speeds, however, competition is even more scarce: 35 percent of Americans face a monopoly at 100/10 Mbps.<sup>13</sup> When consumers have only one or two options for broadband, they are threatened with artificially high prices, lower-quality service, and little innovation.<sup>14</sup>

## Defining sustainability in agriculture

To many farmers, the definition of sustainability incorporates the economic, environmental, and social impacts of agriculture—a “triple bottom line.” Farmers think about the profitability of their operations, not just to sustain the farm from year to year but from generation to generation. Practices that make a small difference in profit margin can have a major impact over the long term. Farmers also consider

how to maintain and improve the environmental conditions of their land, such as soil health, long into the future. And finally, the practices of farmers can affect the entire surrounding community, from the employees who work for the farm to the neighbors who live down the road.

These pillars are all interdependent. Americans are increasingly concerned about the environmental impact of what they buy: nearly 8 in 10 say that sustainability is important to them, and nearly 60 percent of consumers are willing to change their shopping habits to reduce environmental impact.<sup>15</sup> As environmentally conscious consumers demand more, farmer decisions must be both financially and environmentally sustainable.

Broadband access is central to sustainability because connected technologies allow farmers to measure their inputs and outputs, creating opportunities for smarter, more efficient resource management. The adoption of precision agriculture technology has powerful benefits, both for farmers' profitability and for their environmental impact.<sup>16</sup> Precision agriculture, for example, optimizes fertilizer application through reduced overlap and variable rate of inputs. Precision agriculture has improved fertilizer placement efficiency by

**Broadband access is central to sustainability because connected technologies allow farmers to measure their inputs and outputs, creating opportunities for smarter, more sustainable resource management.**

an estimated 7 percent and has the potential to further improve an additional 14 percent<sup>17</sup> with more widespread adoption. This not only saves the farmer money on fertilizer; it also improves water and soil quality and reduces greenhouse gas emissions. Similar benefits accrue in terms of herbicide, fossil fuel, and water use.<sup>18</sup>

What kinds of connectivity do farmers need in the farmhouse or farm office, in the field, and in the community to enable sustainable, data-driven agriculture? This report answers that question in three sections. The first explores the connection needs of the farm operation center, often (but not always) an office within the farmhouse itself. The second examines current and future applications of connected technologies in the field and what kinds of wireless connectivity can support those various applications. The third examines the interdependent relationship between

farmers and their rural communities and examines how increased connectivity can promote the health and well-being of this critical ecosystem. Each section includes actionable recommendations that directly address the connectivity needs of farmers and rural communities. In each section, sidebars offer examples of successful public and private efforts to connect farmers and empower them with the skills they need to employ connected technologies in their work.

In addition to an extensive literature review, we draw on nearly 20 individual interviews, as well as a convening of 24 experts and practitioners in May 2021 for a facilitated discussion of the connectivity needs of farmers and rural communities. Participants included farmers, rural educators, agriculture experts, equipment manufacturers, broadband providers, and experts in public policy at the local, state, federal, and tribal levels.

We build here on the United Soybean Board's rural broadband study to move from the identification of problems to the creation and promotion of practical solutions that boost broadband to farms, fields, and farming communities. This is especially important as we emerge from health and economic crises that have gripped America and deeply impacted American agriculture for over a year. This is the moment when every tool must be made available to farmers. Keeping the land healthy for future generations of farmers and leveraging the latest technological advancements and innovations in agriculture will depend on the deployment of broadband deep into rural America.



# The Farm Office

“Why are you all talking about farmers like we’re a different, special kind of business?” asked Hollee McCormick, CEO of Allamakee-Clayton Electric Cooperative. “We’re just like the bankers, we’re just like the educators, we’re just like every other business out there. We need [broadband] as badly as everybody else.”<sup>19</sup> Like all businesses, farms increasingly use the internet to optimize day-to-day activities.

The farm office, usually located in the home or another farm building, is the operation center of the farm. In one way, this makes the challenge of connecting farms unique: For many farmers, the need for connectivity is inherently both residential and commercial.

**Farmer’s need for connectivity is inherently both residential and commercial.**

The office space is used for administrative tasks such as payroll, banking, recordkeeping, and USDA and state-level reporting, as well as making production and input decisions.<sup>20</sup> Farmers can, for example, use the internet to coordinate sales among multiple small producers and connect directly with buyers, earning on average \$0.35 to \$0.51 cents more per bushel of corn, wheat, rice, or soy.<sup>21</sup>

Many of the tasks completed in the farm office, such as uploading raw sensor data and participating in remote training sessions, require significant upload speeds—much more than the average residential consumer requires. By nature, precision agriculture produces large amounts of data, including shape files and drone or satellite imagery.

**The bandwidth required to support precision agriculture technology has increased exponentially, and that growth will continue. Networks built with the needs of tomorrow in mind are a better investment in the long run because scalable networks can be upgraded with relative ease.**

Many farmers and precision agriculture experts have emphasized the need for symmetric or nearly symmetric connections to farm offices because farmers often need to upload data at the same speeds or even faster than they need to download data.

Dennis Buckmaster, a professor in agricultural and biological engineering at Purdue University, says that “we shouldn’t be talking about anything less than 25/25, and really 100/100. We need to send up data as fast or faster than we get it down.”<sup>22</sup>

In addition to fast, symmetrical speeds, farmers need reliable networks to connect their homes and offices—if service is unreliable, farmers will not make use of it. They depend on networks to aid decision-making around valuable resources, such as pesticides and fuel, and unreliable networks add another layer of uncertainty to an industry already saddled with risk. Meagan Kaiser, a soy farmer from Missouri, described how her slow, unreliable upload speeds deter farmers from

## Fixed-wireless provider Wisper Internet cooperates with farmers

For farms without access to fiber, fixed-wireless providers have helped bridge the digital divide. Wisper Internet provides connectivity to nearly 20,000 customers across rural Arkansas, Illinois, Indiana, Kansas, Missouri, and Oklahoma using hundreds of wireless towers to offer fixed-wireless service. In 2018, Wisper won \$220 million through the Connect America Fund Phase II auction, distributed to the provider over a period of 10 years. The award has allowed Wisper to continue building out its coverage in new regions, often rural communities where residents have no other options for broadband.

Fixed-wireless technology works by placing wireless equipment on existing structures, like water or cell towers. Providers place towers about three to five miles apart, and customers must have a “line of sight” to the tower for service to be effective. Wisper works with farmers to place wireless towers on farm structures like grain elevators and grain dryers, then offers service to the farm for a discounted price. That cooperation benefits both the farmer, who receives discounted service, and the farmer’s neighbors, who gain a closer line of sight to the wireless infrastructure.



using technology that could improve their business. “There are so many times where I’ve just waited for it to run at the cloud all day, and I come back tomorrow, and nothing actually happened—or sometimes it does magically appear—so it’s the uncertainty and the waiting. I think I’ve been more patient than most of my colleagues in trying to make it work; many just can’t give that time allowance, and there’s not a chance they would use it.”<sup>23</sup>

The farm office may not be the only structure on the farm that requires a broadband connection. Other structures—such as grain silos, hog barns, even compost drums—may require connectivity, and connecting structures can improve the quality of life for farmers, too. Many ranchers have installed video monitoring technology in their calving enclosures, allowing them to check on the herd remotely and avoid trips to the enclosure in harsh, cold winters. Suzanne Vold, a dairy farmer from Minnesota, uses a compost drum to recycle manure from her cows. Each day, she reuses the fibrous

part of the manure as fresh bedding for the cow stalls. Twice a year, she applies the liquid part of the manure, which contains most of the nutrients, to her fields at agronomic rates determined by a soil consultant.<sup>24</sup> The compost drum, which is located on the other side of the barn from Vold’s farm office, requires a Wi-Fi connection to work. Although Vold has an adequate connection to her office, she had to run an ethernet cable from the office to the drum through the barn attic.<sup>25</sup> Not all farmers may be as willing or able as Vold to explore technical solutions.

**In sparsely populated rural areas, where building networks requires significant public investment, scalability is particularly important.**

Networks need to be scalable to continue to meet future needs as new applications for precision agriculture develop. The bandwidth required to support precision agriculture technology has increased exponentially, and that growth will continue. Networks built with the needs of tomorrow in mind are a better investment in the long run because scalable networks can be upgraded with relative ease. After all, the cost of additional capacity measured by additional fiber strands is de minimis.<sup>26</sup>

The real costs are digging the trench, navigating the permitting process, dealing with regulatory uncertainty, and acquiring easements. Thus, in sparsely populated rural areas, where building networks requires significant public investment, scalability is particularly important.

Fiber-based broadband technology is best suited to meet the increasing demands of farmers. Fiber-optic networks offer reliable, high-capacity, symmetric service and can easily scale to meet future needs. In places where fiber will not be available for many years, other technologies, like fixed wireless, could be used in the interim to meet current connectivity needs—but these interim solutions are unlikely to continue to meet the ever-increasing bandwidth requirements of new precision agriculture applications. Further, “wireless service requires wires”—meaning that expanding fiber-optic infrastructure deeper into rural America will strengthen backhaul capabilities and enable next-generation networks for agricultural purposes.<sup>27</sup>

## What is an open-access, middle-mile network?

“Open-access” means the network permits any broadband provider to connect to the network on nondiscriminatory terms and conditions. “Middle-mile” networks reach from national and major regional internet backbones to a local connection site (which could be a school or library but which could not be, by definition, a residence). Thus, middle-mile networks transmit data to and from an internet backbone to a connection point in a community where, in turn, traffic is handed off to the “last mile” network that connects to, say, a home or a farm office.

The fundamental economic principle is simple: Open-access, middle-mile networks can provide the savings that spur last-mile providers to build further and faster to reach homes and farms. In his way, an open-access, middle-mile model promotes private investment and competition in last-mile service by reducing capital expenditures required to build last-mile connections.

One strategy to reduce the cost of “last-mile” deployment to farms is the construction of open-access, middle-mile networks. In rural areas, open-access, middle-mile networks can bring fiber deeper into a community that might otherwise not have any access to fiber. Once an open-access fiber connection to a community exists, other providers, such as local electrical cooperatives or fixed wireless providers, can bring service to a farm at a lower cost. For example, in Illinois, the Illinois Century Network, an open-access, middle-mile network originally built to connect schools and libraries, enabled more than 40 last-mile service providers to connect homes, businesses, and farms throughout the state.<sup>28</sup>

Bringing fiber to farms will require nontraditional and community-oriented providers. Cooperatives, in particular, have been critical actors in bringing fiber to farms and homes in rural areas. Telephone and electric cooperatives provide 30 percent of the fiber service available today in rural America.<sup>29</sup> More than 350 cooperatives offer internet service to their customers, and more than 210 cooperatives offer gigabit service to residents or businesses. NTCA—The Rural Broadband Association—which represents more than 850 small, community-based telecommunications companies (including cooperatives)—finds that nearly 98 percent of members offer fiber-to-the-home for some portion of their service area.<sup>30</sup> Nearly all members offer service to farms or ranches, and the average download speed purchased is 72 Mbps.

**Telephone and electric cooperatives provide 30 percent of the fiber service available today in rural America.**



When farmers have the broadband connections they need in farm buildings, they can become more efficient and adopt more sustainable practices. Soy farmer Meagan Kaiser is also a founder of Perry Agricultural Lab Farm Management, a precision agriculture company that utilizes on-farm data paired with geo-spatially mapped soil and plant tissue test results to help farmers make data-driven management decisions. Kaiser remembers when she made the switch from a satellite connection to a wired broadband connection at the lab office. With the satellite connection, a cloudy day might prevent her from uploading a soil report to send to a client. A wired connection was much more reliable and much faster. Projects that previously took three days only took one. That efficiency is crucial for busy farmers. Kaiser explains that if data generated by digital technology takes “all day to upload, most farmers just wouldn’t use it.”<sup>31</sup>



## Illinois Electric Cooperative brings fiber to the farm

Christopher Ali, an associate professor at the University of Virginia, calls cooperatives “the unsung heroes of rural broadband.” They are uniquely situated to deploy broadband in rural America because they are inherently local and often have fiber-based electric grid infrastructure already in place.

Community ties motivated the Illinois Electric Cooperative (IEC) to offer and upgrade its internet service for the past 25 years. Shawn Rennecker, economic development director for the cooperative, notes that IEC was well placed to offer internet service to its members: “Nobody else was going to do it. We’ve been there for many years, and we’re not going anywhere.” As early as the mid-’90s, the cooperative began offering dial-up service to its members. In the years since, the cooperative has progressed through several generations of fixed wireless, seeking creative solutions to build or rent equipment as necessary to cover its six-county territory.

Federal and state funding has allowed the cooperative to deploy fiber in some places. In 2013, the Illinois Century Network, an **open-access, middle-mile network** that runs through every county in Illinois, opened to commercial, last-mile providers. The Illinois Electric Cooperative partnered with the Illinois Century Network to connect a local school and undertake a pilot fiber-to-the-home project in Winchester, Illinois. The success of that pilot project led the cooperative to build another fiber-to-the-home network down the road in Bluffs, Illinois.

A recent award from the Connect Illinois project will allow the Illinois Electric Cooperative to deploy a symmetrical gigabit connection to more than 700 households and 95 unserved businesses, farms, and

## Recommendations

- **Establish performance standards that meet growing demand:** Farmers, like most business owners, need broadband networks that offer symmetrical, robust upload and download speeds and ample monthly usage capacity. Current standards emphasize download, but on farms, upload is crucial for data-driven decision-making. Networks built with public dollars should be scalable and easily upgraded once installed, so that they do not quickly become obsolete as the demand for capacity increases. To meet the growing demand for both upstream and downstream speeds among farmers, networks must be capable of 100/100 Mbps service.
- **Clarify rules around easements and rights of way:** In many instances, fiber networks can be built alongside existing electric infrastructure, but legal uncertainty about whether electrical easements can be used for telecommunications purposes has created costly delays for electric cooperatives, utilities, and other telecommunications companies. This issue can be addressed by allowing electric easements to be used for telecommunications purposes.
- **Incentivize build-out to the operations center:** Not all farm offices are located in the farmhouse. Broadband funding programs can reward applicants that deploy broadband to the operations center of the farm and other critical farm buildings to further incentivize build-out where it is needed.
- **Support open-access, middle-mile networks:** Middle-mile networks offer nondiscriminatory access to private providers, which then connect homes, farms, and other businesses. Such middle-mile deployment can pack a powerful punch by bringing scalable, fiber-based connections deep into rural communities while also lowering the cost of investment for private providers that can build from those communities to nearby farms and neighborhoods.

community anchor institutions in Calhoun County, Illinois, the third-least populated county in the state. That network will improve access to e-learning applications and rural health care resources, stimulate the local economy, and “make agricultural operations more efficient and enhance crop production through precision agriculture tools.”

Easements have presented a challenge for the cooperative, however, because existing easements were originally intended solely for electric lines. Until the state allows greater flexibility for those easements, the cooperative is taking a “cautious and careful” approach by asking individual landowners for fiber easements. The cooperative continues to explore funding that will subsidize fiber construction while it also continuously upgrades its fixed wireless infrastructure to better serve the homes, farms, and businesses in its service territory.

## The Field

Conversations about rural broadband access tend to focus on connections to homes and businesses, but precision agriculture increasingly requires reliable connectivity in the field as well as to the farm office. Farmers need both. Hollee McCormick emphasizes the importance of mobile-friendly, real-time data for her husband and his brothers, who own a farm in Iowa: “They’re not in an office, sitting on a computer all day. They have to have the information on their phones, and they have to have it now.”<sup>32</sup> Dennis Buckmaster counters the idea that decision-making work occurs only in the actual farm office: “The truck, the combine, the tractor is your office. You’ve got to be connected there.”<sup>33</sup>

In the field, farmers rely on wireless connectivity—such as cellular, satellite, and fixed wireless—to make real-time strategic and logistical decisions about their land, crops, animals, equipment, and farm facilities. Making those decisions requires answering “what if” questions, such as “If the moisture in a field is too high, and it’s late in the season, what can be planted?”<sup>34</sup> Precision agriculture can help farmers answer those questions with data drawn from sensors and on farm equipment, but that technology requires far-reaching broadband coverage to fulfill its potential.

Farmers use connected technologies in the field in all stages of agriculture management, from planning to production to market coordination. Mark Lewellen, manager of spectrum advocacy at John Deere, offers the following example of how connected equipment in the field can reduce costs and optimize the use of valuable resources.<sup>35</sup> Using wireless connections, each fall, yield monitors, mounted on combines, can measure the amount and location of material moving through the machine, which can be used to create yield maps. These yield maps are then downloaded to John Deere operations centers. In the spring, the same yield maps are uploaded to the planter, which can then use the data to optimize seed placement. That cooperation between machines can save 10 percent on seed placement costs—“and that’s just the tip of the iceberg,” Lewellen says. Farmers can now use John Deere’s See and Spray technology to disperse herbicide only when weeds are detected, reducing herbicide use by 77 percent on average.<sup>36</sup> That technology not only saves farmers money but also reduces chemical damage to the environment.

Connected sensors in the field—part of the so-called internet of things (IoT)—collect the accurate, timely data that farmers can use to optimize their practices and conserve resources. Sensors in the ground can measure the moisture of soil to improve irrigation systems and reduce water consumption. Weather sensors can predict frost and storm patterns to reduce the risk of

## SpaceX promises connectivity in rural areas with Starlink

SpaceX is currently in the process of creating a low-latency broadband network using thousands of small satellites in low Earth orbit (LEO). The project, called Starlink, gained major national attention and criticism when SpaceX won \$885 million from the Federal Communications Commission’s Rural Digital Opportunity Fund, a major reverse auction intended to subsidize broadband deployment in rural areas. Geosynchronous satellite coverage from providers like Viasat and Hughes is nearly ubiquitous in the United States, but the technology can be unreliable, expensive, and prone to high latency. Starlink, in comparison, claims that its satellite technology will be able to provide low latency and high speeds and cover wide swaths of farmland—a combination that could be transformative for many rural farmers, as well as many other residents of rural America.

Critics doubt whether the network will be able to live up to the hype. A technical analysis prepared for the Fiber Broadband Association and NTCA—The Rural Broadband Association estimated that Starlink would face a capacity shortfall by 2028 and that more than 56 percent of the subscribers that SpaceX promised to serve when applying for the FCC subsidy would not be fully served. A pilot program to evaluate the feasibility of the service for K-12 students who live in two North Carolina counties without broadband infrastructure or reliable cellular service will be one test of this emerging technology’s effectiveness in meeting rural needs.



crop loss. On dairy farms, biosensors can track ovulation cycles to boost pregnancy rates. Irrigation can also be controlled remotely, saving farmers fuel and labor to make trips to the field to manually turn systems on or off. Many sensors connect to mobile applications, allowing farmers to access the data when they need it, wherever they are, as long as they have mobile connectivity.

**High-bandwidth networks can deliver more information than a low-bandwidth network in the same amount of time. Cable and fiber networks, for example, are high bandwidth, while satellite might be considered a low bandwidth connection. LoRaWAN is a very low bandwidth network, but is useful for covering wide areas of farmland and connecting devices that transmit small amounts of data.**

Multiple technologies are able to support precision agriculture applications in the field, which currently tend to require low-speed, broad coverage, and asymmetrical connectivity.<sup>37</sup> Wi-Fi, satellite, and mobile cell connectivity can all fit that profile, especially in tandem with a high-capacity, wired connection to the farm office. As more precision agriculture applications appear for mobile phones, more farmers have turned to their cellphones: According to research from the USDA, 52 percent of farmers reported using a smartphone or a tablet to conduct farm business in 2019, compared with only 44 percent in 2017.<sup>38</sup> And other, less traditional solutions can work, as well. Microsoft has championed the use of TV white space—the unused spectrum between television channels—to provide wireless connectivity for IoT solutions in agriculture through its FarmBeats initiative.<sup>39</sup>

Experts agree that farmers may require multiple, complementary technologies to meet their needs in the field. Paula Boyd, senior director of government and regulatory affairs for Microsoft, notes that farmers will need “low-bandwidth solutions all the way up to higher-bandwidth solutions.”<sup>40</sup> Similarly, Gerard Hayes, CEO of the Wireless Research Center of North Carolina, believes that farmers need a mixture of connectivity technologies in the field that are ultimately application dependent.<sup>41</sup>

## Wabash Heartland Innovation Network's regional approach

The Wabash Heartland Innovation Network (WHIN) is an alliance of 10 counties in north-central Indiana, an initiative that aims to make the region, according to Johnny Park, CEO, into a “a living lab—a physical region where public entities, private companies, universities, and residents form a collaborative, innovative ecosystem to discover, develop, validate, and realize the benefit of new products and services in real-life contexts.” WHIN was officially launched in December 2017 with a nearly \$40 million grant from the Lilly Endowment. To transform the region into a global epicenter for digital agriculture and next-generation manufacturing, WHIN is collaborating with stakeholders including Purdue University and Ivy Tech Community College and is undertaking several projects related to agriculture internet of things adoption and broadband expansion. These include a major connectivity-gap study to determine the current level of broadband adoption and access in the region.

WHIN's Agriculture Alliance offers products and services to farmers to encourage greater adoption of IoT technologies. Alliance members get access to vetted and discounted IoT technologies, such as remote grain monitors, robotic soil sampling, and crop intelligence, from private tech partners. The 47-member Agriculture Alliance, which represents 200,000 acres of corn and soy, also operates a dense network of 180 weather stations installed on farms in the WHIN region. The network allows farmers to access hyperlocal, real-time data about weather conditions via their phones. The network can, for example, predict storm paths and rainfall based on empirical data collected from weather stations currently experiencing a storm. Semiannual summits on IoT best practices and emerging technologies allow farmers to network and learn from one another.

On the farm, wired service in the farm office supports and complements wireless service in the field. However, the difference between the needs of the farmhouse and the field is narrowing as emerging applications require increasing speeds, especially on the upload side. Heather Hampton-Knodle, a farmer in Illinois, is currently taking part in a pilot project around soil-testing technology.<sup>42</sup> Previously, a consultant would go to Hampton-Knodle's farm, pull thousands of soil samples, send the analysis back to a lab, and return the results months later. Through the pilot project, Hampton-Knodle has access to machines that allow her to gather soil data as she goes. If she had better connectivity in her fields, she could immediately upload the data for analysis. Real-time insights from the data would allow her to modify inputs, such as the fertilizer blend, as soon as the next pass.

Latency, a measure of the time it takes to send data and receive a response, is increasingly important as technologies like semi-autonomous vehicles and artificial intelligence become more widely adopted by farmers. “Autonomy” refers to the ability of a machine to operate itself without human intervention. The See and Spray technology previously

**Autonomy refers to the ability of a machine to operate itself without human intervention.**

mentioned, for instance, works by using artificial intelligence to differentiate between weeds and useful crops—a decision that must be made almost immediately as the sprayer moves quickly through the field. Although fully autonomous tractors are not widespread at the moment, they will require

low latency connectivity. Dan Leibfried, director of automation and autonomy for John Deere's Intelligent Solutions Group, predicts that autonomous vehicles in agriculture “will require a continuous heartbeat between the robot and the cloud to say, ‘I'm connected.’”<sup>43</sup>

Emerging and future applications for precision agriculture in the field, like Hampton-Knodle's soil sampling and autonomous agricultural vehicles, illustrate the tension between what farmers need now and what they will need in the future. Leibfried argues for a balancing act between meeting current needs and meeting future needs: “We need a floor of minimum reliable connectivity that can be used to get the most critical information transmitted on a real-time basis. But farmers will consume every bit you give them. The sky is the limit.”<sup>44</sup>

Could 5G be the solution for precision agriculture? Gerard Hayes is hesitant to oversell the benefits for rural America. First, 5G networks will have to be available. And then farmers will have to adopt the technology. “5G can help agriculture. It will. But how useful it will be depends on adoption. You don't want to lose sight of today for tomorrow,” Hayes says.<sup>45</sup> The FCC has earmarked \$9 billion over the next decade to 5G



through the newly established 5G Fund for Rural America, which is meant to bring 5G mobile broadband service to rural areas that would be unlikely to otherwise see deployment of these networks.

The excitement around 5G often obscures the fact that many farmers still lack 3G or 4G connections in their fields. Just how much agricultural land is covered by mobile connectivity is unclear because current FCC data, for both fixed and mobile connectivity, overcounts availability. A study in Yolo County, California, specifically sought to measure mobile coverage on farm fields.<sup>46</sup> More granular testing proved that existing data far overstated the availability of mobile service on the farms in the study, and no farm in the study was fully covered by any single mobile provider. To obtain ubiquitous coverage, then, farmers would have to pay for multiple mobile plans with different providers. Robert Tse, who developed the concept for the study, concludes that “there is no substitute for much more granular measurement of broadband signal to gain an accurate picture of farm field access.”<sup>47</sup>

In the past year, the FCC has instituted new rules for collecting data from both fixed and mobile providers to create more accurate broadband coverage maps, but new maps will not arrive until 2022 at the earliest. The goal of mapping service in the field is complicated by the variety of forms of connectivity that can be used for precision agriculture. “There’s wireless, there’s Wi-Fi, there’s satellite. There’s a variety of tech, which makes it hard to get to the heart of what’s available for a particular farm,” says Catherine Moyer, CEO of Kansas-based Pioneer Communications.<sup>48</sup>

Greater adoption of precision agriculture technologies may be hindered by a lack of interoperability—the ability of different kinds of software to speak to one another and exchange data. In agriculture, interoperability allows farmers to integrate data streams efficiently and effectively. Without it, farmers are often forced to manually enter data as a workaround, lowering productivity and increasing the risk of human error. That frustration can prevent farmers from adopting precision agriculture technologies. “People who became farmers didn’t set out to farm to manually import files, but to grow crops,” says Dennis Buckmaster.<sup>49</sup> One farmer described how she spent two hours on the phone with a farm management

software company because one of her tractors could not communicate with its software. Eventually, she had to plug a flash drive into the tractor, download the data, and then upload the information to the cloud-based software.<sup>50</sup> Suzanne Vold, the Minnesota-based dairy farmer, has a robotic milking system, which is different from the feeding system for the cows, which itself is different from the manure composting system. These machines do not talk to one another—“but wouldn’t it be great if they could?” she asks.<sup>51</sup> Greater interoperability, which we have come to expect in much of our digital lives, will help unlock the full potential of connected technologies in the field.

LoRaWAN, or Long Range Wide Area Network, is a network that covers a wide area and uses low power to wirelessly connect devices, such as soil sensors or temperature monitors, to the internet. To support IoT technologies, WHIN is working to expand broadband and LoRaWAN coverage throughout the 10-county region. During the summer of 2020, WHIN announced a partnership with Watch Communications to deploy a LoRaWAN gateway, which acts as a go-between for a sensor and the internet, in each of the 10 WHIN counties.



WHIN has also launched an aerostat—a blimp-like aircraft—in partnership with RTO Wireless to support WHIN’s research broadband network. The aerostat, tethered between 1,500 and 2,500 feet, offers better lines of sight than land-based wireless towers, supporting both LoRaWAN and broadband coverage. The partnership with RTO Wireless, as well as other private tech partners, will allow WHIN to test innovative broadband solutions and eventually publish the results of those tests.

**Greater adoption of precision agriculture technologies may be hindered by a lack of interoperability.**

Another barrier to adoption of precision agriculture is the concern over data privacy and ownership. Precision agriculture generates a wealth of complex data, which farmers share with outside companies for data analysis. It is unclear who owns the data: Is it the farm? The equipment manufacturer? The fertilizer company? Farmers may be disincentivized from using precision agriculture technologies because data privacy and ownership issues have not been clearly addressed.

## Recommendations

- **Adopt additional performance standards for precision agriculture applications:** New applications for precision agriculture increasingly require stronger upload speeds and lower latency, even in the field. Performance standards for upload speeds and latency should reflect the changing needs of farmers for precision agriculture.
- **Encourage deep fiber build-out to strengthen wireless solutions in the field:** Furthering the adoption of precision agriculture requires the deployment of high-capacity, future-proof networks deep into rural America. Fiber build-out in rural America, even if not directly to the farm, will be needed to support capable wireless connections (which might include mobile, fixed wireless, and TV white space, for instance) for higher-bandwidth applications in the field. Fiber-based, open-access, middle-mile networks, for example, may be a cost-effective solution to bring fiber closer to agricultural lands.
- **Address gaps in mapping on farmland:** As the FCC takes steps to address the shortcomings in its broadband data, it can also address mapping 3G, 4G, 5G, and other technologies on agricultural lands. Federal agencies and states can work together to share data as needed. Maps need to be made available to the public; communities and even individuals can then easily challenge inaccurate data.
- **Advocate for interoperability and privacy standards:** The lack of interoperability in precision agriculture impedes a farmer's ability to use new technologies and integrate data. The National Institute of Standards and Technology is the logical federal institution to be tasked with creating an interoperability standard; this would also support development of a single global standard. Policymakers can then work with industry to encourage the adoption of standards that allow for better interoperability. They can also explore data ownership and privacy standards to promote use of new technologies.
- **Adjust spectrum award mechanisms to reward farmland coverage:** To support deployment on farmland, spectrum auction rules should include geographic coverage requirements in some rural agricultural areas while continuing population-based requirements in urban and more densely populated areas.

# The Community

The economic health of farms and the rural communities that surround them are closely intertwined. Nearly one in five rural counties in the United States is “farming-dependent,” with agriculture constituting the leading industry in the area.<sup>52</sup> Although rural economies have greatly diversified since the 20th century, 1 in 10 jobs in rural counties is still agriculture-related.<sup>53</sup> And farmers themselves often rely on jobs off the farm to support their income. On average, small-farm operators, about 90 percent of all farmers, earn most of their household income from off-farm sources.<sup>54</sup> Even midsize-farm operators earn about a third of their income from off-farm sources.

In other words, farms depend on rural communities, and rural communities depend on farms.

Access to education, access to jobs, and access to health care are the three pillars that support rural communities, according to Joshua Seidemann, vice president of policy for NTCA—The Rural Broadband Association.

“If you are missing one of them,” he says, “the community will suffer.”<sup>55</sup> Each can be improved through affordable, reliable broadband connectivity and the digital skills to make full use of that connection.

**Access to education, access to jobs, and access to health care are the three pillars that support rural communities.**

Aligning educational opportunities with local workforce opportunities and economic development goals builds more vibrant rural communities. For example, Rainbow Communications provides fiber-

based connectivity to Highland Community College across multiple locations in northeast Kansas. These connections enable the community college to teach several career and technical education courses in precision agriculture and diesel mechanics, covering topics such as GPS, emerging precision agriculture technologies, and agricultural resource management.<sup>56</sup> Secondary and continuing education programs online may also allow the next generation of farmers to stay close to home and assist on the farm while advancing their education.

Providers themselves can play a role in building the digital skills of their customers, contributing to the local economies in which they operate. Wisper Internet announced a partnership with Microsoft’s Airband Initiative to foster digital literacy and skills among its customers.<sup>57</sup> Through the partnership, Wisper customers will be able to access skill-building programs like LinkedIn Learning and Microsoft Learn, as well as certifications in Microsoft products at reduced costs. The learning

## The power of deeply anchored community organizations for digital inclusion

When the pandemic forced community anchor institutions to close their doors to the public, the National Digital Inclusion Alliance launched a program called Digital Navigators, intended to “address the whole digital inclusion process—home connectivity, devices, and digital skills” for vulnerable members of a community. Digital Navigators are trained volunteers or staff members in community-based organizations who assist clients in using critical online services. The model is particularly helpful for organizations that are newly entering the digital inclusion space, as was the case for Rural LISC, a branch of the economic-development nonprofit Local Initiatives Support Corporation. Rural LISC has partnered with more than 140 community-based organizations to, in its words, “help rural community developers address the problems rural communities face.”

Rural LISC piloted the Digital Navigators program at nine sites in Appalachia and the Louisiana Delta, adding a “technology layer” to the services already provided by the selected community organizations. Technology support and digital inclusion efforts were a missing part of the social safety net in these communities, according to Christa Vinson, a program officer for Rural LISC, but the belief that “digital equity is all of our jobs” motivated organizations new to the digital inclusion space to step in and join the Digital Navigators model. The sites are diverse, including affordable-housing developers, health providers, financial-opportunity centers, and even a volunteer fire department, but each site possesses the trust of the local rural community.

One of the pilot partners, the Hagood Mill Foundation, runs the day-to-day operations of the Hagood

programs are aimed at a variety of digital learners, offering introductory digital literacy and internet safety lessons as well as more advanced technical training for in-demand jobs.

Broadband enables teleworking opportunities, allowing “people to live in rural areas and can encourage new residents to relocate to rural areas.”<sup>58</sup>

Those remote employees’ wages then flow back into the rural economy and contribute to the economic development of the area. Spouses of farmers who work off the farm consistently cite health care benefits as one of their primary reasons for taking off-farm employment.<sup>59</sup> If broadband could bring remote work opportunities to the farm, those “supporting spouses” could work from home and be more involved in the farm operation—yet still provide the health care benefits.

**Broadband enables teleworking opportunities, allowing people to live in rural areas and can encourage new residents to relocate to rural areas.**

Digital Works, a targeted community revitalization and job growth initiative that began in Ohio, trains participants for remote jobs and then helps participants through the application and interview process. Since the program began in 2013, Digital Works has placed more than 1,000 program participants in remote roles. The program was particularly successful in rural Gallipolis, a community of 5,000 in Ohio, where the nonprofit partnered with the local economic development office to place 180 people in remote, high-demand jobs.<sup>60</sup>

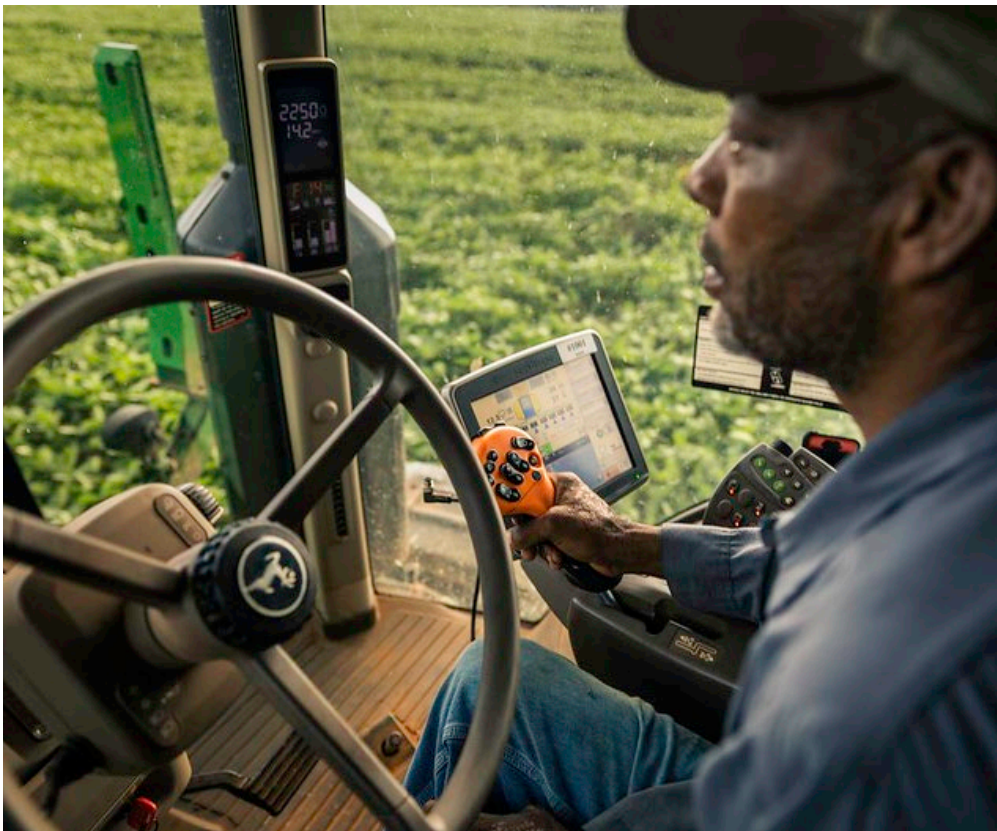
Telehealth can fill an important gap in care for rural Americans, who often lack access to specialized care. The pandemic has caused a “rapid explosion in telehealth applications in rural health care,” according to Terry Hill, founder of the National Rural Health Resource Center.<sup>61</sup> Patients can, for instance, take an EKG at home with an Apple Watch and send it to their cardiologist for review and interpretation. Routine visits can take place over a video call. For the 4.7 million veterans living in rural areas, telehealth expands the reach of Veterans Affairs hospitals, clinics, and other health care facilities.<sup>62</sup>

Mental illness is more common in rural areas than urban areas,<sup>63</sup> but rural communities tend to have fewer mental health resources, which hinders the ability of farmers and their families to receive support when they experience mental health crises.<sup>64</sup> Economic stressors, including falling commodity prices, natural disasters that harm crop yields, and increasing levels of farm debt, have led to higher rates of stress, mental illness, and suicide in farm and ranch families.<sup>65</sup> Teletherapy allows farming families and rural residents to receive support they need, even when those services are located states away.

Broadband access improves the social health of a rural community, too, particularly for the isolated and remote. Dairy farmer Suzanne Vold notes that “churches are a huge part of social interaction” in her rural community of Glenwood, Minnesota.<sup>66</sup> During the pandemic, Bible studies have gone online, and church services have been streamed on YouTube and Facebook. With slow service

Mill Historic Site, a cultural-heritage museum in Pickens County, South Carolina. The site is unusual because the museum does not have the client base of a housing developer or health provider. But because the foundation is a connected and trusted community organization, the site was able to support the technology needs of Pickens County. In addition to upgrading the public Wi-Fi on the museum site, the foundation partnered with the local school system to offer laptops and cash vouchers for internet service for low-income students. Hagood also partnered with the public library, which had not been able to offer digital literacy programming during the pandemic, and allowed the library to use a large, open-air barn on the property that would allow participants to maintain social distance.

The success of the cultural-heritage museum in the Digital Navigator program illustrates that “any deeply anchored community organization is an ally in the effort to increase productive digital participation for all.” Agricultural communities, which often boast numerous community organizations, such as 4H and Future Farmers of America clubs, cooperative extensions, and resource conservation districts, may then be particularly well suited to address digital inclusion.



## Public and private leadership working in tandem in Minnesota

One of the earliest state grant programs, Minnesota's Border-to-Border Broadband Development Grant Program, was created in 2014 to assist localities, private providers, nonprofits, and cooperatives in building out broadband infrastructure in Greater Minnesota. The program funds up to 50 percent of the cost of a last-mile or middle-mile broadband project, including planning, permitting, construction, and installation costs. Since its inception, Border-to-Border has connected more than 56,000 homes, businesses, and anchor institutions to broadband. The eventual goal of the program is universal, "border-to-border" broadband coverage across Minnesota. The state plans to achieve universal 25/3 Mbps coverage by the end of 2022 and universal 100/20 Mbps coverage by the end of 2026.

Working in tandem with state broadband efforts, the Blandin Foundation, a private foundation dedicated to building healthy, inclusive rural communities in Minnesota, has partnered with dozens of rural communities to help them get and use better broadband. Participating communities work through a proven process to define their technology goals and measure current levels of broadband access and use. They receive technical assistance and grant funding to implement projects that help close the digital divide and take advantage of the extraordinary benefits of a broadband-enabled economy.

Communities that have participated in the Blandin Broadband Communities program have earned themselves a seat at the table of broadband planning. Having done the work of assessing what they have, what they want, and what they are willing to contribute to a possible project, they have a voice in what broadband solution is "good enough" for their communities.

incapable of streaming, that avenue for social connection was largely cut off for many members of Vold's community. A farmer from northeast Kansas says that, after years of spotty and unreliable internet service, his new fiber connection "made us feel like a part of the entire community, not so isolated any longer."<sup>67</sup>

Although digital inclusion and digital equity are often framed as urban issues, rural and agricultural communities also struggle to make full use of the connections available to them. Local and state leaders know the challenges facing their own communities—from a lack of local planning and capacity building to a low level of broadband adoption to a lack of affordable broadband options to a dearth of digital skills—and have found solutions to increase adoption and use. For example:

- Multiple states, including Illinois and Maryland, provide support for broadband planning and capacity building. Maryland offers grants to localities and their internet service provider partners for costs associated with federal funding applications, while Illinois offers grants to communities to engage in creating broadband strategic action plans to facilitate broadband access, adoption, and use implementation.
- Illinois launched the Connect Illinois Computer Equity Network, a collaboration between the Illinois Office of Broadband, Cook County, and the national nonprofit PCs for People, to receive, refurbish, and redistribute used computers to those in need, since

more than 1.1 million Illinois households lack at-home computer or tablet devices. Desktop and laptop computers are distributed through regularly scheduled events with community-based organizations across the state and at two retail and distribution hubs—one in Belleville, which handles southern counties, and one in Cook County, which handles the northern half of the state. Computers come loaded with licensed copies of Microsoft Windows 10 and can be paired with mobile hotspots providing unlimited 4G LTE service starting at an affordable \$15 per month.

- Tennessee’s broadband grant program awards additional points for applicants who encourage adoption and community involvement through activities such as digital literacy training, low-income assistance programs (for equipment and/or broadband service), and awareness campaigns.<sup>68</sup> Priority in scoring is also given to rural and distressed communities. This structure allows applicants, which include political subdivisions, cooperatives, and for-profit companies, to adapt their community engagement strategies to local conditions.
- From 2014 to 2017, the Mississippi State University Extension Service Intelligent Community Institute assisted and educated rural communities in planning for, transitioning to, and prospering in the digital age.<sup>69</sup> Roberto Gallardo, who spearheaded that effort and now serves as director of Purdue University’s Center for Regional Development, calls extension, community development, and digital inclusion a 21st century trifecta: “Extension and community development can play a significant role in making communities digital inclusive, better positioning them to adapt and prosper in the digital age.”<sup>70</sup>

Rural communities benefit when they have access to affordable, reliable, high-speed service—but large telecommunications providers, accountable to their shareholders, do not have the market incentives to build out or upgrade infrastructure in much of rural America. In 2019, for example, the Minnesota Commerce Department investigated Frontier Communications and found “discriminatory practices such as ... providing slower repair services in rural areas compared to more populated areas.”<sup>71</sup>

Subsidies can help correct rural broadband market failure, but only if winners are held accountable. In several instances, large providers have not met build-out deadlines even after winning major subsidies from the federal government. For example, CenturyLink won \$505 million in the 2015 Connect America Fund Phase II auction to deploy just 10/1 Mbps to more than 1 million homes in 33 states before 2021. Six years later, CenturyLink had failed to accomplish that deployment target in 23 states.<sup>72</sup> Even if CenturyLink had met its deployment

Nearly half of the network feasibility studies commissioned by Blandin community partners and funded by the foundation have been either fully or partially built. Participating communities have dramatically increased the presence of free, publicly available internet access in libraries, public parks, downtown areas, and township halls, and have distributed more than 2,300 refurbished computers to income-qualifying residents in participating rural communities across Minnesota. Communities also have implemented a variety of digital literacy programs for local residents and businesses. They have spurred more sophisticated use of technology through education, training, community events, learning circles, and innovative partnerships—a total of 292 projects that address community technology goals.

Local governments and other entities across the state have endorsed and adopted Minnesota’s Broadband Vision, first articulated at a 2015 Blandin Broadband conference: “Everyone in Minnesota will be able to use convenient, affordable, world-class broadband networks that enable us to survive and thrive in our communities and across the globe.” This vision inspired the creation of the Minnesota Rural Broadband Coalition, which unites dozens of broadband champions from across the state to sustain broad, bipartisan support for Minnesota’s broadband grant program.

Blandin’s work in Minnesota illustrates the benefits of public and private leadership working in tandem. Investing in the capacity of communities to name and claim their own broadband vision helps to maximize public benefit from public investments such as state grant programs.

goals, a network that offers only 10/1 Mbps would not meet the needs of rural Americans. Kathryn de Wit, project director of the Pew Charitable Trusts' Broadband Access Initiative, considers accountability a critical element in achieving universal broadband access because accountability measures "ensure that projects deliver on their promise to address the digital divide."<sup>73</sup>

Community-oriented providers, such as small telecommunications companies and cooperatives, are often more willing to go the extra mile—literally—for their customers.

Take Pioneer Communications, a cooperative based in Ulysses, Kansas. The cooperative serves a 5,000-square-mile region using a variety of technologies, including fiber, copper, coaxial, and licensed and unlicensed wireless, but customers are not spread out evenly across that territory. Eighty-one percent of Pioneer's customers reside in just 15 square miles, while the remaining 19 percent reside in the other 4,985 square miles.<sup>74</sup> For many people in Pioneer's service territory, the cooperative is the provider of last resort—meaning that if Pioneer does not offer service, the customer will get no service at all. In addition to the legal responsibility to serve otherwise unserved customers, Pioneer and its

employees are integral parts of the communities that the cooperative serves. "I go to football games. I go to the grocery store. I see and interact with our customers on a daily basis," says Catherine Moyer, Pioneer Communications CEO and a resident of Ulysses. "I'm going to be a lot more creative for my local farmer than a bigger company, because I know them."<sup>75</sup>

Rural communities are particularly well suited to community-based solutions because "strong community-based organizations exist in every rural farm community across America," from economic development organizations to farm supply cooperatives to county governments.<sup>76</sup> With

guidance and funding from the federal government, rural communities can work with local organizations, including nonprofits, cooperatives, and community-oriented private providers, to find solutions that meet their needs.

**With guidance and funding from the federal government, rural communities can work with local organizations, including nonprofits, cooperatives, and community-oriented private providers, to find solutions that meet their needs.**

## American Connection Project Broadband Coalition tackles deployment and digital inclusion

The American Connection Project Broadband Coalition, convened by farmer-owned cooperative Land O'Lakes, is composed of more than 140 organizations from a broad swath of industries, including agriculture, health care, technology, and education. Partners in the coalition have created a network of more than 2,800 free, public Wi-Fi locations, though the coalition recognizes that this is a "temporary patch for a much larger systemic issue." To address that systemic issue, the coalition has advocated major federal investment in broadband deployment, better and more granular mapping, and more efficient coordination between federal and state agencies.

A new project from the coalition, the American Connection Corps, will place 50 fellows in select states as part of a two-year pilot to foster digital inclusion in rural and underserved communities. The fellows will work to access state and federal resources for broadband deployment, support broadband mapping projects, deliver digital literacy trainings to marginalized community members, and design digital skilling programs. The American Connection Corps will recruit fellows from the towns and states in which they will work and will encourage fellows to remain in the community even after their fellowship ends, creating sustainable leadership and inclusion services. More than 20 organizations, including nonprofits, private businesses, and educational institutions, have provided funding to support this project.

## Recommendations

- **Adopt comprehensive state broadband plans:** State strategies that are comprehensive and encompass all aspects of a broadband agenda, including deployment, competition, and digital equity, are best suited to meeting states' regional economic development and other goals.
- **Support digital equity programs at the state and local levels:** Digital equity programs led by state and local governments can work with communities to help people make full use of broadband connections, particularly in rural and agricultural communities. Local initiatives, when backed by adequate state and federal funding, can address multiple aspects of digital equity, including broadband affordability, low-cost devices, basic digital skilling, and more advanced technical training for local job opportunities.
- **Encourage local planning and capacity building:** Funding programs can encourage local planning and capacity building, which may include developing local or regional broadband strategies and applying for broadband grants.
- **Implement accountability measures to ensure that federal dollars build scalable networks:** Funding programs for broadband deployment that include strong accountability measures ensure that providers hit their deployment goals, and those accountability measures should be enforced. When reviewing project applications, program administrators can consider whether an applicant has failed to meet funding requirements in earlier programs. As mentioned previously, funding is needed to build high-capacity, scalable networks, not networks that will quickly become obsolete.
- **Encourage local, community-oriented providers:** To stimulate local competition, all programs that support broadband can consciously work to encourage entry from more broadband providers, including cooperative and community-based solutions.
- **Coordination, coordination, coordination:** As broadband funding programs proliferate, policymakers at all levels of government should work together as partners to create opportunities for collaboration, without precluding areas that have won funding through state programs.
- **Coordinate efforts of federal agencies:** Effective coordination between federal agencies, such as the Department of Agriculture, the National Telecommunications and Information Administration, and the Federal Communications Commission, will allow those agencies to synergize their respective expertise and meet the distinct needs of farmers.



# Conclusion

The community, the farmhouse, and the field each have different applications for broadband—but the same network, such as a fiber connection to the community or to the farm itself, could serve them all.

**The transformative power of broadband lies in its ability to connect users to solutions.**

Broadband is not an end in and of itself; instead, the transformative power of broadband lies in its ability to connect users to solutions. A broadband connection to a rural farm not only improves the farmer’s ability to use precision agriculture in the field, but also increases her opportunities for remote training, telemedicine, and social connection in the farm office. A farmer’s family can use that connection, too, for remote school days and telework opportunities, just like any other family. In the community, that network might enable new jobs and businesses and improve access to health care resources. Gerard Hayes, CEO of the Wireless Research Center of North Carolina, points out that “as you broaden the applications, you can lessen the cost of deployment.”<sup>77</sup>

**As you broaden the applications, you can lessen the cost of deployment.**

Broadband will be critical to increasing sustainability in agriculture. Farmers need data to make efficient decisions about resource management. Connectivity-dependent

**Connectivity-dependent precision agriculture allows farmers to more carefully target pesticide, herbicide, water, and fuel use, not only saving the farmer money but also reducing their negative impact on the environment.**

precision agriculture allows farmers to more carefully target pesticide, herbicide, water, and fuel use, not only saving the farmer money but also reducing their negative impact on the environment. Mace Thornton, vice president of communications and marketing strategy for the United Soybean Board, explains how connectivity drives sustainability: “Connectivity of land, equipment, and infrastructure drives the ability to proactively manage digital data at the farm and ranch level. Managing digital data drives precision agriculture, and precision agriculture drives many foundational aspects of measurable sustainability. That is why this issue is so vital to US Soy.”<sup>78</sup>

By 2050, the world will need to increase its food supply by 70 percent to 100 percent to meet food demand.<sup>79</sup> Robert Tse, senior policy adviser to the United States Department of Agriculture, identifies why this will be a challenge: “There’s only two ways you’re going to meet that demand. It’s either you have more land—which we don’t have, and in fact the amount of land in the United States is shrinking—or you increase yield.”<sup>80</sup> Increased yield, he argues, will have to come from broader adoption of precision agriculture.

Sustainability, connectivity, and meeting the world’s food demand are mutually interdependent. Ranveer Chandra, chief scientist for Microsoft Azure Global, provider of enterprise-grade cloud infrastructure, calls connectivity “a fundamental value to the digital transformation of this industry. It’s not a ‘good to have’ but a ‘must have’ because of the world’s food problem. We need to grow more good food without harming the planet.”<sup>81</sup>

But connectivity is not the only barrier to greater precision agriculture adoption among farmers. Evan Feinman, the governor’s chief broadband adviser for the Commonwealth of Virginia, argues that



“access to low-risk capital, training that is available in a format and on a time frame that works for producers, and a dearth of good messengers to the agriculture community” are all factors that limit adoption among farmers.<sup>82</sup> Connectivity, in other words, is imperative but insufficient by itself to achieve precision agriculture adoption.

**Meeting tomorrow's challenges means finally acknowledging that high-performance broadband is a must-have technology for modern agriculture.**

Saddled with inadequate speeds and disappointed by ineffective subsidies to large telecommunications providers, farmers have long made do with less. But meeting tomorrow's challenges means finally acknowledging that high-performance broadband is a must-have technology for modern agriculture.

As the Benton Institute for Broadband & Society interviewed farmers, rural service providers, equipment manufacturers, and other agricultural leaders and experts, broad consensus arose around several key outcomes for rural broadband, such as the need for robust upload speeds, accurate network deployment data, and scalable technologies. Farmers know what they need for sustainable, data-driven agriculture that can keep pace with the world's rising food demand. Now it's time to hear them and deploy the broadband networks and adoption strategies they require to continue to innovate and feed the world.

# Appendix: Federal, State, Tribal, and Local Broadband Programs

While 98.9 percent of urban areas have access to basic broadband speed at 25/3 Mbps, only 85.4 percent of rural areas have the same, leaving at least 9 million rural Americans without a means to connect to the national economy. More than 20 million rural Americans (30.9 percent of rural households) have no option at 100/10 Mbps.<sup>83</sup> New research from the Joint Center shows the particular challenges facing Black communities in the Black rural South: 38 percent of African Americans there lack broadband access, owing to both a lack of affordability and a lack of access.<sup>84</sup> These figures also likely understate the problem dramatically, as there is widespread recognition that Federal Communications Commission data overcounts broadband availability.

Federal, state, local, and tribal governments have all taken steps to address the digital divide, recognizing that without high-quality broadband, millions of Americans are locked out of full participation in our economy and society. This appendix aims to capture some of those steps, though it is not a comprehensive list.

The federal government has funded rural broadband deployment through a number of mechanisms and agencies, from the Federal Communications Commission to the United States Department of Agriculture to the National Telecommunications and Information Administration. Over the past two decades, the federal government has dedicated billions to broadband funding, with much of that funding allocated in only the past year.

States have stepped up to augment federal funding for broadband with their own broadband offices and funding programs. In 2012, only four states had broadband grant programs,<sup>85</sup> but as of 2021, all but 10 states have dedicated funding to broadband.<sup>86</sup>

And while local funding is less common than state, localities can also use local resources, local dollars, and local regulations to support broadband deployment. For example, Arrowhead Electric Cooperative, which operates a fiber-to-the-home network in Cook County, Minnesota, received initial support from Cook County itself, which awarded the cooperative a \$4 million grant to build out service.<sup>87</sup>

The federal government cannot close the digital divide by itself—instead, the federal government can work in partnership with states, localities, and tribal governments, which can knit broadband into regional economic development strategies. Deployment strategies should build on different state, local, and tribal circumstances, including political environments, economic resources, and broadband usage needs. When state and federal programs support localities and community organizations in broadband deployment and digital inclusion efforts, rural communities get the support they need to connect people where they are.

## Federal Funding Opportunities

BroadbandUSA, housed within the National Telecommunications and Information Administration, offers a comprehensive [guide](#) to federal funding opportunities for broadband deployment. Funding opportunities include direct grants, loans, indirect support, and discounts for industry, state and local governments, schools, libraries, small businesses, and other community institutions that are interested in expanding and improving broadband access.

[Guide to Federal Broadband Funding Opportunities in the U.S.](#), a May 2021 report prepared by CTC Technology & Energy for the Internet Society, summarizes federal funding options that could provide financial support to tribal, state, and local governments and utilities in their efforts to expand broadband infrastructure. Varying dramatically in size, these funding opportunities target a wide variety of deployment scenarios and end users. The programs encompass infrastructure build-out, service subsidies, and technical planning assistance.

## State Broadband Efforts

A 2020 report by the Pew Charitable Trusts, [How States Are Expanding Broadband Access](#), examines state broadband programs nationwide, exploring similarities and differences influenced by states' political environments and resource levels, the geography of the areas that remain unserved by broadband, and the entities that provide service. While it is clear that there is no one-size-fits-all approach for state expansion efforts, the report identifies and explores these promising practices through examples in nine states.

[Putting State Broadband Funds to Work: Best Practices in State Rural Broadband Grant Programs](#), a report written by researchers at CTC Technology & Energy and published by the Benton Institute, describes the commonalities among many of the best state rural broadband funding programs and recommends best practices.

The [Georgia State Broadband Plan](#) highlights the objectives and activities of the Georgia Broadband Deployment Initiative. The purpose of the Georgia Broadband Deployment Initiative is to coordinate efforts to deploy high-speed broadband connectivity so that all Georgians have access to health care, education, economic growth and expansion, and other quality-of-life essentials. In 2019, Georgia passed a law to give cooperatives permission to offer broadband service, and now more than a dozen of the state's 41 cooperatives have taken that opportunity.

North Carolina announced the creation of a new [Office of Digital Equity and Literacy](#) in 2021, the first in the nation. The office is part of the Division of Broadband and Digital Equity within the North Carolina Department of Information Technology. The office will execute [North Carolina's plan](#) to expand digital literacy offerings and partnerships across North Carolina, as well as lead the [Digital Equity and Inclusion Collaborative](#) and promote the [NC Digital Inclusion Playbook](#) for local municipalities.

## Tribal Broadband Efforts

A [case study report](#) from the Institute for Local Self-Reliance delves into the experiences of four Native Nations—the Coeur d’Alene, the Nez Perce, the Fond du Lac Band of Ojibwe, and the St. Regis Mohawk—as they created their own internet service providers. The case studies examine the unique challenges Native Nations confront as they seek to build internet infrastructure and address the digital divide while also retaining the tribal sovereignty that is essential to their identity and heritage.

## Local Broadband Efforts

Researchers at the University of Virginia launched the [Virginia County Broadband Survey](#) in January 2021 to better understand what counties across Virginia are doing to close the digital divide in their communities, and how broadband factors into their policy plans for the year. Early results from the survey illustrate the weakness of current mapping data from the Federal Communications Commission when compared to local leaders’ knowledge of what is available in their own community.

In a 2019 report, [Adapting Jobs Programs for Today and Tomorrow](#), published by the Benton Institute for Broadband & Society, John Horrigan explores public, private, and collaborative models for digital skills training that address the needs of “middle-skill” jobs, or those that require some postsecondary education (such as an associate’s degree from a community college).

[Connecting Cuyahoga: Investment in Digital Inclusion Brings Big Returns for Residents and Administration](#), a report by the Cleveland-based nonprofit Connected Insights, explores the ways digital inclusion can improve the operational efficiency of several Cuyahoga County departments while making county services more accessible to a larger number of citizens.

## Other Resources

[Broadband Mapping Across the US: Local, State, and Federal Methods & Contradictions](#) by Next Century Cities offers a snapshot of federal broadband data in each state or territory, background on state data collection initiatives, and local insights. Some states, such as Utah and South Carolina, collect data directly from providers rather than relying on information from the Federal Communications Commissions, and others, such as Wisconsin, use a combination of state and federal data.

[A Case for Rural Broadband](#), an April 2019 report from the United States Department of Agriculture, explores the intersection of broadband internet infrastructure and the digital next-generation precision agriculture technologies that will depend on improved e-connectivity. The report includes illustrative examples of how farmers use precision agriculture in their day-to-day activities and estimates the possible economic benefits of expanding rural e-connectivity to farms and ranches.

[From Fiber to Field: The Role of Rural Broadband in Emerging Agricultural Technology](#), a report by Joshua Seidemann, vice president of policy for NCTA–The Rural Broadband Association, provides an overview of agricultural markets and technology in the United States, offering examples of “precision agriculture in action.” Seidemann demonstrates the imperative to deploy, develop, and maintain connectivity in rural U.S. agricultural regions.

# Acknowledgements

We would like to extend special thanks to all those who made this work possible, particularly our partners at the United Soybean Board (USB). USB's [Rural Broadband and the American Farmer: Connectivity Challenges Limit Agriculture's Economic Impact and Sustainability](#) included interviews with thousands of farm operators across a wide range of agriculture sectors and demonstrated that farmers who contribute nearly \$80 billion to U.S. GDP still run their businesses on limited internet connections. This project, which offers key principles and highlights practical broadband deployment and adoption solutions, builds on USB's work and goals: closing current broadband gaps to increase agriculture's productivity and sustainability.

Over the past year, we were fortunate to speak with many people who are hard at work to bring farmers and rural communities across the nation the broadband they need. Armed with new insights, the Benton Institute for Broadband & Society convened a small group of agriculture leaders, broadband practitioners, and policy experts in May 2021 for a facilitated, off-the-record discussion about the broadband needs of rural communities and the best ways to create, and build awareness for, a rural broadband agenda among key agriculture leaders. We appreciate that all those participants we cite gave us permission to use their words.

We are particularly grateful to those who reviewed all or some parts of this report, lending their special expertise, raising important questions, and offering insightful recommendations. The report is better because of their contributions.

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