Climate Change Impacts in the United States

CHAPTER 14
RURAL COMMUNITIES

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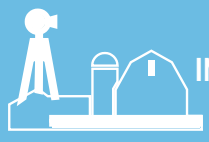
Recommended Citation for Chapter

Hales, D., W. Hohenstein, M. D. Bidwell, C. Landry, D. McGranahan, J. Molnar, L. W. Morton, M. Vasquez, and J. Jadin, 2014: Ch. 14: Rural Communities. *Climate Change Impacts in the United States: The Third National Climate Assessment*, J. M. Melillo, Terese (T.C.) Richmond, and G. W. Yohe, Eds., U.S. Global Change Research Program, 333-349. doi:10.7930/J01Z429C.

On the Web: http://nca2014.globalchange.gov/report/sectors/rural-communities



INFORMATION DRAWN FROM THIS CHAPTER IS INCLUDED IN THE HIGHLIGHTS REPORT AND IS IDENTIFIED BY THIS ICON

14 RURAL COMMUNITIES

Key Messages

1. **Rural communities are highly dependent upon natural resources for their livelihoods and social structures. Climate change related impacts are currently affecting rural communities. These impacts will progressively increase over this century and will shift the locations where rural economic activities (like agriculture, forestry, and recreation) can thrive.**

2. **Rural communities face particular geographic and demographic obstacles in responding to and preparing for climate change risks. In particular, physical isolation, limited economic diversity, and higher poverty rates, combined with an aging population, increase the vulnerability of rural communities. Systems of fundamental importance to rural populations are already stressed by remoteness and limited access.**

3. **Responding to additional challenges from climate change impacts will require significant adaptation within rural transportation and infrastructure systems, as well as health and emergency response systems. Governments in rural communities have limited institutional capacity to respond to, plan for, and anticipate climate change impacts.**

More than 95% of U.S. land area is classified as rural, but is home to just 19% of the population (see also Ch. 13: Land Use & Land Cover Change).[1] Rural America's importance to the country's economic and social well-being is disproportionate to its population, as rural areas provide natural resources that much of the rest of the United States depends on for food, energy, water, forests, recreation, national character, and quality of life.[2] Rural economic foundations and community cohesion are intricately linked to these natural systems, which are inherently vulnerable to climate change. Urban areas that depend on goods and services from rural areas will also be affected by climate change driven impacts across the countryside.

Warming trends, climate volatility, extreme weather events, and environmental change are already affecting the economies and cultures of rural areas. Many rural communities face considerable risk to their infrastructure, livelihoods, and quality of life from observed and projected climate shifts (Ch. 12: Indigenous Peoples). These changes will progressively increase volatility in food commodity markets, shift the ranges of plant and animal species, and, depending on the region, increase water scarcity, exacerbate flooding and coastal erosion, and increase the intensity and frequency of wildfires across the rural landscape.

Climate changes will severely challenge many rural communities, shifting locations where particular economic activities are capable of thriving. Changes in the timing of seasons, temperatures, and precipitation will alter where commodities, value-added crops, and recreational activities are best suited. Because many rural communities are less diverse than urban areas in their economic activities, changes in the viability of one traditional economic sector will place disproportionate stresses on community stability.

Climate change impacts will not be uniform or consistent across rural areas, and some communities may benefit from climate change. In the short term, the U.S. agricultural system is expected to be fairly resilient to climate change due to the system's flexibility to engage in adaptive behaviors such as expansion of irrigated acreage, regional shifts in acreage for specific crops, crop rotations, changes to management decisions (such as choice and timing of inputs and cultivation practices), and altered trade patterns compensating for yield changes (Ch.

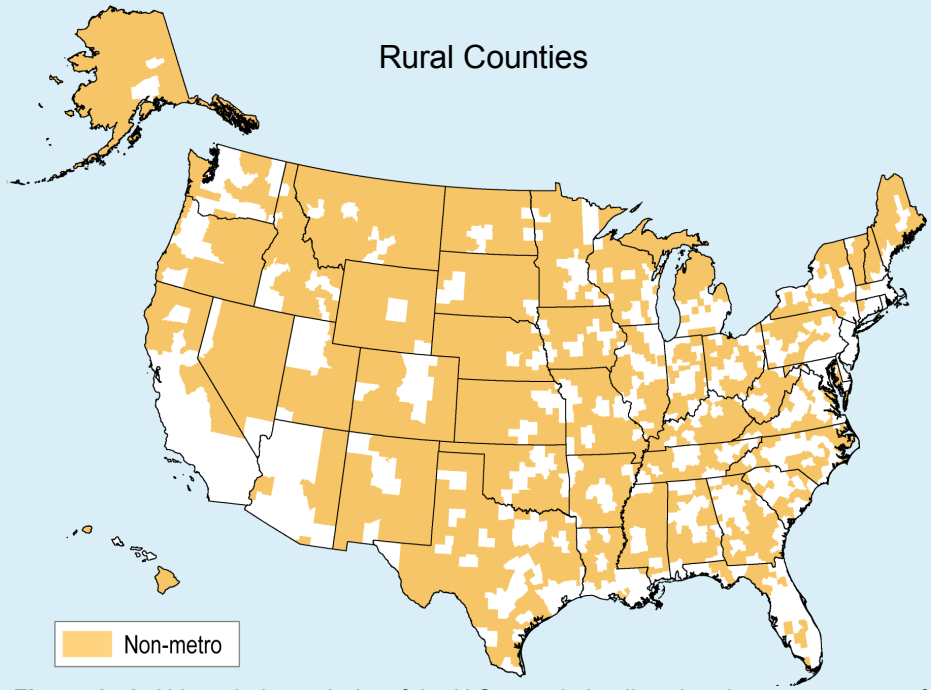


Figure 14.1. Although the majority of the U.S. population lives in urban areas, most of the country is still classified as rural. In this map, counties are classified as rural if they do not include any cities with populations of 50,000 or more. (Figure source: USDA Economic Research Service 2013[3]).

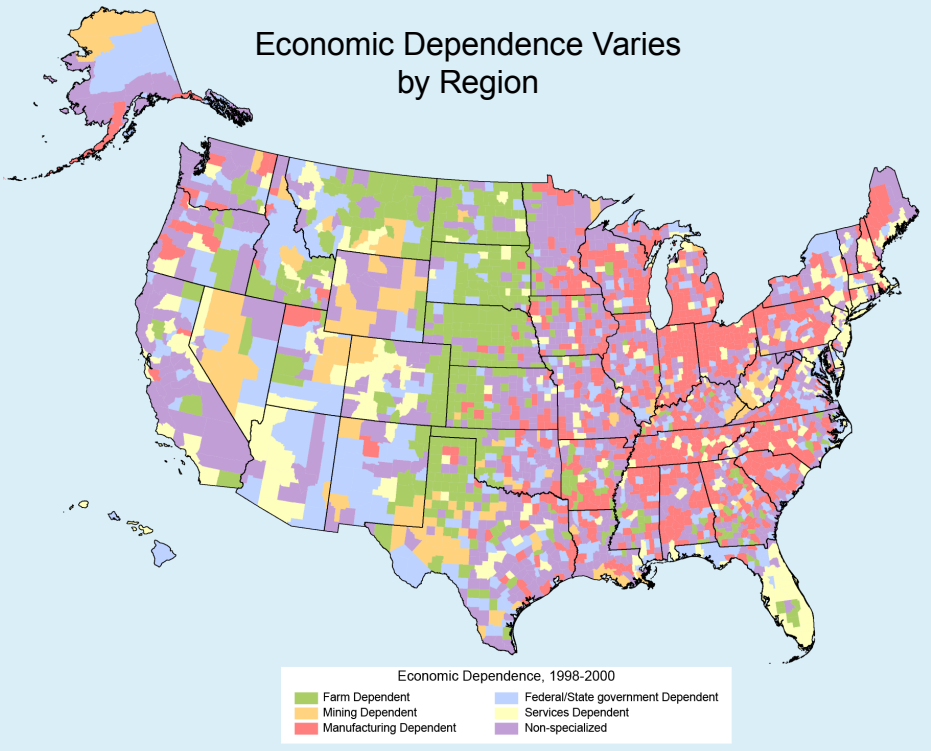


Figure 14.2. Much of the rural United States depends on agriculture, mining, and manufacturing. Climate changes will affect each region and each economic sector in complex and interrelated ways. The economic dependence classification used in the map indicates the largest share of earnings and employment in each county. (Figure source: USDA Economic Research Service 2013[3]).

6: Agriculture; Key Message 5).[4] Recreation, tourism, and leisure activities in some regions will benefit from shifts in temperature and precipitation.

Negative impacts from projected climate changes, however, will ripple throughout rural America. Agricultural systems in some areas may need to undergo more transformative changes to keep pace with future climate change (Ch. 6: Agriculture, Key Message 5). In lakes and riparian areas, warming is projected to increase the growth of algae and invasive species, particularly in areas already facing water quality impairments.[5] Mountain species and cold water fish, such as salmon, are expected to face decreasing range sizes due to warming, while ranges could expand for some warm water fish, such as bass.[6] Alaska, with its reliance on commercial and subsistence fishing catch, is particularly vulnerable. Warmer weather and higher water temperatures will reduce salmon harvests, creating hardships for the rural communities and tribes that depend upon these catches (Ch. 12: Indigenous Peoples, Key Message 1).[7] Communities in Guam and American Samoa, which depend on fish for 25% to 69% of their protein, are expected to be particularly hard hit as climate change alters the composition of coral reef ecosystems.[8]

Across the United States, rural areas provide ecosystem services – like carbon absorption in forests, water filtration in wetlands, wildlife habitat in prairies, and environmental flows in rivers and streams – whose value tends to be overlooked. Preserving these ecosystem services sustains the quality of life in rural communities and also benefits those who come to rural communities for second homes, tourism, and other amenities. They also provide urban residents with vital resources – like food, energy, and fresh water – that meet essential needs. This layered connection between rural areas and populous urban centers suggests that maintaining the health of rural areas is a national, and not simply a local, concern.

Key Message 1: Rural Economies

Rural communities are highly dependent upon natural resources for their livelihoods and social structures. Climate change related impacts are currently affecting rural communities. These impacts will progressively increase over this century and will shift the locations where rural economic activities (like agriculture, forestry, and recreation) can thrive.

Rural America has already experienced some of the impacts of climate change related weather effects, including crop and livestock loss from severe drought and flooding,[9] infrastructure damage to levees and roads from extreme storms,[10] shifts in planting and harvesting times in farming communities,[11] and large-scale losses from fires and other weather-related disasters.[12] These impacts have profound effects, often significantly affecting the health and well-being of rural residents as well as their communities, and are amplified by the essential economic link that many of these communities have to their natural resource base.

River flood waters illustrate threats rural areas face in a changing climate.

Rural communities are often characterized by their natural resources and associated economic activity. Dominant economic drivers include agriculture, forestry, mining, energy, outdoor recreation, and tourism. In addition, many rural areas with pleasant climates and appealing landscapes are increasingly reliant on second-home owners and retirees for their tax base and community activities.

Nationally, fewer than 7% of rural workers are directly employed in agriculture, but the nation's two million farms occupy more than 40% of U.S. land mass – and many rural

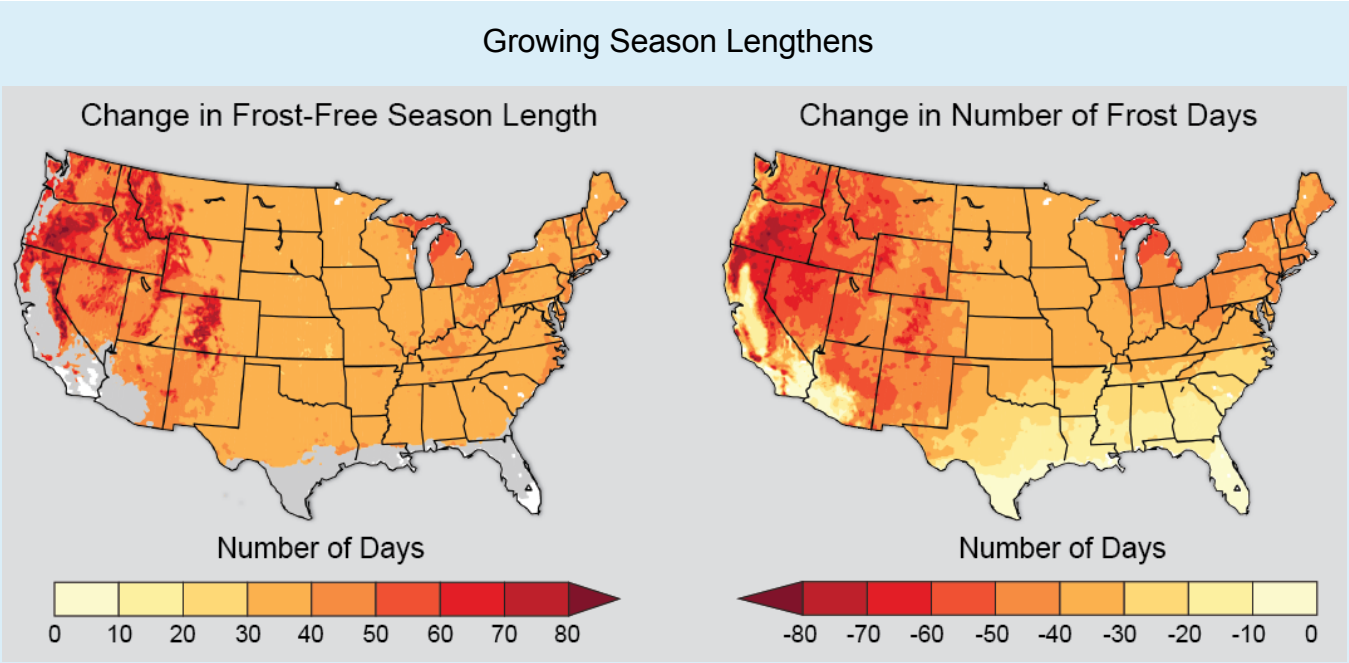


Figure 14.3. The left map shows that if emissions continue to increase (A2 scenario), the U.S. growing season (or frost-free season) will lengthen by as much as 30 to 80 days by the end of the century (2070-2099 as compared to 1971-2000). The right map shows a reduction in the number of frost days (days with minimum temperatures below freezing) by 20 to 80 days in much of the United States in the same time period. While changes in the growing season may have positive effects for some crops, reductions in the number of frost days can result in early bud-bursts or blooms, consequently damaging some perennial crops grown in the United States (See also Ch. 6: Agriculture). White areas are projected to experience no freezes for 2070-2099, and gray areas are projected to experience more than 10 freeze-free years during the same period. (Figure source: NOAA NCDC / CICS-NC).

communities rely extensively on farming and ranching (Ch. 6 Agriculture; Ch. 13 Land Use & Land Cover Change).[13] Farmers are responding to climate change by shifting cropping patterns and altering the timing of planting and harvesting. This may result in additional use of herbicides and pesticides with the accompanying human exposure to additional health risks.[14] Changes in rainfall, temperature, and extreme weather events will increase the risk of poor yields and reduced crop profitability. For example, the increased frequency and intensity of heavy downpours will accelerate soil erosion rates, increasing deposition of nitrogen and phosphorous into water bodies and diminishing water quality.[15]

Many areas will face increasing competition for water among household, industrial, agricultural, and urban users (Ch. 3: Water).[16] Reduced surface water will place more stress on surface water systems as well as groundwater systems (Ch. 3: Water; Key Message 4). In-stream flow requirements for the maintenance of environmental resources are an equally important water demand. While irrigated cropland is an important and growing component of the farm economy,[17] water withdrawals necessary for generating electricity in thermal power plants are already roughly equal to irrigation withdrawals.[18] As climate change increases water scarcity in some regions, there will be increased competition for water between energy production and agriculture.[19] Mining also requires large quantities of water, and scarcity resulting from drought associated with climate change may affect operations. Changes in seasonality and intensity of precipitation will increase costs of runoff containment. Climate change impacts on forestry have important implications for timber and forest-amenity-based rural communities. Shifting forest range and composition, as well as increased attacks from pests and diseases, will have negative effects on biodiversity and will increase wildfire risks (Ch. 7: Forests).[8,20] Shifts in the distribution and abundance of many economically important tree species would affect the pulp and wood industry. As ranges shift and the distribution of plant species in forests changes, the range of other forest-dependent animal species will also change, causing additional economic and sociocultural impacts.

Tourism contributes significantly to rural economies. Changes in the length and timing of seasons, temperature, precipitation, and severe weather events can have a direct impact on tourism and recreation activities by influencing visitation patterns and tourism-related economic activity.

Climate change impacts on tourism and recreation will vary significantly by region. For instance, some of Florida's top tourist attractions, including the Everglades and Florida Keys, are threatened by sea level rise,[21] with estimated revenue losses of $9 billion by 2025 and $40 billion by the 2050s. The effects of climate change on the tourism industry will not be exclusively negative. In Maine, coastal tourism could increase due to warmer summer months, with more people visiting the state's beaches.[22] Employing a Tourism Climatic Index (Figure 14.4) that accounts for temperature, precipitation, sunshine, and wind, one study finds that conditions conducive for outdoor recreation will be shifting northward with climate change, though it is unclear whether absolute conditions or relative weather conditions will be more important in influencing future tourist behaviors.[23]

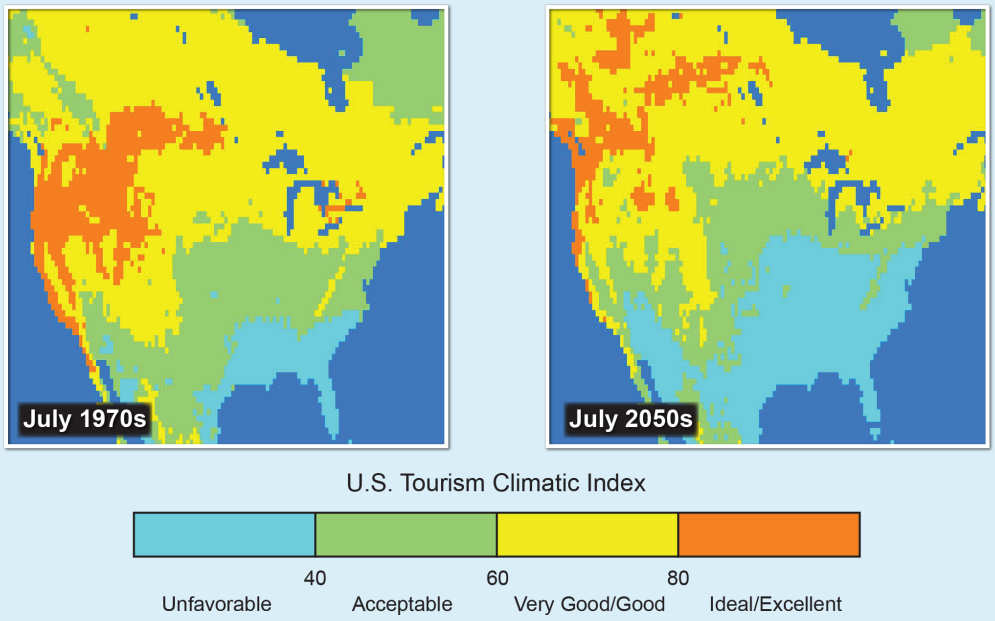


Figure 14.4. Tourism is often climate-dependent as well as seasonally dependent. Increasing heat and humidity – projected for summers in the Midwest, Southeast, and parts of the Southwest by mid-century (compared to the period 1961-1990) – is likely to create unfavorable conditions for summertime outdoor recreation and tourism activity. The figures illustrate projected changes in climatic attractiveness (based on maximum daily temperature and minimum daily relative humidity, average daily temperature and relative humidity, precipitation, sunshine, and wind speed) in July for much of North America. In the coming century, the distribution of these conditions is projected to shift from acceptable to unfavorable across most of the southern Midwest and a portion of the Southeast, and from very good or good to acceptable conditions in northern portions of the Midwest, under a high emissions scenario (A2a). (Figure source: Nicholls et al. 2005[24]).

Climate change will also influence the distribution and composition of plants and animals across the United States. Hunting, fishing, bird watching, and other wildlife-related activities will be affected as habitats shift and relationships among species change.[25] Cold-weather recreation and tourism will be adversely affected by climate change. Snow accumulation in the western United States has decreased, and is expected to continue to decrease, as a result of observed and projected warming. Reduced snow accumulation also reduces the amount of spring snowmelt, decreasing warm-season runoff in mid- to high-latitude regions.

Similar changes to snowpack are expected in the Northeast.[26] Adverse impacts on winter sports are projected to be more pronounced in the Northeast and Southwest regions of the United States.[8] Coastal areas will be adversely affected by sea level rise and increased severity of storms.[22,27] Changing environmental conditions, such as wetland loss and beach erosion in coastal areas[28] and increased risk of natural hazards such as wildfire, flash flooding, storm surge, river flooding, drought, and extremely high temperatures can alter the character and attraction of rural areas as tourist destinations.

The implications of climate change on communities that are dependent on resource extraction (coal, oil, natural gas, and mining) have not been well studied. Attributes of economic development in these communities, such as cyclical growth, transient workforce, rapid development, pressure on infrastructure, and lack of economic diversification suggest that these communities could face challenges in adapting to climate change.[13,29,30]

Key Message 2: Responding to Risks

Rural communities face particular geographic and demographic obstacles in responding to and preparing for climate change risks. In particular, physical isolation, limited economic diversity, and higher poverty rates, combined with an aging population, increase the vulnerability of rural communities. Systems of fundamental importance to rural populations are already stressed by remoteness and limited access.

Relatively rapid changes in demographics, economic activity, and climate are particularly challenging in rural communities, where local, agrarian values often run generations deep. Changing rural demographics, influenced by new immigration patterns, fluctuating economic conditions, and evolving community values add to these challenges – especially with regard to climate changes.

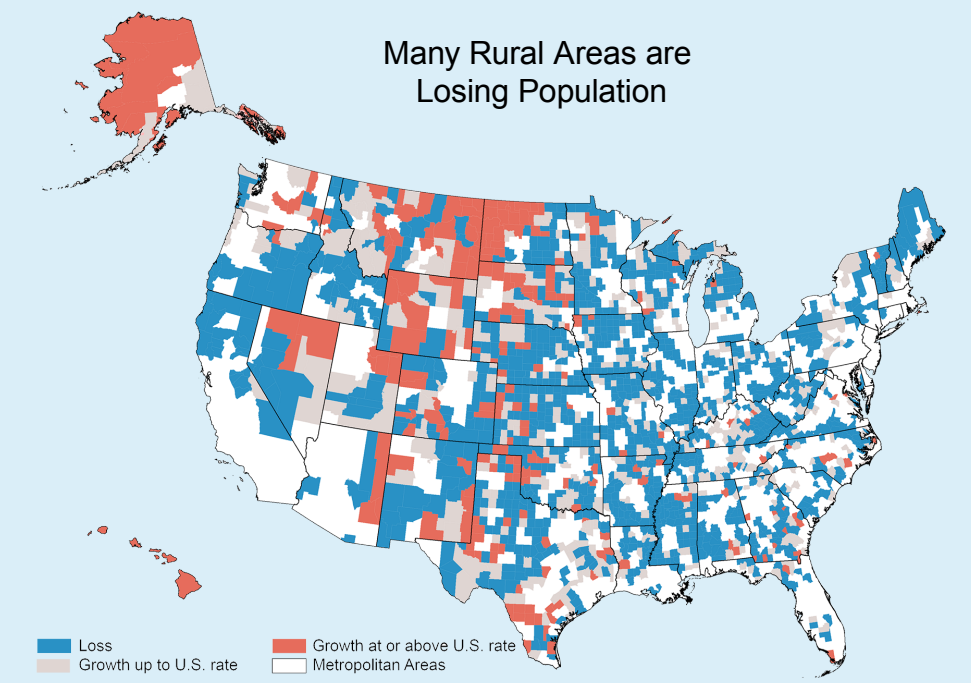


Figure 14.5. Census data show significant population decreases in many rural areas, notably in the Great Plains. Many rural communities' existing vulnerabilities to climate change, including physical isolation, reduced services like health care, and an aging population, are projected to increase as population decreases. (Figure source: USDA Economic Research Service 2013[3]).

Modern rural populations are generally older, less affluent, and less educated than their urban counterparts. Rural areas are characterized by higher unemployment, more dependence on government transfer payments, less diversified economies, and fewer social and economic resources needed for resilience in the face of major changes.[8,31] In particular, the combination of an aging population and poverty increases the vulnerability of rural communities to climate fluctuations.

There has been a trend away from manufacturing, resource extraction, and farming to amenity-based economic activity in many rural areas of the United States.[32] Expanding amenity-based economic activities in rural areas include recreation and leisure, e-commuting residents, tourism, and second home and retirement home development. This shift has stressed traditional cultural values[33] and put pressure on infrastructure[34] and natu-

ral amenities[35] that draw people to rural areas. Changes in climate and weather are likely to increase these stresses. Rural components of transportation systems are particularly vulnerable to risks from flooding and sea level rise.[36] Since rural areas often have fewer transportation options and fewer infrastructure redundancies, any disruptions in road, rail, or air transport will deeply affect rural communities.

Power and communication outages resulting from extreme events often take longer to repair in rural areas, contributing to the isolation and vulnerability of elderly residents who may not have cell phones. The lack of cellular coverage in some rural areas can create problems for emergency response during power failures.[37]

In some parts of the country there has been a recent trend in Hispanic population growth in rural regions that have not been traditional migrant destinations. New Hispanic immigrants are often highly segregated residentially and isolated from mainstream institutions,[38] making them more vulnerable to changes in climate. Low wages, unstable work, language barriers, and inadequate housing are critical obstacles to managing climate risk.

Rural communities rely on various transportation modes, both for export and import of critical goods (Ch. 5: Transportation). Climate changes will result in increased erosion and maintenance costs for local road and rail systems, as well as changes in streamflows and predictability that will result in increased maintenance costs for waterways. More frequent disruption of shipping is projected, with serious economic consequences. For example, in 2010, about 40 million tons of cereal grains were shipped by water to Louisiana, while less than 4 million tons traveled by rail.[10] While rail can help ameliorate small-scale or off-peak capacity limitations on the Mississippi River, it seems unlikely that the rail system can fully replace the river system in the event of a prolonged harvest-time disruption. Events that affect both rail and barge traffic would be particularly damaging to rural communities that depend upon these systems to get commodities to market.

Health and emergency response systems also face additional demands from substantial direct and indirect health risks associated with global climate changes. Indirect risks, particularly those posed by emerging and reemerging infectious diseases, are more difficult to assess, but pose looming threats to economically challenged communities where health services are limited. Direct threats (such as extreme heat, storm events, and coastal and riparian flooding) tend to be more associated with specific local vulnerabilities, so the risks are somewhat easier to assess.[39]

The socioeconomic and demographic characteristics of rural areas interact with climate change to create health concerns that differ from those of urban and suburban communities. Older populations with lower income and educational levels in rural areas spend a larger proportion of their income on health care than their urban counterparts. Moreover, health care access declines as geographic isolation increases. Overall, rural residents already have higher rates of age-adjusted mortality, disability, and chronic disease than do urban populations.[40] These trends are likely to be exacerbated by climate change (Ch. 9: Human Health).

Governments in rural areas are generally ill-prepared to respond quickly and effectively to large-scale events, although individuals and voluntary associations often show significant resilience. Health risks are exacerbated by limitations in the health service systems characteristic of rural areas, including the distance between rural residents and health care providers and the reduced availability of medical specialists.

The effects of climate change on mental health merit special consideration. Rural residents are already at a heightened risk from mental health issues because of the lack of access to mental health providers. The adverse impact of severe weather disasters on mental health is well established,[41] and there is emerging evidence that climate change in the form of increasing heat waves and droughts has harmful effects on mental health (Ch. 9: Human Health, Key Message 1). Droughts often result in people relocating to seek other employment, causing a loss of home and social networks. Studies have shown that springtime droughts in rural areas cause a decrease in life satisfaction.[42] The primary care physicians who form the backbone of rural health care often have heavy caseloads and lack specialized training in mental health issues.[40] Additionally, patients referred to mental health specialists often experience significant delays.[43]

The frequency and distribution of infectious diseases is also projected to increase with rising temperatures and associated seasonal shifts. Increased rates of mutation and increased resistance to drugs and other treatments are already evident in the behavior of infectious disease-causing bacteria and viruses.[44] In addition, changes in temperature, surface water, humidity, and precipitation affect the distribution and abundance of disease-carriers and intermediate hosts, and result in larger distributions for many parasites and diseases. Rural residents who spend significant time outdoors have an increased risk of exposure to these disease-carriers, like ticks and mosquitoes (Ch. 9: Human Health).

Key Message 3: Adaptation

Responding to additional challenges from climate change impacts will require significant adaptation within rural transportation and infrastructure systems, as well as health and emergency response systems. Governments in rural communities have limited institutional capacity to respond to, plan for, and anticipate climate change impacts.

Climate variability and increases in temperature, extreme events (such as storms, floods, heat waves, and droughts), and sea level rise are expected to have widespread impacts on the provision of services from state, regional, local, and tribal governments. Emergency management, energy use and distribution systems, transportation and infrastructure planning, and public health will all be affected.

Rural governments often depend heavily on volunteers to meet community challenges like fire protection or flood response. In addition, rural communities have limited locally available financial resources to help deal with the effects of climate change. Small community size tends to make services expensive or available only by traveling some distance.

Local governance structures tend to de-emphasize planning capacity, compared to urban areas. While 73% of metropolitan counties have land-use planners, only 29% of rural counties not adjacent to a metropolitan county had one or more planners. Moreover, rural communities are not equipped to deal with major infrastructure expenses.[45]

Communities across the United States are experiencing infrastructure losses, water scarcity, unpredictable water availability, and increased frequency and intensity of wildfires. However, local authorities often do not explicitly associate these observed changes with climate, and responses rarely take climate disruption into account. Even in communities where there is increasing awareness of climate change and interest in comprehensive adaptation planning, lack of funding, human resources, access to information, training, and expertise provide significant barriers for many rural communities.[46]

If rural communities are to respond adequately to future climate changes, they will likely need help assessing their risks and vulnerabilities, prioritizing and coordinating projects, funding and allocating financial and human resources, and deploying information-sharing and decision support tools (Ch. 26: Decision Support). There is still little systematic research on the vulnerability of rural communities and there is a need for additional empirical research in this area. Impacts due to climate change will cross community and regional lines, making solutions dependent upon meaningful participation of numerous stakeholders from federal, state, local, and tribal governments, science and academia, the private sector, non-profit organizations, and the general public (Ch. 28: Adaptation, Key Message 3).

Effective adaptation measures are closely tied to specific local conditions and needs and take into account existing social networks.[47,48] The economic and social diversity of rural communities affects the ability of both individuals and communities to adapt to climate changes, and underscores the need to assess climate change impacts on a local basis. The quality and availability of natural resources, legacies of past use, and changing industrial needs affect the economic, environmental, and social conditions of rural places and are critical factors to be assessed.[13,30,49] Successful adaptation to climate change requires balancing immediate needs with long-term development goals, as well as development of local-level capacities to deal with climate change.[48,50]

Potential national climate change mitigation responses (Ch. 27: Mitigation) – especially those that require extensive use of land, such as permanent reforestation, constructing large solar or wind arrays, hydroelectric generation, and biofuel cropping – are also likely to significantly affect rural communities, with both positive and negative effects.[51] As with the development of rural resource-intensive economic activities, where national or multi-national companies tend to wield ownership and control, local residents and communities are unlikely to be the primary investors in or beneficiaries of this kind of new economic activity. For example, mitigation policies that affect coal production could have a substantial economic impact on many rural communities, as could policies to promote production of non-fossil-fuel energy such as wind.

Decisions regarding adaptation responses for both urban and rural populations can occur at various scales (federal, state, local, tribal, private sector, and individual) but need to take interdependencies into account. Many decisions that significantly affect rural communities may not be under the control of local governments or rural residents. Given that timing is a critical aspect of adaptation, as well as mitigation, engaging rural residents early in decision processes about investments in public infrastructure, protection of shorelines, changes in insurance provision, or new management initiatives can influence individual behavior and choice in ways that enhance positive outcomes of adaptation and mitigation.

Local Responses to Climate Change in the San Juan Mountains

The San Juan Mountains region straddles the southern edge of the Southern Rocky Mountains and the northeastern tip of the arid Southwest. The high mountain headwaters of the Rio Grande, San Juan, and major tributaries of the Upper Colorado River are critical water towers for five states: Texas, Nevada, California, Arizona, and New Mexico. The diversity of the landforms, high plateaus, steep mountains, deep canyons, and foothills leads to a complex and diverse mix of coniferous and deciduous forested landscapes.[52] County populations in the area range from 700 to 51,000 people. Population changes between 2000 and 2010 ranged from a 25% decline to an 86% increase. Public lands account for 69% of the land base.[53] Over half of the local economies are dependent upon natural resources to support tourism, minerals and natural gas extraction, and second home development.

Average annual temperatures in the San Juan Mountains have risen 1.1°F in only three decades,[54] a rate of warming greater than any other region of the United States except Alaska.[55] The timing of snowmelt has shifted two weeks earlier between 1978 and 2007, and this earlier seasonal release of water resources is of particular concern to all western states.[56] Current challenges for the region include changes in forests due to pests and diseases, intensive recreation use, fire management for natural and prescribed fires, and increasing development in the wildland-urban interface. Communities are vulnerable to changes from a warmer and drier climate that would affect the frequency and intensity of wildfires, shift vegetation and range of forest types, and increase pressures on water supplies.

In response, the San Juan Climate Initiative drew together stakeholders, including natural resource managers, community planners, elected officials, industry representatives, resource users, citizens, non-profit organizations, and scientists. By combining resources and capabilities, stakeholders have been able to accomplish much more together than if they had worked independently. For example, local governments developed a plan to reduce greenhouse gas emissions and identify strategies for adaptation, signing the U.S. Mayor's Climate Protection Agreement in 2009. Climate modelers at University of Colorado and National Center for Atmospheric Research analyzed regional trends in temperature, precipitation, snowpack, and streamflow. Researchers at Mountain Studies Institute, University of Colorado, and Fort Lewis College are partnering with San Juan National Forest to monitor alpine plant communities and changes in climate across the region, and to document carbon resources. San Juan National Forest is developing strategies for adapting to climate changes in the region related to drought, wildfire, and other potential effects. La Plata County is leading an effort to plan for sustainable transportation and food networks that will be less dependent upon carbon-based fuels, while the Mountain Studies Institute is leading citizen science programs to monitor changes to sensitive species like the American pika.

Hiker in the San Juan mountains, Colorado.

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SUPPLEMENTAL MATERIAL
TRACEABLE ACCOUNTS

Process for Developing Key Message:
The key messages were initially developed at a meeting of the authors in Charleston, South Carolina, in February 2012. This initial discussion was supported by a series of conference calls from March through June, 2012. These ensuing discussions were held after a thorough review of the technical inputs and associated literature, including the Rural Communities Workshop Report prepared for the NCA[57] and additional technical inputs on a variety of topics.

Key message #1 Traceable Account

Rural communities are highly dependent upon natural resources for their livelihoods and social structures. Climate change related impacts are currently affecting rural communities. These impacts will progressively increase over this century and will shift the locations where rural economic activities (like agriculture, forestry, and recreation) can thrive.

Description of evidence base
The key message and supporting text summarizes extensive evidence documented in the Rural Communities Workshop Report.[57] Thirty one technical input reports on a wide range of topics were also received and reviewed as part of the Federal Register Notice solicitation for public input.

Evidence that the impacts of climate change are increasing is compelling and widespread. This evidence is based on historical records and observations and on global climate models, including those driven by B1 (substantial emissions reduction) and A2 (continued increases in global emissions) scenarios. This evidence is clearly summarized and persuasively referenced in the "Our Changing Climate" chapter of this Assessment and in the Scenarios developed for the NCA.[58]

The dependency of rural communities on their natural resources has been demonstrated,[13] with a number of studies showing that climate change results in crop and livestock loss,[9] infrastructure damage to levees and roads,[10] shifts in agriculture practices,[11] and losses due to disasters.[12] A number of publications project these impacts to increase, with effects on the natural environment[8,15,20] and increased competition for water between agriculture and energy.[19] Studies have projected that tourism locations in the Everglades and Florida Keys are threatened.[21] Meanwhile, Maine's tourism could increase,[22] which coincides with a projected northern shift in outdoor recreation.[23] Hunting, fishing, and bird watching will be affected by beach erosion and wetland loss,[28] and changing plant and animal habitats and inter-species relationships (see also Ch. 8: Ecosystems). Outdoor recreation and tourism in many areas in the U.S. are affected by early snowpack melt.[8,26]

New information and remaining uncertainties
Key remaining uncertainties relate to the precise magnitude, timing, and location of impacts at regional and local scales.

Assessment of confidence based on evidence
(See confidence level key on next page)

Given the evidence and uncertainties, there is **very high** confidence that rural communities are highly dependent on natural resources that are expected to be affected by climate change, especially the many communities that rely on farming, forestry or tourism for their livelihoods.

Given the evidence and uncertainties, there is **high** confidence that climate change is currently affecting rural communities.

Given the evidence and uncertainties, there is **very high** confidence that impacts will increase (see Ch 2: Our Changing Climate).

Given the evidence and uncertainties, there is **high** confidence about shifts in locations of economic activities.

Key message #2 Traceable Account

Rural communities face particular geographic and demographic obstacles in responding to and preparing for climate change risks. In particular, physical isolation, limited economic diversity, and higher poverty rates, combined with an aging population, increase the vulnerability of rural communities. Systems of fundamental importance to rural populations are already stressed by remoteness and limited access.

Description of evidence base

The key message and supporting text summarizes extensive evidence documented in the Rural Communities Workshop Report.[57] Thirty one technical input reports on a wide range of topics were also received and reviewed as part of the Federal Register Notice solicitation for public input.

With studies showing that rural communities are already stressed,[33,34,35] a number of publications have explored the barriers of rural communities to preparing and responding to climate change.[8,31] Some studies provide in-depth looks at the obstacles created by limited economic diversity[32] and an aging population.[40]

New information and remaining uncertainties

Projecting the interactions of these variables with each other and applying this analysis to local or regional realities is complex at best, with uncertainties at every level of analysis.

Assessment of confidence based on evidence

Given the evidence and uncertainties, there is **high** confidence that the obstacle of physical isolation will hamper some communities' ability to adapt or have an adequate response during extreme events.

Given the evidence and uncertainties, there is **high** confidence that the obstacle of limited economic diversity will hinder rural communities' ability to adapt.

Confidence Level
Very High
Strong evidence (established theory, multiple sources, consistent results, well documented and accepted methods, etc.), high consensus
High
Moderate evidence (several sources, some consistency, methods vary and/or documentation limited, etc.), medium consensus
Medium
Suggestive evidence (a few sources, limited consistency, models incomplete, methods emerging, etc.), competing schools of thought
Low
Inconclusive evidence (limited sources, extrapolations, inconsistent findings, poor documentation and/or methods not tested, etc.), disagreement or lack of opinions among experts

Given the evidence and uncertainties, there is **high** confidence that the obstacle of higher poverty rates will significantly increase vulnerability of many communities from adapting properly.

Given the evidence and uncertainties, there is **high** confidence that the obstacle of an aging population will hinder some rural communities and prevent them from having an adequate response.

Given the evidence and uncertainties, there is **high** confidence that fundamental systems in rural communities are already stressed by remoteness and limited access.

Key message #3 Traceable Account

Responding to additional challenges from climate change impacts will require significant adaptation within rural transportation and infrastructure systems, as well as health and emergency response systems. Governments in rural communities have limited institutional capacity to respond to, plan for, and anticipate climate change impacts.

Description of evidence base

The key message and supporting text summarize extensive evidence documented in the Rural Communities Workshop Report.[57] Thirty one technical input reports on a wide range of topics were also received and reviewed as part of the Federal Register Notice solicitation for public input.

Rural communities are not equipped to deal with major infrastructure expenses.[45] Work has been performed illustrating the need to tie adaptation measures to specific local conditions and needs and take into account existing social networks.[47,48] Publications have shown that there are a number of critical factors to be assessed, including the quality and availability of natural resources, legacies of past use of resources, and changing industrial needs that affect economic, environmental, and social conditions.[13,30,49] Additionally, studies have expressed the requirement of accounting for both near- and long-term needs for climate change adaptation to be successful.[50]

New information and remaining uncertainties

It is difficult to fully capture the complex interactions of the entire socioeconomic-ecological system within which the effects of climate change will interact, especially in regard to local and regional impacts. Impact assessments and adaptation strategies require improved understanding of capacity and resilience at every level, international to local. The policy context in which individuals and communities will react to climate effects is vague and uncertain. Identification of informational needs alone indicates that adaptation will be expensive.

Assessment of confidence based on evidence

Given the evidence and uncertainties, there is **high** confidence that rural communities have limited capacity to respond to im-

pacts, because of their remoteness, age, lack of diversity, and other reasons described in the text.

Given the evidence and uncertainties, there is **high** confidence that rural communities have limited capacity to plan for impacts, as explained in the text.

Given the evidence and uncertainties, there is **high** confidence that rural communities will have limited capacity to anticipate impacts because of the lack of infrastructure and expertise available in rural communities.

Given the evidence and uncertainties, there is **high** confidence that significant climate change adaptation is needed for transportation in rural communities.

Given the evidence and uncertainties, there is **high** confidence that significant climate change adaptation is needed for health care and emergency response in rural communities, so that rural communities can handle climate change impacts.