The Social Impact of Broadband: A Case Study of Red Cliff, Colorado

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Abstract - While broadband access has become an essential tool of daily life for most Americans, 24 million Americans lack broadband access as of 2016 [1]. Rural Americans face a significant connectivity disadvantage, as over 30% lack broadband access. Red Cliff, Colorado was on the wrong side of the digital divide until late 2017 when fixed terrestrial broadband service became available for the first time, even though broadband services have been generally available to much of the rest of the state for almost 20 years. Red Cliff provides a unique opportunity to examine the impact of broadband delivery on a town. This paper examines the lengthy process the town experienced on its journey to connectivity, and it measures the impact broadband has had on Red Cliff residents.

Based on surveys and interviews, Red Cliff residents already possessed a high level of digital literacy and a strong appetite for broadband service, which helped deliver substantial and immediate social benefits to the community. Nearly all respondents had access to broadband at work and many routinely drove up to 10 miles for access in a nearby town. The delivery of broadband offered greater video programming options: 82% of respondents indicated they planned to switch to a streaming video service as a result. Residents overwhelmingly believed the community would experience positive benefits from broadband, though some expressed concerns. In addition, Residents believe they and others will have more opportunities to work from home and 75% indicated an openness to accessing healthcare or telemedicine via broadband connection. Finally, while the town has no mobile service, residents were content with Wi-Fi and VoIP calling and 26% of respondents indicated they had been in an emergency and needed to call 9-1-1, but had no service.

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1. INTRODUCTION

For the majority of Americans, broadband access has become an essential tool of daily life. As of 2016, 92.7% of Americans had access to fixed terrestrial broadband, while 7.7% or 24.8 million Americans lacked access to broadband as currently defined by the Federal Communications Commission (FCC) [1]. In urban areas, broadband is nearly ubiquitous, with 97.9% of population having access to 25 Mbps download speeds and 3 Mbps upload speeds. But in rural areas, the digital divide is dramatically wider as 30.7% of residents or roughly 19.3 million rural Americans lack access to broadband [1]. According to Jordan Beezley at the Colorado Department of Regulatory Agencies (DORA), 50,000 Colorado households lack access to 10 Mbps download speeds and 1 Mbps upload speeds and 150,000 Colorado households lack access to 25 Mbps download speeds and 3 Mbps upload speeds [33].

Before Broadband Access

One community that found itself on the wrong side of the digital divide was Red Cliff, Colorado. Founded in 1879 during Colorado's silver mining boom, Red Cliff was once a bustling mining town and economic hub during the early 20th Century, serving at the county seat of Eagle County from 1883 until 1921 [2][3].

Like many rural communities across the United States, Red Cliff fought to bring broadband to its roughly 250 residents for years [4]. As of November 2017, the town lacked fixed terrestrial broadband in homes. In addition, mobile wireless service drops off roughly 10 miles outside of town, leaving residents with satellite Internet as the only option for Internet access. A number of residents were already satellite Internet subscribers but were very disappointed by the price and quality of service. Many residents reported paying $120 to $160 per month for low data caps, slow speeds, and high latency, all while experiencing regular weather-related outages during the town's frequent snowstorms since parts of Eagle County receive 150 to 350 inches of snow annually [5]. This changed in December 2017 when a wireless Internet service provider (ISP), FORETHOUGHT.net, delivered fixed terrestrial broadband to Red Cliff - the first broadband service of any kind for the mountain town.

Broadband deployment in Red Cliff did not come without challenges. When Scott Burgess, Red Cliff's former mayor from 2012 to 2016, was elected, he vowed to make broadband a priority. In 2014, Mayor Burgess was invited to attend a broadband deployment meeting hosted by Nate Walowitz, Regional Broadband Program Director at Northwest Colorado Council of Governments (NWCCOG). Among the participants were regional town and county officials and representatives of the local incumbent telephone company for the region, CenturyLink. During the meeting, Mayor Burgess confronted CenturyLink about their unwillingness to consider Red Cliff for fiber. From their perspective, extending fiber lines from their existing locations to roughly 120 homes in Red Cliff was very costly and offered little return on investment.

CenturyLink rejected the mayor's invitation to deploy in Red Cliff; however, a representative named Bill Jones from High Country Internet approached Mayor Burgess and explained he might be able to serve the town via a fixed wireless system. Mr. Jones persuaded the Mayor to allow him to test beaming a signal from Leadville, roughly 20 miles away, to an unpermitted makeshift tower connected to a car battery in Red Cliff. The test was successful and proved that transmitting a signal into Red Cliff from a remote location was possible.

Municipal Broadband Approval

In order for Red Cliff to pursue a municipal broadband network, the town had to first approve by a vote an exemption to Senate Bill (SB) 152. Approved in 2005, SB 152 prohibits municipalities from owning or operating a broadband network without voter approval. As of 2015, some 21 states had a municipal broadband prohibition of some kind [32]. Red Cliff's Administrator, Barb Smith, played a key role in arranging for this vote to occur. She was also in attendance at the NWCCOG meeting in 2014. Following the meeting, she took the steps necessary to get the question on the November 2014 election ballot, which Red Cliff voters ultimately approved by a vote of 83 to 29. This vote helped Red Cliff become one of the first towns in Colorado to approve a municipal broadband network.

Project Financing

Next, the community developed a plan to finance the project. Before Red Cliff could apply for and receive grant funding from the state, the community had to address its serious fiscal situation. At that point, the town was experiencing financial stress due to a handful of high-interest loans the town had taken out from the Department of Agriculture (USDA) Rural Development in the previous three decades. The town was paying roughly $3,000 per month on these loans, and that did not even cover the interest. Red Cliff was able to refinance these loans, lowering their monthly payment to roughly $1,600. Another area of savings came from finding a new water supplier, reducing the town's monthly cost from $14,000 to $3,000. In addition, the town made several budget cuts, and even stopped paying its electric bill in order to save every penny. This prompted the utility company to come and remove the town's streetlights completely. Eventually, Red Cliff was able to come up with the resources to purchase land for a wireless tower site and contribute their portion of two matching grant programs.

Internet Service Provider

Two years ago, High Country Internet notified the town they were no longer able to help with the project, and Red Cliff was forced to look for another willing wireless ISP. At that point, Nate Walowitz from NWCCOG reached out to multiple ISPs to replace HCI. FORETHOUGHT.net agreed to serve Red Cliff. FORETHOUGHT.net provided the town with an engineering design plan that was necessary to apply for the grant applications, which are discussed in the following section. Importantly, the new ISP had secured a lease of the Eagle County School District's Educational Broadband Service (EBS) spectrum license in the 2.5 GHz band. This spectrum is utilized to provide the town with high-capacity 4G LTE service, which is able to reach broadband service speeds of 25 Mbps download and 3 Mbps upload per subscriber.

State Grant Programs

Two state grants programs were vital in financing the Red Cliff broadband project. The Colorado Department of Local Affairs (DOLA) provides grants to municipalities and counties to support broadband planning and middle mile broadband infrastructure projects. Last-mile projects are not eligible through this fund. Roughly $20 million was set aside for this project through the Energy & Mineral Impact Assistance Fund [6]. The minimum local match for the Middle Mile Infrastructure Grants is 50%. Red Cliff was successful in securing a grant, which covered the tower construction in Red Cliff, a portion of the land for the tower, and a portion of the trenching at Ski Cooper to bury fiber, which is explained in detail below. Table 5, in the Appendix, shows a breakdown of the DOLA grant for this project. In total, Red Cliff contributed $77,500 and DOLA contributed $144,100 to this portion of the project.

A second grant program was also critical to this project. In 2014, the Colorado General Assembly approved legislation to create a Broadband Deployment Fund to support buildout in unserved areas of the state [7]. The

Board was funded by transitioning funds from the state's existing high-cost support program, which was used to support telephone deployment, to be used for broadband deployment. The fund is overseen by the Colorado Department of Regulatory Agencies (DORA) and is only available to Internet service providers for last-mile projects. The grants can cover up to 75% of the infrastructure project costs. In 2016, the Board awarded its first group of grants totaling $2.1 million to a select group of applicants, which included FORETHOUGHT.net for broadband deployment in Red Cliff. Table 6, in the Appendix, shows a breakdown of the contributions for this portion of the project. DORA contributed $70,103, and Red Cliff and FORETHOUGHT.net and its parent company, Futurum, made up the remainder for a total of $144,577.84. This grant provided funding for radio equipment on both the Red Cliff and Ski Cooper towers, part of the fiber connection at Ski Cooper, and installation and engineering costs.

Tower Siting

In order to deliver broadband, two towers were necessary. The first tower needed to be in or near town as a last-mile link. The second tower needed to be within 20 miles as a wireless backhaul link. Figure 9, in the Appendix, shows Red Cliff's broadband network diagram. When it came time to identify a location to construct a wireless tower in Red Cliff, the town first considered the land used to site the unpermitted tower for the initial test. The town had originally budgeted $40,000 to purchase the land. Because the land was owned by a local resident, Mayor Burgess and the town's Board of Trustees preferred keeping the money for a tower siting within the community. After offering the full amount to the landowner, he countered with a 50% higher asking price, and the town decided to look elsewhere.

The town then pursued the land directly adjacent to the original target land and offered the original $40,000 amount. The new landowner accepted, but during the process it was discovered that there were two parties who owned the land. The town was able to identify the other party and the two landowners split the $40,000. The DOLA grant helped fund a portion of this land purchase. Once acquired, Red Cliff now had a site for tower construction. For the backhaul link, the town had originally planned to transmit data toward Leadville. After the discovery of fiber at the base of Ski Cooper, the ski resort's second motor house became the ideal location for backhaul tower equipment.

While the land offered an excellent perch to construct a wireless tower, accessing the eventual tower location presented another challenge. In order for the tower company to access the land for construction and maintenance, they would need a temporary road that was roughly 300 meters long. After negotiations with the tower company, town staff had to physically construct the road in order for the company to access the site.

U.S. Forest Service

The biggest delay in the project came in getting approval from the United States Forest Service (USFS) for approval of backhaul infrastructure. As of 2016, High Country Internet, Brainstorm.net, and FORETHOUGHT.net had all submitted applications to the USFS. The USFS had initially deemed these earlier applications incomplete because they were submitted by commercial entities. After the town, USFS, and other county, state, and federal officials met, it became clear Red Cliff would need to submit its own detailed application. The application would require detailed technical data demonstrating not only proof of concept but also disproving alternative methods of providing service. Mayor Bales credits Nate Walowitz of NWCCOG for single-handedly compiling the application and supporting documentation for Red Cliff.

In October of 2016, a new Forest Ranger was appointed to cover the National Forest that included Ski Cooper, the site where wireless equipment was to be installed to serve as backhaul to Red Cliff [8]. The new ranger was more open to the project, but requested that the town bury the fiber as opposed to stringing the fiber up the ski lift towers. The fiber backhaul was necessary to connect the radio equipment on the second ski lift motor house at Ski Cooper to the CenturyLink fiber ring some 7,000 feet away, at the base of the mountain. This added an expense of roughly $60,000 to the project, according to FORETHOUGHT.net, but provided an easier connection to the backbone network.

The Other Side of the Digital Divide

In January of 2018, Red Cliff Mayor Anuschka Bales officially declared the town was now connected, not with a ribbon cutting, but rather with a ribbon tying ceremony to symbolize the occasion. Today, Red Cliff residents enjoy true broadband speeds as defined by the FCC – 25 Mbps download speeds and 3 Mbps upload speeds. After a $250 installation fee, subscribers pay FORETHOUGHT.net $70 per month for service and $5 per month for renting a router. Roughly 65 homes out of 120 homes have had service installed and a handful more plan to sign up for service according to FORETHOUGHT.net. So far, residents have experienced only minor technical issues, and no snow-related outages, according to the mayor.

The delivery of broadband to Red Cliff provides a unique opportunity to understand the impact of broadband on a community that has never had it before. This paper examines that social impact through five separate lenses: broadband access, broadband adoption, video marketplace competition, digital commerce, and social impact. This report also comments on the feasibility of mobile broadband deployment at some point in the future.

2. RELATED WORK

Federal policy has long championed the benefits of broadband. The United States National Broadband Plan opens with a prophetic view of broadband:

"Like electricity a century ago, broadband is a foundation for economic growth, job creation, global competitiveness and a better way of life. It is enabling entire new industries and unlocking vast new possibilities for existing ones. It is changing how we educate children, deliver health care, manage energy, ensure public safety, engage government, and access, organize and disseminate knowledge" [9].

Since the FCC published the National Broadband Plan in March 2010, significant progress has been made at closing the broadband access gap. In 2010, nearly 100 million Americans lacked access to broadband, which was defined at 4 Mbps download speeds and 1 Mbps upload speeds. Since then, nearly 75 million more Americans have access to broadband, which is now defined by the FCC as 25 Mbps download speeds and 3 Mbps uploads speeds [1][10].

Broadband Access

For nearly two decades, researchers have studied the impact of broadband access and adoption, as well as rural and urban broadband trends, to determine if broadband truly is the economic and social rocket fuel that governments have touted. The evidence of positive economic impact from broadband is abundant. Thompson and Garbacz show that a 10% increase in broadband penetration is associated with a 3.6% increase in economic efficiency [11]. Rural broadband also provides direct employment and economic benefits in communities. Hans Kuttner shows that rural broadband providers in Colorado provided a total economic impact of $300.3 million and supported 840 jobs in 2015 [12].

Other researchers have analyzed what happens when new service is introduced in a region. Arthur Little [15] showed that doubling broadband speeds resulted in a 0.3% increase in gross domestic product and that a ten-percentage point increase in broadband penetration translates into a 1% GDP increase. Dr. Heather Hudson, et al. [13] examined the impact that new broadband services have on small and large businesses, local and state governments, tourism, commercial fishing, financial institutions, native corporations, and education in a remote region of Southwest Alaska. The new broadband service offered 6 Mbps to consumers. The report concluded that high-speed, affordable broadband can be an important tool for economic development when provided, but that capacity in rural areas still lags, and most importantly, affordability remained a critical barrier that prevented maximum benefit from reaching all parts of the community.

Broadband Adoption

The Alaska research shows while broadband access is a critical issue, especially in many rural areas, adoption is perhaps more important to the social and economic impact of a region. Tomer and Kane show that even when broadband is available, approximately 25% of Americans choose not to subscribe [16]. The impact of broadband depends upon adoption and speed availability. In 2014, Whitacre et al. [14] found that high levels of broadband availability did not necessarily translate into positive benefits, but that high levels of adoption are positively associated with more jobs and businesses.

Horrigan and Duggan found that a number of factors influence whether a household adopts broadband, including price, the availability of broadband outside the home, the cost of computers or other Internet-enabled devices, and quality of service or speed [17]. Monica Anderson of the Pew Research Center shows that income level correlates very strongly with adoption rate in the United States. Just 53% of American adults earning under $30,000 per year have a home broadband connection as compared to 94% of those earning more than $100,000 [18].

Video Marketplace Competition

Research has also continued to show new trends regarding the consumption of video programming. Cord cutting or the process of switching from traditional cable and satellite video services to video services accessed exclusively through the Internet (over-the-top) is a trend that has seen increasing popularity over the last decade. In the third quarter of 2017 alone, DIRECTV and DISH each lost close to a quarter of a million satellite video customers [20]. During that same period, DIRECTV and DISH both saw a similar increase in customers in their respective over-the-top platforms, DIRECTV NOW and SLING TV. One cause of this could potentially be broadband availability, as 84% of cord-cutters have "advanced Internet access" in the form of either a smartphone or home broadband subscription [23]. As broadband becomes available in more areas and to more

people, video customers can consider the option of switching to cheaper over-the-top streaming services.

There are several reasons why consumers may prefer over-the-top services over traditional pay-TV services. These advantages include more affordable programming; new original content from over-the-top services and providers, which have earned award nominations in recent years; no monthly cable box rental fees; and no long-term contracts. The primary disadvantage of these services is that they are only available to consumers with broadband access. In addition, live and local news programming may not be available on all platforms. By the end of 2017, some 22 million homes had cancelled their pay-TV subscription, and a full 25% of homes no longer have cable or satellite service [25][26]. Communities like Red Cliff have relied on satellite video for decades and have never had the opportunity to engage in the new video revolution of over-the-top services. Broadband deployment will enable new opportunities and new competition within the video industry in places that currently lack broadband connectivity.

Future trends show pay TV services losing roughly 10% of subscribers over the next six years. Non-pay TV viewers will nearly double over the same time frame. Cord-cutters will continue to grow from 16.7 million to 40.1 million from 2016 to 2021 [21]. It is possible that with broadband deployment in Red Cliff, residents of Red Cliff will join this trend and become cord cutters themselves, replacing satellite video services with over-the-top products now available.

Digital Commerce

Digital commerce continues to be an increasing trend across the United States, as shoppers move to online platforms and move away from traditional retail stores. Currently, 79% of Americans shop online with 15% of Americans shopping online weekly. Cost and lower prices are driving consumers online more so than even the convenience of shopping from home. Cheaper prices can be found online along with the ability to research costs and product reviews ahead of purchase [22]. Given Red Cliff's proximity to retailers and store fronts, around 20 miles from Vail and 112 miles from Denver, it is possible that broadband deployment will lead to an increase in online shopping from Red Cliff residents. Broadband may eliminate the need for residents to drive long distances to buy groceries and other everyday items.

In addition to providing consumers with greater choice and flexibility in purchasing, broadband also opens the door for consumers to sell products or services. According to Stringfellow, there are now more than 50 different gig economy platforms in the marketplace

today [24]. These platforms allow users to rent their homes on platforms such as Airbnb or VRBO, sell products on websites such as Etsy or Amazon, or earn additional income as a worker in the gig economy on platforms such as Wag or Rover.

Social Impact

While the economic impact of broadband deployment is well-documented, fewer studies have measured the social impact of broadband. One study that explored this social impact was conducted in a remote Atlantic region of Canada that had recently gained broadband access. Selouani and Hamam examined these changes in the Acadian Peninsula of New Brunswick with a focus on the town of Shippagan. Their research showed that the deployment of broadband significantly increased the ease of life for 81% of the community and improved the access to needed information for 75% of the population [28]. The research also showed new uses and activities as a result of broadband, however, little change was seen in behaviors, attitudes, and norms within the population.

The majority of prior research on broadband deployment focuses on the economic impact, income increases, and other economic related benefits as described above. This research project was intended to explore the social impact of broadband deployment including quality of living, ease of life, and other social benefits related to increased broadband availability.

3. SURVEY METHODOLOGY

In order to collect data for analysis, we chose to survey Red Cliff residents. We designed a 42-question survey that covered a variety of topics. Our survey was designed to be short enough to elicit a high response rate, but long enough to uncover meaningful trends about broadband adoption and use, as well as the social impact experienced by residents. The survey was conducted using a mixed-method: both face-to-face and online methods were used.

According to the 2010 Census, Red Cliff has 117 households in the community. We received responses from 16 households. Eight responses were collected in-person, and another eight responses were collected via online survey. This sample population provides a 90% confidence level with a +/- 19.25% confidence interval. This sample size provides moderately accurate results and by comparison, slightly better than the sample size used by than the United States Census Bureau in its 2016 Demographic and Housing Estimates [29].

4. RESULTS

While there are a variety of conclusions that can be made from the survey responses, this paper focuses on five specific areas: broadband access, broadband adoption,

video marketplace competition, digital commerce, and social impact. In addition, the paper will touch on the possibility of introducing wireless mobile service in Red Cliff.

Broadband Access

With the delivery of broadband to Red Cliff, every resident now has the opportunity for broadband access. Our research first focused on how residents accessed broadband outside the home. This tells us the level of digital literacy that residents may or may not have had prior to broadband deployment in Red Cliff. We asked residents whether or not they had broadband at work and whether or not they had driven to another town for broadband access, and if so, what distance. Figure 1 shows that 15 out of 16 respondents had broadband access at work, and 75% had driven to another town for broadband access, usually traveling an average of 10 miles. This high level of access outside of home demonstrates at least some level of existing digital literacy among Red Cliff residents. In addition, the high number who had driven to another town shows that there was a strong desire for access before broadband had been deployed.

**Figure 1 - Broadband Access Outside of Home**
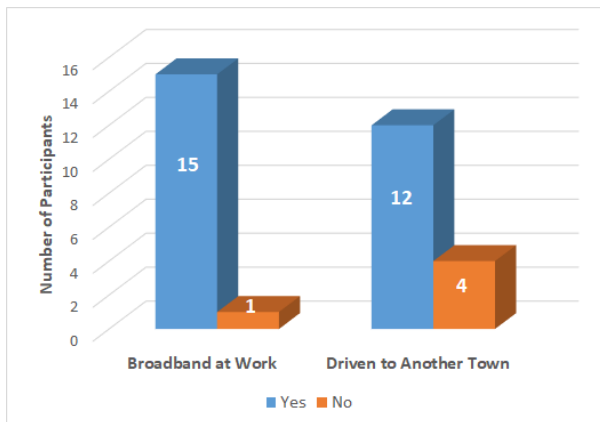
Broadband Adoption

As was noted in the literature review, even when Americans have broadband access, only a portion will subscribe to broadband services. This is particularly true for certain demographic groups, including rural residents. Our survey questions to residents focused on whether or not they had subscribed to service at home and who their provider was. We also asked residents who did not sign up for service reasons why they did not subscribe. According to the ISP, FORETHOUGHT.net, approximately 65 homes had been installed and another 10 had signed up but had not yet been installed as of March 27, 2018. Once these homes are installed, the penetration rate will be roughly 65% based on these

estimates. Despite service only being available for four months, Red Cliff's adoption rate of roughly 63% is higher than the national average of 53.5% for 25 Mbps/3 Mbps fixed broadband service [1] and demonstrates strong demand from residents. Of our survey respondents, as shown in Figure 2, 14 out of 16 already had the new service installed. Of those who did not yet have the new service, one had recently purchased a home and another was engaged in a 2-year contract with a satellite internet service provider, but planned to consider FORETHOUGHT.net at the end of their contract.

Figure 2 - Broadband Adoption
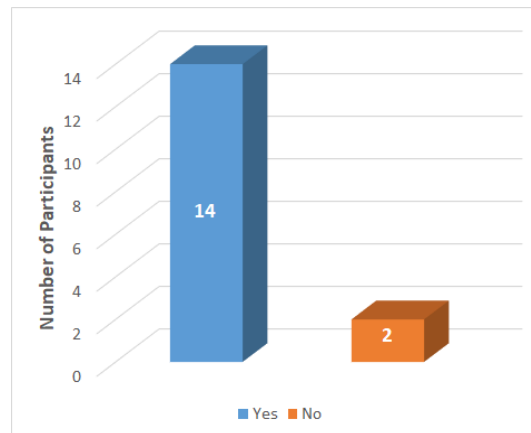
Video Marketplace Competition

Many Americans today enjoy streaming video programming over a broadband connection. Before broadband was deployed in Red Cliff, the only option for local television service was through a satellite television provider, like DirecTV or DISH Network. To examine video marketplace competition, we asked residents whether or not they subscribed to a pay-TV service, whether they subscribed to an over-the-top streaming video service, and if they planned to replace their satellite service with a streaming service.

Of those who responded, 9 out of 11 residents indicated plans to substitute pay-TV service with over-the-top service now that broadband was available. This represents 82% of those who answered the question. An additional 5 respondents did not answer the question, perhaps because they were uncertain what over-the-top streaming services meant. Tables 1 and 2 illustrate the results.

Table 1 - Video Marketplace Competition

|		Do you subscribe to cable, satellite, over-the-air TV?		
		Yes	No	Total
Do you currently subscribe, to over-the-top service?	Yes	4	1	5
	No	5	4	9
	Total	9	5	14

Table 2 - Replace Satellite with Over-The-Top Video Programming

		Do you subscribe to cable, satellite, over-the-air TV?		
		Yes	No	Total
If you have a satellite television subscription, do you plan to replace it with Over-the-Top Service?	Yes	8	1	9
	No	1	1	2
	Total	9	2	11

Digital Commerce

We wanted to understand whether Red Cliff residents behaved like other Americans with broadband access following deployment as it pertains to digital commerce. We asked residents how often they shopped and if broadband would have a positive, negative, or no impact on their ease of life. The results are shown in Figure 3.

**Figure 3 - Frequency of Online Purchases**
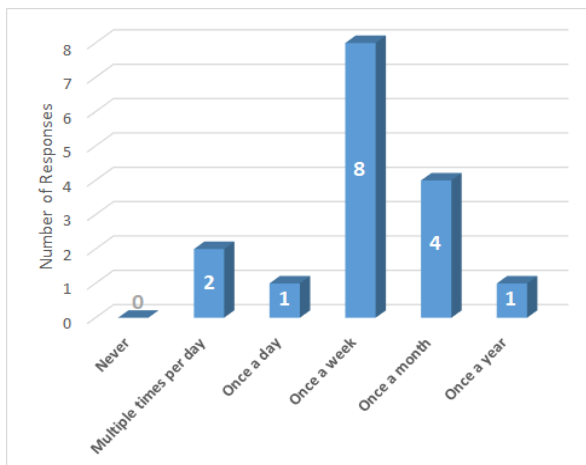
Red Cliff residents already participate in digital commerce. According to survey respondents, 11 out of 16 indicated they shopped online at least once per week. Given the 10-mile drive to the nearest retail shopping and the availability of delivery directly to the home, digital commerce offered by broadband availability presents a significant improvement in ease of life for residents. One resident explained how easy it was to order pet supplies and other goods that would normally take at least a half-hour trip to Vail. In addition, it was explained how the few businesses in town can bundle orders together much easier with online inventory and ordering systems.

Impact on Community

Prior research on broadband impact focuses on economic impact, income increase, and other benefits. We wanted to explore the social impact of broadband in our study. To measure social impact, we asked residents what impact broadband access would have on their ease of life (pay bills, buy goods and services, interact with others, etc). We have also asked residents if they would work from home and if they would access healthcare services, such as telemedicine, due to broadband availability. Figure 5 shows the results.

Figure 4 - Impact on Community
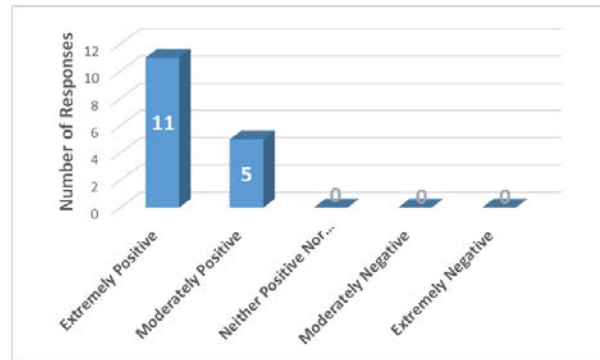
Of the respondents, 11 out of 16 or 69% indicated they thought broadband would have an extremely positive impact on Red Cliff, and 5 residents out of 16 or 31% indicated they thought broadband would have a moderately positive impact on the community. While these responses demonstrate a strong belief in the impact of broadband, when asked why residents responded the way they did, 3 residents expressed concern about connectivity. One explained it was difficult to get children off their devices, another commented that more screen time is not necessarily a good thing, and another indicated a strong liking that the town was not constantly connected.

Figure 5 - Broadband Impact on Work and Health

Figure 6 - Mobile Service Subscription
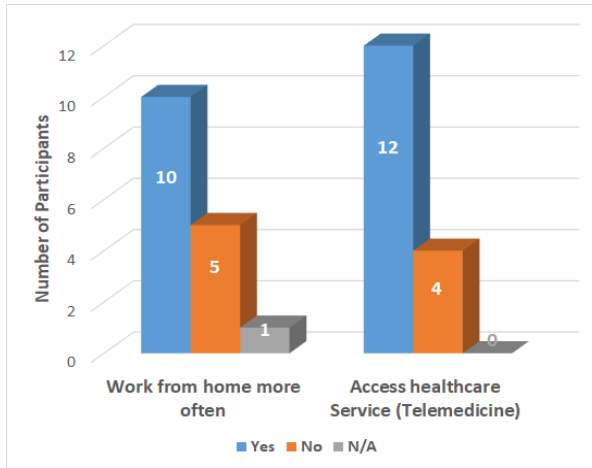
When asked whether they or somebody they knew would work from home more often, 10 out of 16 respondents indicated "yes" and 5 indicated "no." This shows that many Red Cliff residents or those they know would be potentially be able to forego the commute of 10 or more miles to work. When asked "If offered by your healthcare provider, would you use broadband to access healthcare services or telemedicine from your home?", 75% of respondents indicated they would be interested, indicating a high interest in telehealth. Both these responses show a potential for a impact on ease of life that was not available prior to broadband access.

Mobile Service Feasibility

One of the areas we wanted to touch on in our study was cellphone service in Red Cliff. While almost 5% of U.S. homes rely on cellphones alone for a telephone connection [27], that is not an option for Red Cliff residents. Red Cliff's remote location and rough terrain make it hard for wireless providers to offer service.

While studying the impact of broadband, we also wanted to understand how Red Cliff residents manage not having cell phone service in town. We also wanted to examine the need for cellphone service in Red Cliff. We began by asking residents whether they have cellphones or not. What the survey revealed was surprising. Although residents didn't have in town wireless phone service, 13 out of 15 residents said they already subscribed to wireless service. Results are showing in Figure 6. With majority of residents already subscribed to wireless service and the introduction of broadband service, which will allow residents with cellphones to take advantage of Wi-Fi calling, adding commercial mobile phone service is mostly unlikely. Residents seem content with the ability to make Wi-Fi calls thus making them less likely to switch carriers should one particular carrier become available in Red Cliff.
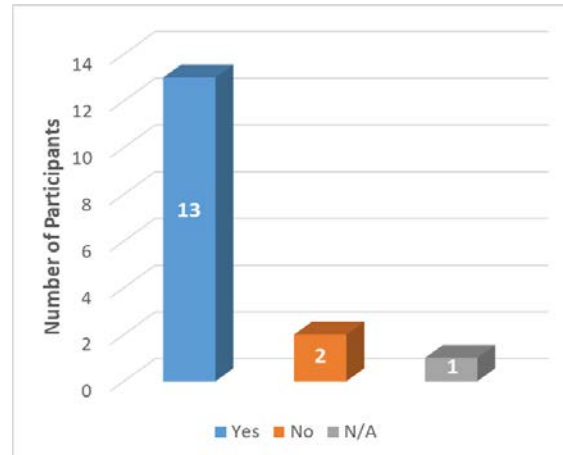
Next, we wanted to understand if Internet-based phone services are of interest to Red Cliff residents. To do that, we asked residents if they would replace their long-distance telephone calls with internet-based calls. Table 3 shows the results.

Table 3 - Landline vs. Internet-Based Calling				
	Yes	No	N/A	Total
Replace landline calls with Internet-based calling	12	3	1	16

Finally, we asked residents whether or not they had been in emergency situation and needed to call 9-1-1 but could not because of a lack of mobile service. Just 4 out of 15 respondents indicated they had been in such a situation. Table 4 shows these results.

Table 4 - Mobile Service for Emergency				
	Yes	No	N/A	Total
Respondents who had been in an emergency but not been able to dial 9-1-1 on their mobile phone	4	11	1	16

5. CONCLUSION

While broadband remains elusive to so many rural communities in America, others, like Red Cliff, have spent nearly a decade fighting for access. The town of Red Cliff provides a unique and isolated case study to understand the barriers faced in broadband deployment but also the economic and social effects of connecting a town that has never had access to high-speed mobile or fixed broadband. Red Cliff experienced significant positive social impacts from broadband deployment due in part to the experience of residents with broadband at

work and in areas with access; however, the town faced challenges from regulators on their journey to achieve access. Officials at every level of government were required to work together to address these challenges and streamline deployment. Grant programs proved indispensable to finance both backhaul and also help make ISP deployment a successful economic opportunity. Addressing broadband deployment challenges such as those experienced in Red Cliff will help expand these positive social impacts to connect the over 24 million Americans who currently lack access to broadband today.

6. FUTURE AREAS OF RESEARCH

The deployment of broadband in Red Cliff has had a profound impact on the community. In many cases, residents were already using broadband at work or traveling to other towns for access. Broadband access immediately improves the convenience and ease of life and allows residents to participate in the digital economy. While these findings are meaningful, there are several areas of future research that could be considered to help paint a more vivid picture of the social impact of broadband study.

Survey Methodology

We used a mixed-methodology of face-to-face surveys and online surveys to collect data. One advantage of this methodology was to improve survey participation; however, we received fewer responses than we would have liked, and admittedly the survey response rate skews toward those who had already adopted broadband. Our face-to-face surveys were conducted at a local restaurant, which limited the response rate to those families who were eating out on a Friday night. This perhaps limited responses from those who can afford or those who may not be interested in subscribing to broadband. Likewise, our online survey was only available to those with access to broadband. There are roughly 50 homes who have yet to subscribe to broadband and future research might better investigate these non-adopters.

Longevity of Research

Our survey served as a one-time snapshot of broadband adoption and use in Red Cliff. One area of future research would be to track residents over time as they begin to utilize services and become more comfortable with broadband at home. By tracking residents over time, researchers could measure if residents truly adopt a streaming service as a substitute to video or measure new ways in which residents use broadband service to make their lives easier, communicate with one another, take online classes, monitor their health, or engage in digital commerce. Finally, some residents have explained to us

they did not subscribe to broadband service initially because they had signed a two-year contract with a satellite Internet provider that was months away from expiring. Tracking residents over time would account for those who adopt once those prior contracts expire or were terminated.

Depth of Research

As researchers, we designed our survey instrument to be short enough to elicit a high response rate, but long enough to get meaningful data. As a result, we were able to explore many topics, but not with desirable depth in some cases. Part of the rationale for this survey design was that we did not fully understand what residents might answer and to assume specific topics may have led to missing out on some of the findings we were able to uncover. A future area of research would be to drill down deeper on some specific topics including delivery of healthcare via telemedicine, digital commerce, real estate prices and community growth, and educational uses. Many of these were topics where we detected interest and use from residents, but we were unable to ask a number of follow-up questions to fully understand what interesting uses of broadband by residents might be and help shine light on the true social impact of broadband. Finally, we chose not to explore trends with regard to age, race, ethnicity, or income. Not only did this reduce risks associated with collecting and handling sensitive personally identifiable information, it also allowed us to avoid expanding the size and scope of our survey, which may have led to an even lower response rate.

Pre-Deployment Data

Given the timeline of our research project, we were unable to collect meaningful pre-deployment data from residents. While we were able to ask questions about broadband access before deployment, there are potentially qualitative stories about life without broadband that we were unable to uncover in our research. There is no opportunity to go back in time, but future researchers measuring the social impact of broadband might consider a robust pre-deployment survey of a community without broadband and a similar post-deployment survey to help understand the true delta on particular topics.

Public Policy Analysis

Another future area of research involves examining the impact of government policies - at the city, county, state, and federal level - on broadband deployment, both in Red Cliff and in other areas where deployment is or is not occurring. While the benefits of broadband are overwhelmingly clear, rural broadband deployment

remains one of the greatest economic challenges of our time. The federal government has recognized the unique barriers for deployment and promoted a variety of policies, including subsidy programs and grants over the past decade to support deployment in unserved and underserved areas. As Brake [19] concludes, these programs have had mixed success. As part of the American Recovery and Reinvestment Act of 2009, what has popularly been dubbed the "stimulus bill," the federal government extended approximately $7 billion to broadband grant and loan programs at the United States Department of Agriculture Rural Utility Service (RUS) and the National Telecommunications and Information Administration (NTIA). The RUS program, known as the Broadband Initiative Program, concluded that millions of dollars were spent in areas where broadband providers already offered services [19]. In 2011, the FCC also adopted substantial reforms to its universal service program by transitioning the fund from phone subsidies to broadband subsidies, but it is too early to tell what impact this transformation has had on broadband access and adoption.

There are three primary areas worth examination: public funding, spectrum, and regulatory policy. With regard to funding, Congress is now considering an infrastructure proposal put forth by the Trump Administration, which would provide $50 billion in funding for rural areas in the form of state block grants [30]. While there are no dedicated funds for broadband deployment, broadband projects would be eligible under this plan. Should Congress approve this investment, a particularly interesting topic would be to examine which states are best able to close the digital divide. A comparison between states with broadband funds and existing regulatory infrastructure, like Colorado, and those without would be an important area of focus. Another issue related to cost is the type of technology that is deployed. Fiber is the most expensive technology, especially in low population areas with fewer potential customers and lower revenues, whereas wireless presents perhaps the most cost-effective way to deliver broadband to remote areas.

Any discussion of wireless naturally involves spectrum policy, which is managed at the FCC, as well as fiber because of its utility in wireless backhaul. In Red Cliff, FORETHOUGHT.net had in place a lease agreement with the Eagle County School District for the 2.5 GHz spectrum, also known as Educational Broadband Services band. The FCC stopped issuing licenses to educational entities for this spectrum in 1995, and large areas of rural America currently have no licensee. The FCC is expected to release a Further Notice of Proposed Rulemaking (FNPRM) for this spectrum at its April 2018 meeting.

Regulatory policy has also played a significant impact on broadband deployment. Some state programs, like Colorado, link the definition of broadband to the FCC (25 Mbps/3Mbps), whereas the Connect America Fund Phase II (CAF II) program only requires 10 Mbps download speeds and 1 Mbps upload speeds. This 25/10 digital divide could be an interesting topic to explore, especially if consumers continue their trend of increasingly relying upon streaming video services, which require greater bandwidth. According to DORA, there could be as many as 100,000 homes that might experience this 25/10 divide. Finally, wireless infrastructure deployment requires extensive involvement in siting, environmental, and historical reviews. In March 2018, the FCC approved a rulemaking to reduce red tape associated with 5G infrastructure deployment. As of March 22, 2018, 14 states had approved legislation to make small-cell investment easier, and another 19 were considering legislation this year [31].

8. APPENDIX

Table 5 - DOLA Grant Contribution Breakdown

Entity	Amount Contributed	Percentage Contributed
Town of Red Cliff	$77,500	36.6%
Department of Local Affairs (DOLA)	$144,100	63.4%
TOTAL	**$211,600**	**100%**

Figure 7 - DOLA Grant Contribution Breakdown

Figure 9 - Broadband Network Diagram
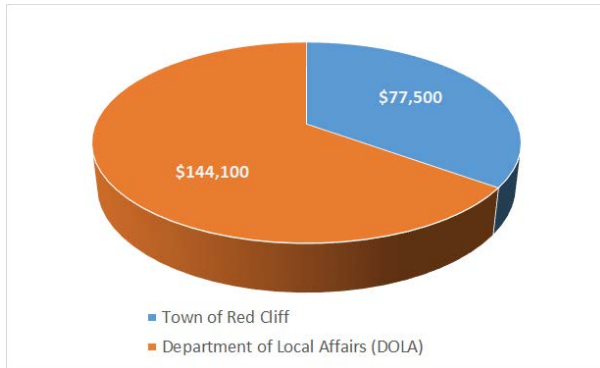
Table 6 - DORA Grant Contribution Breakdown

Entity	Amount Contributed	Percentage Contributed
Town of Red Cliff	$55,984*	38.7%*
FORETHOUGHT .net	$18,490*	12.8%*
Department of Regulatory Agencies (DORA)	$70,103	48.5%
TOTAL	**$144,577**	**100%**

Figure 8 - DORA Grant Contribution Breakdown
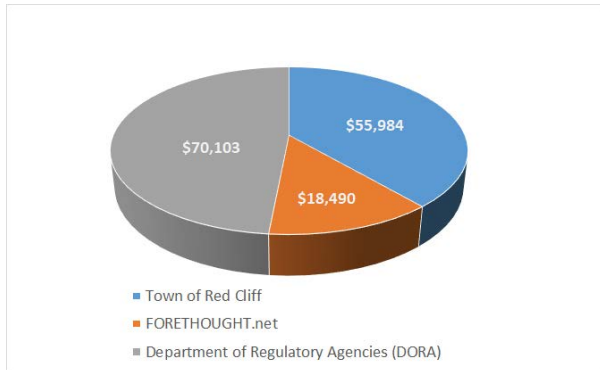
* These figures are approximate totals
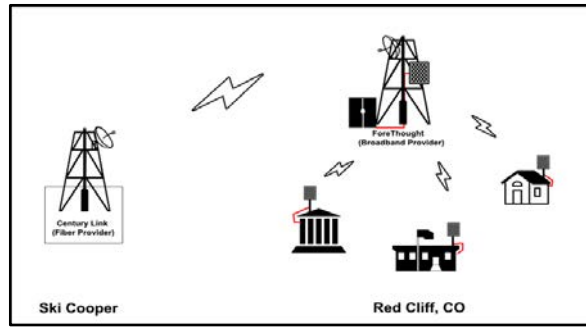
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Alexander Schumann is a dual degree graduate student at the University of Colorado-Boulder pursuing M.B.A. and M.S. Telecommunications degrees. Alex has extensive experience working for telecommunications companies serving remote regions of Alaska. He is familiar with the installation of consumer satellite broadband terminals and the effect that new broadband services bring to underserved and unserved communities. Along with a B.S. in mathematics from the University of Alaska Anchorage, Alex has completed his M.B.A. requirements at CU, where he developed and therefore has an understanding and past experience conducting research and economic case studies.

Ayman Shakfa is a senior Radio Frequency Engineer with over 11 years of telecommunication experience. In his current position at Sprint, he has held multiple roles ranging from managing cell sites' performance at the local market level to being involved in LTE deployment and new features testing and rollout strategy at the National level. His experience include RF design, new 4G/5G features testing, and RF optimization. Ayman earned his B.S. in Computer Science from Kean University, New Jersey. He's currently in his second-year in the Interdisciplinary Telecommunications Program pursuing a Master's Degree in Telecommunications.