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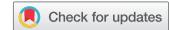
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Mapping potential motorised sightseeing recreation supply across broad privately-owned landscapes of the Southern United States

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ABSTRACT

The recreational opportunities available across landscapes of the Southern United States can be broad and diverse, and collectively are considered a subset of cultural ecosystem services. In describing the settings of recreational opportunities, a number of methods have been proposed that are based in part on geographic information and that can be facilitated by geographical analyses. Presented here are two expedient and cost-effective methods for assessing the recreation supply potential of large, heavily-roaded areas that are situated mainly with privately-owned land in the Southern United States. One land classification process uses fine-scale aerial imagery and other geospatial data in a process that results in three recreational opportunity setting zones with a focus on motorised sightseeing: foreground, background, and remote areas. Within these zones, land cover was derived and aggregated into three major land cover classes, including forest, agriculture, and bare ground classes. Further, a second process uses fuzzy classification methods, and through this highly suitable recreation settings were identified. Each recreational opportunity zone is further subdivided by public- and privately-owned land. We feel these types of recreation setting models can allow managers and planners to gain an understanding of the passive recreation potential of heavily-roaded privately-owned landscapes typical of the Southern United States.

KEYWORDS

Recreation; motorised sightseeing; private land; geographic information systems; supervised classification

1. Introduction

Some of the most popular recreational activities in the United States include viewing natural scenery and sightseeing (Betz, English, & Cordell, 1999; Cordell, 2012). These activities are estimated to be engaged in by 50% or more of the population of the United States each year (U.S. Department of Agriculture, 2012). Many of these activities are associated with motorised travel activities, which have experienced growth in the last decade. Recreation of this sort within developed landscapes is expected to continue to grow, particularly in the Southern United States, as more people undertake multipurpose recreational excursions (Bowker et al., 2012; <http://www.srs.fs.usda.gov/futures/reports/draft/Frame.htm>). The importance of assessing available recreation supply was brought to the forefront starting in 1958, with the formation of a bipartisan congressional Outdoor Recreation Resources Review Commission. The main goals of the commission included determining the desired recreational opportunities from

the present to the future, assessing the recreation resources available in the United States to meet the needs of its citizenry, and determining programmes and policies appropriate for reaching the desired outcome (Olson, 2010). The resulting policy and programme recommendations led to the establishment of the Bureau of Outdoor Recreation, and the passage of legislation, including the Wilderness Act of 1964 and the Wild and Scenic Rivers Act of 1968. From 1958 on, recreation and land management have coexisted as components of land management. The supply of outdoor recreation opportunities is ultimately dependent on the goals and desires of the owners of land, and the region or area in which the land exists. For example, state organisations play a significant role in outdoor recreation in the Eastern United States due to the presence and proximity of state lands to populated areas (U.S. Department of Agriculture, 2012). However, private landowners in the United States also play a major role in providing recreational opportunities (Betz et al., 1999; Snyder & Butler, 2012), particularly in the Southern United States, where nearly 90% of forest land is privately owned, and private landowners are relatively free to choose the use of the land. When recreation opportunities are within close proximity to populated areas, regardless of land ownership, recreation is one of the highest valued cultural ecosystem services (Bastian, Haase, & Grunewald, 2012).

While an assessment of the current character of land may be of value in assessing recreation potential, recognition of the history of land use is also of value. The private lands of the Southern United States have undergone significant modification since the initiation of European colonisation. Agricultural markets were the main drivers of land cover change from 1700 to 1860. Some of these lands have shifted between forest and agriculture uses several times since. Those areas that continuously remained in forest uses have perhaps had trees harvested four or five times since European colonisation (Bettinger et al., 2013). Along with these modifications of the environment, the development of roads and other infrastructure have in many locations altered the natural appearance of the landscape. While people today can enjoy the scenery these lands provide through travel along public roads, only a small percentage of these lands are physically accessible to the public for more specific recreational activities such as camping or hunting. Physical access to private lands in the United States is often unavailable except through an agreement with the landowner or through incentives provided to private landowners (Snyder & Butler, 2012). Though the land has been altered from the pre-colonisation state, the relative wildness or perceived naturalness of landscapes can still be defined using geographic information so that potential recreational experiences can, in part, be assessed (Carver, Comber, Morran, & Nutter, 2012). As the emphasis on sustainable development increases, an assessment of these resources at a landscape scale becomes more important (Stanwick, 2002).

Although hunting, hiking, boating, and cycling are all common recreational activities in the Southern United States, sightseeing associated with motorised travel activities is among the most popular (Cordell, 2012; Hallo & Manning, 2009). Therefore, aesthetic values (scenery) are important considerations in the management and assessment of recreational settings (U.S. Department of Agriculture, 1995). One objective of this paper is to provide a brief review of the geographic models that have been proposed to assess the distribution of recreation settings across broad landscapes. Since our focus is on the predominately privately-owned land and heavily-roaded landscape of the Southern United States, during this review we periodically reference the usefulness of these approaches to this region. A second objective of this paper is to describe two models that may be applicable to the Southern United States, using freely available geospatial data, and demonstrate the use of these models through a case study county in North Florida.

2. Recreation setting modelling

An analysis of recreation supply can involve the use of validated models (calibrated based on data), data collected specifically for an area of interest, and implicit modelling within other valuation processes (Schägner, Brander, Maes, & Hartje, 2013), each typically requiring significant information and effort. The supply is influenced by components, the facilities available, the activities typically pursued, and the setting (Hayden et al., 1996). We are mainly concerned with the setting in this work, as the facilities are assumed to be roads, and the activity is assumed to be motorised sightseeing. Geospatial approaches

alone have also been favoured over more direct surveys of recreational values, due to the time and cost involved and potential problems with survey responses (Kliskey, 2000). From a recreational use perspective, a landscape can be described as a physical setting, or perceived through the land and water resources viewed from a distance (Brabyn & Mark, 2011), containing resources that can be situated within complex political and cultural boundaries (Olson, 2010). One frame of reference for communicating the ability of a landscape to supply recreational opportunities involves landscape classification (Brabyn & Mark, 2011) often involving geographical analysis, as the adequacy of the setting is in part a function of the spatial distribution of opportunities (U.S. Department of Agriculture, 1986). One objective of recreation-based land classification systems is to help managers avoid inconsistencies, or times when the physical, social or managerial aspects of land fail to contribute to the same type of recreational opportunity (U.S. Department of Agriculture, 1986). Applications to the recreational capacity of an area have been suggested in order to accommodate various uses of land resources (U.S. Department of Agriculture, 1982). While not the focus of this study, the carrying capacity concept has long been used as a conceptual model for managing recreational supply mandates (Beeco & Brown, 2013; Wagar, 1951).

Perhaps the most widely used system of land classification for recreational purposes, the recreation opportunity spectrum (ROS) was designed to help managers understand the amount of diverse recreational settings that an area can provide, in order to facilitate planning efforts (Clark & Stankey, 1979). The ROS is a framework based on the premise that across the landscape there are settings that range from urban to primitive lands, and there are opportunity types that determine the range of activities that can be accommodated (Ahn, Lee, & Shafer, 2002; Clark & Stankey, 1979). The ROS system emphasises natural features, infrequent social interactions, and solitude at one end of the spectrum (primitive areas), and managed landscapes with frequent social interactions at the other end (urban areas). A recent modification of the process extended it to water resources and involved assessments of water, air, and noise, among other aspects of the physical, social, and managerial settings (Haas, Aukerman, & Jackson, 2011). However, the process was originally designed for the extensive areas of public land in the Western United States, rather than the heterogeneous mixture of smaller landownerships of the Eastern United States (More, Bulmer, Henzel, & Mates, 2003). One broad assessment of the Southeastern United States combined the ROS with a model that accounted for natural and cultural systems, and used rural, transitional, suburban, and urban classes to describe areas that were not necessarily natural in appearance (Hayden et al., 1996). In heavily-roaded areas typical of the Southern United States, for example, the outcomes would generally only include the urban, rural, and roaded natural classes. In Hayden et al. (1996), private lands accounted for nearly all of the rural recreation settings, and a majority of the roaded natural settings, but higher-density recreational settings were mainly located on public land.

Similar to the ROS, Caspersen and Olafsson (2010) developed seven experience classes for landscapes in Denmark that ranged from wilderness areas to specific facilities that provide the assurance of safety and security. In addition to the wilderness class, the other classes were called 'feeling of forest' (compact forest areas), panoramic views (facilitating the experience of wide spaces), biodiversity and landform (biologically or geographically special places), cultural history (areas of tangible or intangible heritage), activity (e.g. facilities for golfing) and challenge (e.g. rock climbing, hang gliding), and service and gathering (facilities, such as picnic areas for social gatherings). Some of these classifications were developed for highly populated areas, while others required a spatial analysis of the proximity of land to features, such as streams, power lines, and urban areas. In contrast with the ROS, where primitive areas are located a great distance from roads, the wilderness class in this system needed only to be 75 m from high voltage power lines, 250 m from urban areas, and a certain distance from roads and railways where the noise level drops below 45 dB.

Hamilton (1996) described a method whereby a target recreational activity was selected, and the important attributes of the landscape for this activity were then identified and rated individually. The degree to which each attribute contributed to the experience was weighted and a single score (0–10) was created from the individual parts based on expressed preferences of recreationists. In an example, three sets of attributes were identified: natural physical features, man-made physical features, and

social features. Some of these require local knowledge of available resources, making this method very challenging to apply to broad landscapes.

Considerable effort has been spent in assessing landscapes based on their scenic beauty and attractiveness (Brown & Daniel, 1984). Scenic beauty and attractiveness can be assessed through surveys, inventories, or evaluations of preferences. These models could be used to map scenic beauty, assuming the landscape was entirely forested and the appropriate inventory data were available. Buhyoff, Hull, Lien, and Cordell (1986) presented a similar approach for Southern United States pine forests. Other efforts have been based on vegetation conditions, landforms (slope), inherent scenic attractiveness (U.S. Department of Agriculture, 1995).

Other models have also been proposed. For example, a model described by Stanwick (2002) recognised the role played by agriculture and forestry in the perception of United Kingdom landscapes, and landscape character was described as a distinct pattern of elements that occurred on a landscape. Additionally, a geographical assessment of recreation potential with regard to the visibility of terrain could be employed, focusing on the visual attractiveness of the landscape from particular points of interest. The mean distance of forests to regional roads was used as a variable in the analysis of factors that affect visitation levels (Colson, Garcia, Rondeux, & Lejeune, 2010). A wealth of information on assessing land resources for recreational purposes can be located through an exhaustive literature review. We have attempted to describe the main approaches above due to their applicability to large landscapes, the use of widely available data, or the association with recreational habits of people of the Southern United States. Our proposed models concentrate on the assessment of dispersed, predominately privately-owned and heavily-roaded landscape of the Southern United States rather than specific recreational areas, such as national forests or national parks. Although many of the privately-owned lands of the Southern United States are not open for public access, they can provide an aesthetic backdrop for users of adjacent roads, and thus, are of value to passive recreationists who enjoy viewing resources from a distance rather than directly entering them (Millward, 1991).

3. Case study area

While about 57% of the forested land in the United States is privately owned, our example setting is the Southern United States, where about 88% of the forest land is privately owned (Bettinger et al., 2013; Food & Agriculture Organization of the United Nations, 2010). These private forests average about 4 ha in size (Oswalt, Smith, Miles, & Pugh, 2014). Across the region, forested areas are generally considered to be composed of temperate and subtropical coniferous and broadleaved tree species. Agricultural land uses dominated the landscape of the Southern United States from about 1700 to 1860, and forests were cleared for these purposes. In the late 1800s, large expanses of abandoned agricultural land became colonised with early-successional coniferous forests (Schultz, 1997), and since around 1900, large areas of idle, formerly agricultural land have also been reforested.

Jackson County, Florida (Figure 1) was selected in order to demonstrate this recreation opportunity supply analysis. This county was chosen primarily due to its rural nature combined with the abundance of geospatial data available for the county, including county-wide parcel data. The county is located in the panhandle of North Florida, and its southwestern corner is about 57 km from the Gulf of Mexico. The county contains 247,057 ha of land, of which 90% is privately owned and about 1% of which are developed areas. An estimate of the human population in 2012 was about 49,000 (<http://quickfacts.census.gov/qfd/index>), of which nearly 9000 lived in the centralised county seat, Marianna. There are over 41,000 land parcels, and about 950 km of Class 3 (e.g. urban and rural local access roads that are passable under all types of weather conditions) or higher roads in the county.

4. Modelling methods

We conducted the recreation setting analyses on a county-level scale, using high spatial resolution digital orthophotographs and geographically depicted land ownership parcels. Specifically, we used the



Figure 1. Excluded areas in Jackson County, Florida.

United States Department of Agriculture's Farm Service NAIP (National Agriculture Imagery Programme) 2013 digital orthophoto mosaics covering Jackson County. NAIP imagery is 1 m spatial resolution imagery available in natural colour digital ortho quarter quads (DOQQ) of compressed county mosaics obtained during the agricultural growing season for the continental U.S. (<http://www.fsa.usda.gov/FSA/apfoapp?area=home&subject=prog&topic=nai>). Using this high-resolution imagery, a supervised classification was performed dividing the landscape into eight unique land cover classes: bare ground, deciduous forest, hardwood forest, pasture, hay fields, and two spectrally unique crop classes (a general cropland class and an emergent cropland class). Additionally, a shadow class was created in order to reduce confusion between land cover classes with a similar spectral reflectance as those areas covered by shadows. These eight land cover classes were then aggregated into three general classes which included bare ground, forest, and agriculture.

A sequence of processes was created to develop the landscape setting descriptors and to utilise and transform the geographic information into databases from which estimates of recreation setting could be summarised. A significant amount of data pre-processing was performed before the recreation supply analysis was conducted. Agricultural areas and forested areas (along with other minor classes) were primarily identified through the supervised classification of the NAIP imagery. The NAIP imagery also acted as the reference data for the classified map. The agreement between the classified map and the reference database was based on our assumption that the units are homogeneous within the reference data (even though the spatial resolution was only 1 m). In order to apply this assumption, our assignment rule indicated the dominant (primary) reference land cover class within each sample unit, which was defined as a pixel, a common assessment unit choice (Stehman, 2009). In this process, we determined a single, dominant land class for each sample unit area using criteria we developed to describe the eight land classes from the supervised classification process. Photo interpretation errors were minimised using a single photo interpreter with experience using aerial images. While locational error might be a concern around edges of land cover classes (Selkowitz & Stehman, 2011; Stehman, 2009), through frequent verification of geospatial location of the validation data, we found this to not

be evident. Our objective for the response design was to establish protocols that were practical and consistently implemented (Olofsson et al., 2012).

Using an equalised random sample, the accuracy of the supervised classification was assessed with a goal of an overall accuracy of 70% and a within-class user's and producer's accuracy of at least 70%. Given the high variability involved when using a relatively small spatial resolution data-set (NAIP), this level of accuracy is consistent with other recent work (Merry, Siry, Bettinger, & Bowker, 2013). While there is no consensus in the literature on the minimum sample size needed to adequately assess accuracy (Chen & Wei, 2009), we selected a minimum of 100 samples for each class. Our sample size was a practical compromise between the time available and data necessary to adequately assess the classification process (Stehman & Czaplewski, 1998). An omission-commission matrix and four measures of accuracy are derived as indicators of the accuracy of the classification process. These measures include overall, producer's, and user's accuracies, along with a kappa statistic. The omission-commission matrix illustrates the proportion of agreement for each land cover class and the proportion of area misclassified (Stehman & Wickham, 2011).

Several land cover classes were excluded from the supervised classification. While we rely on bare ground, agricultural areas, and forested areas to be identified through the classification process, developed areas and focused recreation areas required photo interpretation of the digital orthophotography and subsequent digitisation into a geographic database. These areas contained both specialised uses and a heterogeneous collection of land classes, yet they needed to be identified and contained within specific regions for subsequent analysis of recreation supply. The land in these two classes, as in the water class, could not be assigned to other classes (e.g. focused areas have priority over developed areas), nor any of the remaining classes.

The National Wetland Inventory (NWI) (<http://www.fws.gov/wetlands/>) served as the initial point for defining wetlands across the county. In assessing the accuracy of the NWI, many wetlands present in the NAIP imagery were not found within the NWI data. Additionally, boundaries of wetlands identified with the NAIP imagery varied from those in the NWI. This is most likely the result of the temporal difference between the NWI (2010) and the NAIP data (2013) combined with the variable nature of wetland boundaries. Due to the inconsistencies between the spatial data-sets, the NWI was edited through a visual assessment using photo interpretation of wetlands within the county creating a more consistent wetlands data-set. We inspected each database and were compelled to physically adjust (through addition, subtraction, or modification) many of the features to best represent the landscape using the NAIP imagery as a base. Although the NAIP imagery includes inherent positional error, the two main reasons for these actions were (a) the NAIP imagery was to be subjected to a supervised classification process, therefore where the classification of the imagery suggested a road, a road needed to exist in the road database, and (b) there were numerous errors in various databases. In addition to editing the wetlands, both the roads and parcels data-sets needed to be modified before they could be used in the recreation opportunity supply assessment. The roads database included missing roads, fictitious roads (not really existing), and poorly drawn roads. Further, the parcel database needed to be rubber-sheeted to better reflect the position of parcels with respect to the obvious features observed in the NAIP imagery. Following a visual assessment of the NAIP imagery, a water mask was developed by digitising water polygons across the county which augmented a hydrography data-set obtained from the U.S. Geological Survey. This water mask included small bodies of water (retention ponds, agriculture ponds, and small lakes) across the county that were not included in either the hydrography data-set or the NWI. With the variability of the spectral reflectance values of the various waterbodies within Jackson County, this mask was created to simplify the supervised classification by eliminating the water class.

Several GIS data-sets are readily available and freely accessed through the Florida Geographic Data Library (<http://www.fgdl.org/metadataexplorer/explorer.jsp>). Through data from their data portal in combination with the previously mentioned water mask, any additional land uses were incorporated into excluded areas, including focused recreational facilities (e.g. baseball fields, golf courses), developed areas, cultural centres, schools, parks, religious facilities, and cemeteries. Also included in these excluded areas were buffered major roads and power lines. Both roads and power lines were buffered based on

randomly sampled measurements taken across each database creating a variable width buffer. This buffer was derived to represent right-of-ways accompanying the roads and power lines. Parcel data for Jackson County was used to classify land ownership as either public or private.

Jackson County was further geographically subdivided into foreground areas, background areas, and remote areas. Foreground areas were those land areas within 500 m of a main county, state, or federal road. Background areas were land areas that fell between 500 and 2000 m of a main county, state, or federal roads. Remote areas were all lands beyond 2000 m of a main county, state, or federal roads. The proximity to roads and the type of nearby land use is important in assessing the quality of rural, yet heavily-roaded settings. We follow the convention described in Liu, Luo, and Li (2012), where any land within .5 km of a main road was considered 'front country,' while land within .5–2 km of a main road was considered 'back country.' A class of 'remote areas' was considered to be within 2–10 km of a main road, and all other areas were considered to be either primitive or semi-primitive with respect to recreational opportunities. All roads considered to be primary or greater in class were considered main roads in Liu et al. (2012). Here, we consider Class 3 roads or greater (urban and rural local access roads passable in all types of weather) as main, drivable roads in our analysis. Roads below this class contained a mixture of paved, dirt, and native surfaces, and for this exercise were not included in the delineation of these classes. While soil types can be used to describe areas supporting recreational activities (Lyle & Stutz, 1983), these did not seem necessarily useful for our analysis. We are not suggesting empirical testing of the proposed model, as this would require surveys or other methods to assess the correspondence of the assigned land class with people's perception of the recreational value of the landscape. Among models such as this that have been presented in the literature, empirical testing is often lacking (Tviet, Ode, & Fry, 2006). These methods describe a fairly discrete method for landscape classification of recreation supply.

Finally, a model was developed using fuzzy classification techniques. Fuzzy classification methods have been used to identify wilderness areas in Scotland (Carver et al., 2012), coastal erosion risk zones in Canada (Jadidi, Mostafavi, Bédard, & Shahriari, 2014), and ecological habitats in Maine, USA (Zhang et al., 2004). Fuzzy classification is a modelling approach that takes into account the vagueness and uncertainty inherent in spatial model inputs (Fisher, Cheng, & Wood, 2007; Robinson, 2003; Zadeh, 1968). Specifically, fuzzy methods reduce the hard edges of discrete model input. For example, a model input classifying distance to roads standardised into discrete classes eliminates those pixels that fall outside of the 250 km limit in a suitability model and arbitrarily eliminating pixels that still may actually be suitable but fall outside the crisp 250 km edge. Using discrete classes instead of fuzzy memberships might lead to data loss important to modelling phenomena (Burrough, 1989). Fuzzy methods allow for degrees of acceptance into a membership class ranging from 0 to 1, with 1 indicating that a model input has full membership in a membership class. Once all model inputs have been organised into its respective membership class, those inputs are overlaid resulting in a suitability model identifying, in this case, places across Jackson County that are highly suitable recreational settings based on their distance from developed areas, distance from powerlines and other utilities, including cellphone and radio towers, distance from city centres, and the land cover type from the supervised classification. The distance model parameters were fit to fuzzy membership sets assuming that those places furthest away from the source on the landscape were assumed to be more suitable for recreation. Land cover classes were converted from discrete classes to a continuous scale giving forest classes a fuzzy membership set value closer to 1, or highly suitable (i.e. full membership in the membership class), pasture and hay a moderate suitability value, and crops and bare ground given low suitability values.

5. Results

Jackson County, FL has a total land area of 247,039 ha. Of that, 69,979 ha were excluded from the analysis either because it was considered developed (occupied by houses or otherwise impervious surfaces), focused recreational land (sports fields, golf courses), water, or wetland. Wetlands made up the largest portion of excluded area of Jackson County. Of the remaining land, 97% was identified through the parcel data-set as privately owned, and 3% was public land (mainly state owned). Using

the discrete method for recreation supply, Figure 2 provides an example of a small portion of Jackson County subdivided into the three recreation opportunity setting zones based on private and public land ownership. Of the privately-owned land, 29% fell within the foreground zone, 52% within the background zone, and 19% in the remote zone (Table 1). Within the foreground zone, both agriculture and forest land cover classes were relatively equally distributed. In the background zone, nearly 50% of the private land fell into the forest class; the agriculture class comprised 43% of the background zone. However, in the remote zone, a large proportion (53%) of privately-owned land was in agricultural use, compared to 41% being forested. In each zone, bare ground accounted for approximately 7% of the land cover.

While public lands comprise a very small amount of Jackson County, 29% fell within the foreground zone, 60% within the background zone, and 11% within the remote zone (Table 2) using the discrete method. Public land in the foreground zone was predominantly classified as agriculture (51% of the land cover), while forested land was estimated to be 43% of the land cover in the foreground zone. In the background zone, 43% of the public land was classified as agriculture, while 54% was classified as forested. Remote areas were predominantly agriculture land (50% of public land) and forested land (46%). Again, across each zone, bare ground made up very little of the land cover, and ranged from 4 to 6% of the land cover on public land.

Using the results from the fuzzy classification model (Figure 3), a total of 89,639 ha of land area were classified as highly suitable for recreational activity in Jackson County (Table 3). For the purposes here, those assigned a fuzzy membership value greater than .8 are considered highly suitable. Of that, 14% fell within the foreground zone, 26% within the background zone, and 11% within the remote zone. On private land, the majority, 24%, of land valued as highly suitable settings fell within the background zone. Thirteen per cent and 10% of land falling within the foreground and remote zones, respectively, were valued as highly suitable for recreational activities. On public land, less than 1% of the land area across all three zones was valued as highly suitable recreation settings. Unlike the discrete method previously described, this model provides a spatially continuous valuation of recreation supply. There is agreement among the two modelling approaches. Through our review of the literature it would seem

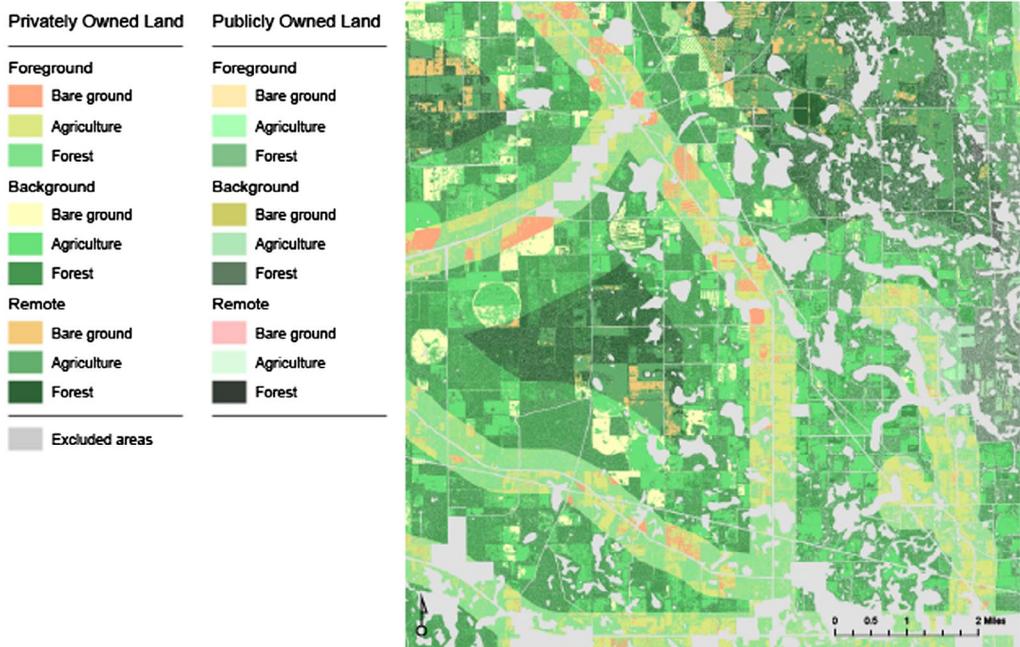


Figure 2. Private and public land within a subset of Jackson County, Florida, and the recreation supply.

Table 1. Amount and type of privately-owned land in Jackson County, Florida allocated to the three recreation supply classes.

Recreation supply class	Agriculture (ha)	Forest (ha)	Bare ground (ha)	Total (ha)
Foreground	20,296	21,297	2954	44,548
Background	34,500	39,832	5474	79,806
Remote	15,418	11,998	1937	29,354

Table 2. Amount and type of public land in Jackson County, Florida allocated to the three recreation supply classes.

Recreation supply class	Agriculture (ha)	Forest (ha)	Bare ground (ha)	Total (ha)
Foreground	749	628	93	1470
Background	1299	1644	107	3050
Remote	267	244	22	533

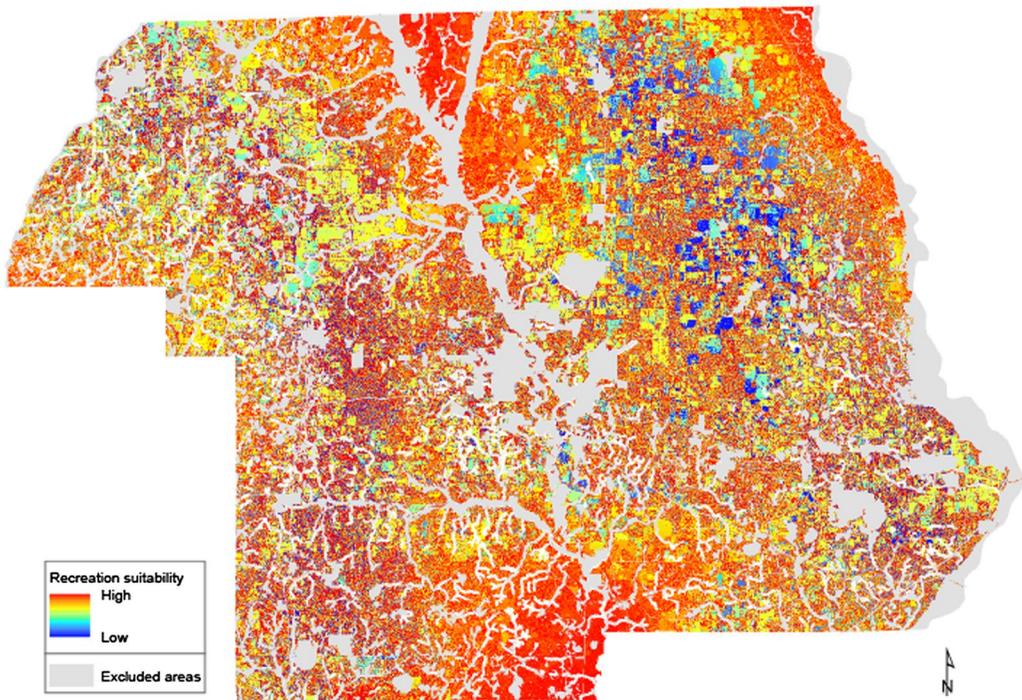


Figure 3. Fuzzy classification results identifying the area in Jackson County, Florida considered highly.

Table 3. Amount of land considered highly suitable recreation settings based on fuzzy classification and ownership type in Jackson County, Florida allocated to the three recreation supply classes.

Recreation supply class	All (ha)	Private (ha)	Public (ha)
Foreground	24,229	23,590	639
Background	44,627	42,950	1677
Remote	18,896	18,465	431

that preference for one over the other may depend not necessarily on the mathematics involved, but on the perceived usefulness (and accuracy) as determined by a decision-making group.

These estimates of recreation supply and recreation suitability rely heavily on the estimates of land cover. With respect to the accuracy of the supervised classification of the NAIP imagery, the resulting

omission-commission matrix of the accuracy assessment revealed that at the pixel-level, the overall accuracy between the classified map and the NAIP reference data were 72% (Table 4). The overall accuracy represents the number of correctly classified pixels for each land cover class in relation to the total number of sample units. The producer's accuracy of the supervised classification process ranged from 49 to 97%, and the user's accuracy ranged from 24 to 96%. The producer's accuracy is an expression of the error of omission or how well training sets used to classify the image represents each land cover class, and the user's accuracy is an expression of the error of commission or the likelihood that a classified pixel is actually representative of that class. In general, the producer's accuracy of each land cover class meets the criteria of being 70% or better. The pasture class fell below this threshold at 49%. Most often the pasture class was confused with the hay field and crops classes. There were four instances when the user's accuracy fell below the 70% threshold, including the hardwood forest (69%), hay field (68%), general cropland (64%), and emergent cropland (24%). In both the hay field and general cropland classes, the confusion was among the other agriculture classes. This loss of accuracy might be negated with the aggregation of the pasture, croplands, and hay field classes into one larger agriculture class. The emergent cropland class was most often confused with the two forest classes and the pasture class. This is most likely due to the similarity in the spectral reflectance values between the three classes. The overall kappa coefficient associated with this classification process was .68, suggesting a 68% agreement between the classification and the ground truth. The kappa coefficient indicates how well the land classification map agrees with the reference data, and the computational process involves all of the cells in the error matrix (Stehman, 1997).

6. Discussion

The recreation setting modelling approaches presented here were based on an examination of the literature related to the mapping of recreation settings across broad areas. They involved spatial rules that were applied to geospatial databases that are considered widely available in North America, although some of these required editing prior to their use. The methodology presented here involves mainly the use of non-validated models that are based on assumptions of causality, and other information acquired from the literature. No observational information was acquired and used to test or calibrate the effectiveness or validity of the model. This is not a unique problem, as most complex models rely to some extent on assumptions (Schägner et al., 2013). If validation is necessary, a recreation user's group can provide corroboration of scores, but this will lack robustness, and will only be viewed as a coarse level of validation; actual user data would help validate the model (Kliskey, 2000). Further, a survey approach could be used to develop key indicators that have an impact on the experiences of recreationists or travellers (Pettengill & Manning, 2011). The interface between the physical landscape and its perception by people with regard to motorised recreation quality could possibly be assessed through a survey of local residents or non-local travellers using roads in landscapes containing a large portion of privately-owned land. As was faced by Kliskey (2000) in the recreation terrain suitability mapping effort in Canada, the time and expense of implementing a survey like this remains a concern when verifying the assumptions of a model. We recognise this limitation in our ability to spatially

Table 4. Accuracy assessment results for the supervised classification of NAIP 1 m spatial resolution aerial imagery.

Land class	Producer's accuracy (%)	User's accuracy (%)
Bare ground	80	84
Deciduous forest	75	96
Hardwood forest	73	69
Pasture	49	78
Hay fields	70	68
Emergent crops	75	24
General cropland	74	64
Shadows	97	96

define and accurately depict the motorised recreation perceptions of people travelling through largely private lands of the Southern United States. However, we also see this as a promising and fruitful area of further research regarding recreation supply in Southern North American landscapes, and we are currently pursuing it.

We must acknowledge that there will be differences among individual preferences for recreation value based on age, gender, ethnicity, socio-economic group, level of education, location of residence, profession, type of preferred recreational activity, and forest type (Edwards et al., 2011). The quality of an experience may depend as much on the expectations of the recreationist as the setting in which the activity is located (Wagar, 1974). Further, we can expect that there will be differences in recreational settings with imagery captured at different times of the year or with different years. While computer processes were utilised to help extract estimates of recreation settings in a subset of Jackson County, if these are applied to two different sets of input, each with their own inherent variations in spectral reflectance values and land use changes, the results are subject to one of the problems Wagar (1951) noted involving human interpretation of recreational quality: we are not as able to compare the same area viewed at two different times as we are to compare two different areas viewed at the same time. Other factors, such as the noise associated with aircraft or construction activities, could affect the recreational setting. Within this county alone, there are three airfields and several surface mines.

Errors in the estimation of recreation settings can occur due to the uniformity and generalisation of classes, from interpretation of land classification rules, and from confusion and inaccurate delineation representative of the original spatial data. The assumption of uniform values may not hold for areas where the diffusion of visitors away from certain points implies that within a class, there are relative value differences among land areas (Schägner et al., 2013). Further, topographic features (dips, rises, overlooks) that may provide enhanced or depressed viewing opportunities along roads were ignored. While the case study county was relatively flat in nature, these features may be important in other areas of the Southern United States. Errors in land classification through the supervised classification of the NAIP imagery are moderate, in our case study area. Given that NAIP imagery is a composite of several aerial images, developed likely through a bundle adjustment process and containing different sun angles throughout, this is not surprising, and is similar in scope to recent classification efforts using NAIP imagery (Merry et al., 2013).

With respect to the assumptions of our model, we targeted motorised recreation opportunities, therefore, we considered distances from roads that assumed where an individual might reasonably experience their immediate landscape (Carver et al., 2012; Liu et al., 2012). As we noted in the methods section, we ultimately followed the convention described in Liu et al. (2012), where any land within 500 m of a main road was considered front country (29% of the landscape), while land beyond was considered either back country (60%) or remote areas (11%). As was suggested in Carver et al. (2012), variations in distances assumed for foreground and background provide some room for future adjustments to the zonation assumptions and to address definitional uncertainties, and stakeholder input from surveys can complement these assessments. However, as it stands, we feel that our work can inform recreation planning policies of large heterogeneous (with respect to ownership) landscapes and can, therefore, support assessments of landscape character.

The vast majority of time spent preparing for the geographic analysis was dedicated to pre-processing the roads, streams, and wetlands databases. Inaccuracies were found throughout each data-set so manual editing was required to provide an accurate picture of the landscape. Additionally, the rubber-sheeting of the parcel data took several weeks to accomplish. The 1 m resolution NAIP imagery required minimal storage space and supervised classification of the imagery was completed quickly using a Dell Precision T5500 desktop computer with 4 GB RAM and 64-bit processor. Space requirements and processing time may become a concern for larger counties or regional analysis or when only minimal processing capacity is available. All this considered, we present here a process for assessing available recreation settings using readily available geographic information that could be replicated at varying scales (i.e. city, county, region) and also that can be extended to include other landscape features (e.g. elevation, overlooks).

In sum, geographical analyses of recreation settings may be essential in reflecting the land carrying capacity for recreational activities (Liu et al., 2012). A combination of tools and analyses, rather than a single approach, would likely be more effective in the planning and management of a sustainable recreation programme (O'Mahony, Gault, Cummins, Köpke, & O'Suilleabhain, 2009). This effort is process oriented and demonstrates a procedure by which remotely sensed information can be used to assess the supply of recreational opportunities. We recognise that recreational opportunities can be defined in many different ways and that in many cases these values, however defined, could be inferred from remotely sensed information. Consequently, even if other researchers define these opportunities in a different manner from the one used here, the general processes would still apply.

While our proposed analysis lacks the user perception surveys, on-site inventories, and stakeholder workshops that would be complementary, it is conducted with high-resolution geographic data, and it represents an advancement in the recognition of private lands when assessing recreation settings and may assist in the development of local and regional land-use-related programmes and planning efforts. As Edwards et al. (2011) suggest, a recreation value framework probably needs to be adjusted for each region within which it is applied, as factors such as the accessibility of different forest types may influence an individual's perception of the value of a recreation experience. Unlike many other landscape assessments addressing the recreational opportunities spectrum for large, publicly-owned resources, here, the focus has been on predominantly private and fragmented land ownership typical of the Southern United States and several European countries, which is a new setting for assessing the associated recreational opportunities with its own, specific challenges. While much of the previous research has focused on the demand side of recreational activities, we have attempted to provide insights into assessing the supply side in a novel setting.

7. Conclusions

Although private lands in the Southern United States do not generally allow free physical access to the public for recreational purposes, the ability of the public to at least view and enjoy the scenery that private lands provide continues to be freely available to those who travel the roads of the Southern United States. The processes we described here are but two models for the classification or description of recreational supply across heterogeneous landscapes. They were designed to allow planners and managers to understand the potential of highly developed rural lands to meet the needs of certain passive recreational activities situated within a broad setting. The high density of roads and the heterogeneous nature of land ownership (mainly private) suggest that systems such as these might provide useful information for regional or national assessments of recreation supply.

Disclosure statement

No potential conflict of interest was reported by the authors.

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