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Connecting local environmental knowledge and land use practices: A human ecosystem approach to urbanization in West Georgia

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Abstract. Issues of urban sprawl and migration of exurban residents into the surrounding countryside of metropolitan areas have generated considerable debate across the US. These debates often revolve around the ecological footprint of urban areas and the erosion of quality of life indicators associated with rapid expansion of urban and residential areas. Although there has been much research done on the environmental and socioeconomic impacts of urbanization, little attention has been given to cultural impacts. This paper focuses specifically on the role of local environmental knowledge as an important resource in human ecosystems, and looks at the implications of environmental knowledge loss associated with urbanization and its related demographic changes. We compared environmental knowledge among rural, urban, and developing watersheds in western Georgia, and also look at relationships between local environmental knowledge and variables such as gender, education, income, and participation in outdoor recreational activities. We then explored how variations in environmental knowledge affected land use practices at the household level. The mean knowledge scores of residents in all three classifications of rural watersheds were higher than those living in developing and urban watersheds. We found residents of managed pine watersheds possessed the highest mean scores ($p = 0.006$), while urban watershed residents were the lowest. We also found that local environmental knowledge was influenced by active participation in outdoor recreation, with active bird-watchers having the highest environmental knowledge scores. However, we found less influence of factors such as education and income on environmental knowledge. We also found a clear connection between local environmental knowledge and land management practices. Timber owners scored higher than non-timber owners ($p = 0.099$), and landowners who constructed streamside management zones (SMZs) scored higher than those who did not ($p = 0.034$).

Keywords: environmental knowledge, urbanization, human ecosystems

Introduction

Public debate over the direction and regulation of land use change and economic development are assuming increasing importance in many US communities. The tension between the desire for economic growth and perceived need for environmental conservation and maintenance of a high "quality of life" may lead to political conflict at all levels of government. Increasing public participation in these development conflicts suggests a research approach to human ecological interactions that explores people's perceptions of the effects of urbanization and land use change on environmental quality and ecosystem relationships. Interdisciplinary studies of land use change have acknowledged that cultural values, knowledge, and environmental perceptions are important drivers of land use practices (Agarwal *et al*., 2000; Brown *et al*., 2000; Evans *et al*., 2001; Moran and Brondizio, 1998; Nassauer and Corry, 1999). Our research focused on the relationship between environmental knowledge and specific land use practices of landowners and renters in rural, urban, and developing watersheds in western Georgia. We were specifically interested in local knowledge about the impacts of increased urbanization and its associated land use patterns on water quality, biodiversity, and forest ecosystems. We wanted to know how knowledge varies by factors such as residence in rural, urban, or developing watersheds, and other socioeconomic variables. Furthermore, we were interested in how these variations in knowledge influenced land use practices at the household level.

This research project was part of a larger endeavor (see Lockaby *et al*., this issue) to understand the effects of urbanization on land use practices, ecosystem functions and services in western Georgia, drawing from the human ecosystem approach described by Grove and Burch (1997) and Machlis *et al*. (1997). The human ecosystem model is a tool for integrating human and biophysical dimensions of ecosystem management through the examination of critical resources (i.e., natural, socioeconomic, cultural) and "allocation mechanisms" (i.e., ecological processes, political authority, knowledge, information). The project described looks specifically at the role of knowledge within this context. We examined how local environmental knowledge varies according to geographic and socioeconomic criteria, and then related this distribution to specific land management practices. We viewed this research project as a first step in a larger investigation of social differentiation in the study area. Social differentiation is an important concept for studies of human ecosystems because it points attention to the allocation of critical social resources such as political power, wealth, status, and knowledge (Grove and Burch, 1997). The spatial patterning of these types of resources is an important determining factor in the distribution and dynamics of natural or biophysical resources in the same area. The ultimate goal of human ecosystems research is to increase understanding of social and natural resilience, persistence, and variability in the ecosystem as a whole (Pimm, 1991).

Conceptual framework and theoretical background

Our project began with the assumption that local environmental knowledge at the individual level varies according to degree of exposure to the natural world (Guest, 2002). Degree of exposure to the environment can be affected by a variety of variables which may pertain to cultural traditions, geographic residence, occupation, economic pursuits, recreational activities, differential access to information, and unequal power relations (Johnson and Griffith, 1996; Maffi, 2001).

Anthropological studies in ethnoecology, ethnosemantics, symbolic anthropology, political ecology and cultural consensus approaches offer useful tools for representing knowledge through cultural models or semantic domains (Alley, 1998, 2000, 2002; Maffi, 2001; Nazarea *et al*., 1998; Paolisso, 2002; Peet and Watts, 1996), or through descriptions of key symbols or rituals and their operations through time (Rappaport, 1979). Drawing upon the insight that anthropological analysis brings to the study of cultural knowledge, the research takes direction from cultural models and cultural consensus approaches to examine the nature of local environmental knowledge. We work with the assumption of culture as consensus (Romney *et al*., 1986), utilizing techniques originating from this methodology to examine peoples' thinking about the environmental impacts of specific land use practices.

Much of the research done on cultural models of the environment addresses the different ways cultural groups understand plants and animals most important to their survival. These studies pose a key question: when are variations in models simply idiosyncratic and when do they indicate a distinct, alternative understanding? (Johnson and Griffith, 1996). Variations have been explained as different manifestations of cognitive structure (Berlin *et al*., 1974; Berlin, 1992; Strauss and Quinn, 1999) or as a result of differential access to knowledge through various kinds of power relations (D'Andrade, 1995; Haenn, 1999; Johnson and Griffith, 1996; Posey, 2001). Many studies have focused on tribal or rural peoples in the non-industrialized world, assuming these groups have a more complex understanding of human ecology than residents of the industrialized world. There is, however, a growing interest in examining environmental knowledge in industrial and urban settings.

In a study of environmental knowledge in the US, Kempton *et al*. (1995) used a cultural model approach to study environmental values and debates. They focused on beliefs and values that underlie environmentalism and that, when combined, form cultural models. They argued that US cultural models of the environment are based on a view of nature as a highly interdependent system in a balanced state, vulnerable to "chain reactions" triggered by human disturbance. These models develop as public understanding of environmental problems such as global warming and air pollution increases, and become integrated with core US values such as parental responsibility, obligation to descendants, and traditional religious teachings (Kempton *et al*., 1995). The interviews which formed the basis for analysis focused on large-scale environmental issues, such as climate change, ozone depletion, and air pollution, and did not examine human interaction with the environment in terms of land use practices and the use, management, and disposal of resources.

Other work on cultural models of the environment in the US has centered on small scale understandings of the natural world, and their relationship to public policy. Paolisso (2002) found that local ecological knowledge and beliefs and values among commercial fishers and farmers (Paolisso and Maloney, 2000) formed alternatives to scientific and regulatory approaches to resource management problems. Other work has examined perceptions and knowledge pertaining to water pollution and its effects on seafood resources (Johnson and Griffith, 1996), and to ecological damage caused by oil spills. Some have looked into links between economic and ecological cycles in fisheries (Acheson and Steneck, 1998).

In this study, we seek to understand variation in environmental knowledge among resident groups that may differ in relation to demographic and socioeconomic criteria. However, we also seek to examine connections between knowledge of environment, land use practices, and other human impacts on the environment. This study elicits a long debate in environment-behavior literature regarding which comes first—attitude (cognition) or behavior (Azjen and Fishbein, 1977; Azjen *et al*., 1980). In our case, we assume a reciprocal relationship, and do not attempt to prove first cause.

Research setting

This study was conducted in three counties in west-central Georgia, Muscogee, Harris, and Meriwether. The third largest city in the state, Columbus, is the largest urban center in the region, and is expanding northward. The impact of this urban expansion on the surrounding landscape can be appreciated by examining population statistics for the three contiguous counties aligned in a northeasterly direction from the city. Columbus is located in Muscogee County, a small county for the region. In 2000, the county's population of 186,291 showed a density of 331 persons/km^2. This contrasts with the more rural Harris County (total population = 23,695, density = 20 persons/km^2) and Meriwether County (total population = 22,534, density = 17 persons/km^2). However, the rural landscapes of Harris County are being rapidly transformed by the growth of subdivisions and other residential facilities, driven by a population growth rate of 33% between 1990 and 2000. Harris County's growth is a direct result of its proximity to north Columbus. This rapid growth is not, at the moment, occurring in Meriwether County, but we predict that will evolve if current trends continue. The population increase in Meriwether County has remained very modest over the past decade (0.5% between 1990 and 2000).

Twenty watersheds were selected in this three county area to represent an urban-rural gradient. The watersheds average about 2,000 hectares in size, and range in population from a few landowners with very large landholdings in rural areas to dense urban populations. Satellite image analysis of the study area's landcover characteristics, based on Landsat-7 TM (March, 2002), produced the following results: urban/transportation (4.8%),[1] evergreen forest (25.8%), mixed forest (42.9%), transitional (15.9%), grass-covered fields (8.4%), barren (0.2%), and open water (1.9%). A substantial portion of the evergreen forest landcover is in pine plantation, and transitional lands include clearcuts, abandoned agricultural fields, and scrub forest. Approximately 70% of the urban/transportation landcover in the study area is located in Muscogee County, 20% in Harris County, and 10% in Meriwether County.

Research design and data collection

The main goal was to measure the correlation between local environmental knowledge and a set of socioeconomic characteristics, demographic factors, and land use activities. A mail survey was designed to elicit environmental knowledge, measure consensus, and gather information on household practices, recreational activities, land ownership, and land management activities.

To measure consensus in environmental knowledge, we developed a set of 25 questions that tested knowledge of basic attributes of the local environment (Table 1). Questions centered on fundamental characteristics of some the most common plant and animal species and the impact of specific land use activities on ecosystems. The ingredients of these questions were built from the knowledge base of ecologists, biologists, and foresters working in the area and from a preliminary mail survey and interviews with landowners. The options for each question were: 'agree,' 'disagree,' and 'do not know.'[2] These responses were not on a scale. The survey was pre-tested with respondents representing the study watersheds.

Table 1. Environmental knowledge questions included in survey of residents in western Georgia

1**	Forests help maintain water quality in this area.
2	Dogwood fruit provide food for many species of birds.
3	Wildfire is a natural part of the landscape in West Georgia.
4	Male deer defend their territories against other male deer.
5	Deer lose their antlers each year.
6	The rut is the time period when most deer migrate north.
7*	Deer have a keen sense of sight.
8*	Deer in Georgia mainly breed in January.
9	Deer eat mostly tree bark.
10	Mockingbirds imitate songs of other species.
11*	Red-shouldered Hawks kill chickens & other farm animals.
12	Red-cockaded woodpeckers live only in non-pine forests.
13	Some forest plants are originally from another country.
14**	Acorns are the fruit of oak trees.
15*	Urbanization lowers the number of songbirds in this area.
16*	Logging leads to poor water quality.
17	Deer behavior does not cause any conflict with humans.
18**	Wildfires benefit some plants.
19**	Forests help conserve plant and animal biodiversity.
20*	Pine seedlings grow well in the shade.
21**	Urbanization leads to soil erosion.
22	Wildfires benefit some animals.
23*	Plants can escape from gardens or yards and become pests.
24**	Urbanization leads to warmer local temperatures.
25	Abandoned cats are a threat to songbird populations.

As noted in the text of the paper, those statements with high agreement (>80% of respondents agreed) are marked with two asterisks; those statements eliciting disagreement (<60% of respondents agreed) are marked with one asterisk.

The survey was mailed to residents of twenty watersheds in Muscogee, Harris, and Meriwether Counties. Watersheds were classified as urban (4 watersheds), developing (3 watersheds), managed pine forest (4 watersheds), mixed or natural forest (7 watersheds), and pasture dominated (2 watersheds). In Harris and Meriwether Counties, all households within the study watersheds were identified from tax rolls. However, tax rolls could not be used to reach residents of the watersheds in Muscogee County because of urban density. Instead, we used a random sample of residents in the urban watersheds. Two locations within the watersheds, corresponding to water quality sampling stations were selected and 443 residents within a 3.2 km radius of water quality sampling stations were then chosen from resident databases. Surveys were mailed to 1,054 households including 611 in Harris and Meriwether County. After multiple mailings, 447 were completed and returned. The overall return rate was 42%.

Data analysis

Consensus analysis, as an analytical tool, can be used to assess whether a body of shared knowledge exists within populations and subpopulations. It can also be used to analyze the extent to which an individual's response pattern correlates with the collective. This model uses factor analysis to establish the degree of consistency among individual responses. According to the model, if Eigen values for the first factor are at least three times the second eigen value, then there is only one response pattern in the population or sub-population analyzed.[3] This would suggest that shared knowledge exists within the group assessed (Romney *et al.*, 1986). If there are two large eigen values (when the ratio is less than three), then there are at least two different response patterns, and it is assumed that shared knowledge does not to exist among the population or sub-population.

Data collected in the survey were run through a consensus analysis using Anthropac software. Eigen value ratios were determined for each of the major watershed classifications, and knowledge scores were generated for each individual respondent. Knowledge scores ranged from 0 to 1 and reflected the degree of similarity between an individual's answers and the collective, demonstrating the extent of knowledge they have on the topic in comparison to others.[4] For example, if we were comparing the local knowledge scores of two individuals with a score of 0.70 and another with a score of 0.50, we could state that the person with the score of 0.70 knew 20% more than the person with the score of .50 (Romney, 1999). Then mean knowledge scores for different groups or sub-populations can then be compared using comparisons of means (t-tests) to assess different levels of knowledge in different demographic and socioeconomic groups and sub-populations. We used these scores to assess mean knowledge among: (1) residents of the five watershed classifications, (2) males and females, (3) education levels, (4) income levels, (5) residents with various land use characteristics, and (6) levels of participation in outdoor recreational activities.

Results

The assumption that environmental knowledge varies with degree of exposure to the natural world was supported by the analysis, but the types of contact and experience individuals have with the natural world influences knowledge to varying degrees. Geographic residence and active participation in outdoor recreation activities strongly influenced knowledge scores, while income and formal education showed very little influence.

Local environmental knowledge and socioeconomic factors

When all survey participants' responses were run through the consensus analysis model, some interesting patterns emerged regarding local environmental knowledge and residence

Table 2. Consensus analysis: Local environmental knowledge and residence in urban, developing, and rural watersheds in western Georgia

Population	First factor	Second factor	Eigen value ratio	Model outcome
Overall	4.4	2.6	1.7 to 1	No Consensus
Urban Watersheds	4.7	1.3	3.6 to 1	Weak Consensus
Developing Watersheds	3.6	1	3.6 to 1	Weak Consensus
Rural Watersheds (Combined)	11.4	1.1	10.4 to 1	Strong Consensus
Managed Pine Forest	15.3	1.1	13.9 to 1	Strong Consensus
"Natural" Forest	10.3	1.2	8.6 to 1	Consensus
Pasture	8.1	1.5	5.4 to 1	Consensus

in rural, developing, or urban watersheds (Table 2). When the 447 survey respondents were analyzed as one population, the model did not show consensus in their responses, indicated by an eigen value ratio of 1.7 to 1. This meant that there were at least two different response patterns (and probably more) associated with subgroups in the population (ratios over 3 to 1 signify consensus, and ratios over 10 to 1 indicate strong consensus). When we analyzed watershed residence as a characteristic of a sub-population, the model showed consensus within each watershed group, however, consensus varied considerably between urban, developing, and rural watersheds. Rural watersheds were combined for analysis and then broken into three separate classifications based on the dominant land use type. Rural respondents (10.4 to 1) and, more specifically, residents of managed pine watersheds (13.9 to 1) displayed strong consensus in their responses. Urban and suburban populations (3.6 to 1) displayed consensus in their answers, but not at the strong levels seen in rural populations.

Given the lack of consensus among respondents as a whole, but consensus among watershed groups, the question became: are there systematic reasons why some statements have high agreement and others low agreement? We compared statements in which 80% agreed with statements in which less than 60% agreed. Table 1 provides a list of the questions used in the survey with identification of questions with high and low agreement.

Those questions that generated disagreement were of two kinds: statements about specific characteristics of plant and animal species (7, 8, 11, 20); and statements about the urbanization or the forest industry in general (15, 16, 23). In contrast, statements that elicited high agreement concerned more general relationships between urbanization and the environment (21, 24), or knowledge or attitudes toward the environment in general (1, 18, 19). We interpreted these findings to mean that respondents seemed to agree that urbanization has negative impacts on the environment, but the nature of these impacts was unclear. Although some questions regarding potential negative impacts of urbanization led to low agreement (15), the majority of respondents agreed that there were negatives associated with urban growth. The breakdown in consensus among the respondents overall was primarily related to disagreement on questions on knowledge of specific characteristics of plant and animal species, and this likely is the reason for the lack of consensus overall, but strong consensus among specific groups.

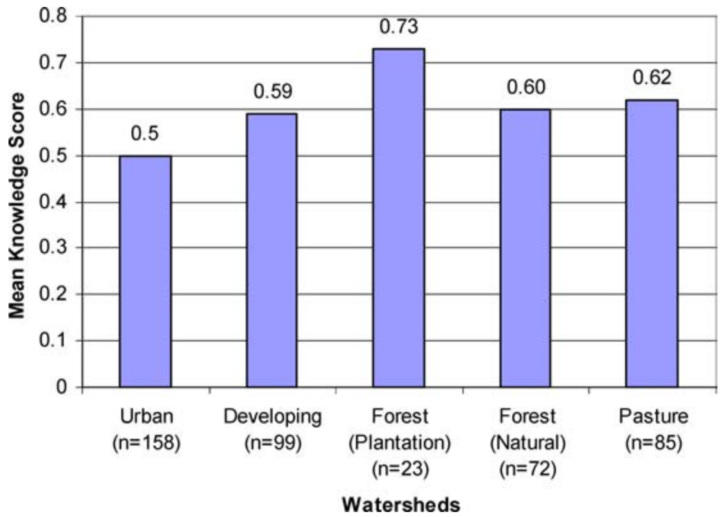

Figure 1. Environmental knowledge scores for residents of five different watershed classifications in West Georgia.

The relationship between mean environmental knowledge scores of individuals and residence in rural, urban, and developing watersheds is presented in figure 1. Mean knowledge scores are on a scale of 0 to 1. Forest (pine) refers to watersheds dominated by managed pine plantations. Forest (natural) refers to watersheds with mixed pine/deciduous forests, and non-plantation "natural" pine forests. In a comparison of means using one-tailed t-tests, the mean knowledge scores of residents in all three classifications of rural watersheds were higher than those living in developing and urban watersheds. We found residents of managed pine watersheds possessed the highest mean scores at 0.73 (significantly higher than all other watersheds, $p = 0.006$), while urban watershed residents were the lowest at 0.50 (significantly lower than all other watersheds). Mean knowledge scores for developing and natural forest watersheds were nearly identical.

Gender, education, and income did not demonstrate a strong relationship with local environmental knowledge. The mean score for males was 0.62, compared to 0.58 for females, but these differences were not statistically significant ($p = 0.165$) in a one-tailed t-test. Formal education was not significantly related to increased environmental knowledge (figure 2). There was no difference between those with a high school degree and those with post-graduate education. Those without a high school degree scored lower, but the low sample size of those without the high school degree rendered this insignificant ($p = 0.266$). This score might have had more to do with illiteracy and unfamiliarity with mail surveys. A similar pattern was found when looking at the relationship between income and mean knowledge scores. Putting the lowest level of income aside, we found no real difference in mean knowledge scores between those making between \$20,000 and \$40,000 and those making over \$140,000 (figure 3).

We also examined the relationship between mean knowledge scores and levels of participation in outdoor recreation activities. Respondents were asked how often they participate

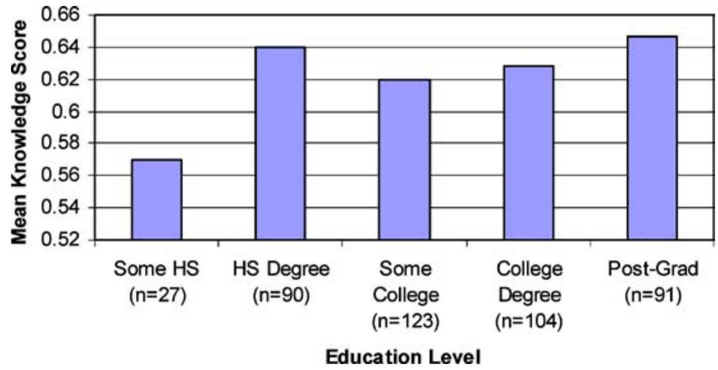

Figure 2. The relationship between environmental knowledge scores and level of education for survey respondents in western Georgia.

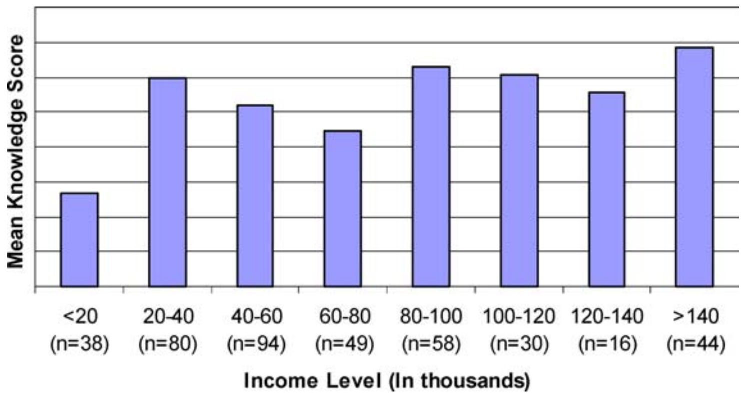

Figure 3. The relationship between environmental knowledge scores and level of income for survey respondents in western Georgia.

in activities such as hunting, hiking, bird watching, and off-road vehicle riding. Possible responses were never, rarely (one to two times per year), occasionally (three to five times per year), or often (one or more times per month). For each of the activities, mean knowledge scores were higher for the more active participants (figure 4). Moreover, the relationship between outdoor recreation and environmental knowledge showed two different patterns. In the first pattern, knowledge increased with a low level of participation. This was indicated by the measure of hunting where knowledge scores rose to a high level for those choosing the 'rarely' level of participation. Knowledge scores stayed at almost the same level through active participation at the 'often' level. On the other hand, hiking appeared to influence knowledge only at high levels of participation. Knowledge scores did not rise to their highest levels until participation reaches the 'often' level. This appeared to show that hunters have a relatively high degree of environmental knowledge regardless of how often they participate, while hiking only improves environmental knowledge after it becomes a

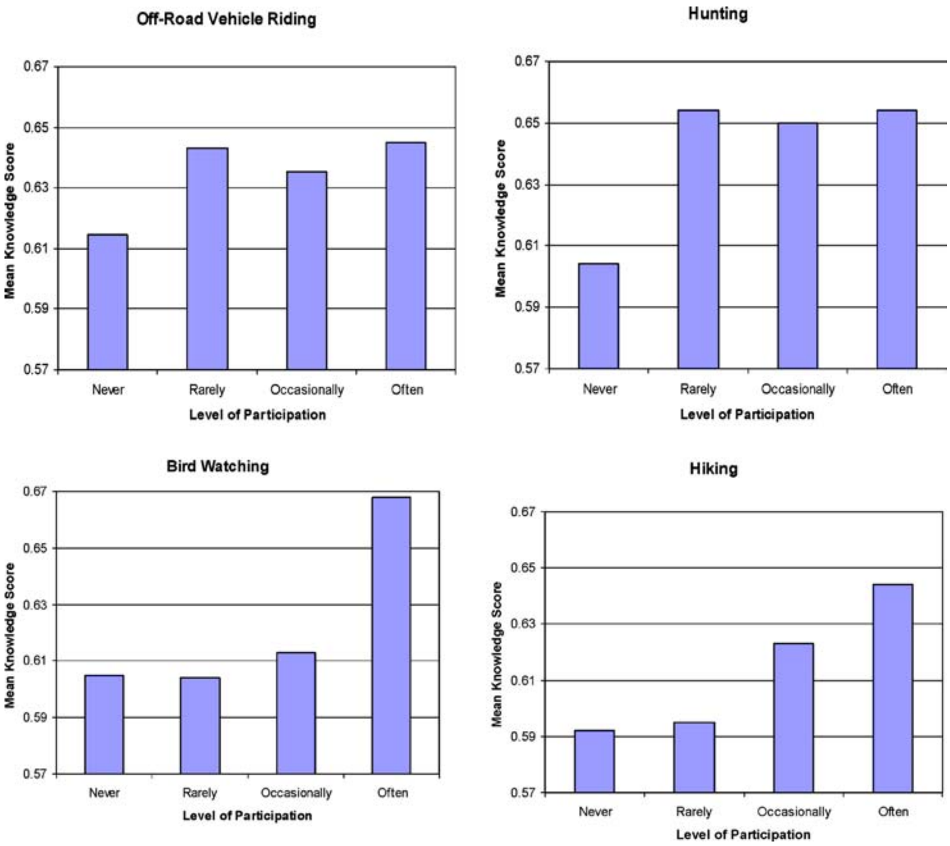

Figure 4. The relationship between environmental knowledge scores and levels of participation in outdoor recreation activities for survey respondents in western Georgia.

regular activity. The same pattern was shown in comparing participation in off-road vehicle riding and bird watching. Off-road vehicle enthusiasts' scores increased slightly with a minimal amount of participation. But bird watching affected environmental knowledge only at a high level of participation. In this case, the increase was relatively large with active bird watchers scoring the highest among any activity with a 0.664 mean score.

In the survey, more residents of urban and developing watershed residents claimed they were active hikers and bird watchers when compared with rural residents. The latter were more likely to hunt and ride off-road vehicles. However, scores for active hikers and bird watchers were comparable or even higher than those of hunters and off-road vehicle riders.

Local environmental knowledge and land use

Our survey attempted to draw out the relationship between environmental knowledge and land use practice. Overall, 70% of respondents were landowners, and the remaining 30%

Table 3. Land use acreage on property owned by survey respondents in western Georgia ($n = 313$)

Land use classification	# of properties	Acres reported
Row crop agriculture	83	764
Pasture	130	7,320
Orchard	49	143
Pine forests	90	11,677
Hardwood forests	79	3,390
Mixed forests	176	11,966
Commercial/industrial	11	122
Total	618	35,382

Table 4. Landowners grouped by acreage owned for survey respondents in western Georgia

Acres owned	# of Respondents	% of Respondents
Less than 10 acres	152	48.6%
10–99 acres	103	32.9%
100–499 acres	44	14.1%
500 acres or more	14	4.4%
Total	313	100.0%

were renters. Table 3 shows acreage reported by landowning respondents according to each category of land use on their property. The research area is heavily forested, and this was reflected in the acres reported under each land use. Pine forests and mixed pine/hardwood forests accounted for almost 67% of the acres reported and when combined with hardwoods, they accounted for 76%. Pasture accounted for a significant 20% of land use, but agriculture land uses was almost nonexistent in the participants responses. Table 4 showed that almost half of the respondents own 10 acres or less, and there were a significant number of respondents in both the 11–99 acre and 100–499 acre categories.[5] Very few respondents held over 500 acres.

Table 5 related information on land management practices that were relevant for understanding the context of local environmental knowledge. Forty-seven percent of the survey respondents owning 100 acres or more have leased their land for hunting; and this was almost identical to the number of participants engaged in active wildlife management on their property. Twenty-five percent of all landowners have sold timber, and the percentage increased up to 74% for landowners owning 100 acres or more. Sixty-six percent of all landowners have some type of surface water on their property, and this increased up to 98% for those with more than 100 acres. However, of those residents harvesting and selling timber, only 15% have developed streamside management zones (SMZs).[6] Only 38% of large landowners have SMZs. Fertilizers were used by 50% or more residents of all land size categories, while pesticides and herbicides were used by 26%.

Table 5. Land management activities reported by landowning survey respondents in western Georgia

Land management	Overall ($n = 313$)	10–99 Acres ($n = 161$)	100 Acres or more ($n = 58$)
Leased land for hunting	–	23%	47%
Active wildlife management	29%	37%	48%
Sold timber	36%	55%	74%
Plan to sell timber	19%	48%	67%
Use pesticides	26%	26%	30%
Use herbicides	26%	33%	40%
Use fertilizers	50%	58%	70%
Have streams or creeks	66%	84%	98%
—Developed streamside management zones (SMZs)*	25%	26%	40%

*Calculated solely for respondents who reported selling timber ($n = 113$).

Table 6. The relationship between environmental knowledge scores and land use activities for survey respondents in western Georgia

Land use activity	Mean knowledge score	Result
Timber Owners ($n = 100$)	0.69*	Timber owners score higher
Non-timber owners ($n = 219$)	0.61	$p = 0.099$
Stewardship is a goal ($n = 79$)	0.67*	Stewardship scores higher
Stewardship is not a goal ($n = 240$)	0.62	$p = 0.055$
Have developed SMZs ($n = 43$)	0.71*	SMZ builders score higher
Have not developed SMZs ($n = 247$)	0.60	$p = 0.034$
Uses fertilizers ($n = 153$)	0.65	No difference
Does not use fertilizers ($n = 152$)	0.63	$p = 0.423$
Uses pesticides ($n = 82$)	0.66	No difference
Does not use pesticides ($n = 227$)	0.64	$p = 0.532$
Uses herbicides ($n = 81$)	0.64	No difference
Does not use herbicides ($n = 226$)	0.65	$p = 0.748$

Comparisons of mean were conducted using one-tailed t-tests

Finally, we compared timber owners with non-timber owners in regard to mean knowledge scores. We found that timber owners showed a marginally higher mean score on the knowledge questions (Table 6). Those who listed stewardship as a reason for owning land and a primary objective of their land management also had a higher mean score than those who did not list that criterion. We compared those who had built SMZs around streams and creeks on their property and those who had not and found the same pattern. Those who built SMZs had a higher mean score. Differences in mean knowledge scores did not emerge when contrasted between those who did or did not use fertilizers, herbicides, and pesticides, indicated by almost identical mean knowledge scores between users and non-users.

Discussion and policy implications

While the link between outdoor recreation and knowledge was not surprising, the relationship between knowledge and residence offered some unanticipated insights. Active involvement with land management by residents of managed pine watersheds may explain the higher scores and stronger influence in general that residence in rural watersheds had on knowledge scores. This interpretation was supported further in the analysis and discussion of the relationship between knowledge and land use practices. However, these findings bring forward several questions that are overlooked in debates regarding urbanization and development policy. We argue that there are three questions that should be asked in relation to urban expansion: (1) what are the environmental knowledge and cultural impacts of urbanization in this area? (2) Should those impacts be mitigated? If so, (3) then how should impacts be mitigated?

We have shown that knowledge of the local environment is tied to experience with the land and the local environment, as opposed to increases in socioeconomic indicators such as wealth and education, which are often viewed as the positive aspects of growth. This suggested that active land management leads to more awareness of environmental impacts. The more time people spend working in the forests, fields, and waters of their local area, the more they understand its characteristics and dynamics. Overall these results suggested that there was a potential for a strong negative cycle in urbanization processes. As urbanization proceeds, local environmental knowledge appears to decline.

As urban areas expand into the surrounding countryside, new residents move in and bring with them cultural models of the natural world that are much less rooted in knowledge of the local environment. The natural environments in which those communities are situated are also transformed in the urbanization process, leaving less foundation for building local environmental knowledge and awareness. Residents may translate their lack of knowledge into public policies that promote growth and further erode the local knowledge base. This loss of knowledge may have negative consequences for responsible land management unless concerted efforts are made to educate new residents.

New landowners, in what has become known as the "wildland urban interface," need information on critical issues such as watershed health and management, wildlife conservation, wildland fire prevention and mitigation, and land use planning and policy (Macie and Hermansen, 2002). These efforts can be enhanced or sped up through the creation of economic incentives to landowners for land use activities that produce public goods, such as building riparian buffers or protecting endangered/native species. Forest management programs have traditionally targeted larger landholdings with specific timber production objectives in mind. But land management education programs should formulate a range of management objectives for large and small tract sizes. Education campaigns should target local policy makers who are highly influential in setting land use policy at the county level. Local policy makers should be targeted with workshops and education campaigns that take a holistic approach to land use planning, incorporating the range of negative impacts of land use change.

These findings also suggested that local environmental awareness can be promoted by opportunities for outdoor recreation, especially among urban populations, and this finding has been supported by other research showing links between outdoor recreation and pro-environment behavior (Theodori *et al.*, 1998). These opportunities can be provided by maintaining green space and creating areas for outdoor recreation. But allocations of public lands for high quality outdoor recreation can also affect the quality of natural resources (Cordell *et al.*, 1999). Research is needed to identify the potential of private lands, greenways, and urban forests for creating outdoor recreational opportunities. There is also a need to assess cultural preferences for recreational opportunities, and the differing needs and expectations that user groups have (Duryea and Hermansen, 2002).

We also believe that the dynamics of local environmental knowledge should be researched by examining links between environmental knowledge and awareness of land use impacts and the economic and public policy drivers of urban expansion. In other words, when residents become aware of the negative ecological consequences of urbanization, do they respond through political and economic actions? The role of citizen action groups should also be investigated through these links. In this tri-county area, a number of environmental organizations and neighborhood associations have formed over the past decade and are demanding a voice in zoning and planning decisions that affect their communities. These groups are demanding change in public policies on zoning, planning, taxation, county facilities, and environmental regulation. This kind of inquiry should look at the ways policy makers respond to and work with activist citizens.

Conclusions

These findings provide support for the working hypothesis that environmental knowledge, like water quality and biodiversity, is affected by urbanization. As forests and the communities that live and work in them are transformed through urbanization, local environmental knowledge and awareness of the impacts of land use practices on the local environment is reduced. The lack of a relationship between environmental knowledge and variables such as education and income demonstrated that environmental knowledge was distributed in a much different pattern than other types of education, and was most closely aligned with variables that indicate an individual's exposure to the natural world.

This research draws attention to the cultural impacts of urbanization, and to some of the processes that increase the negative effects on natural and human aspects of ecosystems through certain types of urban expansion. It is our hope that this work will expand the debate regarding the direction and regulation of land use change and economic development. We also hope that it will result in an increased understanding of the role of human knowledge, values, and perceptions as a driver of urbanization processes and subsequent changes in land use practice.

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Notes

1. Includes impervious surfaces—roads, rooftops, parking lots, driveways, and sidewalks.
2. 'Do not know' was included to reduce the effect of correct guesses to answers. Of all responses to all questions, 'do not know' was listed 7.1% of the time.
3. Eigen values are the amount of variance expressed by each factor. The first factor represents the maximal variance of all variables together, and the second factor maximizes remaining variability (Morrison, 1990; Romney, 1999).
4. Knowledge scores represent the percentage of a respondents' answers that match the most agreed upon answer of the collective group of respondents. Some of the questions asked are purely opinion, and as such, are not correct or incorrect.
5. Acres were used in the survey per local use. One acre equals 0.405 hectares.
6. The creation of SMZs is a standard best management practice for minimizing negative water quality impacts associated with different phases of timber production. Similar SMZs are also built to minimize impacts of agriculture and livestock production on waterways.

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