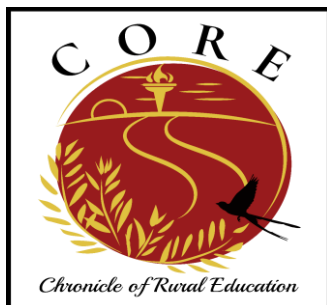




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Rural America's Digital Divide and Hybridized Internet Access

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The digital divide in rural America is characterized by significantly lower internet access (ranging from 0.2% to 57% compared to urban areas, with around 98.5% access) and creates a critical barrier to educational access. This paper reviews the effects of this deficit on students, citing evidence of lower homework completion rates, grades, and college enrollment. BEAD, ReConnect, and RDOF are current federal programs that focus on deploying costly fiber-optic cable, which can be prohibitively expensive in rugged terrain with low population density, reaching as high as \$40,000 per mile. This analysis supports a hybridized approach to delivering high-speed internet to rural America. Using a foundation of fiber-optic, Fixed Wireless Access (FWA), and targeted school-issued mobile hotspots, this model significantly reduces the cost of infrastructure deployment. Some models predict a cost reduction from \$42,000 per person for fiber-only internet access to under \$18,000 per person using a hybrid model. This paper concludes by advocating for a cost-effective strategy using multiple technologies, coupled with the reinstatement of federal subsidies such as the Affordable Connectivity Program (ACP), to ensure that every school-aged child in rural communities has access to reliable, affordable broadband.

Introduction

Recent research has consistently shown a gap in access to technology, specifically in broadband internet access, in rural America. Broadband internet access has gone from a nicety to an essential infrastructure component in communities (Statti & Torres, 2020). However, a disparity in availability, termed a “digital divide,” persists, resulting in significant disadvantages for people in rural and economically disadvantaged communities where broadband is not readily available (Bauer et al., 2020). Historically, 39% of rural Americans have lacked access to broadband internet (Statti & Torres, 2020). Reliable internet access is essential for modern rural learners to achieve their best educational success. This access can best be provided through a hybrid approach to delivering internet across the United States.

Delivery of internet access to rural Americans is both a well-established federal government goal and a problematic solution with high costs for private companies that provide installation services. In addition, once service is available, internet access may be expensive. Approximately 39.5% of rural Americans earn less than \$50,000 per year (FHFA, n.d.), and the average monthly cost of broadband internet access ranges from \$70 to \$76 (Supan, 2025). This means that for many rural Americans, broadband internet access may be almost 2% of their monthly income.

Several federal grant programs exist to establish internet delivery to rural households. Both the Federal Communications Commission’s (FCC) Broadband Equity, Access, and Deployment Program (BEAD) (Erann, 2023; NTIA, n.d.-a) and the U.S. Department of Agriculture’s (USDA) ReConnect (USDA, 2025b) programs are grant programs that fund the deployment of fiber-optic internet to rural households. In addition, the FCC’s Rural Digital Opportunity Fund (RDOF) (Abilla, 2025; USAC, n.d.) focuses on both fiber-optic and satellite-provided internet. However, the inclusion of a hybridized approach that included line-of-sight wireless internet to geographically isolated rural locations may be an additional avenue to explore.

Internet Access in Rural America

The FCC defines broadband internet access as having a download speed of at least one Gigabit per second (Gbps) and an upload speed of at least 500 Megabits per second (Mbps) (FCC, 2024). The FCC reports that, as of the end of 2022, approximately 24 million Americans lack broadband internet access (FCC, 2024). This includes “almost 28% of Americans in rural areas, and more than 23% of people living on Tribal lands...” (FCC, 2024). The USDA (2025a) reiterates these statistics, noting that “... only 1.5 percent of Americans in urban areas” do not have broadband internet access.

A significant study from Michigan State University (Bauer et al., 2020) identified several issues among rural students in Michigan and will be cited repeatedly throughout this paper. 54% of rural Michigan students lacked home broadband internet access, compared with 22.3% of suburban Michigan students (Bauer et al., 2020).

Boerngen and Rickard (2021) found several estimates regarding rural internet access. Among them was a 2018 Microsoft study that found 163 million Americans without access to broadband internet (although these individuals are not exclusively rural Americans). They also found that in 2019, 75% of American farms (i.e., as defined by the USDA “...any place from which \$1,000 or

more of agricultural products were produced and sold, or normally would have been sold, during the year”) had some form of internet access, with 76% of those indicating that they had broadband access. This accounts for 57% of total US farms having broadband internet access (Boerngen & Rickard, 2021).

Additionally, Statti and Torres (2020) reportedly found that 39% of rural Americans lacked broadband internet. Travis (2006) reported that, in 2003, “more than thirty percent of American homes lacked internet access...”, and “[r]oughly two-thirds of American households did not have high-speed Internet access in 2005”.

Cooper (2025) identified internet access at the regional and state levels, highlighting several concerns. Among these were a national fiber broadband coverage of 49.7% and affordable broadband access of 81.4%. However, the availability differs by state and region. Alaska has broadband coverage over 0.2% of the state. Cooper (2025) also found an affordability gap: broadband access is available, but the high cost of installation makes it unaffordable for users. One often-neglected subsection of rural America is tribal lands occupied by Native Americans. Yoo et al. (2021) examined internet access on tribal lands and the rural areas immediately surrounding them. They found that 41% of citizens on tribal lands and 68% of citizens in the surrounding rural regions lacked broadband internet access (Yoo et al., 2021).

There has been an increase in internet access among American adults. Greenberg-Worisek et al. (2019) found an increase in broadband access from 32.83% to 77.87% between 2003 and 2011. However, Greenberg-Worisek et al. (2019) also found a decrease in broadband access, with an availability of 55.93% in 2019. Greenberg-Worisek et al. (2019) related this to an increase in cellular network access between 2008 and 2017 (from 6.86% to 65.43%).

Overall, broadband internet access in rural America has increased in the 21st century. However, it still lags far behind broadband internet access in urban and suburban America, where rates may reach 98.5% (USDA, 2025a), compared with rates of 0.2% in Alaska (Cooper, 2025) and 57% on farmland (Boergen & Rickard, 2021).

Reasons for Internet Need/ Student Outcomes

Significant evidence indicates that limited access to reliable internet has a detrimental effect on learner outcomes. The outcomes focus on differences in homework completion rates, average course grades, standardized test scores, and college follow-up rates.

Anderson and Perrin (2018) found that 17% of teens reported being regularly unable to complete their homework due to a lack of reliable internet access. Among teens in households with annual incomes below \$30,000, 24% reported that their lack of reliable internet access prevented them from completing their homework (Anderson & Perrin, 2018). 12% of adolescents reported using public Wi-Fi at least sometimes to complete homework because they lacked internet access at home (Anderson & Perrin, 2018). Cell phones were often used to complete assignments, with Anderson and Perrin (2019) reporting that 35% of teens often or sometimes used their cellphones

to complete homework, and 45% of teens in households with an annual income of under \$30,000 sometimes relied on their cellphones to complete homework.

Bauer et al. (2020) found that among the Michigan students they surveyed, 64% of those without home internet access were often or sometimes unable to complete their homework. 14% of students without home internet access never completed their homework, whereas 54% of students in other groups completed it. Bauer et al. (2020) reported that Michigan students with reliable home internet access had higher grades than those without such access. The reported difference in grades between students with and without home internet access equaled approximately half a letter grade per class: roughly the difference between a B and a B- (Bauer et al., 2020). Among surveyed Michigan students who lacked reliable home internet access, 53% did not plan to attend college (Bauer et al., 2020). Only 35% of students with reliable internet at home responded similarly (Bauer et al., 2020).

NCES (2018) found several disparities between students with and without home internet access. In 2015, average scores for 8th-grade students were higher among those with home internet access than among those without internet access for reading (267 versus 242), math (285 versus 262), and science (156 versus 136) (NCEA, 2018).

In summary, students who lack home internet access tend to have poorer outcomes than those with reliable internet access. 8th-graders reportedly have lower standardized test scores. They also had lower rates of completing homework, lower GPAs, and lower grades in individual classes. Finally, students who lack internet access at home are less likely to attend college. In every measurable way, a lack of home internet is instrumental in reducing students' learning outcomes.

Plans to Provide Internet Access

The federal government recognized that home broadband internet access is a modern necessity. Three main programs currently exist for delivering internet access to rural homes through various federal government departments. There are several benefits, drawbacks, and costs associated with each of these programs, as well as a potential missed opportunity to deliver cost-effective internet access.

The Broadband Equity Access and Deployment (BEAD) program had an allotment of \$42.45 billion starting in 2023 to deploy high-speed internet to unserved and underserved communities (NTIA, n.d.-a; Erran, 2023). States may apply to use these grant funds to deliver internet to their communities (including rural communities). As of November 2025, 53 of 56 states or territories have applied for funds, but none have been approved or distributed (NTIA, n.d.-a).

The Rural Development Broadband ReConnect Program (ReConnect), administered by the USDA, provides grants or loans to states to provide internet access to rural areas. Since 2019, the ReConnect program has provided approximately \$4.53 billion in grants and loans (USDA, 2025b).

The FCC's Rural Digital Opportunity Fund (RDOF) has, since 2022, provided funds to the lowest-bidding internet service provider to pay for delivering high-speed internet to rural communities (Abilla, 2025; USAC, n.d.). The funds were allocated \$20.4 billion over ten years. However, the last award was given in 2022, and only \$9.2 billion had been awarded; \$2.8 billion of that was lost due to default by the bidding internet providers (Telecompetitor, 2023). This program, although still on the federal government's books, appears to have ceased operation.

NTIA's Tribal Broadband Connectivity Program (TBCP) has \$3 billion for delivering internet to tribal lands. As of 2025, they have utilized approximately \$2.2 billion of those funds to deliver internet access through 223 projects (NTIA, n.d.-b).

Regardless of the program, they share a common goal: making broadband internet available to all Americans in rural areas, primarily by deploying fiber-optic cable infrastructure to homes. However, another potentially more cost-effective plan may exist.

Hybrid Internet Access

The federal government's programs for delivering broadband internet access to rural communities primarily focus on installing fiber-optic cable to households (NTIA, n.d.-a). Given the geographic features of the United States, including vast tracts of unoccupied land, mountains, rivers, and other natural landscapes, this task can be daunting. Erann (2023) estimated that the cost of delivering fiber-optic cable to the most rural parts of the United States may range from \$60,000 to \$80,000 per mile, accounting for all materials and labor. Abilla (2025) estimated the per-mile cost of fiber-optic internet to range from \$20,000 to \$40,000 in rural areas. Meanwhile, Erran (2023) also noted that the \$42 billion BEAD grant fund would be insufficient, and the actual cost may be as high as \$200 billion to provide fiber-optic broadband internet to the entire country.

Private companies provide this internet, and any excess costs beyond the grants would be passed on to consumers. In the United States, internet service costs between \$50 and \$90 per month, with an average of about \$65 (Supan, 2025). However, internet costs vary significantly by location. 80% of the total cost of delivering internet service to a home is attributable to the "last mile," where service is delivered from the main infrastructure to the home (Seitz, 2025). This can result in high internet costs in rural areas. A few examples of this include the average cost of internet per Mbps by state: Alaska (\$2.92 per Mbps), Idaho (\$1.27 per Mbps), Montana (\$2.63 per Mbps), and West Virginia (\$1.88 per Mbps) (Seitz, 2025). As a reference, the average cost of internet service on a per Mbps basis in the United States is \$0.49 (Veney, 2025). When considering that about 39.5% of rural Americans make less than \$50,000 a year (FHFA, n.d.), and the average broadband internet access costs \$70-\$76 a month (Supan, 2025), this means that for many rural Americans, broadband internet access may be almost 2% of their monthly income.

There was help available for rural American households to pay for internet access. The Affordable Connectivity Program (ACP) offered a monthly subsidy of \$30 or \$75 for those residing on tribal lands (Hollimon et al., 2025). The ACP expired in 2024 and quickly resulted in fallout affecting rural communities: "13% of recipients immediately canceled their internet service, and another 12% planned to do so" (Hollimon et al., 2025).

The “last mile” problem makes many costs associated with providing internet access to rural areas prohibitively high. However, a hybrid approach utilizing Fixed Wireless Access (FWA) broadband may provide a solution. Rysavy (2025) described FWA as a direct line-of-sight method of delivering internet at broadband speeds. By placing FWA transmitters at altitude, such as on existing cellular towers or building antennae, wireless internet can be provided to residences with an FWA receiver within range of the transmitter. Because fiber-optic costs are high and cannot be spread among many residents in low-population-density areas, a wireless method may be more cost-effective.

Eran (2023) examined a hybrid approach to providing internet access and evaluated costs in several case studies. Using a combination of fiber broadband delivery to buildings and homes and a network of FWA transmitters, they prepared three scenarios. In Osage County, OK, the per-person cost of fiber-only internet access was \$42,272, while a hybrid approach was estimated to cost between \$15,000 and \$18,000 per person (Erran, 2023). In Navajo County, AZ, the per-person cost was \$5,805 with all-fiber delivery, whereas the per-person cost for a hybridized approach was \$1,700- \$2,500. Finally, Winnebago, NE, had a per-person cost of \$53,738, and \$ 9,500- \$14,500 per person with a hybrid approach (Eran, 2023).

There are three frequency ranges for FWA (Jasso, 2023). Low-band FWA offers speeds of up to 250 Mbps but has a potential range of hundreds of square miles. Mid-band FWA can provide up to 1 Gbps and has a range of up to 10 miles. High-band FWA has speeds of 1 Gbps or higher, but its range is typically less than 1 mile (Jasso, 2023).

One advantage of the FWA delivery method is that having a receiver at home can also serve as a Wi-Fi access point for the property (Rysavy, 2025). As Greenber-Worisek et al. (2019) demonstrated, broadband access declined between 2011 and 2019, attributed to increased cellular network access. Bear in mind that students who relied on cell phones for homework had a lower completion rate than those with home internet. Anderson and Perrin (2018) found homework rates of 35% among cell phone users, higher than the 14% rate among those with no internet access. If students are using their cell phones, it is a better resource than nothing at home. FWA can help provide that access.

Hotspot Access

Another potential component of a hybrid access model is cellular hotspot devices provided to students. A cellular hotspot device (hereinafter, a “hotspot”) is a mobile device that uses cellular networks to provide Wi-Fi internet access. The monthly operating cost ranges from \$86 to \$100 (Palmer, 2025), whereas the device’s cost varies significantly. However, a cursory internet search found prices ranging from \$150 to over \$700 (Google, n.d.).

Salsbury and Hansen (2022) reported on Montana State University’s pilot program, which used \$4,997 in federal grant funds, along with undisclosed state funds, to purchase 17 hot spots. Over the course of one academic year, 23 students without reliable internet access successfully used these hot spots. Salsbury and Hansen (2022) noted that the program had a limited window of

time. However, they would continue to use it, demonstrating a potentially reliable method for repeatedly deploying the same devices to assist multiple students over time. In rural areas without broadband access, providing students with school-issued hotspots on an as-needed basis can serve as an additional hybridization option.

Conclusion

The lack of reliable broadband internet access in homes is a pervasive issue in rural America. In urban America, broadband is available to upwards of 98.5% of the population (USDA, 2025a). Meanwhile, rural broadband access ranges from 0.2% in Alaska (Cooper, 2025), 23% of citizens on tribal lands (FCC, 2024), 54% of rural Michiganders (Bauer et al., 2020), and 57% of rural farmland (Boerngen & Rickard, 2021).

This lack of broadband access has a detrimental effect on learners. Students are less likely to complete homework (Anderson & Perrin, 2018), have poorer grades, as Bauer et al. (2020) showed a decrease of half a letter grade in each subject among Michigan students, poorer standardized test scores in reading, math, and science (NCES, 2018), and lower college go-on rates (Bauer et al., 2020).

The federal government has several programs to deliver broadband access to rural America. While at least one appears to have stalled due to defaulted losses, and one has yet to begin distributing funds, they all share one common problem: they focus on delivering fiber broadband to the home. This can incur substantial costs, particularly when providing fiber-optic broadband over long distances in low-population-density areas with rugged terrain.

Expanding federal grant programs to include FWA, in addition to fiber, would provide a more cost-effective means of delivering broadband speeds to homes with students who need them. Specifically, the Mid-range FWA offers an optimal combination of range and network throughput. This could effectively reduce taxpayer costs, as the high cost of deploying physical fiber cable to every residence in rural America can be mitigated by using line-of-sight FWA capabilities (Erann, 2023).

Additionally, new federal grant funds that allow schools to purchase hotspots and cover ongoing cellular access can provide internet access to students who are currently isolated from the internet. Schools can assess individual family needs and issue devices to students as needed. With high start-up and monthly plan costs, each device could cost a school over \$1,000 per year (\$85.99 per month for 9 months, plus approximately \$200 per device). However, federal grant funds used for this purpose could help achieve higher successful graduation rates among rural students.

Finally, the ACP program, which subsidized internet access costs for rural Americans (\$30 a month or \$75 a month for tribal citizens), ended in 2024. The program's ending immediately resulted in 13% of users canceling their internet access, and 12% of others planning to cancel their access. This program was a cost-effective way to help rural Americans, especially those with

lower incomes, connect to the internet. At the very least, this program should be reinstated for families with school-aged children to support those children in achieving a successful education.

A hybridized approach to delivering broadband internet services to rural America, one that combines fiber, FWA, and mobile hotspot technologies, can provide more access at a lower price than is currently possible, coupled with federal subsidies for low-income rural families with school-aged children to help pay for access. A well-implemented hybrid plan can ensure internet access for every school-aged child in areas with limited internet coverage, and it is one way to provide successful educational opportunities for students in rural environments.

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