MODELING THE SCENIC BEAUTY OF THE HIGHLAND SCENIC HIGHWAY, WEST VIRGINIA

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Abstract.—Finding sites with a pleasant view is important to maximize visitors' scenic satisfaction. A geographic information systems analysis of viewsheds is helpful for locating sites with maximum visibility. Viewshed analyses can also be combined with public perceptions of scenic beauty for selecting the most scenic sites. This research modeled the perceived beauty of the Highland Scenic Highway of West Virginia with the visible land cover features in early and late fall 2007. The area of each land cover type visible from 16 different locations was calculated, and photographs taken at each of the sites were used to elicit public perceptions of scenic beauty. Forest cover was significantly related to the scenic beauty of late fall but not to that of early fall. This result shows that leaf cover diversity is a major factor in perceived scenic beauty in the study area.

1.0 INTRODUCTION

Enjoying scenery is one of the most common and popular recreation activities in the United States (Hammit et al. 1994) and other areas of the world (e.g., Hsieh et al. 1992, Carr and Axelson 2005). Passive sightseeing recreation activities like bus tours are particularly popular for older visitors (Steinitz 1990). Sightseeing depends on the scenic quality of features in the landscape (Hammit et al. 1994). The perceived benefits of sightseeing are directly related to the efforts of agencies that manage, protect, and develop sites for viewing and other uses (Hammit et al. 1994). Increasing demand for scenic quality and related recreational activities has led to official state and national designations of scenic byways and highways. Scenic byways and highways are tourist highways with roadsides or viewsheds (i.e., areas of land cover types visible to the human eye from a fixed vantage point) that provide scenic and recreational opportunities (The National Scenic Byways Program 2009). However, sites along byways and highways cannot all provide the same level of scenic satisfaction to visitors since scenery and viewing distance vary from site to site. Therefore, to provide maximum scenic satisfaction to visitors, it is important to identify sites that can offer the best viewing opportunities.

In reality, finding the best sites for scenic beauty in the natural environment may be time-consuming and troublesome. It may also require detailed knowledge about the area and the types of land cover visible from particular sites. Several studies on scenic evaluations of forest environments have asked the public to rate photographs of specific landscape scenes (Shafer et al. 1969, Zube et al. 1975, Buhyoff and Leuschner 1978, Brown and Daniel 1984, Noe and Hammit 1988). Difficulties with this method are associated with calculating the total visible area and the land cover types. However, viewshed tools in geographic information systems (GIS) can help landscape designers and environmental managers locate sites with maximum visibility and desirable land cover(s) (Germino et al. 2001).

Viewshed analysis in GIS determines the visible areas on the landscape from a specified location (O'Sullivan and Unwin 2003). This type of spatial analysis is conducted using Digital Elevation Models (DEMs). The view to all other points on the DEMs is calculated by an imaginary profile being drawn from the vantage point to every other grid point. Successive heights along each profile are listed where it crosses a grid line to determine whether the point is visible (O'Sullivan and Unwin 2003). Grid cells are assigned a value "1" if visible and a value "0" if not. The output map displays the visible area from specific points on the DEMs. Various studies (e.g., La Kose 2004, Sevenant and Antrop 2007) have used GIS in this way to calculate viewsheds. Wing and Johnson (2001) conducted a viewshed analysis in the McDonald Forest, Oregon, to estimate the areas visible from roads and

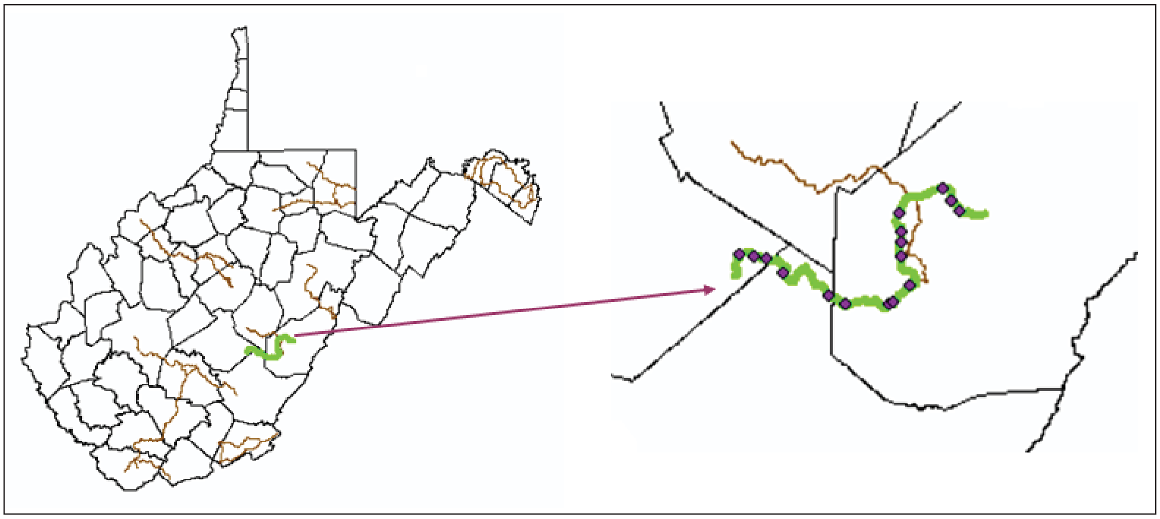

Figure 1.—Map showing the location of GPS points along the Highland Scenic Highway.

trails that visitors may use. Using the viewshed tool along with DEMs and land cover maps of the area, analysts can determine the total area of different land cover types visible from particular points on the ground.

Maximum visibility, however, does not necessarily correspond with scenic beauty. Scenic beauty is a relative measure of visual preference for a landscape (Daniel and Boster 1976), which may also vary with season. Therefore, selection of the best sites for scenic beauty in the natural environment requires integration of the visibility factor with perceived beauty metrics. Most research on scenic beauty assessments has focused on local features, rather than distant views. Adequate models of distant views have not been developed (Meitner and Daniel 1997). Therefore, the purpose of this paper was to model the perceived scenic beauty of the Highland Scenic Highway (HSH), West Virginia, in early and late fall of 2007 using both public preferences and viewshed analysis. The specific objectives were to explore what and how much can be seen along the HSH in West Virginia and to model the perceived beauty of the HSH with the visible land cover features.

2.0 METHODOLOGY

2.1 Study Area

The section of the HSH selected for this study is approximately 69.2 km long and runs through Pocahontas, Greenbrier, and Nicholas counties in West Virginia. The highway passes through mountainous terrain of the Alleghany Highland and Plateau. It is one of the most forested scenic highways in the state. The elevation along the highway ranges from 708 m to more than 1371 m above mean sea level.

2.2 Dataset

The data used for calculating the viewshed included topography from 30-m U.S. Geological Surveys, DEMs, and land cover maps created using Thematic Mapper satellite images for the WV Gap Analysis Project (GAP) (Strager and Yuill 2002). In addition, GPS points and photographs of the study area were used. The effect of vegetation on the viewable area was estimated by adding the average height of vegetation classes to local elevation in the DEMs. The height of the vegetation was estimated using data on the average height of trees from the U. S. Department of Agriculture site (http://fiatools.fs.fed.us/fiadb-downloads/datamart.html). The estimated average height of the trees for the study area was 17.5 m.

2.3 Viewshed Calculation

Sixteen GPS points were selected along the highway. Some of the selected points were located at mountain ridges or existing overlooks, and some were random points along the highway. Figure 1 shows the location of the 16 points along the highway (point 1 to point 16 from left to right). These GPS points were used as input data along with DEMs of West Virginia for the viewshed analysis. Land cover maps were used to calculate the area of each land cover type visible from each of the sites.

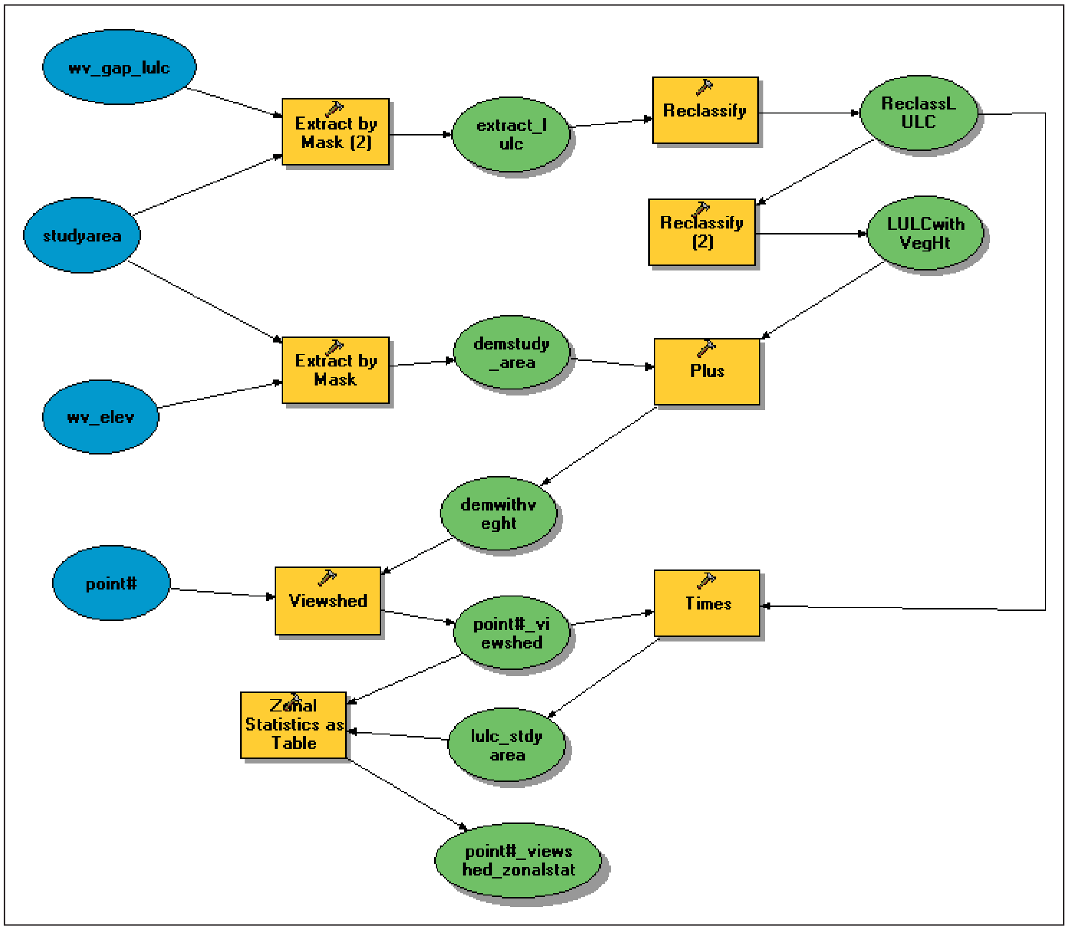

Figure 2.—Model for the calculation of viewshed.

The following steps were used to define the viewshed in ArcGIS:

1) DEM and land cover grid of the study area were extracted from their respective maps of West Virginia.
2) Twenty-six land cover types from the West Virginia GAP were reclassified into seven broad categories (developed, agriculture, shrubland/woodland, forested land, water, wetland, and barren land).
3) The average height of the trees for the study area (17.5 m) was added to the reclassified map from step 2.
4) To include the tree height in the DEM, the map obtained from step 3 was added to the DEM of the study area.
5) Using the DEM of the study area and the GPS points, viewsheds were calculated for every point.
6) Using the reclassified map from step 2 and viewshed maps from step 5, land cover types visible from the points were calculated.
7) Finally, the area of each land cover type in each viewshed was calculated.

The calculation of the viewshed was adjusted by adding an attribute item in the attribute table of the observer points. For this study, the observer height was set at 1.7 m above the elevation of the surface (i.e., the average viewer's eyes are expected to be approximately 1.7 m above ground level). The observer was positioned at the top of the canopy in cases where the height of vegetation at the observation point was higher than 1.7 m. The outer radius for the viewshed was set at 39 km based on La Kose's (2004) reasoning that air pollution is likely to prevent views over longer distances. Figure 2 shows the general work flow diagram (model) for calculating the viewsheds.

 

Figure 3.—Examples of photographs used for scenic beauty assessment for point 16 (left is September, right is October).

2.4 Scenic Beauty Estimation

Digital photographs of each study site were used to gather information on perceptions of scenic beauty. Photographs were taken from the same points with 360-degree coverage in September and October 2007; Figure 3 shows photographs taken from point 16 at the two different times. Eighty-four photos were taken in September (early fall) of 2007, but due to ongoing construction work along the highway, only 64 photos were taken in October (late fall) 2007. Photographs taken at the sites were shown to 35 undergraduate students at West Virginia University. Research has shown that college students tend to make similar scenic beauty judgments as the general public (e.g., Daniel and Boster 1976, Buhyoff and Leuschner 1978, Anderson and Schroeder 1983). The students were asked to rank the scenic beauty of the photographs on a scale of 0 to 10, with 0 indicating the lowest scenic beauty and 10 indicating the highest. They were told that the study was attempting to determine the public's scenic perception of several landscapes. Participants were not told anything about the sites and the seasons in the photographs because past studies in the other disciplines have shown that people tend to rank familiar areas more highly than unfamiliar areas (Jackson et al. 1978, Hammitt 1979, Balling and Falk 1982). Research by Cook and Cable (1995) and Buhyoff et al. (1986) used a scenic beauty estimation method proposed by Daniel and Boster (1976). However, this study used the actual ratings assigned to the photographs to avoid further calculations and transformations of the scenic beauty indices.

2.5 Data Analysis

The total area (in hectares) of all land cover types visible from each of the 16 points was calculated. The mean scenic beauty value was calculated for each of the points for September and October. T-tests were used to evaluate differences in the perceived scenic beauty of each point between early fall and late fall. Multiple linear regressions were used to model the relationship between the different land cover types (explanatory variables) and scenic beauty (response variable) for each time period.

3.0 RESULTS AND DISCUSSION

3.1 Viewshed Calculation

Point 9 had the largest viewshed area, followed by points 16, 11, 12, and 10, in that order (Table 1). These were also the only points from which all seven land cover types were visible. The point with the smallest viewshed was point 3, followed by points 2, 1, and 4, in that order (Table 1). Figure 4 shows point 16's GIS viewshed analysis with visible land cover types.

3.2 Scenic Beauty Estimation

The average values of perceived scenic beauty ranged from 3.13 to 7.48 for September and from 3.98 to 7.93 for October. The average perceived scenic beauty values for all 16 points for the two time periods are presented in Figure 5. Except for points 4, 5, and 15, all points have higher values in October than in September. T-test results showed significant differences between scenic beauty values for September and October (p-value <0.015).

Table 1.—Viewshed results for all 16 points with qrea of visible land cover types in hectares

Point	Developed	Agriculture	Shrubland/ Woodland	Forested Land	Water	Wetland	Barren Land	Total
1	3.60	0.09	0.00	245.73	0.00	0.00	0.00	249.42
2	0.18	0.09	0.00	236.72	0.00	0.00	0.00	236.99
3	0.00	0.18	0.00	228.89	0.00	0.00	0.00	229.07
4	0.00	0.18	0.00	260.40	0.00	0.00	0.09	260.67
5	0.00	0.00	0.00	343.96	0.00	0.36	0.00	344.32
6	0.00	0.00	0.00	708.10	0.00	0.18	0.00	708.28
7	0.00	19.63	3.24	879.36	0.00	0.09	0.00	902.32
8	0.00	11.71	13.06	3667.18	0.00	11.89	0.00	3703.84
9	3.69	1969.51	124.17	12,465.60	89.50	44.48	1.17	14,698.12
10	0.54	72.93	29.71	7298.44	0.81	3.51	1.71	7407.65
11	9.54	110.66	53.40	12,233.20	1.53	0.63	26.20	12,435.16
12	3.51	136.78	44.03	10,906.60	0.72	1.08	55.65	11,148.37
13	0.00	3.24	3.51	697.65	0.00	0.00	0.00	704.4
14	0.00	71.31	22.87	3914.08	0.18	5.49	0.27	4014.2
15	9.09	92.29	28.54	6323.63	0.00	1.44	6.75	6461.74
16	12.52	647.95	83.11	11,658.20	47.63	3.06	13.42	12,465.89

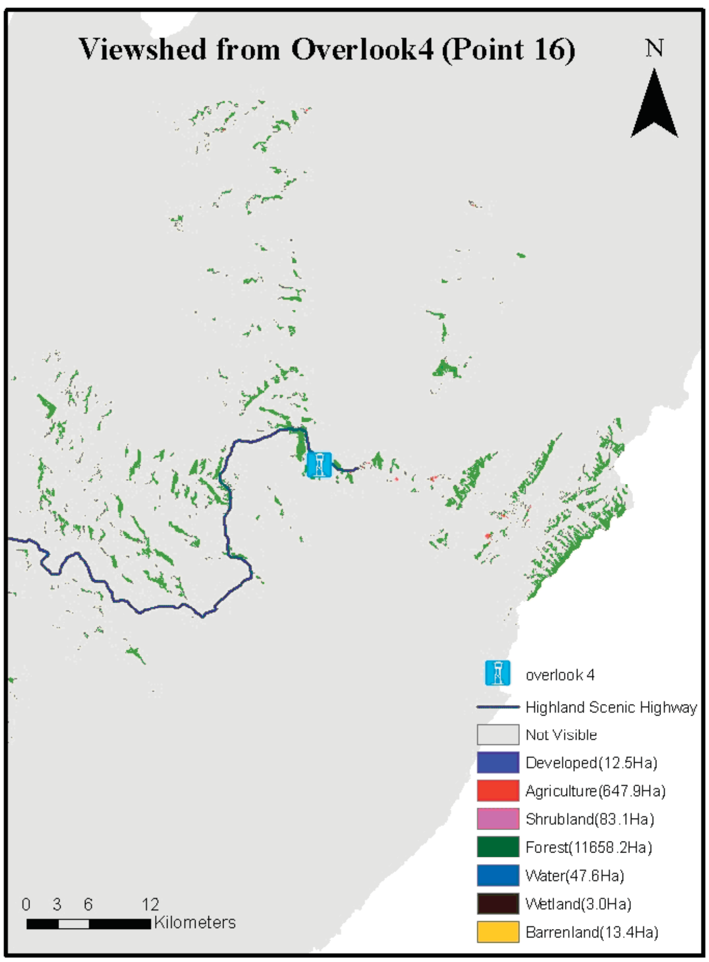

Figure 4.—GIS map showing viewshed from point 16.

3.3 Scenic Beauty Modeling

The independent variables (i.e., the land cover types) considered for the regression had high levels of correlation. As a result, only the forest, agriculture, and nonvegetated land (combined barren land and developed area) variables were used. Tables 2 and 3 show the regression estimates of scenic beauty for each month. The regression for September was not significant, but the regression for October was significant at the 5 percent level of significance, and the variables in the model explained 43 percent of the variation in scenic beauty values. Only the variable "forest" was significant at the 5 percent level. The positive sign indicated that increasing the total forest area would increase the value of the scenic beauty in late fall. Furthermore, the negative sign of the nonvegetated areas (i.e., barren and developed) indicates an inverse relationship with scenic beauty values when other factors are held constant.

Forest cover had a significantly positive relationship with scenic beauty for October but not for September, implying that scenery in the area is more beautiful in October than in September. Although the area of land

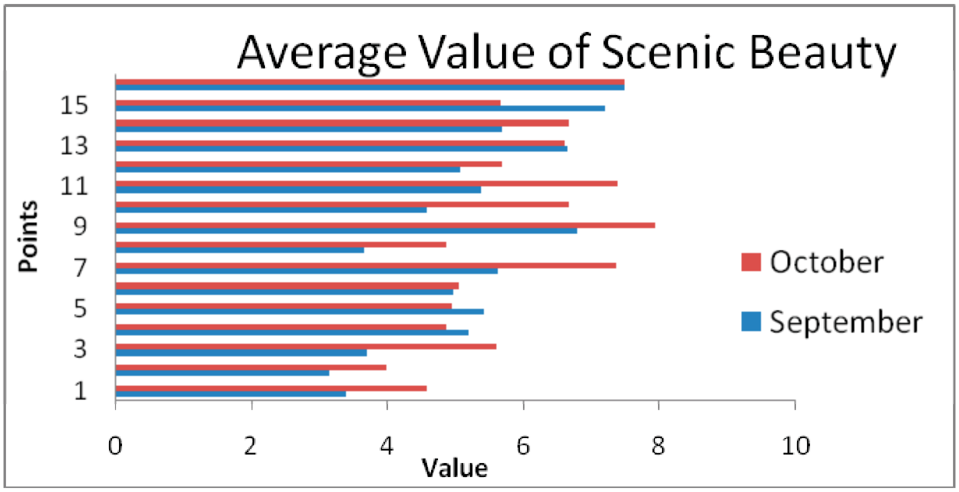

Figure 5.—Average value of scenic beauty for all 16 points for September and October.

Table 2.—Linear regression estimate for scenic beauty for September 2007

Ordinary Least Squares estimates using the 16 observations

Dependent variable: September Scenic Beauty

Variable	coefficient	std. error	t-ratio	p-value
const	4.6401	0.4533	10.2358	0.0000
Forest	0.0001	0.0001	0.9746	0.3490
Agriculture	0.0007	0.0008	0.7974	0.4407
Barren and Developed	-0.0140	0.0343	-0.4079	0.6905
P-value(F)	0.2232			
R-squared	0.2962			
Adjusted R-squared	0.1203			

Table 3.—Linear regression estimate for scenic beauty for October 2007

Ordinary Least Squares estimates using the 16 observations

Dependent variable: October Scenic Beauty

Variable	coefficient	std. error	t-ratio	p-value
Const	5.1550	0.3301	15.6166	0.0000
Forest	0.0002	0.0001	2.3066	0.0397
Agriculture	0.0005	0.0006	0.8629	0.4051
Barren and Developed	-0.0343	0.0250	-1.3721	0.1951
P-value(F)	0.0205			
R-squared	0.5443			
Adjusted R-squared	0.4303			

cover visible from all the points is the same for both months, diversity in leaf color in October (late fall) seems to add to the perceived beauty of the area. This result is consistent with previous findings that people prefer diversity in the landscape of forested regions (Cherem and Traweek 1977, Ribe 1986, Axelsson-Lindgren and Sorte 1987).

Forests are the most visible land cover type from all points along the Highland Scenic Highway, followed by agriculture land; water and wetland are the least visible land cover types. The average viewshed at all 16 points is 97.6 percent forest, which means that forests have the largest influence on scenic beauty in the area. The negative relationship between scenic beauty and barren land implies that planting vegetation on barren land and reducing clear cutting would help increase the perceived natural beauty of the area. In addition, planting trees in and around the developed areas would both benefit the local environment and provide a better vista for tourists.

Regarding the results from the viewshed analysis and the perception of scenic beauty for each location, sites with diverse land cover types and larger visible areas were generally ranked higher than sites with fewer cover types and smaller viewsheds. According to these criteria, point 9 is the most suitable for sightseeing, followed by points 16 and 11. Points 16 and 11 are existing scenic overlook spots on the HSH. All the points except 4, 5, and 15 have higher values in October than September; points 4, 5, and 15 may experience earlier leaf-off conditions than other points.

Although the viewshed tool in GIS and the survey of photographs are promising in explaining the relationships between scenic beauty and the visible land cover for two different months, certain limitations might have influenced the findings. This study used a land cover and elevation dataset with 30-m resolution. This coarse resolution strongly affects calculations of the area of the different land cover types in each viewshed. In addition, some of the sites' viewsheds included land in Virginia, but data for Virginia were not included in the analyses.

Future research needs to examine simultaneous observations of topographic variation like shapes and patterns of the features within the viewshed for a given point. This type of investigation will test variables that can explain more variation in scenic beauty estimates. In addition, this study examined scenic beauty for two months; a longer period of observations might help expand and refine the findings. Finally, high resolution datasets would be extremely beneficial in future viewshed analyses.

4.0 CONCLUSIONS AND IMPLICATIONS

Forest was found to be the major land cover type providing scenic beauty in the HSH. There was a significant relationship between scenic beauty and visible land cover types in October but not September. These results indicate that as the diversity of leaf color increases, the level of perceived scenic beauty also increases. The types of land cover visible from the particular locations and the area of each land cover type can be directly calculated using tools in GIS. This approach provides a powerful way to model scenic beauty using the diversity and extent of visible land cover types. Additionally, the negative relationship between scenic beauty and nonvegetated land suggests that basic land-use planning focused on increasing vegetated land cover could increase perceived scenic beauty in the area. This kind of study could be used to select locations for new overlooks or viewing towers. The extent of visible land cover types could be described in interpretive signage to educate visitors about how land cover types are related to scenic aesthetics. Findings from this type of analysis could also be displayed in travel guides and on tourism websites to attract prospective visitors and promote season-based tourism in the area.

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