Exploring linkages between people and rural landscapes at broad ecological scales

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\textbf{Abstract}

Effective conservation and management of natural resources requires integrating knowledge of ecological systems with an understanding of the cultural, social and economic characteristics of people who live and work in ecological landscapes. This study explores how people with distinctive social attributes are situated spatially across the landscape at the level of ecological section and subsection in Missouri. We identify prominent (statistically significant) social variables that may have implications for policy making at these two levels. We also examine the composition and spatial distribution of social groups within each level. To do so, we link non-urban, statewide U.S. Census data with units of the Missouri Ecological Classification System. Results show that: (1) education trumps other social variables such as income and employment as the most prominent variable differentiating people by ecological section in Missouri; (2) housing and income also emerge as prominent partitioning variables for people across ecological sections; and (3) social groups tend to be more spatially fragmented in ecological subsections with low physiographic gradients. The findings suggest a variety of research questions for addressing regional policies relative to education and homestead tenure as well as the ecological effects of spatial distributions of people with different social attributes. The findings establish a broad socio-ecological context for natural resource studies at more magnified levels of ecological scale at which more specific hypotheses can be designed and tested. We discuss possible research questions and hypotheses underlying each finding as well as management implications.

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\textbf{1. Introduction}

Effective conservation and management of natural resources requires integrating knowledge of ecological systems with an understanding of the cultural, social and economic characteristics of people who live and work in different ecological settings (Jaret, 1995; Evans and Moran, 2002; Gustafson et al., 2005; Hodgson et al., 2007). Landscapes at different levels of geographic scale comprise a spatial hierarchy with reference to which various kinds of conservation and management actions may be conceived and undertaken (Berkes and Folke, 2000; Soini, 2001). Whether it be the nation as a whole or states for which policies are enacted by political bodies; economic or administrative areas within state boundaries for which plans are formulated (e.g., national or state forests); or local landscapes and sites where specific management activities are implemented; identifying socioeconomic factors at various levels of geographic scale that influence policy making, program planning and design, and management implementation is essential for effective natural resource conservation and management (Mulder and Coppolillo, 2007).

This exploratory study seeks to better understand the interrelationships of people and the landscape by systematically identifying social attributes of people in places at two broad levels of ecological scale. The state of Missouri is the focus for this exercise. Missouri's diverse ecological fabric includes till plains left by retreating glaciers, forested hills of the ancient Ozark mountains, the eastern edge of the Great Plains' tallgrass prairie, and the bottomlands of the Mississippi River. Protecting this rich ecological heritage is becoming increasingly difficult, as highlighted in a report by the Brookings Institution (2002) which examined the direction, scope, and implications of development in the state of Missouri. The report concluded that Missouri's current pattern of population growth is: (1) eroding the state's rural heritage; (2) threatening the environment and natural areas; (3) imposing significant costs on communities and taxpayers; and (4) hurting Missouri's competi-
tiveness by eroding its quality of life. One key step in addressing these difficulties is to enhance our understanding of how people with distinctive social attributes are situated spatially across the landscape.

To pursue our objectives, we first classify people using statistical methods into social groups based on their demographic and socioeconomic attributes at two broad levels of an ecological hierarchy—section and subsection (Cleland et al., 1997). In the process we identify prominent (statistically significant) social variables that may have implications for policy making at these two levels. Next, we examine the composition and spatial distribution of social groups within each hierarchical level. Focal questions include: What social attributes are prominent in ecological sections and subsections? Are ecological units characterized by a uniform or diverse array of social groups identified in terms of these attributes and are such groups distributed uniformly across the landscape or in patterns that are spatially fragmented? How might knowledge of the substantive character and spatial distribution of the groups identified in this study enriching context for natural resource management? What avenues of research should be further explored?

This research parallels studies that employ geodemographic segmentation, a multivariate statistical classification technique for discovering whether the individuals of a population fall into different groups by making quantitative comparisons of multiple characteristics (see, for example, Troy, 2008). Such studies thus examine population characteristics set within a spatial context by combining geographic and demographic variables. In this study comparable quantitative classification methods are applied to identifying social groups in ecological settings in terms of socioeconomic and demographic attributes. However, this study expands upon traditional geodemographic segmentation studies in the following ways. First, most of these latter studies delineate the geographic territory via political or administrative boundaries (e.g., county or metropolitan area) as opposed to ecological boundaries (Pebbley, 1998; Theodori and Luloff, 2000; Liu, 2001; Field et al., 2003; Guo et al., 2003; Hammer et al., 2004; Nikodemus et al., 2005). Increasingly, however, more studies are incorporating an ecological classification system (ECS) and utilizing ecological units therein for spatially delineating study areas (Palik et al., 2003; Hawbaker et al., 2005). Secondly, many geographic segmentation studies focus on metropolitan areas and/or their surroundings. Grove et al. (2006), for example, examined whether vegetation structure varied among urban neighborhoods in the city of Baltimore, linking this to whether the motivations and actions for vegetation management varied among households and communities.

The geographic/ecological area of this study encompasses the entire state of Missouri, with broad spatial units delineated ecologically, being derived from an ecological hierarchy encompassing local to global scalar levels. Studies at such broad levels provide the context within which “problem areas” at more magnified (i.e., less extensive) levels of geographic scale may be identified and more detailed studies designed. Thus we focus on observational or geographic scale as the spatial extent of the study or the area of coverage. Under this usage, a large-scale study covers a larger area, as opposed to a more magnified small-scale study that encompasses a smaller study area. This should be contrasted to measurement scale, commonly called resolution, which refers to the smallest distinguishable parts of an object, such as pixels in a remote sensing image (Sheppard and McMaster, 2004). In the ecological domain, resolution is often referred as “grain.” As a complement to traditional geodemographic analyses, this study can provide helpful information for state policy makers, regional planners, and others concerned with protecting the state’s ecological heritage by effectively addressing regional socio-economic and environmental issues and opportunities.

2. Data and methods

2.1. Ecological data

Ecological data for this study consists of units delineated at two broad levels of the Missouri Ecological Classification System (Nigh and Schroeder, 2002), which is adopted from the National Hierarchical Framework of Ecological Units (Cleland et al., 1997)—a spatial-hierarchical representation of the ecological landscape. The national hierarchy, which draws heavily on ecosystem geography (Bailey, 1996), is a systematic framework for classifying and mapping ecological areas based on associations of ecological factors at different geographic scales. From ecoregions consisting of broad zones of similar climate, a descending spatial hierarchy of subregions and landscapes culminates in land units derived on the basis of soils, slope, and plant associations.

This study focuses on sections and subsections in Missouri, the two ecological units mapped at the subregional level of the above hierarchy. Sections are broad areas of similar subregional climate, geomorphic process, stratigraphy, geologic origin, topography and drainage networks. Subsections are smaller areas within sections.
with similar surficial geology, lithology, geomorphic process, soil groups, subregional climate, and potential natural communities (Cleland et al., 1997).

The state of Missouri is characterized by four ecological sections (Fig. 1b): the Central Dissected Till Plains (TP); the Ozark Highlands (OZ); the Osage Plains (OP); and the Mississippi River Alluvial Basin (MB). The Till Plains lies north of the Missouri River and consists of moderately dissected glaciated plains covered in loess and glacial till deposited by pre-Illinoian ice sheets. The Osage Plains in west central Missouri is a gently rolling landscape characterized by unglaciated plains historically composed of tallgrass prairie. The upper part of the Osage Plains is marked by extensive wetland ecosystems. The Ozark Highlands extends across much of the southern part of the state. It originated as a low structured dome with horizontally bedded layers but has been undergoing erosion and weathering for millions of years. The result is a dissected plateau comprised of restricted plains, knobs, forested hills, and river breaks. The Mississippi River Alluvial Basin in the extreme southeastern part of the state consists of alluvial plains and distinctive sand ridges and hills formed primarily from fluvial action of the Mississippi and Ohio Rivers. The state’s four sections are further divided into 31 subsections, 9 of which are in TP, 16 in OZ, 2 in OP, and 4 in MB. The geographic areas of subsections vary considerably from a few thousand ha to 100 thousand ha (Nigh and Schroeder, 2002).

2.2 Social and economic data

Social-spatial data for Missouri consists of variables compiled in the 2000 U.S. Census of Population and Housing (Baer, 2005). For this study, the level of block group was selected for use because it is the lowest hierarchical level for which detailed sample data on population and housing is available for public use. Block groups are geographic subdivisions of census tracts; their primary purpose is to provide a geographic summary unit for census block data. A block group generally contains between 600 and 3000 people, with an optimum size of 1500 people. Its area may vary considerably depending on whether it originates from an urban or rural location. Thus, for example, while census blocks (of which block groups are comprised) are small in area in urban areas—e.g., a block bounded by city streets; in sparsely settled areas they may contain many square miles of territory.

Each block group is characterized by a variety of demographic and socioeconomic variables describing people living within it. A core data set of 220 census variables for detailed social analysis for Missouri counties is maintained by the Office of Social & Economic Data Assessment (OSEDA) at the University of Missouri. In this study 84 of these variables were purposively selected to represent nine key kinds of social attributes for people living within the boundaries of ecological units. Variable types include basic population characteristics, age, race, household attributes, education, employment, occupation, income, and housing.

For Census 2000, the Census Bureau classifies as “urban” all territory, population, and housing units located within an urbanized area (UA) or an urban cluster (UC). The Census delineates UA boundaries to encompass densely settled census block groups or blocks that have a population density of at least 1000 people per square mile, along with adjacent census blocks that have an overall density of at least 500 people per square mile and together encompass a population of at least 50,000 people. A UC consists of contiguous, densely settled census block groups and census blocks with a population density of at least 1000 people per square mile, along with adjacent census blocks that have an overall density of at least 500 people per square mile and together encompass a population of at least 2500 people, but fewer than 50,000 people (Federal Register, 2002). In addition, under certain conditions, less densely settled territory may be part of each UA or UC (U.S. Census Bureau, 2003). The Census Bureau’s classification of “rural” consists of all territory, population, and housing units located outside of UAs and UCs.

For this study, block groups with an urban population (as defined above by the U.S. Census) of 90% or greater were excluded from this analysis because these areas have already been converted from relatively undisturbed ecological landscapes to ones dominated by humans. This is not to suggest that urban residents do not have significant connections to the landscape and natural environment (see, for example, Dwyer et al., 1994). Rather, use of this ‘urban mask’ in this study ensured that social patterns revealed in ecological sections or subsections would be attributed primarily to the interrelationship between people and landscapes not already transformed into urban settings.

It should be noted the Census Bureau does acknowledge that under its quite complex procedure for delineating urban areas, under certain conditions, less densely settled territory may be part of a UA or UC (U.S. Census Bureau, 2003). Thus some areas that would otherwise by considered rural are in fact included within the urban mask utilized in this study. Nonetheless, given their location within a broader urbanized environment, these areas would be the most likely of all ‘rural’ landscapes in the state to eventually be transformed into urban status. Thus the urban mask in this study accepted the census designations for urban landscapes.

2.3 Linking ecological and social data

Map layers of the Missouri Ecological Classification System and Missouri census block groups were combined using ArcGIS (version 9.1) to create a single coverage including all pertinent ecological and social data. The resultant coverage is such that with each block group there are associated 84 social variables and two ecological variables, the latter being the units of section and subsection within which the focal block group is situated. Unlike most studies using data from the U.S. Census, it is ecological features that provide the basis for delimiting boundaries of spatial units on the landscape, in contrast to boundary definitions based on administrative, political or statistical units such as counties or metropolitan areas. In this study, block groups were sampled within these ecological units. The boundaries of ecological units (sections or subsections) rarely coincide exactly with those of census geographic units. To accommodate this, any block group that did not fit entirely within an ecological unit was split with respect to that unit’s boundary; and social variables and values thereof were assigned to each of the split portions.

2.4 Identifying prominent social attributes for ecological units

The most important social attributes that distinguish people living within ecological sections and subsections in Missouri were identified via a Classification and Regression Tree (CART) analysis (Venables and Ripley, 2002). This is a form of multivariate divisive partitioning that has been employed in geographic and geodemographic segmentation analyses (Troy, 2008). A robust data analysis tool for the classification of cases, CART utilizes hierarchical, tree-building algorithms to successively partition a set of variables to be classified until a threshold of similarity in a focal or ‘dependent’ variable is reached. In this study, ecological units identified categorically serve as the dependent variables and sampled block groups are classified into broader social groups whose spatial (residential) location or pattern most closely matches the focal variable—the ecological landscape delineated via the units of section and subsection. The result is a dendritic classification tree whose leaves (terminal or end nodes) are social groups (sets of block groups) described in terms of the pathway of partitioning variables from the top branching point or ‘root node’ of the tree to each social...
group. These partitioning or prominent social variables that serve to construct the classification tree comprise a much smaller subset of the original 84 social variables sampled from each block group.

In a CART analysis, all block groups spatially situated within a given ecological unit must have an equal opportunity of being selected. Therefore, an equal random sample of block groups was taken in each ecological unit. The sample size for each section was set at 116, the number of block groups in the section with the least number of block groups (the Mississippi Basin). The sampling process was replicated 10 times to ensure an accurate representation of the social dimension within ecological units. This resulted in 10 replicate classification trees, many of which were identical. The tree of the social dimension within ecological units. This resulted in 10 replicates, thereby enabling measurement of their social pattern. Here, a social pattern consists of the composition (homogeneity/diversity) and spatial configuration (clustering-fragmentation) of social groups across the landscape. The former refers to the qualitative differences among social groups found in ecological units while the latter refers to whether the block groups comprising those social groups are clustered or dispersed across ecological units.

Social composition is measured by the Simpson’s Diversity Index (SIDI) that is widely used to quantify diversity within a landscape (in this study, social group diversity). A SIDI value of 0 indicates an entirely homogeneous social pattern, whereas a SIDI value of 1 suggests that all possible social groups are present in equal proportion. The degree of social fragmentation is measured by the perimeter-to-area ratio (PARA), which is also commonly used to measure the degree of fragmentation of landscape pattern (McGarigal and Marks, 1995). It is measured on a scale from 0 to $\infty$ (infinity), with 0 reflecting a dense or clustered spatial pattern and a higher number indicative of a more dispersed or fragmented spatial pattern (McGarigal and Marks, 1995). The focus of this latter measure is similar to that of the clustering dimension of traditional sociological studies of residential segmentation (Massey and Denton, 1988), where an index of spatial proximity measures the degree of clustering. In this study SIDI and PARA were derived using the FRAGSTATS statistical package (McGarigal and Marks, 1995).

As noted earlier, census block groups in sparsely settled rural areas may be much more extensive spatially than those in urban settings. This may or may not impact social diversity, which is defined in terms of prominent variables in classification trees. Just because there is more space within which social groups (or parts of such groups) may be situated does not in itself imply there is a greater variety of social groups (higher diversity). This must be determined empirically.

At the same time, with respect to social fragmentation – which involves the pattern of spatial location (clustered or dispersed) of social groups within an ecological unit (in this study, section or sub-section) – it might be questioned whether the larger spatial area encompassed by a rural, as opposed to urban, block or block group may increase the likelihood of higher values for social fragmentation, simply because there is a (sometimes much) more extensive area across which people might be dispersed. This is indeed a possibility. While in this study, the use of the urban mask effectively filtered out block groups in urban settings, there still could be some effect on social fragmentation based on the spatial extent of different rural block groups. This warrants further attention in future studies, particularly those in which both rural and urban geographic units are included.

### 3. Results

In the CART analysis differentiating people across Missouri’s ecological sections, social attributes related to education and housing emerged as most prominent at both first and second nodes for the 10 classification tree replicates. The representative tree selected from the replicate set (Fig. 1) displays five end nodes which identify five social groups (each a set of block groups) whose spatial situation best matches or fits the spatial geography of the four ecological sections in Missouri; and four social variables serve to construct the classification tree which partitions people (block groups) into those five social groups. Each social group may thus be described in terms of prominent variables that create the branching pathway from the top of the classification tree to that particular social group (end node) (Table 2). The partitioning or prominent variables ‘no high school degree’; ‘median house value’; ‘percent public assistance income’; and ‘high school grad or GED’ best reflect...
Table 2
Social groups associated with Missouri ecological sections: prominent attributes, social composition and fragmentation indices.

<table>
<thead>
<tr>
<th>Ecological section</th>
<th>Social group</th>
<th>%Sample</th>
<th>Prominent social attributes</th>
<th>Social composition (SIDI)</th>
<th>Social fragmentation (PARA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mississippi River Alluvial Basin</td>
<td>1</td>
<td>82</td>
<td>No high school degree (≥0.105)</td>
<td>.227</td>
<td>2.38</td>
</tr>
<tr>
<td>Central Dissected Till Plains</td>
<td>5</td>
<td>68</td>
<td>High school degree or better (≥0.105)</td>
<td>Median house value (≥$81,350)</td>
<td>.513</td>
</tr>
<tr>
<td>Ozark Highlands</td>
<td>4</td>
<td>21</td>
<td>High school degree or better (≥0.105)</td>
<td>Median house value (≥$81,350)</td>
<td>.710</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>15</td>
<td>High school degree or better (≥0.105)</td>
<td>Median house value (≥$81,350)</td>
<td>.716</td>
</tr>
<tr>
<td>Osage Plains</td>
<td>2</td>
<td>34</td>
<td>High school degree or better (≥0.105)</td>
<td>Median house value (≥$81,350)</td>
<td>.716</td>
</tr>
</tbody>
</table>

- A terminal (end) node of the classification tree; the set of block groups described in terms of prominent social variables (attributes) along the pathway of tree branches from the root to the focal terminal node.
- Percent of the 116 block groups sampled in the ecological section belonging to the social group.

how ecological sections in Missouri are described spatially in terms of social attributes of people who live within them. As we shall see below, among the five social groups, numbers 1, 2 and 5 best match the spatial location of the Mississippi Basin, the Osage Plains, and the Central Dissected Till Plains, respectively; while the remaining two social groups (# 3 and 4) are most contiguous spatially with the Ozark Highlands (Fig. 2).

Fig. 1 reveals that the variable ‘no high school degree’ is the most prominent social variable at the state level in that it immediately sorts all 464 sampled block groups into two subsets defined in terms of level of educational attainment. The lower-achieving subset (social group 1) clearly predominates in the Mississippi Basin in that 95 (82%) of the 116 sampled block groups in this section are identified exclusively by a higher percentage (greater than 10.5%) of people with ‘no high school degree.’ Thus social group 1 is differentiated entirely in terms of a single educational attribute.

At the second node of the section classification tree, the prominent variable ‘median house value (mhw)’ serves to partition a second social group (mhw ≥ $81,350) from remaining tree block groups (mhw < $81,350); and this second group (social group 5) is most spatially contiguous with the Central Dissected Till Plains. Seventy-nine (68%) of the 116 sampled block groups in the Central Dissected Till Plains are identified by the pair of social variables ‘high school degree or better’ (the alternative to ‘no high school degree’) and ‘higher median house value.’ Thus the Central Dissected Till Plains is distinguished socially from the Mississippi River Alluvial Basin by a higher level of education and from the Osage Plains and Ozark Highlands, which emerge in association with variables at lower tree nodes, by a relatively higher median house value. The structure of this section classification tree is typical of the CART partitioning process in that a substantial part of the partitioning of sampled block groups is done by the first two prominent variables (this is also reflected in the vertical length of branches between nodes in classification trees).

The lower two tree nodes partition the remaining 145 block groups into three social groups (end nodes) that are matched spatially to the remaining two sections—two with the Ozark Highlands and one with the Osage Plains. Social group 4 is established at the third node of the classification tree and is comprised of 35 block groups characterized by a higher proportion of residents with a completed high school education (node 1), a lower median house value (node 2) and a relatively greater percentage (0.15%) of people who receive public assistance income (node 3). Twenty-four of the 35 block groups in this social group are located in the Osage Plains section (about 21% of the sample block groups in the Ozark Highlands). Of the remaining block groups at the third node (the left pathway) receiving relatively less in public assistance, social group 3 is further characterized at the fourth tree node by another education variable (i.e., less than 36.5% of people have attained a high school degree). Social group 3 is situated predominately in the Ozark Highlands, where 17 of its 27 block groups may be found (i.e., approximately 15% of sample block groups in the Ozark Highlands). Thus the Ozark Highlands is the only ecological section to which two of the five social groups from the classification tree are assigned.

Finally, social group 2 is also established at the fourth node of the classification tree. It consists of 83 block groups, of which 39 are located in the Osage Plains section (i.e., roughly 34% of the sample block groups in the Osage Plains).

Fig. 2 reveals that the Ozark Highlands and Osage Plains display greater variety in their overall composition (that is, contain block groups from more than one social group) than do the Central Dissected Till Plains and the Mississippi River Alluvial Basin. This is reflected in measurements of diversity and fragmentation for each section (Table 2). The Mississippi Basin displays the least heterogeneity of social groups among the state’s four ecological sections and social groups in MB are distributed in a spatially clustered fashion. The Till Plains exhibits a moderate degree of social diversity; as well as a low-to-moderate level of fragmentation. The Osage Plains and the Ozark Highlands exhibit a much more heterogeneous composition and spatially dispersed social pattern than either the Mississippi Basin or the Till Plains.

3.1. Social patterns within Missouri ecological sections

Results from CART analyses for each of Missouri’s four ecological sections revealed that housing and employment variables appeared most frequently in replicate trees for Till Plains and Mississippi Basin subsections, respectively; while some variant of income was the most frequent type of prominent variable to appear in trees for subsections of the Osage Plains and Ozark Highlands (Fig. 3). Given that these latter sections are the least and most complex ecological sections in Missouri – with 2 and 16 subsections for OP and OZ, respectively – and that they also display the smallest and largest number of types of prominent variables – 2 for OP and 7 for OZ (Fig. 3) – we examine these two sections at the more magnified level of ecological subsection.

For Osage Plains subsections, nine of the ten replicate trees displayed an income-related variable at the root node (Fig. 3), the only node in trees for OP subsections. Subsections in the Osage Plains are
characterized by two social groups—identified in terms of higher or lower median household income (Fig. 4). The Scarped Osage Plains (OP1) displays a clustering of higher-income (greater than $32,220) block groups bordering the Kansas City metropolitan area. OP1 is the more socially homogeneous (SIDI = 0.357) and less fragmented (PARA = 2.6) of the two OP subsections. The Cherokee Plains (OP2) is characterized by a mix of higher and lower income groups and it is more socially diverse (SIDI = .465) and socially fragmented (PARA = 3.11) (Fig. 4).

For subsections in the Ozark Highlands, prominent variables at the root nodes of the 10 classification tree replicates included those related to employment, housing, and income, the latter being the most prominent (Fig. 3). Prominent variables at the second nodes were represented fairly evenly among social categories. The representative classification tree from among the ten replicates for OZ subsections may be found in Fig. 5. While not possible to discuss results for each of the 16 OZ subsections, two subsections differing extensively in their physiographic make-up – the Central Plateau (OZ5) and St. Francois Knobs and Basins (OZ10) – are discussed here (Fig. 4).

The Central Plateau (OZ5) is characterized by relatively low physiographic gradients. It spans a large portion of the Ozark Highlands, encompassing a wide range of people, from suburbanites in the outer reaches of the St. Louis area to the rural townspeople of southern Missouri (Fig. 4). The Central Plateau displays the most distinctive distribution of social groups in this section as reflected in high diversity (SIDI = 0.8825) and fragmentation measures (PARA = 6.54). The social composition of these groups varies considerably. Social group 10 predominates in the northeast portion of the Central Plateau in close proximity to St. Louis and is characterized by relatively higher values for median family income and mean travel time to work, along with a lower level of graduate and professional degree attainment (Fig. 5). In contrast, social group 123 found mostly in the southern half of OZ5 (Fig. 4) is defined by relatively lower values for median family income and persons of minority background and several other less significant, but nonetheless distinguishing attributes (Fig. 5). The St. Francois Knobs and Basins subsection (OZ10) contains topographically rugged lands of breaks, knobs, ridges, and basins left from centuries of erosion and weathering (Nigh and Schroeder, 2002) (Fig. 4). Moderate values for social diversity (SIDI = 0.6968) and fragmentation (PARA = 5.06) are found in this subsection, with a distinct group (240) of relatively lower income Caucasians predominant in this area (Fig. 5) (Baer, 2005).

4. Discussion

Results of this study reveal that education trumps other social variables such as income and employment as the most prominent variable differentiating people by ecological section in Missouri. Results have explicitly linked educational differences to the ecological landscape in that the Mississippi River Alluvial Basin (MB) – a particular ecological area with its own concomitant social history in which forests were cleared, swamps drained, and the cotton-based economy of sharecropping appeared and declined (Stepenoff, 2003) – is revealed as one where educational attributes of its inhabitants serve to distinguish it from all other ecological areas in
the state. It is also likely that this process reflected in Missouri's ecological landscape has blended with other contemporary social trends with a scope extending well beyond the historical dynamic noted here. In this regard, Domina (2006) has documented a dramatic rise in educational segregation that has occurred both among and within American communities during the last half of the 20th century. These national trends are not related to those of racial and economic segregation, but rather reflect the spatial concentration of human capital in places specializing in management, commerce and technological innovation. Ecological places like Missouri's Mississippi Basin thus bear the brunt of both historical and contemporary forces for educational segregation that may intensify and extend social and economic inequality across generations (Harrison, 1984).

Previous studies have suggested that education is a key ingredient to natural resource conservation (e.g., Groom et al., 2005). From a statewide perspective in Missouri, findings in this study provide additional support for the prioritization of educational funding in state budgets relative to other equally important social programs related to income, employment and the like; and particularly for those policies aimed at reducing or minimizing regional differences in educational achievement (Peters, 2000). These results also point to the following research questions: Is education the most important issue in conservation for the state of Missouri? How are regional educational disparities, clearly evident in MB, tied to and reflected in people's interactions with the landscape and what policies might best erase such disparities while in the process enhancing ecological and social sustainability?

Study results also reveal that housing variables are most prominent in the Central Dissected Till Plains (TP). Not only was median house value the most powerful partitioning variable at the section level (Fig. 1), but the subsection classification tree (not presented in this article for space considerations) average age of housing units was the most prominent variable defining the first or root node of the classification tree, and thus responsible for doing the 'bulk' of the partitioning work.) Thick fertile soils especially suited to growing corn, and a network of slow-moving rivers and streams characterize this ecological section where farming has long been established. In this light, the prominence of housing attributes in TP may be a subtle manifestation of ties to the land forged across generations in this traditionally agricultural area of the state (University of Missouri Extension, 2004).

Steiner (2004) observes that during much of the late 19th and early 20th century the farmers in northern Missouri were satisfied with the status quo and rejected any calls for radical reform or major changes in the agricultural economy. However, despite this historical stability of agricultural life, certain other dynamics were undoubtedly at work, perhaps not as evident as those driving historical change in MB, which led to the present-day prominence of housing attributes in the Till Plains. Financial incentives in the form of farm programs benefitting larger farms; legislation creating loans to large investors; rising costs of equipment and machinery; vertical integration where corporations become involved in more than one step of the production process; farmer income offset by inflation; and the emigration of the younger generation from rural to urban settings have all contributed to the withering away of family farming operations that occurred throughout much of the 20th century. Larsen (2004), for example, observes that in Gentry County in Northwest Missouri the number of farms dropped over a 100 years from 2699 in 1900 to 625 in 2000.

At this point the hypothesis that social processes underlying family farm shrinkage have contributed to the prominence of housing attributes in a particular ecological area of Missouri is a tentative result of this exploratory study. It does suggest further important research questions: Will policies focused on sustaining the residential – in contrast to agribusiness – relationship of farmer to land in these times be necessary given the continuing patterns of the urban expansion and the disappearance of the traditional "family farm?" How can residency as reflected in housing attributes be maintained and strengthened in the face of the inevitable momentum of agribusiness and what elements of the ecological landscape might be preserved or enhanced in the process?
At the level of ecological subsection, study results reveal that social groups tend to be more spatially fragmented in regions with low physiographic gradients. This is reflected in the Osage Plains, whose two subsections are comprised almost entirely of pure tall-grass prairie. The clustered higher household income group found in the Scarped Osage Plains (OP1) (Fig. 4) is the result of the suburban expansion of the Kansas City metropolitan area (Ji et al., 2006). The mixture of higher and lower income groups in the Chero-kee Plains subsection (OP2), which is at a greater distance from metropolitan Kansas City, suggests that both agricultural land uses with associated rural incomes, as well as the effects of sprawl from the Kansas City region in OP1, are contributing to the spatial manifestation of social fragmentation in this subsection. This suggests that social fragmentation, here fueled by exurban expansion, is not hindered and perhaps even encouraged by low physiographic gradients across ecological subsections. A similar relationship between physiographic gradient and fragmentation is evident in the Central Plateau subsection (OZ5) of the Ozark Highlands, where physiographic gradients are also low and social fragmentation extensive. This somewhat counterintuitive result – linking lower physiographic gradients with higher social fragmentation – clearly merits further investigation, both directly and in other areas of the country to see if this is a phenomenon peculiar to Missouri or has broader geographic and ecological relevance. Perhaps such gradients contribute to easier extension of existing physical infrastructure, which would in turn facilitate development across broader geographic areas where potential urban sources of social diversity exist (in Missouri, for example, Kansas City and St. Louis).

On the other hand, study results also show that steeper physiographic gradients tend to preserve or limit social fragmentation on the landscape (Bartlett et al., 2000). This is revealed in the topographically rugged St. Francois Knobs and Basins subsection (OZ10). Relatively few social groups and lower values for social diversity and fragmentation are found in this subsection. A distinct group of relatively low income Caucasians (i.e., median family income less than $36,940 and less than 9.5% of persons in a minority) exemplifies this pattern.

The combination of social diversity and fragmentation in ecological units may have important implications for conservation planning and management. Spatially homogeneous and clustered social patterns within ecological units may be a factor in contributing to similar perspectives or attitudes toward various conservation policies: while diverse and fragmented social patterns are more likely to be indicative of different types of people in different places who may differ in their interests and opinions regarding conservation goals and natural resource management (Bateman et al., 2002; Hawbaker et al., 2005). Moreover, not only the spatial distribution of social groups but differences in their prominent social attributes could also have varying effects on ecological sustainability. For example, the OZ10 subsection is characterized by a socially homogeneous, minimally fragmented social group of low-income Caucasians whose inclination to participate in collaborative efforts for conservation might differ greatly from that of a higher-income, well-educated social group in another O2 subsection (e.g., group 10 or II in Fig. 4).

In this light, the following research questions and hypotheses may be asked: What implications do patterns of social diversity and fragmentation in ecological units have for conservation planning and management? Are social groups with lower diversity and spatially clustered distribution or higher diversity and more extensive spatial distribution more likely to differ in their conservation goals and interests, amenability to participating in collaborative conservation planning, and perspectives on managing natural resources?

5. Conclusion

This study has asked the question: When we look at people from an ecological perspective – here, in terms of their location in areas delineated by two broad levels of an ecological scale – what stands out socially, that is, in terms of social attributes of people in ecological places (sections and subsections)? An important role of this study lies in its potential to provide the broader ecological context for studies of individual ecosystems at more magnified (i.e., less extensive) levels of geographic scale. It helps identify areas where more targeted studies can be designed and more specific hypotheses can be tested. Such studies may include social marketing analyses that identify substantive attributes of forest landowners (Butler et al., 2007; Richter, 2005); survey-based instruments within which hypotheses may be formulated; as well as interpretive social analyses designed to elucidate individual and group perceptions of their interrelationships with the ecological environment.

Of special interest here are geodemographic analyses (Troy, 2008) that draw upon a broad range of census or other kinds of profiling data to create sketches of people living in areas with particular ecological characteristics (Grove et al., 2006); as well as analyses of the wildland–urban interface (Radoloff et al., 2005) and concurrent expansion of urban environments. These studies more closely correspond to the more magnified levels of ecological landscape and landtype phase in the ecological hierarchy on which this study is based—levels at which local conservation management and planning may be conducted and implemented (Radoloff et al., 2000, 2001; Jobin et al., 2003; Jackson et al., 2004). Such studies may be even more effectively conducted when the broad ecological context such as the one this study provides is taken into account.

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