THAT GOOD COUNTRY AIR:

THE EMERGENCE OF RURAL COMMUNITY WIRELESS NETWORKS

IN THE UNITED STATES

by

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That Good Country Air: The emergence of rural community wireless networks in the United States

Thesis directed by Professor Kenneth E. Foote

Despite the increasing importance of broadband internet access in today's society, the availability and affordability of residential broadband access in the United States remains uneven due to many factors, a significant one being geographic location in rural areas. This research examines the emergence of small-scale, local wireless access strategies, commonly called community wireless networks (CWNs), and the extent to which they provide broadband access to under-serviced rural areas. Specifically, the following three questions are addressed: How many community wireless networks are providing service to rural areas? Are there socioeconomic patterns in the demographics of the rural areas being serviced by these networks? What are the differences, if any, between urban and rural networks? These questions were investigated through a national survey of CWNs and demographic analysis of their service areas. While CWNs were found to be equally located in both rural and urban areas, there are enough significant differences between urban and rural networks to suggest two diverging network models. There were no significant demographic patterns found within the rural service areas based on age, income or education level; although proximity to universities and colleges may be a possible catalyst for CWNs. The consistent, shared growth rate of these CWNs despite a diversity of locations and strategies suggests that further collaboration and support between CWNs and from telecommunication policy-makers would be a valuable and constructive step towards affordable, universal broadband access in the United States.

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INTRODUCTION AND BACKGROUND

This study focuses on rural community networks in the United States. In recent years broadband technologies have increased the speed and quality of Internet access in the United States. Yet the availability and affordability of this broadband access to individual households is highly uneven due to many factors, a significant one being geographic location in rural areas. While demands for universal broadband access have been voiced, several technological, economic and regulatory restrictions of the private telecommunication industry have limited the response. Yet the recent response from the public sector—particularly at the municipal level—has pushed for more affordable and universal access, championing wireless platforms as the means. Municipally-owned wireless networks are now emerging in many major metropolitan centers such as San Francisco and Philadelphia. Despite increasing momentum, municipal networks still tend to be more of an urban phenomenon than rural.

There is yet a third strategy in broadband access in addition to private and municipal efforts. This third strategy has emerged from smaller-scale, often community-based or non-profit organizations fostering a grassroots framework for providing local broadband internet service. This research examines the geographic distribution of these networks—informally grouped as 'community wireless networks' (CWNs)—in the United States, in order to assess, in part, the degree to which these networks are servicing rural residents in under-serviced areas. This research offers a unique geographic perspective on cutting edge technology and community-based rural telecommunications. It examines a newly emerging strategy that challenges conventional broadband deployment both in its physical infrastructure and its political and social organization. This research is also unique in that it surveys newly emerging community wireless network strategies on a national scale. Empirical evidence is lacking in current research on rural telecommunication infrastructure and policy, especially at the scale of individual wireless networks.

Through the use of survey methods and spatial analysis, I will address the following questions: *How many community wireless networks are providing service to rural areas? Are there socioeconomic patterns in the demographics of the rural areas being serviced by these networks? What are the differences, if any, between urban and rural networks?* Accordingly, the purpose of my study is to determine (1) the location and amount of networks providing service to rural areas, (2) whether or not there are any socioeconomic patterns in the demographics of the rural areas being serviced, and (3) the differences between urban and rural CWN networks.

The first two of these questions relate to the important issues of: (i) the concept of access—specifically the physical availability of broadband services in rural areas and the policy and market forces that limit the geographic extent of access, (ii) the physical characteristics of wireless infrastructures and how they allow community networking strategies, (iii) the meaning of 'rural' as both a social and statistical construction, and (iv) the concept of rural social restructuring—how social, economic and cultural changes in rural demographics can affect the local construction of 'community' and mobilize local human resources in new ways.

The third question—differences between urban and rural CWN networks--relates to how different community wireless networks operate. This includes a wide variety of organizational and technical options: static versus dynamic networks, cooperatives versus non-profit organizations, volunteer versus paid staff, and a range of connection speeds, costs, and coverage areas. In this study, nine conceptual characteristics were operationalized in survey questions: geographic context, network profile/type, formation, management, coverage extent, user group, local availability, growth, and challenges. These characteristics were used as a conceptual platform on which to examine differences between rural and urban networks. The interrelatedness of these characteristics were also explored; for example, the difference between the cost of urban (typically free) and rural networks (paid access) largely has to do with the relative costs of building a network architecture in the given environment and the type of use intended (public space versus residential household). In this introductory chapter, I discuss the main characteristics that typically differ between rural and urban networks—network topology, cooperative strategies, and coverage area.

The Challenge of Rural Broadband Access

At the most general level, my research relates to debate surrounding the 'digital divide': "the gap between those who do and those who do not have access to computers and the internet. Access first of all meant physical access: having a personal computer and internet connection" (van Dijk 2005, 1). Those who have examined the digital divide closely have expanded the meaning of access to include other factors such as skills, motivation and actual usage, meaning that the divide is as much social and economic and technological (Mossberger, Tolbert and Stansbury 2003; van Dijk 2005). In the case of my research, I am focusing on a physical divide—the degree to which rural areas have less access than urban areas.

It should be noted, however, that physical networks alone are insufficient to meaningfully bridge the digital divide. Much research has shown that strategies to 'bridge the digital divide' that only provide the material basis for access are limited in their success (Strover 2003). An over-emphasis on the hardware and software of information technologies can easily blind us to continuing, underlying inequalities among users such as income, education, age and race. Even with physical access to the internet, people can lack the awareness to navigate possible resources, the skills for using multimedia and interactive features, or even the motivation to choose to go online. Thus, despite a logical prioritization for physical access to technologies such as the internet, there are other crucial factors involved in the holistic concept of equal access.

While it is important to acknowledge the broad possible meanings of access, the focus of this research is on the physical connection or availability of broadband services. But by examining physical access that is specifically provided through community-based technology efforts, political, economic, educational and social factors are to a certain degree unavoidable in any meaningful discussion concerning access strategies. These factors make the issue of access a more complex and difficult research subject, but also one that is rich and applicable to the current problems of broadband access.

> "With the proliferation of community-based technology efforts, understanding how such projects unfold, what difficulties they face, how they either exploit technological opportunities or fall victim to them, and how organizational settings function become important to flesh out holistic understandings of how to attack inequities in information technology opportunities" (Strover 2003, 277).

Specifically, I will examine access as the ability of a residential household to access broadband internet service. Inherent in this focus is the importance of the speed of internet connection provided by broadband connections; I am specifically looking at broadband, and not 'dial-up' internet access. In the context of this study, the term broadband can be loosely defined as an internet connection that offers a high data-transmission rate—higher than 'dial-up' connection rates (56 kilobits per second (Kbps)). According to the Federal Communications Commission (FCC), this would include any connection rate faster than 200 Kbps in at least one direction (FCC 2007). This is a very modest definition in comparison to the growing use of much faster connection rates of 5 to even 50 Mbps. Generally speaking, a broadband connection makes use of a wide range of frequencies, over a 'broader' range of bandwidth, which allows for a faster transmission speeds.

Across the United States broadband access is expanding yet is still highly variable. As the Pew Internet and American Life Project reports, the number of Americans with residential broadband has increased 40% between March 2005 and March 2006, from 60 million to 84 million (Horrigan 2006). Some of the largest increases in broadband adoption were seen in categories of ethnic minorities, lower income and lower education levels. The pace of adoption has also increased in rural areas (39%), yet is not any faster than urban and suburban adoption growth; "It is still the case that broadband penetration rates in rural areas lag behind those in suburban and urban areas" (Horrigan 2006, 3). Thus the digital divide is still apparent based on geographic location and/or community type. Rural broadband access continues to be a problem; one that is largely based on the relationship between geographic location and market forces of broadband service provisioning.

Although broadband providers are continuing to expand their service areas, they still have not succeeded in offering their service universally. And this conflicts with the growing attitude that broadband is beginning to reach the status of a required 'universal service,' like telephone, electricity, mail, that is fundamental for a sufficient connection with current society. It is increasingly argued that without broadband access, a household resident is unfairly disadvantaged in terms of access to essential public information and government services, among many other social, educational and economic resources (McChesney and Podesta 2006). It is in question, then, whether the Federal Communications Commission (FCC) should help promote broadband service nationwide, as it did for telephone service, due to the growing importance of the internet in emergency and government services, and basic daily life.

Telecommunication Policies

Government policies and regulations often play a significant role in the affordability, availability, distribution and overall efficacy of the deployment of a certain technology and such is the case with broadband technologies. The FCC's Telecommunications Act of 1996 expanded the services subsidized by the Universal Service Fund (USF)—previously directed only towards subsidizing nation-wide telephone service primarily for high-cost areas and low-income households. The 1996 Act expands universal services to include access to emergency services, operator services, and directory assistance. Section 254 of the Act describes universal service as "an evolving level of telecommunications services," and the FCC must account for advances in telecommunications (FCC 1996). Presently, broadband internet access is not considered a universal service; hopefully the 'evolving' conceptualization of universal service will soon include broadband internet as a universal service.

Several federal and private programs have provided economic incentives for rural Internet access or 'universal access,' yet the success of such initiatives is questioned

(Strover 2003; Malecki 2003; Stenberg 2000; Vasquez 2006; McMahon 1999). Often, these grants, loans or funds are criticized for discouraging competition and requiring impractical application processes (such as the Rural Utility Services' Broadband Loan Program). The Universal Service Fund's E-Rate Program provided broadband connections to poor, rural schools and libraries, yet did little to aid residential access. Currently, there is no meaningful universal service policy for broadband (Hundt 2005, 278). As Reiter states "the challenge for the industry and policy-makers alike is how to embrace change and create new value without disrupting the economic engine that makes everything possible" (2006, 1).

The interrelated complexity of the national telecommunications infrastructure, however, does not permit an easy answer for embracing change. As Kyle Nicholas explains, the presence of this infrastructure can be seen through 'geo-policy barriers,' or "chokepoints, mechanisms of control created through the interaction of geography, market forces, and public policies" (Nicholas 2003, 1). Geography creates challenges through uneven distributions of the population and costly realities of service extension. Service networks relying on line of sight must be built around impenetrable topographic features such as mountains, hilly terrain, and even dense tree-cover and buildings. Market forces steer the development of infrastructure based on unequal patterns of demand and profitability. Public policy can subsidize certain services and also can dictate what components of the national infrastructure can or cannot be shared, which includes radio frequencies. Rural broadband access remains restricted due to all three of these factors, and the complex interactions between them.

Accordingly, telecommunications policy is currently not in a good position to help advance universal and rural broadband availability because it has not yet embraced the new possible infrastructure that wireless and other recent broadband technologies can offer. While more in-depth investigation of the complexities of federal and state telecommunication policy is beyond the scope of this research, the common challenges and criticisms that face these policies—highlighted in a significant body of literature (Best and Maclay 2002; Bell, Reddy and Rainie 2004; Lehr, Sirbu and Gillett 2006; Nicholas 2003; McChesney 1996; Prieger 2003; DACA 2005)—are an important foundation for understanding why wireless strategies—particularly community, grassroots, and cooperative networks—have appeared throughout the country.

The Role of Private Providers

Wireline providers—cable companies and telephone companies—currently constitute the primary providers of broadband in the United States. The providers provide such service through cable modems and digital subscriber lines (DSL), respectively. Together, these two platforms continue to dominate the residential market—as of 2006, DSL connections made up 50% of the broadband market, and cable modems made up 41% (Horrigan 2006). Yet neither platform has ultimately expanded into "truly big" broadband giant (Hundt 2005, 269). Both platforms have failed to adequately provide broadband service to the country as a whole. The large private cable and DSL providers direct their service to only about half the population; there is a potential demand from 50 million more homes (Hundt 2005).

Private providers of broadband service have been slow to penetrate most rural areas of the U.S.. Why aren't these large private providers successfully extending their market into these areas? One answer is largely economic. Areas with low-density populations tend to be high-cost. Another answer is demand. Rural demand is growing, yet it still is not equal to the demand found in urban areas. And while broadband access might be considered a public good in the near future, it is still currently provided based on market demand. In her research on broadband service in Pennsylvania, Glasmeier raises the point that providers have to consider the 'take rate'—the actual use of broadband service when available—of rural areas (Glasmeier, Wood and Kleit 2003). Commonly, rural areas have lower take rates than suburban and urban areas, which decreases the financial incentive to offer service to areas where relatively few households will subscribe.

A third potential answer why private cable and DSL providers have yet to provide universal service is largely technological. Neither of these platforms were originally built to provide internet access. In a sense, both telephone lines and cable wires were jury-rigged to transmit data using the TCP/IP internet protocol. Both cable and DSL platforms have expensive physical infrastructures that must be built in time-consuming stages. "Almost everyone agrees that neither telephony nor cable is optimally designed for broadband." (Hundt 2005, 269).   Yet once built, large wired infrastructures can achieve economies of scale that currently far exceed wireless solutions. But as patterns of current and planned broadband service deployment suggest, wireless technologies have a potential to leapfrog wired technologies in servicing areas that are still without any service. The initial capital required to build a wireless network is substantially lower than that of a wired network.

A final point I want to make is that access to single providers does not alone mean that the resulting service is adequate. Even when one provider does extend services to low-density areas, the services offered can vary in quality. "Since competition for broadband is especially important considering that quality, costs and speeds of service can vary dramatically, having little or no choice in broadband providers can cause users to settle for inferior service" (Glasmeier, Wood and Kleit 2003, 7). Rural areas that are then, in theory, 'serviced' by a broadband provider, may in fact have limited access due to high costs, slow speeds and poor quality connections. This is important to consider when examining the emergence of community wireless networks in areas that are already serviced by other providers.

At present, rural broadband access has not caught up to those of suburban and urban areas, and neither federal policies nor the dominant national private broadband providers have broken through the geo-political barriers that remain from the wired telecommunications industry. Wireless technologies, on the other hand, are starting to have a presence in the market, and have tremendous potential especially in rural areas. Yet given the radically different nature of wireless platforms, there is much contention over how wireless can or should be regulated, and the degree to which it should be a public service, and whether wireless can be marketed in way that will generate sufficient returns on private investment. As these debates go on, rather than waiting for broadband service to come to them, informal groups around the country have already begun to implement new strategies of broadband service through grassroots and community-based organizations. In the absence (or inadequacy) of commercial broadband providers, other groups and individuals are developing what have come to be known as "community wireless networks."

Wireless Infrastructures for Community Networks

Broadly defined, the term community wireless network (CWN) encompasses a diverse range of informal, ad-hoc strategies that use wireless technology to distribute broadband access on a local level. CWNs are particularly interesting because they are experimenting both with a variety of organizational, governance and entrepeneurial strategies as well as new and emerging technologies. Some CWNs are the fruits of individual hobbyists, while others have grown from community meetings filled with people fed up with poor or non-existent broadband access. Other networks emerged as a form of civic participation contesting the privatization of the internet: "Many CWNs were founded or organized around the idea that they could provide an infrastructure *alternative* to that of the increasingly commercialized internet" (Powell 2006, 4). Overall, a CWN can broadly be considered a 'bottom-up' approach to broadband service provision, in which the users (or potential users) of a network infrastructure actually build a self-enabled service provision for their own use and purposes.

There are a variety of organizational strategies currently being implemented to manage community wireless networks. Some organizations follow traditional cooperative structures that have been used in the past for similar purposes of local service provisioning. Some existing rural electric and telephone cooperatives are addressing the need to provide their users with broadband internet, and have incorporated broadband into their services. Other strategies have begun as a typical non-profit organization, receiving funds from large grants or donors. And other networks have begun out of informal interactions between only a few individuals in what Malecki conceptualizes as a 'soft network:' "(b)uilding networks to encourage interaction among entrepreneurs, and between entrepreneurs and other local leaders in education and government, rather than isolation, will increase information-sharing that might not take place otherwise" (2003, 212). This concept of a 'soft network' is an important way of understanding how some CWNs have been built from the technical expertise and entrepreneurship of a few individuals. For the purposes of this research, a community wireless network is a network that can have any these organizational strategies, that offers wireless broadband access (along with other possible services) to residential households, and that is not affiliated with pre-existing private providers, a university, or any municipal, government-based efforts.

To understand why and how these networks are forming, it is also important to understand physical characteristics of new wireless technologies. The physical structure of wireless is fundamentally different than wired platforms; and these differences translate into major financial and operational differences. For these reasons, wireless is naturally suited for a different nature of service provision than what has been the status quo for cable and telephone services. Without the unique physical characteristics of wireless broadband technologies, CWNs would not exist.

Yet wireless technologies today still rely on a 'backbone' of wired connections, and before discussing wireless technologies specifically, it is necessary to understand a certain amount about the physical infrastructure of broadband access as a whole. Current uses of wireless broadband access are primarily being implemented at the 'last-mile' level. Access to the internet in the United States is made possible through an impressive interconnected network of networks that is most often described in three levels: the internet backbone, the middle mile, and the last mile. The internet backbone, initially building off of federal investments nearly fifty years ago, now consists of large private-owned networks of fiber-optic cable that connect large metropolitan areas. Over forty companies, such as MCI, Verizon and AT&T, have their own private networks that consist of tens of thousands of miles of fiber-optic cable (Glasmeier 2003). Middle-mile facilities connect to the backbone to distribute the services regionally. Often these facilities are owned by the large private backbone providers as well, but can also belong to regional scale cable or telephone companies. Already at this level, costs to physically connect a rural middle-mile network to the internet backbone (through a T-1 cable line) can be prohibitive—likely involving laying out expensive fiber cables over a long distance. Lastly, the last mile is the technological platform that connects an individual household to the internet. The major platforms are DSL, cable modems, wireless, and to some extent, satellite services. A wired connection and installation is required for DSL and cable, while wireless (and satellite) are based on antennae that send (as transmitters) and receive (as receivers) signals remotely.

So what makes wireless broadband technologies different than wired ones? As Rob Flickenger states in his 'how-to' book on building wireless community networks, "(w)ireless data networking is probably the most 'magical' technology to evolve in recent times" (2003, 1). Wireless technology bypasses the need for a physical connection for digital communication between computers, and it can operate faster and more efficiently. Wireless can offer several financial advantages to wired platforms for last-mile service. These include incremental growth, less distanced-based costs, low spectrum barriers to entry, and affordable, publicly available parts.

Once a connection to internet backbone or middle mile is established through one or more T-1 lines, this connection can be distributed from a radio transmitter/receiver that can then 'speak' or link with other radio transmitter/receivers installed at individual homes. This infrastructure allows for the network to be grown incrementally: once a main antenna is put up (often on a tower), intermediate antennae can be built as needed to further relay the signal to homes and businesses farther away. This gradual build-out process doesn't require a huge initial investment.

Secondly, wireless signals traveling via unlicensed spectrum are free to use (excluding the initial costs for the hardware that can access these signals). Unlike wired broadband connections, you don't have to pay any costs proportional to the distance the signal must travel. Thus the distance between the main transmitter and a household receiver is less important than the strength of the signal. Signals do weaken over distance and with any interferences such as foliage and weather; yet with a clear line of sight (LOS), most wireless signals can remain clear. "It didn't take long for some sharp hacker types to realize that by using wireless client gear in conjunction with standard radio equipment, effective range can extend to more than twenty miles and potentially provide thousands of people with bandwidth reaching DSL speeds, for minimal hardware cost" (Flickenger 2003, 3). Wireless networks introduce a completely different cost-to-coverage-area ratio, which is an essential reason why these networks can be the most affordable strategy in isolated, low-density rural areas.

Additionally, federal standards play a critical role in the use of free, unlicensed radio-frequency spectrum. In 1997, the IEEE Standards Committee approved 'Wi-Fi,' or the 802.11 protocol for unlicensed wireless local area networks. The 802.11 protocol uses the 2.4 GHz microwave band and provides speeds of one or two megabits. A later extension of this protocol, 802.11b, was established in 1999 and allowed for fasters speeds of up to 11Mbps and a longer range of about 1,500 feet in open space (Werbach 2005). 802.11b uses spectrum bandwidth at the 2.4 GHz band. Two other unlicensed standards, 802.11a (at 5.7 GHz) and 802.11g (at 2.4 GHz) can also be used for wireless purposes; they have better speeds (54 Mbps) but shorter, signal ranges than 802.11b. Although several additional developments in 802.11 protocol have expanded the possible speed and quality of wireless signals, "the ratification and wide acceptance of

802.11b in late 1999 is widely regarded as the start of the popular wireless phenomenon" (Flickenger 2003, 3).

Lastly, wireless networks can be very affordable to build. The availability of the necessary hardware was perhaps the main reason why wireless networks began to be built in the first place. "Wi-Fi emerged in the 1990s as a grassroots phenomenon: amateurs built home networks using a combination of vendor products and do-it-yourself ingenuity" (Bradley 2005, 208). Specifics about the necessary hardware (Ethernet cards, routers, antennae, mounting hardware, etc.) and software can now be found on many websites and in several books and manuals (Flickenger 2003; Gast 2002; Prasad and Prasad 2002; Walke, Mangold and Berlemann 2006). As I will discuss, however, there is a certain amount of expertise needed to assemble and operate this hardware that cannot be overlooked. Building a wireless network is only 'easy' in relative terms; the required local motivation and skill can be a limiting factor, especially in some rural communities.

These four advantages of wireless are only generalized points about the overall infrastructure and operation of a wireless network—there are many specific strategies that can be developed to fit particular purposes. I will discuss specific characteristics and challenges of these strategies in further detail later in this chapter; and the results of this research will help to tease out a few likely models of typical CWNs. While relatively few in number, CWNs offer tremendous insight into feasible alternatives to last-mile services currently dictated by large-scale commercial providers. These networks are not back-water oddities but cutting-edge, real-world applications of emerging broadband technology; and quite possibly harbingers of a new telecommunications paradigm.

What is Rural?

When discussing the problem of rural broadband access, what is the actual definition of rural? Defining rural is a difficult and contentious issue; one dealt with in many different ways. "The broad category of 'rural' is obfuscatory, whether the aim is description or theoretical evaluation, since intra-rural differences can be enormous and rural-urban similarities can be sharp" (Hoggart 1990, 245). The meanings of urban and rural can be more accurately described as a continuum rather than a dichotomy, and thus researchers always need to be clear about how they choose to subdivide this continuum. Some definitions attempt to distinguish differences based on quantitative demographic distinctions, while others are based on qualitative factors including social perceptions and community self-identification. Rural is most often used dichotomously with urban, yet drawing the line between the two is extremely difficult, especially with today's sprawling development patterns. For the purposes of this research, I define rural based on demographic characteristics, with an additional validation based on the opinion of the survey respondent. I chose this strategy because it aligned with previous research on rural telecommunications, it allowed national comparisons using US census information, and it also provided some insight into local, subjective views about an area's 'ruralness.'

The term rural, as it is used within US broadband telecommunication policy, analysis research and infrastructural debates, is largely part of a discourse of rural in which "problems of rural areas are seen as the product of underdevelopment, and rural development initiatives are required to integrate rural areas into markets and socioeconomic structures" (Woods 2005, 12). Definitions of rural within this discourse tend to be descriptive, focusing on socio-spatial characteristics such as population and population density (Beale 2002; RUPRI 1999). They also tend to be negatively defined—all non-metropolitan areas, or areas not incorporated as a city, town, etc.. To apply for rural broadband access loans from the Rural Utility Service (RUS), an 'eligible rural community' must be a place "not contained in an incorporated city or town with a population in excess of 20,000 inhabitants" (RUS 2003, 2). This negative definition also correlates with the definition of rural as given by the US Census Bureau, wherein rural areas are "all territory, population and housing units not classified as urban," and wherein urban is "all territory, population and housing units in urban areas, which include urbanized areas and urban clusters; an urban area generally consists of a large central place and adjacent densely settled census blocks that together have a total population of at least 2,500 for urban clusters, or at least 50,000 for urbanized areas (U.S. Census Bureau 2006). In my survey I asked respondents to broadly identify their location based on these definitions for an initial division of urban and rural networks.

Yet these broad definitions of urban (or urban cluster) and rural begin to break down when examining demographic information of specific geographic units. The Census Bureau addresses this problem by allowing this classification to "cut across other hierarchies and can be in metropolitan or non-metropolitan areas" (U.S. Census Bureau 2006). In further explanation, the Bureau states that it "does not identify or classify entire counties as urban or rural. Geographic entities such as places, counties, metropolitan areas, etc., are often split between urban and rural territory, and the population and housing units they contain are then classified as part urban and part rural" (U.S. Census Bureau 2006). This means that in order to categorize a small spatial unit as either urban or rural, such as a ZIP-code, one must make an estimation based on the percentage of urban or rural population within that ZIP-code unit. My demographic analysis of ZIP codes serviced by a CWN is based on this strategy of urban/rural classification based on the percentage of urban population (complementary with rural population) within each unit.

Despite the usefulness of these descriptive statistics, they are inherently problematic. It is important to consider the practical and theoretical weaknesses of statistical socio-spatial definitions of rural. Practically, the numerical division in any descriptive statistic made between urban and rural areas is largely arbitrary, based upon the purpose and goals of a particular analysis (Wood 2005). Exactly when does the number of people per square mile exceed that which can be called rural? In reality there is no clear dividing line, but fluctuating gradients of change, so no one line can accurately describe the transition. This division is only growing more difficult, and perhaps even irrelevant, as suburban development and sprawl continue to expand in untraditional patterns away from city centers. The continued use of the urban/rural dichotomy is problematic, yet current national demographic information, such as the US census, still use this dichotomy; areas are categorized based on narrow indicators, and there is little means to adequately account for the heterogeneity within each category. Rural indices by Cloke (1977) Cloke and Edwards (1986), and Beale (2002) use gradients, but where these divisions are made is still problematic. It is fair to say that all divisions of urban and rural based on socio-spatial characteristics are estimations severely limited by levels of statistical aggregation and artificial lines of classification.

Theoretically, the validity of quantitative measures of a human phenomenon based on aggregate data is highly contentious. Despite the universality of using a pre-defined quantitative measure to define rural areas, this strategy fails to recognize any of the unique values, behaviors and attitudes that we so often associate with the term rural.

It ignores the power of socially constructed meanings of rural, based on individual and community identities. "(W)hatever academics might say about the difficulty of defining rural areas, there are still millions of people who consider themselves to be 'rural,' to live in 'rural areas,' and to follow a 'rural way of life.' (Woods 2005, 10). When mapped, statistical definitions of rural areas will not perfectly align with the areas where people identify their locations as rural.

Thus a more subjective, yet equally valid way to define rural is to rely on how people construct the meaning in their own minds, based on experience, cultural signs and symbols and images. Cloke and Milbourne describe it as "a world of social, moral and cultural values in which rural dwellers participate" (1992, 360). These constructions or values, whether held on the individual or community level, may translate into powerful motivational factors in actions towards self-reliance and local needs-based activism—such as community wireless networks. I felt it was important to somehow test for the presence of these socially constructed identifications of rural where CWNs were located. For this reason, I included questions in the survey that asked for the respondent's opinion of the degree of 'ruralness' of the serviced area. While these meanings are more difficult to generalize, they serve a crucial role in 'ground truthing,' in a way, statistical analyses based on aggregate data.

The multiplicity of meanings given to the term 'rural' is problematic for research addressing rural telecommunication infrastructures. The term is widely used for a variety of places, landscapes and situations. Any clear theoretical division between rural and urban has been deconstructed, and the boundaries between them blurred in the contemporary US landscape. Yet rural is still a powerful term of distinct cultural patterns of place-based identities, activism for development, idealism, and shared imaginings.

For this study I have chosen to define rural as aggregate units (ZIP-codes) that contain less than 60% 'urban population' (more than 40% 'rural population') as defined by the US Census Bureau. This method will be discussed in more detail in Chapter Three. By dovetailing with census definitions, I can relate my research to a national demographic data set. And in addition, I used a subjective, opinion-based meaning of rural to cross-check this quantitative definition. Two survey questions will request the respondent's opinion of the 'ruralness' of the network's service area. This combination of approaches, although only an estimation, offered a strong quantitative and qualitative basis for qualifying certain CWNs and their service areas as rural.

Rural restructuring

In order to address my second research question regarding socioeconomic patterns *within* the rural areas being serviced by CWNs, it is necessary to consider what kinds of demographic differences *between* rural areas could influence the likelihood of a local CWN being created. This question raises the issue that rural areas are hardly homogeneous, and there are increasing socio-economic differences between them. Are there socio-economic differences that determine why certain rural places have established community networks while other places do not? In an attempt to address this question, I first offer two traditional reasons why rural areas routinely fall behind in technological advances—the 'rural penalty,' and the traditional rural demographic profile of poor, less educated, older populations. Then I will discuss current, uneven patterns of 'rural restructuring' that contrast these traditional views and offer reasons why rural areas might have the human and financial capital needed to start a CWN.

In economic terms, the geographical characteristics that traditionally put rural areas at a disadvantage is often called the 'rural penalty.' This concept, attributed to Hite (1997), is used to explain the continuing challenge of rural development. It is based on the existence of a "low density of population and therefore a low density of most markets, and greater distance to those markets as well as to information, labor, and most other resources" (Malecki 2003, 201). The rural penalty can be clearly applied to the lack of an adequate broadband telecommunication infrastructure in most rural areas in the United States. It is manifested through the refusal of large private internet service providers (ISPs) to extend their services to areas that do not offer a profitable take-rate (or demand density). The rural penalty fits well with the utilitarian discourse of rural, which tends to naturalize the inability of rural communities to improve their conditions except through external initiatives (such as private market penetration or federal policies). This view acknowledges the dominance of market forces in the economy of today's telecommunications industry. As an initial qualification, I expected that CWNs are emerging in rural areas that are inadequately serviced by private providers due to the rural penalty.

Inadequate broadband access is also commonly associated with certain demographic variables that, when viewed spatially, suggest other geographic patterns of access disparity. Common variables that are most often associated with access to digital technologies are age, income and education level (Parker et al. 1989; Mossberger, Tolbert and Stansbury 2003; Strover 2003). Recent research by Mossberger, Tolbert and Stansbury suggests that "the most unlikely demographics to have internet access were the poor, less-educated, [and the] old" (2003, 30). Not surprisingly, these demographic characteristics are also traditionally correlated with rural areas (Parker et al. 1989; Ilbery 1998; Woods 2005; Cloke 2003). These variables are highly interrelated, but simply put, one could make the general assumption that rural populations tend to be older, with less education and income than urban populations and thus they are more likely to lack broadband access. Could we then extrapolate that rural areas that don't follow these demographic patterns may also present a different pattern of broadband access.

While these two traditional perspectives of the rural penalty and the common rural demographic profile can generally explain the challenges of rural broadband access, they fail to suggest why some rural communities have been able to counter these disadvantages through such strategies as CWNs. I would like to suggest that current patterns of 'rural restructuring'—specifically increasing new migrants and return migrants to some rural areas may offer an explanation for why some rural areas have the resources to build CWNs.

The ability of a rural community to collectively create a local solution to broadband access is likely largely dependent on human capital—the economic value of one's intangible assets, including expertise, knowledge, social networks and collaborative abilities. Malecki (2003) suggests a significant shortcoming limiting rural access is the shortage of human capital—such as technical expertise, entrepreneurship and education. "Rural citizens often lack the skills or knowledge to realize the importance of digital information and communication and … to assure digital infrastructure in their areas" (Strover 1999, 16).

Yet current demographics changes in some rural areas may be offering the necessary human capital to act upon community needs for broadband access. Many rural areas are seeing an influx of 'newcomers,' who are relocating for quality-of-life reasons; migration trends suggest that "many educated Americans, including relatively young retirees, find rural America appealing" (Malecki 2003, 209). As business shifts to a more digital platform, the options for telecommuting and home offices have become more viable. Ironically, the very technologies that make telecommuting from a rural area a theoretical option are not practically available in many rural areas. Yet this is exactly the dilemma that can motivate these newcomers to push community action for better broadband service.

Another trend that increases the potential human capital of rural places is the return migration of young, educated people. Young people often permanently leave their rural homes for school and work opportunities, but about one-half return, typically with increased educational and financial resources (Gibbs 1995). Thus, likely surrogates for gauging these new and returning migration patterns—that have been shown to increase the local human capital that could in turn build the capacity for a local CWN—relate to the same variables (*viz.,* age, education, and income) that are also correlated with internet access.

More specific indicators such as digital entrepreneurship or technological expertise would perhaps be even more telling than age, education and income, yet the census data that was available for this research does not include such indicators. I reviewed all possible indicators available on the long-form summary file of the 2000 U.S. census, and the three traditional variables still remained the most pertinent to the human and financial resources likely needed to develop a CWN.

Differences between rural areas can be substantial, and these differences will likely affect the types of challenges for broadband access. A community wireless network strategy is not an equally viable option for all rural areas; the creation of a local network requires certain human and financial resources. After reviewing literature that addresses the relationship between digital technologies the rural penalty, rural demographics, and rural restructuring, I expected that rural areas with younger, better-educated and more affluent communities are more likely to have the resources to create CWNs. Broadly speaking, I chose indicators that would best capture the overall landscapes of human capital within which the formation process of locally-initiated service provisioning is occurring.

Network Characteristics: Urban and Rural Differences

A significant body of work in rural telecommunications has expressed the importance of a spatial perspective in understanding how well different telecommunication strategies are suited for rural areas (Calabrese 1991; Calabrese and Jung 1992; Glasmeier, Wood and Kleit 2003; Malecki 2003; Nicholas 2003). In the early 1990's, Calabrese and Jung suggested "the geographical considerations for rural markets may dictate different technological and organizational strategies in rural than in urban areas, and perhaps even across rural areas" (1992, 227). Following this argument, geographic considerations for rural CWNs may dictate different technological and organizational strategies than urban CWNs. My third and final research question asks how rural and urban CWNs may differ at the network level. This final section of this chapter includes a brief discussion of why the physical, spatial qualities of the network are important to consider and more detailed consideration of the main differences I would expect to find between urban and rural networks, based on previous research.

The growing body of research on broadband access primarily focuses on either the policy level or the user level (using national statistics of household connection, use, pay rates, etc.), while the physical infrastructure of the networks providing this access are less often discussed (Cossette et al. 2005; Meinrath 2005; Powell 2006). While "the availability of wireless broadband service is growing rapidly and offers tremendous potential for underserved rural areas," little research has documented how this 'potential' plays out in material form (Glasmeier, Wood and Kleit 2003, 14). I argue that especially in order to understand problems and potential solutions of rural broadband access, the spatial and structural characteristics of wireless and other broadband platforms are crucial to consider. For this reason, the scale of this research is based not on the individual, nor on the state or federal policy level, but on the network—the actual infrastructure and management system that physically provides the broadband connection to the user.

The dual examination of telecommunication networks and the physical spaces of their material infrastructure is an essential contribution of geography to literature on the internet and cyberspace (Graham and Marvin 1996; Longan 2000; Wilson 2003). Research on the important physical and spatial dimensions of telecommunications is in part a response to the theoretical standpoint as to the invisibility, or lack of acknowledgement, of the telecommunications infrastructure, especially in geography (Kellerman 1993; Graham 1997; Hillis 1998). This research is in a position to contribute to this response to invisibility, exposing evidence of the geographical complexities of not only the physical infrastructure of a wireless network but also the localized human effort involved in creating and maintaining this infrastructure.

Urban and Rural Differences

In order to conceptualize important characteristics of a CWN, I decided it was insufficient to review the small amount of previous research. As an intermediary step, I did a preliminary study of one rural CWN to familiarize myself with the general social, logistical, technical, managerial and physical factors that can be involved in its operation. The network chosen for this preliminary was the nearest network in the dataset due to limitations in time and funding. This network was the Magnolia Road Internet Cooperative, based in Coal Creek Canyon, a few miles south of Boulder, Colorado. The study included attending two volunteer meetings, participation in a site-visit to a new member's home, several conversations, and on-going email dialogues with several key members. This study gave me the primary foundation to prioritize and categorize the network characteristics that I addressed in my survey. The following is a discussion of some of the most important characteristics when differentiating likely rural and urban network strategies.

Network Topology, Cost and User Type

One of the most fundamental differences I would expect to find between urban and rural CWNs would be the network topology. Common CWN topology can be split into two general categories—static ('hub and spoke') and dynamic ('mesh') networks (Meinrath 2005). Static networks typically begin at a centralized antenna, usually high up on a tower or roof, and then distribute the specified bandwidth out to either relay stations or end users. Networks of this sort can include local multi-point distribution services (LMDS), point-to-point networks of 'line of sight' antennae, or wireless local area networks (WLAN). Dynamic, or mesh networks, operate in a decentralized manner, passing bandwidth between any two points connected within the network. In other words, an end-user can also redistribute a received signal to any other points within range. Mesh networks can be faster, cheaper, and can avoid physical obstacles by rerouting signal through different network pathways (Meinrath 2005). A third means of Wi-Fi access, although not technically a network, are 'hot spots'. Hot spots are single points of Wi-Fi access, commonly in public spaces or private venues. The distribute access within a certain radius—commonly a few hundred feet.

Given these network types, I would expect to find static networks more in rural area since the topology is more traditional, less technologically extensive, and is well-suited for residents desiring a simple, single point of connection at a household. In urban areas, I would expect that mesh networks and hot spots would be more common; cities have the human and social capital to quickly adjust to innovation and also a higher density of people using shared public and outdoor spaces for which hot spots are well-suited. Mesh networks and hot-spots also offer user mobility, an advantage more commonly desired in urban landscapes than rural.

Since urban community networks may be more orientated towards users that are out and about during the day, while rural networks are more likely directed towards residential access at home, there is likely a difference in the price for service. I would expect that rural networks must charge residents for installation and service in order to afford to operate. In urban settings, CWNs are more likely aimed at providing social and economic equity in broadband access (versus geographic equity), and thus would perhaps aim for low-cost or free service. Moreover, if access is provided in public spaces as a public service, it seems appropriate for this services to cost very little.

Concurrently, I would expect a difference in the expected user group of rural and urban networks. Rural networks that charge for service would naturally be aimed at residents who join the CWN, while urban networks are likely aimed at the public at large. In addition, an incentive to begin a rural network is the lack of other local broadband providers. Thus rural users are more likely those that have little to no other options in providers. Urban networks that exist in more dense areas with stronger market penetration and more private provider options are likely to offer service to those that already have access to cable or DSL service.

Cooperative Management Strategies

The technological characteristics of wireless strategies influence how they can be managed. As Calabrese and Jung stated nearly fifteen years ago, "(t)he different architectures of broadband delivery systems suggest different approaches to ownership and control" (1992, 227). This conceptual relationship between technological 'architectures' and political ownership and control will be used in this research to understand the differences between of CWNs as operated by rural and urban community organizations.

The main difference I would expect to find the formation and management of rural and urban CWNs is that cooperative strategies would be more prevalent in rural areas. The term cooperative can imply many types of cooperative action, yet in this research I am referring to a 'consumer cooperative' that is "a business owned and democratically controlled by consumers to provide themselves with goods and services on a not-for-profit basis," (Hoyt 2004, 265). Cooperative theory has a well-established relation to rural development, and the cooperative's unique marriage of political strategy and social goals dovetails with issues of rural internet access in interesting ways. "The cooperative model is also being extended to public services in sparsely populated rural areas that otherwise would be without these services. Cooperative business forms are becoming a major tool in local development, and they are being used in innovative ways to serve rural constituents" (Merrett and Walzer 2004, 1).

In contrast, previous research by Sandvig (2004) would suggest that the cooperative model is primarily being used by the expert elite in more urban areas.

> "While activists and policymakers working on [community network] CN and public access projects take as a central premise that their facilities exist to provide free or subsidized access to under-serviced populations (the socio-economically disadvantaged, under-serviced rural areas, etc.), Wi-Fi co-ops often exist to provide free access to an inexpensive service for the rich—it may take over a thousand dollars of personal equipment to participate in a co-op (laptop/palmtop, wireless cart, etc.). In some areas co-ops have been employed to establish point-to-point broadband connections to rural households that are not serviced by cable modem or DSL services, but it is fair to say that the bulk of the Wi-Fi co-op activity is occurring in wealthier metropolitan areas." (Sandvig 2004, 10).

Thus the amount of cooperative CWNs in rural versus urban areas is debatable and worthy for further investigation. This distinction is of further interest because of the many ways that a cooperative strategy in turn can strengthen or weaken the overall operation of the network. Advantages can include lower costs, awareness of community needs and additional community-based services (such as local weather or message board web-pages), flexibility, and a shared sense of positive collective action; disadvantages can include the challenges of orchestrating volunteer work, unreliability, disorganization, lack of financial capital for large infrastructural investments, long wait-lists for service, and lack of expertise.

If a cooperative strategy can manage a wireless network efficiently, it could sufficiently compete with local private providers (if, of course, any exist). Cooperative networks can do "what commercial providers find difficult to do well: represent local culture, local relevance, local pride, and a strong sense of community ownership" (Morino Institute 1995). Yet it is very feasible that the complexities (and headaches) of running a wireless network cooperatively outweigh any economic or social benefits. Cooperative strategies of broadband access are one of the most interesting and iconoclastic characteristics occurring in CWNs, and so the question of whether these strategies are occurring more in urban or rural areas poses further questions about the types of resources needed for local, collective action in a increasingly digital world.

Coverage Areas

A final difference in urban and rural networks involves network coverage area, and factors that may limit its growth. In a most general sense, residential users are more spread out in rural areas, requiring a larger coverage area to connect the equivalent amount of urban residents. This would lead me to expect larger coverage areas overall for rural networks. At the same time, however, geographic challenges are likely to pose more of a challenge for the extendibility of rural networks. Issues such as line of sight (LOS) and signal strength become difficult issues with diverse topography and land cover.

Wireless distribution is strongly influenced by topography—line of sight is typically required to deliver a clear radio signal from one network node to the next, especially when using unlicensed spectrum that has limitations on speed and range. "As with any wireless service connection, quality depends on physical geography and the local spectral environment" (Werbach 2005, 327). Distributing wireless to rural households in mountainous, hilly, or heavily forested terrain requires additional hardware to feed the radio signal up and around geographic features. More hardware (such as repeater towers, antennae, power sources, radio adaptors) means more installation and more maintenance needed for the network. I would expect that rural networks, while likely having larger coverage area, are more challenged by local topography and infrastructural costs of overcoming such geographic obstacles.

While rural CWNs are likely to extend their services farther to individual households, it is unlikely that rural networks can provide universal coverage over an entire area. Urban networks, presumably based more on public hot-spots or mesh networking, offer a more feasible strategy at extending access over wider areas. Potential challenges of urban extendibility, however, could include competition and lack of public interest due to a much deeper urban penetration by private providers. In addition, urban environments filled with large buildings can also pose topographic challenges to wireless networks. While both rural and urban networks face challenges of service area growth, the reasons for these challenges are fundamentally different in nature and can largely be attributed to their geographic context.

To review, the main differences that I expect to find between urban and rural networks are based on the following characteristics: network topology, cost, user type, cooperative management, coverage area and challenges to its growth. Together, these predicted urban and rural network differences make up the fifth and final point of my conceptual framework.

In summary, the main points of my conceptual framework are the following: 1) differential broadband access in the US and the role of private providers and federal policy, 2) how aspects of wireless infrastructures can naturally encourage ad-hoc, informal use, 3) the challenge of defining rural within the context of inadequate broadband service provisioning, 4) how elements of rural restructuring can increase the local human capital needed to develop local alternative strategies for broadband access such as CWNs, and 5) how rural CWNs can vary from urban ones, based on general differences in geographic and social contexts.

CHAPTER II
RESEARCH DESIGN AND METHODS

Based upon the literature and theory reviewed in the previous chapter, I chose to examine three questions about the emergence of community wireless networks in rural and underserved parts of the United States. These questions will be posed as hypotheses and tested in the next chapter.

The first research question is about the geographic distribution of community wireless networks in the United States. Are the networks providing service mostly to rural areas, urban areas, or both? I expect to find that CWNs are more prevalent in rural areas, or in areas with few other broadband providers. A null hypothesis will be tested that there are equally as many urban as rural CWNs.

My second question is whether the socioeconomic patterns rural areas served by these networks differ from comparable rural areas. Based on the reviewed literature, I expect to see evidence of a possible relationship between the location of networks and indicators of rural restructuring and the presence of the 'creative class:' young, affluent, or well-educated areas. An indirect indicator I will also investigate is the presence of a nearby college or university.

The final question is whether or not there are any differences between the characteristics of rural and urban networks. I would expect that differences between rural and urban networks do exist—particularly coverage areas, user groups, and the formation process. I will test the null hypothesis that there are no differences based on the network's geographic context.

This research gathered two types of data: survey information from network providers and selected socio-demographic information about the areas in which the networks are located. The combination of these two types of investigation offered the opportunity to explore the three key questions of the study.

Survey Population

There are presently few dependable sources of up-to-date comprehensive data—or even contact information—about CWNs in the United States, for several reasons. First, there are few and, second, as small start-up organizations with changing websites, names, funding, managerial structures, or organizational partnerships, they are difficult to track. A third, and possibly the most important reason, is that unlike other telecommunication entities, these networks are rarely regulated or taxed. As a consequence, local, state and the federal government do not collect on these networks.

In the absence of official sources, several websites proved useful to gather this information. These include the Free Press (www.freepress.net), The Association for Community Networking (www.afcn.org), WirelessCommunities by the Personal Telco Project (wiki.personaltelco.net), a wireless community network list on Toaster (www.toaster.net), Wireless REVOLUTION (wireless-revolution.net), MuniWireless (www.muniwireless.com), Wireless Community Networks (wcn.cnt.org), Media Access Project (www.mediaaccess.org), municipal broadband listings on ecoustics-cnet.com, and comprehensive lists of both private and non-profit networks for each state on (www.onelasvegas.com/wireless). While several of these sites provide information about wireless networks in general, they most often focus on either municipal or private networks. The Free Press website offers the most comprehensive list of networks and is the only listing that differentiates among community, private, and municipal networks.

Thus, the population chosen for this project came from Free Press, a national nonpartisan organization. Their website, freepress.net, includes information on community internet networks in the United States. An interactive map highlights the location of hundreds of broadly defined 'community' internet networks and displays a window of summary information about each network via cursor roll-over. The map also allows the viewer to classify the networks by 'Owner Type,' 'Network Status,' 'Implementation, and 'Unlicensed Spectrum Use.' All of the community networks shown in figure 2.1 were sent questionnaires.

Figure 2.1. Community wireless networks in the United States. All of these networks were surveyed. This map was developed from an interactive map by Free Press (online at www.freepress.net/communityinternet/networks.php).

This map was created from a more detailed database, researched by Brian Hodgdon, a research associate at Free Press. Mr. Hodgdon has accumulated information about community networks from news articles and posts on web/techoriented blogs since 2001. He has updated the database on a continuous basis. Mr. Hodgdon supplied me with this database for my research. For purposes of comparison, I searched for other lists of community network contact information on the web and failed to find any that approached the collection identified by Free Press.

The data set included 443 networks. The data included, although often only in part, the ZIP code, city, county and state location of the network, the network name, the date of research, the network status, use of unlicensed spectrum, type of internet platform, informal notes and links to articles about the network, and any known contact information. Over 270 of these were categorized as 'municipal,' and were thus not considered a community network for this research. The remaining 173 networks could be broadly categorized as either 'community', 'private', a public/private combination, for public safety, or unknown. From this data, I selected all wireless networks that were categorized as non-profit, community, or a cooperative. These categories best fit with the population in question in this research. This eliminated the following network types from the sampling population: private, non-wireless platforms, Canadian/international, public safety uses, universities, and statewide programs. Subsequently, the population under examination was the remaining 65 community-based, non-profit networks. Due to its relatively small size, I decided to survey the entire population in order to gather all possible responses. Additional research online was needed to fill in the gaps in information regarding status, location and contacts for these networks.

Questionnaire Design

I developed a questionnaire to gather the needed information from the sample population. I chose an editable digital document (a Microsoft Word document) attached to an email to keep costs low and to provide a quick turnaround for responses. This strategy had many advantages over in-person and phone survey methods. First, results from questionnaires are typically more easily generalizable than other surveying methods. Since little research has been done on CWNs, I sought primarily generalizable information rather than more detailed narrative accounts. Also, it eliminates the interviewer-induced bias likely in in-person interviews, and more complicated questions and answers can be written out more precisely than explained verbally (Sheskin 1985). A written questionnaire can also allow the respondent to consult with others (as is useful in this research), and gives more leniency in how long respondents take to answer questions (Sheskin 1985). Lastly, questionnaires are one of the best methods for geographically disperse samples. And, if the sample is homogenous and specialized (as is for this research), respondents are likely to be located (Chambliss and Schutt 2003). Questionnaires can thus offer a spatial coverage much larger than more in-depth studies in the time given. Email addresses were also the most complete contact information available for the sample. Written forms are also good for technical and detailed information.

Despite these advantages, "(n)o survey fully satisfies the theoretical ideals of scientific inquiry" (Babbie 1973, iii). Perhaps the greatest limitation with respect to this study is that written surveys have a high likelihood of bias. This arises because those that feel most strongly about the subject matter are most likely to respond (Babbie 1973). In an effort to counterbalance this bias in initial responses, I made follow-up phone-calls and emails with unresponsive contacts. This technique introduces another bias through the subjectivity of phone and email dialogue, yet it was necessary to achieve as high a response rate as possible. This final dialogue technique nearly doubled the initial response rate.

The initial draft of the questionnaire was refined by gathering comments from two chosen contacts at sample networks that would not be involved in answering the main survey. Responses from these pilot questionnaires were used to revise the final draft. Specifically, changes were made to inconsistencies and redundancies in closed-ended answer options. Overall, the responses about the general structure and content of the questionnaire were positive. Human Research Committee review was then obtained.

The final questionnaire, shown in Appendix B, consisted of 25 questions and took roughly twenty minutes to complete. It was administered over a 3-month period in the fall of 2006. Questions focused on location, coverage area, history and formation of the network, and major challenges. Sample survey questions pertaining to specific network characteristics are shown in table 2.1.

Table 2.1. List of Sample Survey Questions.

Network Characteristics	Sample Survey Questions
Geographic Context	8. Which best describes the primary geographic context of your network? (Urban, Urban Cluster, or Rural)
	9. In your opinion, do you consider your network to cover a 'rural' area in whole or part? Please rank your coverage area between 1-a wholly urban area, and 5-a wholly rural area.
Profile/type	4. What wireless standard are you using?
	5. What is the approximate monthly cost for the broadband internet access service that your network provides?
	11. The service you provide is primarily at which speed?
Formation	22. Which best describes the formation of your network: (may check more than one)
	23. Was your network a grassroots effort by local citizens?
Management	2. Which best describes the entity that manages your network?
	24. Please give an approximate percentage of the amount of responsibility each of the following groups have in running your network? (Total should be 100%)
Coverage Extent	5. Please list one or more zip codes that are serviced by your coverage area:
	18. Approximately how many households or businesses do you currently service?
User Group	7. For whom is the network intended to serve? (Check all that apply.)
	16. Do you provide service to residences that are in locations not serviced by DSL and cable modem providers?
Competition and Coverage	12. Please rate the demand for broadband service in your coverage area, 1 being lowest and 5 being highest:
	13. Does your network currently compete with private providers in your coverage area?
Growth	19. How do you expect the size of your network will change in the next few years? Use the rating scale below:
	25. Do you have a waitlist for your service?
Challenges	27. Please check any of the following factors that limit the use of your network:
	20. Among the challenges you have faced in establishing your network, which FIVE have been the most difficult?

The questionnaire was designed similarly to what Sheskin describes as the most common research questionnaire design, "in a deductive fashion with inductive overtones" (1985, 3) Most questions were designed to address the pre-defined research problems regarding the geographic context of the network, and issues that may differentiate rural and urban networks. A few questions were included to collect information inductively, to test whether other tangential information regarding management and operations of the networks may illumine patterns that relate to the main research problems. Thus, most questions were either attribute-based—to classify certain characteristics of the network—or attitudinal questions—to rank challenges, issues, concerns, or priorities of the network as understood by the respondent. The questionnaire included both open and closed-ended questions, and gathered nominal, weakly-ordered data, and strongly-ordered data in Likert scales.

The questions focused on the network as the 'individual' under examination. No questions requested information about individual members of a network. The contact that personally responded to the questionnaire was most often the director of the network or someone who had experience in both technological and managerial aspects of their network. The contact was asked to identify their role in the organization at the end of the survey. They were also given the option to receive the results of the research and to include their contact information for possible follow-up phone calls. Confidentiality was maintained throughout the research process.

Each returned questionnaire would be coded and entered into a database for further analysis. The answers to the closed-ended questions would be either coded as ordinal data if mutually exclusive, or binary data if not mutually exclusive. Open-ended questions would be pre-coded with response categories and coded as qualitative categories (i.e. 'management issues' as 1, 'financial issues' as 2, etc.).

Data Collection for Geographic Location

Two important issues had to be addressed in the analysis of the locational distribution of the networks: 1) how to differentiate rural from urban; and 2) what unit of spatial aggregation to use for analysis. To address the first issue, the classification of a network as either 'rural' or 'urban' was necessary for analysis and determined by both qualitative and quantitative means. First, responses to two different qualitative closed-ended questions regarding geographic context (questions # 8 and # 9) were classified for all respondents. Responses to question #8 were given as one of three categories (urban, urban cluster, or rural), a classification method employed by the US Census Bureau. If the response was either 'urban' or 'rural', the networks were preliminarily defined as such. If the response was 'urban cluster' or 'not sure,' answers to question #9 were then examined to determine the network classification. These answers were given as a 'rural ranking' (one being the least rural, five being the highest). A score from one to three would be classed as urban, four to five as rural. A chi-squared test would be used to test the null hypothesis that there are equally as many urban CWNs as there are rural CWNs.

The question of which unit of aggregation to use for the study presented a number of problems. Most importantly, there was little likelihood that the service areas of the networks corresponded to any common used unit, whether ZIP, census tract, census block, or county. Yet one of these units would be necessary in order to draw demographic data from the US census information. The smallest unit, and one that I could likely expect survey respondents to know, is the ZIP code. Using the ZIP codes as the spatial units of aggregation for this analysis has its advantages, yet is also problematic. In terms of accurately describing the spatial extent of a network's service area, ZIP codes were likely more familiar to survey respondents and potentially better descriptors than census tracts. County-wide data would be too generalized. The smallest unit that the US Census disk SF3 data could be broken into was the ZIP code. Unfortunately, the size of ZIP codes varies substantially in rural or exurban areas. This lack of consistency proves to be a weakness in this analysis; but for the purposes of this research, ZIP codes proved to be the most useful unit of aggregation.

Thus this unit of analysis was based on the ZIP-codes that were listed for question #5: "Please list one or more ZIP-codes that are serviced by your coverage area." Before analysis, these ZIP codes listed on the questionnaires were cross-checked with ZIP codes listed in the original Free Press data and with USPS current ZIP code listings. Any discrepancies were examined on a case-by-case basis, and I chose the most accurate representation of any service areas in question. The majority of respondents were also available for follow-up questions if needed.

The ZIP codes that were listed as the network's coverage area were assessed in terms of percentage of their urban population based on the 2000 US Census. Since the census defines populations, but not geographic areas, as rural or urban, I created a surrogate definition of a rural area based on the percentage of urban population within a spatial unit. If the urban population within the ZIP code was less than 60%, this ZIP code and any CWN based within it was deemed 'rural' for purposes of this research. If a ZIP code included 60% or more urban population, the ZIP code was not considered rural and any CWN based in this ZIP code would be considered urban.

As are all empirical indicators of broad concepts, this definition of rural is inevitably imprecise and oversimplified. Yet, this 'rural indicator' can be considered a useful, logical tool at approaching a meaningful understanding of rural for the purpose of this research. This working definition was not intended to be normative, but to screen out the data largely representing urban areas. It was a strategy intended to sharpen an analysis involving the ambiguous concept of rural in order to yield more meaningful results.

If a network only listed one ZIP code as its service area, the rural percentage of that ZIP code would determine its rural/urban classification. If a respondent listed several ZIP codes for a network, and they included both 'rural' and 'urban' ZIP codes by the above definition, the network would be classified based on the status of the majority of ZIP codes. If no ZIP code was listed, I would select the most appropriate ZIP code to represent the network based on other geographic information available from the survey and network website.

The above method of identification and classification was used to define and locate rural community wireless networks. In addition, I also evaluated networks based upon the extent of local broadband competition. Several survey questions (#10, 12, 13, 14, and 17) asked for information regarding the local availability of broadband, the local demand, whether or not the network has direct local competition, whether the competition was a wireless platform, and how well area previously covered before network. I expected to find that while urban networks would have a high level of local broadband service competition, rural networks would feature next to none. I will discuss the descriptive statistics of the responses to these questions in the following chapter.

Data Collection for Demographic Characteristics

The ZIP codes listed for each network's service area were also used as the basis for the analysis of the rural network's demographic context. This analysis was necessary to address the second research question—*whether or not there are any socioeconomic patterns in the demographics of the rural areas being serviced by these networks*. I sought to see whether the socioeconomic patterns in rural areas served by these networks differ from comparable rural areas, especially with regard to indicators of rural restructuring and the presence of the 'creative class:' areas with young, affluent, or well-educated populations. For this study, I selected the indicators of age, education, and income. I also looked at proximity to colleges and universities.

The statistical indicators I chose came from the demographic variables available from the US Census Bureau's Census 2000 Long Form CD, Summary File 3 (U.S. Census Bureau 2002). I surveyed all possible variables to find the most suitable ones to act as surrogates demographic changes that may act as catalysts in creating community wireless networks. As established in the conceptual framework of the previous chapter, I sought empirical indicators that could work to operationalize the concepts of rural restructuring and the creative class. I decided upon the following five indicators for the three variables of income, education and age: average household income, median per capita income, percentage of the population with a bachelor's degree or above, percentage of the population with a master's degree or above, and percentage of the population between twenty and forty years of age. These demographic measurements were chosen as a broad representation of socio-economic characteristics in the local population.

Since this research question focuses only on the rural areas being serviced, only the ZIP codes individually identified as rural of a rural network were analyzed. In other words, if a rural network serviced both rural and urban ZIP codes, the urban ZIP codes would be removed from the analysis. As stated above, these would include all ZIP codes that had an urban population of 60% or more. These ZIP codes would be removed before comparisons to national, county and state rural census statistics were calculated.

The remaining ZIP codes representing the rural service areas of 'rural' CWNs were then examined on the basis of the five demographic indicators based on the 2000 US census. Descriptive statistics of this demographic data were gathered for each rural ZIP code serviced by a rural CWN. These statistics were then compared to national averages of those indicators in all rural ZIP codes (defined in the same way).

While a national level analysis gave me a basis for comparison, the huge aggregation of data severely limited my ability to pinpoint any specific patterns. It was clear that my working definition of rural (less than 60% urban population) was helpful, but could be broken down into more specific classes. Thus, in order to try to see more specifically how network service areas compared to similarly situated rural areas across the country, all ZIP codes were divided into three natural break 'sub-classes'—with 0% urban population, 1-30% urban population, and 31-59% urban population. All ZIP codes serviced by each rural network were again compared to national averages, and also to state averages, but this time they were only compared to those in their rural sub-class.

Data Collection for Urban and Rural Differences

A third method was used to address the final research question regarding differences between urban and rural networks. The same rural/urban classification from the first methodological step was used to divide the networks. Then, comparisons between rural and urban networks were made based on nine different network characteristics that were linked to specific survey questions (see Table 2.2).

Table 2.2. List of characteristics and corresponding survey questions.

Characteristics	Survey Question	Topics addressed in questions
1. Geographic Context	8, 9	An urban, urban cluster, or rural area, rank of 'ruralness'
2. Profile/type	3, 4, 11, 15, 26	Type of wireless platform, wireless standard used, speed of service, cost of service, additional services
3. Formation	22, 23	Nature of formation process, grassroots or not
4. Management	2, 24	Managerial structure/type of entity, % of volunteer work
5. Coverage Extent	5, 6, 18	ZIP codes served by network, approximate size of coverage area, number of households and businesses serviced
6. User Group	7, 16	Intended users for network, service to those without DSL or cable access?
7. Competition and Coverage	10, 12, 13, 14, 17	Local availability of broadband, local demand, local competition, wireless competition, how well area previously covered before network.
8. Growth	19, 25, 28	Ranking of speed of growth, existence of a waitlist, year the network began.
9. Challenges	20, 21, 27	Ranking of challenges, biggest challenge and why, listing of limitations to network.
Respondent Information	29, 30	Description of role at network, willingness to participate in follow-up phone calls if needed.

The responses to questions 4, 11, 14, 18 and 28 proved ill-suited for generalization and were not used.

An analysis of variance would be performed on the survey responses based on the nominal variables of urban versus rural. This analysis was performed to test the null hypothesis that there were not significant differences between rural and urban networks. The two additional analyses of nominal variables, based on cooperative and grassroots characteristics, were implemented as a basis of comparison to the results of the rural/urban differences. It could be possible that rural/urban differences may result only as a surrogate of fundamental differences in how the network was created and managed. The categories of cooperatives and grassroots networks were much easier to define, simply by the binary yes/no responses from questions #2 and #23. The results of these three analyses of variance are shown in the following section.

To review, networks would be classified as either rural or urban based upon both the respondents answers to both the qualitative questions regarding geographic context, and also the percentage of urban population in the ZIP codes that respondents listed as part of their service area. If there were discrepancies in classification type between these two methods, cases would be further examined individually. All urban ZIP codes listed in the service area of a rural network would be removed before the demographic analysis. The demographic analysis is intended to examine differences specifically in the rural areas being serviced, not differences between networks at large. For this reason, distinctions between rural and urban ZIP codes had to be made. And finally, differences between rural and urban networks were analyzed based on nine network characteristics—each of which was specifically operationalized by several survey questions.

CHAPTER III
RESULTS OF ANALYSIS

Thirty-three of 65 surveys were returned, a response rate of 51%. This relatively small sample size meant I could examine the results using some descriptive and predictive statistics, but limited my ability to explore some detailed breakdowns of geographic and demographic characteristics in relation to network types. The majority of the respondents were highly involved in the management and operation of their networks. Fifteen respondents (45%) were self-identified as the founder, president, or executive director of the network. Fourteen respondents (42%) were some type of manager, coordinator or board member; one respondent was a volunteer, and three did not provide this information. Secondly, almost all networks were currently operational as of fall, 2006. Twenty-eight out of the thirty-three networks were identified as fully operational. Out of the remaining five networks, two are currently being constructed, one is being proposed, one is no longer active, and one is temporarily non-operational.

Rural or Urban Locations

As described in the previous chapter, networks were divided into two groups, rural or urban. The first step of this analysis was based on survey questions regarding geographic context. Of the 33 responses, 13 networks (39%) operated in an 'urban' area, 5 networks (15%) in an 'urban cluster, 13 networks (39%) in a 'rural' area, and two (6%) answered only by comment. Out of the 'urban cluster' responses, four of the five were classes as urban, one as rural. The two 'not sure' responses were both classed as rural.

The second step of this analysis was based on ZIP codes listed as the network's service area. Only one ZIP code was listed by 16 respondents; Five responses listed two, and eleven responses more—up to 13 in one case. One survey response was excluded in the analysis because no specific ZIP code was given and a complete listing of all ZIP-codes that would be covered by the known city area was too general to include with the analysis of the more specific, individually listed ZIP codes.

ZIP-codes were also eliminated from the analysis if, upon further investigation, they were no longer in use by the U.S. Postal Service. As stated on the U.S. Postal Service Website, "only 43,000 out of 100,000 possible ZIP codes are currently in use" (U.S. Postal Service 2006). Seventeen out of 135 ZIP-codes were not analyzed due to this reason.

With the remaining ZIP-code information, percentages of urban population were calculated. All networks defined as rural in the first step were reaffirmed as rural by this second step; they all serviced at least a majority of rural ZIP codes.

Based on this division process, the responses consisted of 52% (17 responses) urban networks, and 48% (16 responses) rural networks. I used a chi-squared test to determine whether CWNs are equally as likely to be found in urban as they are in rural areas. Presuming a 50/50 distribution, 16.5 of the 33 respondents should be both rural and urban. My results, of 17 out of 33 urban, and 16 out of 33 rural, yielded a chi-square value of .03, which calculates to a p-value of .8625. This p-value is greater than a .05 significance level. Thus this test does not dispute the null hypothesis that there is equally as many urban as rural CWNs. This approximately equal balance between the two was not expected; the hypothesis was that there would be more rural networks than urban. These results reject this hypothesis.

Not only did I expect that there would be more CWNs in rural areas, but I expected that rural CWNs would have much less local competition and serve areas that previously have very poor broadband availability. In addition to the analysis of geographic location based on rural/urban classification, I also analyzed the networks' location in terms of competition. To do this I performed an analysis of variance on responses to five questions that represented the 'Local Availability' characteristic in the questionnaire (table 3.1).

Table 3.1 Urban/Rural Differences in Local Availability

	Questions	P-value
10.	Please rank the broadband availability in your coverage area without your network:	
	High (4 or 5) or Low (1 or 2)	0.00**
12.	Please rate the demand for broadband service in your coverage area, 1 being lowest and 5 being highest:	
	High (4 or 5) or Low (1 or 2)	0.43
13.	Does your network currently compete with private providers in your coverage area?	
	Yes	0.31
17.	Please rate the extent that your coverage area was previously serviced in terms of broadband access:	
	High (4 or 5) versus low (1 or 2)	0.00**

Questions 10 and 17 are quite similar, and both yielded a significant result at the .05 level. Urban networks were significantly more likely to be in an area of high broadband availability and access. However, a difference in demand was not found to be significant; nor was the amount of local competition. This final result rejects the hypothesis that there would be less local competition for rural CWNs.

Demographic Characteristics of Service Areas

The second part of the analysis focused on the demographic characteristics of the coverage areas of the rural networks, based on the ZIP codes listed by the respondents. As I discuss in Chapter Two, defining rural is a contentious issue in and of itself. Yet for the purposes of this study, I define rural networks based on survey responses and the percentage of urban population (a variable from the US census) in their service areas. The purpose of this analysis was to examine whether there was pattern to the type of rural areas being serviced by CWNs, specifically in terms of higher income, higher education level and greater percentage of the adult population in the 20-40 year-old age range. As described in the previous chapter, sixteen networks were analyzed, covering a total of forty-three rural ZIP codes in thirteen different states.

Only rural ZIP codes (with less than 60% 'urban' population as defined by the US cense) of rural networks were analyzed. Sixteen out of fifty-nine ZIP codes that were serviced by these 16 rural networks were eliminated because they had an urban population percentage greater than or equal to 60%. Forty-three ZIP codes remained for study. These statistics were then compared to national and state averages of rural ZIP codes (defined in the same way). The data for this step was limited, allowing some descriptive comparisons and statistical tests, and yielded few consistent results.

The first comparison (table 3.2) was made between the rural network ZIP codes and the averages for all rural ZIP codes in the United States. An unbalanced one-way analysis of variance between the two groups did not yield any significant results.

Table 3.2 Comparison of service area demographics to national averages

Demographic Percentages	Average for all ZIP codes serviced by rural CWNs	Average for all rural U.S. ZIP codes (< 60% urban)
Percentage urban	3%	0%
20-40 years-old	23%	25%
A bachelor's degree or higher	14%	9%
A master's degree or higher	7%	5%
Average household income	$39,409	$33,187
Median per capita income	$19,949	$16,490

These descriptive statistics suggest a possible relationship between the location of rural CWNs and higher levels of education and income. Yet at this level the degree of generalization at the county is very high; counties with no urban population with grouped with counties with up to 59% urban population. There is also contention in comparing unlike aggregate units; the disparity between ZIP codes and counties increases likelihood of error.

Because national averages may obscure patterns at more local levels, I decided to look at the comparisons at the state level. A second scale of analysis was by state. Like at the national scale, state averages (of all ZIP-codes with less that 60% urban population) were first compared to the CWN serviced ZIP codes of that state. These thirteen states were Alaska, California, Colorado, Illinois, Kansas, Maine, Massachusetts, Maryland, Minnesota, New Mexico, North Carolina, Washington and Vermont. These comparisons yielded mixed results. Network ZIP codes were not consistently higher for all three variables than state averages. Most commonly, however, one of the three variables was higher for a CWN ZIP code than the state average; yet, no strong relationship of any single demographic variable was found.

Further comparisons were made using three 'rural sub-classes'—with 0% urban population, 1-30% urban population, and 31-59% urban population. All ZIP codes serviced by each rural network were again compared to state and national averages, but this time they were only compared to those in their rural sub-class. The majority of these network ZIP codes (39) fell into the 0% class, with one in the 1-30% class, and three in the 31-59% class.

A one-sample two-sided t-test of the 0% class of network ZIP codes was performed using a population mean based on the demographic averages of 0% urban U.S. ZIP codes. Of the five indicators, only a difference in median per capita income proved to be significant at the .05 level. T-tests were not run for the other two rural classes due to sample size (with an n=1 and n=3), but table 3.3 provides a summary of the comparisons.

Table 3.3 Sample demographic comparison between service areas and national averages.

Demographic Percentages	**1-30% Urban**		**31-50% Urban**			
	US ZIP mean	Carlisle, MA	US ZIP mean	Burbank, WA	Farmington, ME	Golden, CO
Urban population	16%	15%	47%	36%	42%	53%
20-40 years-old	25%	15%	26%	25%	30%	30%
Having obtained a bachelor's degree or higher	17%	59%	17%	10%	16%	28%
A master's degree or higher	6%	39%	6%	5%	9%	15%
Average household income	$43,635	$129,811	$41,358	$50,299	$27,981	$68,406
Median per capita income	$19,881	$59,559	$19,234	$17,800	$14,092	$32,323

As with the initial demographic comparisons of all rural ZIP codes, the results of the rural sub-class comparisons find interesting, yet inconsistent results. Several variables—such as the percentage population with a master's degree or higher, or the average household income—are higher in some of the network coverage areas, but not consistently across all networks.

Similar comparisons based on rural sub-classes were performed at the state level as well. For example, a network ZIP code in Maine that serviced an area with 42% urban population was compared to the average of all Maine ZIP codes in the 31-59% urban population class. Even when dividing the rural ZIP codes into three classes and examining one state at a time, there was still not a consistent pattern in the five indicators to suggest a strong relationship between them and the formation of a CWN. This result suggests that these rural networks are not forming solely based on the relative age, wealth, or education level of the surrounding population.

Upon further investigation of the location of these rural networks, I considered another indicator related to the demographic indicators, yet slightly more general—the local presence of a university or college. 'College towns' that are located in rural areas have a tendency to attract a younger, more educated, potentially more affluent population than rural areas without institutions of higher education.

Not surprisingly, sixteen out of the seventeen urban networks had universities based in their cities, but of course there are colleges and universities in hundreds of cities across the U.S.. There is little evidence to differentiate the influence of the urban context from the university context for these networks. As for the sixteen rural networks, thirteen were either based in a university/college town, or just on the outskirts of one (see table 3.4).

Table 3.4 Rural networks and nearby colleges and universities

Network	**Nearest town or city**	**Local Universities**
Hoonah.net	Hoonah, AK	Initially funded by University of Fairbanks, but no local university.
La Canada	Santa Fe, NM	St. John's College
Columbia Rural Electric Association	Walla Walla, WA	Whitman College
Colorado Wireless Exchange Network	Fort Collins, CO	Colorado State University
Magnolia Road Internet Cooperative	Boulder, CO	University of Colorado
Mountain Area Information Network	Asheville, NC	University of North Carolina at Asheville
Pinelink	Bayboro, Oriental, Grantsboro, NC	Pamlico Community College, Grantsboro
Wheatland	Wheatland, KS	n/a
Boreal	Grand Marais, MN	Lakehead University in Thunder Bay, Ontario
Red Rock Community Internet	Lamberton, MN	Southwest Minnesota State University, Marshall
Lower Shore Broadband Cooperative	Snow Hill, MD	University of Maryland at College Park. Wor-WIC Community College, Salisbury
Southern Vermont Broadband Cooperative	Stamford, VT	Williams College, Williamstown, MA Massachusetts College of Liberal Arts, North Adams, MA
Ripton Broadband Cooperative	Ripton, VT	Middlebury College, University of Vermont
Hartwell Road Network	Carlisle, MA	n/a
Rural Broadband Initiative	Farmington, ME	University of Maine in Farmington
Western Sonoma County Internet Cooperative Corporation	Sebastopol, CA	n/a

The proximity of many local universities and colleges to rural community internet networks is very suggestive. It was performed using the public map server, Google Maps, and searching for colleges and universities in a particular town or city within, or nearby a rural network service area. This possible connection is still inconclusive, however, and calls for further investigation.

Rural and Urban Network Differences

For the purposes of testing whether there are differences between urban and rural networks, I used the urban/rural classification as my independent variable for analysis of variance tests of the following network characteristics: management type, formation, profile/type, coverage extent, local availability, growth, and challenges (table 2.2). Answers to specific survey questions were analyzed as the empirical indicators associated to these concepts. Open-ended and ordinal answers were tested in the simplified forms in which they were coded, and were often divided into binary data for more generalizable analysis results. The results, seen in table 3.5, were tested at the .05 level.

Table 3.5 Significant Differences between Urban and Rural CWNs.

Analysis of Variance based on Geographic Context (urban versus rural).		
	CHARACTERISTIC and related questions	**P-value**
	MANAGMENT	
2.	Which best describes the entity that manages your network?	
	Cooperative	0.02**
	PROFILE/TYPE	
3.	Which of the following best describes the type of wireless network in use?	
	A static network (see Appendix C for further definition)	0.00**
	Mesh or a hotspot-based network	0.01**
15.	What is the monthly cost for your broadband internet access service?	
	Free	0.00**
	COVERAGE EXTENT	
6.	Which of the following best describes the approximate coverage area of your network?	0.00**
	USERS	
7.	For whom is the network intended to serve?	
	For all local residents	0.00**
	Only for those who join	0.00**
16.	Do you service households in locations not serviced by DSL and cable modem providers?	
	Yes	0.00**
	LOCAL AVAILABILITY	
10.	Please rank the broadband availability in your coverage area without your network:	
	High (4 or 5) or Low (1 or 2)	0.00**
17.	Rate how well your coverage area was previously serviced in terms of broadband access:	
	High (4 or 5) or Low (1 or 2)	0.00**
	CHALLENGES	
20.	Which FIVE challenges have been the most difficult for your network?	
	Increasing Membership	0.02**
	Local Topography	0.01**
27.	Please check any of the following factors that limit the use of your network:	
	Local Topography	0.01**
	Price of network services	0.03**
	FORMATION	
22.	Which best describes the formation of your network:	
	A formal group, association, or non-governmental organization	0.01**

As a final note, I also tested differences in network characteristics based on two other possible independent variables, grassroots-based, and cooperative-based. Only a few statistics were significant in both these analyses, neither of which was as strong as the analysis of rural/urban differences. This result suggests that cooperative and grass-roots variables did not have as strong an explanatory power as the rural/urban variable.

CHAPTER IV
DISCUSSION

How many community wireless networks are providing service to rural areas?

I expected that more community wireless networks would be found in rural, rather than urban areas. This result was not found: an equal amount of networks were found in both rural and urban contexts. Another surprising and related finding was that there was no significant difference in the amount of local competition between rural and urban networks. Even though rural networks are covering poorly serviced areas with significantly less broadband availability and access, they are still often competing with other providers (that may also use wireless or perhaps satellite).

So while I initially expected that CWNs were forming primarily in rural places where there was little competition, an opposite trend was found. CWNs are emerging and expanding in both rural and urban areas where there is other local competition. This suggests that the reasons for CWN formation go beyond just providing an option for broadband access, but a *better* option. The services that CWNs offer may be better quality, more affordable, more community-oriented with additional services, or more attractive as a local organization than competing private providers.

Are there socioeconomic patterns in the demographics of the rural areas being serviced by these networks?

With respect to rural networks, demographic indicators of income, education and age were not strongly associated with CWN location. We may extrapolate that the relative demographic heterogeneity found in rural CWN service areas suggests that the local resources needed for creating a CWN cannot be easily generalized at the aggregate level. Networks can be formed through a variety of ways, in a diversity of geographic and demographic contexts.

The expected demographic pattern in areas serviced by rural networks—more affluent, educated, and young communities—was not found to any consistent degree. Individual variables often stood out in a particular service area, such as a particularly high education level, but the three variables did not routinely fluctuate in tandem. This result suggests that although these basic demographic indicators are frequently used to measure a local population's level of human capital, and theoretically linked to local entreprenuerism, economic restructuring or community-activism, they are not always adequate indicators.

As a secondary investigation, network proximity to universities and colleges proved just as suggestive, if not more suggestive, than the initial demographic variables. Further research could be done viewing CWNs within the broader relationship between institutions of higher education and rural development.

However, one of the main limitations to answering this question with certainty is that the CWN service areas do not correspond to units commonly used for the spatial aggregation of demographic data—census blocks and tracts and ZIP code zones.

What are the differences, if any, between urban and rural networks?

The most substantial and striking findings of this research appeared in the investigation of the differences between urban and rural networks. The analysis of variance between rural and urban survey responses shows significant differences in some, but not all network characteristics. Not all empirical indicators linked to a particular characteristic were found to be significant. Thus, a closer examination of each of the characteristics operationalized by the survey—network type, formation, management, coverage extent, user group, local availability, growth and challenges—may help to reveal both major and minor patterns of difference.

The *type* of network that was most common for rural networks was a static network (including local multi-point distribution service (LMDS), point-to-point and point-to-multipoint networks), while urban networks tended to be mesh networks or hot-spots. The differing nature of these network types is also reflected in the cost of service—urban hot-spots and mesh networks offered free service significantly more than any type of rural network. There was no significant difference in the amount of additional services provided by the network. As fore mentioned, the speed of connection and wireless standards used were too varied to be accurately generalized for analysis.

Network formation was only slightly different in that urban networks were significantly more likely to be formed by a formal group, association, or non-governmental organization. More rural networks were formed by informal groups or individuals, yet this difference was not significant. There was also little difference in the amount of networks formed through grassroots initiatives. *Management* structures differed in that rural networks were significantly more likely to be cooperatives. There was no significant difference in the amount of other types of management structures. The amount of networks that were run primarily by volunteers was nearly identical.

Coverage extent was very different between rural and urban networks. Rural networks were significantly more likely to cover a area larger than twenty square blocks. The intended *user groups* for the networks also varied strongly. Urban networks were significantly more likely to be intended to serve all local residents, while rural networks were significantly more likely to be intended only for those who join. These results correlate with the differences in cost of service and network type. Free urban hot spots or mesh networks are clearly more likely to be open for public use. Static rural networks with monthly fees would logically be interested only in paying members. Those residents that were a part of a rural network were also significantly more likely to be in a location not serviced by DSL or cable modem providers.

There were mixed results for differences in *local availability*. Rural networks were significantly more likely to service an area with both current and past low broadband availability (not including the network itself). At the same time, there was little difference in the level of *demand* for broadband service. Urban demand was actually slightly higher than rural demand. There was also not any significant difference found for the '*growth*' characteristic, as would be suspected since the majority of both urban and rural networks indicated rapid network expansion. There was also no significant difference in whether or not the network had a *waitlist* for their service. The majority of both rural and urban networks did not have a waitlist.

Lastly, the main *challenges* that these networks face appear to be of slightly differing natures. Of all the challenges listed in question #20, only 'increasing membership,' and 'local topography' were significantly more likely for rural networks. The expansion of rural networks was also significantly more limited by local topography and the price of network services than was the expansion of their urban counterparts. Overall, the greatest challenges for both rural and urban networks were equally likely to be related to either maintenance, the cost of hardware, or topography. No significant differences appeared in the limitations caused residential location/dispersion, lack of interest, or lack of awareness.

In summary, the most apparent differences between urban and rural networks were found surrounding the characteristics of network type, coverage extent, and user groups. Other important differences includes the greater likelihood of a rural network being created without support of a formal organization, being a cooperative, servicing an area that has been, and continues to be an area of poor broadband availability, and being limited by local topography and funding issues. Three characteristics that remained most consistent across rural and urban networks included the amount of *grassroots organizing*, the *demand* for broadband access, and the fast rate of network *growth*.

Network Models

Taken together, these differences and similarities of rural and urban network characteristics can be woven together to suggest general models for the development of current rural and urban networks. Just as urban/rural divisions are never completely accurate, generalizations about urban and rural network models can never fully capture the variety of real strategies that are currently in use. So while it is impossible to condense the variety of technological and organizational into two models, I attempt to do so here in an effort to show how different characteristics tend to fit together to create an overall strategy. I also include related quotes from survey respondents that confirm my generalizations and reveal some basic realities about network operations.

From the results of this research, a general model of rural CWN can be suggested. This rural network model consists of a static tower-to-tower network that covers a large area, in the range of 25 - 250 square miles. Typically transmission speeds vary between main and secondary towers. Users are paying members, the majority of which do not have access to DSL or cable modem broadband providers (although they may have access to other wireless or satellite providers); "we don't serve close in urban [city name], only the area where DSL and cable are typically not available." Rural members are also likely to be using broadband for work purposes—"Most household members use the [network] extensively for home based businesses or remote access (home office) to access their employer's network via VPN. Probably half of our membership work from home at least several days a week, if not full time."

A typical rural network model would be formed through an informal process and organized into a cooperative, run by volunteers. This strategy can have many management challenges—"Crossing the chasm from hobby to business has been the biggest challenge. User expectations are higher even if the technical understanding has decreased, requiring more technical support. The co-op needs a full-time professional staff to complement the volunteers. Personnel funding has been directed toward technical support first." Other main challenges for the rural network are maintaining hardware (both financially and manually) and the problems presented by local topography. The financial price of maintaining service can be high, since it includes continually investing in or repairing necessary hardware and software. In addition, many rural networks operate in poorer areas—"Our rural area has a student free and reduced lunch count percentage of 80%. Our residents are of limited income." The local topography often presents problems such as going up and over mountains or large hills, down into valleys or canyons, or penetrating heavily vegetated areas. "Our area has many trees, hills, and rocks which cause signal loss. The biggest issue our customers seem to have is the ability to get a strong enough signal, given the obstacles between them and the transmitter." A model rural network would need strategies to face the difficulties of always finding clear lines of site between routers. "We are very flat (no high places to transmit down from) and covered with forest (over 70% forested with 25% protected forest) and most of our rural members have heavy forest blocking a signal in more than one direction."

Despite the many challenges, rural networks are growing rapidly, with moderate to high demand. The typical rural network is continuously adding new members, and may have a small waitlist since volunteers do the installation work. One network reported that they "install between two to five new members per week."

Overall, while rural network members are attracted to the community-oriented aspect of a CWN, they need to have realistic expectations of the type of service that can be provided by a community-based organization. Participation is often needed by new members. "People have made new friendships and new business connections [through the CWN]. However, as new subscribers come on, they have the expectation we are a business that does not require their participation. At some point, we may need to limit subscribers who do not volunteer." On the other hand, networks with a sufficient work force are able to provide additional services such as mailing lists, classified adds, community calendars, local grain market postings and even forest fire smoke sighting 'web cams'.

The urban network model, in contrast, is typically a handful of hot-spots located throughout the downtown of a small city. The service is provided for free, and the main users are tourists, local businesses, and local residents. A model network would begin with the help of a formal non-profit organization, yet was initiated by grassroots activity. The urban network may be as financially challenged as the rural network, because even if the coverage area is smaller, hardware maintenance and consistent funding are major challenges. "With us being a nonprofit it's very expensive for the organization to obtain some of the necessary tools needed to maintain a excellent signal." Topography can be challenging not due to natural features, but the built environment—"since not everyone wants to install an antenna on their house, the best spot isn't the one we can usually get." Public awareness and marketing are common issues since it "is difficult to promote awareness of an essentially invisible public resource."

Urban networks more commonly involve the cooperative efforts of more than one organization—and these partnerships, relationships with donating companies, or agreements with private or public entities can add to the challenge of network management. "Signage remains poor and on-site technical assistance is often lacking since we do not own, operate or manage the networks that we build for our partner organizations." The complexities faced by urban networks is summarized well in the following response:

> "Simply keeping the network up and running is probably the most difficult thing. After we set it up, it'll run fine for weeks or months, but then we may hear about an outage from a user – then someone must determine which of the donating companies is responsible for the problem (network, hardware, gateway, web host, etc.), or if its simply user error, or some other problem, then someone needs to manage the fix. This is probably our biggest challenge. As it's strictly a donated free service, we offer no technical support, which can be an issue for some users."

A final generalization about urban networks is that they are no less grassroots-based and community oriented as their rural counterparts. As one urban respondent stated, "Our philosophy is not as much to connect to the internet as much as getting the community to connect to each other. This is a community building effort where the process of developing a CWN is as important as actually getting internet access." While the community that an urban CWN can help build may not be as place-based as a rural CWN, this effort can be an attractive advantage over private providers.

Extensions of research

This research was, in many ways, exploratory in nature—little research has been done on community wireless networks in the United States. These networks have primarily emerged only in the past five years, and even while operating their strategies are still in flux. While this research created new data on network locations and characteristics, there are several other related issues that could be examined in further research. One useful investigation would be surveying individual residents about the local provider competition and service availability. User level data may provide a more accurate, detailed assessment of the degree to which providers and CWNs are in competition in certain areas. It would also be valuable to gather further information about the level of demand in under-serviced areas.

A second suggestion for further research would be to use different aggregate units to make different comparisons of local contexts. The nature of community wireless networks is not naturally attached to any one kind of spatial unit. For example, the location of CWNs could be examined in relation to Designated Market Areas, units based on main media distribution patterns that centralize on major metropolitan areas. Another possibility is to investigate service area information from private providers, and assess CWNs in terms of the distance from these service areas.

Conclusion

In conclusion, there are five main points I would like to make from the discussion above. The first is that CWNs are working. Nearly all respondents, urban and rural, indicated rapid growth of their network. This point alone suggests that these networks are successfully navigating the current challenges of wireless deployment and management, and their strategies to overcome these challenges would prove valuable and applicable to the many municipalities, counties and states that are currently trying to create strategies to address broadband access disparities in their populations.

Secondly, the variety of locations where CWNs are emerging suggests that they may be a possible solution for access problems in many places, not just wealthy or elite communities. The possible link between CWNs and universities does suggest that building a network may still link to certain levels of available human and financial resources, but overall the results of this research did not support the assumption that these networks are only for the technologically or financially elite.

A third point is that all of these networks are making use of unlicensed radio-frequency spectrum. The future of community-based wireless strategies is largely influenced by the decisions made by the FCC regarding the allocation of radio-frequency spectrum for unlicensed or public uses. The services that these networks provide could benefit from funding and additional spectrum allocation at the federal level. In this way this research can be related to the implications of current debates in telecommunication policy.

Fourthly, although CWNs may not be explicitly filling in the 'digital divide,' these networks are playing an important role in spurring competition with private providers in areas where competition may still be relatively low. Their presence makes a statement that there is a demand for broadband in the area, and this may challenge private providers to provide more affordable quality broadband access. Whether or not CWNs will last alongside private providers in the long term is uncertain—but their role in answering local demands and igniting change sends a critical message to the telecommunications industry at large.

Lastly, I wanted to emphasis that out of the thirty-three CWNs that were surveyed, very few had ever collaborated or been in contact with another CWN. Many respondents mentioned how the initial network members took it upon themselves to figure out a way to 'make it work.' Unfortunately, while there are many advantages from grassroots efforts that grow from the local context, these efforts can also remain insular without the awareness of parallel projects in other places. Due to the large amount of shared characteristics and common challenges that were found between networks, I strongly recommend the creation of a type of forum where CWNs can collaborate, exchange ideas and learn from other networks. Commonly there are only one or two people at each network that are in charge of a particular aspect of the network: software or hardware technologies, physical maintenance, volunteer management, membership applications, etc.. By establishing a forum, these individuals could directly connect to their counterparts at other networks, and perhaps address the challenges of their work more in more informed ways. Ironically, the challenges that these isolated networks face on a day-to-day basis directly relate to the hurdles that still face wireless broadband deployment strategies around the world.

World-wide, public interest in wireless platforms is increasing; the economic and political implications of a wider adoption of wireless broadband are immense. There are myriad websites and internet blogs about the global-scale viability of wireless platforms and possibilities of universal wireless service, and in the US, municipal adoption of city-wide, public wireless programs is growing in popularity and feasibility. With so much potential, it is critical to learn the most we can from current experimentation, no matter the scale.

Community wireless networks, while relatively small in size, are live, real-world experiments that suggest solutions to such large issues as the rural digital divide. This research has significant value for present and future developments in wireless broadband access. Unfortunately, the idiosyncrasies and myriad challenges of CWNs do not bode for their easy expansion as promoted and subsidized through national policies such as the Universal Service Fund (USF). With that said, these findings could be useful for any individual rural or urban community seeking improvements in wireless broadband access or public policy-makers who are currently undertaking the major challenge of revising federal and state regulation to accommodate for wireless networks.

By examining the successes and challenges of these networks, a future generation of wireless networks can be better directed, more technologically sound, more efficient, more affordable, and perhaps better suited to provide users with the services they need. It is true, however, that the geography of telecommunications is rapidly transforming and CWNs may only exist as a brief snap-shot of continually evolving wireless possibilities. Yet even if new developments in public broadband service evolve beyond community efforts (perhaps towards municipal or state level services), the valuable lessons learned from these early CWNs will likely be useful for the improvement of forthcoming wireless strategies.

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APPENDIX A
QUESTIONNAIRE

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Marjorie.holmberg@colorado.edu October 2, 2006

Questionnaire for Public and Community Wireless Broadband Networks

Hello, I am writing to you and members of approximately forty other community-based wireless broadband networks across the country as part of my research for my Masters degree in Geography at the University of Colorado, Boulder. I am interested in learning more about the types of locations where the networks are being created especially those outside of major metropolitan areas, the people and organizations that are creating them, and those that the network is intended to serve. There are no foreseeable risks to taking this questionnaire. You also may return the questionnaire only partially completed, although full completion is most useful. There are thirty short questions and it should **only take about fifteen minutes**. I appreciate your participation very much and your answers will be very helpful in developing an up-to-date inventory about in the degree to which different types of wireless networks are affecting nation-wide levels of wireless broadband access. By returning a completed questionnaire you will be giving your consent to participate. You will also have the opportunity to receive the results of this research by simply checking this option at the end of the questionnaire. Thank you very much for your time!

Please type and "X" to the left of your answer, or a number when asked to rank the answers. For any comments, explanations, or open-ended answers, please type these below the question. Feel free to add comments.

1. What is the current status of your network?

___ Proposed, but no concrete plans formulated
___ Being planned
___ Being built/Constructed
___ Operational
___ Other (please describe below)

2. Which best describes the entity that manages your network?

___ Cooperative
___ City government
___ County government
___ Private business
___ Non-profit organization
___ Other: (please describe)

3. Which of the following best describes the type of wireless network in use? (There may be some redundancy in the categories listed, choose the best description of your network.)

___ Wireless local area network (WLAN)
___ A local multi-point distribution service (LMDS)
___ A point-to-point network of 'line of sight' antennas
___ A combination of point-to-point and point-to-multipoint networking
___ Mesh networking (a type of ad-hoc or peer-to-peer networking)
___ One 'hotspot'
___ Two or more 'hotspots'
___ Other (please describe)
___ Not sure

4. What wireless standard are you using?

___ IEEE 802.11 (2.4 GHz; 1, 2 Mbps)
___ IEEE 802.11a (5 GHz; 6, 9, 12, 18, 24, 36, 48, 54 Mbps)
___ IEEE 802.11b (2.4 GHz; 5.5, 11 Mps)
___ IEEE 802.11g (2.4 GHz; 6, 9, 12, 18, 24, 36, 48, 54 Mbps)
___ IEEE 802.11n (expected in 2007; 2.4 GHz; 540 Mps)
___ IEEE 802.16 (WiMAX or WirelessMAN)
___ Other (please describe below)
___ Not sure

5. Please list one or more zip codes that are serviced by your coverage area: List here:

6. Which of the following best describes the approximate coverage area of your network?

___ Small commercial area (1 to 5 square blocks)
___ Large commercial area (6 to 20 square blocks)
___ Small residential area (1 to 5 square blocks)
___ Large residential area (6 to 20 square blocks)
___ Larger area (i.e. city or county-wide, please describe)
___ Other
___ Not sure

7. For whom is the network intended to serve? (Check all that apply.)

___ All local residents
___ Only residents who subscribe/join
___ Local businesses
___ Local government agencies/buildings
___ Other (please describe below)
___ Not Sure

8. Which best describes the primary geographic context of your network?

___ Urbanized Area (within a central city of at least 50,000 or in the densely settled surrounding area with at least 1,000 people per square mile) such as Boston, MA, Austin, TX, Portland, ME, or Boise, ID.

___ Urban Cluster (in a place with a population of at least 2,500 but less than 50,000 or in the densely settled surrounding area with at least 500 people per square mile) such as Laramie, WY, Price, UT or Charlottesville, NC.

___ Rural area (all areas that are not included in Urban Areas or Urban Clusters) that may include small towns such as Ripton, VT and Nederland, CO.

___ None of the above (please describe)

9. In your opinion, do you consider your network to cover a 'rural' area in whole or part? Please rank your coverage area between 1-a wholly urban area, and 5-a wholly rural area:

1___ 2___ 3___ 4___ 5___ Not sure___

10. Please rank the broadband availability in your coverage area without your network:

1___ (None) 2___ 3___ 4___ 5___ (Fully serviced) Not sure___

11. The service you provide is primarily at which speed?

___ Speeds of at least 200 Kbps but less than 1 Mbps.
___ Speeds between 1 Mbps and 11 Mbps.
___ Speeds between 12 Mbps and 60 Mbps.
___ Other or a mixture (please describe)
___ Not sure

12. Please rate the demand for broadband service in your coverage area, 1 being lowest and 5 being highest:

1___(low) 2___ 3___ 4___ 5___(high) Not sure___

13. Does your network currently compete with private providers in your coverage area?

___ Yes
___ No
___ Not sure

14. If yes, are these providers using wireless platforms?

___ Yes
___ No
___ Not sure

15. What is the approximate monthly cost for the broadband internet access service that your network provides?

___ Free
___ $1.00 - 15.00
___ $16.00 - 25.00
___ $26.00 - 35.00
___ $36.00 - 45.00
___ $46.00 - 60.00
___ More than $60.00 a month.
___ Not sure

16. Do you provide service to residences that are in locations not serviced by DSL and cable modem providers?

___ Yes
___ No
___ Not sure

17. Please rate the extent that your coverage area was previously serviced in terms of broadband access:

1___(Poorly serviced) 2___ 3___ 4___ 5___(Very well serviced) Not sure___

18. Approximately how many households or businesses do you currently service?

Households __________ Businesses ____________ Other _______________

19. How do you expect the size of your network will change in the next few years? Use the rating scale below:

1___(shut down) 2___ (decrease) 3___ (stay the same) 4___ (moderately increase)
5___(double in size or more) ___ Not sure

20. Among the challenges you have faced in establishing your network, which FIVE have been the most difficult?
Please add any specific comments on each to the right.

___ Cost of Hardware
___ Maintenance/upkeep of hardware
___ Cost of software
___ Maintenance/upkeep/upgrade of software
___ Public awareness/marketing
___ Increasing Membership

___ Getting Volunteers
___ Management
___ Technical Support for users
___ Governance
___ Local Topography (creating network in hilly area, trees, long distances, etc.)

21. Of these five challenges, which has been the greatest and why?

22. Which best describes the formation of your network: (may check more than one)

___ The work of one individual
___ A handful of individuals (friends, neighbors, informal group of community members)
___ A formal group, association, or non-governmental organization
___ Several community groups working together
___ Local government agencies or officials
___ State or federal government agencies or officials
___ Other (please describe)
___ Not sure

23. Was your network a grassroots effort by local citizens?

___ Yes
___ No
___ Not sure

24. Please give an approximate percentage of the amount of responsibility each of the following groups have in running your network? (Total should be 100%)

___ Volunteers
___ Professional/paid workers
___ Government employees
___ Other: (please describe)
___ Not sure

25. Do you have a waitlist for your service?

___ Yes
___ No
___ Not sure

26. Does your network provide any of the following services in addition to network access? (check all that apply)

___ Community message board
___ Email service
___ Web hosting

___ Local news postings
___ Weather/environmental information
___ Other (please list)

27. Please check any of the following factors that limit the use of your network:

___ Residential location/dispersion
___ Local topography
___ Price of network services
___ Lack of interest
___ Lack of awareness of network
___ Other: (please describe)

28. What year did your network begin (or will begin) its service?

29. Please describe your title or role for this network:

30. Would you be willing to be contacted for a brief follow-up interview over the phone?
___ Yes
___ No

If yes, what number is best for contacting you? _________________

If you have any comments or thoughts that the questions did not seem to address, please include those comments here in the space below:

Please enter an "X" here _____ if you would like the results of this research and please write the email address you which it to be sent to here: _______________________.

Thank you very much for your time. Your input is greatly appreciated and will add to our growing knowledge of recent trends in public and community-based broadband networks. If you have any questions or concerns, please call Molly Holmberg at 801-599-7072 or email at Marjorie.holmberg@colorado.edu.