Golden LEAF Rural Broadband Initiative Evaluation

2011-2016 Longitudinal Study Summary

Prepared by the UNC School of Government's Center for Public Technology

EXECUTIVE SUMMARY

The purpose of the Golden LEAF Rural Broadband Initiative longitudinal evaluation is to examine the impact and added value of broadband connectivity on North Carolina communities, businesses, and citizens. Special attention is paid in this evaluation the impacts and advancements facilitated by the capital investment made by Golden LEAF. The identification and assessment of the changes stimulated by broadband connectivity will provide evidence about whether broadband is a worthwhile investment.

This report examines the short-term, longitudinal impact of the Golden LEAF Rural Broadband Initiative from 2010-2016, as well as offers case studies and details related to the advancement of broadband across the state of North Carolina as a result of the Golden LEAF investment.

KEY FINDINGS

The data collected for this Golden LEAF Rural Broadband Initiative annual report show several interesting trends. The bolded statements are particularly salient as the reader considers the impact of broadband investments throughout North Carolina.

- **Seventy-one (71) of the 100 North Carolina counties have over 60% of their households connected to broadband at the end of 2015 (FCC data reported in December 2015), compared to only seventeen (17) counties at the start of the Golden LEAF Rural Broadband Initiative in 2010.**

- **Average price per Mbps is slightly lower in counties where Golden LEAF Rural Broadband Initiative funds have been expended.**
- **There has been a substantial increase in total broadband providers across NC counties, increasing from 7.14 providers per county on average in 2009 to 13.55 providers per county on average in 2015.**
- **Statistically significant relationships between broadband availability and both reading and math standardized test scores exist, even when controlling for traditional measures impacting student achievement (wealth, parental educational attainment).**
- **Access to high-speed broadband continues to be the single most important predictor relative to school district virtual enrollments.**
- Broadband availability continues to increase as percentage of private industry mix increases, as has been found annually since 2011.
- Broadband availability continues to increase as median household income increases, as has been found annually since 2011.
- Average broadband pricing data continues to decrease annually, leading to consumers receiving higher connectivity speeds at the same price as lower speeds in previous years.

In addition to statistically significant findings, several success stories resulting from the Golden LEAF Rural Broadband Initiative have been identified and are included in this report to demonstrate the qualitative impact of the investment made in North Carolina's broadband infrastructure.

SECTION 1. PROJECT OVERVIEW

High-speed broadband Internet access has become a fundamental part of improving educational opportunities, quality of life and economic performance, as evidenced by substantial financial and policy investments in improving accessibility and affordability of such access. Access to high-speed, broadband Internet has become one of the great economic dividing lines in the 21st century and is viewed as a fundamental part of any plan to improve a community's overall quality of life including education and economic opportunities. The National Broadband Plan refers to broadband Internet access as essential infrastructure in the 21st century and is "transforming the landscape of America more rapidly and more pervasively than early infrastructure networks" (pg. 3). The skills that can only be developed as a result of access to high-speed, broadband Internet—such as search engine use and knowledge of multiple browsers—are now absolute requirements for job seekers across the country. The Pew Home Broadband Adoption survey found that 43% of Americans believe lack of Internet to be a disadvantage for conducting particular activities, primarily job seeking and building career skills. Skills that can only be developed as a result of access to high-speed, broadband Internet—such as search engine use and knowledge of multiple browsers—are now absolute requirements for job seekers across the country. North Carolina has been proactive in expanding broadband infrastructure and improving broadband speeds, primarily to

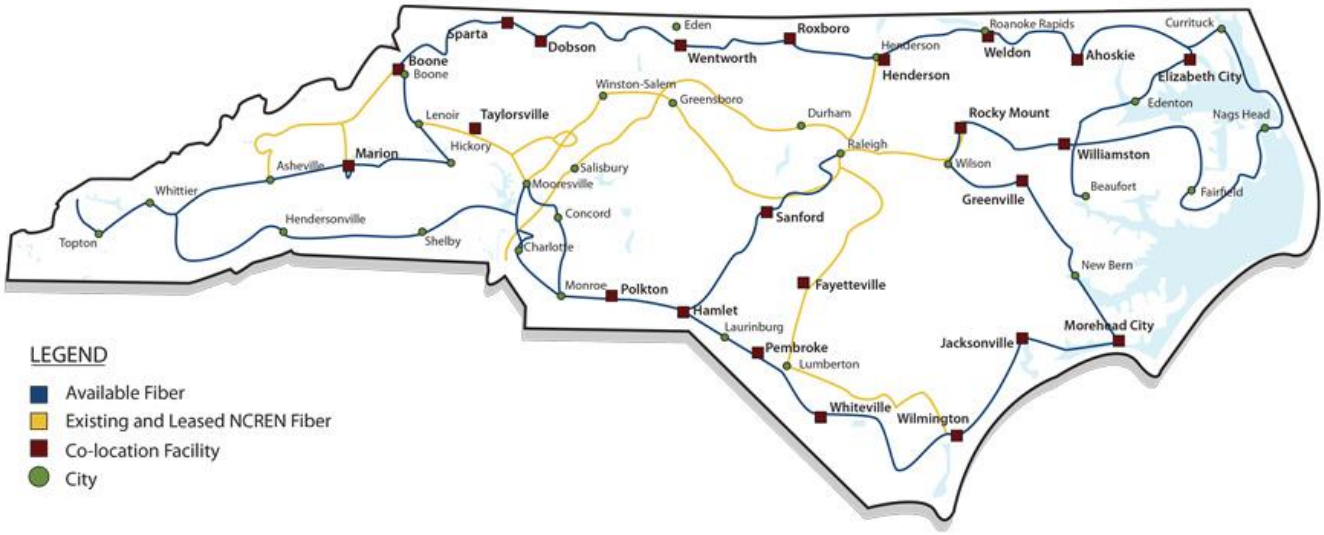
underserved areas and key institutions, through the Golden LEAF Rural Broadband Initiative, among other efforts.

The purpose of the Golden LEAF Rural Broadband Initiative evaluation is to examine the impact and added value of broadband connectivity on North Carolina communities, businesses, and citizens, particularly as facilitated by the capital investment made by Golden LEAF. The identification and assessment of the changes stimulated by broadband connectivity provides evidence about whether broadband is a worthwhile investment. This longitudinal report offers both context and data comparing pre-Golden LEAF RBI data to current state data, as well as demonstrates the changes which have occurred, in large part due to the efforts undertaken by Golden LEAF and MCNC. Additionally, the report offers detailed insight into the perceived importance of broadband access through case studies, coupled with quantitative evaluation of said importance.

Research Design and Methodology Review

The evaluation for the Golden LEAF's Rural Broadband Initiative and MCNC's BTOP awards utilizes both quantitative and qualitative approaches to data collection, analysis, and presentation in order to offer a full contextual framework for evaluation. The four primary areas of evaluation focus on output and outcome metrics, with output metrics reported throughout the life of the project and outcome metrics expected to emerge throughout the project and beyond. Data was collected for all 100 counties in North Carolina to provide comparative analysis, on a monthly, quarterly, or annual basis from 2010-2016, as determined by data source update frequency.

The Reach of the Golden LEAF Rural Broadband Initiative



Through a $144 million investment in broadband infrastructure (approximately 99.3% spent in the private-sector), the Golden LEAF Rural Broadband Initiative has created substantial fiber assets in the state. This highway to the future can be a highway for prosperity for enterprises & service providers looking to grow their network, own and operate a network, or create more route diversity.

Source: mcnc.org

Report Structure

The report is organized based on the four key evaluation areas of: 1) market impact; 2) economic impact; 3) educational impact; and, 4) societal impact. Within each area of evaluation, the report offers longitudinal data comparison from 2010-2016, along with key effects noted during any specific year of the project. Additionally, case studies are offered to provide context and qualitative impact

statements related to the Golden LEAF Rural Broadband Initiative in each of the four evaluation areas. National data comparisons related to broadband deployment and adoption are also presented to provide reference points for the evaluation and subsequent report.

Following the analysis and discussion in each of the four substantive evaluation areas, the conclusion contains an overview of study limitations and challenges, as well as potential opportunities for additional impact. An overview of staffing for this project, along with roles and responsibilities is included in the Appendix, to demonstrate the scope of effort undertaken as part of the multiyear longitudinal evaluation.

SECTION 2. MARKET IMPACT ANALYSIS

"Communities across the nation know that access to robust broadband is key to their economic future--and the future of their citizens"
FCC Chairman Tom Wheeler

North Carolina has invested substantial resources to improve its broadband connectivity and adoption rates as a means to achieve economic, education, and societal equity through the Golden LEAF Rural Broadband Initiative. This evaluation tracks level of market penetration, competition, and costs to subscribers to help ascertain the impact of these investments. This section focuses on those areas using the following metrics:

- Broadband adoption rates by county (as reported to the FCC in aggregate form)
- Baseline rates of providers in each county (updated semi-annually)
- Baseline number of providers per county (as reported to the FCC)

Together, these metrics have been used to test hypotheses related to competition, provider pricing, and broadband adoption across North Carolina counties, utilizing descriptive statistics, correlation, and time-series analysis.

Research Questions and Findings

In designing the evaluation plan for the Golden LEAF Rural Broadband Initiative, two primary research questions related to market impact were established and are tested in the evaluation process. The following questions have interesting findings, as briefly noted below and discussed in greater detail on the following pages.

1. **Does the provision of low-cost middle-mile connectivity lower the barrier of entry for new last-mile providers in many rural communities, thereby increasing the number of providers in a given North Carolina county?**

Over the course of the Golden LEAF Rural Broadband Initiative evaluation, most year over year comparisons have demonstrated a loss of providers due to mergers and acquisitions, while connectivity levels have steadily increased. However, looking at the data longitudinally, there has been a substantial increase in total broadband providers across NC counties, increasing from **7.14** providers per county on average in 2009 to **13.55** providers per county on average in 2015. Furthermore, the 2010-2016 data demonstrates a positive correlation between the number of providers in a given county and the average level of household connectivity, which has potential for impacting the next research question.

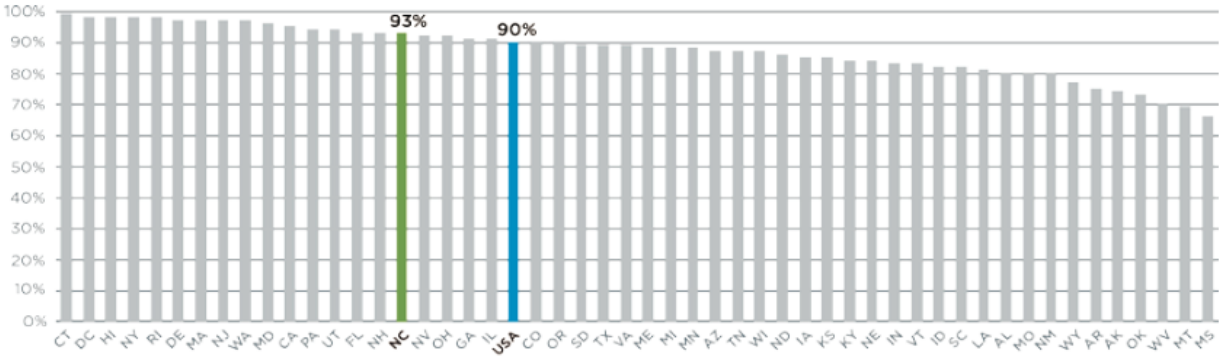
2. **Does the provision of low-cost middle-mile connectivity across North Carolina lead to lower costs for broadband customers, either as a function of wholesale transit costs or increased competition for the last-mile providers?**

More significant and impactful findings are demonstrated in the realm of broadband pricing for residential consumers. First, residents of North Carolina continue to see a decline in average broadband pricing per Mbps. **An even more important finding is that those counties touched by the Golden LEAF Rural Broadband Initiative demonstrate slightly lower pricing compared to non-impacted counties.** Thus, the data lends credence to the proposition that increased access to middle-mile connectivity will lower average broadband costs for household consumers.

Provider and Deployment Findings

In 2009, North Carolina ranked 14th among U.S. states for broadband adoption rates. The Federal Communications Commission (FCC) updated the recommended broadband "availability" target speed from xxx to 25 Mbps/3 Mbps in January 2015 (up from the previously recommended 4 Mpbs/1Mbps established in 2010). Utilizing the newly recommended speeds, North Carolina ranks 9th in the United States in terms of broadband deployment. As noted in Figure 1 below, North Carolina's broadband deployment rate (93%) is slightly higher than the national average (90%).

FIGURE 1. BROADBAND DEPLOYMENT RATE COMPARED TO OTHER STATES



Source: FCC 2016 Broadband Progress Report, data current as of 12/3/14

As part of this assessment, we have gathered and analyzed data about the rate of North Carolina broadband deployment at the county level from 2010-2015 via data reported annually to the FCC[1]. The longitudinal data related to overall household broadband access in North Carolina indicates a positive increase over time. Seventy-one (71) of the 100 North Carolina counties have over 60% of their households able to connect to broadband at the end of 2015 (FCC data reported in December 2015), compared to only seventeen (17) counties at the start of the Golden LEAF Rural Broadband Initiative in 2010.

Over the course of the evaluation, three counties had been noted as areas of concern due to their broadband availability rates. According to 2015 data, all counties in North Carolina now have broadband deployment rates of 40% or higher, compared to the 40 counties below 40 percent in 2009.

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[1] The FCC uses a scale to represent the percentage of households connected, as follows[1]:

0=Zero households connected per 1000 households
1=Greater than 0 and less than/equal to 200 households connected per 1000 households
2=Greater than 200 and less than/equal to 400 households connected per 1000 households
3=Greater than 400 and less than/equal to 600 households connected per 1000 households
4=Greater than 600 and less than/equal to 800 households connected per 1000 households
5=Greater than 800 households connected per 1000 households

A deeper analysis of the data reveals that counties designated in 2011 as Tier One, those most economically distressed, had slightly larger increases in broadband availability, compared to Tier 2 and Tier 3 counties. This information is particularly encouraging, as it indicates that the most distressed areas of the state are continuing to focus on broadband connectivity as a way to increase economic opportunity and improve residents' quality of life. Furthermore, the longitudinal data indicates a pattern of increased access to broadband Internet in the most distressed counties in the state.

According to the FCC data, the following counties showed no movement in household broadband connectivity between December 2009 and December 2015, while all other counties demonstrated a positive gain in adoption rates:

Counties with No Household Broadband Availability Change 2009-2015

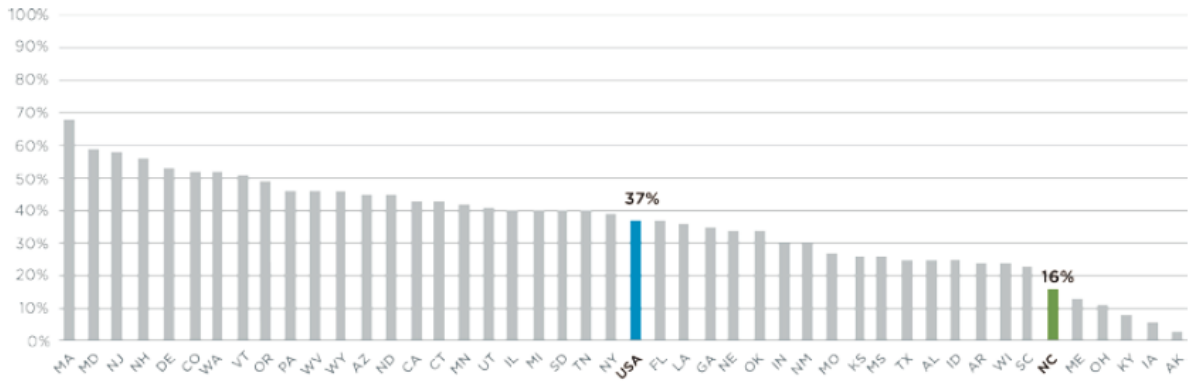
Lenior County (40-60%)
Craven County (60-80%)
Cumberland County (60-80%)
Dare County (80-100%)
Onslow County (80-100%)
Watagua County (80-100%)

Despite the appearance of static broadband availability rates, this is largely due to the twenty percent (20%) range of measurement unit. In fact, each of these counties has experienced a demonstrated increase in availability within the 20% range itself.

Broadband Subscription Findings

Unfortunately, while our deployment rate is above average, the actual adoption rate (households who subscribe) is among the lowest in the United States, with only 16% of households subscribing at the recommended speeds of 25 Mbps/3 Mbps (see Figure 2 below).

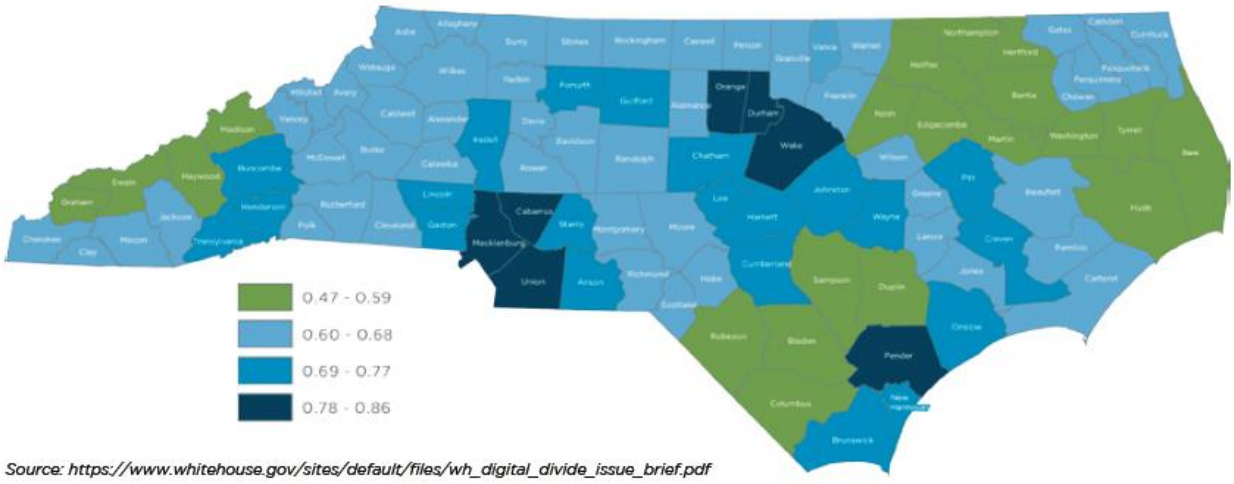
FIGURE 2: BROADBAND ADOPTION RATE COMPARED TO OTHER STATES*



*out of 45 reporting states. Source: FCC 2016 Broadband Progress Report, Data Current as of 12/14

Particularly distressing is the not-surprising finding that the most economically distressed and sparsely populated counties lag behind the more dense and wealthy counties, as noted in Figure 3 below.

Figure 3. County-Level Adoption Rates



Source: https://www.whitehouse.gov/sites/default/files/wh_digital_divide_issue_brief.pdf

The North Carolina Broadband Infrastructure Office's 2017 Broadband Plan offers several commendable recommendations for increasing household broadband adoption, including educational campaigns, subsidies for qualified households, and statewide digital literacy efforts.[2]

Other notable data findings include:

1) A slight but not statistically significant decrease in the price of broadband service is tied to an increase in residential broadband adoption rates across the state; and,
2) A positive relationship between median household income and residential broadband adoption rates, as is consistent with national findings, and exacerbates the digital divide challenges found in rural communities across North Carolina.

Pricing and Competition Findings

The longitudinal data analysis highlights a substantial increase in total broadband providers across NC counties, increasing from **7.14** providers per county on average in 2009 to **13.55** providers per county on average in 2015. Furthermore, the 2010-2016 data demonstrates a positive correlation between the number of providers in a given county and the average level of household broadband availability.

[2] https://ncbroadband.gov/wp-content//uploads/2017/02/NC-Broadband-Plan_2017_Online_FINAL_PNGs3www.pdf)

More significant and impactful findings are demonstrated in the realm of broadband pricing for residential consumers. First, residents of North Carolina continue to see a decline in average broadband pricing per Mbps. As is consistent with national trends, North Carolina customers are being offered more bandwidth for increasingly lower prices and generally have more bandwidth choices based on this longitudinal analysis.

An even more important finding is that those counties touched by the Golden LEAF Rural Broadband Initiative demonstrate slightly lower pricing compared to non-impacted counties. Thus, the data lends credence to the proposition that increased access to middle-mile connectivity will lower average broadband costs for household consumers. This bodes well for the future long-term outcomes associated with Golden LEAF's Rural Broadband Investment, assuming the challenge of household subscription rates can be addressed adequately through other means, such as effective education and marketing campaigns, increased reliance on household high-speed access for North Carolina's student populations (K-20), and increased competition among providers.

Additionally, there is substantial evidence from governmental and private sector customers that their costs have decreased significantly by leveraging the high-speed network created by the Golden LEAF Rural Broadband Initiative. Finally, companies like Google Fiber and AT&T have partnered with local communities to offer Gigabit services to residential customers due to the pro-fiber groundswell that has occurred as a result of the Golden LEAF and MCNC investments. The following case studies are offered as qualitative evidence of impact.

MARKET IMPACT CASE STUDY

Inteliport: The Impact of the Golden LEAF Rural Broadband Initiative On a Local Internet Service Provider

Steve Lane, the president of Inteliport, a local ISP in eastern North Carolina, is convinced that his current business model would not be possible without MCNC and the GLRBI. In fact, without the GLRBI middle mile, Inteliport would not be here today at all! According to Mr. Lane, MCNC was the only organization which could build the broadband network that they did at the time because of their neutrality and their understanding of the needs and economic situations in rural North Carolina.

GLRBI has enabled broadband in North Carolina to grow organically, allowing smaller companies to gain access to an infrastructure that would otherwise be out of their reach. On one hand, it is challenging for a smaller ISP to get funding from a bank for fiber construction or access. But on the other hand, without fiber, it is not possible to grow the broadband infrastructure necessary for gaining customers. Without GLRBI and its affordable middle mile fiber infrastructure, larger incumbent providers have an insurmountable advantage compared to smaller, local companies. Unfortunately, those companies often choose not to serve areas with sparse population density or limited wealth, thereby increasing the digital divide and leaving rural and distressed communities to fall even further behind. In partnership with MCNC and the Golden LEAF Rural Broadband Initiative, Inteliport

has been able to self-fund its fiber to the home product in Perquimans County through a creative, collaborative approach with future customers.

Inteliport also offers a wireless network using microcells and then feeding back to GLRBI. They are continuing to work with MCNC to identify opportunities for better reach into rural locations, exploring fiber to the curb and then a wireless connection, for example. MCNC enables Inteliport and other smaller providers to explore creative partnerships and ideas, such as the "mte" approach out of Scotland and partnering with TENG locally. In addition, MCNC offers the opportunity to explore creative funding models, establish collaborations, and recognize the positive impacts to the community of broadband availability. This type of venture is successful with small businesses such as Inteliport which are committed to the wellbeing of the community.

MARKET IMPACT CASE STUDY

The North Carolina State Highway Patrol: The True Value of the Golden LEAF Rural Broadband Initiative

The North Carolina State Highway Patrol has experienced several positive impacts as a direct result of the North Carolina Golden LEAF Rural Broadband Initiative. An interview with Allan Sadowski, formerly of the NC SHP and now Director of Infrastructure for FirstNet, was conducted and he highlighted the following realized benefits.

1. **Cost:** The NC GLF RBI has resulted in dramatic lower cost for high-speed connectivity (compared to equivalent commercial high bandwidth providers) at many major Patrol locations.
2. **Bandwidth:** The network performance has improved substantially for moving data throughout the Highway Patrol. Of particular note, the Highway Patrol has an enhanced ability to do video teleconferencing and distance learning at several Patrol locations with high-quality audio and video, due to sufficient and stable bandwidth. In addition, the increased bandwidth also extends to mirroring storage arrays and associated virtual servers for off-site data processing, thereby improving disaster recovery processes.
3. **Reliability/redundancy:** Major communications and IT nodes now have backup/redundant high bandwidth connections. This same capability supports a high speed backup link between the three VIPER control nodes, which is critical to VIPER functionality and performance.

4. **Support to public safety partners:** A secondary impact is that several partners in public safety have been able to take advantage of the GLF RBI/MCNC fiber brought in to the VIPER system controller sites for their own connections (from their dispatch operation to VIPER).
5. **Backup Connections:** Another secondary impact is that as a result of the Patrol working with MCNC and leveraging the NC GLF RBI, the NC Department of Public Safety has been able to establish a backup connection between servers at the Western Data Center and Joint Forces HQ (NCNG) Data Center.

MARKET IMPACT CASE STUDY

The Town of Holly Springs:
Leveraging a Next-Generation Network for Governmental Efficiency and Effectiveness

Thanks to the Golden LEAF Rural Broadband Initiative and MCNC, a multi-loop, underground fiber optic network now serves the internal telecommunications needs of the Town of Holly Springs. While the network's base was completed in 2014, the network continues to grow and its impact continues to evolve.

The Fiber Project dramatically enhances the Town's internal communications, and the government is no longer constrained by bandwidth. In addition to meeting the Town's needs, the network allows innovation and efficiencies that were inconceivable in the previous environment. Financially, the build-out of a private Town network has demonstrated a payback period of less than ten years compared to current lease rates with private providers, while allowing connectivity speeds of almost 20 times what those current providers in the community were offering.

While the impacts on the governmental operations have been substantial, thereby increasing efficiency and effectiveness of tax dollar expenditures, there have been remarkable unanticipated benefits as well. Most recently, the fiber connectivity was leveraged to offer free Wi-Fi at the Town's Food Cupboard so the employees and volunteers could help residents who have fallen on hard times apply for the benefits available to them, as well as help them look for work.

As the FCC continues to assess laws restricting municipal broadband, the Town had foresight in its network design. While North Carolina law currently prohibits the Town from directly offering broadband services to its residents, the fiber project was specifically designed to enable a private company to offer advanced services to homes and businesses in the future. The network includes substantial amounts of spare fiber optic strands and underground conduit space that can be leased by a competitive provider. The wide-reaching impact of the Town's network infrastructure would not have been possible without the low-cost, high-speed, reliable connectivity offered by MCNC through the Golden LEAF Rural Broadband Initiative.

MARKET IMPACT CASE STUDY

Reaching the OBX: Partnerships in Productivity

Nags Head and the Town of Kill Devil Hills partnered to move on to the MCNC BTOP fiber, funded through the Golden LEAF Rural Broadband Initiative, in 2014. The Town of Kill Devil Hills was able to save $3,000 per month on broadband service (paying $1,000 instead of $4,000) while doubling their Internet speed. The Town of Nags Head felt that they were "at the mercy" of their provider who was trying to pull out from the Town and could do so at any time and increased their speed tenfold. In addition to saving money, the Town of Nags head found that the increased bandwidth meant that streamed commissioner meetings are no longer bottlenecking over the Internet.

One of the most substantial impacts of the access to the MCNC fiber ring is that the Towns have complete and automatic redundancy with border gateway protocol ensuring that if the Internet is down for more than a few seconds, the redundancy kicks in. This redundancy is of critical importance on the Outer Banks where storms can lead to deadly results and quick and efficient communications are key. The positive experience with the improved service and the excellent customer experience has led to conversations about connecting the North Carolina Aquarium System at the Nags Head Pier to MCNC.

SECTION 3. ECONOMIC IMPACT ANALYSIS

A number of studies have reported economic growth related to broadband. *Measuring Broadband's Economic Impact* (2010) found that, nationwide, broadband contributed to job creation, the number of businesses (with greater growth in the IT-intensive sector in areas with more broadband), and property values, but no statistical impact was found for wages. A study by Jed Kolko (2010) also found mixed results nationwide, as broadband was not found to be associated with employment rate or wages, but did impact business activity. A study conducted in 2006 demonstrated positive economic outcomes for communities which had installed broadband connections across the United States (Lehr, Osorio & Gillett, 2006). An increase in gross sales in a community in Florida was attributed to its municipally-owned broadband network (Ford & Koutsky, 2005). Finally, a study of the commercial benefits of broadband in the rural Appalachia region found modest impact on firm productivity and wages in particular regions and scenarios (Burton & Hicks, 2005). Other studies have estimated gross economic impact, job creation, and employment rates in communities, states, and nations achieved through broadband investment and adoption.

This section examining the economic impact of the Golden LEAF Rural Broadband Initiative focuses on the following areas:

- Gross sales
- Number of businesses (SML)
- Annual median household income
- Average annual wages
- Job creation and retention
- Industry mix (namely, the percentage of IT-intensive jobs)
- Self-employment rate
- Employment rate
- Population density
- Percentage of private sector employment
- Home ownership

Research Questions and Findings

The primary research question related to the economic impact of the Golden LEAF Rural Broadband Initiative is:

1. **Does increased access and adoption of broadband connectivity in households lead to positive economic outcomes in North Carolina counties?**

As has been observed nationally, the data trend of median household income and rates of broadband adoption being positively correlated holds true across North Carolina counties, meaning that as household income increases, so do the rates of broadband availability and adoption. This finding is not to posit that broadband availability increases median household income levels, rather that higher median

household income levels likely drive the presence and adoption of broadband in those counties. Additionally, broadband adoption rates have a negative correlation with unemployment rates (as broadband adoption rates increase, unemployment rates decrease).

The most substantial finding related to economic impact deals with employment rate. Employment rate and broadband availability have a statistically significant positive relationship (36%). In the early years of this longitudinal study, this positive relationship was present even when controlling for wealth measures, population density, and industry mix (these measures typically influence broadband adoption so they were controlled for in the analysis). However, this trend has slowly lessened and is no longer statistically significant when controlling for wealth measures, population density and industry mix. One interpretation of this change is that the presence of broadband is no longer a necessary and sufficient condition related to employment rate, but rather, the lack of broadband availability is likely due to lack of population density and lower income levels, further deepening the schism between the haves and have-nots.

This finding is very promising for the state of North Carolina because of the substantial Golden LEAF investment in middle mile infrastructure, which as previously demonstrated has increased competition and broadband extension across the state of North Carolina.

It is also worth noting that there is also a positive relationship between a county's tier and the rate of broadband adoption. This means essentially that the wealthiest counties in the state have, on average, higher rates of broadband adoption and access than the poorest, most underprivileged counties, although all counties' broadband access have improved substantially over the duration of the study. Finally, there is a positive longitudinal correlation between the amount of private sector industry in a given county and the level of broadband adoption in said county.

As demonstrated by the various factors examined, there are strong correlations between several economic variables and broadband adoption rates. However, these relationships are not necessarily causal in nature, as they are influenced by various other factors in a given county and have all improved over the course of this study, just as the rate of broadband adoption as improved. The case studies on the following pages are offered as further evidence of the significant effect of broadband on economic outcomes in our communities.

ECONOMIC IMPACT CASE STUDY

Teleworking in Alleghany County

Telework allows employees to work from off-site locations and to keep in touch with supervisors and coworkers and clients through the use of computers, telephones, and other communications equipment. Telecommuting is a more limited term that refers to work done from home, without any commute at all. Two examples in **Alleghany County** illustrate what is meant by these terms. An entrepreneurial firm offering medical transcription services to clients in multiple states established operations in the Blue Ridge Business Development Center precisely to take advantage of the high-speed, redundant broadband services that are available at this telework center, but not at the entrepreneur's rural residence. Down the road at Alleghany Medical Hospital, medical transcription, once an on-site function, now is served off-site and via telework, as is radiology diagnosis. In both cases the managers cite the critical need for competitive broadband services. Jobs that could go anywhere can be retained locally as long as the broadband infrastructure provides the quality of connectivity needed to support this vital service.

Telework is an increasingly important factor in business competitiveness. Objective studies done at the local, state, national and international levels have shown telework to be a business power tool that is associated with impressive increases in productivity, profitability and employee empowerment. This killer- app can be especially important for smaller and rural communities that can attract and

retain high-value jobs with relatively modest investments in up-graded broadband infrastructure. While not all jobs lend themselves to telework, it is estimated that the work done by between 40 and 50 percent of all employees could be done remotely, at least part-time, while 25 percent have the potential to be full-time telework positions. Benefits of telework are well-documented: firms with progressive telework policies experience an average 25 percent increase in productivity, annual savings of $2,000 per employee resulting from 63 percent reduction in absenteeism, up to 30 percent savings in facilities cost, increased responsiveness, expanded access to talent pools of handicapped and retired workers and up to 85 percent increase in employee retention. When compared to traditional workers, those who telework experience greater job satisfaction, improved health, reduced stress and better time management.

Telework is green, it's inexpensive and it's good for businesses, employees and communities. A year-long telework pilot study of 150 North Carolina State Employees in 2000 documents environmental benefits that for each 1,000 workers would produce 70 tons reduction in pollution, 50 work years of reduced traffic congestion, 200,000 gallons of fuel reduction and 500,000 miles of reduced vehicle mileage. Given a state workforce in excess of 4 million, a one percentage point increase in teleworkers would save more than 8 million gallons of fuel and 20 million vehicle miles annually!

In the United States, 34 percent of workers are estimated to work from home at least one day per month and another 17 percent are full-time teleworkers. Comparison with our state data tells a familiar story of two North Carolinas. A 2011

statewide survey of more than 1,500 households and 6,000 organizations conducted by Strategic Networks Group for NC Broadband revealed that 32.8 percent of North Carolina workers telework at least part-time, with regional breakdowns as follows: Research Triangle 40.2 percent; Charlotte 38.2 percent; Advantage West 28 percent; Piedmont Triad 26.4 percent; Southeast 21.9 percent; Northeast 20.5; and East 19.7 percent. We need to understand the reasons behind these differences.

Telework is highly relevant to economic opportunities and challenges facing the state. Call center recruitment and farm-shoring opportunities combine with extended and potentially crippling transportation projects to create a pressing need to encourage interest in telework. Telework adoption needs to be monitored and tools, policies and statutes promoting its use implemented.

ECONOMIC IMPACT CASE STUDY

Rutherford County Broadband

Like much of North Carolina, broadband services have drastically expanded and improved in Rutherford County over the past decade. However, Rutherford County's strategies and successes in using their broadband infrastructure for expanding and improving economic development efforts are unique. The primary fiber infrastructure was funded and installed through a partnership with the county, the Golden Leaf Foundation and other funders, and local non-profits PANGAEA and Foothills Connect.

Based out of Polk County, PANGAEA or the Polk Area Network for Government, Academic and Enterprise Activities, provides and sells fiber fostered broadband services to local government agencies, education facilities, healthcare providers and other non-profits (http://www.pangaea.us/company/history.php). Foothills Connect Business and Technology Center was founded by local citizens and funded by the e-NC Authority in 2004. Both PANGAEA and Foothills Connect have been at the forefront of the broadband expansion as well as the utilization of broadband as an economic development tool. Foothills Connect is involved in a host of efforts aimed to improve the local economy through technology. Interviewees believe the increased broadband services are partly responsible for the location of businesses such as Facebook and the State Data Center in Rutherford County, according to County economic development staff.

In addition to the assistance they provided in administering the grant from the Golden LEAF Foundation for the original fiber, Foothills Connect is now establishing a high-speed wireless network for residents. The wireless network will serve as the "last-mile" connection needed to reach as many residential units as possible. The current broadband infrastructure serves, between 200 and 400 residential connections per 1000 households, according to FCC data. Most notably, interviewees perceive the low residential connection rate to be an impediment to education and economic development efforts and thus are now focusing on improving the rate.

Rutherford County is unique because it has multiple different organizations working towards expanding broadband services throughout the county with the goal of improving their economy. Located in western North Carolina, Rutherford County, NC is an economically depressed, Tier 1 County. Primarily a rural county, Rutherford's economy historically heavily relied on agriculture and then textile manufacturing. When textile manufacturers relocated, Rutherford County's economy suffered dramatically. Today, due in part to the expansion of broadband services, Rutherford County hosts several high-tech firms. As the county and its partners continue to improve this infrastructure and use it in innovative ways, they will continue to improve economic development efforts in Rutherford County.

SECTION 4. EDUCATIONAL IMPACT ANALYSIS

Research demonstrates that broadband connectivity in schools leads to increased stability and reliability of operations (Crabtree and Roberts, 2003; Underwood *et al*., 2003; 2004). Other studies have linked reliable operations to positive impacts on teacher confidence in using technology in the classroom. Although the primary focus of the longitudinal Golden LEAF Rural Broadband Initiative evaluation focuses on examining the impact of broadband connectivity on virtual education, we also examined school performance data and teacher attitudes about technology to determine if additional educational benefits are derived. The education impact analysis uses quantitative research methods, such as descriptive statistics, regression analysis, and time-series analysis, along with qualitative methods, such as case studies, to add perspective and depth to the evaluation.

The following metrics were used to assess the impact of broadband connectivity on education in North Carolina:

Student Performance	Teacher/Classroom Performance	Virtual Enrollments	Societal Controls
•EOG/EOC test scores •AP placements •Dropout rates •SAT/ACT scores (% students taking) •Student connectivity at home •Discipline incidents •Attendance	•Usage of technology •Advanced degrees •NBCT •Certified Media Coordinators •Certified Instructional Technology Facilitators •1-1 Computing •Students per Internet-connected device	•Virtual enrollments in K-12 •Virtual community college enrollments •Virtual university/college enrollments	•Educational attainment levels •Poverty level •Median household income •Etc.

Research Questions and Findings

The two primary research questions related to educational impact are:

1. **Does an increase in high-speed Internet access (increased reliability and stability of operations) improve teacher confidence in technology, and subsequently increase technology use in the classroom?**

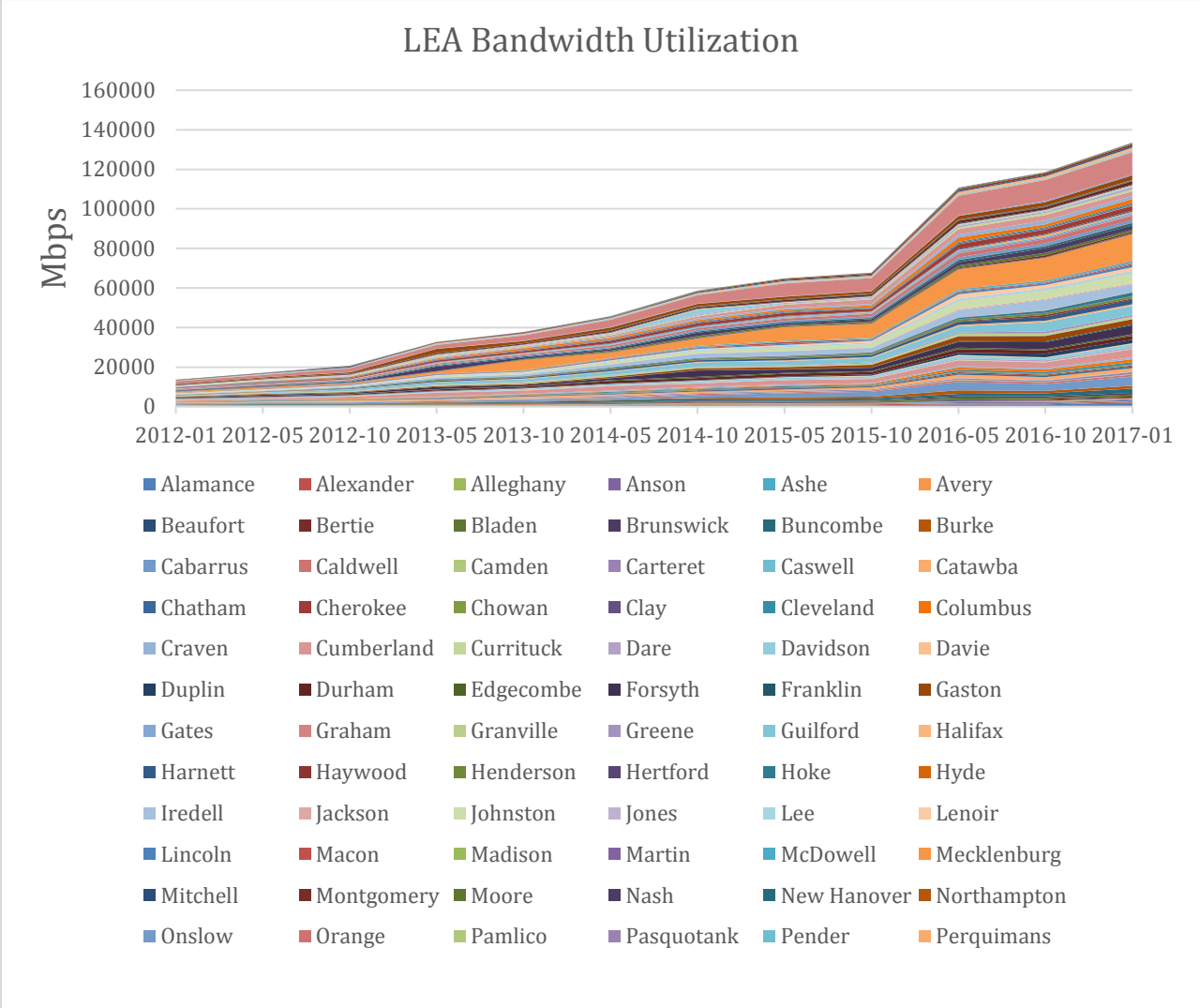
Improving access to technology, including high-speed Internet access, can have a profound impact on student learning and achievement, when teachers are trained in the use of the new technology resources. While there are no statistically significant findings between high-speed Internet access and technology usage in the classroom, largely due to the almost ubiquitous high-speed access across all North Carolina public schools via MCNC, the real and direct impact of high-speed internet access in the classroom cannot be overstated.

For example, the Alleghany County Schools Chief Technology Officer noted,

"The significance of high-speed connectivity in our district is immeasurable. High speed connectivity has enhanced every level of education from Pre-K through high school in Alleghany County Schools. It has helped our teachers to obtain advanced degrees through distance learning programs, and it offers our students various opportunities that would not be available without the high speed connections. This form of communications technology has extended educational experiences for our kids far beyond the walls of their classroom here in rural Alleghany County.

Given that we live in a very rural community, the high speed connections play a critical role in providing our students exposure to the rest of the world in a way that was not even imaginable a few short years ago. As advances in technology turn into tomorrow's standards, the vision for students in Alleghany County Schools must be one that includes the rapid changes that take place in all areas of technology. We cannot be blind to the fact that, as educators, if we do not keep abreast of all of these rapid changes, our students will not be prepared for the world of commerce as it exists today and will exist in the future."

Additionally, data provided by MCNC about school broadband peak usage rates demonstrates the veritable explosion of data usage between 2012 and 2017. The following graph offers a visual representation of this growth.



The statewide average increase in bandwidth utilization is 10X from 2012-2017, further highlighting the criticality of sufficient broadband infrastructure for NC. The following case study offers qualitative and quantitative insight into the major issues associated with classroom technology deployment. Essentially, while high-speed connectivity is a necessary condition for the use of technology tools in the

classroom, it is not a sufficient condition, as teacher training and support are substantially more impactful on actual classroom use by teachers. Harnett County Schools was able to achieve positive impacts, in part thanks to having a high-speed, robust Internet connection provided by the Golden LEAF Rural Broadband Initiative.

EDUCATIONAL IMPACT CASE STUDY

Harnett County Public Schools: Using Technology to Positively Impact Student Achievement

Harnett County Schools is a rural school district with a significant transient population located in the heart of North Carolina and positioned between two major urban areas of Raleigh and Fayetteville. The Fayetteville area is home to the Fort Bragg military installation, which includes the Army and Pope Field, both of which are directly adjacent to Harnett County. The Fort Bragg installation is also the home of the newly combined headquarters of the U.S. Armed Forces Command (FORSCOM) and the U.S. Army Reserve Command (USARC).

The proximity of Harnett County to military bases and major urban areas contribute to the diverse nature of the 20,400 student population. Many families work outside Harnett County but choose to live in the area due to the affordable cost of living. OrEd Laboratories (2010) conducted a land-use study to predict student population numbers for Harnett County Schools and provided the following growth predictions: 2011-12 +336, 2012-13 +612, and 2013-14 +437, with the vast majority of the growth impacting the nine targeted schools. The influx of students coupled with historical budget reductions will result in a significant increase in the number of students in each classroom and will present significant challenges for student achievement.

Harnett County has an unemployment rate of 11.6%. Because of diminishing industry and services, the impact will be even greater than the percentage indicates.

All of Harnett County's seventeen elementary schools are classified as Title I schools. (The definition of a Title I School is a poverty rate of 40 % or more based upon the participation in the Federal School Lunch Program.) The five middle schools and four high schools also have 40% or more of their students receiving free or reduced lunches as well; therefore, they meet the definition of poverty as delineated by the Title I Program. Overall, 54% of Harnett County Schools' students qualify for the Federal School Lunch Program. As a result of the ongoing economic climate and the historically low funding for Harnett County Schools, the district lacks resources for textbook adoption, inquiry-based science kits, math manipulatives, and technology deployment. Due to this lack of financial resources, availability of 21st Century teaching and learning tools has been significantly impacted. This impact has resulted in an inequity of access as compared to neighboring and comparable LEAs.

At the time of the application and subsequent award of the Department of Defense Education Activity (DoDEA) Grant, Harnett County Schools was identified as being in Local Education Agency (LEA) improvement in the area of Mathematics and remained in that category through the conclusion of the first year of the grant implementation. It is because of this weakness that the primary goal of the grant project is to increase student achievement in Mathematics. Though the area of Science is one that has just recently become included in the state-wide testing requirements at the 5th and 8th grades, Harnett County Schools has identified the importance of Science in the development of 21st Century job skills. Finally, to use 21st Century technology devices and skills to accomplish these program objectives

will also serve to better prepare our students to be college and career-ready upon their graduation.

The overarching goal of the *PowerUp!* project is to increase K -12th grade student math and science literacy at the target schools through innovative and rigorous technology-integrated instruction in order to enhance the educational experience, increase proficiency, and improve student preparation for future careers. The specific outcomes expected as a result of the *PowerUp!* program is detailed below:

Outcome 1. *By June 2014, 80 percent of 4th-12th grade students at the target schools will score proficient or above on the state End of Grade/End of Course (EOG/EOC) assessment in math, an average increase of 10 percent over the SY 09/10 level.*

Outcome 2. *By June 2014, 71 percent of tested 5th - 12th grade students at the target schools will score proficient or above on the state science assessment, an average increase of 10 percent over the SY 09/10.*

As the Power Up! Project is concluding year 3, numerous successes can be identified and will be reported below. The administration, faculty, staff, and students from Harnett County have worked really hard to fully implement the components of the grant. Many obstacles challenged the project. From the outset, there was a delay in the equipment being delivered to the district by the vendors and suppliers. There was a significant curriculum change, in which the state of North Carolina moved to the Common Core Standards, which impacted Year 2 end of grade testing. Even with these challenges, the district was still able to improve

throughout this process. The hard work of faculty, staff, administration and students of Harnett County Public Schools could only accomplish this monumental task.

As it stands now, Harnett County has fully implemented the grant as specified in the grant. Improvements continued to be made to the process. A key to the process has been the hiring of the Instructional Technology Facilitators (ITF). Where the ITFs have been full-time and integrated into the curriculum process, it has positively affected the schools ability to implement strategies of using technology to enhance the learning experience for the students and teachers. As a result, we have been able to document increased test score results.

Data was collected for Year 3 from the End-of-Grade (EOG) and End-of-Course (EOC) assessments for the 2013-2014 school year. Data was then compared to previous years EOG and EOC test scores. The percent proficiency figures were calculated by taking averages of student composite scores on the state-mandated tests of Mathematics and Science. "Proficiency" for the purposes of this project is defined as a composite score of a "3" or "4".

An examination of the available data yields several points worthy of discussion. First, an overall glance at the available data in summary seems to show a positive trend in achievement data. Scores across the board increased by several percentage points. While overall scores are low, it must be noted that major progress was made from year 2 to year 3 of the grant. In some cases, such as in 5th grade and science, 8th grade science, and Algebra I, a double-digit increase from year two to year three of the grant was realized.

Though there were several areas of significant improvement in achievement data, the overall results of Year 3 have not met the expectations of the grant project. The most glaring data point is the achievement level in Mathematics. Overall scores for math was 50%. The overall math scores dropped, but several individual grades showed improvement in math. Though any increase is student achievement is never "insignificant", the overall level is considerably lower than the goal of 80%. Likewise, the overall proficiency in Science was did not meet its intended goal of 71%. However, the increases in percentage points for science scores were much more aligned with the interim goals of the grant. If the grant were to be extended for two more years, it is my estimation that Harnett County would reach the intended goals of the grant. It also should be noted that the entire state of North Carolina experienced a decrease in test scores due to the statewide mandate to move toward the common core standards.

One unplanned benefit of the grant has been the acceptable of the ITFs. Several school level principals have dedicated local school funds to continue to fund this position. There is clear evidence this position is having an impact on the ability of teachers to successfully integrate technology in the classroom. The grant allowed the individual schools to see the importance of this type of support for teachers in the classroom especially when integrating new age technology in a way that compliments and enhances the traditional delivery of instruction. Another unplanned outcome has been the purchasing of technology for other schools not associated with the grant. Harnett County is moving toward 1 to 1 throughout the district and is quickly adopting technology as a standard for classroom delivery.

2. **Does increased high-speed Internet access lead to better educational outputs, such as test scores, in part due to improved attendance and reduced discipline incidents?**

Based on a time series analysis, **student End of Grade test scores in Math and Reading have a slight positive statistically significant relationship with household broadband deployment rates** when controlling for other known influencing variables (i.e. median household income level, parents' education level, etc.). Lag effects are typically associated with specific investments on education impact so this positive relationship offers substantial promise for even greater effects in coming years. Furthermore, the following vignette from Lenoir County provides qualitative evidence of the real impact of high-speed connectivity at the classroom level, which is often lost in big data macro-analysis.

Portrait of Broadband Impact in Education

In Lenoir County, the NC Connectivity Project has resulted in an increase in bandwidth to our LEA. This high speed connectivity has had the following positive impacts in our district:

- An increase in the number of students who are able to simultaneously participate in online formative assessments.
- Student strengths and weaknesses can be quickly identified allowing for immediate interventions.
- Access to educational and administrative resources including Learn and Earn Online, NCWISE, LEARN NC, NCWISE Owl, and others.
- Greater global awareness via student participation in virtual field trips.
- An increase in on-line delivery of Professional Development to Teachers.
- Reimbursement of WAN connectivity costs has allowed infrastructure improvements that otherwise would not have been funded.

It is hard to imagine how the students of Lenoir County will be able to compete on a national or global level without high-speed connectivity.

Student Attendance and Disciplinary Incidents

In the aggregate, the rate of student attendance nor the number of discipline incidents do not have a statistically significant relationship with increased access to high-speed Internet connectivity (in households or schools). However, as demonstrated in the Harnett County and Lenoir County Schools examples, these variables can be affected at the individual school level, particularly as new teaching technologies are brought in and effectively used by the teachers. However, during case study analysis, there were clear examples of such outcomes at the individual county level. For example, one county school system noted that attendance for students and teachers and discipline incidents decreased markedly when new technology (i.e. laptops, iPods, and iPads) were brought into the classroom. It is possible that this type of positive effect is temporal in nature, and as the technology-generated excitement fades, the attendance and discipline issues return.

Additionally, there is no statistically significant correlation between household broadband subscribership and average student SAT scores, in either the aggregate or when isolated to only those counties who experienced increased in household connectivity rates over the course of the evaluation.

Virtual Enrollments

Another significant and consistent finding annually related to education and household broadband adoption is the impact of broadband access on virtual enrollments. **The analysis revealed that access to high-speed broadband in the household is the single largest predictor of virtual enrollment, from a LEA**

perspective. This finding continues to highlight the need for broadband accessibility and affordability projects, like the Golden LEAF Rural Broadband Initiative, to continue mitigating the digital divide and ensure equal educational opportunities for all North Carolina students. A case study from PARI, noted below, provides even greater insight into the impact of high-speed access as it relates to student engagement and opportunity.

EDUCATIONAL IMPACT CASE STUDY

Pisgah Astronomical Research Institute: Reaching Students Across the State

Pisgah Astronomical Research Institute is based in the remote mountains of North Carolina. PARI is a public not-for-profit foundation dedicated to providing hands-on educational and research opportunities for a broad cross-section of users in science, technology, engineering and math (STEM) disciplines. PARI's telescope is a unique gem in North Carolina and it generates tremendous amounts of data. The bandwidth provided by the Golden LEAF Rural Broadband initiative is a key factor in some of its successes.

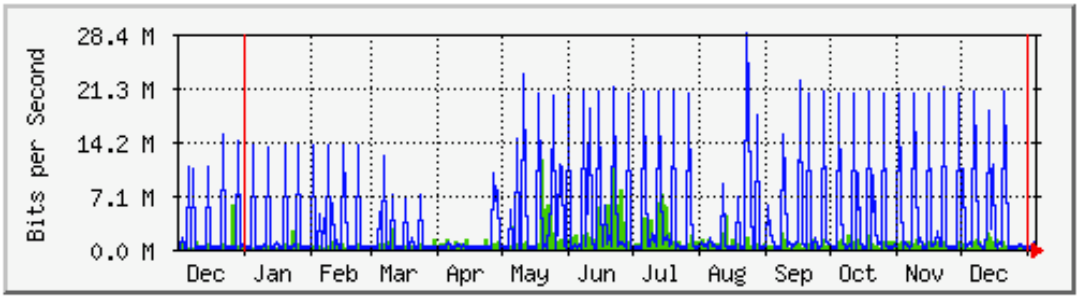
Tim DeLisle was a student at UNC-G when he did a summer internship at PARI. This internship continued into the school year. Tim's responsibility was to design the ability to remotely control the radio telescope, SMILEY, with a user interface that was accessible for people with no previous experience with radio telescopes. While many factors contributed to the successful deployment of this project, the fact that Tim was able to work remotely in Greensboro and test responsiveness real time through the Golden LEAF Rural Broadband funded network and to make rapid changes was a crucial element of its success. Moreover, Smiley provides the ability to save and re-access both data from one's own exploration and data saved by others. This requires a high speed high end connection for any virtual users who want to access the vast treasure trove of data stored through SMILEY.

Duke University's Talent Identification Program is dedicated to being a global leader in identifying academically talented students and providing innovative programs to support the development of their optimal educational potential. Programs for students, families, and educators will be of such excellence that they will become models for the education of academically talented students worldwide.

TIP has a program each summer at PARI. While there, the students do research projects. The high speed internet access (which is a given for many of them in their hometowns) is a key feature to the development of the research that they undertake. One of these students from 2015 used his summer research project as the basis for his application to Cornell University where he was recently accepted. The graph demonstrates the clear use of the network that the Golden LEAF Rural Broadband Initiative has funded.

PARI BROADBAND USAGE

`Yearly' Graph (1 Day Average)



	Max	Average	Current
In	14.9 Mb/s (1.5%)	887.1 kb/s (0.1%)	223.7 kb/s (0.0%)
Out	28.3 Mb/s (2.8%)	3100.5 kb/s (0.3%)	211.3 kb/s (0.0%)

2016 Update

In 2016, Pisgah Astronomical Research Institute (PARI) has continued to thrive with the GRLBI fiber and its relationship with MCNC as a key element that was especially important as they are in the process of developing their new Master Plan. The Master Plan will transform PARI from a remote research center to more publicly focused science center that does research and STEM education; excellent connectivity is a key prerequisite for this transition.

PARI added a second Internet controllable12 meter radio telescope this year. This telescope offers higher quality data than Smiley and could potentially double the number of users which requires excellent broadband capability. By way of background, this telescope was originally used during the cold war to spy on Russia and is now being re-purposed for STEM, shifting the telescope from an instrument of war to an instrument of education.

The Duke TIP students were able to use the telescope this year to conduct hands on science experiments, broadening the reach and impact of this program. The Duke TIP students are able to do real and not canned research, even generating new scientific knowledge that did not previously exist or at least that is new and primary to them. For example, one student team used the instrument to calculate the mass of the Andromeda galaxy. Even for students that will not continue in this field, the common research paradigm that is required for these analyses is broadly transferable and it is the type of work that excites students and motivates them to pursue STEM.

Virtual Enrollments at the Higher Education Level

Another significant and consistent finding annually related to education and household broadband adoption is the impact of broadband access on virtual enrollments. **Again, the analysis revealed that access to high-speed broadband in the household is the single largest predictor of higher education virtual class enrollment.** Similar to the data from MCNC about K-12 bandwidth consumption, students taking virtual courses through various higher education institutions has skyrocketed in the past 5 years. For example, the chart on the following page demonstrates the level of enrollment growth within the UNC system from 2012-2015, Most notably, many of the counties with substantial growth in virtual enrollments are rural counties who have experienced a significant increase in broadband availability over the course of the Golden LEAF Rural Broadband Initiative.

Chart 1. UNC System Virtual Course Enrollment Growth Rate by County Sorted by Largest to Smallest % Increase, 2012-2015

County Name	% Growth	County Name	% Growth	County Name	% Growth
Pasquotank	121.53%	Warren	46.88%	Harnett	31.74%
Bertie	112.50%	Polk	46.30%	Anson	31.58%
Wake	100.74%	Edgecombe	45.45%	Wilkes	31.40%
Robeson	97.10%	Lincoln	45.17%	Davie	30.23%
Guilford	92.64%	Transylvania	45.12%	Johnston	30.05%
Washington	92.31%	Carteret	44.68%	Yadkin	28.47%
Forsyth	91.81%	Cabarrus	43.87%	Franklin	27.80%
Durham	91.02%	Dare	43.07%	Sampson	27.69%
Catawba	89.78%	Mitchell	42.31%	Pamlico	26.67%
Pitt	86.13%	Union	41.91%	Lenoir	24.06%
Buncombe	85.91%	Wilson	40.00%	Person	23.62%
Jones	85.71%	Caldwell	39.77%	Yancey	23.08%
Jackson	81.12%	Moore	39.52%	Chowan	22.73%
Onslow	78.98%	Rutherford	39.39%	Clay	22.22%
Orange	76.03%	Halifax	39.29%	Stokes	21.60%
Gates	75.00%	Rowan	39.17%	Caswell	21.36%
Cumberland	73.28%	Cleveland	39.13%	Granville	21.28%
Northampton	72.00%	Hertford	38.30%	Alamance	20.50%
Wayne	67.64%	Duplin	38.24%	Davidson	20.30%
Haywood	67.14%	Montgomery	37.50%	Madison	19.23%
Cherokee	63.64%	Swain	37.08%	Martin	19.23%
Mecklenburg	63.09%	Scotland	36.70%	Beaufort	19.15%
New Hanover	62.45%	Iredell	36.41%	Greene	18.42%
Watauga	54.53%	McDowell	35.94%	Bladen	18.29%
Henderson	54.15%	Nash	35.49%	Rockingham	15.82%
Macon	53.76%	Craven	34.89%	Hyde	14.29%
Burke	51.41%	Vance	34.62%	Randolph	13.93%
Gaston	51.34%	Currituck	34.15%		
Columbus	51.15%	Ashe	33.80%		
Alexander	50.00%	Pender	33.78%		
Alleghany	50.00%	Brunswick	33.49%		
Graham	50.00%	Lee	32.95%		
Tyrrell	50.00%	Surry	32.45%		
Perquimans	48.28%	Richmond	32.32%		
Hoke	47.73%	Chatham	32.30%		
Stanly	47.04%	Camden	32.00%		

In addition, the following case study from Mayland Community College offers additional qualitative and descriptive evidence of the impact of access to broadband.

Criminal Justice at Mayland Community College

The first online program (in criminal justice) at Mayland Community College (which serves Avery, Yancey and Mitchell Counties) was created fourteen years ago and has had a tremendous impact on both the community college itself – as teachers seek to follow its model and to individuals whose lives have changed as a result of the program.

The 14 year old online program provides an affordable option to students who are unable to complete a program in-person. Often criminal justice students already work in the field and the nature of their jobs and hours, such as shift work, makes it difficult to commit to in-person classes. Additionally, given the nature of the served counties, many students live far enough away from Mayland Community College to make attending classes regularly untenable.

Students often mix and match the in-person and online approaches, attending some classes in-person and the remainder online. In many ways, according to Dr. Ron Davis, who created and runs the program, online programs are more challenging as there may be more work to do. He notes that over time, as technology and connectivity have improved the online program has become much easier to manage both for him and for the students. As a result of MCNC and the Golden LEAF Rural Broadband Initiative's effort to spur broadband availability, enrollment in the program, completion of the program, and quality of the program has improved as students now have better access at more reasonable prices.

SECTION 5. SOCIETAL IMPACT ANALYSIS

There is widespread belief that broadband access is a critical part of rural community development and helps facilitate improvements in health care, economic conditions, and overall quality of life. Ruiz (2004) found that broadband access is an important part of enhancing rural community development by improving the economy, health care, and general quality of life. This section will discuss the transformational impact on individuals in communities as a function of the Golden LEAF Rural Broadband Initiative. Among the variables that were included in this evaluation are:

- Mortality rate
- Voter participation
- Total number of households
- Home ownership rate
- Housing rent
- Median household income
- Crime index.

Research Question and Findings

The primary research question related to the societal impact is: **Does increased access and adoption of broadband connectivity in households lead to positive societal outcomes in North Carolina counties?** We have defined measures of societal outcomes to include infant mortality rates, voter participation, personal wealth measures, and crime rates. As noted in previous years, there is a strong, statistically significant relationship between personal wealth measures and broadband availability and adoption rates. In fact, median household income and median home value all have a strong, positive correlation with broadband availability and rates. Additionally, the percentage of the county population below the poverty line has a negative relationship with broadband availability (meaning that counties with higher rates of poverty have lower rates of broadband availability). These findings are not surprising but do highlight the impact of wealth on broadband deployment and adoption.

There is no significant relationship between broadband availability or adoption rates and infant mortality rates or voter participation rates, when controlling for other influencing variables. However, other key qualitative case studies emerged to demonstrate the more localized societal impact of broadband availability in our North Carolina counties. The first case study presented highlights a traditional community anchor institution, Braswell Memorial Public Library in Rocky Mount. The second case study features Bald Head Island to present a holistic view of the need for and lack of access to sufficient broadband from a local government-citizen perspective.

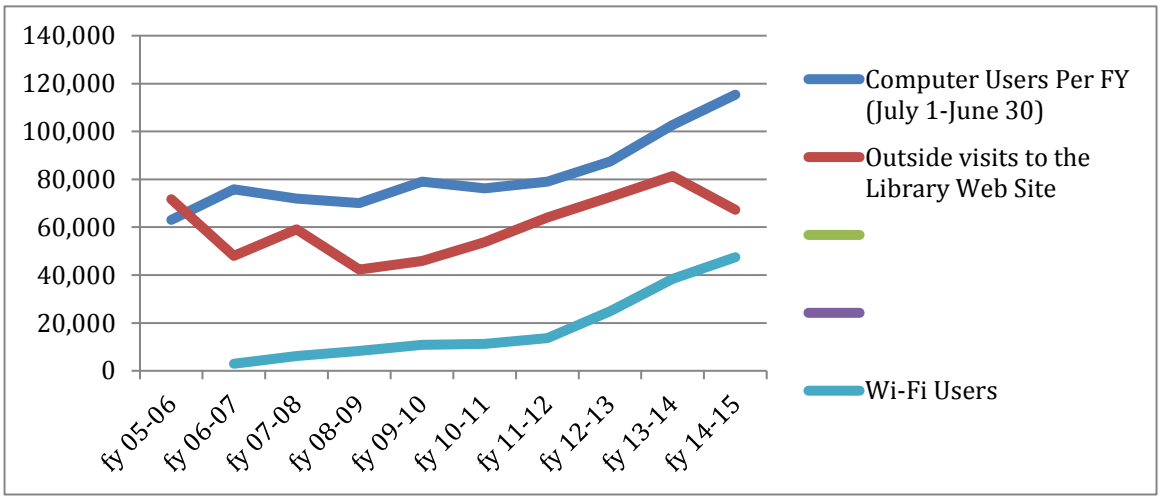
SOCIETAL IMPACT CASE STUDY

Braswell Memorial Public Library

One of the libraries that connected as a result of the BTOP/GLF RBI initiative is the Braswell Memorial Library. Braswell is a hub for 15 libraries in 4 counties including two college libraries. The less expensive and greater bandwidth offered by MCNC enables them to offer improved connectivity and leverage the Internet connection for their automated systems. The two college libraries and the public libraries in Tarboro and Halifax also benefit from being on NCREN. All of these libraries are able to offer the public free Wi-Fi at higher bandwidths and have seen sharp growth in the use of their public Wi-Fi networks. Because they did not have to pay any up front construction costs, their monthly costs with BTOP are less than they previously paid for connectivity and their bandwidth is significantly improved. They are able to allocate these dollars elsewhere, often by buying more bandwidth.

Job hunters are big users of the library computers as many jobs require an online application. The computers at the library also offer customers the opportunity to improve their skillsets. The library offers classes and support services for technology. Some of the libraries in the region are still on DSL and an NCREN connection to the smaller communities would be beneficial. The monthly charge paid by Braswell to MCNC is less than these libraries are currently paying for comparative bandwidth of their DSL connections.

The increase in computer users and Wi-Fi users since FY 05-06 can be seen in the graphic below, further illustrating the widespread need for affordable and accessible high speed Internet access.



SOCIETAL IMPACT CASE STUDY

Bald Head Island– Looking to the Future

Bald Head Island in Brunswick County, North Carolina, is an example of where the future can go for the rural counties of North Carolina. Bald Head Island has a year round population of about 165-170 people with the population swelling at the height of the summer season to as many as 7,000. Ten thousand (10,000) of the approximately 12,000 acres of the island are a designated wildlife preserve. There are 1,170 developed lots with the possibility of developing up to 2,285.

Connectivity

- Bald Head Island has cable modem and DSL Internet service. There is a waiting list for the ATT DSL service and in the summer, the services creaks along at a slow rate.
- There was a plan to bring fiber to the home which was included in a bond referendum that was not enacted due to a tie vote.
- When Duke Energy laid cables across the three mile span of the Cape Fear River, they included dark fiber in the conduit. Lighting this fiber and achieving access to the cloud would have a significant positive impact on the island. If these existing fiber strands are not used, the cost of laying new fiber would exceed one million dollars.
- They are currently in discussions with Duke Energy and private providers to address this situation. In addition to the fiber connection, they would need to expand coaxial cable nodes across the island, improving communication

within the island as well as between the island and the county, the state and the rest of the world.

Economics

- The 50 small businesses on BHI could benefit from broadband connectivity and are willing to pay for the services.
- The Village recognizes that individuals have opted not to buy homes or to vacation on the Island because of the lack of broadband connectivity.

Education

- There are no schools on the island (and not many students). Students either take the ferry to the mainland or are home schooled. Those homeschooled students would reap substantial benefits from high-speed broadband access.
- There is a new Barrier Island Study Center on Bald Head Island that would greatly benefit from connectivity to UNC system, as well as national and international research communities.

Government/Public Safety

- There is a significant public safety concern caused by the lack of broadband infrastructure on the island, as the connection to the public safety and 911 Centers located in Brunswick County are currently only reached by unreliable radio service.

Healthcare

- With broadband availability, local residents and visitors would be able to utilize rapidly growing telemedicine services.

Bald Head Island is an example of a rural North Carolina community that has suffered economic impacts from lack of broadband and has significant potential to suffer from emergency issues and health issues as a result of the lack of broadband. Looking at their plan for going forward, it is clear that the Village is committed to finding a feasible solution to meet the needs of its government and its residents. The cost of entry (laying fiber) is a significant barrier to the Village, whereas, the ongoing monthly costs are not an issue. A program like the GLRBI and the BTOP funding is an example of how externally funded fiber can meet the needs of a small rural community. This iteration of the GLRBI did not reach BHI, but it is not difficult to imagine the impact of a scenario where it had or to recognize the business case for doing so.

In addition to the societal impacts demonstrated by the previous case studies, the healthcare field's utilization of broadband as part of its mission-critical infrastructure is undeniable. Vidant Health is a shining example of the real-world benefits of the Golden LEAF Rural Broadband Initiative. The following case study highlights the innovative work made possible, in part, by the Initiative.

SOCIETAL IMPACT CASE STUDY

Vidant Health in Eastern North Carolina

Vidant Health's medical director of health care informatics, Dr. Joe Pye, is committed to using technology to maximize the telehealth capabilities available to residents in rural eastern North Carolina. They are having great luck with services offered between their hospitals, which are connected via the NCTN and GLRBI. Connectivity from the hospital to its clinics is a historically problematic issue and limits the ability to provide telehealth services to doctors, staff, and patients in these clinics. Dr. Pye believes that in providing these services, not only are outcomes being improved for patients, but it is revitalizing eastern North Carolina as better medical care leads to 1) companies staying or moving to the area; 2) working individuals staying or moving to the area; and, 3) retirees, recognizing that they can get excellent health care are staying or moving to the area. Excellent hospitals can make a big difference to local communities and telehealth services enables rural hospitals to offer services that could not otherwise be offered. A robust broadband backbone is necessary for this to be feasible.

Currently, Vidant Health is having great success in a number of areas. Electronic health records are accessible across all of Vidant which means one patient one record. They are using imaging photo-capture at the time of services. These photos are uploaded real-time at the point of care which enables providers to do virtual consults.

As an example, there is an orthopedist based in Greenville who does procedures in Edenton. He is able to return to his primary practice in Greenville. His PA then uses virtual rounding over the audio visual network that enables him to see his patients in Edenton while he is in Greenville. This ability enables virtual care technology for smaller communities.

ECU Physicians are now offering tele-psychiatric consultations into regional hospitals allowing care for patients with acute behavioral health needs. This type of service can lead to more stable hospitals was a wider variety of service offerings in local, small rural communities. It could also lead to more stable local populations which is then more stable for employers.

There is now remote ICU monitoring available with a plan for video visits to ICU. They are also planning more remote consultations of specialists between hospitals both to improve access in case of emergencies and to expand specialist care for non-urgent cases

Currently, Vidant Health is also doing tele-stroke managements. Robots are deployed in hospitals and connect to Wake Forest Baptist, allowing for an acute neurology consult and immediate stroke evaluation. There are similar proposals being reviewed for trauma evaluations.

They are in the process of building the data infrastructure to analyze each of these initiatives and assess their effectiveness. The long term vision for Vidant Health includes image capture for clinical care, virtual care with video visits and connecting to patients at their home which, in particular should lead to a significant decline in re-admits from the Emergency Department.

Vidant Health is also gaining a national reputation for some of its telehealth initiatives, enabled by the Golden LEAF Rural Broadband Initiative.

- In 2015 it moved to 65 on Verispan's annual list of most highly integrated health care networks in the country (up from 89 the previous year). It was recognized for its electronic medical records system that includes the ability to alert clinicians about potential drug interactions, remind them about clinical guidelines and provide images, medications and notes.
- The California Health Care Foundation's Blog noted: "Mark Rumans, CMO at Vidant Health in North Carolina, said that such monitoring tools have "been able to show significant reduction" in patient hospitalizations. For example, a monitoring system used by Vidant for patients with diabetes, heart failure and high blood pressure led to a 74% reduction in hospital admissions for such patients in 2013."

SECTION 6. CONCLUSION

Several key policy implications are discerned from the Golden LEAF Rural Broadband Initiative evaluation, which demonstrate the salience and criticality of the work and investment made by Golden LEAF and MCNC. From economic and market standpoints, the Golden LEAF RBI has increased providers, household availability and adoption, as well as decreased pricing in counties included in the effort. From an educational standpoint, the significant influence of broadband availability on virtual enrollment provides empirical evidence that the digital divide is impacting access to quality educational resources outside of the school walls. This is an issue that Golden LEAF and MCNC have worked working diligently to address and the State continues to reap benefits from their efforts. Furthermore, the most recent data also demonstrates impact of broadband access and adoption on student achievement in both reading and math EOGs, even when controlling for traditional achievement-influencing variables

The Golden LEAF Foundation, MCNC, the State of NC, and communities across the state have long recognized the value and impact of coordinated effort in deploying high-speed connectivity at reasonable costs to our citizens and businesses. The evaluation of the financial investment in broadband connectivity throughout North Carolina via the Golden LEAF Rural Broadband Initiative provides a holistic, longitudinal understanding of the true economic, educational, and societal impact of broadband. It offers a useful model for recognizing the key attributes and deterrents to fully realizing positive impact in communities, thus creating a

roadmap for future investments based on the lessons learned from the Golden LEAF Rural Broadband Initiative.

Study Limitations

Several limitations and challenges related to the longitudinal evaluation of the Golden LEAF Rural Broadband Initiative emerged over the course of the project. One of the major limitations of this study results from disparity between the proposed connectivity of over 200 Community Anchor Institutions across North Carolina to the reality of roughly one-tenth of those actually choosing to subscribe. Interviews with non-subscribing CAIs in various locations indicate two reasons for the limited customer base, largely related to pricing (i.e. pricing for the MCNC/Golden LEAF Rural Broadband Initiative is substantially higher than their current provider and/or they are satisfied with their current provider's speeds and cost). Another challenge associated with the evaluation is the lack of data availability and tracking by several organizations who were original sources for the study. The NC Department of Commerce eliminated the collection of several key data points, as did the federal government, roughly halfway through the evaluation period. In 2012-2013, the NC Department of Public Instruction moved from the ABCs of Public Education assessment model to the READY Accountability Model. As a result of a new level being added to the assessment methodology, there is no true comparison method between old and new data related to test scores, however this study used an approximation method to generate statistically reliable results. MCNC also has limited data tracking, including not having an easily producible list of its customers who receive services directly as a result of the Golden LEAF Rural

Broadband Initiative. For future study purposes, it is imperative to have accurate data related to connected entities to ensure the study can apply proper statistical controls.

Implications and Considerations

From a policy standpoint, the results of our qualitative and quantitative analyses have several important implications and considerations. First, the work of the Golden LEAF Rural Broadband Initiative should continue to see positive impacts in the counties it serves based on the historical trend analysis, regardless of aggregate statistical findings in specific areas. The success stories found in the body of this report are substantial evidence as to the impact and reach of the Golden LEAF Rural Broadband Initiative. Additionally, the statistical analyses have demonstrated positive impacts of the Golden LEAF effort in terms of increasing access to high-speed connectivity across all communities in North Carolina. Finally, the expansion of Gigabit service to households has been a high point for the state of North Carolina and those private providers (Google, AT&T, etc.) often cite the impact of the Golden LEAF Rural Broadband Initiative in their discussions as to why our state has been selected for such offerings. Essential work to expand both the accessibility and the affordability of high-speed broadband continue in North Carolina to maintain and build upon the positive results demonstrated by the Golden LEAF Rural Broadband Initiative.

APPENDIX A. Contributing Faculty and Staff to the Golden LEAF Rural Broadband Initiative Evaluation

Current Staffing:

Principal Investigator: Shannon Tufts, PhD, Associate Professor of Public Law and Government, Director of the Center for Public Technology at the University of North Carolina at Chapel Hill's School of Government

Co-Investigator: Maurice Ferrell, MBA, Assistant Director of the Center for Public Technology at the University of North Carolina at Chapel Hill's School of Government

Qualitative Data Advisor: Willow Jacobson, PhD, Associate Professor of

Field-Based Research Assistant: Wendy Kuhn, MBA, Breakthrough Consulting, LLC

Previous Staffing:

Will Lambe, Economic Development Expert and Subject Matter Investigator

Karl Smith, Econometrics Advisor

Stacey Hypes (Everett), Project Manager

Deborah Watts, Field-Based Research Assistant, formerly employed at eNC

Graduate Student Assistants for Data Collection: Amanda Shomper, Amy Huffman, Anne Davis, Christal Perkins, Maureen McCormick