ASSESSMENT OF LANDSCAPE SCENIC QUALITY IN THE ANGELINA NATIONAL FOREST, TEXAS USING GIS AND HIGH-RESOLUTION DIGITAL IMAGERY

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ABSTRACT

Landscape scenic quality is a valuable and unique resource and it is included in forest planning as an important variable for assessing environmental factors. Scenic quality is known to increase as factors such as topographic relief, proximity to water, diversity of vegetation, and presence of natural landscapes increase. The USDA Forest Service uses the Scenery Management System (SMS) to systematically derive the relative value and importance of scenery in National Forests. However, the collection of scenic data for the SMS has traditionally relied on extensive field work by trained observers and manual techniques. The goal of this project was to use remote sensing and Geographic Information System (GIS) tools to reduce the time necessary to complete landscape visual quality assessments. Advances in remote sensing technology and GIS techniques have provided opportunities for faster and more cost-effective collection of scenic quality variables. In particular, the increased availability of high spatial resolution digital imagery has proved to be ideal for scenic assessments because it allows for finer exploration of visual patterns and relationships between features. In this project, high spatial resolution digital imagery, and other geospatial data such as elevation, land use class, forest cover type diversity, forest stand age, and proximity to lakeshore were used to complete scenic quality assessments in an effective and timely way.

Key words: Scenery Management System, landscape aesthetics, forest planning, GIS, NAIP.

INTRODUCTION

The scenic beauty of a landscape is an important economic and cultural resource and has become an essential component in the forest planning process. The Scenery Management System (SMS) is a framework used for determining the relative value and importance of scenery in a National Forest (Anderson 1995). The system can help managers and planners design forest activities to reduce adverse impacts on natural landscape character and scenic integrity. Generally, natural-appearing and visually attractive landscapes are the most highly valued. In addition, landscapes that contain both diversity and balance have the greatest potential for high scenic quality.

Various methods have been used over time to assess scenic quality. For example, expert- and observer-based descriptions of perceived naturalness, vividness, landscape scene variety, and unity of elements were used in a scenic analysis of highways in California's Central Coast Region (Clay and Smidt 2004). The authors found that vividness and variety were related to scenic preference. Mendel and Kirkpatrick (1999) used grid-based (10 km^2) pictorial representations of relative relief, waterforms, diversity of vegetation, and occurrence of waterfalls and caves to assess the aesthetic resource in Tasmania, Australia. The authors determined that the process was a cost-effective tool for both assessing and planning the expansion of reserve areas. Photographs were also used to evaluate visual quality of rural landscapes in Andalusia, Spain (Arriaza, et al. 2004). The authors found that perceived visual quality was primarily related to the degree of landscape wilderness, presence of attractive human-made elements, color contrast, and amounts of water and vegetation.

The capabilities of modern computers, advancements in geographic information system (GIS) software, and higher resolution data sets can allow landscape assessments to be produced more quickly and efficiently. Brabyn (2005) used a GIS to successfully characterize the degree of naturalness in visual landscapes in New Zealand. GIS was also utilized along with remote sensing in the northwestern coast of Egypt to assess the aesthetic values of the landscape (Ayad 2005). In both studies, the technologies provided reliable, repeatable, and timely scenic

assessments. Another benefit of using GIS techniques to facilitate scenic assessments is that variables can be easily weighted depending on the degree of their contribution to the analyses.

Traditionally, the collection of scenic data for the SMS has relied on trained observers and labor-intensive field work. Advances in remote sensing technology and GIS techniques may provide opportunities for faster and more cost-effective collection of scenic quality variables. The goals of this project were to develop a suitable scenic quality model for the Angelina National Forest, and to determine if the time necessary to complete landscape visual quality assessments could be reduced through the use of remote sensing and GIS tools. Variables used in the project included high spatial resolution digital imagery, land use class, landscape integrity, forest stand age, diversity of forest types, forest type significance, proximity to lakeshore, roadway extent, elevation, and forest planning guidelines.

METHODS

Study Area

The study area was the Angelina National Forest which encompasses 153,179 acres, and is one of four National Forests in Texas. The Angelina National Forest is located in east Texas, USA (Fig. 1) in Angelina, Nacogdoches, San Augustine, and Jasper counties. The forest lies in the Neches River Basin and on the north and south shores of Sam Rayburn Reservoir, an 114,500-acre lake on the Angelina River. The West Gulf Coastal Plain Ecoregion encompasses the forest and the terrain is gently rolling. The predominant forest cover types are loblolly pine (*Pinus taeda*), longleaf pine (*P. palustris*) and shortleaf pine (*P. echinata*), and hardwoods such as oak species (*Quercus* spp.) and sweet gum (*Liquidambar styraciflua*). Generally, the pines are found on the uplands and hardwoods on the bottomlands.

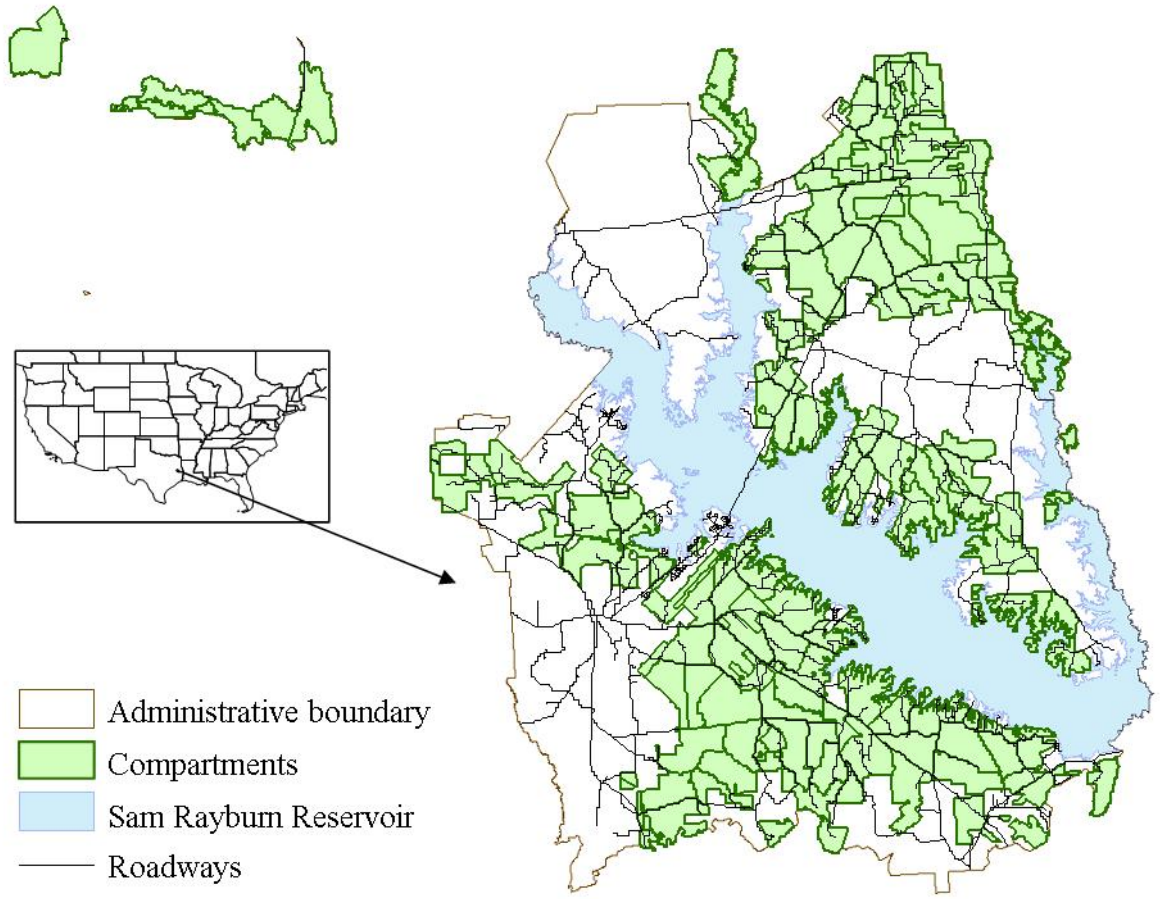

Figure 1. Study area: the Angelina National Forest, Texas, USA.

Data and Analyses

Variables used to model scenic quality throughout the forest included land use class, landscape integrity, forest stand age, diversity of forest types, forest type significance, proximity to lakeshore, roadway extent, elevation, and forest planning guidelines.

- Land use classes were derived from the National Land Cover Database 2001 (USDA NRCS NCGC 2007). Seven land use classes were used in the analyses. In general, visitors value natural areas more highly than those altered by humans, therefore the classes were rated from high to low as follows: forest; wetland; shrubland and herbaceous upland; herbaceous cultivated; barren and developed.
- Landscape integrity was calculated by determining total acreage amounts in each land use polygon. Typically large, intact parcels are valued more than those that are smaller or fragmented. Consequently acreage amounts were rated from high to low in order from the largest to the smallest polygons.
- Forest stand age and type data were obtained from the forest silvicultural database. Greater stand ages are usually valued more than lesser ages, thus stand age was rated from high to low in order from the oldest to the youngest ages.
- Forest type diversity was determined by the proportion of different forest types to total types in each compartment. Greater forest type diversity is typically valued more than lesser diversity, and compartments were rated from high to low in order from the largest to the smallest proportions.
- Forest type significance can vary greatly depending on site variables and desired future conditions but in general, significance was categorized from high to low as follows: longleaf pine; shortleaf pine and white oak (*Quercus alba*); sweetgum-oak, oak spp., and loblolly pine; water tupelo (*Nyssa aquatica*) and green ash (*Fraxinus pennsylvanica*); slash pine (*Pinus elliottii*).
- Proximity to lakeshore is a highly valued amenity, therefore values were categorized from high to low by closeness of forest stands to the Sam Rayburn Reservoir shoreline in increasing increments from 100 ft to 1000 ft (100 ft, 250 ft, 500 ft, 750 ft, and 1000 ft).
- The forest Motorized Vehicle User Map roads layer was overlayed with the forest compartment layer and lengths of roads (ft) per compartment were calculated. Typically areas with few roads are valued greater than those with many roads so compartments were categorized from high to low in order from lesser to greater road levels.
- Elevation values were derived from the National Elevation Dataset (30 m) (U.S. Geological Survey 2009). Visitors generally value higher elevations more than those that are lower thus values were categorized from high to low in decreasing order of elevation values.
- Forest planning guidelines reflect site characterizations (e.g., wilderness areas – preservation, natural bogs and rare plants – retention, and less-sensitive areas – maximum modification). Sites were categorized from high to low scenic guidelines in order as follows: preservation, retention, partial retention, modification, and maximum modification.

The variables were formatted as rasters, and values in each raster were reclassified to five levels from high to low using the Jenks natural breaks algorithm in ArcGIS (ESRI Inc.). A forest-wide model of scenic quality was created by summing the raster variables cell-by-cell through use of the ModelBuilder tool in ArcGIS. A series of models were derived and were adjusted by weighting variables differently depending on their perceived contribution to the scenic quality of the forest. The resultant final model (Fig. 2) was reclassified to five levels from high to low scenic quality, and was assessed by the Forest Landscape Architect for accuracy through visual analyses of National Agricultural Imagery Program (NAIP) 2009 (1 m) (USDA FSA APFO 2009) forest-wide coverage, and expert field knowledge. The assessment was not intended to replace appraisals of model accuracy in the field, but it could reduce the time necessary for field visits.

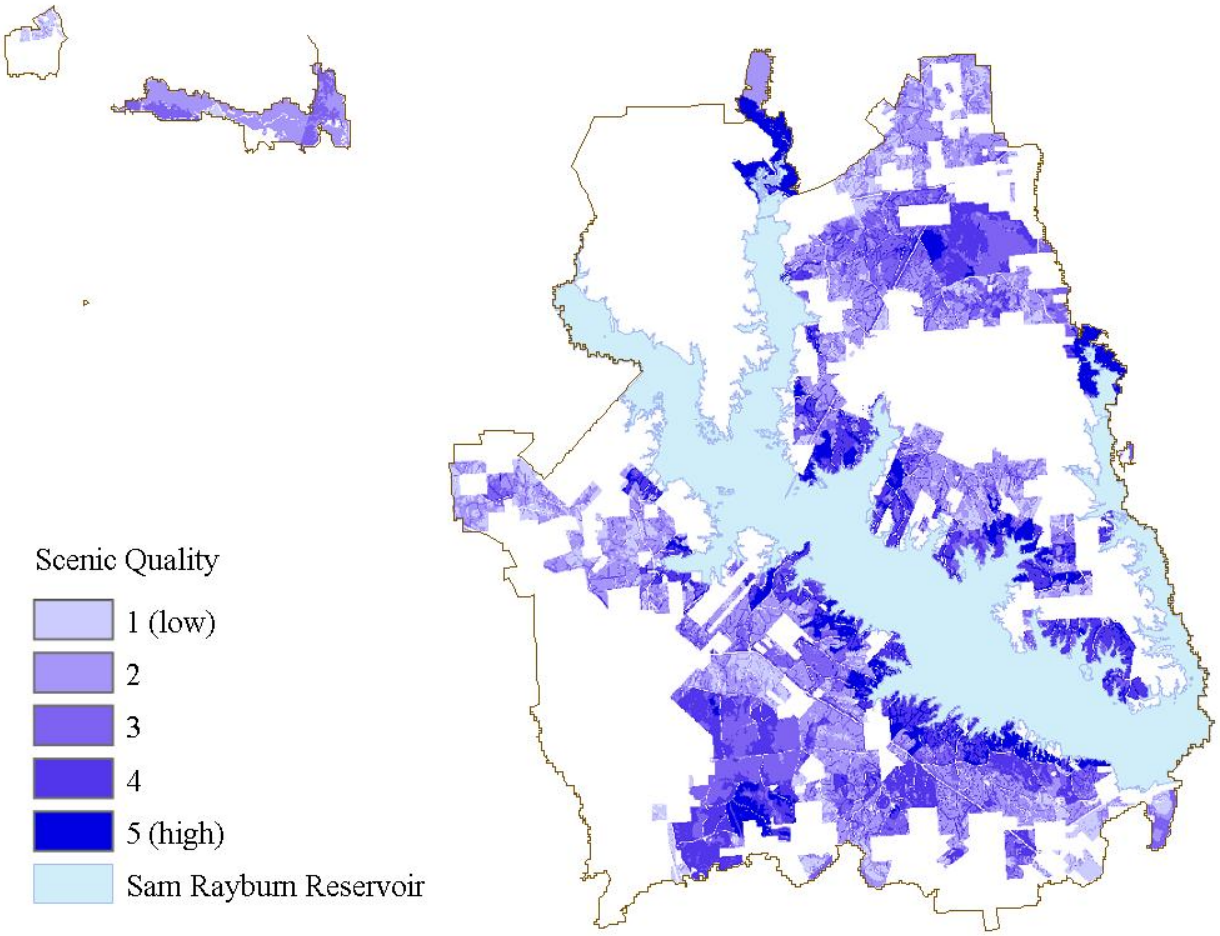

Figure 2. Scenic quality model for the Angelina National Forest.

RESULTS AND DISCUSSION

The aims of the project were to 1) develop a suitable scenic quality model for the Angelina National Forest, and 2) serve as a pilot project to test the reliability and timeliness of remote sensing and GIS methods for scenic assessments in the National Forests in Texas. Both endeavors were achieved. The final model was deemed by the Forest Landscape Architect to be a satisfactory representation of scenic quality throughout the forest. Processing of the models in ArcGIS took relatively little time and model parameters were quickly and easily adjusted.

There are several improvements that could aid the accuracy and utility of the model. For example, a canopy cover variable would have been useful since visitors greatly value open, park-like stands in certain forest areas such as the extensive ridge of longleaf pine in the southern portion of the forest. In addition, a "special places" data layer could have indicated intrinsic values on the forest that are not apparent through use of present data layers. For instance, historic places on the forest like the old Aldridge Sawmill site add visual importance that was not captured in the present model. Lastly, if time had allowed, the information provided by the NAIP imagery could have been more fully utilized. The imagery is useful for a myriad of products, such as forest condition, landscape fragmentation, water turbidity, and change analyses.

The project was conducted in a forest that is different in many ways from the other three National Forests so methods and model inputs will have to be adjusted for the others. For example, elevation levels, predominant forest cover types, and water body extents vary greatly among the four National Forests. However, the techniques can be easily and quickly amended as needed for different areas. In general, the results of the project were encouraging, and

further project goals include fine-tuning of the present model and expansion of the techniques to the other three National Forests in Texas.

REFERENCES

Anderson, L.R., 1995. Landscape aesthetics: A handbook for scenery management, *Agricultural Handbook No. 701*, Washington, DC: U.S. Department of Agriculture, Forest Service.

Arriaza, M., J.F. Cañas-Ortega, J.A. Cañas-Madueño, P. Ruiz-Aviles, 2004. Assessing the visual quality of rural landscapes, *Landscape and Urban Planning*, 69: 115-125.

Ayad, Y.M., 2005. Remote Sensing and GIS in modeling visual landscape change: A case study of the northwestern arid coast of Egypt, *Landscape and Urban Planning*, 73: 307-325.

Brabyn, L., 2005. Solutions for characterizing natural landscapes in New Zealand using geographical information systems, *Journal of Environmental Management*, 76: 23-34.

Clay, G.R., and R.K. Smidt, 2004. Assessing the validity and reliability of descriptor variables used in scenic highway analysis, *Landscape and Urban Planning*, 66: 239-255.

Mendel, L.C. and J.B. Kirkpatrick, 1999. Assessing temporal changes in the reservation of the natural aesthetic resource using pictorial content analysis and a grid-based scoring system – The example of Tasmania, Australia, *Landscape and Urban Planning*, 43: 181-190.

USDA FSA APFO, 2009. "NAIP Imagery".
< http://www.fsa.usda.gov/FSA/apfoapp?area=home&subject=prog&topic=nai>, Accessed September 2009.

USDA NRCS NCGC, 2007. "nlcd_tx_utm14.tif".
<ftp://gateway2.ftw.nrcs.usda.gov/GatewayCatalogDetails/MetaData/NLCD/nlcd_tx_utm14.html>
Accessed August 2009.

U.S. Geological Survey, 2009. "1-Arc Second National Elevation Dataset".
<http://extract.cr.usgs.gov/distmeta/servlet/gov.usgs.edc.MetaBuilder?TYPE=HTML&DATASET=NED>
Accessed August 2009.