

CLASSIFICATION OF FOREST-BASED ECOTOURISM AREAS IN POCAHONTAS COUNTY OF WEST VIRGINIA USING GIS AND PAIRWISE COMPARISON

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Abstract.—Many previous studies have examined ecotourism primarily from the perspective of tourists while largely ignoring ecotourism destinations. This study used geographical information system (GIS) and pairwise comparison to identify forest-based ecotourism areas in Pocahontas County, West Virginia. The study adopted the criteria and scores developed by Boyd and Butler (1994) with some modifications to prepare thematic layers for the different criteria. Weights for each criterion were determined using pairwise comparison. Finally, the weighted thematic layers were overlaid to generate areas suitable for ecotourism, which were then divided into five classes based on equal interval methods. The results show the location, size, and classes of ecotourism sites in the study area. This information and this type of analysis could be used to help ecotourists select sites to visit based on their preferences.

1.0 INTRODUCTION

Tourism is one of the largest industries in the world (World Tourism Organization 2006), and ecotourism is growing faster than the tourism industry itself, with an estimated yearly growth rate of 20-34 percent since the 1990s (TIES 2005). Ecotourism aims to minimize environmental impacts and contribute to the economic development of local communities and has shown potential for successfully funding conservation and sustainable development programs (Drumm and Moore 2005).

The philosophy of ecotourism was proposed in the early 1980s to address the environmental and social consequences of tourism. Ecotourism, as an alternative to mass tourism, was advocated to espouse the goal of symbiosis through the integration of natural resources, environmental education, and sustainable management. Over the past few decades, ecotourism has become a major source of income generation (Olinda 1991, Whelan 1991). However, ecotourism with its growing popularity and increasing pressures on natural areas may generate problems of its own (Deng et al. 2002). With the growth of ecotourism, the question about the extent to which new areas can support ecotourism physically and socio-culturally has drawn the attention of many researchers.

Although it is increasingly recognized that the maintenance of ecological integrity and environmental quality is essential for sustainable tourism development, ecotourism has been examined primarily from the perspective of tourists while largely ignoring one fundamental component—the destinations. Ziffer (1989) emphasized the need to set up standards by which ecotourism destinations or programs can be identified and judged. Boyd and Butler (1993) developed criteria for ecotourism for Northern Ontario then Boyd et al. (1994) used GIS to identify ecotourism areas in Northern Ontario and classify the areas into five different types based on a naturalness continuum. Although they developed criteria and gave scores to different attributes within each of the criteria, Boyd et al. (1994) did not consider the relative importance of each of the criteria. Jankowski (1995) argued that selection of land use allocation requires decisionmakers to consider the importance of different criteria in choosing the best alternative. He presented a framework for integrating geographical information systems (GIS) and multi-criteria decisionmaking (MCDM) methods using a file exchange module and four different MCDM computer programs.

Many studies have used fuzzy theory and analytic hierarchy process (AHP), one of the methods of MCDM, for site selection involving concerned stakeholders in various fields (Kahraman et al. 2003, Strager & Rosenberger 2006). A combined GIS and AHP-based approach has also been adopted for site selection problems, for example by Aguilar-Manjarrez and Ross (1995) for aquaculture development, by Tseng et al. (2001) for artificial reef development, and by Sener et al. (2006) for landfill site selection. AHP basically involves pairwise comparison to create a ratio matrix and produces the relative preference weight for each criterion (Saaty 1980).

Although there are a wide range of studies on the site selection problem, the authors know of no studies on site selection for ecotourism destinations with the involvement of stakeholders in an analytical framework. It should be noted that assessing the quality of natural areas would be more effective than assessing tourist facilities from the perspective of long-term sustainability (Font & Mihalic 2002). This requires appropriate criteria and indicators for the ecotourism areas within an appropriate framework. For ecotourism to be sustainable, there is a need to identify potential areas which could be developed as ecotourism destinations based on acceptable standards and criteria. Thus, the general objective of this study is to apply GIS and pairwise comparison to identify forest-based ecotourism areas in the Pocahontas County of West Virginia, USA. Ecotourism in this study is defined as “environmentally responsible travel and visitation to relatively undisturbed natural areas, in order to enjoy and appreciate nature (and any accompanying cultural features - both past and present), that promotes conservation, has low negative visitor impact, and provides for beneficially active socio-economic involvement of local populations” (Ceballos-Lascurain 1996). Forest-based ecotourism areas in this study refers to areas that are primarily dominated by forests with water bodies (i.e., lakes, rivers) as backdrops and cultural or heritage sites as supplementary attractions. Thus, forest-based ecotourism includes highly forested national parks and protected areas as well as national and state forests with the potential to be developed into ecotourism destinations.

2.0 METHODOLOGY

2.1 Study Area

The long-term objective of this study is to identify forest-based ecotourism in the entire state of West Virginia. However, to test the methods developed, Pocahontas County was examined first as a pilot site. Pocahontas County is the richest county in West Virginia in terms of natural amenities (Wang 2008).

2.2 Model Design

This study is based on a suitability index (S) model developed by Eastman et al. (1995) which is a common aggregation function that combines preference weights (w_i) and criterion scores (x_i) and is usually calculated through weighted linear combination.

$$S = \sum w_i x_i \quad (1)$$

However, applying the suitability model in MCDM consists of two steps: formulating an evaluation matrix E consisting of I * J standardized criterion scores (e) for I criteria across J alternatives and a group preference weight vector W consisting of preference weights (w) for each criterion i (Jankowski and Richard 1994):

$$E = \begin{bmatrix} e_{11} & \dots & e_{1J} \\ \vdots & \ddots & \vdots \\ e_{I1} & \dots & e_{IJ} \end{bmatrix} \quad (2)$$

and

$$W = (w_1, w_2, \dots, w_I), \sum_{i=1}^I w_i = 1 \quad (3)$$

The basic form of the weighted linear combination model can be expressed as

$$\begin{bmatrix} s_1 \\ \vdots \\ s_I \end{bmatrix} = \begin{bmatrix} e_{11} & \dots & e_{1J} \\ \vdots & \ddots & \vdots \\ e_{I1} & \dots & e_{IJ} \end{bmatrix} * \begin{bmatrix} w_1 \\ \vdots \\ w_I \end{bmatrix} \quad (4)$$

The weighted linear combination method can easily be integrated spatially in GIS by using raster-based map algebra (Strager and Rosenberger 2006). In Eq. (2), E can be measured in GIS by raster- or grid-based spatial analysis techniques. Typically, all criterion scores are standardized to a common numeric range such as 0-1 or 0-100 before aggregation. With values represented in equal scales, GIS grid layers can be used to represent each of the criteria, I, in a spatial context. The alternatives J comprise the cell locations for the extent of a study area and the values from Eq. (4) represent the suitability S for a location.

2.3 Criteria and Score

For the identification of forest-based ecotourism sites, this study follows the criteria and score developed by Boyd and Butler (1994) with some modifications. First, the naturalness continuum was developed (Figure 1) and the criteria were selected. The selected criteria were remoteness, wildlife potential areas, distance from logging, distance from mining, slope, and vegetation cover. Thematic layers were prepared for each criterion by assigning scores ranging from 1 to 5 to the different attributes within the criteria based on naturalness of the area (Table 1). Higher scores represent the best sites for forest based-ecotourism (pristine conditions) whereas lower scores represent the least suitable sites (urban conditions). For example, for remoteness criteria, this study follows the Recreation Opportunity Spectrum and divides the study areas from primitive (score 5) to urban/town area (score 1). Finally, an overlay of all thematic layers was done to generate areas suitable for ecotourism. The resulting map was then classified in to five different classes based on equal interval classification method and the layers of town, roads, and water bodies were merged to get the final map.

2.4 Pairwise Comparison Method

Pairwise comparison was done to determine the relative importance of the criteria. A survey using a self-administered questionnaire was carried out among 28 participants from West Virginia University, including 17 undergraduate students taking an ecotourism class, 9 graduate students, and 2 faculty

members from the Recreation, Parks, and Tourism Resources Program. Participants were asked to assign a number to indicate the relative importance of one criterion against another based on the scale adapted from Strager and Rosenberger (2006). Table 2 shows the intensity of importance and their explanation used for this study.

The study adopted the following AHP conceptual model from Duke and Aull-Hyde (2002). The criteria were defined and assembled as one matrix for participants to perform pairwise comparisons. The matrix can take the following form:

$$A = \begin{bmatrix} a_{11} & a_{12} & \dots & a_{1n} \\ a_{21} & a_{22} & \dots & a_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ a_{m1} & a_{m2} & \dots & a_{mn} \end{bmatrix} \quad (5)$$

The a_{mn} values represent the relative degree of importance of criterion m over criterion n. To combine the responses, the geometric mean was used because this is an effective method for calculating an overall rating (Benjamin et al. 1992, Schmoldt et al. 1994). With a survey of p respondents, a composite judgment of their a_{mn} values is the geometric mean of the a_{mn} values, which is defined as

$$a_{mn}^* = \sqrt[p]{\prod_{k=1}^p a_{mn}^k} \quad (6)$$

With the geometric averaged a_{mn}^* values, a set of numerical weights $w_1, w_2, \dots, w_i$ may be computed to represent the relative degree of importance assigned to each criterion (Strager and Rosenberger 2006). Based on the properties of matrices, a consistency index (CI) can be calculated to measure the consistency of participants' judgment in the process of pairwise comparison of criteria using the following formula.

$$CI = (\lambda_{\max} - n) / (n-1) \quad (7)$$

where n denotes the size of the comparison matrix (number of rows or column). The more consistent the comparisons are, the closer the value of $\lambda_{\max}$ is (largest eigen value) to n.

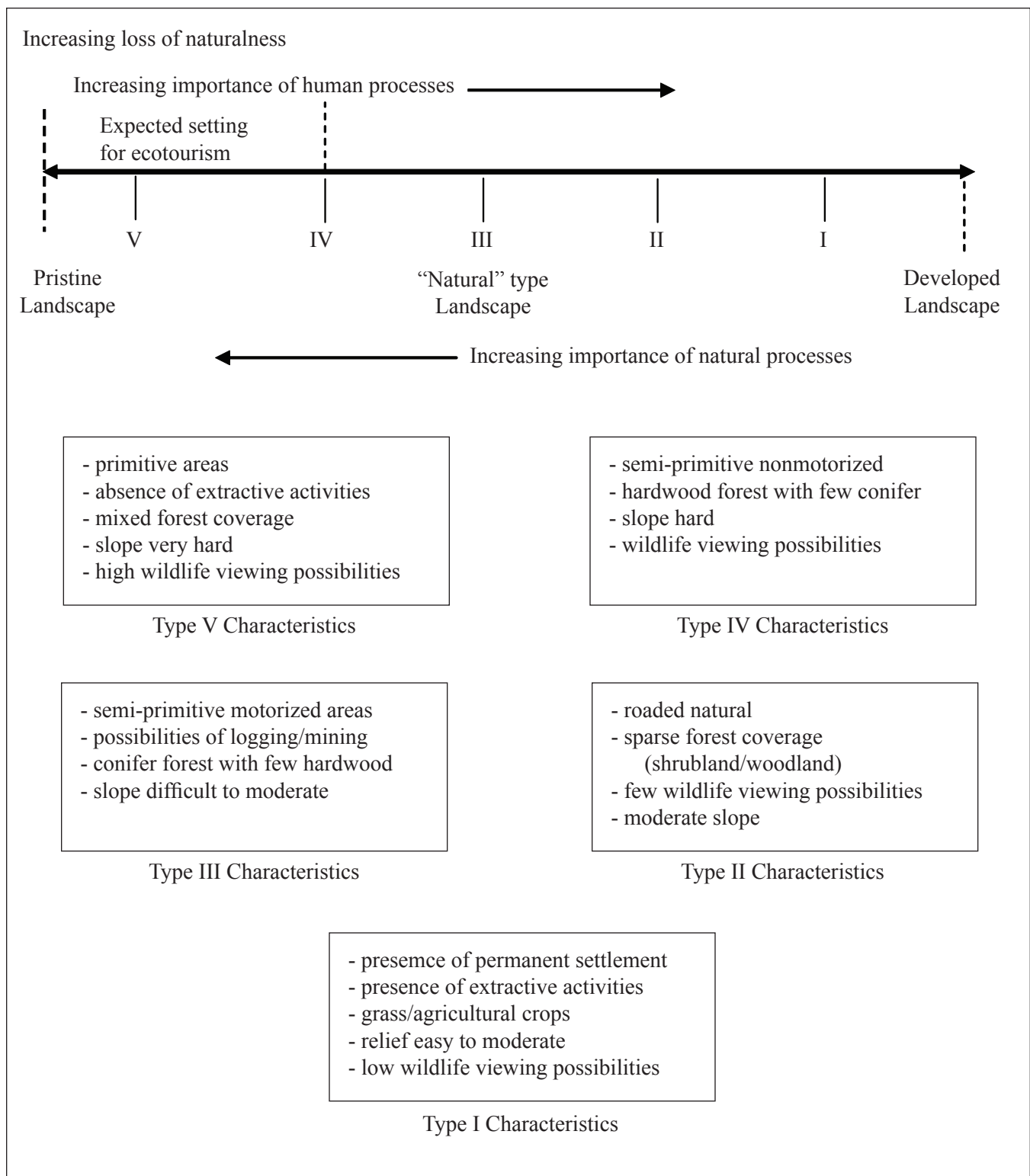


Figure 1.—Naturalness continuum (Source: Boyd and Butler 1994).

Table 1.—Criteria, scores and attributes to establish an area's naturalness

Score	Criteria/Type	Attributes
Remoteness		
5	Primitive	> 3 mi from all roads
4	Semi-primitive non motorized	< 3 mi from all roads >1/2 from unimproved roads
3	Semi-primitive motorized	<1/2 from unimproved roads >1/2 from improved roads
2	Roaded Natural	<1/2 from improved roads
1	Town/Urban area	<1/2 from improved roads and presence of settlement
Vegetation		
5	Mixed forest	Includes non high-elevation forest types such as oak–pine forest. Typically occur as xeric or dry forests along ridges and south–facing slopes in the less mountainous areas of the state.
4	Hardwood forest	Hardwood forests that dominate the areas in the state.
3	Coniferous forest	Single-species planted conifer stands. Can also potentially include Christmas tree farms.
2	Shrubland/woodland	Includes natural shrubland and wooded areas with immature closed canopy forest cover.
1	Grassland and agriculture crops	Includes vegetated pasture/grassland areas and row crops such as corn and soybeans.
Distance from Mining		
5	No presence of mining	Outside 3 mile buffer from mining areas
3	Area nearby operational mining	Between 1 to 3 mile buffer from mining areas
1	Operational mining present	Within 1 mile buffer from mining areas
Distance from Logging		
5	No presence of logging activities	Outside 3 mile buffer from logging areas
3	Area nearby active logging	Between 1 to 3 mile buffer from logging areas
1	Active logging present	Within 1 mile buffer from logging areas
Wildlife Potential		
5	Wildlife setting I	177-217 species
4	Wildlife setting II	136-176 species
3	Wildlife setting III	96-135 species
2	Wildlife setting IV	55-95 species
1	Wildlife setting V	13-54 species
Slope		
5	High slope	>25 degree
3	Medium slope	10-25 degree
1	Low relief	Less than 10 degree

Table 2.—Scale for pairwise comparisons

Intensity of Importance	Determination and Explanation
1	Two attributes are equally important
3	One attribute is slightly more important than the other
5	One attribute is moderately important over the other
7	One attribute is very important over the other
9	One attribute is extremely important over the other

The CI value is then used to estimate the consistency ratio (CR) which measures the coherence of the pairwise comparisons and can be computed as

$$CR = 100(CI/ACI) \quad (8)$$

where ACI is the average consistency index of the randomly generated comparisons. A CR value of 10 percent or less is considered as acceptable (Kangas 1994).

2.5 Dataset and Software

The data used for vegetation cover and predicted wildlife distribution were obtained from maps created through the WV Gap Analysis Project. In addition, data for road, digital elevation models (USGS DEMs), and mining areas were obtained from West Virginia GIS Technical Center. Information about logging areas in the study site was obtained from the West Virginia Division of Forestry. ArcMap software was used for analyzing and displaying the maps and Expert Choice software was used for calculating weights in pairwise comparison.

3.0 RESULTS AND DISCUSSION

3.1 Unweighted Forest-based Ecotourism Map

Figure 2 shows the unweighted forest-based ecotourism map with five classes. Class V (pristine) represents the most suitable sites for forest-based ecotourism and class I (urban) represents the least suitable. Table 3 indicates the percentage of area within each class. The figure and table also show that classes V and II represent 7.86 percent and 2.66 percent of land, respectively, and are mostly located in the southwestern part of the County. Classes IV and III land is dispersed throughout the county and covers 78.43 percent and 9.45 percent of land, respectively. Class I land is scattered all over the county but includes only 1.59 percent of the total county land.

3.2 Pairwise Comparison

Weights obtained from pairwise comparison for each criterion are shown in Figure 3. Among the criteria, vegetation cover received the highest weight (0.236)

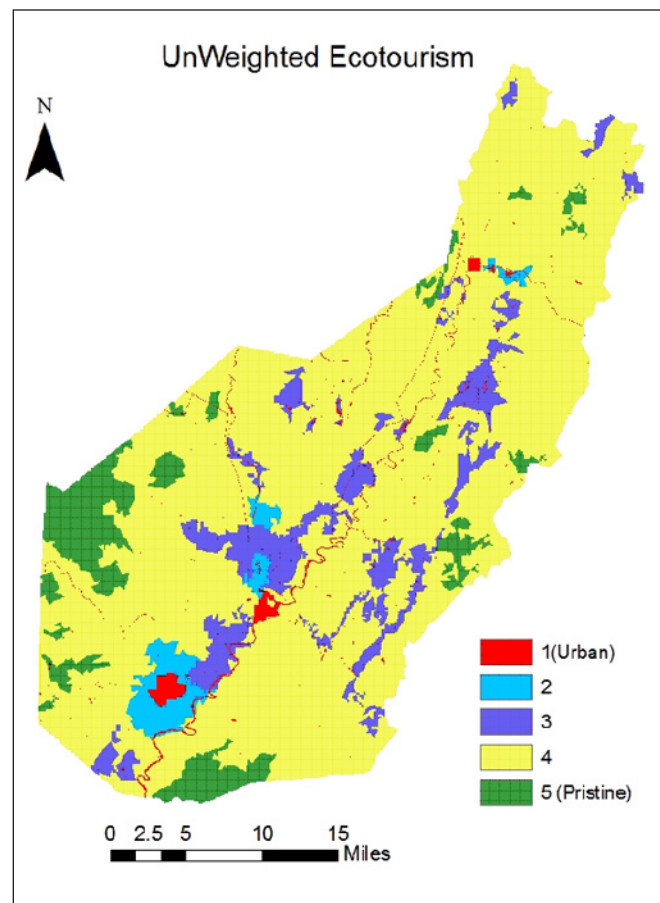


Figure 2.—Map of unweighted forest-based ecotourism land in Pocahontas County.

Table 3.—Unweighted forest-based ecotourism

Class	% of Total Area
1	1.59
2	2.66
3	9.45
4	78.43
5	7.86

followed by distance from mining (0.186) and logging (0.174) whereas slope received the lowest weight (0.077). This implies that vegetated area far from mining and logging are preferred for forest-based ecotourism. The CR for pairwise comparison was 0.04 or 4 percent which is less than 10 percent.



Figure 3.—Pairwise comparison.

3.3 Weighted Forest-based Ecotourism Map

Figure 4 shows the weighted forest-based ecotourism map with five classes. Table 4 indicates the percentage of area within each class. Classes V, VI, and III represent 13.37 percent, 54.50 percent, and 23.30 percent of land, respectively, and are found throughout the County. Classes II and I covers 6.50 percent and 2.33 percent of the land, respectively, and are less dispersed compared to other classes.

Comparing the weighted and unweighted ecotourism maps, area under class IV decreases on the weighted map whereas area of class V increases. Areas far from mining and logging were preferred in pairwise comparison, so the class IV land in the unweighted map becomes less desirable and fall into lower classes. Also, vegetation received the highest weight; therefore some areas in the unweighted map get upgraded and fall in to class V on the weighted map.

For verification, the weighted ecotourism map was compared with the existing forest areas in the county. Most of the state parks and Monongahela National Forest fall in class IV whereas wilderness areas, some portion of national forest, and state parks fall in class V, confirming the consistency between the existing map and the forest-based ecotourism map.

Although the use of GIS and pairwise comparison are promising in identifying areas suitable for forest-based ecotourism with consideration of relative importance of criteria, there are certain limitations which might have influenced these findings. This study used land

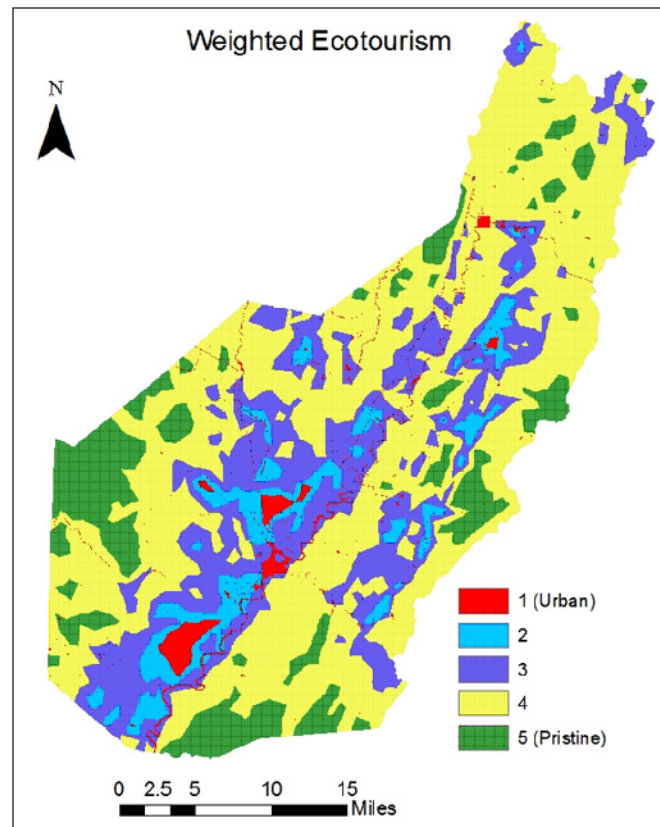


Figure 4.—Map of weighted forest-based ecotourism land in Pocahontas County.

Table 4.—Weighted forest-based ecotourism

Class	% of Total Area
1	2.33
2	6.50
3	23.30
4	54.50
5	13.37

cover and wildlife potential data of 30m resolution. The coarse resolution of this dataset can affect the precision of the area while calculating the areas for each class. Data on cultural and/or historic sites was not found. If available, it would help to address the cultural component in the definition of ecotourism. Data for mining and logging areas were available as points but, in the real world, they are polygons so this might affect the results as well. Some of the data used was from 1992 satellite imagery (for example,

the wildlife potential map prepared by the WVUGAP project) and some was from 2002 (e.g., the mining data). Such discrepancies in the age of the data might also affect the results.

4.0 CONCLUSIONS AND IMPLICATIONS

Based on the results, Pocahontas County is suited for forest-based ecotourism as class III, IV and V land together cover more than 90 percent of the county's land area. The results also indicate that the study site would be suitable for the entire spectrum of ecotourists. More than 10 percent of the county could cater to 'hard' ecotourists who value wilderness (class V). More than half of the county is suitable for ecotourists who value wilderness but also desire some amenities (class IV). This was validated by overlaying a campsite layer on the weighted ecotourism map; most campsites were in areas classified as class IV. Areas under classes I and II are basically suitable for 'soft' ecotourists who value amenities and accessibility.

The weights allocated to each of the criteria changed the amount of area allocated to each class when compared to the unweighted ecotourism map. This shows the relative importance of preference criteria in creating a suitability map. The highest weight was given to vegetation, and since Pocahontas County is heavily forested, the total area under class V increased in the weighted classification. GIS was found to be a useful tool in analyzing and visualizing the outputs of classification and pairwise comparison aided in the ecotourism suitability mapping. The demonstrated framework is flexible in that new criteria and varying weights can be applied during classification to fit the context of the study area.

The results of this study would be helpful in providing information to ecotourists about the type and size of ecotourism sites available in the area. Based on these results, ecotourists could select the sites they would want to visit. The results would also benefit agencies responsible for resource planning and management to assess the potential draw of tourism-focused activities

within the area and advertise them accordingly. Also, information on the size of the different ecotourism areas could help management authorities determine the type of ecotourism activities to be promoted—for example, excursion only or with limited overnight stays. As visitor preferences and areas of land cover change with time, the GIS database prepared for this study can be used to make adjustments to the ecotourism area. Finally, long-term studies dealing with land use changes and visitor trends in the area could provide important insights for better sustainable ecotourism planning.

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