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# Making it Count: Applying Science to Support Universal Broadband

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This special issue presents a series of papers resulting from a two-conference series about closing the digital divide, especially for rural areas. Supported by a conference grant from the USDA National Institute for Food and Agriculture (NIFA), the conference was originally framed to ask whether there was a relationship between demand for broadband to enable smart agriculture and the availability of broadband for nearby rural communities. At a time when national, state, and local governments were expending significant resources to provide or incentivize broadband availability to rural communities and their outlying farms, it seemed critical to understand how farmers' demand for broadband might complement the provision of broadband to rural communities—sparking a virtuous cycle of higher agricultural productivity and increased adoption among consumers and other rural industries, leading to greater rural prosperity.

The onset of the COVID-19 pandemic forced the planning committee to rethink the strategy for surfacing and addressing key research and Extension questions. At the same time, the pandemic shone a very bright light on the digital divide and its implications for those without the benefit of broadband connectivity, digital tools, or digital skills. We changed our plans for both the structure and focus of the conference, highlighting the importance of broadband connectivity for broadly shared prosperity and the importance of using good information to guide policy choices and evaluate programs and funding.

We held two virtual meetings: The first focused on surfacing important questions for researchers and Extension professionals, and the second presented papers that had been developed to address those questions in the intervening months. We also prepared a literature review in advance of the first meeting to offer conference participants an understanding of the current state of the literature related to these issues. The first meeting was structured around four themes: targeting investments, building partnerships, advancing technology, and building a digital-ready workforce. At the conclusion of this meeting, several key research and Extension questions were identified.

**Articles in this Theme:**



The visibility of the digital divide during the pandemic drove unprecedented investments in rural broadband. Recent federal investments include the Broadband

Infrastructure Program, the Tribal Broadband Connectivity Program, and the Connecting Minority Communities Program, all introduced by the Consolidated Appropriations Act of 2021. These programs were added to the existing suite of broadband programs, recently detailed in a publication of the Internet Society (CTC Technology and Energy, 2021).

In addition, President Biden signed the bipartisan $1.2 trillion Infrastructure Investment and Jobs Act into law on November 15, 2021. The package includes $65 billion for broadband projects to close the digital divide, improve internet affordability, and improve service to low-income customers, with much of the money directed toward states. Other bills targeted at the digital divide are still pending in Congress, including H.R. 1783, the Accessible, Affordable Internet for All Act, which authorizes over $94 billion to ensure unserved and underserved communities have affordable high-speed internet access.

While adequate funding to close the digital divide is long overdue, these new programs pose questions about how we might ensure that these funds are used most effectively for broadband adoption and uptake for the greatest number of currently unserved and underserved people. The papers address this broad question through the following topics:

- Data and analysis to inform policy recommendations: What data are needed to accurately assess the state of the digital divide? How can better data contribute to policy and program design to ensure that investments that will reap the greatest returns for communities?

- Data and methods to support broadband program evaluation: What information should agencies collect to assess the effectiveness of new programs and funding? What models or evaluation methods are best suited to the task?

- Federal-state policy and funding interaction: As federal funding and policy changes affect incentives for broadband provision, how might state policies and funding impact the effectiveness of these policies and funding mechanisms? What processes and programs can be engaged in local communities to meet end-user needs?

- Labor market effects and response: How will rural broadband funding and access affect the demand for workers with specific skills in the short term (telecom equipment manufacturing and infrastructure buildout), medium term (providing businesses and households access), and long term (as we move toward adoption)? What investments are required to meet those needs and education assets are best positioned to meet them?

- Broadband business models: What innovative business models, partnerships, and implementation tactics demonstrate the capacity to accomplish universal broadband access and adoption given the increase in federal funds? What changes in community mindsets need to happen to move the needle on their willingness to pursue funding?

Biedny and Whitacre examine the information necessary to plan potential investments to determine where they might be most effective and to assess the effectiveness of new programs and funding as they are rolled out. Specifically, they explore the problem of internet availability data. A common complaint among researchers, policy analysts, and those working toward more equitable access is the lack of quality data about exactly where broadband is available. The most-used data source is derived from the Federal Communication Commission's (FCC's) Form 477, as reported in the annual Broadband Deployment Reports (FCC, 2021). Biedny and Whitacre articulate the well-known weaknesses of these data. They discuss the creation of a "broadband serviceable location fabric" (BSLF), which is being created to address these deficiencies by showing all locations where broadband *could be* provided. They evaluate the first steps being taken to create this data by examining preliminary BSLF data for Oklahoma.

Sanders and Gaffney share the results of an effort to correct the inaccurate data published by the FCC. The Stephens County/Spokane Tribe Washington Broadband Access Team (BAT) led an effort to collect data used to challenge the FCC data published for Stephens County and the Spokane reservation. The BAT, coordinated by Washington State University Extension with participation by state, local, regional, tribal, and congressional representatives, already had a long history of working together on broadband planning and access. They developed and implemented a survey of residents and speed tests to establish where internet services were available, the speed of the service, how services were used, whether there was interest in additional internet services, and the barriers to obtaining adequate service. Their findings were used to inform a state legislative package that set speed and service standards, established capacity at the state level to close the broadband gap, and funded additional BATs across the state. Their case study demonstrates how improved information can drive changes in policy and funding in the areas most in need of additional services.

Canfield, Low, and Gollnick illustrate the power of participatory research methods and the role of Co-Operative Extension in advancing important broadband goals in rural communities. In the context of expanded federal funding to state governments, the paper demonstrates the importance of community participation in broadband research and planning to ensure that the funding is used to best meet the needs of the local community. It also illustrates the power of strong partnerships across state, local, university, nonprofit and internet service providers to address broadband needs and service gaps. Partnership between county-based and campus-based university personnel also play a key role in strengthening community participation in research, thereby improving the policy relevance and its potential benefits.

Gaspard and Baker take a US-Canadian comparative approach to understanding the impact of local demographic and geographic characteristics on rural broadband challenges, the role of local intermediaries, and the menu of policy prescriptions and their effectiveness. They provide evidence that in both countries, intermediaries are essential for providing information, filling gaps, connecting and leveraging resources, and generating the scale necessary to incentivize provision. They argue that universities can and have been effective as intermediaries, playing these roles to connect rural residents to broadband. They point to Virginia and North Carolina as examples of universities serving these intermediary roles. In Canada, they use the example of Southwestern Integrated Fibre Technology, a publicly funded multi-jurisdictional coalition, as an example of an intermediary that is providing the data, technical expertise, local context, and local participation to ensure that the solutions deployed locally are appropriate to fill local needs. The BATs operating in Washington State and described in the Sanders and Gaffney paper are also a great illustration of universities as broadband intermediaries.

One key issue that emerged as we proceeded with this project during the pandemic is that of telework. After offices shut down to obey COVID restrictions, many employers quickly put in place the policy and infrastructure to allow extensive telework. However, not all occupations, workplaces, or households are easily converted to telework. Even where broadband is available, other barriers to telework exist. You simply can't build a building, harvest food or fiber, or produce most goods remotely (although digital technologies are making some aspects of this work more remote friendly; for example, see Immerman, 2021). A study by Gallardo and Florida early in the pandemic showed that rural counties were more vulnerable to job losses due to inability to convert to remote work, either because of occupation, industry, or lack of broadband (Gallardo and Florida, 2020). As we close broadband gaps and become more used to telework, what permanent changes might emerge in the workplace?
Hughes, Chrissy, and Willis argue that the experience of telework during COVID lockdowns has had permanent impacts on the workforce. They investigated the extent of teleworking during COVID and found that rural workers were much less likely to telework than urban and metropolitan workers. The factors that influenced the likelihood of telecommuting also included occupation, industry, income, and education. Thus, eliminating broadband barriers will probably not completely erase differences in remote work between rural and urban areas. However, as more rural and metropolitan workers are allowed to work remotely permanently, they may choose to migrate to rural areas, causing a restructuring the rural workforce toward more remote work-friendly jobs. This will only be possible in areas where broadband is available.

Broadband is not the first utility to have struggled to find a viable private market in rural communities. Greig points to the obvious parallels with rural electrification in the 1930s and argues that the rural electric co-operative (REC) model offers the potential to better serve millions of rural residents. He explores why so few rural co-operatives have filled this need. Using data from a survey of RECs, he identifies accessing and managing federal funding as a key difficulty and makes suggestions for how federal agencies might help RECs overcome these challenges.

## Questions for the Future

Many issues remain unresolved. We are still interested in the extent to which demand by agriculture might tip the economic equation in favor of broadband provision even in remote rural areas. The BSLF discussed by Biedny and Whitacre might bring to light this potential demand and encourage private providers to invest in agriculture-dominated areas. Similarly, we still don't understand how federal and state funding agencies will use improved data to direct funding and whether it will improve the return on that investment. We do have evidence that intermediaries and collaboration between research and Extension can make a difference for communities working to plan and influence broadband investments and adoption. But the question of whether the current swell of investment will be spent according to communities' expressed needs remains. As more local governments and co-operatives offer broadband, they may be more responsive than private sector providers to local needs. Finally, we predict more people will telework post-pandemic because norms and habits have shifted; however, we don't know where the balance between remote and in-person work will land.

## For More Information


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# The Broadband Serviceable Location Fabric, Rural America, and Agriculture

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The “digital divide”—a gap in access to modern information and communication technologies found among different demographic and economic groups, as well as communities and regions across the country—is a recognized problem in the United States and a growing concern in rural America. Not only is access to fast, reliable broadband a necessity in many facets of everyday life, it has become a critical component of farming and agriculture-related activities. The USDA estimates that deployment of broadband connectivity and next generation precision agricultural technologies could result in an annual economic benefit of at least $47 billion (U.S. Department of Agriculture, 2019). Further, several studies have found that broadband availability has an appreciable impact on farm profitability (Kandilov et al., 2017; LoPiccalo, 2022). The 2018 Farm Bill called for the creation of the “Task Force for Reviewing the Connectivity and Technology Needs of Precision Agriculture in the United States” (or “Precision Ag Connectivity Task Force” for short). Its charge is to provide advice and recommendations on how to assess and advance broadband deployment on agricultural land and to promote the use of precision agriculture. The success of such a task force, however, is hindered by the absence of detailed broadband-related data that can guide the formation of policies and strategies that expand broadband access and adoption by farmers, agribusinesses, and other key sectors. FCC chairwoman Jessica Rosenworcel has argued, “You cannot manage what you do not measure” (Tibken, 2021a).

Expanding broadband internet availability requires detailed knowledge of the current status of broadband across the country. However, the U.S. approach to gathering broadband availability data has been widely criticized (Ford, 2011; Grubesic, 2012; Busby and Tanberk, 2020; Ford, 2019). Although data have been collected, they have failed to provide an accurate picture of the country’s broadband needs. This article provides a brief history of the current efforts to collect broadband availability data and the new funding initiatives that are intended to accelerate access to various areas of the country. We highlight ongoing efforts for the creation of a “broadband serviceable location fabric” (BSLF), which is a dataset of all locations or structures where broadband *could* be provided. Next, we explore and analyze preliminary BSLF data for the state of Oklahoma and, as a result, highlight several important takeaways that should be considered as the availability of BSLF data is expanded nationwide.

During the initial onset of the COVID-19 pandemic, Congress passed the Broadband Deployment Accuracy and Technological Availability (DATA) Act (P.L. 116-130) in March 2020, calling for the development of a national BSLF, which must contain georeferenced information on *all locations* where fixed broadband can be installed. Prior data collection efforts (i.e., the Federal Communication Commission’s (FCC) Form 477) based broadband availability percentages on the estimated number of people/households located in each census block (i.e., without geolocations). For example, the FCC’s annual Broadband Progress Reports regularly use block-level population estimates to generate county, state, and national metrics on the percentage of all residents with access to different broadband thresholds (FCC, 2016, 2021). However, this approach fails to include entities that might need broadband connections, such as businesses, community institutions, agricultural facilities, and recreational venues. The legislated BSLF is intended to address these deficiencies.

In November 2021, the FCC selected CostQuest Associates (CQA), a broadband consulting firm, to be the initial provider of data for a national BSLF. As the FCC and CostQuest move forward with the creation of a national BSLF, it is important that the data that be used to tackle the shortcomings associated with the current broadband mapping system, particularly identifying specific property types in need of service. This includes ensuring that the broadband needs of the agricultural sectors are duly recognized and addressed.

## A Concise History of U.S. Broadband Availability Data Collection[1]

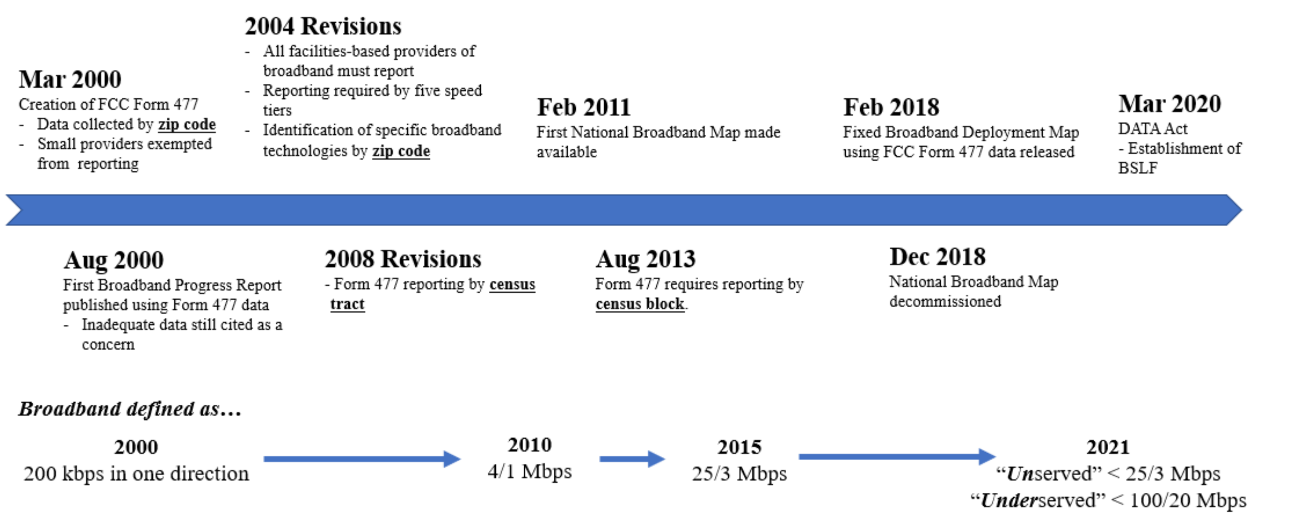
The United States has been gathering broadband data since it was first mandated by the FCC's Telecommunications Act of 1996. Broadband Progress Reports, now known as Broadband Deployment Reports, have been published annually by the FCC since 1999. In 2000, the FCC established Form 477, a standardized tool for collecting semi-annual data regarding broadband services, local telephone service competition, and mobile phone services (FCC, 2000). In its earliest form, only service providers with more than a threshold number of customer (or service) lines in a state were required to report a list of zip codes where services were provided (FCC, 2000, p. 7). Form 477 reporting requirements have changed a number of times since 2000. Some of the most important changes include the delineation of broadband service by technology types (2004) and the collection of data at the census-tract level rather than by zip code (2008). The reporting of data at the census-block level has been standard practice since 2013. Figure 1 presents a timeline showing changes in how the FCC collected broadband data and how it has defined "broadband."

A particularly important element in Figure 1 is the 2008 Broadband Data Improvement Act (BDIA), which introduced and formalized the idea of broadband availability mapping and was subsequently funded by the 2009 American Recovery and Reinvestment Act ("Recovery Act"). The act also established the State Broadband Initiative (SBI) to oversee the distribution of funding at the state level and required each state to semi-annually gather broadband availability data at the census block level from providers within their borders (NTIA, 2009a,b). This data was collected, verified, and standardized at the individual state level and then aggregated to produce the first National Broadband Maps from 2011 to 2015. Although these earliest maps were a substantial improvement from having no map at all, they had noticeable limitations. Three of the most glaring issues were (i) reporting at the provider level was incomplete; (ii) the data did not differentiate between residential and business service; and, (iii) a whole census block was considered "served" if one location within its borders could be provided service within 7–10 days (Grubesic, 2012). This last limitation is undoubtedly the most important one for rural locations since some agricultural structures that might need broadband are not always located near households. Further, census blocks in rural areas can be relatively large and thus are more likely to overstate actual availability.

SBI funding ended in 2015 and the FCC took over responsibility for data collection, which was still being gathered at the census block level. The FCC was unable to continue the data verification work previously done at the state level under SBI, which caused additional uncertainty about the reliability of the data. Despite the growing importance of well-informed maps, the FCC did not publish a new availability map until 2018.

Throughout this process, the availability maps have depended on data gathered directly from internet service providers (ISPs). Providers complete Form 477 updates each June and December, and the FCC publishes a national availability map with roughly a 12-month lag (for example, the January 2022 map uses data from December 2020). The map includes broadband and provider availability for over 11 million census blocks. The map contains details including availability by technology type and speed, provider-specific information such as available speed tiers, and the ability to search for a specific area or location by searching for an address. Despite these improvements, the underlying

**Figure 1. The Evolution of FCC Form 477 and Broadband Speeds**




[1] For additional details, see Whitacre and Biedny, (2022).

data is still subject to the faulty “one served, all served” logic and continues to overstate broadband availability, particularly in rural areas (Engebretson, 2018). Due to the time lag associated with processing Form 477 data from providers, these maps also do not offer a real-time picture of broadband status.

In light of the significant level of funding being targeted for broadband expansion and the pressing need for accurate broadband availability mapping, it is hoped that the BSLF will produce more granular and accurate data to help inform project investments and policy decisions (GAO, 2021; White, 2021).

## Broadband Funding Initiatives

Previous federal broadband funding has attempted to address infrastructure development, adoption, and mapping, but COVID has exacerbated the need for more widespread, reliable internet—particularly in rural areas (Whitacre, 2021). Several COVID stimulus packages have included significant broadband components. Two of the largest and most notable are the American Rescue Plan Act of 2021 (“ARPA,” P.L. 117-2) and the Infrastructure Investment and Jobs Act of 2021 (the “Infrastructure Act,” P.L. 117-58).

Passed in March 2021, ARPA provides over $350 billion for state, county, and local pandemic recovery due to COVID. Unlike other grant-based or otherwise restricted funding initiatives, ARPA grants enormous flexibility as to the types of projects and investments that can be supported with these funds (Lide, 2021a). The act strongly encourages, but does not mandate, that monies be spent on broadband infrastructure (Panettieri, 2021). All states are receiving funds, but the act intentionally allows each state, county, and municipality to determine the best uses of the funding. While some have already identified specific broadband-focused projects, only several states have earmarked funds for general broadband infrastructure and development to date (Read and Wert, 2021; Community Networks, n.d.). ARPA funds are required to be expended by December 31, 2024, giving states time to plan.

The Infrastructure Act, passed on November 15, 2021, allocates approximately $65 billion dollars to various aspects of broadband development and adoption (Lide, 2021b; Sullivan, 2021). The largest portion of this funding, $42.45 billion, is dedicated for the Broadband Equity, Access and Deployment (BEAD) Program. BEAD funding is being administered as a grant program by the National Telecommunications and Information Administration (NTIA), but spending power ultimately rests with each state (Engebretson, 2021). Under the act, states are required to consider input from local governments, cooperatives, partnerships, and other eligible entities, in designing a five-year action plan that addresses the intended uses of funding (Keller and Heckman LLP, 2021). Notably, both ARPA and the Infrastructure Act define underserved areas as those lacking access to 100 Mbps download and 20 Mbps upload speeds (i.e., 100/20)—significantly higher than the FCC’s “unserved” definition of 25/3 Mbps set in 2015.

In addition to these federal funding programs, many states have taken matters into their own hands, seeking to create state-level availability maps in advance of the federal BSLF. Georgia, Maine, Pennsylvania, Illinois, Arkansas, and North Carolina are just a handful of the states working to produce their own state availability maps in order to more appropriately apply for and allocate funds (Noble, 2020; Tibken, 2021b). Our home state of Oklahoma has set aside $2 million in ARPA funds to compile a state-level availability map (Savage and Prather, 2021). The state’s Rural Broadband Expansion Council previously purchased a preliminary version of the BSLF to assess how it might be used as part of a broader mapping effort. The next section discusses the details of the fabric and how it could be used to allocate the pending federal broadband funds.

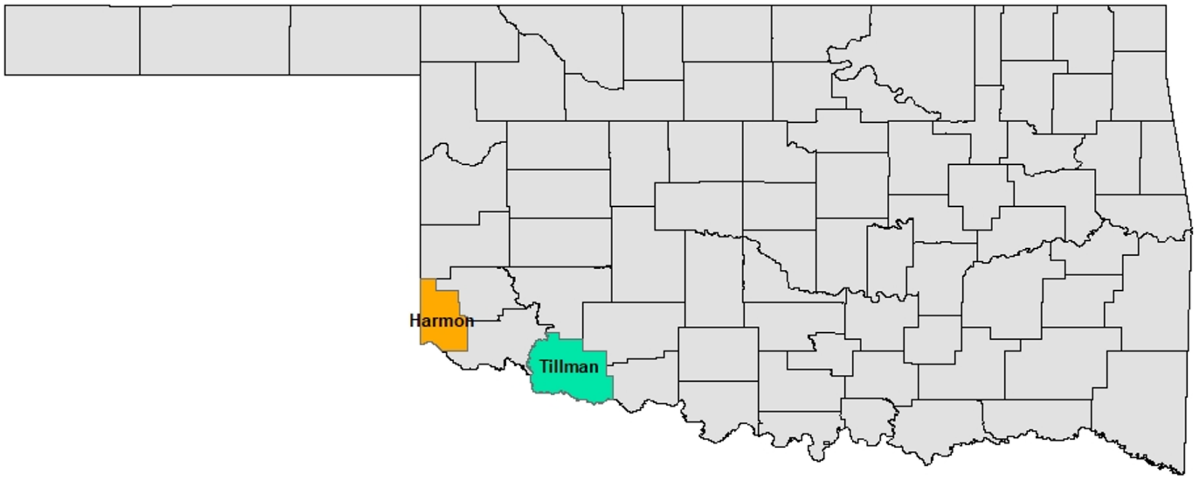
## The Fabric Data and Implications for Agriculture

Since October 2020, CostQuest Associates (CQA) has created three versions of a preliminary BSLF for the state of Oklahoma. The state of Oklahoma licensed this BSLF data from CQA as part of its efforts to create a state broadband availability map. Each dataset contains over 1.5 million entries, or fabric points.[2] Each point represents a specific structure—such as a household, business, or farm building—that could potentially need broadband access. Moreover, each point includes a census block identifier, making it easier to assess whether the structure has 25/3 or 100/20 Mbps service available to it, according to Form 477. However, the limitation of Form 477’s assumption that service for one location implies service for the entire census block remains.

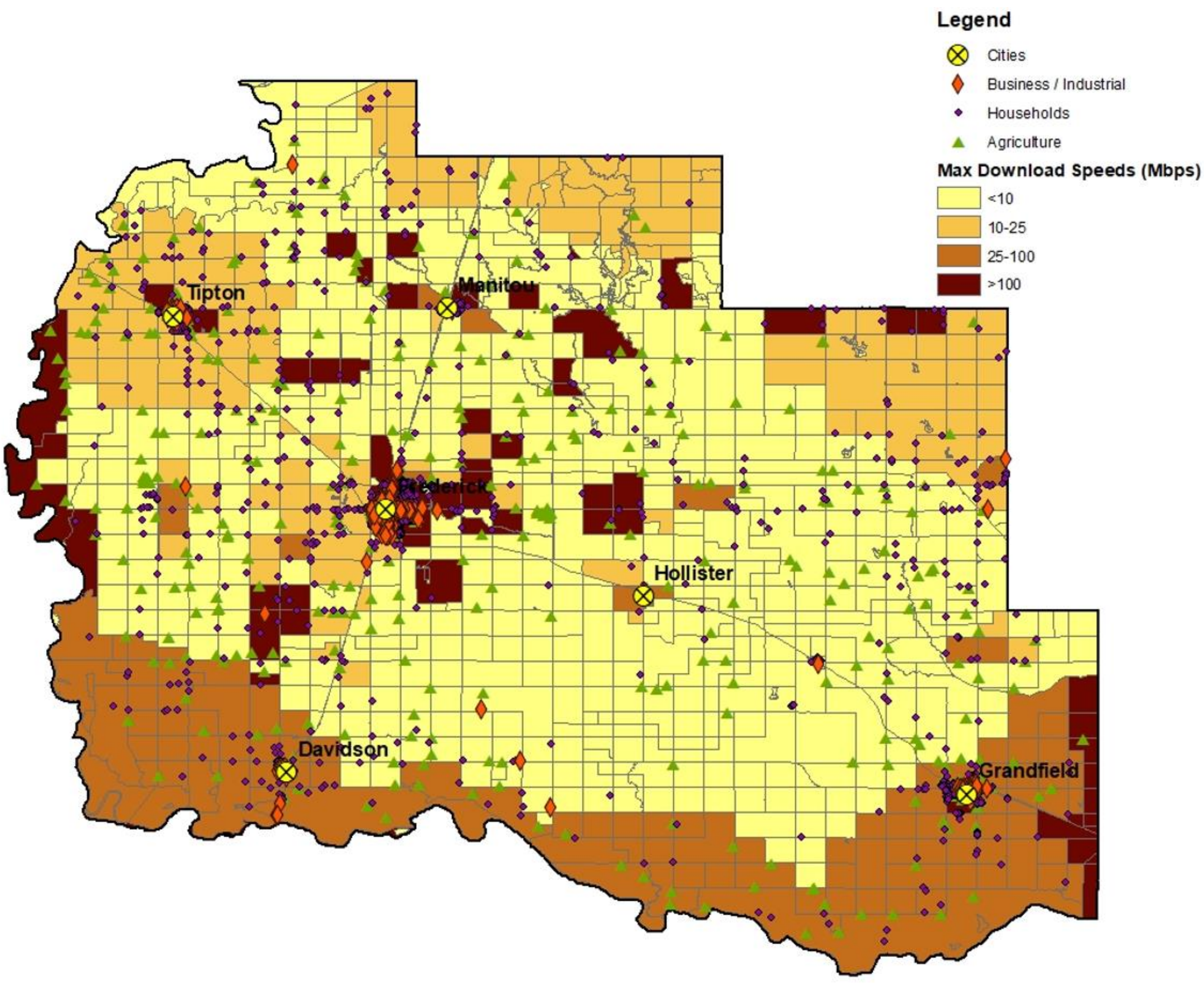
Using the most recent version of the CostQuest data (v3), we take a closer look at two Oklahoma counties: Tillman (2020 population 7,177) and Harmon (2020 population 2,488), both located in the southwest corner of the state, a predominantly rural and farming-dependent region (Figure 2). Both are also classified as persistent poverty counties by the USDA’s Economic Research Service, meaning that at least 20% of the residents have been measured as poor since the 1980 census. We mesh this dataset with the December 2020 Form 477 data on broadband availability from the FCC. Figures 3 and 4 show the resulting maps for Harmon and Tillman Counties.

[2] For more details related to the Oklahoma CQA data, see Whitacre and Biedny (2022).

## Figure 2. Tillman and Harmon Counties, Oklahoma

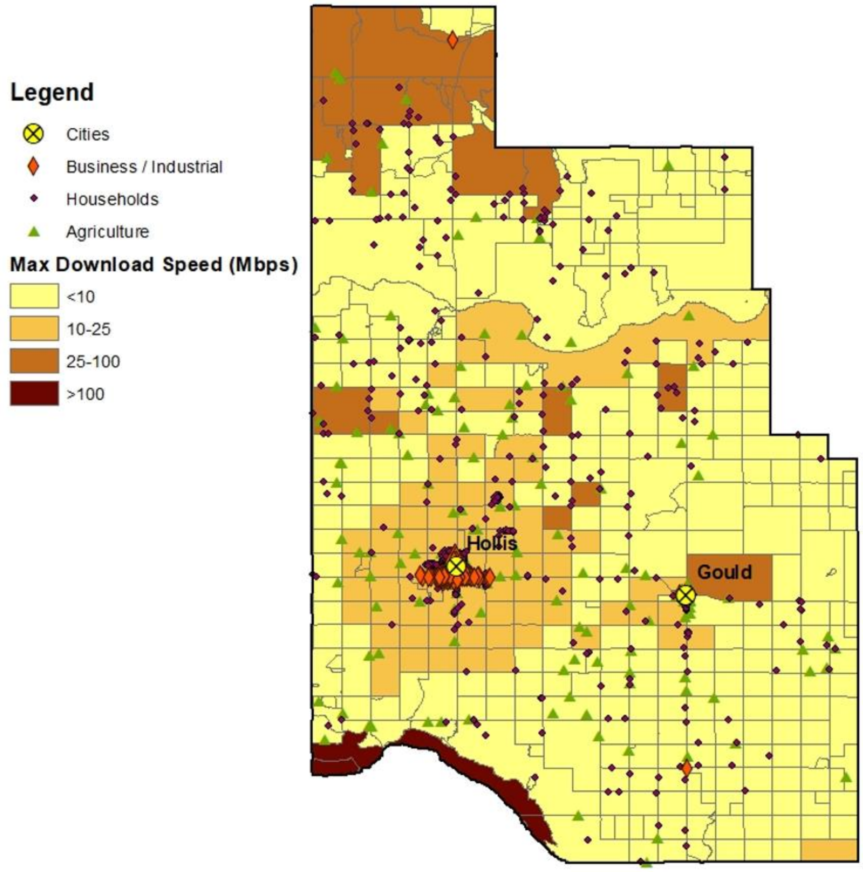



## Figure 3. Tillman County, OK—Broadmand Availability and Structures by Land Use Type




Source: CostQuest Associates Broadband Serviceable Location Fabric, 2021; FCC Form 477 (Dec. 2020).

**Figure 4. Harmon County, OK—Broadband Availability and Structure by Land Use Type**




Source: CostQuest Associates Broadband Serviceable Location Fabric, 2021; FCC Form 477 (Dec. 2020).

An important observation from the preliminary BSLF data is that property type matters. The pockets of "good" broadband service are clearly clustered near cities; the households that are located nearby typically have access to the best speeds in the county. However, agricultural structures are located throughout each county and typically have very poor (<10 Mbps) service available. Summary statistics from each county support this assertion; while only 10%–17% of residential structures lacked access to 25/3 Mbps, more than 60% of agricultural structures fell under this classification (Table 1).

The total number of structures lacking broadband access is also visibly impacted by the categories of structures examined. If only residential BSLF entries are considered, Tillman County had approximately 363 units lacking broadband service at 25/3 Mbps speeds. Adding agricultural and land units nearly doubles the number of structures (over 700) lacking broadband. Similarly, Harmon County had 234 residential units lacking 25/3 Mbps access. Including agricultural and land units again approximately doubles this count to over 455. Such significant variance is likely to have an impact on the total amount of investment that will be necessary to bring "full connectivity" to these counties and may further impact whether they are viewed as unserved or underserved areas. While it may be difficult to determine the cost of achieving full connectivity, a study conducted for the state of Illinois came up with a rough estimate of approximately $4,000/structure served based on recent broadband award documentation from several federal and state grant programs (Horrigan, Whitacre, and Rhinesmith, 2020). Employing this figure, the cost of providing ubiquitous 25/3 Mbps access for Tillman County households would be $1.45 million (363 * $4,000), but providing service for all structures would be over $3 million (772 * $4,000). The estimates in Harmon County would also more than double, from $0.9 million when only residential structures are included to over $1.9 million for all possible structures. The costs would be notably higher for providing 100/20 Mbps service (which is the suggested speed threshold for ARPA/Infrastructure Act funding—see Figure 1), totaling $5.6 million for households and $8.6 million for all structures in Tillman County and $5.3 million for households and $7.6 million for all structures in Harmon County.

These data also highlight the lack of broadband services specifically in agricultural locations. While agricultural units make up only 8% of all units in Tillman County, they represent 32% of the points lacking 25/3 Mbps service. Sixty-two percent of all agricultural units lack

**Table 1. Broadband Availability—BSLF Units by Land Use Category—Tillman and Harmon County, OK**

| | Tillman | | | | | Harmon | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Lacking 25/3 | | Lacking 100/20 | | | Lacking 25/3 | | Lacking 100/20 | |
| Active BSLF Points by Category | Units | Units | % | Units | % | Units | Units | % | Units | % |
| Residential | 3,782 | 363 | 10% | 1,409 | 37% | 1,352 | 234 | 17% | 1,314 | 97% |
| Business/industrial | 375 | 52 | 14% | 143 | 38% | 189 | 16 | 8% | 142 | 75% |
| Agriculture | 394 | 246 | 62% | 352 | 89% | 137 | 92 | 67% | 131 | 96% |
| Land | 363 | 105 | 29% | 227 | 63% | 290 | 129 | 44% | 261 | 90% |
| Other Points | 51 | 6 | 12% | 24 | 47% | 65 | 6 | 9% | 63 | 97% |
| Total | 4,965 | 772 | 16% | 2,125 | 43% | 2,033 | 477 | 23% | 1,911 | 94% |

Notes: 25/3 refers to 25 Mbps download and 3 Mbps upload. 100/20 refers to 100 Mbps download and 20 Mbps upload
Source: CostQuest Associates Broadband Serviceable Location Fabric, v3 (2021). FCC Form 477 Broadband Availability Data (Dec. 2020).

25/3 Mbps and 89% do not have 100/20 service. In Harmon County, agricultural units make up 7% of total units but constitute almost 20% of units lacking 25/3 Mbps speed. Some 67% and 96% of agricultural units lack 25/3 Mbps and 100/20 Mbps speeds, respectively. These data support the efforts of organizations like the Precision Ag Task Force and will be necessary to help identify exactly where agricultural properties are located and how best to extend service to them.

## Conclusion

More detailed maps of broadband availability data are necessary for the efficient expansion of broadband infrastructure and services. Correctly identifying where service is available and which structures exist and need service is required to accurately design policies and dispense funding and design policies to address existing gaps. The creation of a national broadband serviceable location fabric (BSLF)—a map of all locations where fixed broadband can be installed—is an important step in addressing the needs of all property types, not only of the residential properties but also of the agricultural community.

BSLF data obtained by the state of Oklahoma serve as an early opportunity to assess the strengths and limitations of this more granular data product. As a result of our study, we are positioned to offer input on what changes can be made to enhance the value and impact of the BSLF data. For one, cost estimates vary considerably based on the types of structures included. It is important for policy makers and project managers to focus attention to the various types of structures in rural areas when planning broadband infrastructure build-out and the mix of technologies best-suited for these more rural locations. Second, agricultural units make up a disproportionate number of structures lacking 25/3 and 100/20 Mbps speeds. This finding is in line with the recent conclusions of the Precision Ag Connectivity Task Force. Its data and mapping working group has already identified the need to "ground-truth" usability and coverage availability, particularly in agricultural regions (Precision Ag Connectivity Task Force, 2021).

As the winning contractor for the creation of a national BSLF, CostQuest Associates is expected to provide a draft of the national dataset within 4 months.[3] However, this initial version will not be immediately available since ISPs are being given six months to respond to and/or challenge the data. As a result, a national BSLF is unlikely to be available until early 2023, at the earliest. Even then, it is unclear how the proprietary BSLF data will be incorporated into a public-facing format, such as a broadband map, due to data usage rights. Depending on the terms agreed upon by CQA and the FCC, which are so far undisclosed, a public map may only be made available via an end-use licensing agreement (i.e., for a fee). Such a barrier may have significant implications for future research. The CQA data obtained by the state of Oklahoma is similarly restricted with respect to public release, and the state is currently considering how to best utilize the data to implement a state-level broadband availability map while meeting these requirements.

As a final note, a functioning BSLF is by itself not enough to solve the largest problem associated with the U.S. broadband availability maps. Without more detailed information on *exactly where* each provider currently offers each of its broadband packages (i.e., a shapefile or list of addresses as opposed to the current census block approach), the BSLF could still overlook structures within a block that has service "somewhere" but not at the structure's actual footprint. This "exact service area" information is also required by the DATA Act, but the expected date of availability is again unclear (Whitacre and Biedny, 2022). Worth noting is that the BSLF's focus

[3] Lightbox Parent L.P., a competitor to CostQuest, filed a complaint against the FCC's selection process, which delayed FCC/CQA progress with the BSLF timeline (Curi, 2021). This complaint was dismissed in March 2022 (Government Accountability Office, 2022).

on agricultural *structures* excludes most production acres, which can benefit from broadband provision for many precision agriculture techniques (Seidemann, 2021; USDA, 2019). Further, precision agriculture largely uses mobile (cellular) networks instead of fixed connections. Data on mobile broadband deployment is also available from the FCC (2022a), but reports generally show that nearly all (99.9%) of the United States has access to at least 5/1 Mbps speeds and that even in rural areas 90% of the population has access to 10/3 Mbps (FCC, 2021a). These figures focus on population measures as opposed to production acres.

However, a recent update from the FCC regarding the national BSLF dataset has made it clear that the types of structures to be included in the final version are not yet finalized. Unfortunately, the only types of structures included in a preliminary version of the data made available to broadband service providers were three specific building types: business only, residential only, and combined business and residential (FCC, 2022b). This is in direct contrast to the earlier version of the data reported on here—and in Whitacre and Biedny (2022)—where agricultural-specific locations were explicitly identified. This is a disappointing development, since the BSLF holds a great deal of promise for documenting agricultural facilities that could benefit from broadband. The data discussed in this paper suggest that it is possible to identify these locations. It remains to be seen whether the final BSLF dataset provided to researchers, policy makers, and providers will include more categories of structures than just those for business and residential purposes.

Recent federal legislation and funding has paved the way for significant improvement in rural America's broadband situation. Connecting agricultural structures such as barns, silos, or storage should be part of the discussion, but challenges remain. Rural and agricultural advocates should be aware of the pending broadband funding and maintain contact with their state-level entities that are responsible for map development and requests for proposals. The BSLF can help make the case for why agricultural locations should be included in broadband funding decisions. However, each state controls their own purse strings, so the final results may be dependent on local advocacy groups and the strength of the arguments with key decision makers.

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# Informing Broadband Policy Decisions with Better Data

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*JEL Classifications: D52, H54, I23, K23, L86, L96, O3, O18, O52*
*Keywords: Depressed Areas, Incomplete Markets, Internet Services, Public Infrastructure, Regulated Industries, Research Institutions, Rural Development, Technology Policy, Telecommunications*

Coverage maps provided by federal and state sources—particularly those based on data provided by carriers—often provide an unrealistic and optimistic perspective of actual high speed (25/3 Mbps [megabits per second] download/upload) broadband availability in the real world.[1] Frustration with the failure of actual, experienced access to meet stated coverage standards led to a ground-truthing effort that involved collecting better local coverage data to inform policy decisions. Validated local data in this case resulted in different priorities and allowed policy makers to better address actual needs. We describe the collection process and uses made of data from local user surveys of residents in rural areas of Washington to examine how the actual experience of users of high-speed broadband differs from publicly available coverage maps. Second, we address whether the availability of better data will lead to different policy decisions regarding access. Finally, we assess what data collection approaches best support development of validated broadband availability maps.

Facilitated by WSU Extension, members of the Stevens County/Spokane Tribe Broadband Action Team (BAT) in Washington State set out to better understand the differences between what they were hearing from community members about broadband access and what was being reported by commercial providers. This BAT is the first BAT organized in Washington and includes over 45 members representing many organizations, agencies, concerned citizens, and elected officials working to improve internet access and use in this rural area of Washington. Members of the BAT were aware that many rural parts of Stevens County and the Spokane Indian Reservation did not have adequate internet service and that published data and maps about internet availability were not accurate. Accurate broadband mapping is critically important to residents, businesses, and communities to document where robust broadband is unavailable. It was clear to BAT members that the then-current national broadband map was telling the wrong story and did not match actual Stevens County broadband availability. What was needed was documentation of this disconnect in order to inform policy and improve availability. According to the Federal Communications Commission (FCC) data available at the time, Stevens County was considered 100% covered AND at speeds that our research indicated were only available in limited areas. Further investigation led to these discoveries:

- Based on current reporting requirements, providers indicated level of service in areas defined by census block, which includes advertised speed and the available technology if available anywhere within a block, without reference to general coverage across the block(s).
- Provider-advertised speeds are aspirational and also reported at the census block level but may not be available anywhere in the block. In addition, often of the indicated service does not actually meet the FCC's broadband definition of 25/3 Mbps (megabits per second) download/upload times.

To help secure additional information about internet access and use, the WSU Extension-led Stevens County BAT conducted a community broadband survey between January 7 and February 15, 2019, that was made available both online and in hard copy form. Libraries and tribal offices provided hard copies of the survey which when completed were returned and input into data files by WSU Extension staff. During the survey timeframe, 505 responses were received, with 28 additional online surveys submitted in late February for a total of 533 responses. The survey was designed to determine which internet services were available in the community; document the actual experience of home internet availability; and explore how services were or might be used, whether there was interest in additional

[1] For our purposes, we define "high speed" as at or above 25/3 Mbps transfer speeds as adopted by the FCC and the Washington State Legislature in Revised Code of Washington (RCW) 43.330.536 in 2019, which recognizes that this threshold should be advanced to 150/150 by 2028.

internet services, and the barriers to obtaining adequate service. The community survey was promoted through news releases, a radio interview, Facebook posts, posters, word of mouth, and email distribution lists from members of the Stevens County/Spokane Tribe Broadband Action Team, including WSU Stevens County Extension. The survey responses do not represent a statistically valid sample of the population and results cannot therefore be generalized, but they provide an informative snapshot of the circumstances regarding internet availability and use for residents in the county who responded to the survey. The survey response population is, however, broadly representative of the demographics of the county as a whole, with about 78.2% of respondents indicating their race category as White. About 13.4% of those responding indicated their race as Native American—a key element of the population, and typically underserved.

## Speed Test Results

WSU researchers worked in partnership with Measurements Lab (M-Lab), to make available a platform to allow individuals to test Stevens County and Spokane Reservation internet speeds. Survey respondents were asked to complete an online broadband speed test. The website link provided by M-Lab for use during this project allowed us to collect data on 590 speed tests. As Figures 1a, b, and c indicate below, based on the FCC definition of minimum broadband download and upload speeds (25 Mbps download/3 Mbps upload), 83% of respondents were below the minimum for download and 66% were below the minimum for upload target speeds.

## Survey Question Responses

The first question asked survey respondents how much they were currently paying for internet services, both bundled and standalone. The overwhelming majority of responders indicated that their monthly cost was over

**Figure 1a. Download and Upload Speeds—FCC Definition and as Reported via Surveys**

| | | |
|---|---|---|
| FCC definition of broadband minimum internet speeds: | 25 Mbps download | 3 Mbps upload |
| From our survey respondents: | 83% < 25 Mbps | 66% < 3 Mbps |

**Figure 1b. Download Speed**

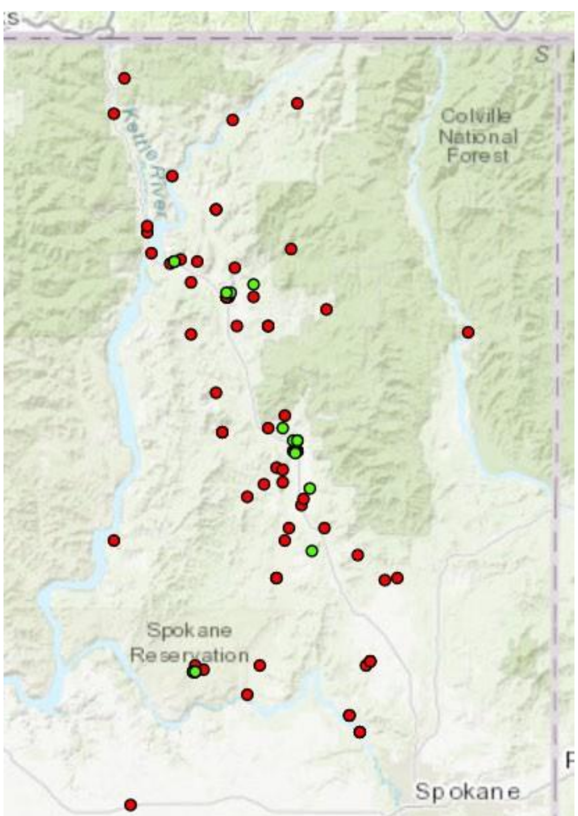
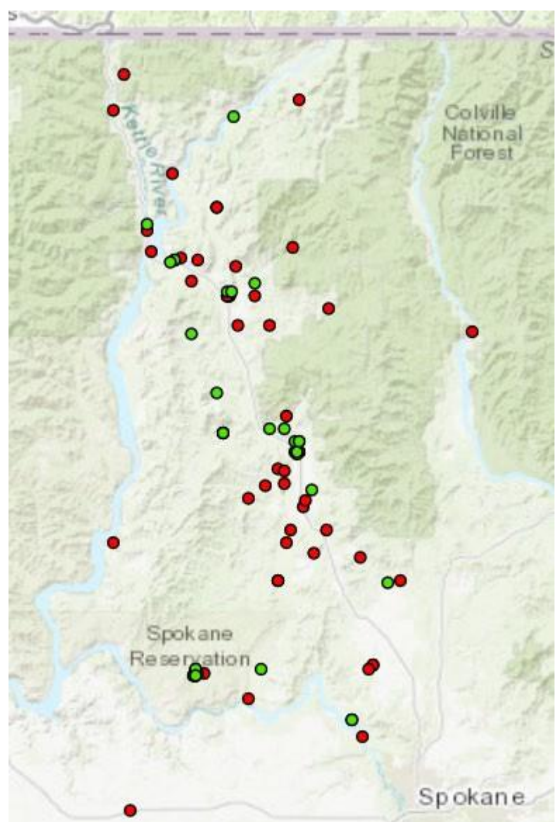



**Figure 1c: Upload Speed**




Note: For Figure 1b, red indicates download speeds of < 25 Mbps and green indicates speeds of > 25 Mbps. For Figure 1c, red indicates download speeds of < 3 Mbps and green indicates speeds of > 3 Mbps.

$100. The next most frequent responses to this question were $70–$79 and $50–$59 per month. The most frequent response to a question about the most they would be willing to pay for internet access was $50–$59 per month, followed closely by $70–$79 per month, indicating that the $100 cost being paid by many is likely well above their preferred rate and likely above what they can reasonably afford. The next question asked respondents about their level of satisfaction with aspects of their internet service. The responses, as displayed in Figure 2 below, indicate high dissatisfaction with price, reliability, speed (highest dissatisfaction), data cap limits, and overall satisfaction. Respondents reported moderate satisfaction with customer service and technical support.

### *How Satisfied or Dissatisfied Are You with the Following Aspects of Your Internet Service?*

When asked how internet services benefit, or would benefit, respondents in their home, survey participants reported current use of their internet for email, access to health care, social media, and passing time. If those responses are overlapped with the need for better speed and reliability, responses indicate that they would use internet services for those purposes and for video conferencing, distance learning, and homework. Asked why they do not have internet service in their home, 39% of respondents reported that it was not available in their area. The second most common response (31%) was that available internet services were too expensive. When asked whether they would be interested in contributing to broadband expansion in their area, 121 (just under 30%) responded with “yes” and provided their contact information, which indicates interest and willingness to participate in a solution for this region. Figure 3 below provides percentage response and the types of assistance that survey respondents indicated they would be willing to support, with 40% indicating that they would be willing to allow use of a high point or tall structure on their property for a cell tower.

The survey also provided an opportunity for participants to provide additional comments or suggestions:

> *We are two retired people in our late 60s. We perceive that we are being left behind in the world that is more and more dependent on information being available quickly and the technology that makes it possible. Ironically– and potentially tragically – since we live in a remote area, sources of information relevant to our safety and wellbeing such as status of weather, fire danger, road conditions, emergencies are all but unavailable with onlya dialup connection.*

> *I can’t tell you how many times I haven’t been able to do important things like online banking, update my business website, the kids can’t do research for homework because of data caps and/or weather disrupting service. It’s very frustrating.*

> *I have had teachers tell me they don’t believe me when I tell them I do not have internet, or that my internet is so bad that I cannot turn in assignments. It makes me very happy to see a survey being put into the communityto try to*

**Figure 2. Level of Satisfaction with Service Aspects**

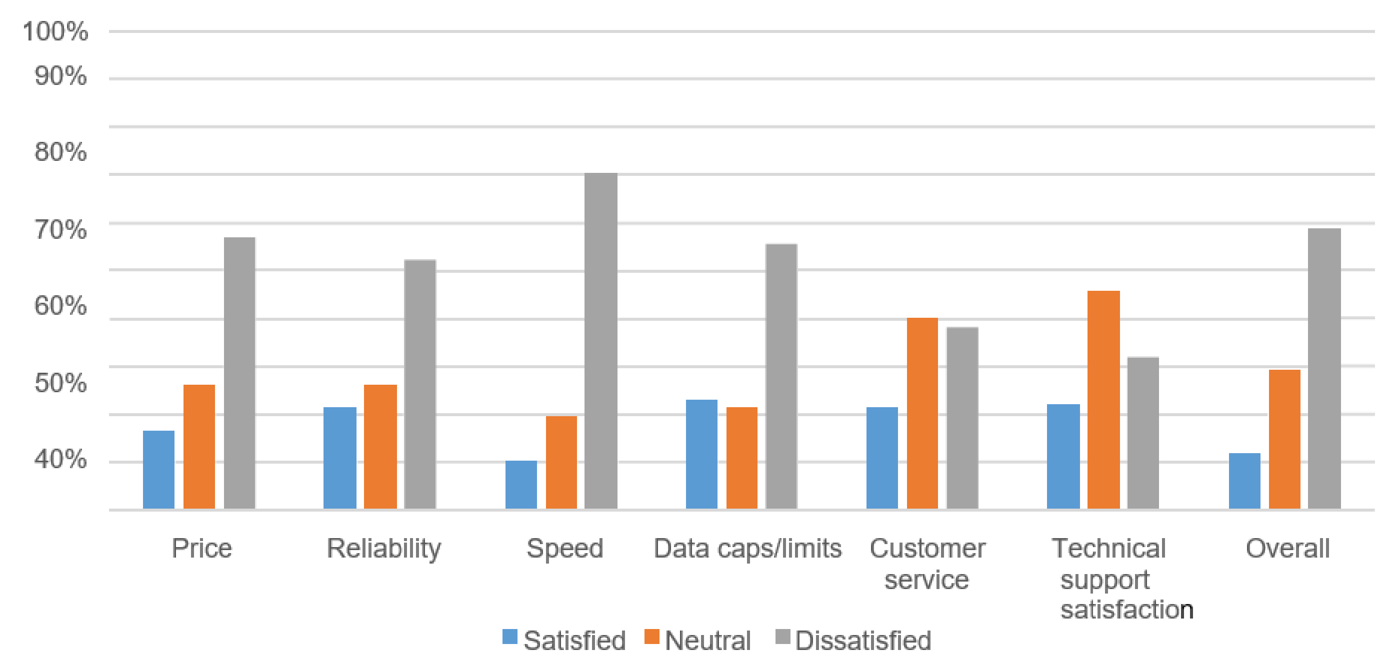
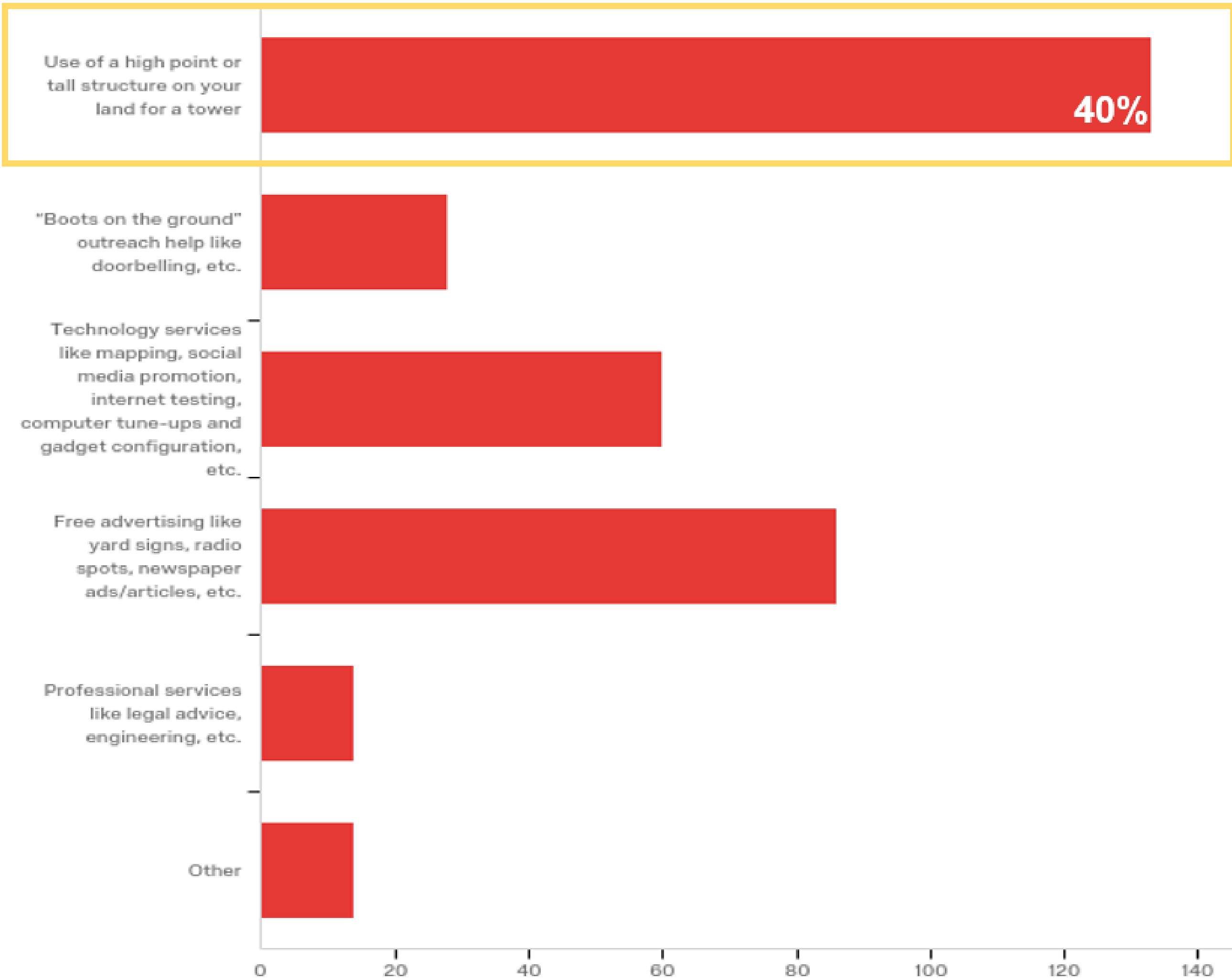


**Figure 3. Types of Assistance Survey Respondents are Willing to Support**




*accommodate for the people who live in areas that are not technologically provided for due to their location.*

## Policy Application

Following the release of preliminary data from this study, the 2019 Washington Legislature passed Second Substitute Senate Bill 5511, which was signed and codified as RCW 43.330.536. That legislation established target broadband speeds for the state, increasing over time, and established the Washington State Broadband Office under the Department of Commerce. That new office has since adopted a "State Broadband Access and Speed Survey" (https://www.commerce.wa.gov/building-infrastructure/washington-statewide-broadband-act/) and has partnered with WSU Extension to dramatically expand the number of Broadband Action Teams across the state using the Stevens County model developed by WSU. There are currently 30 BATs formed in Washington. That office also partnered with WSU Extension early in the COVID-19 pandemic to enlist partners and establish a broad network of "Drive-up Wi-Fi Hotspot" sites across the state to provide access to those in need. Building on that initial student-focused WSU effort, that state effort currently lists several hundred sites. (https://www.commerce.wa.gov/building-infrastructure/washington-state-drive-in-wifi-hotspots-location-finder/)

## Conclusions

The FCC has improved how it acquires data related to speeds on mobile devices but still relies on internet service providers for data on fixed internet speeds. These data on broadband accessibility provided to the FCC by the largest internet service providers is inconsistent—largely because of collection and reporting protocols—with what those who use the service report about how well those services are working for them. With so many students and employees needing to study or work from home, the COVID pandemic shone a light on the challenges presented by no or inadequate broadband access. The FCC has recently implemented programs to help fix the recognized broadband access problems across the country. The State of Washington has implemented a direct assessment model through the Washington State Broadband Office that generates "ground-truthed" access data. Ground-truthed data on actual high-speed access availability, such as described here, can make a positive contribution to identifying and effective targeting of critical access needs.

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# Integrating Research and Extension to Improve Community Participation in Broadband Projects

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*JEL Classifications: O18, L96, H54*
*Keywords: Broadband policies and programs, Community member involvement, Extension, Integrated research/Extension, Participatory research*

With the passage of the bipartisan Infrastructure Investment and Jobs Act in late 2021, billions of federal dollars for broadband infrastructure will be flowing into rural communities via states, whereas most federal broadband infrastructure aid had previously gone directly to internet service providers (ISPs). The idea is that states have greater insights into local conditions and broadband needs. However, due to well-documented gaps in broadband availability data and maps, as discussed by Whitacre and Biedny (2022), states are unable to easily evaluate strategies, policies, and programs. For example, broadband data are currently aggregated and not available at the household level; further, the data represent where ISPs *could* serve customers rather than where they actually do.

In this article, we share how participatory research methods—coupled with an integrated research and Extension approach—can enhance rural community participation in broadband expansion projects. We document how university research faculty, university Extension (county engagement and state specialists), a community development group, and a rural electric co-operative's broadband subsidiary are piloting a novel wireless broadband technology in Turney, a small town in rural northwest Missouri. Although our study is in progress, we share this example now as broadband spending ramps up and the timing is right to share how integrating research and Extension with local participation may enhance broadband expansion projects.

In the context of an evaluation, using a participatory approach helped the project team determine the best mode for data collection, design the experiment and survey methods, and enhance the project's policy relevance. Participant input ensured that researchers had local buy-in, communicated with community participants to increase response rates, and benefited from insights on appropriate comparison communities. We hope our example inspires additional collaborative projects that further leverage Extension field and campus faculty relations to combine participatory research and evaluation methods as decision makers look to improve broadband programs in rural areas of their state.

## Using Participatory Methods to Improve Data Quality

Engaging local participants can conceivably improve the quality of data collected as part of a ground-up approach to broadband program evaluation. However, participation can also bias results by highlighting researchers' desired goals (Eckerd et al., 2021; Zizzo, 2010). Participatory evaluation builds on community-based participatory research principles as well as traditional evaluation techniques. It emphasizes improved communication and coordination with the local community and key stakeholders to improve experimental design, data collection, and data interpretation (via evaluation design). At a high level, stakeholders are groups with vested interest in a given project, such as community organizations (e.g., nonprofits) and community leaders (e.g., mayor, school superintendent, state representatives). See Box 1 for an explanation of community-based participatory research.

A participatory evaluation approach creates value for both academic researchers and community members (Cargo and Mercer, 2008; Vaughn and Jacquez, 2020). For academic researchers, there is value in identifying more relevant research questions, improving research quality, and collaborating with local community members to interpret survey and interview data within the local context and lived experience. Similarly, for community members, there is value in ensuring that research addresses relevant local issues, increases local ownership of a research project to provide a sense of pride and identity, and leverages increased publicity to pursue additional funding and resources. Extension faculty and staff help facilitate a relationship between the

**Box 1.**

Community-based participatory research is a framework for conducting research in partnership with those who will be directly affected by the research. Participatory research is an umbrella term for a wide range of research approaches that all share a common goal of treating participants as partners rather than as subjects. This type of research can also be described as action research, citizen science, or emancipatory research. The goal is to include participants at every point in the research process, from conceptualization to disseminating the results. The degree of participation will vary by project, depending on capacity and interest.

academic researchers and community members, ultimately improving outcomes for the state and residents.

### *Participatory Research and Its Nexus with Extension*

Collaboration across the land grant university can have a bigger impact on a community than any individual research project or outreach effort alone. Extension can be vital to understanding which local groups should be consulted and included in a project. This may include local ISPs, community development coaches and community organizers, economic developers, healthcare leaders, and school districts (Bryson, 2004). Local champions—residents who participate in project planning and management to some degree—play a critical role in building connections and developing buy-in between the community and the research team. Local champions can ensure that a research team understands the local context and answer questions from residents in more casual, and therefore more comfortable, settings.

Participatory methods can blend a variety of engagement opportunities to ensure that many community voices are heard. This may include in-person interactions, such as participating in existing events (e.g., community festivals and standing organizational meetings), hosting special events in the community, and personal one-on-one conversations between project advocates and prospective participants. In addition, community members can be reached via a combination of mailings, phone calls, and door hangers—particularly where there is limited internet access. Online engagement may range from email lists to Facebook groups to discussion boards to Zoom meetings. Even communities with poor broadband access may have sufficient cellular access to participate in online discussions. All these methods can be enhanced by partnering with local organizations and media (e.g., newspaper, radio, roadside signage) for endorsements and advertising.

### *Implications for Research and Evaluation Design*

Participation from those affected improves research and evaluation design. Local input ensures that researchers use an appropriate mode for data collection, communicate with community participants to increase response rates, and benefit from insight on appropriate comparison communities. Consulting local advocates also ensures the survey language makes sense to nonacademics and is positioned to build trust between researchers and participants.

Evaluations can vary in terms of what types of comparisons they make. For example, advance planning allows for comparison before and after a new broadband installation. If an installation is already in place, it is possible to compare communities with different levels of broadband access. However, it is important to ensure that other community characteristics are similar for this to be a valid comparison. It may be necessary to have multiple comparison communities to allow for averaging.

Participatory research methods can also be combined with other methods. In the case of research on broadband, installing connectivity equipment represents a clearly defined change in the status quo. Statistical techniques can exploit this change to better understand the impact with more accuracy than a pre/post comparison.[1]

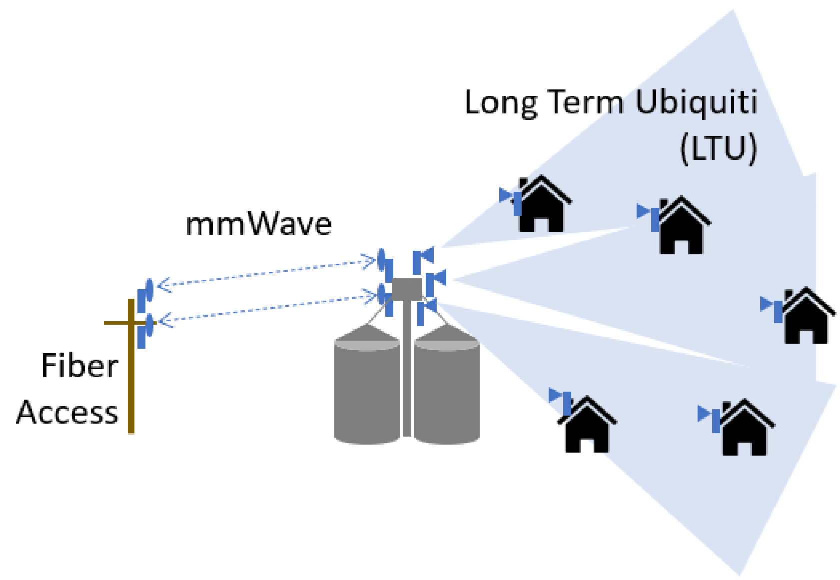
## Wireless Broadband Pilot Project in Northwest Missouri

Over 14 million Americans, and almost a half million Missourians, did not have adequate access to high-speed internet in 2020, according to the most recent federal data (FCC, 2021a). The majority of the unserved live in rural areas, where availability (83%) is 10 percentage points lower than in metro areas. This connectivity gap is especially frustrating for rural communities close to urban centers (i.e., metro-adjacent), which lose daytime population, and their dollars, to commute outside the county for work.

To address this challenge, we deployed a wireless network in Turney, Missouri, to expand the fiber network owned and operated by United Fiber, a subsidiary of United Electric Cooperative. Further, we partnered with a local community development organization and University of Missouri Extension, whose deep local networks allowed us to use a participatory approach in

[1] For example, a statistical technique called difference-in-difference can be used to estimate the effect of broadband installation by measuring incremental improvement between the period prior to installation and the period after, assuming there have been changes over time anyway. For examples, see Rephann and Isserman, 1994, and Biedny, Whitacre and Gallardo, 2022.

**Figure 1. High-Level Overview of Wireless Installation**




our research project. Turney is representative of many small communities in the Midwest with respect to the presence of electric co-operatives as ISPs and Co-Operative Extension resources. Turney, located one hour northeast of Kansas City, has a population of 255, with 91 households, according to 2015–2019 American Community Survey data.

Our project team is cross-industry and cross-disciplinary, including academics (Missouri University of Science and Technology, Worcester Polytechnic Institute), Extension state specialists and county engagement specialists (University of Missouri), and community leaders (United Electric Cooperative/United Fiber and The Clinton County Initiative, supported by Maximize NWMO, the regional vitality initiative of the Community Foundation of Northwest Missouri). The local and regional community development groups are collaborations that include informal and formal leaders in education, health, economy, quality of life and government sectors as well as other interest areas. On-the-ground assistance from University of Missouri Extension and the grassroots infrastructure and engaged volunteer team aimed at inclusivity and shared interests that is supported by Maximize NWMO have been critical to this project. Broadband is a key priority for all of these groups, so we wanted to align our project with the largest number of participants possible in a sparsely populated area.

From a technical perspective, we are developing and testing an "intelligent router" to more dynamically allocate bandwidth between households to improve quality of service in a bandwidth-constrained environment. As shown in Figure 1, this includes a millimeter wave connection from the existing fiber network to the highest point in the center of Turney, a grain elevator. From this point, the network is distributed wirelessly using point-to-multi-point radios that use a proprietary protocol called Long Term Ubiquiti (LTU).

In addition to our project, Turney is partially served by a large ISP that is providing wired (non-fiber, VDSL) access as well as a preexisting fixed wireless provider.[2] Although the large ISP provides high-speed service (above 25 download/3 upload megabits per second [Mbps]), the preexisting fixed wireless provider service is not able to do the same (FCC, 2021b). Our wireless service provides speeds of approximately 200/50 Mbps, which exceed both existing providers and have a similar cost to consumers. As part of this project, we offered participants internet service free of charge from the time of installation (between October 2021 and February 2022) through April 2022 in exchange for participating in the evaluation of the project's effectiveness.

### *Our Participatory Efforts*

In addition to the technical innovation, this project aimed to estimate the social impact of improved broadband access via survey and interview data. Following a community-based participatory research approach, we first began building relationships within the community to identify local champions. Although some of our team members are residents of the study county, none of the

[2] A subset of households in the study community were satisfied with their existing internet provider, the large ISP. Although this provider offered slower service, households were not motivated to switch providers unless they were highly dissatisfied. This is typical behavior, which makes it difficult for ISPs to predict adoption because highly dissatisfied is subjective and unquantified. There is inadequate data on existing providers, and service quality can quickly change if competitors upgrade equipment in anticipation of increased competition.

**Table 1. Comparing Turney and the Comparison Communities**

| Characteristic | Turney | | Comparison Community Avg. | |
|---|---|---|---|---|
| | ACS | Survey | ACS | Survey |
| Households (#) | 91 | 54 | 482 | 36 |
| Residents per household (avg. #) | 2.80 | 2.96 | 1.94 | 2.67 |
| Age 5-17 (%) | 31 | 19 | 23 | 21 |
| Bachelor's degree or higher (%) | 10 | 39* | 12 | 44* |
| White (%) | 90 | 98* | 93 | 94* |
| Households with wired internet access (%) | 53 | 17 | 45 | 53 |

Notes: ACS data from the U.S. Census Bureau's American Community Survey, 2015-19.
*Survey respondent only, does not include the entire household.

original team members were residents of Turney. We targeted local organizations, such as the Turney Historical Society and churches, as well as government representatives, such as the mayor. We identified an Extension employee who is a Turney resident—co-author Debra Davis—as well as a Turney-based pastor to function as local champions.

In April 2021, we launched a community-facing website (https://www.maximizenwmo.org/broadband-project-overcome) to provide a central place for information about the project. In June 2021, we hosted an ice cream social at a Turney picnic shelter to announce the project, raise awareness, and provide opportunities for residents to ask questions. At this event, 19 households signed-up for additional information.

In September 2021, we hosted a kick-off event to announce that the primary network infrastructure was in place and we were ready to begin connecting households. Over 30 people attended this event, including a local state representative and school superintendent. At this point, 34 households expressed interest in participating in the network by completing our presurvey.[3] Because the town of Turney contains only 91 households, this was impressive turn-out—potentially driven by our participatory approach and trust-building in Turney. Unfortunately, only 12 of the households that expressed interest were within line of sight to connect to the network. To increase enrollment and leverage word-of-mouth awareness, we followed locals' advice to install a sign in the middle of town (November 2021) and use door hangers to target specific unenrolled households that met project criteria (January 2022).

Efforts to recruit households continued through February 2022. Ultimately, 29 households have been connected to the network. An additional 21 households expressed interest in participating but had inadequate line of sight due to terrain and tree coverage.[4] Most enrolled households are within one mile of the grain elevator. A few households have been able to connect at farther distances (up to three miles), particularly when near a major roadway that reduces tree coverage or when an additional pole could be installed to extend the wireless signal.

### *Measuring the Impact of the Connectivity Gap*

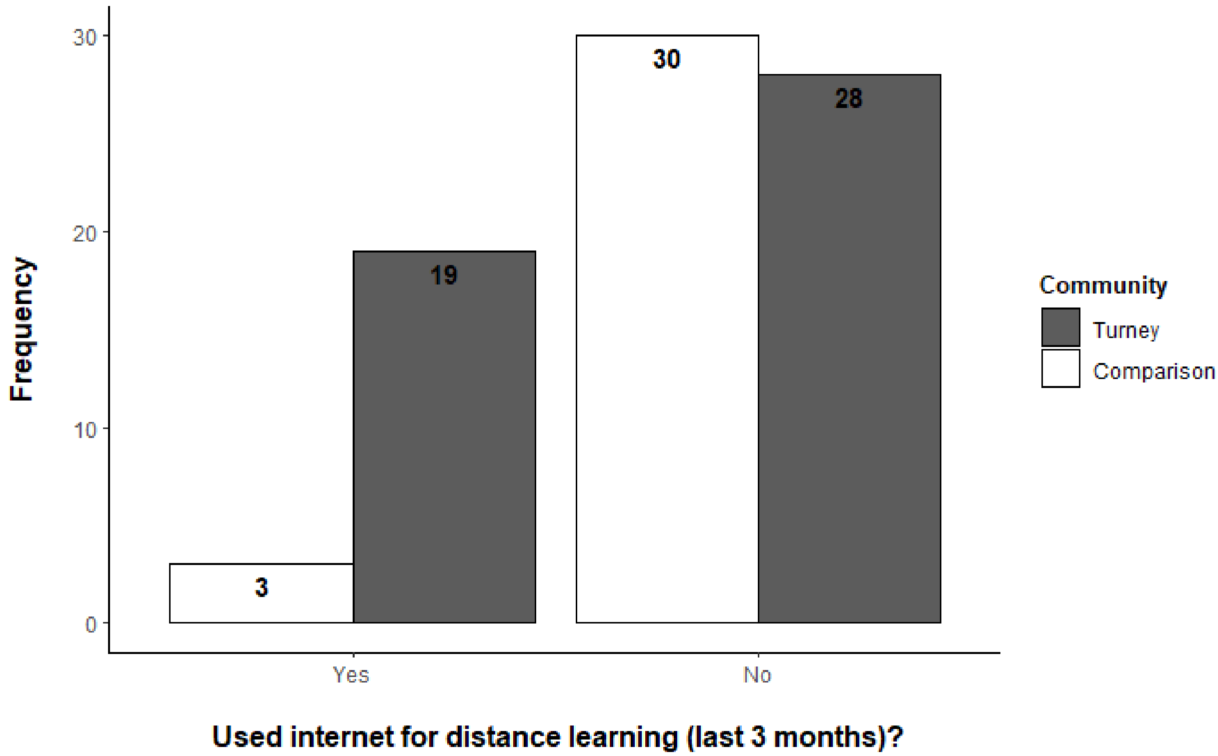
In the evaluation, the key outcomes of interest included use of the internet for employment (especially entrepreneurship and remote work), education, and healthcare. We selected 13 nearby communities as comparison communities, using 2015–2019 American Community Survey (ACS) demographic and broadband data. The comparison communities, on average, were similar to Turney (Table 1). The large margins of error in small-town ACS data led us to also use local input in selecting comparison communities, another instance in which the participatory approach was helpful. Data from the 2020 decennial census, which will be released later in 2022, will include improved estimates.

In August 2021, we launched the evaluation with a mailed presurvey. We mailed 200 surveys to households within a three-mile radius of the grain elevator in Turney as well as 700 surveys, to a random sample of households in 13 comparison communities. We had a 27% response rate (51 respondents) in Turney and a 5% response rate (36 respondents) in the comparison communities. The difference in response rates between Turney and our comparison communities was anticipated. It partially reflects the incentive for Turney participants (i.e., free high-speed internet) and partially reflects the impact of our participatory approach in

[3] Some households had previous negative experiences with fixed wireless service, which was typically unable to provide speeds exceeding 10/1 Mbps. This created some hesitancy to enroll in our study, which uses a much faster wireless technology.

[4] Software tools to estimate wireless propagation are often inaccurate, so signal measurements had to be taken at each household's location to evaluate whether they were a good candidate for connecting to the network.

Figure 2. Example of Survey Data Requiring Local Input for Interpretation




Turney. Ultimately, more than a third of Turney's 91 households are involved and more than half participated in our initial survey.

The participatory approach also supports efforts to interpret the survey results. For example, when asked, "In the last three months, have you used the internet for the following activities?" Turney residents reported higher demand for the internet for education tasks. Approximately, 37% of Turney residents reported using the internet for distance learning, while only 8% of residents in the control communities reported the same (Figure 2). Since Turney participants knew that they were completing this survey for improved internet access, they may have been incentivized to exaggerate demand or consider how they have used the internet over a longer period. In contrast, the comparison communities may be less motivated to remember or only focus on how they have recently used the internet, which may influence their responses.

Our local champions and larger community-based team identified additional explanations for the difference between the Turney and comparison community results. For example, Turney is located further from a public library than some comparison communities, making it more difficult to use the internet at a library. Second, Turney residents may be more likely to work in occupations better suited to remote work. Turney respondents had higher education levels, particularly in post-graduate education, than comparison community respondents, despite the two groups being similar in age. The interpretations gleaned from our community participants help prevent errors in interpreting the results of our research.

## Lessons Learned

Our experience suggests that integrating research and Extension in broadband projects can make a bigger contribution to rural communities than either research or Extension can alone. We use our wireless broadband pilot project in Turney, Missouri, and efforts to measure its social impact as an example of a participatory project that depends on a team of academic researchers, Extension faculty, ISP partners, and community leaders. While this approach of inclusive involvement has not eliminated broader issues associated with data quality or bias in small communities, having strong local participation in the study community has made this project more robust. It has also raised awareness throughout the whole county and surrounding region of the need for more innovative and collaborative approaches to finding solutions to shared needs. Local newspapers have proactively covered the project and local and state elected officials have mentioned the project repeatedly in their public meetings and special interest community forums. Sample size is a major constraint for evaluations in small communities because researchers can only perform simple statistics (Coughlin and Smith, 2016; Riley and Fielding, 2001). Collaborating with local champions to identify strategies for increasing participation via various incentives and touchpoints has increased the quality of this research.

Broadband pilots and strong evaluations are critical for ensuring that government funds are being effectively deployed. It is likely that the determined effectiveness of the first portion of funds from the Infrastructure Investment and Jobs Act may affect eligibility for subsequent tranches. Participatory methods lend themselves to bottom-up evaluations of broadband solutions. When using participatory methods, however, one must carefully consider the incentives being created and how they may affect the research project. Our pilot benefited the community members who received free high-speed internet and research efforts were improved with community participation and on-the-ground feedback, but—as demonstrated—our results may be affected by the free high-speed internet incentive. We hope our study inspires additional participatory research and evaluation as policy makers strive to ensure access to high-speed broadband connectivity for all Americans and as rural communities consider wireless broadband technologies as a medium-term solution until fiber internet service is broadly available.

## For More Information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# Innovation and Digital Connectivity: Comparative Policy Approaches for Connecting Rural Communities in the United States and Canada

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*JEL Classifications: O18, O30, O35, R10*
*Keywords: Connectivity, Broadband, Public and private sectors, Rural communities, Policy*

Current approaches to achieving basic broadband connectivity are fairly well understood from a technical standpoint (Hilbert, 2016) and in specific locales, such as urban settings (Baker, Hanson, and Myhill, 2009), but have been less effective in rural areas, and to a number of underserved populations. Cataloging and evaluating the array of tools, approaches, and partnerships (public-private, purely private, intergovernmental, etc.), would provide useful information for policy makers working on connectivity initiatives. Looking past the importance of basic access, the dimensions of robust connectivity must be understood by unpacking its various aspects. Consider the distinction between simple access—connectivity—and the *usability* and, hence, utility of broadband and associated information-related technologies.

Both rural connectivity and usability pose implementation challenges, given disparate populations, variable terrain, and highly variable, even unpredictable, costs to build and sustain access. Broadband connectivity is relatively common in urban areas, for instance, about 97% in the United States. Conversely, rural connectivity, estimated at about 74% in the U.S. and 46% in Canada (albeit at different speeds), reflects the challenges of building and maintaining access, both in the United States (USDA, 2019; NACO, 2020; FCC, 2020) and in Canada (Gaspard and Khan, 2021; Hambly and Rajabiun, 2021). Typically, the narrative on connectivity is addressed in terms of supply and demand. We argue in this paper, that an overlooked set of actors have an important role to play. These stakeholders—intermediaries—include institutions such as universities, trade groups, and other industry-related organizations (Baker, Gaspard and Zhu 2021). Intermediaries can provide additional opportunities to link resources for connectivity, funding, and infrastructure and the places and people that may want or need the connectivity. This paper reviews the availability of rural connectivity in the United States and Canada, explores the role of intermediaries for connectivity, and discusses two cases (universities in the United States and the SWIFT rural broadband initiative in Canada) and the associated policy implications for connectivity advancement.

## Rural Connectivity in the United States and Canada

Common definitions of rural communities include sparse populations and distance from an urban center (Reimer and Bollman, 2009). Rural communities often struggle for access with varying degrees of distance and isolation from population centers and access to goods and services (Pant and Odame, 2017). From limited health and social services availability to precarious employment and limited or at best, variable, access to broadband, the differences between urban and rural places have been especially pronounced during the pandemic (Weeden and Kelly, 2020). Relative to the United States, United Kingdom, and Australia, Canada has a higher standard (50/10 download/upload megabits per second [Mpbs]) of connectivity coverage (see Table 1).

The need for public investment in rural broadband is reflective of the limited business case for solely private sector investment. Most common, in both Canada, and the United States, are hybrid approaches, in which public subsidies are used to incent the private sector to provide connectivity and access to broadband services, where lacking. As one of its many rural connectivity programs, the U.S. Federal Communications Commission (FCC) uses reverse auctions to encourage private sector activity in rural places with limited or no service. In Canada, various funds and programs subsidize private sector investment to promote rural connectivity.

Missing from much existing research is an in-depth examination of the linking mechanism between funding and connectivity. From locally based not-for-profit

**Table 1.**

| Country | Rural population % (World Bank, 2018) | Connectivity rates of households Note: various speeds and technologies |
|---|---|---|
| Australia<br>(Julian Thomas, et. al, 2020) | 19% | "Internet access"<br>National: 76%<br>Capitals: 78%<br>Rural: 73% |
| Canada<br>(CRTC, 2020) | 18% | 50/10 Mbps<br>National: 87%<br>Urban: 99%<br>Rural: 46%<br>First Nations reserves: 35% |
| United Kingdom<br>(Ofcom, 2021) | 16% | "Superfast" broadband, at least 30 Mbps (download<br>National: 96%<br>Urban: 98%<br>Rural: 83% |
| United States<br>(CRS, 2019) | 14% | 25/3 Mbps (minimum)<br>National: 94%<br>Urban: 98%<br>Rural: 74%<br>Tribal regions: 68% |

organizations to universities, a variety of intermediaries work to leverage either funding or infrastructure/service offerings from providers to foster connectivity in underserved rural places.

In each country, the core actors include private industry carriers, as well as the public sector (federal, state, provincial, municipal), with various other institutions operating as intermediaries. In Canada, for example, Southwestern Integrated Fibre Technology (SWIFT) and Eastern Ontario Regional Network (EORN), are two not-for-profit Ontario-based organizations that aggregate the interests and resources of smaller rural communities to promote connectivity by running procurements. Others, such as O-Net in Olds, Alberta, built their own not-for-profit organization dedicated to providing rural broadband to their community. Analyses of instruments for financing and delivering rural broadband are emerging contributions to the literature (Millard, 2020; Gaspard and Khan, 2021) and merit further attention as policy options for jurisdictions grappling with connectivity.

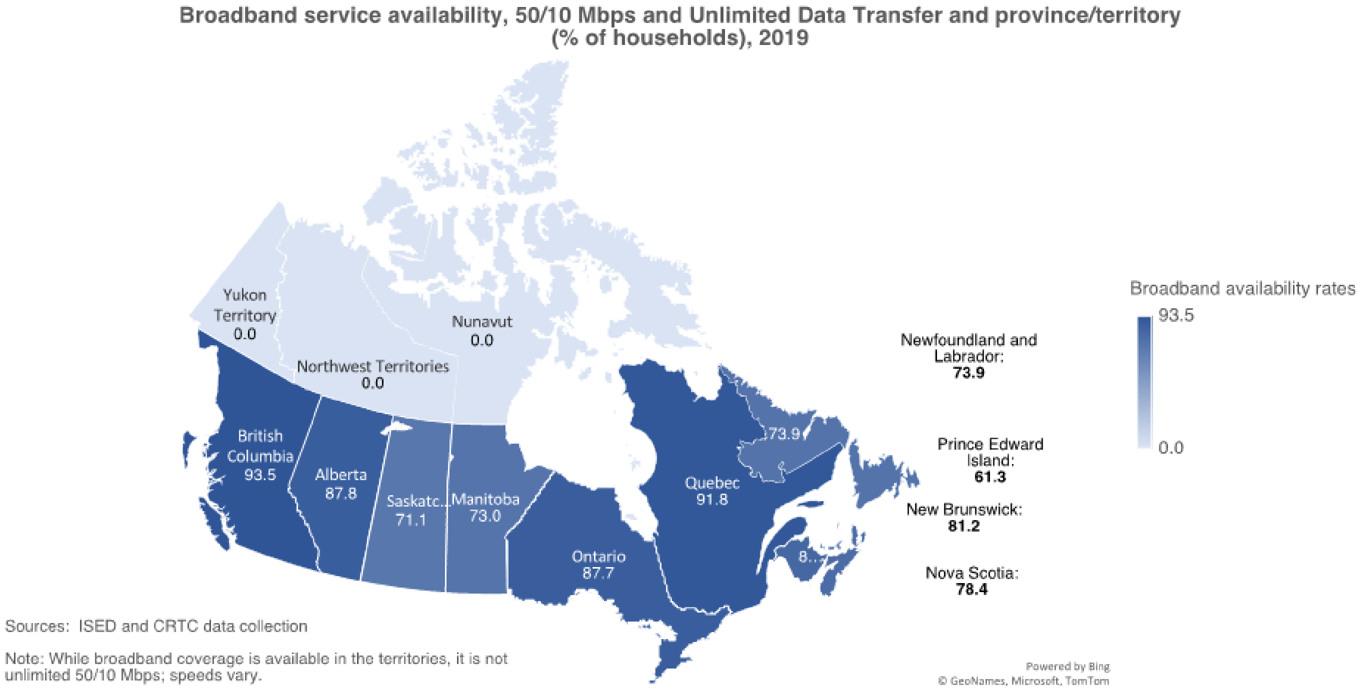
## *Connectivity in Canada*

Nationally, 87% of Canadian households have broadband connectivity at the standard 50/10 Mbps speed. Disparities emerge, however, when connectivity is compared across urban and rural locations. Almost all (nearly 99%) of *urban* households in Canada meet a 50/10 Mbps connection standard, compared to roughly 46% of rural households and 35% of households on First Nations reserves. In Canada, nearly 20% of the population lives in a rural place, which means that a not-insignificant portion of the population is more likely to experience connectivity challenges. Higher rates of rural connectivity in British Columbia (93.5%) and Quebec (87.7%) may be the result of increased provincial engagement in connectivity, with initiatives and funding to leverage investments from the private sector and federal government.

Canada has made a well-defined political commitment to connecting Canadians "wherever they live," reflected in mandate letters to ministers from the prime minister (Gaspard and Khan, 2021). When combined, various sources of federal funding for rural broadband amount to $8 billion (CAD) with an additional $1 billion (CAD) announced in the 2021 federal budget (Gaspard and Khan, 2021). Past estimates by the Auditor General suggest that broad connectivity could be achieved for approximately $6.5 billion (CAD) if multiple forms of technology were used to connect Canadians. Falling within that range, TELUS (one of Canada's three major telecommunications service providers) estimates that it would cost between $6 billion (CAD) and $10 billion (CAD) to connect the 14% of Canadian households currently without access (TELUS, 2020).

In a 2021 survey of instruments for funding rural broadband connectivity, Gaspard and Khan (2021) concluded that Canada's approach would benefit from

**Figure 1. Broadband service availability in Canadian provinces and territories**




Source: Reproduced from Gaspard and Khan (2021), Figure 3, with data from CRTC, 2020.

streamlining and diversification, with the various federal departments and agencies coordinating internally to adjudicate applications and requests for funding. These approaches require data and recognition that differentiation between urban and rural places is necessary. TELUS estimates that the cost of connectivity is 2.5 times greater in rural places than in urban places. With different costs, terrains, consumer uptake, and demand, policy governing spectrum and instruments for financing and delivery should reflect these differences as well. In Canada, typical cost-sharing arrangements between public and private sectors range from 50/50 private-public to one-third private and two-thirds public.

Different mixes of approaches and actors have helped bridge connectivity gaps by working to encourage private sector efforts to build out the infrastructure needed for connectivity, where demand exists. Going beyond traditional supply and demand approaches, network intermediaries in Canada can help facilitate expanded approaches for achieving policy objectives within the existing system. The examples of network intermediaries with regional contexts, offer insights into how to innovatively pool resources and expertise to generate solutions taking into account current system-level challenges.

## *Connectivity in the United States*

In the United States, 20% of the population, some 60 million, reside in rural places. Operating with additional challenges are some 628,000 tribal households who lack access to standard broadband, a rate more than four times that of the general population (FCC, 2020). A 2019 study by the American Indian Policy Institute found nearly one in five reservation residents had no access to the internet in their homes (Howard and Morris, 2019).

An important factor in implementation decisions is the availability of explanatory data, as lack of a complete or comprehensive source of data capturing fully all aspects of the problem increases uncertainty of outcome. Pertinent to this, the National Telecommunications and Information Administration (NTIA, 2021b) observed that “there is no single data source that indicates definitively where broadband services and technologies are available, which speeds they provide, the cost of service, or the rate of subscriptions among individuals, households, businesses, or organizations.” In 2017, high-speed internet was available to about 93.5% of the population through fixed terrestrial technologies like cable, including about 73.6% of the rural population, and high-speed internet was available through satellites to virtually the entire population (Wilmoth, 2019).

In the United States, a range of public sector initiatives at the federal, state, and regional/local levels; public-private partnerships; NGO/advocacy-related activities; and purely private sector initiatives, address rural connectivity in different ways. Federally, direct program funding has come from multiple agencies, including the Department of Agriculture ($167 million); the Department of Commerce (NTIA—$1 billion for Tribal Broadband);

the Departments of Education, Housing and Urban Development, Labor, and Treasury; the National Science Foundation, and the Northern Border Regional Commission (NBRC). Broadly, the American Rescue Plan of 2021 included some $360 billion to address rural connectivity issues. In addition, the FCC operates a series of targeted programs, including the Universal Service Fund (USF), consisting of the Connect America Fund for rural areas, the Lifeline Fund for low-income consumers to purchase internet services, and two funds for schools and rural health care.

States tend to favor incentive-based approaches, encouraging actors to develop connectivity initiatives rather than providing direct funding or public sector infrastructure. Additional policy strategies include research funding initiatives and new approaches to technology deployment, tax incentives, and job creation. States continue to establish programs such as broadband offices and task forces, and to expand the types of entities that can engage in broadband deployment projects or service provision (Read and Gong, 2021).

Overall, we examine the issue of rural connectivity from a multidimensional perspective—the components of the problem, the locale, actors, and possible policy approaches generated by actors:

- **Context of,** and associated **data** available for a given analysis. For instance, what are the geographic parameters, distance, density, and terrains used to inform problem definition?
- **Technological solutions**: What are the technological based solutions to rural connectivity, and how are they implemented?
- **Actor/stakeholder** interests need to be considered in policy alternatives for enhancing rural connectivity and to speak to their priorities and challenges.
- **Objectives/outcomes/impacts** of problem being solved. Does one solution (e.g., local government broadband) "break" another (e.g., subsidized competition with an incumbent carrier)?

## Intermediaries and Their Roles

As the model of service provision becomes more nuanced, the number of involved actors increases. Users (the demand side) can include individuals, communities, institutions, or businesses. An increasingly important player in the provision of information services (including connectivity) are network intermediaries, which can take various forms and can have varied objectives. One such example includes innovation intermediaries, entities that act as an agent or broker in any aspect of the innovation process between two or more parties. Innovation intermediaries are recognized as crucial actors that can facilitate the innovation process (Howells, 2006).

An innovation ecosystem, such as might be present in a rural community, can embody organic and holistic bottom-up approaches to economic development that supports innovation (Gault, 2010). Innovation ecosystems are composed of individuals, communities, organizations, material resources, rules, and policies across large and small businesses, universities, colleges, government, research institutes and labs, and financial markets that collectively work toward enabling knowledge flows. When it comes to connectivity, intermediaries are used here in their functional or operational capacity, rather than how they are structured or classified. That said, the functionality or role of an intermediary can be can be assumed by an actor in the public, private, or third sectors. Business, industry and trade groups, universities, not-for-profits, government-adjacent entities, and economic development authorities can all serve as intermediaries. We focus in this paper on two types of innovation intermediaries: universities and multi-jurisdictional regional coordinating agencies. Universities are typically thought of in their capacity as trainers of knowledge workers or sources of basic research and innovation. But universities can also be translators or network enablers with economic or community development capacity. In terms of rural connectivity, universities can act directly, as providers; secondarily to conduct research in innovation that might generate new means of connectivity; or indirectly, to provide support, say, as part of a cooperative effort. An example of direct action is efforts by Diné College, a TCU (Tribal Colleges and Universities) in Tsaile, Arizona, to enhance student internet access. The college leveraged federal CARES (Coronavirus Aid, Relief, and Economic Security Act) (2020) funding to help purchase Wi-Fi hotspots and laptops for students.

Operating as an amplifier or enabling agent in an *indirect role* represents an underexploited opportunity for universities in advancing broadband connectivity. By participating on multidisciplinary teams that incorporate industry representatives and academic staff and focus on community challenges, university researchers can become more effective citizens of their cities and economies (Chan and Farrington, 2018). Another option is to operate as nodes in innovation networks: the use of ICT to facilitate the establishment of virtual networks, allowing groups of rural entrepreneurs to connect with each other, and explore the obstacles, opportunities and solutions characteristic of broadband connectivity implementation in rural areas (Lyons, T., S. Miller, and J. Mann, 2018; Pew, 2020). Two examples of state-supported efforts include Virginia's Commonwealth Connect Coalition and the North Carolina Digital Equity and Inclusion Collaborative, which bring together universities and private and public sector actors to work to close digital divides (Stauffer et al., 2020).

A Canadian provincial government report underscored the responsibility that academia shares with the government for the health of the workforce and economy

(Premier's Highly Skilled Workforce Expert Panel, 2016). Universities increasingly recognize the importance of their technology transfer, innovation, and workforce development mandates at both the local and the national level (Chan and Farrington, 2018). They provide an example of such a broadband-related collaboration: The multi-year project (Research Partnerships to Revitalize Rural Economies Project), involved five universities and focused on 1) rural knowledge work and entrepreneurship and 2) innovation and sustainability in creative rural communities. Sample projects examined the use of technology by remote small business owners and employment and wage modeling of the impacts of broadband deployment in southern Ontario.

An article by Chan, Hassanein, and Ivus (2011) demonstrated that where the government made costly broadband investments in a region, job employment rates and economic vitality significantly increased. Intermediaries such as SWIFT, a publicly funded multi-jurisdictional coalition, provide an interesting example of how to bridge the gap between the public resources required to promote rural connectivity and data gaps on available opportunities to build solutions. Established as a not-for-profit organization to improve connectivity in a cluster of 15 rural municipalities in southwestern Ontario (with subsidies from the governments of Ontario and Canada), SWIFT leverages public funding and pairs it with private-sector resources to bring connectivity to underserved areas. SWIFT developed robust internal mapping to identify service gaps. The exercise is time- and cost-intensive and other actors engaged in connectivity either did not have the resources, incentive, or data to undertake the exercise. SWIFT operates by providing funding to address infrastructure gaps. The intermediary allocates dollars within its service area based on connectivity needs and competition. Rather than having the government allocate dollars, it streamlines and targets procurements based on its in-depth knowledge of the area and its connectivity.

### *Comparative Assessment*

By utilizing environments in which a variety of instruments can be applied, and not necessarily constrained by traditional supply and demand considerations, intermediaries can engage to close gaps and achieve the goal of connectivity. Canada's federal application and grant-based approach to funding rural broadband would benefit from integrating lessons in instrument diversification. In Canada, intermediaries are often able to successfully navigate the existing system to access funding for rural broadband. In terms of process, local policy makers in both the U.S. and Canada would be well served by 1) defining a baseline context, 2) determining gaps in access, service, cost and awareness, and 3) designing and developing context-specific approaches to improve basic access, and useful connectivity. Community capacity, and need should be defined and aggregated on a geographic basis and up-to-date information ideally used in critical baseline analyses to determine place connectivity, gap analysis, nodes availability, and how resources can be applied to develop solutions.

## Conclusion

As the cases of Canada and the United States suggest, implementation instruments—be they policy/regulatory, economic, financial, or technological—are most effective when designed to consider contextual conditions and reflect the diversity of the target community. A clear understanding of need is critical to attracting private-sector investments and offering sustainable solutions for communities. Mapping existing connectivity and community needs is essential for actors and intermediaries. Developing an understanding of what works and how would add to the literature, as well as provide insight for policy and decision makers. In summary, this analysis found that:

- To foster the deployment and long-term sustainability of rural broadband infrastructure connectivity, policy approaches and associated instruments must respond to contextual realities that reflect the diversity and needs of the community.
- Actors and intermediaries must conduct robust baseline assessment and build geographically based maps of connectivity and community needs (Ali, 2020).
- Attracting private-sector investments and offering sustainable solutions for communities requires a clear, empirically based articulation of needs, which can include direct (public) funding, tax incentives, directed program creation, and regulatory intervention.
- Absent broadband providers, a mix of implementation approaches (public sector, public/private, and non-profit) and intermediary engagement can address connectivity challenges in rural or underserved areas. There is no one-size-fits-all approach.

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# What Does COVID-19 Mean for the Workplace of the Future?

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*Keywords: COVID-19, Rural and urban economies, Telecommuting*

After 18 months of isolated, at-home work, it was widely anticipated that the workforce would enthusiastically return to the office and factory following the end of most COVID-19 workforce restrictions. However, as shown in Figure 1, the normally bustling District of Columbia Metro Center Station was far from crowded at 9 am Tuesday, September 7, 2021, the day after the Labor Day holiday weekend. Why wasn't the Metro station packed during peak hours?

We argue that the COVID-19 pandemic caused many U.S. workers to reassess their work status and the nature of their work, especially as regards working in an office or factory versus telecommuting (working from home). These reassessments are likely having a lasting impact on the U.S. labor market. Accordingly, we investigate some of the factors that likely affected the likelihood of Pennsylvania workers telecommuting during the COVID pandemic over a 9-month period (May 2020–January 2021). Among our findings, occupation, industry, education, and rural versus urban residency help explain who telecommuted and who did not.

## Other Work

Little analysis centers on telecommuting due to COVID. Bick, Blandin, and Merterns (2021) examined the shift to home-based work in May 2020 and found that COVID-based telecommuters were likely to be well-educated, white, and higher income. They also indicated that worker occupation and industry were important influences in the work-at-home decision. Dey et al. (2021) reported differences in COVID-based telecommuting by occupation classification and employee demographics. Albanesi and Kim (2021) examined COVID's impact on the U.S. labor market and reported less work and less looking for work by women due to in-person schooling and reduced access to childcare. Mongey, Pilossoph, and Weinberg (2020) examined the impact of social distancing policies and found that more economically vulnerable (e.g., lower income, less educated) workers were more likely to experience job loss as a result. Others have examined telecommuting before COVID. Gallardo and Whitacre (2018) contended that telecommuting is a benefit for local economies, with positive spillovers to neighboring areas, while Conroy and Low (2022) argued that improved broadband access results in increased rates of new business establishments, especially for women-owned businesses. Dingel and Neiman (2020) found that workers in better paid occupations are more likely to telecommute, while Lund et al. (2020) argue that better educated workers are more likely to do so. However, Frazis (2020) found that women were less likely to telecommute.

Numerous popular press articles have speculated on the likelihood of "the return to the office" once the pandemic eases, given the flexibility that telecommuting provides (Banister, Schenke, and Barragan, 2021, and Schenke, 2021, for example). This information, along with office occupation rates for major metropolitan areas (see the "Kastle Back to Work Barometer," 2022, for example), shows that workers have not returned to the office at anything close to pre-COVID levels. Therefore, we believe that work in general will likely become more virtual on a permanent basis, with many workers engaging in a "mixed" telecommuting work schedule that allows them to travel to the office 1–3 days a week. Because of these changes, we believe that our results speak not only to the impact of COVID on telecommuting patterns but also to emerging new work patterns in a post-COVID world.

## Our Analysis

Our primary data source is the Monthly U.S. Labor Force Survey, part of the Current Population Survey Microdata (the same dataset used by Dey et al., 2021, in their analysis). In our case study, the data are limited to workers living in Pennsylvania. The data were accessed through the Integrated Public Use Microdata Series (IPUMS-CPS). Using monthly data from May 2020 through January 2021, we examined whether an individual telecommuted at all that month, as possibly explained by whether they lived in a city versus a rural community, and their family income, race, educational attainment, and marriage, military veteran, and

**Figure 1. District of Columbia, Metro Center Station, 9AM 9/7/21**

Source: Banister, Schenke, and Barragan (2021).

citizenship status. Number of children and the number of children under 5 years of age in single-parent households were also included, as was family type (whether they are a traditional family or a nonfamily living together), whether their place of work was closed at any time that month due to COVID, whether the worker had more than one job, and month. Worker occupation and industry were also included, with each converted to a telecommuting likelihood value based on Dingel and Neiman (2020) for the former and Lund et al. (2020) for the latter. We limited our analysis to the top two wage earners in a given household, excluding workers who made only minor contributions to household income.

## Results

Among the 9,018 observations, 2,618 (29%) reported telecommuting due to COVID-19. We considered major arguments (hypotheses) regarding location (metropolitan or urban versus rural) as well as the influence of family income, gender, education, and age of the respondents (Table 1). Being a city resident, having higher family income, being female, and having more formal information was expected to positively impact the probability of telecommuting because of COVID, while age was expected to have a negative influence. Working in an industry or an occupation more prone to telecommuting was felt to have a positive influence on telecommuting. We had no idea how the number of children in a household would affect telecommuting, but single parents with children under 5 were expected to be less likely to telecommute due to COVID because of their home childcare responsibilities.

Our analysis tended to confirm these hypotheses (Table 1). Being a resident of a metropolitan area versus a rural area increased the probability of telecommuting due to COVID by 20.8%, while household income and age had a slight positive and a slight negative influence, respectively. Both being a woman or having more formal education had moderate positive impacts on the probability of telecommuting. Not surprisingly, industry and occupation were important drivers in the likelihood of workers telecommuting due to COVID. A 1-percentage-point increase in the occupation telecommuting index led to a 31% increase in the probability of telecommuting due to COVID. A 1-

**Table 1. Major Hypothesis (Key Variables) and Results Regarding Factors Influencing the Probability of Telecommunication Due to COVID for Pennsylvania Workers: Expected Results Versus Estimated Results**

| Variable | Expected Impact (Postive vs. Negative) | Estimated Impact (Postive vs. Negative) | Impact on Probability |
|---|---|---|---|
| Metropolitan | + | + | +20.8% |
| Family income | + | + | +0.42% |
| Gender (female 1) | + | + | +4.60% |
| Education | + | + | +4.90% |
| Age | - | - | -0.14% |
| Occupation | + | + | +31.0% |
| Industry | + | + | +22.3% |
| Children | ? | Insignificant | 0.00% |
| Single with children under 5 | - | - | -8.30% |

percentage-point increase in the industry telecommuting index resulted in a 22.3% increase in the likelihood to telecommute due to COVID. The presence of children in the household in general had no impact. However, there was an 8.3% decrease in the probability of telecommuting due to COVID among single parents with children under the age of 5.

We conducted a separate analysis of rural versus urban areas. Urban residents had a much higher rate of telecommuting than rural residents (31.4% vs 11.3%). Average annual urban household income is $95,488 versus $72,531 for rural households (31.7% greater). Urban households were better educated and more likely to have occupations (such as financial managers) and work in industries (such as professional services, including sectors such as legal services) that were more conducive to telecommuting. Rural areas had more single-parent households with children younger than 5.

Education, occupation, and industry were all much more important for urban than for rural areas, and neither family income nor gender were important for rural areas. These results and our overall results imply that in the short run, removing the digital divide (i.e., the lack high speed broadband in rural areas as compared to urban places) would not completely remove rural-urban differences in telecommuting levels because differences (such as better educated workers in urban areas) would remain. Additionally, industries and occupations more common in rural areas, such as farming and woodworking, offer relatively limited opportunities to telecommute. Lower levels of formal education for rural workers also imply lower rates of telecommuting, even if the lack of high speed internet is not a barrier.

We conducted another separate analysis based on gender. Overall, 33.7% of females and 24.7% of males reported working from home due to COVID. Our analysis shows that education, urban residency, and occupation were more important for females, while family income and industry were more important for males. Most telling, single females with children under five had a 11.9% lower probability of telecommuting to work due to COVID. As pointed out by a reviewer, this result perhaps speaks more to situations as opposed to preferences. Indeed, we strongly suspect that many such individuals would prefer to telework if affordable childcare were available.

## Implications

We argue that our results tell something about the future of telecommuting. As expected, living in a rural area greatly reduces the chance of telecommuting. However, our results imply that not all of this difference is caused by a lack of broadband access. In particular, the nature of the workforce and the nature of their jobs are important. Male rural workers are a larger share of the rural workforce and tend to be less likely than females to telecommute due to COVID. Workers in rural areas have less formal education and so are less likely to telecommute due to COVID. Rural workers also tend to work in occupations (such as routine manufacturing) and industries (such as farming) that do not necessarily lend themselves to telecommuting.

Females were more likely to telecommute than male workers due to COVID. Our results imply that, in general, the presence of children in the household was not important. However, single parents (especially single females) with children under the age of 5 were less likely to telecommute due to the pandemic. These results speak to the need for more available childcare, especially for single women, if they are going to take advantage of virtual workplace in the future.

While our work provides some interesting findings it also calls out for further analysis. In particular, a better job of determining the location of workers and their jobs would be useful (for example, analysis based on the county of residency would provide extra insight). Another interesting area of future analysis is longer-term changes. As telecommunication becomes more accessible in rural areas, the nature of some rural places can be expected to change as telecommuting-prone workers and businesses move there. We would expect to see this happen in higher-amenity rural places and/or those with much lower housing costs relative to higher cost urban areas. We also anticipate that the definition of what is considered a commuting zone will expand for certain industries and occupations. As work options become more virtual in nature (such as going into the office 1 or 2 days a week), commuting longer distances to urban centers might occur. Of course, telecommuting has broader implications that need to be assessed. In particular, economic impacts can be expected for city-based service providers and resource owners as well as rural communities that can anticipate growth. The effects of these changes need to be explored as part of the wider implications with respect to a changing labor market (particularly the impact of the so-called great resignation).

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# Federal Funding Challenges Inhibit a Twenty-first Centry “New Deal” for Rural Broadband

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While the federal government focuses on broadband access as a key twenty-first century infrastructure initiative, one of the primary entities involved in rural broadband expansion, electric co-operatives, has shown a lack of appetite for the federal funding process. Electric co-operatives were the backbone of the Roosevelt administration’s twentieth-century New Deal program and were vital to the expansion of electricity into rural areas. They cover 57% of U.S. landmass and have the potential to bring fiber broadband service to millions of rural homes, farms, and businesses. Yet, according to interviews conducted with National Rural Electric Co-operative Association staff by the University of Tennessee in 2021, only 200 of roughly 900 co-operatives in the U.S. have indicated that they would be willing to apply for federal funding to support residential broadband infrastructure deployment. Further, a survey of electric co-operatives by the University of Tennessee identified several barriers impeding federal broadband funding applications. While there are many barriers to internet infrastructure expansion and other providers with the potential to expand broadband service in rural areas, this study focuses on the specific federal funding barriers identified by a survey of rural electric cooperatives by the University of Tennessee, Knoxville.

## A Digital Divide

Due to differences in methodology, researchers estimate that between 14.5 million and 162 million Americans do not have access to broadband internet (Federal Communications Commission, 2022; Microsoft, 2019); the majority of those without such access live in rural, low-income, and minority areas (Koutsouris, 2010; Prieger and Hu, 2008; Swenson and Ghertner, 2021; U.S. Department of Agriculture, 2019b). In fact, the states with the least internet connectivity are concentrated in the South and in high-poverty areas, and the states with the most internet connectivity tend to have limited rural populations (McNally, 2021). Additionally, the U.S. Department of Agriculture (USDA) has found that 22.3% of rural Americans and 27.7% of tribal Americans (compared to only 1.5% of urban Americans) lack broadband access at download/upload speeds of 25/3 megabits per second (Mbps) (U.S. Department of Agriculture, 2019b). A more recent study found that as many as 35.4% of tribal Americans may be without broadband access (Blackwater, 2020). The gap between those with and those without access to internet and internet-related technologies has been deemed the “digital divide” (Basu and Chakraborty, 2011; Cullen, 2001). The divide often refers to the differences in access between people in urban and rural areas, though it becomes more salient when considering inequalities related to socioeconomic status, location, education, age, and gender. Research has shown that men, people with higher incomes, and younger individuals use computers and internet more than their counterparts (Aubert, Schroeder, and Grimaudo, 2012; Broos and Roe, 2006; Lee, Park, and Hwang, 2015). Additionally, there’s evidence that psychological factors—such as attitudes, norms, and perceived ease of use, usefulness, and risks—are associated with internet and technology use (Aubert, Schroeder, and Grimaudo, 2012; Broos and Roe, 2006; MacVaugh and Schiavone, 2010; Schmit and Severson, 2021).

The divide is further exacerbated by access to internet-reliant technologies. For example, low-income households are more likely to use smartphones than computers for internet access (Apptegy, 2021; Auxier and Anderson, 2021), but exclusively relying on mobile phones for internet access reinforces inequalities in online participation, digital skill sets, content creation, broadband access, and smartphone use (Lee, Park, and Hwang, 2015; Napoli and Obar, 2014). Lee, Park, and Hwang (2015) found that groups with less access to internet and internet-reliant devices were more likely to be women, older, low-income, less educated, and to use the internet less frequently than their counterparts. Galagedarage and Salman (2015) also found that a lack of access to internet infrastructure, affordable internet, and computer skills negatively influenced internet adoption.

## Digital Agriculture

Internet access is imperative to support precision agriculture practices; precision agriculture not only has positive effects on individual incomes and business revenues but also burns 40% less fuel, uses 20%–50% less water, and reduces chemical application by 80% compared to traditional agricultural practices (U.S. Department of Agriculture, 2019a). Farming technology can assist with planting, fertilizing, harvesting, selling, cultivating, treating, weather reporting, entering new market opportunities, and more (Mahamood et al., 2016). In fact, technological innovation is one of the primary drivers of productivity, profitability, and competitiveness for family farms (Petry et al., 2019). Additionally, greater emphasis on the use of data in agriculture will likely lead to core changes in farming practices (Aubert, Schroeder, and Grimaudo, 2012), which will further separate farmers who do not have access to internet and related technologies from the market. Innovations tend to be adopted by resource-rich communities first, leading to greater differences in knowledge and access to government and commercial services as well as worsening other inequalities (Bhatti, Olsen, and Pederson, 2010). The digital divide may be slowing down potential technological developments and productivity of the farming industry (Basu and Chakraborty, 2011; Petry et al., 2019) and is therefore an important consideration for both academics and policy makers.

## A Focus on Funding

Many programs and grants at the state and federal level have addressed unequal broadband infrastructure access and broadband adoption in rural areas. In December 2021, the Federal Communications Commission (FCC) launched the Affordable Connectivity Program, which replaced the early pandemic Emergency Broadband Benefit, to provide monthly discounts for household broadband access and for technology purchases (e.g., computers, laptops) (Federal Communications Commission, 2022). Perhaps the most significant federal investment toward broadband infrastructure expansion and adoption was the recently signed $1.2 trillion Infrastructure Investment and Jobs Act (H.R. 3684), which builds on existing funding for broadband deployment (National Telecommunications and Information Administration, 2022). The act specifically allocates $65 billion to closing the digital divide through several programs targeting different facets of broadband access, including the $42.45 billion Broadband Equity, Access and Deployment (BEAD) Program, the $1 billion “Middle Mile” Broadband Infrastructure Program, the $2 billion Tribal Broadband Connectivity Program, and the $2.75 billion Digital Equity Act Program. Further, the infrastructure bill adds $2 billion to the USDA ReConnect program, which targets less populated regions of the United States with the slowest internet.

The BEAD program is unique in that it provides funding to each state. All states receive a minimum of $100 million, with additional funding based on the number of unserved (defined as lacking broadband speeds of at least 25/3 Mbps, National Telecommunications and Information Administration, 2022), high-cost locations in each state. High-cost locations are usually determined by federal per diem rates (U.S. General Services Administration, 2021). The program also aids community anchor institutions (like libraries, hospitals, nonprofits, etc.) acquire access. The Middle Mile Program targets broadband infrastructure that does not connect directly to an end-user location, primarily using anchor institutions. Additional funding is provided for the preexisting Tribal Broadband Connectivity Program, a National Telecommunications and Information Administration (NTIA) program established under the Consolidated Appropriations Act of 2021, which funds broadband deployment on tribal lands, including telehealth, distance learning, and digital inclusion efforts. Last, the Digital Equity Act Program aims to promote adoption and use of broadband services in low-income, aging, incarcerated, veteran, minority, disabled, and rural individuals, focusing again on community anchor institutions (National Telecommunications and Information Administration, 2022).

## Challenges to Rural Broadband Expansion

Despite increases in funding, there are many existing challenges to expanding broadband access. According to the FCC and USDA, more Native Americans than rural Americans lack broadband coverage at 25/3 Mbps (U.S. Department of Agriculture, 2019b), though funding for rural Americans far exceeds funding for Native Americans, representing inequitable distribution in existing and future broadband infrastructure that extends past location factors, like socioeconomic and race/ethnicity status.

There is also much debate on what threshold should be used to determine which areas should receive funding. For example, while the FCC defines unserved communities as those without access to internet at 25/3 Mbps, several states (like Missouri, Florida, and Oregon) define unserved areas as those without access to speeds of 10/1 Mbps (De Wit and Read, 2021). Therefore, areas may have internet speeds below the FCC guidelines but will not receive funding due to limitations in eligibility criteria. States such as Alaska also restrict funding to communities with populations below 20,000, unemployment rates above 19.5%, and broadband speeds below 0.77/0.20 Mbps (Regulatory Commission of Alaska, 2010). Colorado specifies areas without access to one satellite and one nonsatellite broadband provider (Colorado Broadband Office, 2020).

Further, states set caps on the amount of funding individual projects can receive. Kansas and Pennsylvania set a limit of $1 million, but California permits up to $10 million per project (De Wit and Read, 2021). Other criteria-specific forms of federal funding, such as the Low-Income Home Energy Assistance Program (LIHEAP), have historically served a small fraction of the eligible population (National Energy and Utility Affordability Coalition, 2022; Raimi et al., 2021), mainly due to funding limitations. Broadband needs constant investments to maintain and upgrade the network (Westling, 2022). A one-time BEAD payment will not guarantee sufficient future access for communities that do receive funding, and a one-time payment will not guarantee that other vulnerable populations that fall outside of specified requirements are reached. While these states' policies are attempts to identify and target areas with the most need, these limitations in definitions, requirements, and available funding ultimately restrict individuals' and households' ability to increase broadband affordability and access. Policy makers, then, should consider the role of future BEAD or similar program payments. Future research could also analyze the impacts that BEAD or similar programs have on achieving broadband deployment and reducing digital divides.

More importantly, most federal funding for broadband depends on the FCC's Form 477 broadband maps, which have many noted limitations. The form collects data from internet service providers (ISPs) about their service areas and has historically classified whole census blocks as having broadband service if just one home in the block "has" or (without major investment) "could" currently be served by a provider (Bode, 2022). ISPs like AT&T also have a record of opposing efforts to improve federal broadband mapping (Brodkin, 2020). Many efforts are being made to improve mapping methodologies, largely due to the 2020 Broadband Deployment Accuracy and Technological Availability (DATA) Act, which provided more than $98 million to the FCC (Bode, 2022). This is in addition to state regulations that limit co-operatives' ability to provide broadband services or that create roadblocks to establishing networks (Cooper, 2021). Further, there is some concern about the wording of the BEAD Program bill, as it states that award recipients must match funds equal to "not less than 25% of project costs," though the bill specifies "except in high-cost areas or as otherwise provided by this Act" (Engebretson, 2021). According to the Department of Transportation, the average cost of fiber broadband installation is $27,000/mile (Aman, 2017), though cost varies depending on aerial or underground deployment and the amount of work needed to prepare infrastructure (National Rural Telecommunications Cooperative, 2018). This means award recipients must be able to pay, on average, $6,750/mile up front to receive funding. Research also notes difficult-to-navigate funding processes (Das and Gabbard, 2021), monopolistic ownership of broadband services by telecommunication companies due to mergers after the Telecommunications Act of 1996 (Blackwater, 2020; Paulas, 2017), and high costs of infrastructure installation (Chao and Park, 2020; Horrigan and Duggan, 2015).

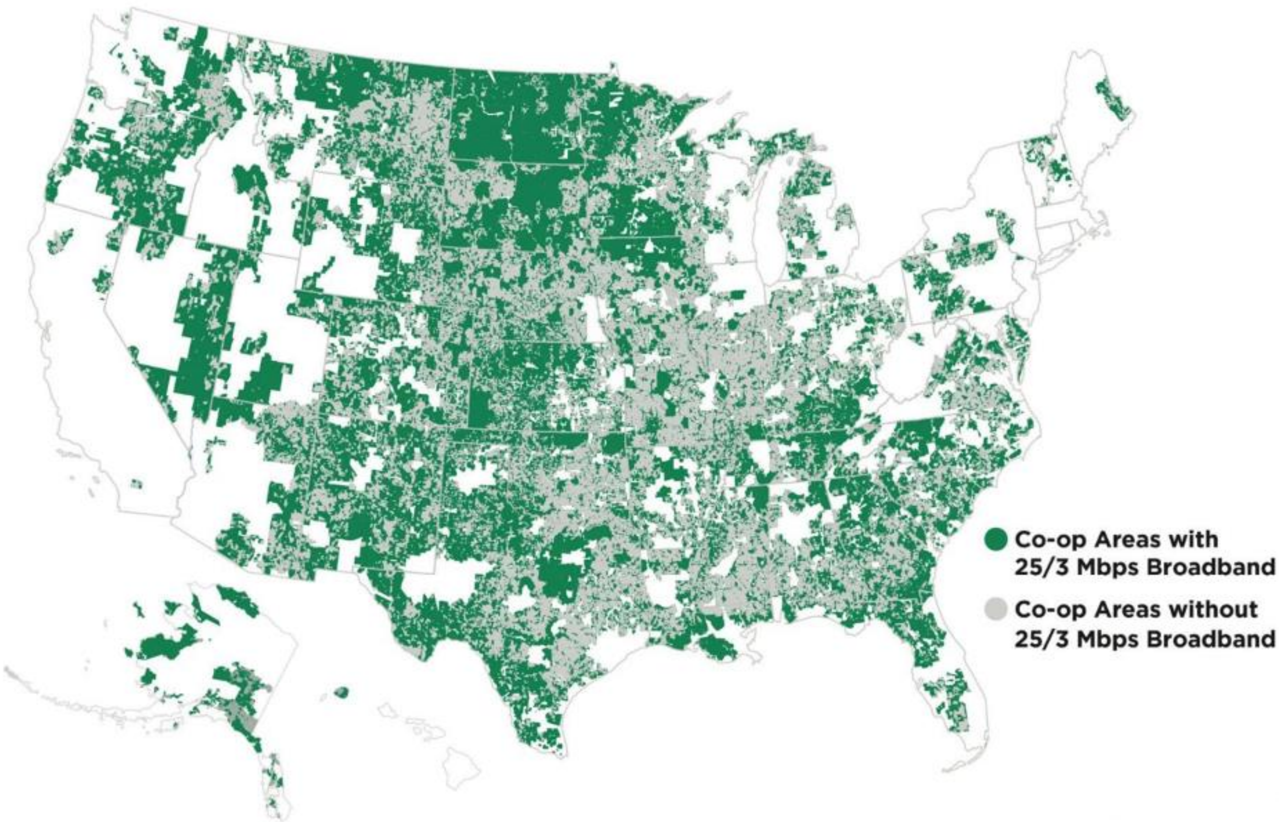
## Electric Co-Operative Background and Potential Impact

Many similarities exist between the current conversation around lack of broadband internet in rural areas in the twenty-first century and programs to expand electricity in the twentieth century. Prior to the 1930s, only 10% of rural areas had access to electricity. Acknowledging this divide and its impact on the agricultural industry, such as many farmworkers moving to urban areas, the Roosevelt administration established the Rural Electrification Administration (REA) in 1936. This was a centerpiece of the New Deal, an economic stimulus package designed to reignite the U.S. economy after the Great Depression. The REA paved the way for thousands of member-owned and not-for-profit rural electric co-operatives. The aim of creating these co-operatives was to bring electricity to areas that had been neglected by private providers, which tend to see no short-term profits in these rural areas. Electric co-operatives are now one of the primary sources of electricity to farms, homes, and businesses in the rural United States, providing electricity to 57% of the U.S. land mass and reaching 42 million people (National Rural Electric Cooperative Association, 2021).

Electric co-operatives could serve an important role in bringing high-speed internet to rural farms and homes. According to data compiled by the National Rural Electric Cooperative Association (NRECA) in 2019 using FCC form 477 broadband provider records, 13.4 million people in 6.3 million households served by electric co-operatives lack broadband access (Figure 1). These entities have the potential to reach millions of rural residents through built-on fiber internet. Via this process, the co-operatives would add fiber lines to their existing electric poles and run fiber internet to their member-owners.

Electric co-operatives primarily invest in advanced telecommunications infrastructure, such as fiber internet, to support their energy distribution systems (National Rural Electric Cooperative Association, 2021). Their access to machines, equipment, and personnel makes the transition to retail fiber broadband deployment possible. However, despite record investment in rural broadband by state and federal agencies, only 200 of roughly 900 U.S. electric co-operatives currently offer or plan to offer retail broadband as a service (National Rural Electric Cooperative Association, 2021). To understand some of the barriers electric co-operatives face in expanding broadband access, the present study conducted interviews in 2021 to gather contextual data to aid in the development of a survey instrument. The survey aimed to identify the perceived challenges that electric co-operatives have in receiving and administering the funds required to provide broadband in

**Figure 1. Electric Co-Operative Service Territories With/Without 25/3 Mbps Broadband Service**




Source: National Rural Electric Cooperative Association (2019).

rural areas. The survey included questions regarding the cost of broadband infrastructure deployment as well as challenges related to federal funding applications identified through NRECA interviews. Three hundred electric co-operatives were identified through contact lists provided by NRECA and were contacted via email to participate in the survey. The survey received 137 complete responses. Due to the anonymity of respondents, we were not able to cross-reference responses with geographic locations.

## Electric Co-Operative Broadband Profile

According to the interviews, of the roughly 900 electric co-operatives in the United States, there are only 200 NRECA member broadband deployment projects (including either, planned, in progress, and built to completion) located unevenly across 39 states. In 2021, electric co-operatives won federal bids equating to over $1.1 billion over 10 years to serve over 616,000 locations via the recent FCC Rural Digital Opportunity Fund Phase 1 auction. NRECA member projects also receive funding through the National Electric Cooperative Finance Corporation (CFC), a nonprofit finance cooperative, the national co-operative bank (CoBank), and various state loan and grant programs.

According to survey responses, the costs of co-operative broadband deployments vary depending on whether the project is aerial or underground and the amount of "make-ready" work necessary to prepare infrastructure (National Rural Telecommunications Cooperative, 2018); however, the average cost of fiber deployment in our study was between $16,500 and $26,520 per aerial mile, with a mean of $21,700. In addition, prior to deployment, it costs between $1,400 and $3,750 to prepare an existing pole for each fiber line attachment, a process referred to as "make ready." Age, pole condition, terrain, and other factors influence the cost of each pole attachment. Laying fiber cable underground costs between $36,000 and $59,000 per mile. Due to the costs and the labor necessary to lay underground fiber, 80%–95% of co-operative deployments are aerial, via pole attachments. Due to differences in the costs of the fiber line, installation, and premise equipment, connecting a home or business to the main fiber line, referred to as a "service drop," costs between $800 and $2,000. For co-operatives, the average "drop" length is 520 feet. Though total project capital expenditures vary widely, the 25th–75th percentile is $28 million to $84 million, with a median of around $65 million. The average internal rate-of-return (IRR) for co-operatives in our survey was 10%, with most respondents reporting IRR in the 8%–13%

range. Feasibility studies allow entities to project total project costs prior to deployment, and 76% of co-operatives reported higher real capital expenditures than their initial study projections. Business feasibility for electric co-operatives could be improved through government funding, tourism, and community support (Schmit and Severson, 2021).

## Private Lenders Dominate Co-Operative Broadband Funding

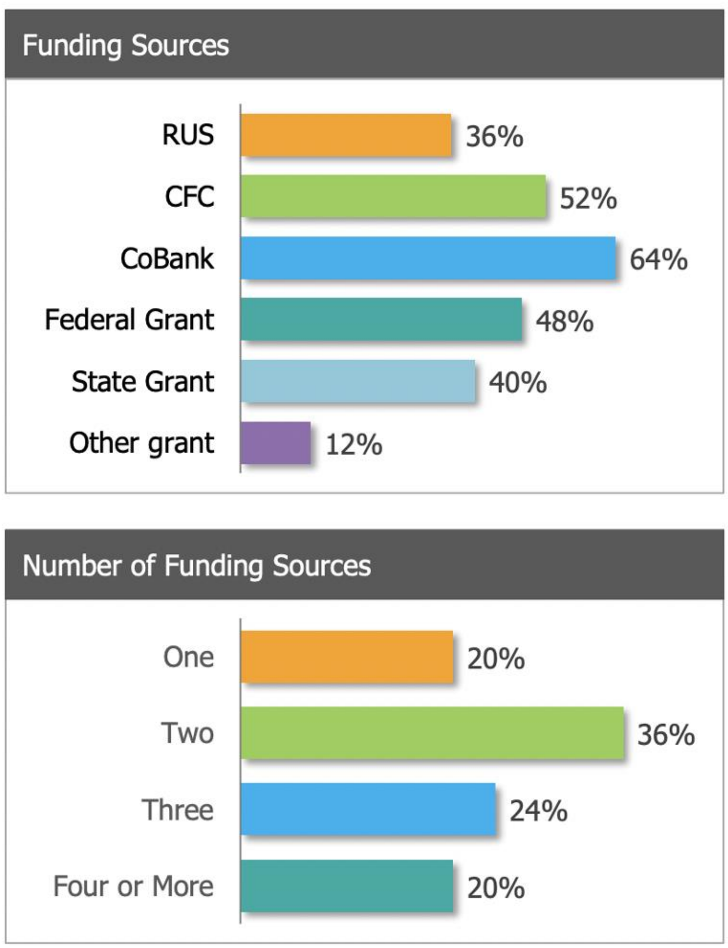
Most study co-operatives reported securing private loans for broadband projects from the CFC (52%) and CoBank (64%) (Fig. 2). An additional 36% reported receiving either a loan or grant from the USDA's Rural Utilities Services. Of these, 45% received funding from the Electric Infrastructure Loan and Loan Guarantee Program, which supports electric co-operatives that build smart energy grids integrated with broadband infrastructure. Another 42% received funding from the Re-Connect Program, which provides up to $2 billion specifically to connect homes and businesses within rural electric footprints. Of the 48% who reported having applied for or received federal funding, 24% mentioned the FCC's Connect America Fund and 21% mentioned the Rural Digital Opportunity Fund. In addition, 40% of co-operatives had applied for various state-administered funds and 80% reported using more than one source for potential funding.

## Federal Frustration

In relation to the lack of co-operatives taking advantage of federal funding, 70% of co-ops reported having a "poor" or "very poor" experience with the federal funding processes (Figure 3). Electric co-operatives who had applied for federal broadband funding have several recommendations for improvements that would encourage broader participation from the industry.

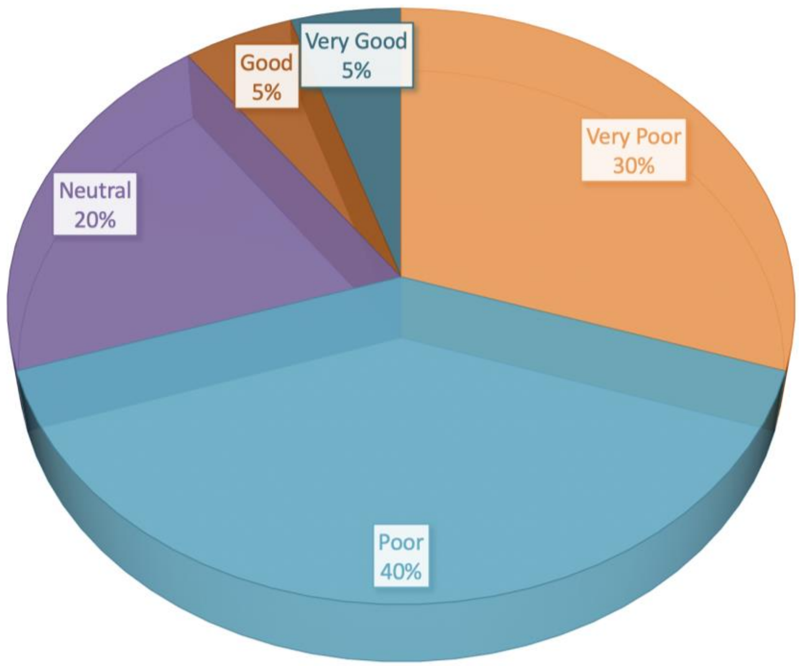
The complexity of funding applications and the staffing resources required to keep on top of compliance is burdensome for many electric co-operatives. Specifically, 34% of co-operatives reported that, as a broadband subsidiary, they have had difficulty supplying the necessary financial and other funding-compliant documents. Often co-operatives establish a subsidiary to comply with utility regulations that are designed to

**Figure 2. Electric Co-Operative "Primary" and "Number of" Funding Sources**




Source: University of Tennessee, Knoxville, National Rural Electric Cooperative Association survey (2021).

**Figure 3. Electric Co-Operative Experience with Federal Funding**




Source: University of Tennessee, Knoxville, National Rural Electric Cooperative Association survey (2021).

protect the energy business; this leads to confusion in applications, where co-operatives must explain that the compliance documentation is technically housed or attached to its electric entity. Additionally, 68% felt that there should be a preproposal stage during which prospective applicants are vetted or applicants are provided with initial feedback. This would cut down the time spent by organizations on applications with little chance of success. Few electric co-operatives employ staff who are responsible for grant implementation and compliance. In this study, 100% of co-operatives reported they “agree” or “somewhat agree” that they often lacked the support staff needed to keep up with each federal agency’s compliance rules. Support in this area, either through training or reducing the post-award administrative burden, would encourage greater participation.

One of the central pillars of the co-operative structure is local development. Given that these entities comprise local member-owners, they have a natural desire to seek investments in their local areas and businesses. Unsurprisingly, 72% of co-operatives believed that more weight in funding applications should be given to local providers than to national entities. Most co-operatives (56%) also reported knowledge of funding being given to national telecommunications entities, where the money either was not used within the stated timeframe or was used to build substandard or outdated infrastructure.

Consistent with previous literature, co-operatives in this study identified significant frustrations with the maps used to identify areas that currently have broadband. For instance, many federal funds require that an eligible area either have no current service providers or no previous internet funding recipients. As such, 85% of co-operatives reported that existing broadband service “availability” within their service territory had disqualified them from receiving funding for areas that lack service. Significantly, 100% reported that the maps used to assess broadband availability by federal agencies are inaccurate. The main criticism lies in the way these data are collected, as these data are self-reported by service providers. Providers are only required to report whether one household in a single census block has an existing service or has the potential to be served given existing infrastructure. Additionally, 90% of the study co-operatives reported that areas within their service territory were not eligible for additional funding due to prior funding being tied to an out-of-date benchmark, and 70% reported awareness of other entities receiving prior funding that had a backdated substandard commitment.

These obstacles and challenges in relation to federal funding help explain why, according to NRECA, only 22% of electric co-operatives “have applied” or “plan to apply” for federal broadband funding. By resolving federal funding issues and reducing challenges, electric cooperatives could provide a vital avenue to closing the rural digital divide. The opportunity is there for electric co-operatives to do for broadband in the twenty-first century as they did for rural electrification in the twentieth.

## Recommendations

Agencies could implement a range of measures to encourage electric co-operatives to apply for federal funding that supports broadband. Providing more guidance for subsidiary businesses could ease the administrative burden felt by entities without large numbers of award support staff. This could include working with regulatory bodies that control electric power distribution contracts to ensure that subsidiaries are following funding requirements or conducting training specifically with rural electric co-operative broadband subsidiaries. Including short-form preproposals in the funding process is also a measure that could reduce the likelihood that entities spend substantial amounts of time on proposals that are unlikely to succeed. Agencies could provide initial feedback to applicants at an early stage or provide an opportunity to invite well-formed proposals to a full submission stage. This would reduce the volume of proposals that make it to the final round and the overall burden on reviewers. In terms of the post-award compliance burden, agencies could provide support or training for smaller entities on how to manage the workflow, which could include examples of how workflow is managed in similar-sized entities. As for the awards, providing greater support to local providers or incentivizing local development (encouraging applicants to partner with local entities) might help garner more support from rural electric co-operatives. This could involve including a condition that a certain percentage of project funds must either be spent through a local procurement process or a local community benefits agreement. These kinds of agreements are usually contracts signed by an entity and the local municipality stating that certain additional community benefits will be accrued over the length of the project. This can range from education initiatives to investment in local businesses. Last, and most importantly, a concerted effort should be made to improve the accuracy and validity of broadband service maps. Many studies have suggested valid recommendations to improve these maps, and these should be consulted and acted upon to improve the rate of successful federal funding applications and awards (Bode, 2022; Kahan, 2019; U.S. Government Accountability Office, 2021).

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