Regional Economic Effects of Wilderness Designations in Six Western States

Marca L. Hagenstad

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REGIONAL ECONOMIC EFFECTS OF WILDERNESS
DESIGNATIONS IN SIX WESTERN STATES

by

Marca L. Hagenstad

A thesis submitted in partial fulfillment of the
requirements for the degree
of
MASTER OF SCIENCE
in
Economics

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UTAH STATE UNIVERSITY
Logan, Utah
1999
ABSTRACT

Regional Economic Effects of Wilderness Designations in Six Western States

by

Marca L. Hagenstad, Master of Science
Utah State University, 1999

Major Professor: Dr. Donald L. Snyder
Department: Economics

This study investigated the existence of impacts on per capita incomes from the designations of wilderness areas. It developed one model to explain county-level per capita incomes in the six western states of Utah, Colorado, New Mexico, Arizona, Idaho, and Wyoming. This model examined effects of various factors believed to affect incomes, such as the industry mix of an economy, population densities, unemployment rates, government expenditures, and the existence of colleges, Indian reservations, and wilderness areas.

The analysis indicated that per capita incomes in these states did not fall by an increase in wilderness lands. In fact, counties in Utah, Colorado, Arizona, and Idaho experienced higher incomes if they contained wilderness areas. Counties in all states experienced higher incomes if a greater percentage of revenues came from the tourism and extractive industry sectors. However, the analysis indicated that, on average,
increases in revenues from tourism increased incomes more than increases in revenues from extractive industries.

No definitive analysis could be performed to determine the difference between wilderness and extractive industry effects because the variables are not measured in the same units. However, the income elasticities were calculated with respect to the means of the relevant explanatory variables. The income elasticity with respect to changes in the extractive industry was the highest elasticity computed, as extractive industry mean values were much larger than the other mean values.

As in all econometric studies, estimated coefficients suggest relationships, not causality. Results from this study in particular cannot be taken out of context and interpreted without close examination of all factors pertaining to the stated results.

(61 pages)
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I thank my committee members — Dr. Christopher Fawson and Dr. W. Cris Lewis — for their support, assistance, and valuable input. Appreciation also goes out to all of the faculty, staff, librarians, and others who took the time to help me locate information and solve various problems.

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Marca L. Hagenstad
CONTENTS

ABSTRACT ........................................................................................................ ii

ACKNOWLEDGMENTS ...................................................................................... iv

LIST OF TABLES .............................................................................................. vii

CHAPTER

I. INTRODUCTION ............................................................................................ 1

Statement of the Problem ............................................................................. 2
Objectives .......................................................................................................... 3
Procedures and Methods .................................................................................. 3

II. LITERATURE REVIEW .................................................................................. 5

Regional Economics ....................................................................................... 5
Wilderness and the Economy Literature ......................................................... 7

The Environment and the Economy ............................................................... 7
Wilderness and the Economy .......................................................................... 9

Econometric Literature ................................................................................... 12

III. DATA AND ANALYSIS ................................................................................ 14

Analytical Procedures ..................................................................................... 15
The Model ......................................................................................................... 16
Econometric Issues .......................................................................................... 18

Multicollinearity ............................................................................................. 19
Autocorrelation ............................................................................................... 20
Heteroscedasticity ............................................................................................ 22
Standard Errors ............................................................................................... 23
t-Statistics ........................................................................................................ 23
R-Squared ......................................................................................................... 24
F-Statistic ......................................................................................................... 24
IV. STUDY RESULTS ................................................................. 25

                                      Preliminary Results ......................................................... 25
                                      Preliminary Results for the Case of Utah ................................ 29
                                      Tests for Multicollinearity, Autocorrelation, and Heteroscedasticity ........................................... 32
                                      Revised Results .................................................................. 35
                                      Revised Results for the Case of Utah ..................................... 39
                                      Comparison of OLS and FGLS Results ..................................... 42
                                      Elasticities ...................................................................... 42

V. SUMMARY, CONCLUSION, AND RECOMMENDATION .......................... 46

                                      Summary ...................................................................... 46
                                      Conclusions .................................................................... 49
                                      Recommendations .......................................................... 51

REFERENCES ................................................................. 52
**LIST OF TABLES**

<table>
<thead>
<tr>
<th>Table</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Percent county population change in the U.S. West, 1960-1990</td>
<td>10</td>
</tr>
<tr>
<td>2. Independent variables and their coefficients for the initial OLS regression estimation</td>
<td>26</td>
</tr>
<tr>
<td>3. Independent variables and their coefficients for the OLS regression estimation for Utah, including urban variables</td>
<td>31</td>
</tr>
<tr>
<td>4. Independent variables and their coefficients for the adjusted FGLS regression equation</td>
<td>36</td>
</tr>
<tr>
<td>5. Independent variables and their coefficients for the adjusted FGLS regression estimation for Utah, including urban variables</td>
<td>41</td>
</tr>
<tr>
<td>6. Income elasticities with respect to relevant variables, evaluated at mean levels</td>
<td>43</td>
</tr>
<tr>
<td>7. Descriptive statistics</td>
<td>45</td>
</tr>
</tbody>
</table>
The Wilderness Act of 1964 established the National Wilderness Preservation System (NWPS), composed of federally owned areas designated by Congress as wilderness to be preserved in their wild state. Wilderness areas are selected from various lands already set aside as national parks, national wildlife refuges, national forests, and lands managed by the Bureau of Land Management (BLM).

An area must be in a natural state to be considered for a wilderness designation. A "natural" area contains only negligible imprints of human activity; it must be roadless and undeveloped. However, the Wilderness Act does permit minor human impacts such as trails, bridges, and fire towers, so long as their overall impact is "substantially unnoticeable" (Watson).

Over the thirty-five years since the passage of the Wilderness Act, there have been more than 95.3 million acres of lands designated as wilderness. Some states have preserved large amounts of land; some states contain no wilderness at all. Two-thirds of all wilderness is located in Alaska.

A wilderness designation is the strictest form of land protection; the range of activities permitted in wilderness is minimal. Nonmotorized recreation including horseback riding, herb gathering, hiking, camping, fishing, and hunting are allowed. Agencies may maintain and construct trails in wilderness. Grazing is allowed to continue at levels consistent with sound resource management if it existed prior to the designation of the area as a wilderness.
The Wilderness Act prohibits such activities as mining, chaining, water development, and timber harvest (although mining may occur where there is a valid pre-existing right to mine). The Act also prohibits use of motorized vehicles and motorized equipment in wilderness except wheelchairs and for emergency circumstances (U.S. BLM). Mountain bikes are not permitted in wilderness areas.

Controlling the type of activity that may occur on wilderness lands can entail several economic impacts. Positive economic impacts may occur through increased revenues from tourism and through the increase of an area's "environmental amenity" package, which may attract permanent residents to surrounding communities, especially retirees and footloose businesses. The more difficult to quantify economic benefits are those accrued by protecting biodiversity (particularly wildlife habitat) and air and water quality. Negative economic impacts may occur because of the limits placed on activity in wilderness areas. The lands will no longer be available for resource extraction and development. People using motorized equipment or mountain bikes may not return. Additional negative economic impacts may occur if tourism-based employment entails a trade-off between low-paying jobs and high-paying jobs.

**Statement of the Problem**

The overall purpose of this study is to examine if counties in six of the western states have experienced a detectable economic impact by designating some of their lands as wilderness. The six western states included in the study are Utah, Colorado, New Mexico, Arizona, Idaho, and Wyoming. The study will determine if counties in these
states which designated some lands as wilderness experienced a positive or negative economic effect from the designations, and will determine if these effects are significant.

**Objectives**

The overall purpose of the research is to determine the regional economic effects of designating a land as wilderness. The specific objectives are to: (1) identify the determinants of per capita income at a county level; (2) estimate an equation (which contains a wilderness variable) explaining per capita income and test results; and (3) explain the results.

**Procedures and Methods**

The specific procedures and methods required to meet each of the objectives given above are:

Objective 1: Identify the determinants of per capita income at a county level.

(a) Review regional economic literature.

(b) Based on economic theory, select independent variables which affect per capita income at the county level.

(c) Determine wilderness variable to be used which might affect per capita income.

Objective 2: Estimate an equation explaining per capita income and test results.

(a) Identify sources of data that includes observations on the variables selected above.

(b) Collect, transform, and enter data on variables selected above.
(c) Prepare data for statistical analysis. In doing so, it is important that the spreadsheet or database program used be compatible with the statistical programs to be used.

(d) Identify possible structural forms for estimation of per capita income at the county level.

(e) Prepare data consistent with the structural forms selected.

(f) Select statistical software suitable for per capita income estimation.

(g) Estimate regression equation for a select number of relevant functional forms.

(h) Test coefficients and overall equation for statistical significance and other econometric problems.

(i) Select/modify functional form as appropriate and perform necessary procedures to correct for problems such as heteroscedasticity and autocorrelation.

Objective 3: Explain the results.

(a) Explain results of estimation.

(b) Explain conclusions.
CHAPTER II
LITERATURE REVIEW

The review of literature is divided into three major areas. First, the economic literature pertaining to regional economics is discussed. Second, literature concerning wilderness and the economy is reviewed. Third, econometric literature containing information pertinent to this study is briefly examined.

Regional Economics

Economists since Adam Smith have been concerned with the economic growth of nations. However, a concern for regional economies did not form until the late 1920s and 1930s, with the bulk of the research being conducted in the mid-50s and mid-60s. This new branch of economics arose to specifically deal with space, location, and urban structure; it treated a region as a “mini-nation” (Richardson).

In 1960, two works (Perloff et al.; Kuznets, Miller, and Easterlin) provided detailed empirical evidence of convergence tendencies in regional per capita incomes. Borts and Stein claimed that the convergence of per capita incomes may be explained by the hypothesis that resources within states have become more efficiently allocated over time, with returns being equalized at the margin. Mills and Hamilton credited the convergence to the equating of production and transport costs across regions, combined with overall declining transport costs.

However, varying degrees of economic differences within and among regions persist. Nissan and Carter, in their study’s results for the years 1929-1990, showed that inequality persisted among regions with a large declining trend up to 1979 with a slight
rise thereafter. Martin, McHugh, and Johnson discovered that, while the past thirty years have brought about significant economic growth, the gap between economic prosperity in rural and urban areas in the United States, which narrowed during the 1970s, widened during the 1980s. My study attempts to explain these regional income differences. However, because my study examines *average* per capita incomes, it cannot make conclusions relating to poverty. Nonetheless, it is important to note that processes of economic change typically result in uneven patterns of development.

Several studies attempt to explain and account for these economic differences. Many seek to identify the economic effects of particular regional characteristics. The regional characteristics that are believed to affect a region’s economy are numerous. Kusmin explored these characteristics and summarized the majority of the empirical studies conducted on this topic between 1978 and 1991. He found that over thirty regional characteristics have been used to help explain the economy of an area. These characteristics include items such as taxes, government expenditures, labor market conditions, demographic characteristics, and industrial compositions, among others. Kusmin did not list any studies which included the factors of wilderness areas or environmental quality. He found few characteristics to have consistent effects across studies; a particular regional characteristic that strongly affected growth in one region, typically had little effect, or the opposite effect, in other studies. Kusmin concluded that further research needed to be done in this area and gave recommendations for conducting similar studies. The recommendations that were taken and applied in my study are to use substate-level data for more detailed analysis and additional degrees of freedom, to include variables to reflect the industrial composition of the regional economy, and to
focus on entire regional economies instead of one sector, such as manufacturing, which may obscure the significance of results on a regional economy as a whole.

Recently, there has been an increase in attention paid to the economic effects of regional amenities. Mills and Hamilton stated that small interregional cost differences have led to amenity orientation, a firm-location criterion based on locational attributes such as climate, culture or environmental quality, rather than on transport or production cost. My study attempts to determine if the regional amenity of wilderness lands can be associated with changes in regional per capita incomes. The next section examines this amenity issue more closely.

Wilderness and the Economy Literature

In this section, the literature reviewed examines how the physical environment in general, of which wilderness is a part, may affect an economy. Then, studies specifically addressing wilderness areas' impacts on an economy are discussed.

The Environment and the Economy

Some recent literature on economic development suggests that intangible amenities have become increasingly important factors in decisions to live in rural areas (Dillman; Williams and Sofranko; Long and DeArc; Deavers; Whitelaw). Amenity differences have also been claimed to generate a divergence of real wages or employment opportunity, and thus can be used to explain migration flows (Greenwood et al.).

Friedmann claimed that environmental amenities in particular can affect migration. He stated that a region's "physical environment does not merely reflect economic conditions, it also helps to bring them about" (p. 170).
Environmental amenities have also been shown to affect property values. Polinsky and Rubinfeld used intraregional variations among property values to find a $900 per capita value of a 50% reduction in certain air pollutants for residents of the St. Louis area. Some studies have used this approach and examined protected area effects on surrounding property values. However, these effects are very location specific and reflect only one type of economic effect. Thus, they cannot offer conclusions regarding effects to an overall economy. I chose to examine effects on incomes, which can incorporate more aggregate effects for an entire region.

Power used environmental amenities to claim economic prosperity in the Pacific Northwest. He stated that despite declines in traditional economic bases of the Pacific Northwest, these states economies performed very well. He attributed this vitality partly to the region’s high quality living environment. He claimed that landscapes provide new jobs by providing natural resource amenities that make the Pacific Northwest an attractive place to work.

However, crediting the environment for economic prosperity is not without flaws. This theory alone fails to be compatible with the significant out-migration experienced by many regions containing vast acreage of wild lands (Fawson). My study addresses this issue by incorporating as many factors as possible, which may determine the success or failure of an economy, so that the individual effects of wilderness areas may be more clearly examined. Polzin stated that amenities are not useful to explain economic conditions because they do not have the fluctuation needed to explain the ever-changing regional economic trends. Thus, they are not useful tools with which to analyze short-run or long-run trends in a region, nor do they appear to be useful concepts to distinguish
between regions. My study examines this statement and tests it by using actual historical data.

**Wilderness and the Economy**

The economic effects of wilderness areas in particular have been examined in several studies. Quantifying these effects remains a difficult task for economists. Public ownership of vast areas of wilderness lands conceals its value; the lack of private and transferable property rights makes it difficult to obtain accurate information about its value (Snyder et al.).

One way for economists to work around these difficulties is to examine population patterns. Rudzitis and Rudzitis and Johansen (1989) found that counties that contain or are adjacent to wilderness areas were among the fastest-growing counties in the nation (Table 1). These studies determined population changes, but did not examine local economic effects from these changes.

Surveys are also popular valuation techniques. Rudzitis and Johansen (1989) reported results of a survey to residents of wilderness counties. They found that employment opportunities were important in people's choice of location for only 27% of the migrants, while the environment or physical amenities were important to 42%. From another survey, they found out that the presence of wilderness in particular is an important reason why 53% of the people move to or live in the area and 81% felt that wilderness areas are important to their counties (Rudzitis and Johansen 1991). Sixty-five percent were against mineral or energy development in wilderness areas, but 43% wanted
Table 1. Percent county population change in the U.S. West, 1960-1990

<table>
<thead>
<tr>
<th>Year</th>
<th>Metropolitan</th>
<th>All Nonmetro</th>
<th>Wilderness</th>
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<tr>
<td>1960-1970</td>
<td>17.1</td>
<td>4.3</td>
<td>12.8</td>
</tr>
<tr>
<td>1970-1980</td>
<td>10.6</td>
<td>14.3</td>
<td>31.4</td>
</tr>
<tr>
<td>1980-1990</td>
<td>11.6</td>
<td>3.9</td>
<td>24</td>
</tr>
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</table>

Source: Rudzitis.

more access to wilderness. There were no large differences between counties and regions despite differences in economic and social characteristics. Another wilderness survey, conducted by Snyder et al., discovered that survey respondents opposing wilderness designations were willing to pay more to preserve multiple use than supporters of wilderness were willing to pay to for wilderness designation. Their study also discovered that respondents were less likely to support wilderness as their level of understanding increased regarding the legal definition of wilderness and the types of activities that are and are not allowed in wilderness areas. My study uses actual historical data, which eliminates the common problems associated with interpretations of surveys.

The main objective of the Snyder et al. study was to determine the potential economic impacts of wilderness designations in Utah. While the authors stated there are numerous economic impacts which they could not quantify, they concluded that the future gains from wilderness recreation would be more than offset by losses associated with a decline in activities incompatible with wilderness, depending on the future of current uses. The anticipated losses were in the livestock sector and the mining and minerals sector. They pointed out that wilderness designations could seriously impede
economic development in some areas, depending on alterations to water rights and levels of restrictions placed on adjacent lands in efforts to create buffer zones.

Power pointed out that the economic benefits of wilderness areas not only include increases in recreation revenues, but also in the more difficult to quantify benefits associated with protected water quality, air quality and habitat. My study does not account for these improvements in environmental quality directly, but may capture them indirectly through possible increased visitation or migration to the area, which may affect incomes. These environmental benefits also accrue to sites beyond the wilderness areas themselves. Downstream water quality (and thus downstream habitat for fish) receives benefits, as well as regional air quality. Protected habitat within wilderness areas can help to support off-site wildlife populations. Because my study examines county-level data, it can indirectly capture some of these off-site benefits, but not the benefits received by neighboring counties.

Rasker and Hackman compared income and employment statistics among four wilderness counties (counties with more than 17% wilderness) and three resource-extractive counties (counties with less than 2% wilderness and large percentage of U.S. Forest Service lands used for resource extraction) in Montana. They found that average employment and personal income levels in the wilderness counties from 1969-1992 grew faster than averages in the resource-extractive counties, the rest of the state, and the rest of the country. The poorest performance was seen in the resource-extractive counties. The wilderness counties also showed lower unemployment rates. The growth rates were compared on an index to take into consideration the differences in absolute size of the economies and populations of the regions. My study takes a more complete approach
and examines all counties, with or without wilderness areas or extraction activities, and attempts to thoroughly explain income levels and then determine individual effects of wilderness areas.

Continuing on from the results of the previous study, Rasker and Alexander tried to explain why wilderness counties may experience higher income and employment growth. They analyzed both the economic and demographic trends in the U.S. and Canadian portions of the “Yellowstone to Yukon” region. In the entire U.S. portion of the study region, over 97% of the growth in personal income in the last 25 years has been in industries other than mining, oil and gas development, and logging. The fastest growing sources of income are nonlabor sources, such as retirement and investment income, and a mix of service and professional industries. They claimed that wilderness counties were able to attract these growing sources of income. However, the authors pointed out that economic growth is not the same as sustainable development; many of the growing and diversifying economies have been diminishing the very environmental amenities so said to have brought the growth.

**Econometric Literature**

None of the current economic literature on wilderness was found to have used econometric methods to estimate economic effects of wilderness areas. Unlike previous analyses, the specific purpose of this study is to quantify the influence wilderness lands have had on county-level per capita incomes. The main econometric procedures followed are discussed in Greene, Studenmund, and Griffiths, Hill, and Judge. Because this study uses panel data, supplemental information was retrieved from Markus and from
Hsiao. EViews and GAUSS econometric software were used to perform the analysis, and thus their manuals were quite helpful in determining appropriate techniques.
Panel data sets are used in this study. They possess several major advantages over conventional cross-sectional or time-series data sets. They give a large number of data points, increasing the degrees of freedom and reducing the collinearity among variables, hence improving the efficiency of econometric estimates. More importantly, panel data allow analysis of many economic questions that could not be addressed using cross-sectional or time-series data alone. However, the use of panel data often requires addressing both the heteroscedasticity frequently associated with cross-sectional data, and the autocorrelation often found when using time-series data.

Most of the county-level data were obtained from the Bureau of Economic Analysis’s Regional Economic Information System (REIS) data (BEA). The data used from this system included annual county-level per capita income, population, government expenditures, and industry earnings over the interval 1969 through 1995 for all counties in each state. Unemployment data were retrieved from the Bureau of Labor Statistics (BLS). Land areas were retrieved from the Managed Areas Database, from the Remote Sensing Research Unit of the University of California at Santa Barbara. The land areas used include areas of counties, Indian reservations and wilderness areas, all given in square miles. In addition, information on institutions of higher education was gathered from the Peterson’s college handbooks. The data were entered into a spreadsheet to provide a uniform basis for data entry and manipulation.
Analytical Procedures

The data were prepared for statistical analysis using a spreadsheet program. Each of the variables was entered and matched to specific counties. The data were arranged such that all observations for the same county were listed consecutively through the 27 years. Statistical analyses were performed using the computer program, EViews. The statistical analyses primarily consisted of the estimation of the regression equation designed to explain county-level per capita income, the dependent variable. Each state’s estimation was conducted separately.

The hypothesis to be tested was that each of the independent variables has no discernable impact on the level of per capita income. In general form, the null hypothesis can be stated formally as:

\[(1) \quad H_0: B_i = 0 \]
\[H_1: B_i \neq 0\]

where \(H_0\) is the null hypothesis, and \(H_1\) is the alternative hypothesis. The null hypothesis states that the slope coefficient of any of the independent variables is zero against the alternative hypothesis, which is assumed not equal to zero. If the null hypothesis is rejected for a particular variable, then one can conclude that the variable does have some effect on per capita income with a determined degree of confidence.

The Model

Several variables were chosen to have an influence on per capita income. The following relationship was estimated for each of the chosen six western states:
INCOME = f(YEAR, POP, UNEMPLOY, GOVT, EXTRACT, HITECH, TOURISM, COLLEGE, INDIAN, WILDERNESS)

In a linear relationship, this equation may be rewritten as:

INCOME = \beta_0 + \beta_1 \text{YEAR} + \beta_2 \text{POP} + \beta_3 \text{UNEMPLOY} + \beta_4 \text{GOVT} + \beta_5 \text{EXTRACT} + \beta_6 \text{HITECH} + \beta_7 \text{TOURISM} + \beta_8 \text{COLLEGE} + \beta_9 \text{INDIAN} + \beta_{10} \text{WILDERNESS}

This model sets per capita income as the dependent variable, and includes ten independent variables. As in all econometric studies, estimated coefficients suggest relationships, not causality. However, it is believed in this study that incomes may respond to wilderness, and not vice versa, for several reasons. Determining areas to be designated as wilderness in these states began in the 1960s and 1970s, with most actual designations occurring in the early 1980s. Most of the growth in incomes in wilderness counties has occurred in the late 1970s, the 1980s, and 1990s (Rasker and Hackman). In addition, the format for designating an area as wilderness does not start by a suggestion from a community: designating wilderness is a federal act stemming from the existence of roadless areas. Nor do wilderness designations end by approval from a community: an Act of Congress establishes wilderness areas, and thus community support or opposition to wilderness must be politically directed towards Congress. Thus, it is believed that wilderness may be a proper explanatory variable. Nevertheless, these results do not state causality, but correlation.
Brief descriptions of all variables are included below, with all dollar amounts measured in 1995 dollars. Expected signs of the coefficients on each independent variable are also reported.

**INCOME** = annual average county-level per capita income, in dollars; (this is the dependent variable).

**YEAR** = year, numbered from 1 through 27, to represent years 1969-1995; expected to be positive to account for increases in incomes over time not accounted for by other variables.

**POP** = annual county population per square mile; expected to be positive because of economies of scale.

**UNEMPLOY** = state annual average unemployment rate; expected to be negative to reflect wage responses to supply of labor.

**GOVT** = per capita government expenditures (federal + state + local), measured in thousands of dollars; expected to be positive because of increased services which foster a stronger economy (education, highways, etc.).

**EXTRACT** = percentage of total county earnings from extractive industries (agriculture, mining and logging); expected sign is unknown because employment in mining and logging usually entails high wages, while agricultural jobs are traditionally lower paying.

**HITECH** = percentage of total county earnings from highly-technical industries (electronics and business services); expected to be positive because of the high wages and growth this industry has been experiencing.
TOURISM = percentage of total county earnings from tourism (hotels, eating and drinking establishments, museums and gardens); expected to be negative because traditionally, tourist-related jobs have low wages.

COLLEGE = dummy variable equal to 1 if a two or four-year college exists in the county, equal to 0 otherwise; expected to be positive to reflect the constant supply of an educated labor force.

INDIAN = percentage of county land that is Indian reservation; expected to be negative because Indian reservations are typically areas of depressed economic activity.

WILDERNESS = percentage of county land that is federally designated wilderness: in these states, is mostly U.S. Forest Service land, with some BLM, U.S. Fish and Wildlife, and National Park lands; expected sign is unknown as traditional theory claims negative effects by withdrawing land from development, while recent studies declare positive effects through increased environmental amenities.

Econometric Issues

The estimation method of ordinary least squares (OLS) is considered the best (minimum variance) linear unbiased estimator (BLUE) available for regression models given certain classical assumptions. When one or more of the assumptions do not hold, other estimation techniques may be better than OLS. The classical assumptions are (i) the regression model is linear in the coefficients and the error term, (ii) the error term has a zero population mean, (iii) all explanatory variables are uncorrelated with the error.
term, (iv) observations of the error term are uncorrelated with each other (no autocorrelation), (v) the error term has a constant variance (no heteroscedasticity), (vi) no explanatory variable is a perfect linear function of other explanatory variables (no perfect multicollinearity), and (vii) the error term is normally distributed (however, this assumption is optional).

The first two assumptions likely are met in this study. Whether the assumptions of no multicollinearity, no autocorrelation, and no heteroscedasticity are met will be discussed in the following chapter, but details concerning these issues follow below.

**Multicollinearity**

Multicollinearity is the violation of the assumption that no independent variable is a perfect linear function of one or more other independent variables. While perfect linearity is clearly intolerable, variables that are highly correlated still cause problems. This imperfect multicollinearity makes difficult the singling out of an effect of a change in one variable while holding all others constant. Thus, explanatory variables' individual effects cannot be isolated and the corresponding parameter magnitudes cannot be determined with the desired degree of precision. However, even if imperfect multicollinearity exists, the estimates of the coefficients will remain unbiased, but their variances will increase, and thus their computed t-statistics will fall.

Multicollinearity can be identified by examining the correlation coefficients between pairs of explanatory variables. The correlation coefficients can indicate linear associations amongst the variables. It is calculated as follows:
\[ r_{xy} = \frac{s_{xy}}{(s_x \cdot s_y)} \]

where \( s_{xy} \) is the covariance between variable \( x \) and variable \( y \), and \( s_i \) is the standard deviation for variable \( i \). A correlation coefficient between two variables of at least 0.8 or 0.9 is commonly used as an indication of a strong linear association and a potentially harmful collinear relationship (Griffiths, Hill, and Judge).

Multicollinearity may also be detected by a calculated variance inflation factor (i.e., VIF). This method detects the severity of multicollinearity by looking at the extent to which a given explanatory variable can be explained by all the other explanatory variables in the equation.

\[ \text{VIF}(B_i) = \frac{1}{(1 - R_i^2)} \]

where \( R_i^2 \) is the unadjusted \( R^2 \) from a regression of \( X_i \) as a function of all the other independent variables in the equation. A common rule is that if \( \text{VIF}(B_i) > 5 \), then multicollinearity is severe; some even suggest using \( \text{VIF}(B_i) > 10 \) when there are many independent variables (Studenmund).

**Autocorrelation**

When using time-series data, oftentimes different observations of the error term are correlated with each other. In the presence of autocorrelation, OLS estimates are still consistent and unbiased, but are no longer efficient. In addition, OLS estimates of the variances of the coefficients are underestimated. Thus, hypothesis testing is unreliable in the face of uncorrected autocorrelation.
The most commonly assumed kind of autocorrelation is first-order serial correlation in which the current observation of the error term is a function of the previous:

\[ \varepsilon_t = \rho \varepsilon_{t-1} + u_t \]

where \( \varepsilon \) is the error term, \( \rho \) is the parameter, called the first-order autocorrelation coefficient, depicting the functional relationship between observations of the error term, and \( u \) is a classical (nonserially correlated) error term. The value of \( \rho \) approaches one in absolute value if the value of the previous observation of the error term becomes increasingly important in determining the current value of the error term. If there is no autocorrelation, then \( \rho \) is zero.

The Breusch-Godfrey Lagrange Multiplier (LM) test may be used to test for autocorrelation. The test statistic is computed by an auxiliary regression as follows. Suppose the regression:

\[ Y_t = X_t b + e_t \]

was estimated, where \( e \) is the residuals. Then the test statistic for order \( p \) is based on the regression:

\[ e_t = \gamma X_t + \alpha_1 e_{t-1} + \alpha_2 e_{t-2} + \ldots + \alpha_p e_{t-p} + \nu_t \]

The LM statistic is computed as the number of observations, times the R-squared from the test regression. This is generally asymptotically distributed as a \( \chi^2(p) \).
**Heteroscedasticity**

Heteroscedasticity often occurs in data sets in which there is a wide disparity between the largest and smallest values. It is expected that the error terms for large observations might have larger variances than those from smaller observations. Thus, in the presence of heteroscedasticity, the variance of the distribution of the error term depends on exactly which observation is being discussed:

(9)

$$VAR(\varepsilon_i) = \sigma_i^2 \quad (i = 1,2,...,n)$$

When observations of the error term do not have constant variance, the OLS estimator is still unbiased, yet is no longer the minimum variance estimator. Heteroscedasticity also causes OLS to underestimate the variances of the coefficients, thus causing higher t-scores than would be obtained if the error terms were homoscedastic, sometimes causing a rejection of a null hypothesis that should not be rejected.

The White’s test is commonly used to test the presence of heteroscedasticity. It is a test of the null hypothesis of no heteroscedasticity against heteroscedasticity of unknown form. The test statistic is computed by regressing the squared residuals on all possible unique cross products of the regressors. The White’s test statistic is asymptotically distributed as a $\chi^2$ with degrees of freedom equal to the number of slope coefficients (excluding the constant) in the test regression.
In the next section regression results are documented. A few statistics are included with regression results. These include standard errors, t-statistics, and the R-squared and F-statistics. These are briefly explained below.

**Standard Errors**

These figures measure the variability of the coefficients. The standard error is the estimate of the square root of the variance on the distribution of the coefficients. The larger the standard error, the more the estimates of the coefficients will vary. The larger the sample size, the more precise the coefficient estimates will be, and thus the smaller the standard errors will be.

**t-Statistics**

Once standard errors are computed, t-statistics can be formed to test the hypotheses that the coefficients are significantly different from zero. The larger in absolute value the t-statistic is, the greater the likelihood that the estimated regression coefficient is significantly different from zero. A result must be declared insignificant if a t-statistic is below the critical t-value, which is selected from a t-table and depends on the chosen level of significance. The level of significance indicates the probability of observing an estimated t-statistic greater than the critical t-value if the null hypothesis of insignificance was indeed correct. A 5% level of significance can be stated as a 95% level of confidence that the alternative hypothesis (significance) is correct.

**R-Squared**

Also called the coefficient of determination, R-squared measures the fit of the
regression equation to the actual data. The R-squared will be a number between zero and one; the higher the R-squared, the closer the estimated regression equation fits the sample data. An adjusted R-squared is also given to adjust the R-squared for the degrees of freedom.

*F-Statistic*

While the t-test is invaluable for hypotheses about individual regression coefficients, it cannot test hypotheses about more than one coefficient at a time. The R-squared and adjusted R-squared measure the overall fit of an equation, but do not provide a formal hypothesis test of the level of significance of that overall fit. Such a test is provided by the F-test. The larger the F-statistic, the higher the level of significance of the overall fit of the equation. A result must be declared insignificant if an F-statistic is below the critical value, which is selected from a table and depends on the chosen level of significance.
Preliminary Results

The following linear regression equation was estimated for each of the chosen six western states:

\( \text{INCOME} = \beta_0 + \beta_1 \text{YEAR} + \beta_2 \text{POP} + \beta_3 \text{UNEMPLOY} + \beta_4 \text{GOVT} + \beta_5 \text{EXTRACT} + \beta_6 \text{HITECH} + \beta_7 \text{TOURISM} + \beta_8 \text{COLLEGE} + \beta_9 \text{INDIAN} + \beta_{10} \text{WILDERNESS} \)  

During the initial analysis, OLS was the regression estimator used. Results from the regressions of this equation for the six states are found in Table 2 and are discussed below.

The R-squared values for the OLS regressions are all at least 0.74, which suggests that at least 74% of the variation in per capita incomes can be explained by the independent variables included in the model. A 5% probability level was used for the null hypothesis that \( \beta_i = 0 \).

Each independent variable will now be examined. No important meaning is extracted from the values given to the intercepts for each state in this case.

\textbf{YEAR:} Values for this variable ranged from 441 in Utah to 668 in Colorado. This amount is the average amount that per capita incomes are annually increasing in these states aside from that which is explained by the variations in the other explanatory variables.
Table 2. Independent variables and their coefficients for the initial OLS regression estimation

<table>
<thead>
<tr>
<th>Variable</th>
<th>Utah</th>
<th>Colorado</th>
<th>New Mexico</th>
<th>Arizona</th>
<th>Idaho</th>
<th>Wyoming</th>
</tr>
</thead>
<tbody>
<tr>
<td>PopDensity</td>
<td>0.411 0.103 1.234 5.766 2.438 19.403</td>
<td>0.411 0.103 1.234 5.766 2.438 19.403</td>
<td>0.411 0.103 1.234 5.766 2.438 19.403</td>
<td>0.411 0.103 1.234 5.766 2.438 19.403</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unemploy</td>
<td>**-68.874 -222.211 **-62.564 **-144.601 **-138.909 **-76.511</td>
<td>46.200 50.401 47.347 77.290 44.255 46.557</td>
<td>46.200 50.401 47.347 77.290 44.255 46.557</td>
<td>46.200 50.401 47.347 77.290 44.255 46.557</td>
<td>46.200 50.401 47.347 77.290 44.255 46.557</td>
<td></td>
</tr>
<tr>
<td>College</td>
<td>-446.368 **-19.344 272.036 1159.355 605.689 **148.763</td>
<td>139.517 128.783 134.347 379.971 208.022 179.575</td>
<td>139.517 128.783 134.347 379.971 208.022 179.575</td>
<td>139.517 128.783 134.347 379.971 208.022 179.575</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

R2        | 0.887 0.858 0.882 0.746 0.823 0.920 |
Adjusted R2| 0.886 0.858 0.880 0.739 0.821 0.919 |
F-statistic| 605.948 1024.074 636.123 107.659 547.200 703.620 |

Notes: Dependent variable is per capita income; numbers below coefficients are standard errors; ** denotes insignificance at the 5% probability level; number of years of observations is 27; number of counties of 27 observations are 29, 63, 32, 14, 44, 23 for the states of Utah, Colorado, New Mexico, Arizona, Idaho, and Wyoming, consecutively.
**POP:** All states experienced increasing per capita incomes as population densities increased. Thus, economies of scale appear to be in the states. This also may reflect the higher costs of living associated with living in urban areas. Colorado and Utah encountered the smallest increases in incomes for increases in population densities, while Wyoming experienced significant increases when densities were greater. In counties in Colorado, per capita incomes increased by just $1 annually for every person per square mile, whereas per capita incomes increased by $101 for each person per square mile in counties of Wyoming. The coefficient was statistically insignificant for counties in Arizona.

**UNEMPLOY:** All states also shared a common response in per capita incomes to unemployment levels. When unemployment levels rose, incomes fell. Thus, in this case, unemployment was a good business cycle indicator, indicating how the economy is performing overall. During stages in the economy where unemployment rose and there were more workers than employment opportunities, incomes fell. Colorado was seen to respond the most to this variable, with incomes decreasing by $222 annually for every 1% increase in the unemployment rate. Incomes in Arizona and Idaho fell by $144 and $138, respectively. The coefficients for Utah, New Mexico, and Wyoming were all insignificant.

**GOVT:** Government expenditures were seen to affect incomes in a positive way in Utah, New Mexico, Arizona, and Idaho by annual increases of $175, $565, $445, and $338, respectively, per thousand dollars of government expenditures, while they decreased incomes by $336 in Colorado. In Arizona, the coefficient was insignificant.
EXTRACT: These coefficients were positive for all states. Incomes in Utah, Colorado, New Mexico, Arizona, Idaho, and Wyoming increased by $16, $57, $56, $51, $50, and $87, respectively, for every percentage increase in revenues from extractive industries (holding revenues from highly technical industries and tourism constant). Thus, incomes were much higher in Wyoming when a larger portion of earnings came from extractive industries than in Utah.

HITECH: These coefficients were positive across all states, except in Idaho, where they were insignificant. Incomes in Utah, Colorado, New Mexico, Arizona, and Wyoming increased by $178, $611, $149, $366, and $279, respectively, for every percentage increase in revenues from highly technical industries (holding revenues from extractive and tourism constant). Colorado is seen to have the greatest positive impact from highly technical industries, with New Mexico having the least.

TOURISM: These values also were positive across all states, except Arizona, where they were insignificant. Incomes in Utah, Colorado, New Mexico, Idaho, and Wyoming increased by $153, $105, $150, $161, and $537, respectively, for every percentage increase in revenues from tourism (holding revenues from extractive and highly technical industries constant). Wyoming experienced the greatest impact from tourism, while Colorado experienced the least.

COLLEGE: These coefficients varied greatly. They were positive in New Mexico, Arizona, and Idaho, negative in Utah, and insignificant in Colorado and Wyoming. Incomes in New Mexico, Arizona, and Idaho increased by $272, $1159, and $605, respectively, by the presence of a two- or four-year college, while in Utah, incomes decreased by $446 by the presence.
INDIAN: Counties with larger areas occupied by Indian reservation generally had lower per capita incomes. This occurred in all states except for New Mexico and Idaho. Incomes in Utah, Colorado, Arizona, and Wyoming decreased by $19, $15, $4, and $47, respectively, for every percentage of a county's land that is occupied by Indian reservations. This is as theory suggests, as Indian reservations are usually areas of depressed economic activity. However, incomes in New Mexico and Idaho increased by $20 and $23 for every percentage of land in a county that is occupied by an Indian reservation.

WILDERNESS: In half of the states, wilderness areas had a positive relationship with income, while in the other half, the coefficients were insignificant. In Utah, Colorado, and Idaho, incomes increased by $211, $91, and $23 for every percentage of land in a county that was designated as wilderness. In no state was the coefficient negative. The largest coefficient was obtained in Utah. However, it must be noted that a special case exists in Utah, which will be furthered explained below.

Preliminary Results for the Case of Utah

In Utah, several million acres of proposed wilderness areas are currently being debated. They are not managed as official wilderness areas, but receive some type of interim management scheme, which involves varying restrictions. These proposed lands were not included in this study also because there exist different proposals, each with different acreage, that have changed through time and each with different management schemes. Thus, considering proposed wilderness proved to be too complex an undertaking for the scope of this study. However, a separate regression was run for Utah.
with a dummy variable added for an urban area (county with a population over 100,000) and another variable added for an urban wilderness area (urban variable multiplied by wilderness variable). The results from this regression are displayed in Table 3.

The addition of the two urban variables changed the results slightly from the original OLS regression. The R-squared increased from .8870 to .8899.

YEAR: This coefficient increased from $441 to $447.

POP: increased from $2 to $3.

UNEMPLOY: remained insignificant.

GOVT: decreased from $175 to $134.

EXTRACT: increased from $16 to $19.

HITECH: increased from $178 to $195.

TOURISM: decreased from $153 to $150.

COLLEGE: decreased from -$446 to -$504

INDIAN: decreased from -$19 to -$20.

WILDERNESS: increased from $211 to $234.

URBAN: This coefficient was positive, but insignificant.

URBANWILDERNESS: This coefficient was -$391.

The result of the WILDERNESS coefficient, coupled with the result of the URBANWILDERNESS coefficient, suggests that if an urban county contains some wilderness, incomes will decrease by a combined effect of $391 - $234 = $157 per percentage land designated as wilderness. Rural county incomes will increase by $243 per percentage land designated as wilderness. The other results are very similar to previous results, and remained as previously explained in the OLS results.
Table 3. Independent variables and their coefficients for the OLS regression estimations for Utah, including urban variables

<table>
<thead>
<tr>
<th>Variable</th>
<th>OLS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>1077.745</td>
</tr>
<tr>
<td></td>
<td>367.602</td>
</tr>
<tr>
<td>Year</td>
<td>448.455</td>
</tr>
<tr>
<td></td>
<td>8.969</td>
</tr>
<tr>
<td>PopDensity</td>
<td>3.708</td>
</tr>
<tr>
<td></td>
<td>0.655</td>
</tr>
<tr>
<td>Unemploy</td>
<td>**-67.615</td>
</tr>
<tr>
<td></td>
<td>45.689</td>
</tr>
<tr>
<td>GovtExp</td>
<td>134.343</td>
</tr>
<tr>
<td></td>
<td>59.531</td>
</tr>
<tr>
<td>Extractive</td>
<td>19.663</td>
</tr>
<tr>
<td></td>
<td>5.004</td>
</tr>
<tr>
<td>Hitech</td>
<td>195.542</td>
</tr>
<tr>
<td></td>
<td>32.077</td>
</tr>
<tr>
<td>Tourism</td>
<td>150.164</td>
</tr>
<tr>
<td></td>
<td>15.311</td>
</tr>
<tr>
<td>College</td>
<td>**-504.965</td>
</tr>
<tr>
<td></td>
<td>139.653</td>
</tr>
<tr>
<td>IndianRes</td>
<td>**-20.932</td>
</tr>
<tr>
<td></td>
<td>2.998</td>
</tr>
<tr>
<td>Wilderness</td>
<td>234.547</td>
</tr>
<tr>
<td></td>
<td>25.268</td>
</tr>
<tr>
<td>Urban</td>
<td>**402.774</td>
</tr>
<tr>
<td></td>
<td>249.952</td>
</tr>
<tr>
<td>UrbanWilderness</td>
<td>**-391.421</td>
</tr>
<tr>
<td></td>
<td>99.032</td>
</tr>
</tbody>
</table>

R2                | 0.890     |
Adjusted R2       | 0.888     |
F statistic       | 518.643   |

Notes: Dependent variable is per capita income; numbers below coefficients are standard errors; ** denotes insignificance at the 5% probability level; number of years of observations is 27; number of counties of 27 observations is 29.
Tests for Multicollinearity, Autocorrelation, and Heteroscedasticity

Tests were run concerning multicollinearity, autocorrelation, and heteroscedasticity, and, where possible, adjustments were made. A discussion of these adjustments follows.

The correlation coefficients were examined to detect any presence of multicollinearity among the variables. A correlation coefficient between two variables of at least 0.8 or 0.9 is commonly used as an indication of a strong linear association. Only in two instances out of 270 were correlation coefficients above 0.8 found. In the data from Utah, the correlation coefficient was 0.816 for wilderness and tourism. In the data from Arizona, the correlation coefficient was 0.850 for population density and highly technical industries. VIFs were then calculated and only Wyoming contained any VIFs greater than the suggested critical level of 5. A VIF of 5.038 was calculated for the year variable and VIF of 6.390 was calculated for government expenditures.

Remedies for multicollinearity include doing nothing, dropping the multicollinear variables, and transforming the variables. It was decided to do nothing for several reasons. Doing nothing is often used as a remedy for multicollinearity because other solution methods often cause other problems for the equation. In addition, multicollinearity in an equation will rarely alter results significantly. It is said that a remedy for multicollinearity should only be considered if and when the consequences cause insignificant t-scores or unreliable estimated coefficients. Also, the two correlation coefficients were below 0.9, and none of the multicollinear relationships were found to be significant under both tests.
The Breusch-Godfrey LM statistics showed evidence of autocorrelation. This is not surprising since autocorrelation is common when using time series data. Remedies for autocorrelation include checking the specification (changing the functional form or correcting for omitted variables) or applying the use of generalized least squares (GLS). GLS is a method of ridding an equation of the autocorrelation, and in the process restoring the minimum variance property to its estimation. The GLS method takes the original equation:

\[ Y_t = B X_t + \epsilon_t \]

and inserting equation (4), the first-order autocorrelation equation \( \epsilon_t = \rho \epsilon_{t-1} + u_t \):

\[ Y_t = B X_t + \rho \epsilon_{t-1} + u_t \]

which can be rewritten as:

\[ \rho Y_{t-1} = \rho B X_{t-1} + \rho \epsilon_{t-1} \]

and can be transformed once again to be stated in terms of \( u_t \), the nonserially correlated error term:

\[ Y_t - \rho Y_{t-1} = B(X_t - \rho X_{t-1}) + u_t \]

The nature of the autocorrelation in this study was detected to be of first order and the \( \rho_i \) for each county in each state were estimated according to the Cochrane-Orcutt method. Then, data were adjusted so that:
Now, the data are adjusted to account for the serially correlated errors, and the minimum variance property is restored to the estimation.

Heteroscedasticity was detected across cross-sections (counties) in each state.

When heteroscedasticity is detected, it is recommended to use a weighted least squares estimation technique or return to the basic underlying theory of the equation and redefine the variables in a way that avoids heteroscedasticity. However, it is the nature of the data to vary in levels across cross-sections, and thus in cross-sectional heteroscedasticity, it is difficult to find variables that will have constant variances across crosssections. Thus, a weighted least squares estimation technique was chosen to remedy the heteroscedasticity.

The econometric software program EViews offers both a cross section weighted feasible generalized least squares (FGLS) estimation or a seemingly unrelated regression (SUR) estimation to remedy heteroscedasticity in panel data. The SUR technique is the proper method to use in the additional presence of autocorrelation, however, it requires more years of data than crosssections, which most do not have. Thus, the FGLS estimation method was used. The FGLS estimated variances are computed as:

\[
\sigma_i^2 = \frac{\sum_{t=1}^{T_i} (y_{it} - \hat{y}_{it})^2}{T_i}
\]

where \(\hat{y}_{it}\) are the OLS fitted values, and \(t\) is the year, with \(T\) total years. The estimated coefficients values and covariance matrix are given by the standard GLS estimator.
Revised Results

The equation was reestimated by a FGLS estimation using the data adjusted for autocorrelation. The regression results are displayed in Table 4.

The R-squared values in the FGLS regressions are all at least .959, which suggests that more than 95% of the variation in per capita incomes can be explained by the independent variables included in the model. A confidence level of 95% was used for the null hypothesis that $B_i = 0$. Very few t-statistics are insignificant; none are continually insignificant across several states.

Each independent variable will now be examined. No important meaning is extracted from the values given to the intercepts in each state in this case.

YEAR: Values for this variable ranged from 429 in Utah to 686 in Colorado. This amount is the average amount that per capita incomes are annually increasing in these states, aside from that which is explained by the variations in the other explanatory variables.

POP: All states experienced increasing per capita incomes as population densities increased. Thus, there appears to be economies of scale at work here. This also may reflect the higher costs of living associated with living in urban areas. Utah encountered the smallest increase in incomes per density ($3 per person per square mile), while Wyoming experienced the most significant increases when densities were greater ($115 per person per square mile). Values for Colorado, New Mexico, Arizona, and Idaho are $8, $14, $25, and $13, respectively.

UNEMPLOY: All states also shared a common response in per capita incomes to unemployment levels. When unemployment levels rose, incomes fell. Thus, in this case,
Table 4. Independent variables and their coefficients for the adjusted FGLS regression estimation

<table>
<thead>
<tr>
<th>Variable</th>
<th>Utah</th>
<th>Colorado</th>
<th>New Mexico</th>
<th>Arizona</th>
<th>Idaho</th>
<th>Wyoming</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>488.545</td>
<td>-438.323</td>
<td>**-69.053</td>
<td>745.683</td>
<td>344.861</td>
<td>-2291.979</td>
</tr>
<tr>
<td>Year</td>
<td>429.214</td>
<td>686.504</td>
<td>482.704</td>
<td>563.569</td>
<td>536.171</td>
<td>562.243</td>
</tr>
<tr>
<td>Unemploy</td>
<td>-61.283</td>
<td>-62.030</td>
<td>**-13.492</td>
<td>-41.781</td>
<td>-86.316</td>
<td>**-85.050</td>
</tr>
<tr>
<td>GovtExp</td>
<td>495.042</td>
<td>-518.836</td>
<td>510.757</td>
<td>-220.995</td>
<td>89.931</td>
<td>1284.339</td>
</tr>
<tr>
<td>Extractive</td>
<td>34.807</td>
<td>54.682</td>
<td>39.712</td>
<td>17.557</td>
<td>38.261</td>
<td>79.546</td>
</tr>
<tr>
<td>Hitech</td>
<td>87.717</td>
<td>258.196</td>
<td>**10.092</td>
<td>-97.552</td>
<td>10.071</td>
<td>326.305</td>
</tr>
<tr>
<td>Tourism</td>
<td>88.679</td>
<td>73.196</td>
<td>22.454</td>
<td>1.382</td>
<td>148.588</td>
<td>432.850</td>
</tr>
<tr>
<td>College</td>
<td>29.781</td>
<td>-35.132</td>
<td>-43.294</td>
<td>82.188</td>
<td>394.512</td>
<td>-238.890</td>
</tr>
<tr>
<td>Wilderness</td>
<td>107.743</td>
<td>85.929</td>
<td>**4.834</td>
<td>55.555</td>
<td>4.906</td>
<td>**-12.094</td>
</tr>
<tr>
<td>R2</td>
<td>0.968</td>
<td>0.959</td>
<td>0.967</td>
<td>0.980</td>
<td>0.977</td>
<td>0.965</td>
</tr>
<tr>
<td>Adjusted R2</td>
<td>0.968</td>
<td>0.959</td>
<td>0.966</td>
<td>0.979</td>
<td>0.976</td>
<td>0.965</td>
</tr>
<tr>
<td>F-statistic</td>
<td>2272.650</td>
<td>3794.547</td>
<td>2372.130</td>
<td>1723.168</td>
<td>4728.983</td>
<td>1626.450</td>
</tr>
</tbody>
</table>

Notes: Dependent variable is per capita income; numbers below coefficients are standard errors; ** denotes insignificance at the 5% probability level; number of years of observations is 27; number of counties of 27 observations are 29, 63, 32, 14, 44, 23 for the states of Utah, Colorado, New Mexico, Arizona, Idaho and Wyoming, consecutively.
unemployment was a good business cycle indicator, indicating how the economy is performing overall. During stages in the economy where unemployment rose and there were more workers than jobs available, incomes fell. Idaho and Wyoming were seen to respond the most to this variable, with incomes decreasing by $86 and $85 for every unit increase in the unemployment rate. New Mexico’s incomes responded the least, with incomes decreasing by $13 for increases in the unemployment rate. Values for Utah, Colorado, and Arizona were -$61, -$62, and -$41, respectively.

**GOVT:** Varying responses to government expenditures were seen across states. Colorado and Arizona experienced lower per capita incomes by $518 and $220 for every thousand dollars spent by the government. All other states experienced higher incomes with more government expenditures, with Wyoming experiencing the greatest impact of $1284. Utah, New Mexico, and Idaho experienced income increases of $495, $510, and $89, respectively, for every thousand dollars spent by the government. These variations may be caused by the grouping together of all expenditures (federal, state, and local) without distinguishing between sector allocations (transfer payments such as unemployment or farm support, education, highways, etc.). Thus, if one state allocates a large portion of its expenditures to income-support programs, then it would be expected that incomes would be lower than in states where a larger portion of expenditures was allocated to education or highways. In addition, stronger or more diverse economies may have government sectors which play minor roles in the overall economy.

**EXTRACT:** These coefficients were positive in all states. Incomes in Utah, Colorado, New Mexico, Arizona, Idaho, and Wyoming increased by $34, $54, $39, $17, $38, and $79, respectively, for every percentage increase in revenues from extractive
industries (holding revenues from highly technical industries and tourism constant). Thus, incomes were higher in Wyoming when a larger portion of earnings came from extractive industries than in Arizona.

**HITECH:** These coefficients were positive in all states, except in Arizona, where they were negative, and in New Mexico, where they were insignificant. Incomes in Utah, Colorado, Idaho, and Wyoming increased by $87, $258, $10, and $326, respectively, for every percentage of revenues attributable to highly technical industries (holding revenues from extractive and tourism constant). Thus, Wyoming is seen to have the greatest positive impact from highly technical industries, with Idaho having the least.

**TOURISM:** These values were positive across all states. Incomes in Utah, Colorado, New Mexico, Arizona, Idaho, and Wyoming increased by $88, $73, $22, $1, $148, and $432, respectively, for every percentage of revenues coming from tourism. Wyoming incomes experienced the greatest impact from tourism, while Arizona incomes experienced the least.

**COLLEGE:** This variable gave the most inconsistent results. The existence of a two- or four-year college affected incomes positively in Idaho by $394 and negatively in Wyoming by $238. Coefficient values in Utah, Colorado, New Mexico, and Arizona were $29, -$35, -$43, and $82, respectively. This variable was chosen to represent a constant supply of an educated labor force. Where the coefficients are positive, it is believed that this is what the variables represent, and that businesses with higher paying jobs desire to locate around an educated labor force. However, it was discovered that the Census Bureau includes the entire studentbody when calculating populations. Therefore, in some counties where students make up a large percentage of the county population,
average incomes will be lower because a significant portion of the population does not work full time. Thus, it is believed that this variable will depend on the demographic characteristics by county.

**INDIANRES:** In all states except Idaho, counties with larger areas occupied by Indian reservation had lower per capita incomes. Incomes in Utah, Colorado, New Mexico, Arizona, and Wyoming decreased by $7, $25, $54, $15, and $37, respectively, for every percentage of a county’s land that is occupied by Indian reservations. This is as theory suggests, as Indian reservations are usually areas of depressed economic activity. However, incomes in Idaho increased by $20 for every percentage of land in a county that is occupied by an Indian reservation. In Idaho, Indian reservations are located in much more populated areas than in the other states.

**WILDERNESS:** In four states this coefficient was positive and in two states (New Mexico and Wyoming) it was insignificant. In no states was it negative and significant. In Utah, Colorado, Arizona, and Idaho, incomes increased by $107, $85, $55, and $4 for every percentage of land in a county that was designated as wilderness. The largest coefficient was obtained in Utah. However, it must be noted again that a special situation exists in Utah, which will be furthered explained below.

**Revised Results for the Case of Utah**

As previously stated, it was decided to run an additional regression for the state of Utah, with a dummy variable added for an urban area (county with a population over 100,000) and another multiplicative variable added for an urban wilderness area (urban variable multiplied by wilderness variable). The results from this regression estimated by
FGLS with the adjusted data are displayed in Table 5. The same econometric procedures were used to address the problems of autocorrelation and heteroscedasticity.

The addition of the two urban variables changed results slightly from the previous FGLS regression. The R-squared decreased only slightly from .9683 to .9680.

YEAR: This coefficient decreased from $429 to $425.
POP: remained close to $3.
UNEMPLOY: decreased from -$61 to -$62.
GOVT: increased from $495 to $501.
EXTRACT: increased from $34 to $35.
HITECH: decreased from $87 to $82.
TOURISM: increased from $88 to $91.
COLLEGE: changed from $29 and significant to insignificant.
INDIAN: increased from -$7 to -$6.
WILDERNESS: increased from $107 to $111.
URBAN: This coefficient was $143.
URBANWILDERNESS: This coefficient was insignificant.

The result of the URBAN dummy variable suggests that if a county contained a population of over 100,000 people, incomes would, on average, be higher by $143.

There appeared to be no difference in effects between wilderness areas in urban counties and in rural counties. The results of the other coefficients are very similar to previous results, and remain as explained in the FGLS results.
Table 5. Independent variables and their coefficients for the adjusted FGLS regression estimations for Utah, including urban variables

<table>
<thead>
<tr>
<th>Variable</th>
<th>Corrected FGLS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>505.921</td>
</tr>
<tr>
<td></td>
<td>142.061</td>
</tr>
<tr>
<td>Year</td>
<td>425.948</td>
</tr>
<tr>
<td></td>
<td>4.908</td>
</tr>
<tr>
<td>PopDensity</td>
<td>3.140</td>
</tr>
<tr>
<td></td>
<td>0.225</td>
</tr>
<tr>
<td>Unemploy</td>
<td>-62.302</td>
</tr>
<tr>
<td></td>
<td>11.039</td>
</tr>
<tr>
<td>GovtExp</td>
<td>501.984</td>
</tr>
<tr>
<td></td>
<td>25.403</td>
</tr>
<tr>
<td>Extractive</td>
<td>35.977</td>
</tr>
<tr>
<td></td>
<td>3.008</td>
</tr>
<tr>
<td>Hitech</td>
<td>82.252</td>
</tr>
<tr>
<td></td>
<td>9.902</td>
</tr>
<tr>
<td>Tourism</td>
<td>91.038</td>
</tr>
<tr>
<td></td>
<td>24.142</td>
</tr>
<tr>
<td>College</td>
<td>**-0.855</td>
</tr>
<tr>
<td></td>
<td>15.412</td>
</tr>
<tr>
<td>IndianRes</td>
<td>-6.919</td>
</tr>
<tr>
<td></td>
<td>2.036</td>
</tr>
<tr>
<td>Wilderness</td>
<td>111.260</td>
</tr>
<tr>
<td></td>
<td>44.393</td>
</tr>
<tr>
<td>Urban</td>
<td>143.399</td>
</tr>
<tr>
<td></td>
<td>15.816</td>
</tr>
<tr>
<td>UrbanWilderness</td>
<td>**8.686</td>
</tr>
<tr>
<td></td>
<td>50.115</td>
</tr>
<tr>
<td>R2</td>
<td>0.968</td>
</tr>
<tr>
<td>Adjusted R2</td>
<td>0.968</td>
</tr>
<tr>
<td>F statistic</td>
<td>1869.340</td>
</tr>
</tbody>
</table>

Notes: Dependent variable is per capita income; numbers below coefficients are standard errors; ** denotes insignificance at the 5% probability level; number of years of observations is 27; number of counties of 27 observations is 29.
Comparison of OLS and FGLS Results

The OLS estimation regresses $Y$ on $X$, whereas the FGLS regresses $Y_{it}^*$ (which equals $Y_{it} - \rho_t Y_{it-1}$) on $X_{it}^*$ (which equals $X_{it} - \rho_t X_{it-1}$). Thus, the adjusted FGLS estimates of the slope coefficients often differ slightly from the OLS ones, in addition to the more reliable t-statistics. These differences are explained below.

Out of sixty total coefficients (for ten variables across six states), twelve variables were insignificant in the OLS regression, while only three were insignificant in the FGLS regression. Almost all coefficients changed values at least slightly. Only in five of the coefficients did the values change signs and remain significant. This occurred for the COLLEGE coefficient in Utah (from negative to positive) and New Mexico (from positive to negative), for the INDIAN coefficient in New Mexico (from positive to negative), and for the HITECH and GOVT coefficients in Arizona (both from positive to negative).

The overall R-squareds increased in the revised FGLS estimations. The lowest R-squared from the OLS estimation was .7458, while the lowest in the FGLS was .9589.

Elasticities

Results from the FGLS regressions in all states were used to form elasticities for each of the coefficients in each state, according to the formula:

$$\eta_{Y,x_k} = B_k \ast (X_k / Y)$$

(17)

Mean values of all $X_k$ and $Y$ were used. Table 6 presents the results for all $\eta_{Y,x_k}$. 
Table 6. Income elasticities with respect to relevant variables, evaluated at mean levels

<table>
<thead>
<tr>
<th>Variable</th>
<th>UT</th>
<th>CO</th>
<th>NM</th>
<th>AZ</th>
<th>ID</th>
<th>WY</th>
</tr>
</thead>
<tbody>
<tr>
<td>POPDENS</td>
<td>0.02533</td>
<td>0.01444</td>
<td>0.02427</td>
<td>0.05597</td>
<td>0.02013</td>
<td>0.03734</td>
</tr>
<tr>
<td>UNEMPLOY</td>
<td>-0.03764</td>
<td>-0.02983</td>
<td>-0.01124</td>
<td>-0.02809</td>
<td>-0.05877</td>
<td>-0.03492</td>
</tr>
<tr>
<td>GOVT</td>
<td>0.07553</td>
<td>-0.05916</td>
<td>0.10902</td>
<td>-0.03208</td>
<td>0.01402</td>
<td>0.16985</td>
</tr>
<tr>
<td>EXTRACT</td>
<td>0.06132</td>
<td>0.11706</td>
<td>0.07883</td>
<td>0.02305</td>
<td>0.07948</td>
<td>0.14621</td>
</tr>
<tr>
<td>HITECH</td>
<td>0.01885</td>
<td>0.03892</td>
<td>insig</td>
<td>-0.02147</td>
<td>0.00293</td>
<td>0.03734</td>
</tr>
<tr>
<td>TOURISM</td>
<td>0.03858</td>
<td>0.03349</td>
<td>0.00964</td>
<td>0.00220</td>
<td>0.04650</td>
<td>0.16543</td>
</tr>
<tr>
<td>WILD</td>
<td>0.01210</td>
<td>0.02713</td>
<td>insig</td>
<td>0.02644</td>
<td>0.00139</td>
<td>insig</td>
</tr>
</tbody>
</table>

These values were calculated to better be able to compare the overall influence of each variable on per capita incomes. GOVT variables did not have consistent effects, as discussed earlier, and thus did not have consistent levels of elasticities. Among the consistent effects, elasticities with respect to the EXTRACT variable had the highest average magnitude of influence, with levels of .06, .12, .08, .02, .08, and .15, for Utah, Colorado, New Mexico, Arizona, Idaho, and Wyoming, respectively. TOURISM elasticities were slightly smaller, with values of .04, .03, .01, .002, .05, and .16 for the respective states. UNEMPLOY elasticities were -.03, -.03, -.01, -.03, -.06, and -.03. POP elasticities were .02, .01, .02, .06, .02, and .04 for the respective states. HITECH elasticities were .02, .04, insignificant coefficient (for New Mexico), -.02, .003, and .04 for the respective states. WILD elasticities were .01, .02, insignificant coefficient (for
New Mexico), .03, .001, and insignificant coefficient (for Wyoming) for the same respective states.

While all of the computed elasticities were small, the income elasticity with respect to changes in extractive industries was the highest elasticity computed. Thus, when the mean magnitude of the observations is taken into account along with the level of the estimated coefficient, the EXTRACT variable had the largest influence on per capita incomes. This is attributable to the fact that the average observation of the EXTRACT variable was 18.71, while the averages for TOURISM, HITECH, and WILDERNESS were 5.26, 1.97, and 3.75, respectively.

This finding is helpful when trying to compare the effects of the WILDERNESS variable with the effects of the EXTRACT variable, since the two activities are incompatible at the same location. As stated before, the EXTRACT coefficient was positive across states, while WILDERNESS was positive across all but two, where it was insignificant. The coefficients alone are difficult to compare because WILDERNESS is measured in percentage of acres and EXTRACT is measured in percentage of revenues. While the elasticity results are still comparing percent of revenues to percent of land, they do offer another way to compare results. A table of descriptive statistics, including the mean levels of the variables, is displayed in Table 7.
Table 7. Descriptive statistics

<table>
<thead>
<tr>
<th></th>
<th>Utah</th>
<th>Colorado</th>
<th>New Mexico</th>
<th>Arizona</th>
<th>Idaho</th>
<th>Wyoming</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Means:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Income</td>
<td>8411.78</td>
<td>10908.17</td>
<td>8727.84</td>
<td>9116.36</td>
<td>9328.35</td>
<td>11370.65</td>
</tr>
<tr>
<td>PopDensity</td>
<td>52.57</td>
<td>110.46</td>
<td>25.70</td>
<td>24.97</td>
<td>19.60</td>
<td>4.94</td>
</tr>
<tr>
<td>Unemploy</td>
<td>5.62</td>
<td>5.51</td>
<td>7.91</td>
<td>6.57</td>
<td>6.65</td>
<td>5.17</td>
</tr>
<tr>
<td>Govt</td>
<td>1.40</td>
<td>1.29</td>
<td>1.85</td>
<td>1.47</td>
<td>1.35</td>
<td>1.65</td>
</tr>
<tr>
<td>Extract</td>
<td>15.65</td>
<td>20.03</td>
<td>15.96</td>
<td>13.60</td>
<td>20.59</td>
<td>23.29</td>
</tr>
<tr>
<td>Hitech</td>
<td>1.57</td>
<td>2.09</td>
<td>2.11</td>
<td>2.38</td>
<td>2.11</td>
<td>1.50</td>
</tr>
<tr>
<td>Tourism</td>
<td>3.79</td>
<td>5.57</td>
<td>4.34</td>
<td>18.86</td>
<td>2.83</td>
<td>4.05</td>
</tr>
<tr>
<td>Indian</td>
<td>7.99</td>
<td>1.60</td>
<td>5.18</td>
<td>15.68</td>
<td>5.76</td>
<td>2.78</td>
</tr>
<tr>
<td>Wilderness</td>
<td>0.77</td>
<td>3.30</td>
<td>1.46</td>
<td>4.36</td>
<td>1.65</td>
<td>2.28</td>
</tr>
<tr>
<td><strong>Numbers of:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Counties</td>
<td>29</td>
<td>63</td>
<td>32</td>
<td>14</td>
<td>44</td>
<td>23</td>
</tr>
<tr>
<td>Counties w/college</td>
<td>8</td>
<td>21</td>
<td>17</td>
<td>10</td>
<td>9</td>
<td>8</td>
</tr>
<tr>
<td>Counties w/Indian</td>
<td>12</td>
<td>3</td>
<td>10</td>
<td>9</td>
<td>10</td>
<td>2</td>
</tr>
<tr>
<td>Counties w/wilderness in 1995</td>
<td>13</td>
<td>29</td>
<td>16</td>
<td>13</td>
<td>9</td>
<td>6</td>
</tr>
</tbody>
</table>
CHAPTER V
SUMMARY, CONCLUSION, AND RECOMMENDATION

Summary

The overall purpose of this study was to examine if counties in six of the western states have experienced a detectable economic impact by designating some of their lands as wilderness. The study determined if counties that designated some lands as wilderness experienced a positive, negative, or insignificant economic effect from the designations. The six western states included in the study are Utah, Colorado, New Mexico, Arizona, Idaho, and Wyoming.

The specific objectives were to: (1) identify the determinants of per capita income at a county level; (2) estimate an equation (which contains a wilderness variable) to explain per capita income and test results; and (3) explain the results.

The equation to explain county-level per capita incomes in each of the states is as follows:

(18)

\[ \text{INCOME} = \beta_0 + \beta_1 \text{YEAR} + \beta_2 \text{POP} + \beta_3 \text{UNEMPLOY} + \beta_4 \text{GOVT} + \beta_5 \text{EXTRACT} + \beta_6 \text{HITECH} + \beta_7 \text{TOURISM} + \beta_8 \text{COLLEGE} + \beta_9 \text{INDIAN} + \beta_{10} \text{WILDERNESS} \]

More than 5,500 observations of these ten different variables were gathered and arranged for statistical analysis. The data were stacked in a spreadsheet such that all observations for the same county were listed consecutively. Each state’s data were entered and estimated separately. Adjustments were made in response to autocorrelation and heteroscedasticity.
There are several interesting and important findings from this study, assuming the nature of equation (18) accurately describes the relation between wilderness and per capita income. The results of this analysis indicate that counties that contain federally designated wilderness areas did not experience lower per capita. In fact, counties in Utah, Colorado, Arizona, and Idaho that contained wilderness areas actually experienced higher per capita incomes than counties without. Additional increases in incomes due to wilderness areas may be incurred if the area experiences population density increases. As pointed out by Rudzitis, population densities of counties containing wilderness areas have been increasing at greater percentages than nonwilderness counties, and as the results from this study show, higher population densities translate into higher per capita incomes.

The effects of extractive industries and tourism are consistently positive across all states. In all of the states except New Mexico and Arizona, the increase in per capita income from tourism revenues is larger than the increase from revenues from extractive industries. If a county increased its earnings from extractive industries by 10%, annual per capita incomes would be higher by $348.07, $546.82, $397.12, $175.57, $382.61, and by $795.46 in Utah, Colorado, New Mexico, Arizona, Idaho, and Wyoming, respectively. Holding all other variables constant (this would entail that the increased percentage of economic activity in the extractive sector would come about not by decreasing the percentage of activity in tourism or highly technical industries). Likewise, if a county increased its earnings from tourism by 10%, incomes would increase by $886.79, $731.96, $224.54, $13.82, $1485.88, and $4328.50 in Utah, Colorado, New Mexico, Arizona, Idaho, and Wyoming, respectively. The extractive industries coefficient and the tourism coefficient were both highest in Wyoming, compared to their levels in other
states. However, when elasticities were compared rather than coefficient levels, the elasticity of per capita incomes with respect to changes in all of the explanatory variables examined was highest with respect to extractive industries (except for the year variable).

Unexpectedly, the highly technical industries coefficient was higher than the extractive industries and tourism coefficients only in Colorado. It was expected to be higher in all states because of the high wages and employment growth this sector has experienced. However, their aggregate effects are not large in this case. They do not make up a large portion of economic activity; the total average percentage of all revenues from 1969-1995 from highly technical industries is 1.97, compared to 5.26 from tourism, and 18.71 from extractive industries.

Population densities were shown to affect per capita incomes positively. This is consistent with the theory of economies to scale. This reflects the higher costs of living in urban areas as well. Unemployment rates also consistently displayed results according to theory, that in times when the economy does not offer enough jobs, it also offers lower wages.

There was no uniform effect of government expenditures on per capita incomes. Breaking down the government expenditures according to how they are allocated might offer superior results than lumping them together. The existence of a college also displayed no uniform effect. Using an average educational attainment of the workforce might produce superior results, but as previously mentioned, these types of annual data are not so readily available at the county level.

The presence of Indian reservations had a negative effect on per capita incomes in all states except Idaho. In most states, Indian reservations are generally located in
sparsely populated regions and are areas of low levels of economic activity. It was noticed that in Idaho they are located in areas with higher populations than in the other states examined.

It should be noted that these estimates cannot be interpreted as marginal values. Of course an economy needs a balance, and would at some point experience declining incomes if all of an economy was based on highly technical industries or if all land was designated as wilderness, especially since the all-state average area of a county that is wilderness is currently 3.75%.

Conclusions

This study found no evidence that protecting land as wilderness is detrimental to the economy. When per capita incomes were examined in 205 counties in the West, no decreases in incomes could be attributed to the presence of wilderness areas. In fact, incomes in Utah, Colorado, Arizona, and Idaho increased in the presence of wilderness areas. In addition, incomes in all states studied increased with increases in revenues from tourist-related employment and extractive industries employment.

Unfortunately, comparing the effects of acres of wilderness to the effects of percentage of revenues from extractive industries proves to be a difficult task. Coefficients across states were lower on average for the extractive industry variable than for the tourism industry variable. However, the elasticity of per capita incomes with respect to changes in all of the variables was observed to be highest with respect to extractive industries, as extractive industries comprise a large part of the economies studied.
As previously stated, most of the wilderness areas in this study are located on U.S. Forest Service lands, with some located on BLM, U.S. Fish and Wildlife Service, and National Park lands. Thus, results may be slanted towards results for U.S. Forest Service wilderness. Only time will tell if similar results are experienced on the BLM wilderness lands that will likely be increasing, particularly in Utah. However, as an example, Arizona has forty-six BLM wilderness areas, thirty-six U.S. Forest Service wilderness areas, four U.S. Fish and Wildlife wilderness areas, and four National Park wilderness areas; results in Arizona for the wilderness coefficient were just about at the observed average, at a level of a $55 increase in per capita incomes per percentage of county land designated as wilderness.

As in all econometric studies, estimated coefficients suggest relationships, not causality. As noted earlier, it is believed in this study that incomes may respond to wilderness, and not vice versa, because (1) while wilderness determination began in the 1960s and 1970s, and were essentially complete in the early 1980s, most of the growth in incomes in wilderness counties has occurred in the late 1970s, the 1980s, and the 1990s; (2) the foundation for designating an area as wilderness depends on the existence of roadless areas, not on community suggestion; and (3) wilderness designations require an act of Congress, not just community approval. Thus, it is believed that wilderness may be a proper explanatory variable. Nevertheless, these results do not state causality, but correlation.
Recommendations

Further analysis should be made with respect to the functional form. Linear and multiplicative forms (for Utah) were used in the study, but many other functional forms are available. While providing an adequate fit of the data, both linear and multiplicative forms impose restrictions that may or may not conform to the data.

Improvements could be made in the variables, as previously mentioned. Government expenditures could be separated by type and average education levels could be used instead of the presence of a college. Different variables for extractive industries and wilderness could be constructed in a way that their coefficients could be more meaningfully related. Additional land use variables could be incorporated, such as national forests, national and state parks, recreation areas, etc. This would offer more values to compare and would ensure a more singled out effect of wilderness, instead of the possibility that wilderness effects are due to their proximity to other types of public lands which allow more types of uses.

Finally, additional empirical work needs to be done to test the direction of causality, i.e., whether wilderness designation induces positive changes in per capita income or vice versa. While the former suggests that incomes are a function of wilderness designation, the latter would suggest that higher incomes in an area result in wilderness designation. The policy implications of the direction of causality are very significant in this case.
REFERENCES


