

Natural Amenities and Rural Population Migration

A Technical Document Supporting
the Forest Service 2010 RPA Assessment

H. Ken Cordell, Vahé Heboyan,
Florence Santos, and John C. Bergstrom



The Authors:

Ken Cordell is a Pioneering Research Scientist, U.S. Department of Agriculture, Forest Service, Southern Research Station, Athens, GA 30602; **Vahé Heboyan** is a Research Associate and Lecturer, Department of Agricultural and Applied Economics, The University of Georgia, Athens, GA 30602; **Florence Santos** is a Research and Evaluation Specialist, Rural Development Institute, Seattle, WA, and a former Graduate Research Assistant, The University of Georgia, Athens, GA 30602; **John Bergstrom** is Russell Professor of Public Policy and Professor of Department of Agricultural and Applied Economics, The University of Georgia, Athens, GA 30602

Product Disclaimer

The use of trade or firm names in this publication is for reader information and does not imply endorsement by the U.S. Department of Agriculture of any product or service.

December 2011

Southern Research Station
200 W. T. Weaver Blvd.
Asheville, NC 28804

**Natural Amenities and Rural
Population Migration:
A Technical Document Supporting
the Forest Service 2010 RPA Assessment**

H. Ken Cordell, Vahé Heboyan, Florence Santos, and John C. Bergstrom

Contents

Summary	1
Introduction	1
Review of Amenity Migration Concepts and Previous Studies	2
Estimation of the Influence of Natural Amenities on Population Migration	5
Forecasting the Effects of Changes in Natural Amenities on Rural Population Migration Patterns	8
Summary and Implications	11
Literature Cited	13
Endnotes	14
Appendix tables	
Appendix table A.1—Regional and sectoral impacts of climate change in the United States.	15
Appendix table A.2—Data description and sources for rural amenity migration model, 1990-2007.	16
Appendix table A.3—Summary statistics for rural amenity migration model variables	18
Appendix table A.4—Estimated explanatory variable coefficients for rural amenity migration model	19
Appendix figures	
Appendix figure A.1—Forecasted effect of natural amenities on rural population change, 2007–2010	20
Appendix figure A.2—Forecasted effect of natural amenities on rural population change, 2007–2015	20
Appendix figure A.3—Forecasted effect of natural amenities on rural population change, 2007–2020	21
Appendix figure A.4—Forecasted effect of natural amenities on rural population change, 2007–2030	21
Appendix figure A.5—Forecasted effect of natural amenities on rural population change, 2007–2040	22
Appendix figure A.6—Forecasted effect of natural amenities on rural population change, 2007–2050	22
Appendix figure A.7—Forecasted effect of natural amenities on rural population change, 2007–2060	23

Natural Amenities and Rural Population Migration: A Technical Document Supporting the Forest Service 2001 RPA Assessment

H. Ken Cordell, Vahé Heboyan, Florence Santos, and John C. Bergstrom

Abstract

Research suggests that significant relationships exist between rural population change and natural amenities. Thus, understanding and predicting domestic migration trends as a function of changes in natural amenities is important for effective regional growth and development policies and strategies. In this study, we first estimated an econometric model which showed the effects of natural amenities, such as climate and landscape variables, on rural population migration patterns in the United States between 1990 and 2007. The estimated model was then used to predict the effects of changes in these variables on rural county net migration and population growth to 2060 under alternative future climate and land use projections. Results suggest that people prefer rural areas with mild winters and cooler summers; thus we can expect a direct impact of climate change on population migration when areas associated with these conditions change. Results also suggest preference for varied landscapes that feature a mix of forest land and open space (e.g., pasture and range land). During the projection period from 2010 to 2060 in the United States, changes in natural amenities were predicted to have positive effects on rural population migration trends in most parts of the Intermountain and Pacific Northwest regions, and some parts of the Southeastern, South Central, and Northeastern U.S. regions (e.g., Southern Appalachian Mountains, Ozark Mountains, northern New England). Changes in natural amenities were predicted to have negative effects on rural population migration trends during the projection period in Midwestern regions (e.g., Great Plains and North Central regions).

Keywords: Amenity migration, climate change, landscapes, natural amenities, rural population change.

Summary

Previous studies have suggested that significant relationships exist between rural population growth and the presence of natural amenities. Thus, understanding and predicting domestic migration trends as a function of changes in natural amenities is important for effective regional growth and development policies and strategies. It is especially important to understand and predict the effects of weather-related natural amenity variables which may undergo major variations in the future due to global climate change.

In the study discussed in this report, we first estimated an econometric model which showed the effects of natural amenities, such as landscape and weather, on rural population migration patterns in the United States between 1990 and

2007. This model was estimated for 2,014 rural counties in the continental United States using various national data bases and sources. The estimated model was then used to predict the effects of changes in these variables on rural county net migration and population growth to 2060 under alternative future climate and land use projections.

Results suggest that people prefer rural areas with mild winters and cooler summers; thus, we can expect a direct impact of climate change on population migration when areas associated with these conditions change. For example, we may observe a shift in population migration patterns from hot and humid areas in the Southern United States to originally colder Northern United States regions as temperatures in these regions become warmer (especially in the winter months). While changes in migration patterns attributed to climate change are beyond the control of local policymakers, regions that are most likely to suffer climate-change induced population loss should be prepared with mitigating policies. Our results also suggest preference for varied landscapes that feature a mix of forest land and open space (e.g., pasture and range land). Local policymakers in areas endowed with such landscapes should keep this in mind when formulating zoning laws and rural development plans.

During the projection period from 2010 to 2060 in the United States, changes in natural amenities were predicted to have positive effects on rural population migration trends in most parts of the Inter-mountain and Pacific Northwest regions, and some parts of the Southeastern, South Central, and Northeastern U.S. regions (e.g., Southern Appalachian Mountains, Ozark Mountains, northern New England). Changes in natural amenities were predicted to have negative effects on rural population migration trends during the projection period in Midwestern regions (e.g., Great Plains and North Central regions).

Introduction

With a recent history of a highly mobile population and decreasing birth rates in the United States, domestic migration has long been established as a significant cause of demographic change across the country and an important

source of concurrent changes in regional economic growth. Accurately understanding and predicting domestic migration trends is therefore important for effective regional growth and development policies and strategies. Many factors influence domestic migration trends, including job opportunities, family ties, access to good schools and health care, and the presence of natural amenities (Green 2001, McGranahan 1999).

This report focuses on the relationships between natural amenities and domestic population migration trends. Its primary goal is to examine the effects of natural amenities on recent county-level rural population migration trends in the United States. The specific objectives of this study were to: (1) review amenity migration concepts and previous studies; (2) use recent annual climate, land use, and other natural amenities data, along with recent county-level annual economic and U.S. Census migration data, to estimate the effects of different natural amenities on rural population migration in the United States; and (3) forecast the effects of changes in natural amenities on county-level rural net migration and population growth from 2010 to 2060 while holding non-amenity factors constant.

The remainder of this report is structured as follows. The next section provides a background review of amenity migration concepts and previous studies. Next, the report discusses the empirical model used to estimate the effects of natural amenities on rural population migration, describes the data used to estimate the models, outlines the estimation methodology, and discusses empirical results. Next, the report discusses the forecasted effects of changes in natural amenities on rural population migration trends during the projection period from 2010 to 2060. The report concludes with a summary and discussion of policy implications.

Review of Amenity Migration Concepts and Previous Studies

Defining Natural Amenities and Amenity Migration

The National Geographic Society (2005) defines human migration as the movement of people from one place in the world to another for the purpose of taking up permanent or semi-permanent residence, usually across jurisdictional boundaries. Domestic migration (also called internal migration) is defined as movement of people within a country. International migration is defined as movement of people across country borders (Perry 2006). According to the International Organization for Migration (2004), no universally accepted definition of a migrant exists. It usually refers to the people who freely decide to migrate for reasons of “personal convenience.”

A natural amenity can be defined in many different ways.¹ For example, Power (1988) defined an amenity to be a quality of a region that makes it an attractive area in which to live and work. McGranahan (1999) takes this definition further by stating that an amenity is “an attribute that enhances a location as a place of residence” and that “natural amenities pertain to the physical rather than social or economic environment and are meant to exclude much of what is man-made, such as historical buildings or casinos (p. 1).” Although other amenity definitions exist in the literature (Stewart 2000), a majority of studies have opted to use the McGranahan (1999) definition, including Rasker and Hansen (2000) and Vias and Carruthers (2005).

So why are many Americans attracted to amenity-rich areas? The most widely cited reason is that they value the higher quality of life that natural amenities offer; yet this is not the only reason. In a broad sense, reasons that people are migrating to amenity-rich areas include changes in retirement norms, technological advancements, and recreation and tourism experiences (Stewart 2000).

Natural amenities contribute to human well-being in a number of ways. For example, a beach, which is considered a natural amenity, provides sunbathing as a recreation-related amenity service. A beach can also drive household and business location decisions since being located in an amenity-rich area may provide some people with happiness or utility. There are other forms of amenity services as well, all of which hold value. For example, people may hold positive value for a whitewater rafting trip or a mountain view from their home (Dissart and Dellar 2000, English and Bowker 1996, Knapp and Graves 1989, McKean and others 2005, Peterson and others 1988, Song and Knapp 2003).

Many amenity-rich communities have become dependent on marketing their amenity services to potential visitors, residents, and businesses. In some cases, communities have done a complete reversal regarding their economic development strategy, switching from historically resource-extractive sectors to retail- and service-based sectors (Green 2001).

Measuring Natural Amenities

In acknowledging that natural amenities play a role in where some individuals decide to live, McGranahan (1999) created an amenity scale (hereafter referred to as McGranahan’s natural amenity scale) which measures the relative appeal of a county in terms of its enduring physical characteristics. The scale consists of six key measures, including the average number of days of sun in January, moderate January (winter) temperatures, low average humidity in July, moderate July (summer) temperatures, topography, and water area. This

scale is a popular natural amenity index and has been used in several recent studies (Henderson and McDaniel 2005; Vias and Carruthers 2005). McGranahan (2008) extended his measures of natural amenities to include landscape features such as land use.

Typically, natural amenities are measured at the county level as data are often collected and reported at this level. County-level data are also likely to be less error prone compared to smaller areas such as census tracts or neighborhoods. It is common for amenities to vary in quality and quantity within a county, such as in the Western United States where counties can be quite large and encompass a wide variety of ecosystems (Clark and Murphy 1996; Rasker and Hansen 2000).

Impacts of Climate Change on Natural Amenities

Climate measures (such as precipitation, snow cover, temperature) are not only important factors for recreation development at a county and/or regional level, but also determine the quantity and quality of other natural amenities. For example, biodiversity, species endemism, water resources, and forests are all supported and determined by climate, and disturbances in climate can lead not only to decreased recreation and migration, but also decreased well-being of the communities that rely on it (Dale and others 2000, Gonzalez-Abraham and others 2007, Rosenberger 2007, Varis and others 2004). Thus, in a study of amenity migration, it is relevant and important to review the possible impacts of global climate change on ecosystems and natural resources.

Since the 18th century, increased concentrations of atmospheric greenhouse gases have already contributed to increased global temperatures and precipitation. Climate change projections suggest that concentrations of greenhouse gases will continue to rise at higher rates, which may result in increasing global mean temperatures by approximately 2-3 °C (3.6-5.4 °F) by 2100 (Smith 2004).

The Pew Center on Global Climate Change recently released a synthesis report of potential climate change impacts on the United States. This report concluded that U.S. biodiversity is likely to suffer from climate change due to the limited ability of plants and animals to adapt to predicted changes. Managed sectors such as agriculture and forestry may be better able to adapt to certain climate changes, and thus may be able to limit possible negative effects of these changes. However, such adaptation will not be perfect or cost-free (Smith 2004). Global climate change may significantly alter ecosystems including increased loss of coastal wetlands, disappearing coral reefs, alpine forest species likely migrating to higher altitudes, and perhaps complete extinction of other plants

and animals. The impact of global climate change on U.S. ecosystems and biodiversity may be especially severe because past ecosystem interventions for development purposes (e.g., roads, dams, subdivisions) have already significantly altered ecosystems, such as introducing barriers to species migration that will likely get worse as climate change progresses (Smith 2004).

The overall impact of climate change is also expected to vary across major regions in the United States shown in figure 1. Smith (2004) suggests that the southern regions are more vulnerable to adverse climate change effects as compared to northern regions. Warmer and dryer conditions may significantly alter agriculture and forestry production capacities in the Southern United States as well as the availability of water for aquatic ecosystems. In contrast, in the northern regions, global climate change may benefit agricultural and forestry activities and reduce energy costs (e.g., lower winter heating bills). However, these positive gains are likely to be reversed if temperatures keep rising. Coastal areas in the Southern and Northern United States may be adversely affected by rising sea levels including increased flooding risks, beach erosion, and property damage. Appendix table A.1 provides an overview of regional climate change impacts in the United States as synthesized by Smith (2004). These impacts are summarized below.

In the Northeastern region (outlined in fig. 1), agriculture and forestry production in general is projected to increase with an exception of certain species that may disappear (e.g., maple trees). The recreational industry in the northeastern region, which is highly dependent upon winter sports, may see relatively large negative impacts from warmer global and U.S. temperatures. Coastal communities in this region may greatly suffer from rising sea-levels (e.g., communities dependent on the highly productive estuaries of the Chesapeake Bay).

Similar to the Northeastern region, the relatively cooler Midwestern region may benefit in some ways from a warmer climate (e.g., warmer temperatures may favor some types of agriculture). However, warmer temperatures will most probably decrease Great Lakes water-levels and biodiversity (e.g., reduction of cold water fish species).

The Southeastern region of the United States is more vulnerable to the changing climate and warming temperatures. For example, the heavily developed coastal areas in this region may experience serious ecosystem damage due to sea-level rise resulting in negative socio-economic impacts such as loss of jobs and housing displacement. Increasing temperatures may also flood coastal wetlands reducing biodiversity in the region's estuaries, decrease water supply due to drought and increased evaporation, and cause

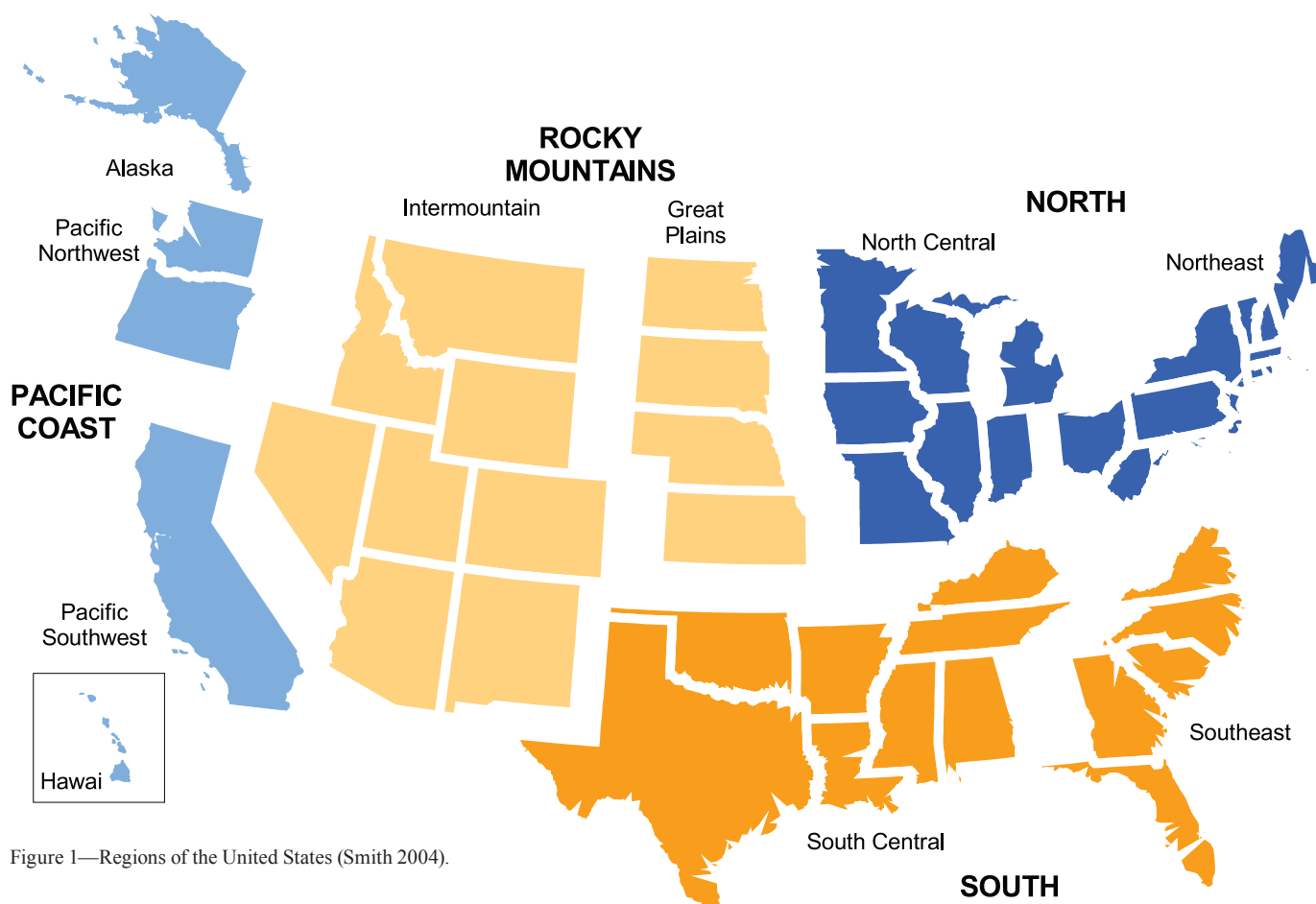


Figure 1—Regions of the United States (Smith 2004).

declines in agricultural and forestry production. The Southern Great Plains region may experience similar changes due to a warming climate, however at a lower rate as compared to the southeastern region.

The Southwestern region of the United States may experience extreme water supply changes. Early snowmelt will cause winter flooding and summer scarcity, thus resulting in serious damages to agricultural production and winter sports-based industries. Biodiversity is also expected to be reduced due to manmade structures that will obstruct movement of water and land species as the climate becomes warmer.

The Northwestern region of the United States may be least impacted by climate change. Rising sea-level will most likely impact the highly developed Puget Sound area leaving other coastal areas unaffected. Agricultural production may generally benefit from a warmer climate, while forestry may benefit some. While vegetation productivity is expected to increase, biodiversity is likely to decline, especially the valuable salmon runs that may be at risk due to warmer temperatures and changing runoff patterns resulting from sea-level rise.

The effects of predicted global change on regional ecosystems and economies discussed above may translate into noticeable population migration changes at regional, county, and community levels. For example, global climate change may result in migrations of people from one U.S. region to another as people follow changes in employment patterns (e.g., relocation of agriculture and forestry jobs) and/or seek different natural amenities (e.g., more moderate temperatures). These changing migration patterns may create serious challenges for local planners and policymakers as their community either loses or gains population. Being able to foresee how migration trends may be impacted by changes in natural amenities and other factors would help local planners and policymakers better prepare for the future.

Rural Population and Natural Amenities

Rural areas during the 1990s experienced a 10.3 percent population growth compared to only 2.7 percent during the 1980s, and the 2000s appear to show similar trends. From 2000 to 2004, the majority of large metropolitan areas were found

to have a net loss in domestic migration according to the U.S. Census Bureau. Numerous studies have empirically addressed different factors influencing migration trends, emphasizing not only economic and employment determinants, but also natural amenities such as climate, topography, and water area as major drivers of population migration. Research suggests that amenity-rich regions and counties have attracted migrants at disproportionately high rates (Johnson and Beale 1998; Johnson and Fuguitt 2000; McGranahan 1999, 2008; Rudzitis 1999; Shumway and Davis 1996).

Results of surveys of new residents and businesses in the Western United States show that people moving to counties with high levels of natural amenities identify nonmarket commodities such as scenery, environmental quality, pace of life, outdoor recreation, and climate to be more important reasons for relocation than job opportunities or cost of living (Johnson and Rasker 1995, Rudzitis 1999). Population growth in rural counties in Idaho, Montana, and Wyoming was found to be influenced by topography, climate, the presence of protected areas, land use/cover, and access to larger population centers and markets (Rasker and Hansen 2000). Several economists suggest that a high-quality environment is the greatest economic asset in the Western United States. (Power 1998, Rasker 1993). Overall, these studies cite mountainous or coastal scenery, access to outdoor recreation, proximity to open space and wilderness, and moderate climate as important drivers for people migrating to the Western United States from other parts of the country.

Natural amenities have also been found to have significant effects on population growth in the Southeastern United States, partly compensating for lower wages in this region (Nzaku and Bukenya 2005). For example, Cromartie (2001) found that migration to rural areas in the Southeastern United States has been influenced by people's attraction to its warm climates and access to water-based recreation. Also contributing to this migration is access to relatively abundant and affordable land for commercial, industrial, and residential development.

McGranahan (1999) found that some of his amenity measures, such as temperate summer and topographic variation, were highly correlated with rural population change. During the period 1970-96, rural counties which were low on the natural amenities index experienced a 1 percent population gain on average, whereas over half of these counties experienced a net population loss. Meanwhile, counties scoring high on the index experienced a gain of about 120 percent on average over a 25-year period (McGranahan 1999). Results from a national survey cited proximity to wilderness to be associated with rapid population growth (Rudzitis and Johansen 1991). Other

studies observed that population growth between 1990 and 2000 in recreational counties² with high levels of natural amenities was 2.5 times higher than the normal population growth rate for rural counties (English and others 2000, Johnson and Beale 1998, 2003).

In McGranahan's (2008) rural migration model, which draws its theoretical foundations from the landscape literature, landscapes composed of various land use/cover are argued to be important drivers of rural population migration. His results show that broad landscape features, such as forest cover, have positive effects on rural population growth. For a more thorough review of literature on amenity-driven migration, refer to Hill and others (2009).

Estimation of the Influence of Natural Amenities on Population Migration

Empirical Model Specification and Estimation

Following previous studies, in this study population net migration is modeled as a function of natural amenity variables such as different climate variables, water area, proximity to a coastline, land use/cover, and Federal protected land (McGranahan 1999, 2008). Our empirical amenity migration model, which follows the general amenity migration theory discussed in Santos (2010), uses a panel data model to estimate the effects of natural amenities on county-level migration trends in the United States between 1990 and 2007, while controlling for population density, employment, and income factors.³

The use of a panel data model⁴ helps to control for a potentially large number of unobserved explanatory variables, thus reducing bias and ensuring more accurate model estimation. In contrast to most previous studies that were only able to control for broad regional differences or differences across States, our panel data model controlled for all unobserved characteristics that vary across counties, but not across time (e.g., people's propensity to migrate which are related to local cultural factors).

The general form of our amenity migration panel data model was:

$$Y_{it} = \alpha_0 + X_{it}\beta + Z_i\eta + c_i + \varepsilon_{it} \quad (1)$$

where

Y_{it} = the population migration variable
 $i = 1, 2, \dots, N$ are the counties
 $t = 1, 2, \dots, T$ are the years
 X_{it} = the time-varying explanatory variables
 Z_i = the time-invariant explanatory variables
 β and η = parameters for the time-varying and

time-invariant explanatory variables, respectively
 ε_{it} = the error term
 c_i = the unobserved/individual effect that captures all unmeasured characteristics that vary between individuals (in our case, counties) but not over time.

For empirical estimation, equation (1) was specified as:

$$RInternalMig = \alpha_0 + \beta_1 pcemp_{it} + \beta_2 meansmmr_{it-1} + \beta_3 ppt_{it-1} + \beta_4 pcrop_{it-1} + \beta_5 pcrop^2_{it-1} + \beta_6 lnpcy_{it-1} + \eta_1 meanwintr_{it-1} + \eta_2 pforest_{it-1} + \eta_3 pforest^2_{it-1} + \eta_4 ppasture_{it-1} + \eta_5 ppasture^2_{it-1} + \eta_6 prange_{it-1} + \eta_7 prange^2_{it-1} + \eta_8 lnpcfd100_i + \eta_9 lnpcfd100^2_i + \eta_{10} percmount_i + \eta_{11} coast_i + \eta_{12} snowmed_i + \eta_{13} pwetland_i + \eta_{14} lnpd_{it-1} + \eta_{15} lnpd^2_{it-1} + \eta_{16} TER_i + c_i + \varepsilon_{it} \quad (2)$$

The left-hand side (dependent) variable and right-hand side (independent) variables in the equation (2) are defined in Appendix table A.2. Following Plümper and Troeger (2007), equation (2) was estimated using the Fixed Effects Vector Decomposition (FEVD) econometric estimation method. FEVD was used because it provides a technique for examining the effects of time invariant and rarely changing variables,⁵ which are the variables of most interest in this study. A detailed description of the approach and estimation process is provided in Santos (2010).

Data Description

Equation (2) was estimated using annual data for 2,014 rural counties in the entire continental United States for the 18-year study period, 1990-2007. These data were drawn from several sources (Appendix table A.2). The dependent variable, domestic net migration rate per county from 1990 to 2007, was obtained from the U.S. Census Bureau. Domestic net migration for a given county is defined as the difference between domestic in-migration and out-migration during a specified time frame. The rate of domestic net migration, as reported by the U.S. Census Bureau, is calculated by dividing total net domestic migration by the average population living in that area over the same time period and multiplying the resulting figure by 1,000.

Variables reflecting job-related factors in the model included average annual per capita real income and percent change in employment computed from the Bureau of Economic Analysis Regional Economic Information System (BEA REIS). Climate variables included annual historic average summer temperature, average winter temperature, and mean monthly precipitation per year compiled by the Forest Service, U.S. Department of Agriculture (Coulson and Joyce 2010) and the average annual days of snow (≥ 1 inch)

compiled from the National Climate Data Center (NCDC). Following McGranahan (2008), we also tested for the influence of different landscape variables, including forest, rangeland, cropland, and pasture land.

In the model, per capita Federal designated land was specified within a 100-mile radius of a county. Generating this variable involves two stages. First, we summed the acres of all the Federal designated land⁶ found within the 100-mile radius of each county (centroid-to-centroid⁷). Second, we divided these sums over the annual population estimate from the U.S. Census Bureau for each county in each year. Water area, presence of mountains, and an indicator of coastal areas were also among the natural amenities variables included in the model.

Lastly, secondary data on population density and property tax expenditure ratios were acquired from the U.S. Census Bureau. Appendix table A.3 provides summary statistics for each variable, specifying the means, standard deviations, and minimum and maximum values. All of the time varying explanatory variables are lagged 1 year to avoid simultaneity with the dependent variable.

Empirical Results

Preliminary analysis of the summary statistics (Appendix table A.3) for the explanatory variables used in this study showed that some time-varying natural amenities variables such as forest, pasture, range land, per capita Federal designated land, winter temperature, and population density are changing over time, but very slowly. Thus, following the suggestion in Plümper and Troeger (2007), we considered these variables as “almost time invariant” (for a more detailed discussion and explanation, see Santos 2010).

The coefficient estimates and corresponding statistics for the empirical amenity migration model equation (2) are presented in Appendix table A.4. Based on these results, table 1 presents the effects of natural amenity variables on rural net migration rates.

From a temporal perspective, our results indicate that as percent change in employment (pcemp) increases over time, rural net migration increases as well, as expected. From a cross-section perspective, our results also suggest that counties with more employment opportunities experience more positive net migration, also as expected. The per capita real income (lnpcy) is statistically significant and negative, which seems counter-intuitive. However, since no cost of living adjustments were made across counties, the negative sign may be a reflection of less migration to rural areas with high costs of living as reflected by high per capita real income.

Table 1—Average effects of natural amenities on rural population net migration^a

Variable	Coefficient estimate	Explanation
pcrop	-0.2296	1 percent increase in cropland will cause rural population to decrease by 230.
meansummr	-0.2989	1° C increase in average summer temperature will cause rural population to decrease by 299.
ppt	-0.0024	1 mm increase in average monthly precipitation per year will cause rural population to decrease by 2.
lnpwater	0.6029	1 percent increase in percent water area will cause rural population to increase by 603.
percmount	0.0249	1 percent increase in mountainous area will cause rural population to increase by 25.
Coast	1.3188	Coastal counties (compared to non-coastal counties) will in average experience an increase in rural population by 1,319.
pwetland	-0.0173	1 percent increase in wetland area will cause rural population to decrease by 17.
lnpcfd100	0.3596	1 unit increase in per capita Federal designated land area will cause rural population to increase by 360.
snowmed	0.0591	1 unit increase in average annual number of days with snowfall ≥ 1 inch will cause rural population to increase by 59.
meanwinr	0.1104	1 degree (Celsius) increase in average winter temperature will cause rural population to increase by 110.
prange	0.0668	1 percent increase in range land will cause rural population to increase by 67.
pforest	0.2152	1 percent increase in forestland will cause rural population to increase by 215.
ppasture	0.1479	1 percent increase in pasture land will cause rural population to increase by 148.

^a Net migration rate is measured per 1,000 population

The climate variables (meanwintr, meansummr, ppt, except snowmed) are also statistically significant with signs consistent with conceptual expectations. Our results generally suggest preference for cooler summers and warmer winters. Coastal areas attract more domestic migrants as indicated by the estimated positive coefficient on the variable (coast). Multiple rural migration studies have cited counties adjacent to a coastline as attracting in-migrants. Hoehn and others (1987) found that households give up \$468 per year to live in a county adjacent to a coastline, showing the value people associate with living near this amenity. Similarly, the more mountainous (percmount) a rural county is, the more attractive it is to amenity migrants.

Rural counties with a relatively high percentage of water (lnpwater) also attract more migrants, indicating that people's decision to move is directly influenced by their preference to live close to areas where they can enjoy aesthetically pleasing water views and water-based recreational activities such as fishing, water skiing, recreational boating. The findings with respect to the effects of natural amenity variables on domestic migration discussed in the above paragraphs are generally

consistent with several previous studies (e.g., Deller and others 2001; McGranahan 1999, 2008; Mueser and Graves 1995). ⁸

The forestland (pforest), range land (prange), and pasture land (ppasture) variables all have a positive coefficient on the first term, and a negative coefficient on the squared term indicating that people prefer more of these types of landscapes, but only up to a certain point (e.g., the positive effect diminishes with continued increases in each landscape type). On the other hand, the first term of the cropland (pcrop) variable is negative and its squared term is positive. These results described in this paragraph are generally consistent with McGranahan (2008).

Our results suggest that per capita Federal lands (lnpcfd100) positively affect rural migration, which is consistent with Rudzitis and Johansen's (1991) findings from a survey in the Western United States where 53 percent of respondents expressed that the presence of designated wilderness was an important motivation for them to relocate or stay in a county. Other migration and regional development studies also observed the same general result (e.g., Duffy-Deno 1998, Lewis and others 2002).

The wetlands (pwetland) variable coefficient is negative and statistically significant, perhaps indicating that the presence of wetlands hinders in-migration into a county. This negative effect could be due to the presence of wetlands limiting the amount of developable land in a county (which could also drive up property values). The negative coefficient may also be indicative of negative amenities associated with living near wetlands (e.g., mosquitoes).

Population density (lnpd) has a positive coefficient on the first term and a negative coefficient on the squared term which is similar to McGranahan's (2008) result. The literature on landscape preferences suggests preference for fewer rather than more built structures, which explains the negative coefficient of the squared term, ln²pd. However services are usually sparse in very thinly populated areas, thus some (but not too much) settlement is preferred.

Since counties in the Western United States are relatively larger in land area compared to counties found in the Eastern United States, we also specified a model including a Western/Eastern United States dummy variable which specifies whether a county is located east or west of the Mississippi river.⁹ Our objective was to see how robust our model coefficient estimates were to the geographies of the Western United States vs. the Eastern United States. (e.g., relative county size). In the model, this dummy should have roughly accounted for the large differences in county size between Eastern vs. Western United States counties. As a result of adding this dummy variable and re-estimating the model, the coefficient signs remained mostly the same with the magnitude of only a few variables changing slightly, thus indicating robustness of the results.

Forecasting the Effects of Changes in Natural Amenities on Rural Population Migration Patterns

Climate Change Projections

For the 2010 Renewable Resources Planning Act (RPA) Assessment, the Forest Service developed a number of county-level climate change projections (Coulson and others 2010), which were based on general circulation models driven by greenhouse gas emission scenarios documented in the Special Report on Emissions Scenarios (SRES) of the Intergovernmental Panel on Climate Change (IPCC) as a global context/link to the RPA national analyses (Coulson and others 2010, Intergovernmental Panel on Climate Change 2007, Nakicenovic and Swart 2000). For the analysis of future changes in amenities on rural county migration reported in the section, we used climate projections based

on the CGCM 3.1, CSIRO 3.5, and MIROC 3.2 general circulation models and the A1B scenario.

All three general circulation models project a warming future global climate. The MIROC 3.2 model predicts the relatively warmest future climate and the CSIRO 3.5 model predicts the relatively coolest future climate (but still warmer than the present). The CGCM 3.1 model predicts moderate warming in between the MIROC 3.2 and CSIRO 3.5 models.¹⁰

The A1B scenario assumes a growing world population that peaks in the mid-century and a global economy supported by introduction of new and more efficient technologies. This scenario emphasizes balanced technological growth, which does not rely too heavily on one particular energy source (Coulson and others 2010, Intergovernmental Panel on Climate Change 2007, Nakicenovic and Swart 2000).

Rural Population Forecasts for RPA Future Climate Change Projections

Coefficient estimates from the empirical amenity migration model discussed earlier (see pages 5 and 6) were used to forecast effects of changes in natural amenities on rural population net migration for the three climate projections discussed above. In order to focus on and synthesize the effects of natural amenities on future net migration, we computed future amenity migration effects holding non-amenity factors (pcemp, lnpcy, ln²pd, ter) from equation (2) constant at the 2007 baseline level.

We forecasted population migration rates for each of the three climate projections discussed above for the years 2010, 2015, 2020, 2030, 2040, 2050, and 2060. This process involved several steps. First, the rate of net migration (RInternalMig) for each scenario and projection year was computed from forecasted natural amenity explanatory variables in the estimated model equation (2) while holding non-amenity variables in equation (2) constant including the population and income variables.

Forecasted changes in natural amenity variables were based on two sources. First, changes in the climate variables (meanwintr, meansummr, ppt) over time and over different global climate change assumptions were based on climate change projections provided by Coulson and others (2010). Second, changes in landscape variables (pforest, prange, ppasture, pcrop) were based on land use change projections provided by Wear (2011).

We state above that when forecasting changes in net migration, we hold non-amenity variables including population and income variables constant. This statement

may be somewhat misleading since the Coulson and others (2010) climate change forecasts and the Wear (2011) land use change forecasts account for projected future changes in income and population at the county level as estimated by Zarnoch and others (2010). Thus, although the population and income variables in equation (2) are held constant, changes in population and income at the county-level have indirect effects on our amenity migration projections through the effects of changes in these variables on the forecasts of changes in the climate and land use variables in equation (2).

Second, the percent change (PChange) in the forecasted net migration rate was calculated as:

$$PChange_t = \frac{RInternalMig_{t-1} - RInternalMig_{t-1}}{RInternalMig_{t-1}} \times 100\%$$

where $t = 2010, 2015, 2020, 2030, 2040, 2050, \text{ and } 2060$.

Third, the forecasted rate of net migration (FRIM) was calculated as:

$$FRIM_t = PChange_t \times RIM_{2007} + RIM_{2007} \quad (3)$$

where RIM_{2007} = the 2007 baseline rate of domestic net migration from the U.S. Census.

In the fourth step, the forecasted population (FPOP) for rural counties was calculated as:

$$FPOP_t = \frac{FRIM_t \times PopEst_{2007}}{1,000} + PopEst_{2007} \quad (4)$$

where $PopEst_{2007}$ = the baseline U.S. Census population estimate for 2007.

In the final step, future population percentage change was calculated using the formula:

$$\Delta POP_t = \frac{FPOP_t - PopEst_{2007}}{PopEst_{2007}} \times 100\% \quad (5)$$

Following the above steps, we projected the effects of changes in natural amenities under the three Forest Service future climate change projections previously discussed. The results showed little variation between these three climate change projections. Thus, for ease of exposition, we report and discuss below the results only for the moderate Coulson and others (2010) climate change projections based on the CGCM 3.1 general circulation model with the A1B socio-economic variable assumptions, and the Wear (2011) land use projections based on the A1B socio-economic variable assumptions.

Figure 2 displays the projected gradual impact of changing natural amenities on county-level rural migration during 2010, 2030, and 2060 as compared to the 2007 U.S. Census baseline under the moderate climate change projections. Individual illustrations of these effects for each projection period outlined above are provided in Appendix figures A.1 to A.7. In figure 2 and Appendix figures A.1 to A.7, the “moderate-high” positive effect is defined when the rural net migration equals or exceeds 2 percent and the “low-moderate” positive effect is defined when net migration is between 0 and 2 percent. Similarly, the “moderate-high” negative effect is defined when the rural net migration equals or exceeds -2 percent and the “low-moderate” negative effect is defined when net migration is between 0 and -2 percent.

With respect to RPA regions (fig. 1), projected effects of changes in natural amenities on rural population migration trends indicates significant positive population changes for most parts of the Inter-mountain and Pacific Northwest regions, the Southern Appalachian parts of the Southeast region, and some parts of the South Central (e.g., Ozark Mountains), and Northeast regions (e.g., northern New England). As the global climate becomes warmer, the natural amenities (e.g., more moderate temperatures) in these areas will make them more desirable to new residents (e.g., retirees and people with transportable jobs) and new businesses seeking to locate in pleasant environments for their owners and employees, say as compared to areas of the country that already have relatively hot climates (e.g., lower and hotter elevations in the southeastern and southwestern regions). Although one may think that warming global temperatures would make the Great Plains and North Central regions more attractive to amenity migrants since these areas are relatively cooler, our results suggest this is not the case. These results are probably due to the relative lack of other natural amenities in these regions which are valued by amenity migrants, such as proximity to mountains, water, and public lands (e.g., National Forests, National Parks).

Our results with respect to the predicted effects of changes in natural amenities on rural county migration are quite consistent with the projections outlined in the Pew Center report on global climate change (Smith 2004) and the McGranahan (1999, 2008) natural amenity studies. For example, the McGranahan (1999, 2008) studies show that the Midwestern U.S. region has the lowest amenity scale, while the Inter mountain western region of the country has the highest concentration of the natural amenities.

Our projection results need to be interpreted with caution, and inferences should be made exclusively within the framework and scope of this study, its model, and assumptions. The model used in estimating and forecasting the effect of natural

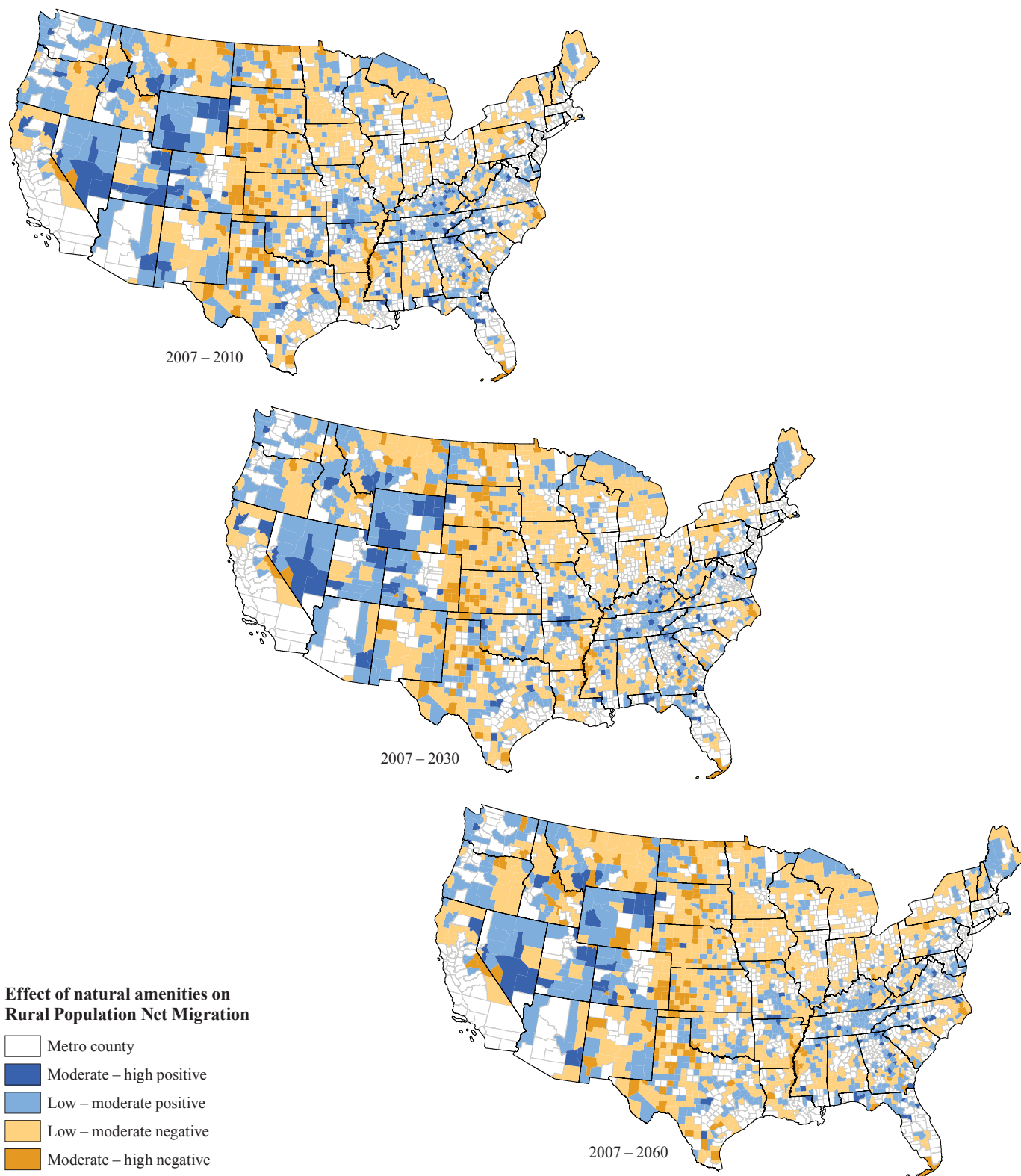


Figure 2—Forecasted effects of natural amenities on rural population growth under moderate climate change projections. 2010 RPA Climate Scenario A1B, Projections CGCM 3.1.

amenities on county population changes is a partial equilibrium model that excludes the effects of births/deaths and immigration on population changes. Additionally, the model forecasts effects at a single county level without considering possible spatial interrelationships and dependencies between counties. The model also does not account for significant economic opportunity and employment changes, such as changes in job prospects due to the recent “great recession.”

The study is also limited by the availability of secondary data. The U.S. Department of Agriculture Natural Resource Inventory (NRI) data, for example, merged independent cities in Virginia with another Virginia county. The data from Woods and Poole and the BEA also merged some counties together. Most of the data are annual data, but the land use data from NRI is released on a 5-year interval, prompting us to interpolate the annual values. Overall, the data involves approximately 55,000 entries coming from over 2,000 rural counties over 18 years; thus, we believe these limitations did not substantially alter our findings.

Summary and Implications

Previous research has provided considerable evidence supporting a strong relationship between quality and quantity of natural amenities and people’s migration decisions. For example, Johnson and Rasker (1995) and Rudzitis (1999) found that natural amenities were identified as more important reasons for migrating to the Western United States than the cost of living or job prospects. Similarly, Rasker and Hansen (2000) found that rural population growth in the northern Rocky Mountains was strongly influenced by natural amenities and climate. Furthermore, Nzaku and Bukenya (2005) and Cromartie (2001) found that migration to the Southeastern United States and other parts of the Sun Belt has been influenced by people’s preference for natural amenities such as a warmer temperatures and access to water-based recreation.

Building upon previous amenity migration research, this study had two primary objectives or tasks. First, we estimated an amenity migration model which quantified the effects of selected natural amenities on population growth in rural counties in the continental United States between 1990 and 2007, while controlling for job-related factors using a panel data econometric modeling approach. Second, using the results of the empirical amenity migration model, we forecasted the effects of changing natural amenities under the Forest Service county-level moderate climate change projections on rural population migration patterns between 2010 and 2060.

Our amenity migration model indicated that the rate of population net migration at the rural county level was significantly influenced by climate-related and landscape factors. For example, the results indicated positive preferences for milder winters and cooler summers and landscape variables such as proximity to public lands (e.g., National Forests, National Parks). Our amenity migration modeling results are generally consistent with conceptual expectations and previous amenity migration literature.

Our projections of the effects of changing natural amenities on rural migration patterns indicate future projected changes in natural amenities will make the Midwestern United States (e.g., Great Plains and North Central regions) less desirable as places to move for natural amenity reasons. On the positive side, our projections suggest that projected changes in natural amenities will make the most of the Intermountain and Pacific Northwest regions more desirable as places to move for amenity reasons. Our projections also suggest that some parts of the Southeast, South Central, and Northeast regions that already have more moderate climates (e.g., Southern Appalachians, Ozark Mountains, northern New England) will become more desirable as places to move for amenity reasons as the global and U.S. climate warms. In parts of the Southeast and Southwestern regions that already have relatively hot climates (e.g., counties at lower elevations), our results suggest that these areas will become less desirable as places to move for amenity reasons.

Results of this study have important policy implications for rural development. Changes in rural population migration flows are an important rural development factor. Job-related factors such as employment and income growth are well-known to be strong drivers of rural population growth and economic development. In addition to job-related factors, our results confirm the findings of previous studies suggesting that natural amenities are also major drivers of rural population growth and development. Thus, local planners and policymakers in conjunction with State and Federal agencies who have some control over natural amenities (e.g., public land management agencies) should follow an integrated planning approach which considers the effects of both job-related and natural amenity factors on population growth, economic development, and overall public welfare or well-being.

For example, our results suggest preference for varied landscapes that feature a mix of forestland and open space (e.g., pasture and range land). Local planners and policymakers in areas endowed of such landscapes should keep this in mind when formulating zoning laws and rural development plans. Without recognizing the role that landscapes have in attracting migrants, development of these rural counties might pose a threat to the landscape that

helped to pave the way to population growth and economic development in the first place.

In addition, land use planners and policymakers in regions likely to experience increases in amenity-driven population growth should consider how best to prepare for future population growth. For example, land use planners and policymakers may use zoning or property tax incentives to keep development out of high amenity lands (e.g., riparian areas) and cluster developable lands to facilitate cost-effective infrastructure rather than allowing low density ranchette, “mini farm,” or rural estate developments. Similarly, local officials may start considering plans for wastewater/sewer systems to handle increased effluent wastes. At the present time, rural areas often allow incremental development using septic tanks that eventually outrun the capacity of the environment to assimilate wastes resulting in pollution of the very lakes and rivers that attracted people to move there.

Furthermore, since upper-income individuals likely have high values for scenic beauty and recreation/leisure opportunities, there is a large window of opportunity for these rural counties to attract upper-income migrants who can bring more money into the local economy. This high potential for attracting more amenity migrants is especially true for counties located near public lands such as National Forests and Parks which provide scenic backdrops and outdoor recreation opportunities such as hiking, wildlife observation, and downhill or cross-country skiing. Thus, public land management agencies may play a major role in some areas by either encouraging or discouraging more amenity migration through their land management plans and practices. For example, clear-cutting forests in a particular view shed may reduce the aesthetic value and attraction of the view shed to amenity migrants. Our results suggest that changes in climate variables such as temperature may influence rural migration patterns in the future in selected areas. For example, since our results indicate that people prefer rural areas with mild winters and cooler summers, we may observe a future shift in migration patterns from some hot and humid regions to some originally cooler regions of the United States (e.g., Rocky Mountains, Pacific Northwest, Southern Appalachian Mountains, northern New England) as global and U.S. temperatures rise. In its Climate Change 4th Assessment Report, the IPCC also projects increased frequency of heavy rainfall and severe flooding, with the Great Plains being particularly vulnerable (IPCC 2007). Our results suggest that heavy precipitation has a negative effect on amenity migration. Thus, areas where rainfall is expected to increase due to global climate change may also become less desirable places to move for amenity reasons.

Our results suggest that proximity to the coast and water in general attracts amenity migrants. Rising sea-levels under future global climate change projections may significantly

alter the quantity and quality of water-related amenities. For example, rising sea-levels may result in land loss along the U.S. Atlantic, Pacific, Gulf of Mexico, and Great Lakes coasts. The extent of the impact of climate change on population migration and rural development in rural coastal counties will depend on the degree of vulnerability of property and risk to human health and safety that rising sea-level, storm-surge flooding, and shoreline erosion will cause. The degree of readiness and adaptation in these areas will highly influence whether we see a continued influx of amenity migrants to rural coastal counties or experience a reverse trend of net out-migration. For example, it is prudent for coastal communities to consider implementing mitigation strategies in a timely fashion such as investing in sea walls and beach restoration and enrichment projects (Rosenberger 2007).

In general, while global climate change is beyond the control of local planners and policymakers, gauging the possible impacts of climate change requires government and public attention. It is important for planners and policymakers in regions most likely to suffer population loss because of changing climate to be prepared with mitigating policies. For example, if a community is likely to become less desirable to new migrants because of global climate change (e.g., increasing temperatures), that community may need to make up for the negative effects of climate change by increasing other services valued by new migrants such as job opportunities, education, health care, and public parks.

It is also important for planners and policymakers in regions most likely to experience population gains because of changed climate to be prepared for the potential future influx of new migrants. For example, if people continue to be attracted to move to the Intermountain West United States for amenity reasons, State and local planners and policymakers will need to be proactive in planning infrastructure for these new migrants including adequate domestic water supplies. Planners, policymakers, and resource management agencies in amenity-rich areas also need to be proactive in protecting land and water resources (including public lands) from an influx of new residents who may “love these areas to death” if use is not managed in an environmentally sustainable manner.

Acknowledgments

Research upon which this report is based was supported by the U.S. Department of Agriculture Forest Service through the project “Population migration trends and patterns in the U.S. and their relationship to natural resources” dated June 8, 2010, through August 31, 2011, of Cooperative Research Agreement Number 10-CA-11330109-062 and

the Georgia Agricultural Experiment Station through the W-2133 Regional Research Project.

The authors acknowledge and thank Elizabeth Hill, former Graduate Research Assistant, The University of Georgia, Athens, GA, for her assistance with collection and review of background natural amenity and population migration literature. The authors also gratefully acknowledge very thorough and helpful comments from Linda Langner and Linda Joyce (both on the internal RPA Specialists Assessment team) and two external reviewers. Any remaining errors are the responsibility of the authors.

Literature Cited

- Breusch, T.; Ward, M.B.; Nguyen, H.; Kompas, T.** 2011. On the fixed-effects vector decomposition. *Political Analysis*. 19(2): 123-134.
- Clark, D.E.; Murphy, C.A.** 1996. Countywide employment and population growth: an analysis of the 1980s. *Journal of Regional Science*. 36(2): 235-256.
- Coulson, D.P.; Joyce, L.A.; Price, D.T. [and others].** 2010. Climate scenarios for the conterminous United States at the county spatial scale using SRES scenarios A1B and A2 and Prism Climatology. http://www.fs.fed.us/rm/data_archive/dataaccess/US_ClimateScenarios_county_A1B_A2_PRISM.shtml. [Date accessed: May 2, 2011].
- Coulson, D.P.; Joyce, L.A.** 2010. Historical climate data (1940-2006) for the conterminous United States at the county spatial scale based on PRISM climatology. http://www.fs.fed.us/rm/data_archive/dataaccess/US_HistClimateScenarios_county_PRISM.shtml. [Date accessed: May 2, 2011].
- Cromartie, J.B.** 2001. Migrants in the rural South choose urban and natural amenities. *Rural America*. 15: 7-18.
- Dale, V.H.; Joyce, L.A.; McNulty, S.; Neilson, R.P.** 2000. The interplay between climate change, forests, and disturbances. *The Science of the Total Environment*. 262: 201-204.
- Deller, S.C.; Tsai, T.-H.S.; Marcouiller, D.W.; English, D.B.K.** 2001. The role of amenities and quality of life in rural economic growth. *American Journal of Agricultural Economics*. 82(3): 352-365.
- Dissart, J.C.; Deller, S.C.** 2000. Quality of life in the planning literature. *Journal of Planning Literature*. 15(1): 135-161.
- Duffy-Deno, K.T.** 1998. The effect of Federal wilderness on county growth in the Intermountain Western United States. *Journal of Regional Science*. 38: 109-136.
- English, D.B.K.; Bowker, J.M.** 1996. Economic impacts of guided whitewater rafting: a study of five rivers. *Water Resources Bulletin*. 32(6): 1319-1328.
- English, D.B.K.; Marcouiller, M.; Cordell, H.K.** 2000. Tourism dependence in rural America: estimates and effects. *Society and Natural Resources*. 13(3): 185-202.
- Gonzalez-Abraham, C.E.; Radeloff, V.C.; Hammer, R.B. [and others].** 2007. Building patterns and landscape fragmentation in Northern Wisconsin, USA. *Landscape Ecology*. 22: 217-230.
- Graves, P.E.; Mueser, P.R.** 1993. The role of equilibrium and disequilibrium in modeling regional growth and decline: a critical reassessment. *Journal of Regional Science*. 33: 69-84.
- Green, G.P.** 2001. Amenities and community economic development: strategies for sustainability. *The Journal of Regional Analysis and Policy*. 31(2): 61-75.
- Greene, W.** 2011. Fixed effects vector decomposition: a magical solution to the problem of time invariant variables in fixed effects models? *Political Analysis*. 19(2): 135-146.
- Henderson, J.R.; McDaniel, K.** 2005. Natural amenities and rural employment growth: a sector analysis. *The Review of Regional Studies*. 35(1): 80-96.
- Hill, E.; Bergstrom, J.C.; Cordell, H.K.; Bowker, J.M.** 2009. Natural resource amenity service values and impacts in the U.S. <http://warnell.forestry.uga.edu/nrrt/nsre/IRISDemo/IrisDemo2rpt.pdf>. [Date accessed: May 3, 2011].
- Hoehn, J.P.; Berger, M.; Blomquist, G.C.** 1987. A Hedonic model of interregional wages, rents, and amenity values. *Journal of Regional Science*. 27: 605-620.
- International Organization for Migration.** 2004. International Migration Law N°1 - glossary on migration. http://publications.iom.int/bookstore/index.php?main_page=product_info&products_id=198. [Date accessed: May 3, 2011].
- Intergovernmental Panel on Climate Change (IPCC).** 2007. Climate change 2007: synthesis report. Contribution of working groups I, II and III to the fourth assessment report of the intergovernmental panel on climate change. http://www.ipcc.ch/publications_and_data/publications_ipcc_fourth_assessment_report_synthesis_report.htm. [Date accessed: May 3, 2011].
- Johnson, K.M.; Beale, C.L.** 1998. The rural rebound. *Wilson Quarterly*. 22(2): 16-27.
- Johnson, K.M.; Beale, C.L.** 2003. Nonmetro recreation counties: their identification and rapid growth. *Rural America*. 17(4): 12-19.
- Johnson, K.M.; Fuguitt, G.V.** 2000. Continuity and change in rural migration patterns, 1950-1995. *Rural Sociology*. 65(1): 27-49.
- Johnson, J.D.; Rasker, R.** 1995. The role of economic and quality of life values in rural business location. *Journal of Rural Studies*. 11(4): 405-416.
- Knapp, T.A.; Graves, P.E.** 1989. On the role of amenities in models of migration and regional development. *Journal of Regional Science*. 29(1): 71-87.
- Lewis, D.J.; Hunt, G.; Plantinga, A.J.** 2002. Public conservation land and employment growth in the northern forest region. *Land Economics*. 78: 245-259.
- McGranahan, D.A.** 1999. Natural amenities drive rural population change. *Agricultural Economic Report No. 781*. Washington, DC: U.S. Department of Agriculture, Economic Research Service. 32 p.
- McGranahan D.A.** 2008. Landscape influence on recent rural migration in the U.S. *Landscape and Urban Planning*. 85(3-4): 228-240.
- McKean, J.R.; Johnson, R.L.; Taylor, R. G.** 2005. Can superior natural amenities create high-quality employment opportunities? The case of nonconsumptive river recreation in central Idaho. *Society and Natural Resources*. 18(8): 749-758.
- Mueser, P.R.; Graves, P.E.** 1995. Examining the role of economic opportunities and amenities in explaining population redistribution. *Journal of Urban Economics*. 37: 176-200.
- Nakicenovic, N.; Swart, R., eds.** 2000. Special report on emissions scenarios: a special report of working group III of the Intergovernmental Panel on Climate Change. Cambridge, UK: Cambridge University Press. 599 p.
- National Geographic Society.** 2005. Xpeditions: human migration guide (grades 6-8), 2005. <http://www.nationalgeographic.com/xpeditions/lessons/09/g68/migrationguidestudent.pdf>. [Date accessed: May 3, 2011].

Nzaku, K.; Bukenya, J.O. 2005. Examining the relationship between quality of life amenities and economic development in the southeast USA. *Review of Urban and Regional Development Studies*. 17(2): 89-103.

Perry, M.J. 2006. Domestic net migration in the United States: 2000 to 2004. <http://www.census.gov/prod/2006pubs/p25-1135.pdf>. [Date accessed: May 3, 2011].

Peterson, G.L.; Gregory, R.; Driver, B.L. 1988. *Amenity resource valuation: integrating economics with other disciplines*. State College, PA: Venture Publishing, Inc. 265 p.

Plümper, T.; Troeger, V.E. 2007. The estimation of time-invariant and rarely changing variables in finite sample panel analyses with unit effects. *Political Analysis*. 15(2): 124-139.

Plümper, T.; Troeger, V.E. 2011. Fixed-effects vector decomposition: properties, reliability, and instruments. *Political Analysis*. 19(2): 147-164.

Power, T.M. 1998. *Lost landscapes and failed economies: the search for a value of place*. Washington, DC: Island Press. 317 p.

Power, T.M. 1988. *The economic pursuit of quality*. Armonk, NY: M.E. Sharpe, Inc. 218 p.

Rasker, R. 1993. Rural development, conservation and public policy in the greater Yellowstone ecosystem. *Society and Natural Resources*. 6: 109-126.

Rasker, R.; Hansen, A.J. 2000. Natural amenities and population growth in the greater Yellowstone Region. *Human Ecology Review*. 7: 30-40.

Rosenberger, R.S. 2007. Social and economic issues of global climate change in the Western United States. Joyce, L.; Haynes, R.; White, R.; Barbour, R.J., tech. coords. Bringing climate change into natural resource management: proceedings of a workshop. Gen. Tech. Rep. PNW 706. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station: 67-90.

Rudzitis, G. 1999. Amenities increasingly draw people to the rural west. *Rural Development Perspectives*. 14(2): 9-13.

Rudzitis, G.; Johansen, H.E. 1991. How important is wilderness? Results from a United States survey. *Environmental Management*. 15(2): 227-233.

Santos, F. 2010. Modeling the influence of natural amenities on recent trends in U.S. population migration. Athens, GA: The University of Georgia. 64 p. M.S. thesis.

Shumway, J. M.; Davis, J.A. 1996. Nonmetropolitan population change in the mountain west: 1970-1995. *Rural Sociology*. 61(3): 513-29.

Smith, J.B. 2004. A synthesis of potential climate change impacts on the U.S. Arlington, VA: Pew Center on Global Climate Change. 44 p.

Song, Y.; Knaap, G.-J. 2003. New urbanism and housing values: a disaggregate assessment. *Journal of Urban Economics*. 24: 218-238.

Stewart, S.I. 2000. Amenity migration. *Trends*: 369-378.

Varis, O.; Kajander, T.; Lemmela, R. 2004. Climate and water: from climate models to water resources management and vice versa. *Climatic Change*. 66(3): 321-344.

Vias, A.C.; Carruthers, J.I. 2005. Regional development and land use change in the rocky mountain west, 1982-1997. *Growth and Change*. 36(2): 244-272.

Wear, D.N. 2011. Forecasts of county-level land uses under three future scenarios for the 2010 RPA Assessment. Gen. Tech. Rep. SRS-141. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station. 41 p.

Zarnoch, S.J.; Cordell, H.K.; Betz, C.J.; Langner, L. 2010. Projecting county-level populations under three future scenarios: a technical document supporting the Forest Service 2101 RPA Assessment. Gen. Tech. Rep. SRS-128. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station. 8 p.

Endnotes

- ¹ For the remainder of this manuscript, “amenity” will refer only to natural amenities, unless stated otherwise.
- ² Johnson and Beale (1998) used various indicators such as recreational employment, recreational earnings, and seasonal housing in a multistep process to identify recreational counties.
- ³ As noted by Graves and Mueser (1993), job-related opportunities may have a major impact on migration patterns. Thus, in order to focus on natural amenity effects on migration, it is important to hold these factors constant.
- ⁴ A combination of multiple county observations over multiple time periods.
- ⁵ As with all econometric estimation techniques, the FEVD approach has its limitations and its critics as pointed out by one of the reviewers of this report. However, at the time the data analysis for this study was conducted, the FEVD approach appeared to be the best available estimation technique for the purposes of this study as demonstrated by peer-reviewed literature, and no peer-reviewed and published articles critical of this approach were known to the authors. Recently, a lively debate over the merits of the FEVD approach has appeared in the literature; e.g., see Breusch and others 2011, Greene 2011, Plumper and Troeger 2011 and other articles appearing in a special “Symposium on Fixed Effects Vector Decomposition” appearing in the journal *Political Analysis*, Vol. 19, No. 2, Spring, 2011. It is beyond the scope of this report to determine who is right in this ongoing debate. Until this debate is settled in the peer-reviewed literature, we continue to believe that the FEVD approach is adequate for the overall purposes of this study. Moreover, Santos (2010) compared FEVD estimates of our amenity migration model with other estimation approaches including a random effects (RE) approach which was suggested by one of the reviewers of this report as an alternative to the FEVD approach. We note that the RE estimates of our amenity migration model reported in Santos (2010) is very similar to the FEVD estimates. We also re-estimated our amenity migration projections using the RE model coefficient estimates and observed that our overall, bottomline results and conclusions with respect to the effects of natural amenities on rural population migration patterns are essentially the same under the FEVD and RE approaches.
- ⁶ Lands owned or administered by the Federal government. National parks, National Wildlife Refuges, military reservations, Federal prisons, and public-domain land are all examples of lands owned or administered by the government of the United States. The Federal government is responsible for managing and protecting these lands to preserve the resources of the United States, to conduct the business of the government, and to provide recreational and other opportunities to the public. Source: <http://www.nationalatlas.gov/mld/fedlapp.html>.
- ⁷ County centroid is the geographic center of the county.
- ⁸ In the case of counties that extend out into large lakes or oceans, McGranahan (2008) set the percentage of water to a maximum of 25 percent. Mueser and Graves (1995) use only lake areas.
- ⁹ Results of this specification are not presented in this report since they were out of scope of this study and did not alter the results and overall implications of the discussed model. Results are reported and discussed in Santos (2010).
- ¹⁰ CGCM 3.1: Coupled Global Climate Model Version 3.1. Canadian Centre for Climate Modeling and Analysis (CCCma), Third Generation (<http://www.cccma.bc.ec.gc.ca/models/cgcm3.shtml>). CSIRO 3.5: Australian Commonwealth Scientific and Industrial Research Organization Climate System Model (http://www.cmar.csiro.au/e-print/open/gordon_2002a.pdf and http://www.pcmdi.llnl.gov/ipcc/model_documentation/CSIRO-Mk3.5.htm). MIROC 3.2: Model for Interdisciplinary Research on Climate (MIROC) Version 3.2. Japanese Centre for Climate System Research, University of Tokyo; National Institute for Environmental Studies (NIES) and Frontier Research Center for Global Change (FRCGC). <http://www.ccsr.u-tokyo.ac.jp/kyosei/hasumi/MIROC/tech-repo.pdf>. APPENDIX A (Appendix table A.1—Regional and sectoral impacts of climate change in the United States).

Appendix table A.1—Regional and sectoral impacts of climate change in the United States

Region	Sector							
	Agriculture	Water	Coastal Communities	Health	Terrestrial Ecosystem Productivity	Terrestrial Biodiversity	Forestry	Aquatic Biodiversity
Northeast	↓ Low	?	↓ High	↔ Medium	↑ Low-Medium	↓ Medium	↑ Low	↔ Low-Medium
Southeast	↓ Medium	↓ Low	↓ High	↔ Medium	↔ Low	↓ Medium	↔ Low	↓ Medium
Southern Great Plains	↓ Medium	↓ Low	↓ High	↔ Medium	↔ Low	↓ Medium	↔ Low	↓ Medium
Midwest	↑ Medium	↓ Low	↓ N/A	↔ Medium	↑ Low-Medium	↓ Medium	↑ Low	↔ Low-Medium
Southwest	↔ Medium	↓ Low	↓ High	↔ Medium	↔ Low	↓ Medium	?	↓ Medium
Northwest	↑ Medium	↔ Low	↓ High	↔ Medium	↔ Low	↓ Medium	?	↓ Low-Medium

Source: Smith 2004

Notes:

↑ indicates positive effect such as increased productivity

↓ indicates negative effect such as net damages or reduced productivity

↔ indicates mixed effects, i.e., positive and negative

? indicates uncertainty about the direction of change

N/A = not applicable

The size of the arrow is related to the magnitude of the effect. Low, medium, and high are the levels of confidence in the direction of change.

Appendix table A.2—Data description and sources for rural amenity migration model, 1990-2007

Variable name	Description	Sources
RInternalMig	Net migration rate (the difference between domestic in-migration to the area and out-migration from the same area during a time period. Domestic in- and out-migration consist of moves where both the origin and the destination are within the United States, excluding Puerto Rico. The rate expresses net domestic migration during a time period as a proportion of an area's population at the midpoint of the time period. Rates are expressed per 1,000 population).	U.S. Census
pcemp	Percent change in employment. Was developed from annual county total employment variable.	Developed based on data from BEA REIS
meansummr	Mean monthly summer temperature degrees Celsius across June, July, and August	Developed from RPA Assessment Historic Climate Data
meanwintr	Mean monthly winter temperature degrees Celsius across December, January, and February	Developed from RPA Assessment Historic Climate Data
ppt	Mean monthly precipitation per year in mm	Developed from RPA Assessment Historic Climate Data
pcrop	Percent cropland in county i at year j. Includes areas used for the production of adapted crops for harvest. Two subcategories of cropland are recognized: cultivated and noncultivated. Cultivated cropland comprises land in row crops or close-grown crops and other cultivated cropland, for example, hay land or pastureland that is in a rotation with row or close-grown crops. Noncultivated cropland includes permanent hay land and horticultural cropland.	Developed based on Natural Resources Conservation Service (NRCS) National Resources Inventory (NRI) data for years 1982, 1987, 1992, and 1997.
pforest	Percent forest land in county i at year j. Forest land is a land cover/use category that is at least 10 percent stocked by single-stemmed woody species of any size that will be at least 4 meters (13 feet) tall at maturity. Also included is land bearing evidence of natural regeneration of tree cover (cut over forest or abandoned farmland) and not currently developed for no forest use. Ten percent stocked, when viewed from a vertical direction, equates to an aerial canopy cover of leaves and branches of 25 percent or greater. The minimum area for classification as forest land is 1 acre, and the area must be at least 100 feet wide.	Developed based on NRCS National Resources Inventory (NRI) data for years 1982, 1987, 1992, and 1997.
ppasture	Percent pasture land in county i at year j. Pasture is a land cover/use category of land managed primarily for the production of introduced forage plants for livestock grazing. Pastureland cover may consist of a single species in a pure stand, a grass mixture, or a grass-legume mixture. Management usually consists of cultural treatments: fertilization, weed control, reseeding or renovation, and control of grazing. For the NRI, includes land that has a vegetative cover of grasses, legumes, and/or forbs, regardless of whether or not it is being grazed by livestock.	Developed based on NRCS National Resources Inventory (NRI) data for years 1982, 1987, 1992, and 1997.
prange	Percent range land in county i at year j. Rangeland is a land cover/use category on which the climax or potential plant cover is composed principally of native grasses, grass like plants, forbs or shrubs suitable for grazing and browsing, and introduced forage species that are managed like rangeland. This would include areas where introduced hardy and persistent grasses, such as crested wheatgrass, are planted and such practices as deferred grazing, burning, chaining, and rotational grazing are used, with little or no chemicals or fertilizer being applied. Grasslands, savannas, many wetlands, some deserts, and tundra are considered to be rangeland. Certain communities of low forbs and shrubs, such as mesquite, chaparral, mountain shrub, and pinyon-juniper, are also included as rangeland.	Developed based on NRCS National Resources Inventory (NRI) data for years 1982, 1987, 1992, and 1997.

(table continued on following page)

Appendix table A.2— (continued) Data description and sources for rural amenity migration model, 1990-2007

Variable name	Description	Sources
lnpcfd100	Per capita Federal designated land within a hundred mile radius of county i at year j. A land ownership category designating land that is owned by the Federal government. It does not include, for example, trust lands administered by the Bureau of Indian Affairs or Tennessee Valley Authority (TVA) land. No data are collected for any year that land is in this ownership.	Developed based on USDA Forest Service compiled data
lnpwater	Natural log of percent of water area of county i. Annualized water area values in acres are divided with the total number of acres per county to obtain percent water area in county i at year j.	Developed based on NRCS Water and Climate Center
percmount	Percent of mountainous area in county i. The variable acres of mountains was divided by county total acres to create percent of mountainous area in county i.	Bailey's eco region dataset, USDA Forest Service
coast	Coastal county indicator. 0=no 1=yes. Data contains coastal/noncoastal classification of 3,142 counties in the United States. Coastal/noncoastal variable was turned into a 1-0 coast dummy variable and merged with other RPA amenities migration variables by Federal Information Processing Standard (FIPS).	NRCS Water and Climate Center
snowmed	Average annual number of days with snowfall ≥ 1 inch (per station) in county i.	Developed based on snowfall data from the National Climatic Data Center(NCDC)
pwetland	Percent wetland of county i. Lands transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water. For purposes of this classification wetlands must have one or more of the following three attributes: (1) at least periodically, the land supports predominantly hydrophytes; (2) the substrate is predominantly undrained hydric soil; and (3) the substrate is nonsoil and is saturated with water or covered by shallow water at some time during the growing season of each year. (Cowardin, L.M., Carter, V. Golet, F.C. LaRoe, E.T. 1979. Classification of wetlands and deepwater habitats of the United States. FWS/OBS-79/31. U.S. Department of the Interior, Fish and Wildlife Service.)	Developed based on NRCS National Resources Inventory (NRI) data
lnpd	Natural log of population density of county i in year j. Population is computed by dividing the total population within a geographic entity (for example, United States, state, county, place) by the land area of that entity measured in square kilometers or square miles. Density is expressed as "people per square kilometer" and "people per square mile" of land area.	Calculated from U.S. Census population data
npcy	Average annual per capita income in county i at year j. This measure of income is calculated as the personal income of the residents of a given area divided by the resident population of the area. In computing per capita personal income, BEA uses the Census Bureau's annual midyear population estimates.	Per capita income in Regional Economic Information System (REIS) Data developed by the Bureau of Economic Analysis (BEA)
ter	Property tax and government expenditure ratio	Calculated from U.S. Census – county data files

Appendix table A.3—Summary statistics for rural amenity migration model variables

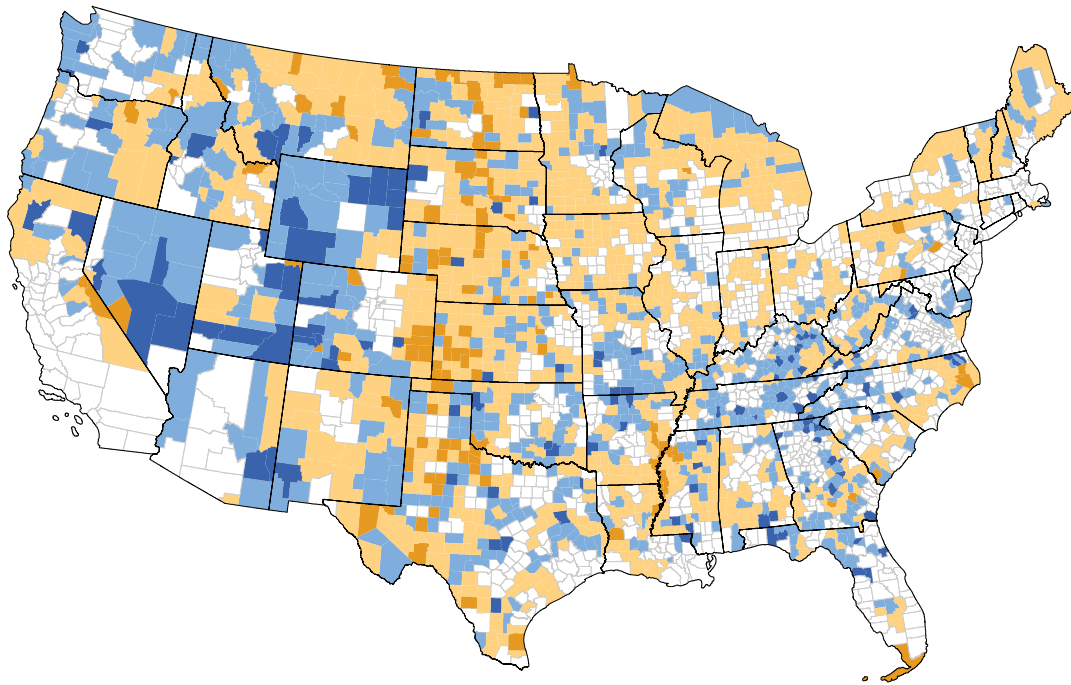
Variable	Mean	Std. Dev	Min	Max	Observations
RInternalMig	2.18	16.67	-1287.28	352.81	N = 55278
pcomp	1.48	3.54	-51.48	268.22	N = 55278
prange	11.80	22.47	0.00	99.61	N = 55278
pforest	28.85	26.63	0.00	95.26	N = 55278
pcrop	26.09	25.40	0.00	94.98	N = 55278
ppasture	9.36	10.10	0.00	77.71	N = 55278
Lnpd	3.68	1.63	-2.71	11.16	N = 55278
Lnpwater	-0.04	1.82	-8.00	4.51	N = 55278
percmount	12.39	29.47	0.00	100.00	N = 55278
Coast	0.21	0.40	0.00	1.00	N = 55278
Pwetland	10.17	13.50	0.01	93.19	N = 55278
meansummr	23.05	3.44	8.37	34.20	N = 55278
meanwintr	1.80	6.29	-17.50	21.36	N = 55278
ppt	83.01	33.43	1.40	317.97	N = 55278
Lnpcy	9.90	0.29	8.33	11.44	N = 55278
snowmed	3.63	2.01	1.00	9.00	N = 55278
lnpcfd100	2.60	2.25	-5.52	10.07	N = 55278
Ter	0.27	0.14	0.00	2.64	N = 55278

Appendix table A.4—Estimated explanatory variable coefficients for rural amenity migration model

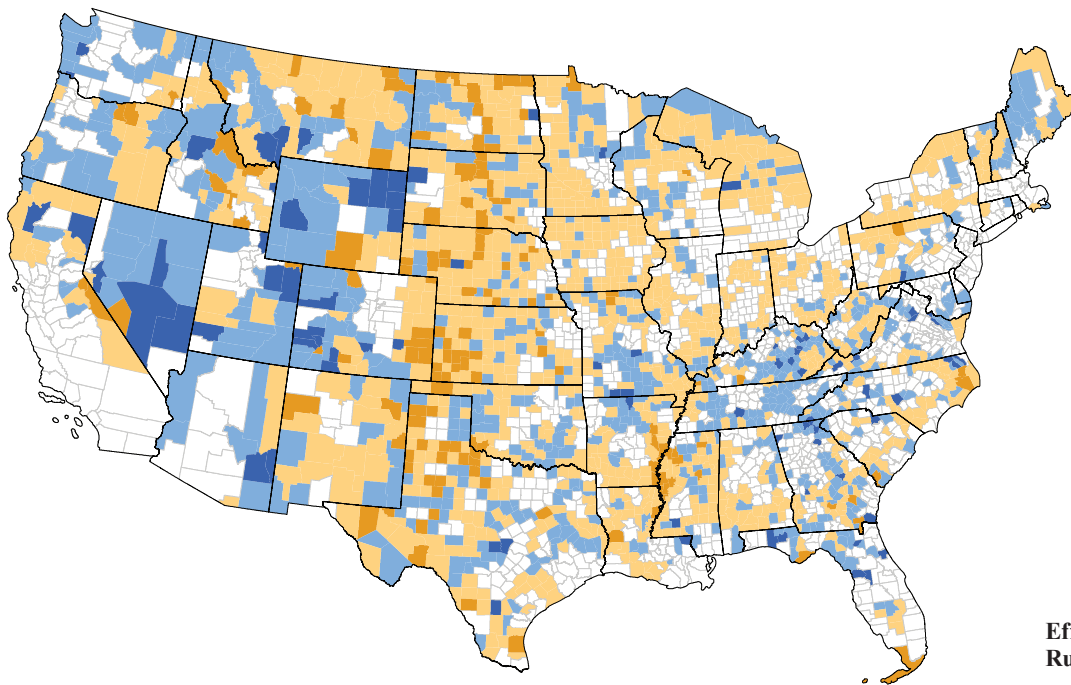
Variable	Coefficient estimate	t-value
pcomp	0.3550 ^c	21.64
pcrop ^a	-0.2296 ^b	-25.02
pcrop ^{2a}	0.0023 ^b	20.67
meansummr ^a	-0.2989 ^b	-7.91
ppt ^a	-0.0024	-0.92
lnpcy ^a	-5.8580 ^b	-28.09
lnpwater	0.6029 ^b	16.18
percmount	0.0249 ^b	9.97
coast	1.3188 ^b	6.92
pwetland	-0.0173 ^b	-2.88
lnpcfd100	0.3596 ^b	9.11
snowmed	0.0591	0.93
meanwintr ^a	0.1104 ^b	5.45
prange ^a	0.0668 ^b	6.42
prange ^{2a}	-0.0008 ^b	-7.48
lnpd ^a	3.219 ^b	19.18
lnpd ^{2a}	-0.2391 ^b	-8.82
pforest ^a	0.2152 ^b	18.16
pforest ^{2a}	-0.0029 ^b	-23.44
ppasture ^a	0.1479 ^b	9.08
ppasture ^{2a}	-0.0011 ^b	-3.25
Ter	5.9511 ^b	14.82
eta	1.0000 ^b	186.48
Constant	54.1785 ^b	23.61

^a Variables are modeled in lags (t-1)

^b Significant at 1 percent level .



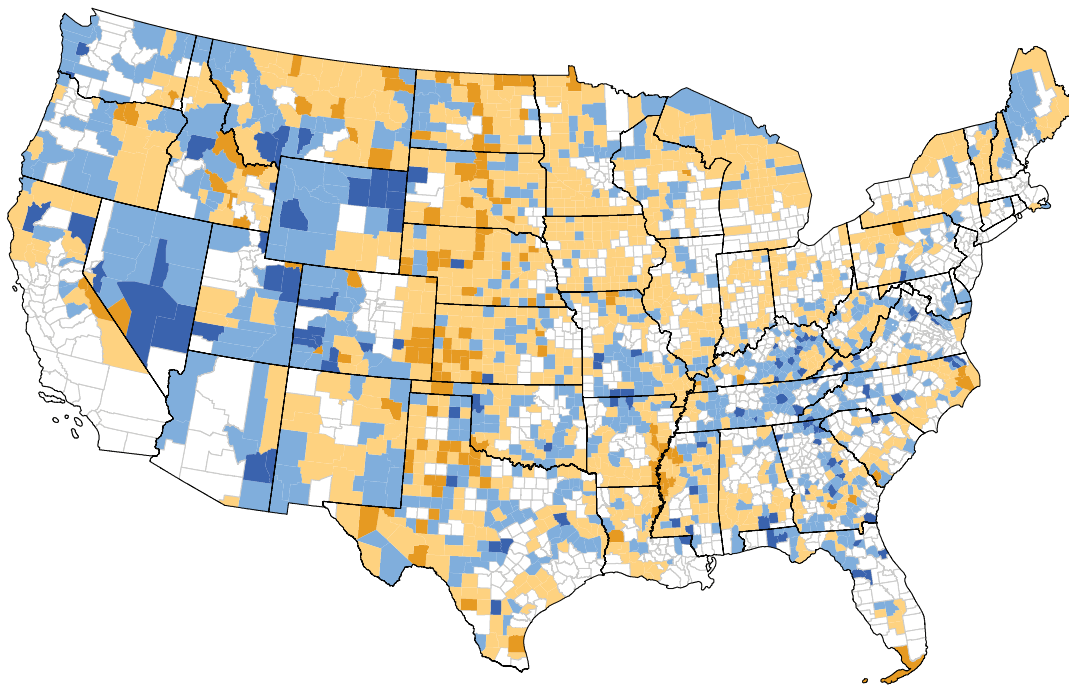
Appendix figure A.1—Forecasted effect of natural amenities on rural population change, 2007–2010
2010 RPA Scenario A1B, climate projection CGCM 3.1.



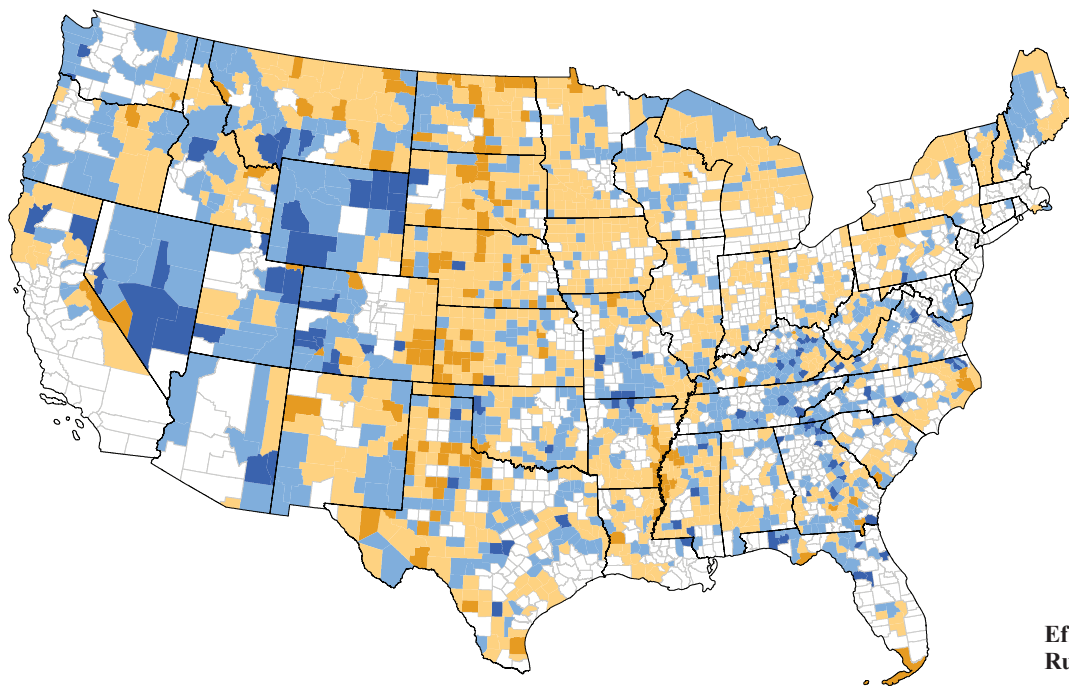
Appendix figure A.2—Forecasted effect of natural amenities on rural population change, 2007–2015
2010 RPA Scenario A1B, climate projection CGCM 3.1.

**Effect of natural amenities on
Rural Population Net Migration**

- Metro county
- Moderate – high positive
- Low – moderate positive
- Low – moderate negative
- Moderate – high negative



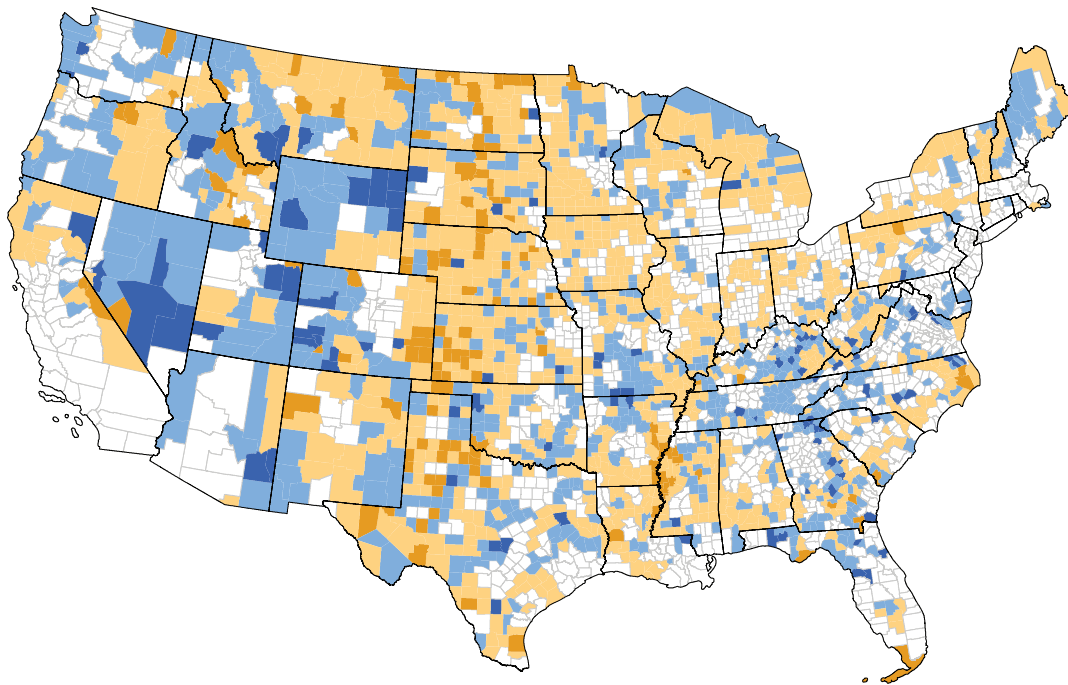
Appendix figure A.3—Forecasted effect of natural amenities on rural population change, 2007–2020
2010 RPA Scenario A1B, climate projection CGCM 3.1.



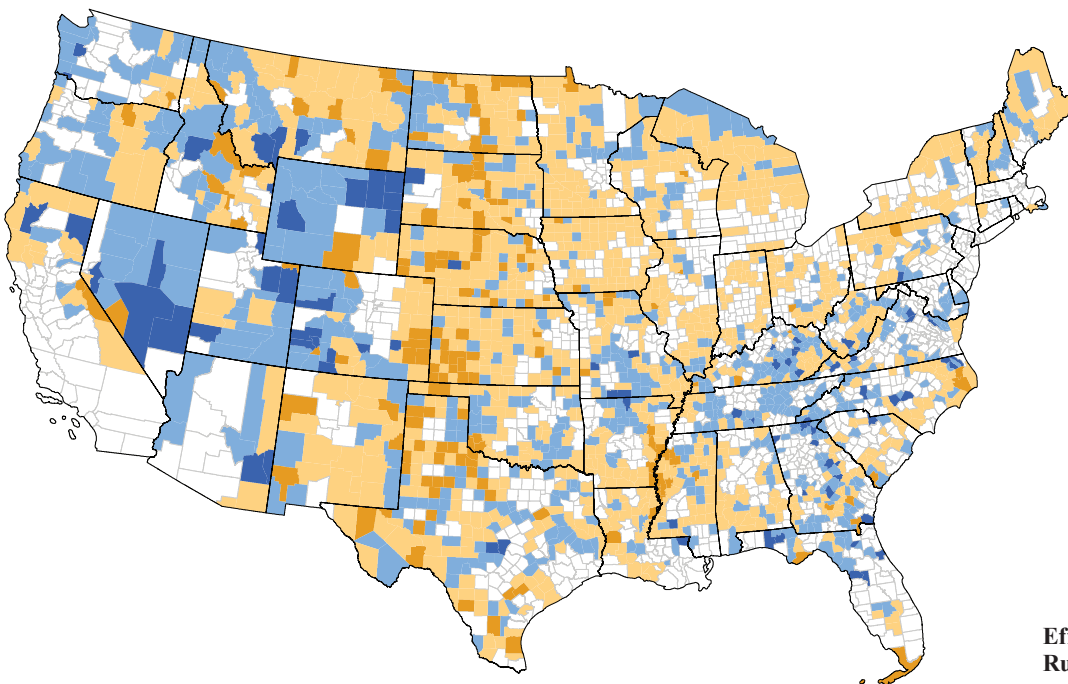
Appendix figure A.4—Forecasted effect of natural amenities on rural population change, 2007–2030
2010 RPA Scenario A1B, climate projection CGCM 3.1.

**Effect of natural amenities on
Rural Population Net Migration**

- Metro county
- Moderate – high positive
- Low – moderate positive
- Low – moderate negative
- Moderate – high negative



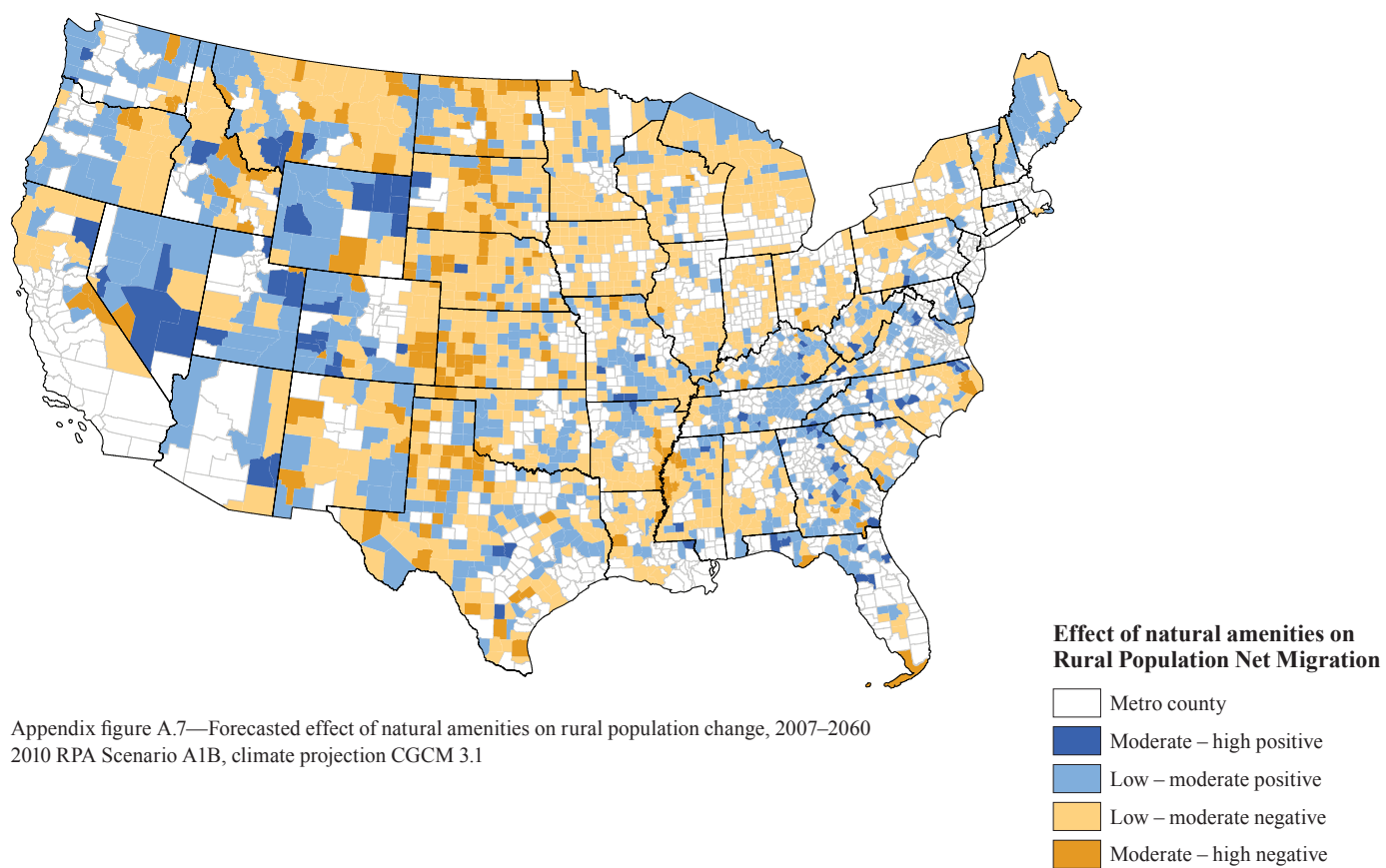
Appendix figure A.5—Forecasted effect of natural amenities on rural population change, 2007–2040
2010 RPA Scenario A1B, climate projection CGCM 3.1.



Appendix figure A.6—Forecasted effect of natural amenities on rural population change, 2007–2050
2010 RPA Scenario A1B, climate projection CGCM 3.1.

**Effect of natural amenities on
Rural Population Net Migration**

- Metro county
- Moderate – high positive
- Low – moderate positive
- Low – moderate negative
- Moderate – high negative



Appendix figure A.7—Forecasted effect of natural amenities on rural population change, 2007–2060
2010 RPA Scenario A1B, climate projection CGCM 3.1



The Forest Service, United States Department of Agriculture (USDA), is dedicated to the principle of multiple use management of the Nation's forest resources for sustained yields of wood, water, forage, wildlife, and recreation. Through forestry research, cooperation with the States and private forest owners, and management of the National Forests and National Grasslands, it strives—as directed by Congress—to provide increasingly greater service to a growing Nation.

The USDA prohibits discrimination in all its programs and activities on the basis of race, color, national origin, age, disability, and where applicable, sex, marital status, familial status, parental status, religion, sexual orientation, genetic information, political beliefs, reprisal, or because all or part of an individual's income is derived from any public assistance program. (Not all prohibited bases apply to all programs.) Persons with disabilities who require alternative means for communication of program information (Braille, large print, audiotape, etc.) should contact USDA's TARGET Center at (202) 720-2600 (voice and TDD).

To file a complaint of discrimination, write to USDA, Director, Office of Civil Rights, 1400 Independence Avenue, SW, Washington, D.C. 20250-9410, or call (800) 795-3272 (voice) or (202) 720-6382 (TDD). USDA is an equal opportunity provider and employer.

Cordell, H. Ken; Heboyan, Vahé; Santos, Florence; and Bergstrom, John C. 2011. Natural amenities and rural population migration: a technical document supporting the Forest Service 2010 RPA Assessment. Gen. Tech. Rep. SRS-146. Asheville, NC: U.S. Department of Agriculture Forest Service, Southern Research Station. 23 p.

Research has suggested that significant relationships exist between rural population change and natural amenities. Thus, understanding and predicting domestic migration trends as a function of changes in natural amenities is important for effective regional growth and development policies and strategies. In this study, we first estimated an econometric model which showed the effects of natural amenities, such as climate and landscape variables, on rural population migration patterns in the United States between 1990 and 2007. The estimated model was then used to predict the effects of changes in these variables on rural county net migration and population growth to 2060 under alternative future climate and land use projections. Results suggest that people prefer rural areas with mild winters and cooler summers; thus we can expect a direct impact of climate change on population migration when areas associated with these conditions change. Results also suggest preference for varied landscapes that feature a mix of forest land and open space (e.g., pasture and range land). During the projection period from 2010 to 2060 in the United States, changes in natural amenities were predicted to have positive effects on rural population migration trends in most parts of the Inter-mountain and Pacific Northwest regions, and some parts of the Southeastern, South Central, and Northeastern U.S. regions (e.g., Southern Appalachian Mountains, Ozark Mountains, northern New England). Changes in natural amenities were predicted to have negative effects on rural population migration trends during the projection period in Midwestern regions (e.g., Great Plains and North Central regions).

Keywords: Amenity migration, climate change, landscapes, natural amenities, rural population change.



United States Department of Agriculture



Forest Service



Southern Research Station

General Technical Report SRS-146

December 2011

