

The North Carolina Geographer
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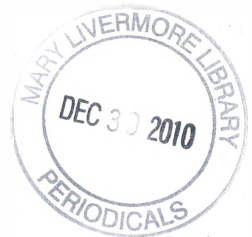
From the Editor

Dear fellow Geographers:

This 17th volume of *The North Carolina Geographer* is a double issue spanning 2009 and 2010. It includes articles on the diverse geography of the state from the mountains to the coastal plain. A Carolina Landscapes article reviews maps of Native American settlements and a sample lesson plan engages students by examining the influence of climate change on coastal environments. A report of the 2010 annual meeting of The North Carolina Geographical Society is also included, along with a citation of the North Carolina Geographer of the Year awarded to Ron Mitchelson of East Carolina University. Finally, we memorialize the significant contribution to Geography of Professor Frank Ainsley, who passed away after a short illness during the summer of 2010.

Michael E. Lewis
Editor

On the Cover: Bodie Island light station and keeper's house, Cape Hatteras National Seashore. Photograph by Amy Terrell.





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The North Carolina Geographer

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A GIS Model for Identification and Classification of Carolina Bays

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Although Georgia and South Carolina have created inventories of Carolina bays, North Carolina has no such inventory. This article proposes some primary characteristics for classifying depression wetlands as Carolina bays using cartographic modeling and GIS to inventory the bays of Bladen County, North Carolina. A category classification system is demonstrated to effectively represent differences in the kinds of bays in the study region. Carolina bays were selected manually and ranked on a 6 inch resolution. The model successfully identified 79.5% of the bays. This research offers the first step toward a unified definition of Carolina bays and offers a potential alternative to manual digitization.

Keywords: Carolina bays, GIS, wetlands, cartographic model, Bladen County, classification.

Introduction

Carolina bays are unique features of the Atlantic Coastal plain. They appear as topographic depressions, tending to be oval in shape, and with the longest axis generally oriented northwest to southeast. In some cases, an elevated sand rim is present (Johnson 1942; Prouty 1952), and some Carolina bays have parallel axes (Johnson 1942; Ross 2003). These distinct wetlands were described in North and South Carolina in the 1800s (Tuomey 1848; Glenn 1895), but their true relative distribution and abundance wasn't discovered until the 1930s when aerial photography was done on private timberlands (Savage 1982; Ross 2003).

Figure 1 shows the form of a typical Carolina bay. A debate arose in the 1930s surrounding the circumstances of their origin (Savage 1982; Ross 2003). It was divided between a meteor strike thesis (Prouty 1952; Savage 1982) and complex terrestrial processes (Johnson 1942; Savage 1982). Over time, the debate subsided, never to be fully

resolved (Sharitz and Gibbons 1982; Ross 2000). A widely accepted single theory has not been reached, as evidenced by the description of bay formation given in the state's gazetteer (Powell and Hill 2010). The current prevailing theory of bay formation attributes them to terrestrial processes Kaczorowski (1977) compared Carolina bays to oriented lakes. After examining processes that form oriented lakes and conducting his own experiments, Kaczorowski concluded the Carolina bay phenomenon must have been the product of a "...strong, unidirectional wind on water ponded in surface depressions..." (Horton and Zullo 1991; Willoughby 2008). The directional wind caused the wave action from water held in each bay to elongate the depressions into their distinctive oval shape (Kaczorowski 1977; Horton and Zullo 1991; Willoughby 2008). This may also explain the parallelism common among bay long-axes, and account for the deposition of sand along the outer rims of some bays (Ross 2003).

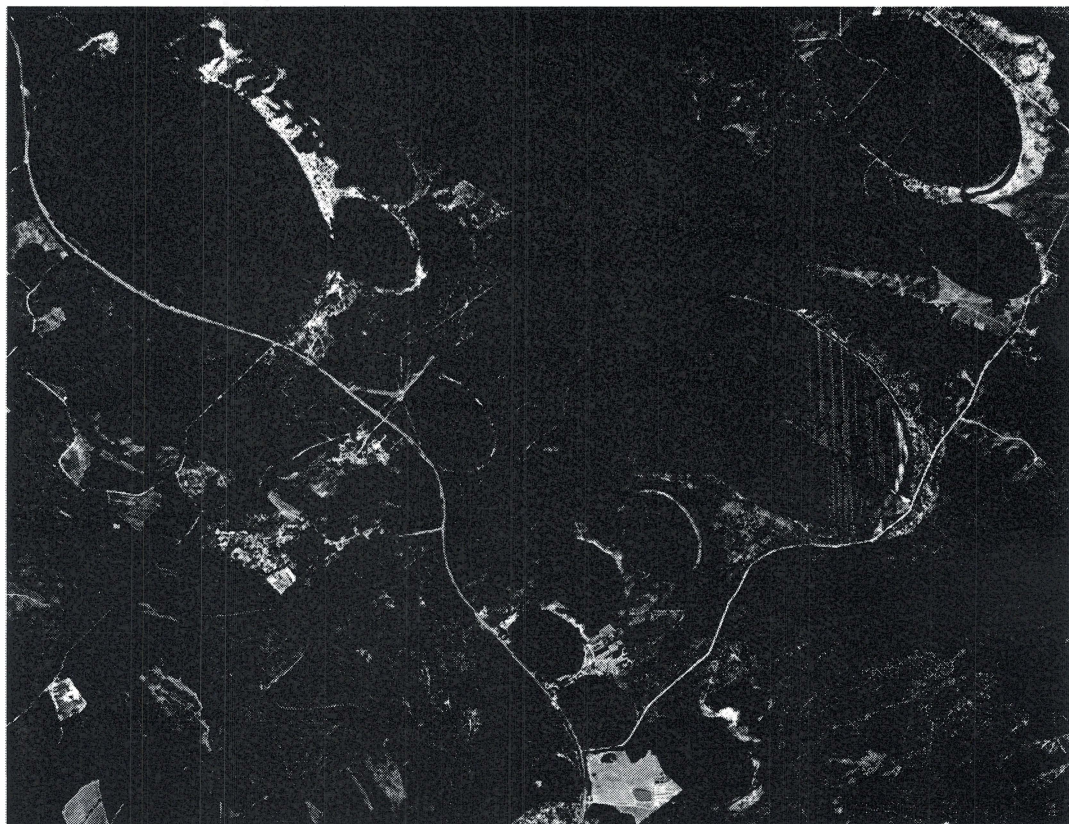


Figure 1. Aerial photography of Carolina bays in Bladen County, North Carolina.

Research into the age and origin of Carolina bays continues, but with less controversy (Brooks, Taylor, and Grant 1996). Bay scholar and bibliographer Thomas Ross notes that bay research since the late 1950s generally trends toward the study of their ecology and soils (Ross 1987; Ross 2000). These topics lean toward the functioning of Carolina bays as wetlands and the value they provide ecologically, rather than focusing on their unique form and age (Nifong 1998; Ross 2003). The aim of this paper is to provide a method to help automate the process of recognizing and inventorying Carolina bays to support related research in geomorphology and ecology.

Previous Inventories

The first attempts to inventory Carolina bays for their ecological value were conducted in South Carolina (Schalles et al. 1989; Bennett and Nelson 1991) by the Savannah River Ecology Laboratory (SREL) which produced an inventory and distribution map in 1989. The purpose of their inventory was to quantify the existing Carolina bays at the DOE Savannah River site and compile an overview of the knowledge of Carolina bays up to the date of publication (Schalles et al. 1989). About the same time as the SREL inventory, the South Carolina Nongame and Heritage Trust program conducted a statewide survey using hardcopies of aerial photos (Bennett and Nelson 1991). The survey

evaluated the distribution and condition of Carolina bays in order to select bays for field visits (Bennett and Nelson 1991). During field visits, additional information about disturbance and vegetation was collected so that bays could be chosen for conservation efforts (Bennett and Nelson 1991).

The South Carolina studies of the late 1980's and early 1990's established Carolina bays as a research interest with a conservation focus. More recently, Carolina bays and the general class of depression wetlands to which they belong have had their federal protection status called into question (Batzer and Sharitz 2006; Sharitz 2003). A federal court case known as the Solid Waste Agency of Northern Cook County, Maryland (SWANCC) versus the US Army Corps of Engineers, of 2001 determined the Corps had overextended their authority to regulate "isolated" depression wetlands under the clean water act and that such wetlands could not be considered "waters of the state" (Sharitz 2003; Tiner 2003; Leibowitz 2003; Batzer and Sharitz 2006). Carolina bay wetlands in particular are sensitive to this ruling in that they typically lack a connection to flowing water, receiving most hydrologic input from precipitation (Sharitz and Gibbons 1982; Sharitz 2003; Batzer and Sharitz 2006). This characteristic places them on the "dry end" of the wetlands continuum of permanent inundation and dry uplands used in defining wetlands (Richardson 1995; Sharitz 2003).

The SWANCC ruling and Carolina bay studies conducted by other states were the motivation for the Georgia Department of Natural Resources to produce an inventory (Van De Genachte and Cammack 2002). Using publicly available datasets, the Georgia DNR created a shapefile inventory with ESRI's ArcView by digitizing bays onscreen (Van De Genachte and Cammack 2002). Similar to the South Carolina inventory, Georgia used the digital database to select bays for field visits, and attributed the bays with several metrics to examine disturbance, hydrologic connectivity, the presence of a sand rim among other features (Van De Genachte and Cammack 2002).

An Inventory for North Carolina?

Considering the previous efforts to locate and evaluate the condition of Carolina bays prior to the SWANCC case and renewed efforts to understand distribution of isolated depression wetlands in general after the ruling (Tiner 2003; Munoz et al. 2009), it would be expected that North Carolina also have an inventory of its bays. However, according to NC Department of Environment and Natural Resources botanist Bruce Sorrie, North Carolina has no distribution map of Carolina bay wetlands and is in need of such an inventory (Sorrie 2009). While a large scale ecological study of bays has been conducted within the state (Nifong 1998), it was primarily a survey of "vegetational diversity" (Nifong 1998) common to Carolina bays in the Carolinas and not a distribution map of North Carolinas bays.

Motivated by the SWANCC ruling, the North Carolina Division of Water Quality has been working on a GIS based project to estimate the extent of depression wetlands in a test area spanning eight counties in North and South Carolina (Munoz et al. 2009). This project uses commonly available datasets to create a probability surface of depression wetlands within a GIS platform and, while their study includes Carolina bays, it is not exclusive to them. A model for identifying a Carolina bay is more complex than wetland identification due to the fact that many Carolina bays are dry due to natural or man-made drainage.

Defining Carolina bays

While previous inventories have created an estimation of the number and location of Carolina bays in other states, there have been concerns over what features should be used to classify a Carolina bay (Lide 1997; Ross 2003). Robert F. Lide, a former research affiliate at the SREL in Aiken, South Carolina was concerned previous studies included features that had few or none of the characteristics of Carolina bays (Lide 1997; Ross 2003). Additionally, the Carolina bays of Lewis Ocean Bay Heritage preserve in South Carolina are "...imbedded within a mosaic of

non-bay depression wetlands...” (Laliberte et al. 2007) in which definitive bay shapes grade into the ambiguous. This may have caused differences in the overall estimates of their numbers (Lide 1997; Sharitz 2003). Lide’s (1997) minimum requirement is that it must be at least oval or round in shape. This minimum requirement is needed as bays outside of the Carolinas have slight differences in orientation and in some cases are more round than elliptical. When evaluating bays from satellite imagery or aerial photography, this rule has allowed their digitization such as in the SREL and Georgia efforts, or to be marked on a hard copy of an image (Bennett and Nelson 1991). However, the problem in consistency in methods used for the classification of geomorphic features is not unique to Carolina bays (Mark 1993).

Methods

Data sets used for the model were downloaded from the web in 2009 and included the US Soil Survey Geographic dataset (SSURGO), the North Carolina GAP Program Land Use and Land Cover (LULC) dataset, and the National Wetlands Inventory (NWI) dataset for Bladen County, North Carolina. In addition to these, a set of 6 inch resolution, infrared orthophotos taken in 2008 were provided by Hans Rohr, a forester with Bladen Lakes State Forest. All processing and analysis was done using ArcGIS 9.3. Characteristics of Carolina bays within the National Wetlands Inventory were chosen based upon their inclusion in Sharitz and Gibbons 1982 study and the description of the palustrine class provided by Cowardin et al. (1979). Both volumes are US FWS references, and the community profile states that a majority of Carolina bays exist within the palustrine class of the Cowardin classification system used to structure the NWI. Therefore, all wetlands within the boundaries of Bladen County classified as palustrine were selected from the NWI for inclusion in the model.

The North Carolina GAP Land Use Land Cover (LULC) selection process began by using a similar approach. Using Schafale and Weakley’s (1990) work as a guide, naturally

occurring land cover identified within bays or on their sand rims were included. The land cover classes selected from the GAP coverage did not match perfectly with the Natural Communities guide for two reasons: (1) not all land cover in Bladen County is a naturally occurring, minimally disturbed, vegetation community, and (2) the generalization of types due to the 30 meter spatial resolution of the data. Included with the dataset was a table that indicated how the GAP coverage categories fit within the natural communities established by Schafale and Weakley. Additional landcover classes were chosen based on their absence in this volume and their appearance within oval shapes that could be seen within the GAP coverage. Soil selections were made based upon their appearance within oval shapes in the SSURGO shapefile of Bladen County soils.

Creating the raster model was an iterative process. Initially, the model characteristics were selected from each dataset, reclassified, and ranked on a common scale of 1-5, with Rank 5 having the highest likelihood of being associated with Carolina bay wetlands (see Figure 2). Eight weighted linear models were run with varying rank values and weights given to each reclassified dataset. Since no differences in the distribution of or in the total number of pixels in each class using this method were found, the following basic model parameters were used. Each reclassified characteristic was given a value of 1 and each dataset was added together without weight. This produced a surface that was identical in pixel distribution and number to the other eight models, but without different pixel ranks. Each pixel occurrence within the model held a value of 3 and was representative of the co-occurrence of three characteristics within the same pixel column and 30 meter resolution. This was the model chosen for evaluation:

$$Model = (NWI_Reclass) + (SSURGO_Reclass) + (GAP_Reclass)$$

+NWI Palustrine 5
 +GAP Coastal Plain Mixed Bottomland Forest 1
 +GAP Seepage and Streamhead Swamps 1
 +GAP Coniferous Regeneration 2
 +GAP Cypress Gum Floodplain Forest 2
 +GAP Peatland Atlantic White Cedar Forest 2
 +GAP Water 3
 +GAP Xeric Longleaf Pine 3
 +GAP Coastal Plain Nonriverine Wet Flat Forests 4
 +GAP Coastal Plain Fresh Water Emergent 5
 +GAP Pocosin Woodlands and Shrublands 5
 +SSURGO Lynchburg fine sandy loam 1
 +SSURGO Centenary sand 1
 +SSURGO Autryville loamy sand 0-3% slopes 1
 +SSURGO Goldsboro sandy loam 1
 +SSURGO Duplin sandy loam 0-3% slopes 2
 +SSURGO Woodington loamy sand 2
 +SSURGO Rains fine sandy loam 3
 +SSURGO Pantego loam 3
 +SSURGO Water 3
 +SSURGO Croatan muck rarely flooded 4
 +SSURGO Lynn Haven and Torhunta Soils 4
 +SSURGO Torhunta mucky sandy loam 4
 +SSURGO Croatan muck rarely flooded 4
 +SSURGO Pamlico muck rarely flooded 5

Figure 2. Model Layers and Rank Values.

Evaluating the Model

Two of the previous inventories had Carolina bay data layers digitized based upon the occurrence of oval or circular shapes identified within an aerial image. This process typically results in a polygon representing a Carolina bay, and depending upon which agency created the inventory, has different attributes that represent it as a geographic entity. The issues inherent to classification were addressed by ranking level of "bayness" or the likelihood that a feature is a Carolina bay and general disturbance within the SREL inventory. A similar approach has been used here in which bays were identified in the

orthophotos, marked within a point shapefile layer, and attributed with a qualitative ranking of "bayness." This ranking system was based upon the core-radial cognitive model used in Mark's (1993) classification of geographic entity types as well as the terminology used in the SREL and Georgia DNR inventories. Bays were ranked as falling into an "exemplar", "less distinct", or "bay-like" category.

Bays in the *exemplar* category (Figure 3) are unmistakably Carolina bays. Such bays tend to have well defined edges, are oval in shape, are oriented northwest to southeast, and may or may not have a sand rim. They tend toward minimal visible disturbance, although no attempt was made to quantify or rank disturbance levels. There are cases in which the above characteristics are all present, but the feature has been significantly altered from its natural state.

"*Less distinct*" is a category taken directly from the scheme used in the SREL inventory (Figure 4). It represents features that are bays, but with a diminished quality or presence of characteristics. Bays in this class typically have enough of their borders intact to show a portion of an oval, but it may be indistinct in places. These bays show increasing levels of disturbance, which may affect the crispness of their boundaries. In other cases, vegetation may be too thick to show a definable edge, or bays may appear within other bays, sometimes overlapping or underlying each other. Such conditions make the bays less distinctive in some way, to the point that they are still considered a bay, but not a well formed example.

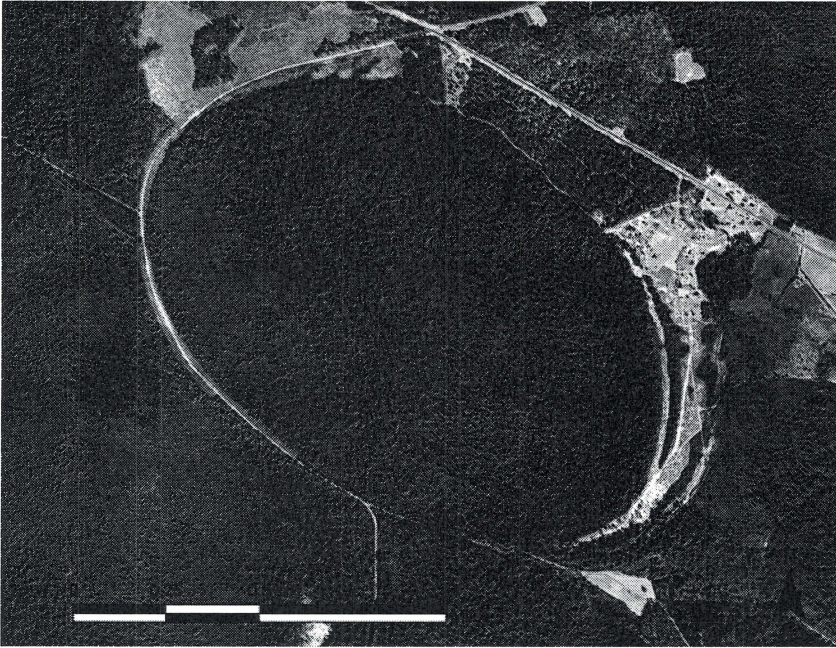


Figure 3. Rank 1: Exemplar category.



Figure 4. Rank 2: Less Distinct category.

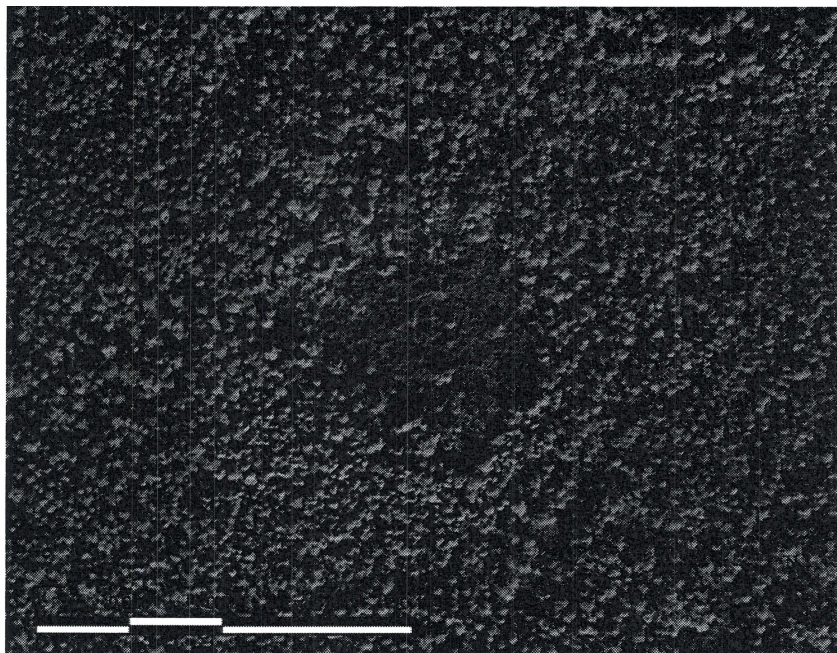
Identification and Classification of Carolina Bays

Figure 5. Rank 3: Bay-like category

The name “*bay-like*” also has been appropriated from the SREL inventory (Figure 5). Perhaps the greatest challenge in creating an inventory is deciding what should be included in this particular class and what should be left out altogether.

The SREL inventory has accounted for this difficulty through an implementation of Lide’s idea that when inventorying Carolina bays, it, “may be more appropriate to consider ‘Carolina bays and similar wetland depressions’” (Sharitz 2003; Lide et al. 1995). By creating a category termed *depression wetland – baylike*, the SREL included features that fit on the outside of the core radial cognitive model reviewed by Mark (1993). Features here can show very indistinct

boundary lines, or they may be more round than elliptical. This category grades into the more amorphous, questionable features.

Results

After bay features were identified and digitized into a layer using the orthophotos, the model layer was overlaid. The bay ranking system was used to determine how well the model predicted the Carolina bays a technician may have selected during standard methods of digitization.

Two USGS quadrangles were chosen for preliminary analysis of the model: Elizabethtown North and White Lake located in Bladen County in southeastern North Carolina (Figure 6)

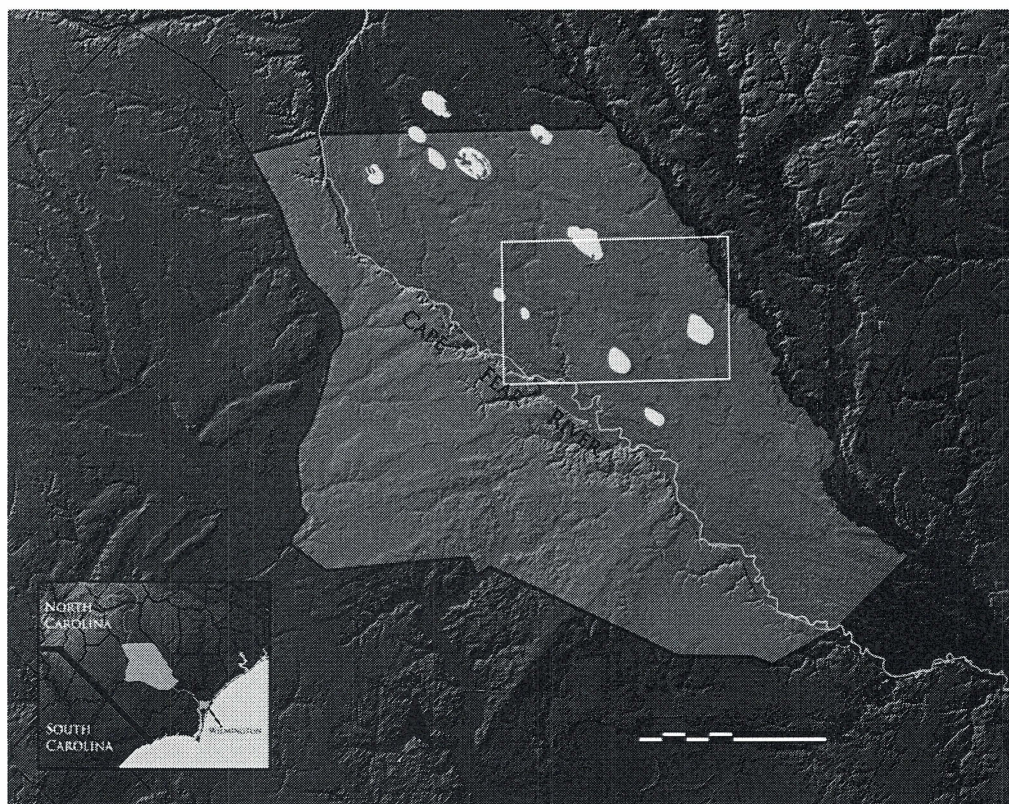


Figure 6. Bladen County study area in southeastern North Carolina.

Figure 7 describes 132 selected and ranked bays. Of the total number, 22 (16.7%) were exemplars, 64 (48.5%) were less distinct, and 46 (34.8%) were bay like. When compared to the features identified and ranked on the orthophoto, the model positively identified 105 out of the total number of 132.

Of the 22 Rank 1 exemplars, 21 (95.5%) were identified in some way by the model. 57 out of 64 (89.1%) of the Rank 2 less distinct bays and 27 of the 46 (58.7%) bays in the Rank 3 bay like category were identified.

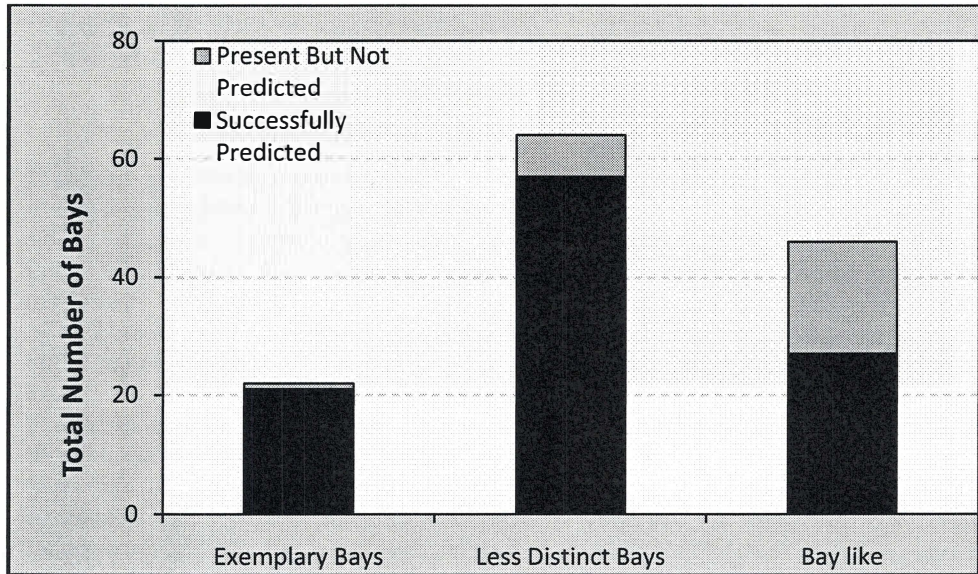


Figure 7. Model results for the three categories of Carolina bays.

Discussion

The goal of this project was to test a GIS method to automate the process of inventory of Carolina bays, while creating a digital classification scheme to address issues of vagueness in categories of geographic entities. It was anticipated that if the model were to accurately predict the locations of bays, then the locations could be converted to polygons, attributed and analyzed. While this approach does show the potential to accomplish this, the cartographic model has itself an amount of vagueness to it. Only after considering this model and its weaknesses can a more complete and definitive model be built. Therefore, the following factors should be addressed to enhance further bay models:

1- *Determining a positive identification.*

Model selections do not always completely fill the bay features the way that onscreen digitization would. This means that determining a positive identification is somewhat subjective, requiring an estimated cutoff in some cases. For the purposes of this project, if a feature was estimated to have at least half of its area identified by the model, then it was considered a positive

identification. The example shown below is presented to demonstrate one of the more difficult cases included as a positive identification in the exemplar class.

Open water within Carolina bays was also not identified. This is because standing deep water has been identified in the NWI as the Lacustrine class, which has been excluded here. Water existed in both of the other datasets (NWI and SSURGO) and was included but because of its absence in the included NWI classes, it was not modeled. Bays within Bladen County, North Carolina are exceptional in that they appear to contain lakes more often than other counties that contain Carolina bays. Future iterations of this model should therefore include the Lacustrine NWI class if a reliable digital classification scheme for bays is to be developed for Bladen.

2- *Spatial resolution and bay size limitations.*

The spatial resolution for the model was chosen based upon the coarsest known resolution within the included datasets. The North Carolina GAP LULC dataset was created from 1992 Landsat TM at 30 meter resolution. However, NWI data at 30 meter

resolution has been noted in previous studies as a problem for identifying smaller Carolina bays (Sharitz 2003). While the model seems to positively identify Carolina bays at this resolution, it does so in such a way that the smaller the bay is, the less definitively the model defines the oval shapes when it does identify them. By comparison of the model to a previously digitized inventory, such as the bay inventory at the SREL, or the Georgia inventory, it may be possible to quantify the differences in area and identification size of Carolina bays at a 30 meter resolution and experiment with optimal resolutions for future iterations.

3 – No separation of features

Model characteristics are certainly common to other places on the earth's surface. Statistically, such occurrences are known as false positives and are difficult to quantify. Selecting additional datasets specific to morphology may alleviate this if oval shaped, oriented depressions and sand rims can be defined within and extracted from digital elevation models. A digital representation of morphology will also bring the cartographic model closer to characteristics that define a Carolina bay. Bay features are sometimes difficult or impossible to separate because they are in reality not distinctly separate. Examples of these phenomena can be seen within the bay complexes of Bladen County, in which Carolina bays are either overlapping or diverging. In either case, at this time this

preliminary attempt at modeling is unable to articulate these complex overlapping relationships.

Conclusion

Carolina bays have long intrigued geologists, geographers, and ecologists due to their mysterious nature. Defining their primary attributes for classification and modeling is a challenging task for GIScientists. However, this research has aimed to clarify the vagueness inherent to the classification of the variety of these geomorphic features and to help provide a better understanding of processes resulting in their formation. This provides a first step toward creating an effective classification of Carolina bays that may improve GIS modeling of other categories of depression wetlands. With future work and ever increasing availability of higher resolution data, it may be possible for an automated statewide inventory for North Carolina to be completed in this way and throughout the entire range of this unique feature of the Atlantic coastal plain.

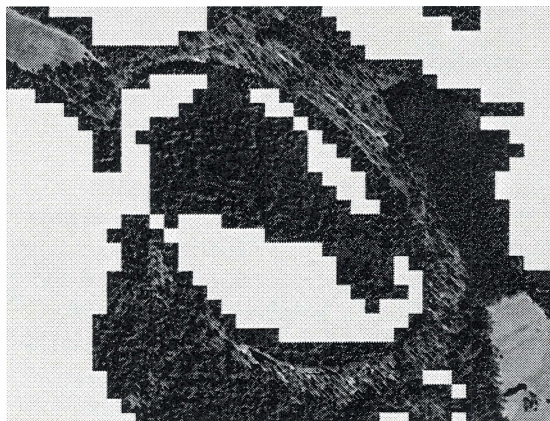
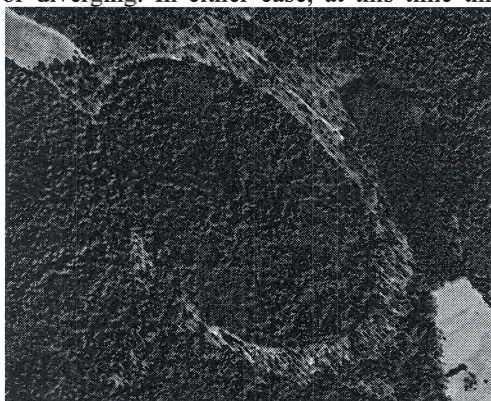


Figure 8. Examples of Model Selection Issues

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Antebellum Plans for Reopening Roanoke Inlet

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Roanoke Inlet closed between 1792 and 1798, thus depriving the northeastern North Carolina port towns of an outlet to the Atlantic. In 1820, Hamilton Fulton, civil engineer to the State of North Carolina, devised a plan for reopening the inlet. During the next twenty-five years, civil engineers in the employment of the State of North Carolina and engineers of the United States Army Topographical Bureau conducted a number of other surveys of the Albemarle Sound region while Congress considered the practicality of the plan. The project was never undertaken. However, the reports of the engineers provide a detailed account of the dramatic geomorphic changes that took place in Croatan Sound after Roanoke Inlet closed. This article presents extracts from these reports alongside details of historic maps that document these changes.

Key Words: Roanoke Inlet, Albemarle Sound, Croatan Sound, Hamilton Fulton, Coastal Plain Geomorphology

Introduction

The maritime commerce of the Albemarle Sound region of North Carolina expanded during the closing decades of the Colonial Era as more land in the vast Roanoke River Basin came under cultivation. The closing of Roanoke Inlet in the late 1790s curtailed the development of a major port in the state's northeast. Beaufort Harbor and the port of Wilmington were located too far to the south to be beneficial; and the Dismal Swamp Canal, completed in 1805 (improved during the 1810s), attracted the produce entering Albemarle to the Norfolk market. Hamilton Fulton, while serving as civil engineer for the State of North Carolina, prepared a plan for reopening Roanoke Inlet in 1820. The plan involved dredging Roanoke Inlet and closing Croatan and Roanoke sounds to prevent the flow from Albemarle Sound to Pamlico Sound

from causing Roanoke Inlet to close again (Combs, 2003, 1:1-27; Merrens, 1964, 85-172; Murphey, 1818, 18; North Carolina, 1820, 11, 14-15). The State of North Carolina did not have the resources to undertake such an ambitious project at the time. The United States Government, considering the project's potential for improving commerce and national defense, commissioned additional surveys.

Historic Maps

The sequence of gradual changes that occurred around Roanoke Island prior to Fulton's visit is recorded on several historic maps. The Edward Moseley Map of 1733 shows marshland extending across Croatan Sound between Roanoke Island and the mainland. He labels Croatan Sound "The Narrows," and includes a note about Roanoke

Acknowledgements

I would like to express my thanks to Donna Kelly in the Historical Publications Section of the Division of Historical Resources in the Office of Archives and History in Raleigh for facilitating permission to use maps from *North Carolina in Maps* by W.P. Cumming and to the Map Division of the Library of Congress for providing a copy of the map prepared by Hamilton Fulton.

Inlet: "Roanoke Inlet has generally 10 feet at low water, where it rises commonly about 4 feet, but those Shoals shifting, it was not thought proper to lay them down at large, as ye other Harbours. The Channel may be seen within from ye Mast head (tho' ye Bar breaks) so as to guide a Vessel in" (Figure 1). The John Collet Map of 1770 provides more detail of shoals surrounding Roanoke Island. The narrow channel through Croatan Sound is

labeled as "Through Fare," and there is a cluster of marshes between Roanoke Island and the mainland at the southern mouth of this channel (Figure 2). The Price-Strother Map of 1808 shows in intricate detail the marshland connecting Roanoke Island to the mainland. The passage through the marshland is little more than a ditch. The shoaling of Roanoke Inlet appears to be filling in the passage from the sound side (Figure 3).

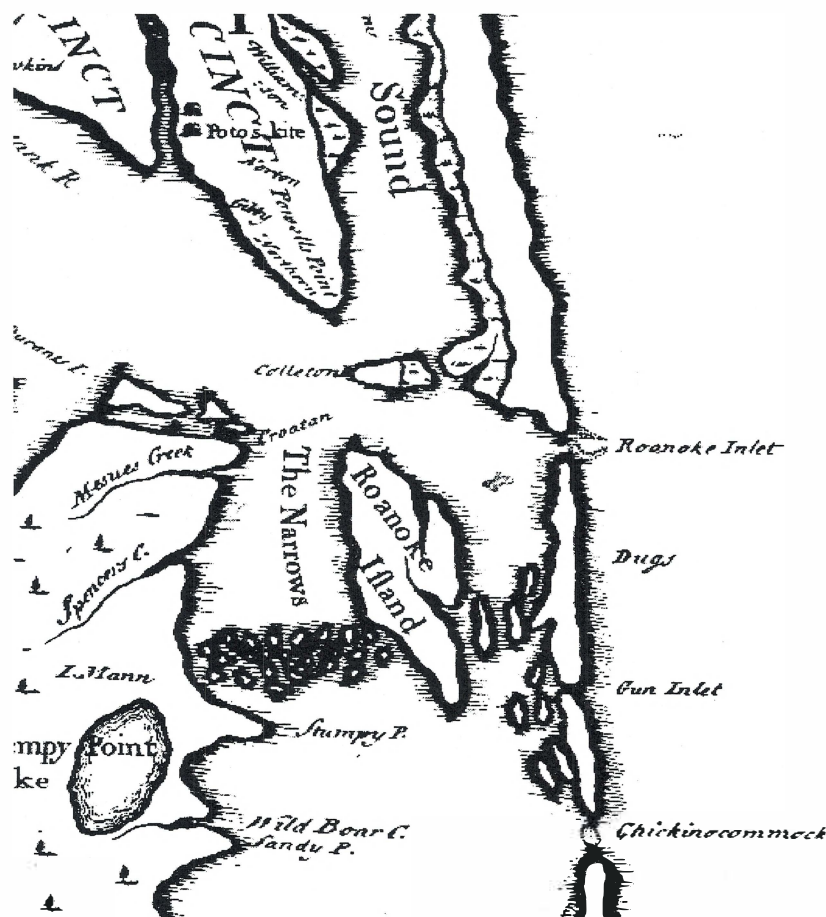


Figure 1. The 1733 Map of North Carolina by Edward Moseley depicts the shoaling at Roanoke Inlet and the marshes at the southern end of Croatan Sound between Roanoke Island and the mainland. Source: Cumming, W.P. (1966). *North Carolina in Maps*. Plate VI.

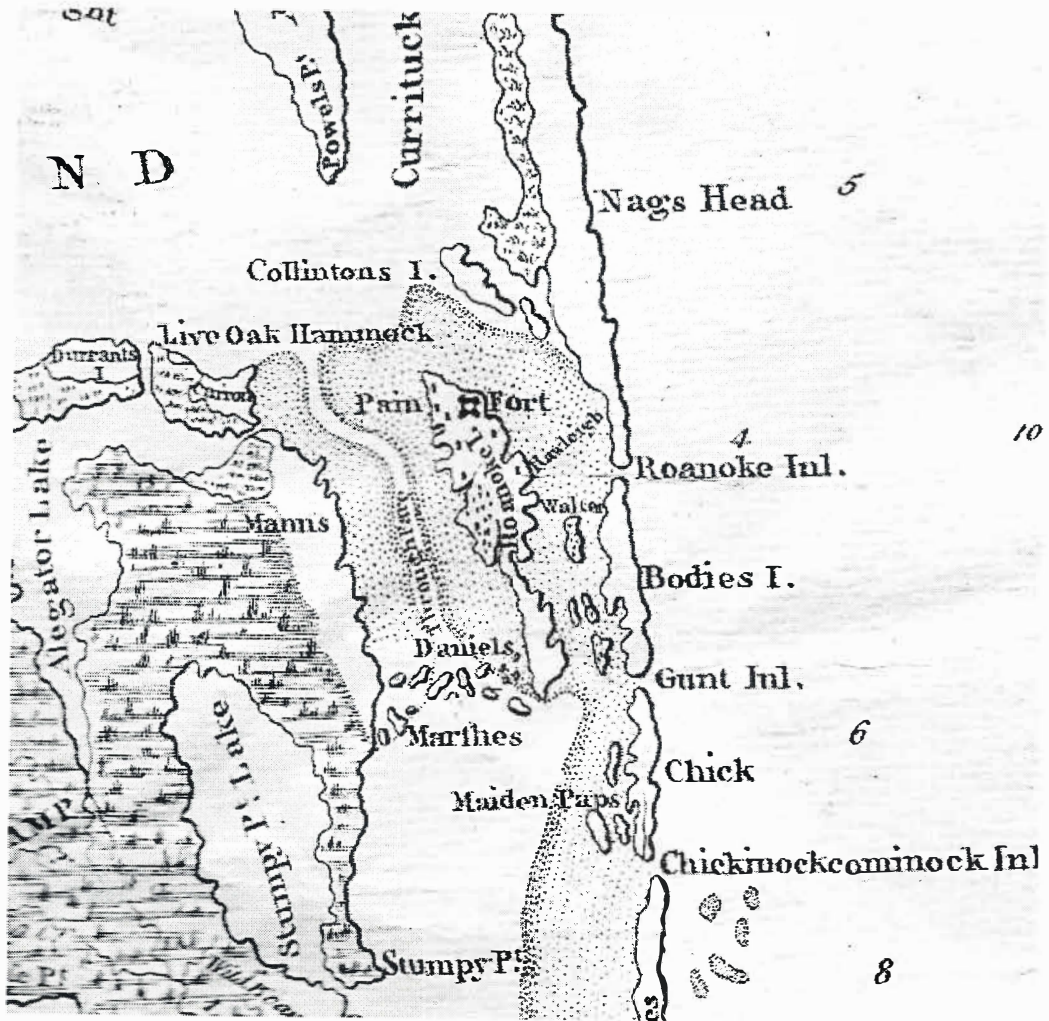


Figure 2. The 1770 Map of North Carolina by John Collet depicts the ship channel through Croatan and the marshes at the southern end of the sound. The barrier islands near Roanoke Island are broken by three inlets. Source: Cumming, W.P. (1966). *North Carolina in Maps*. Plate VII.

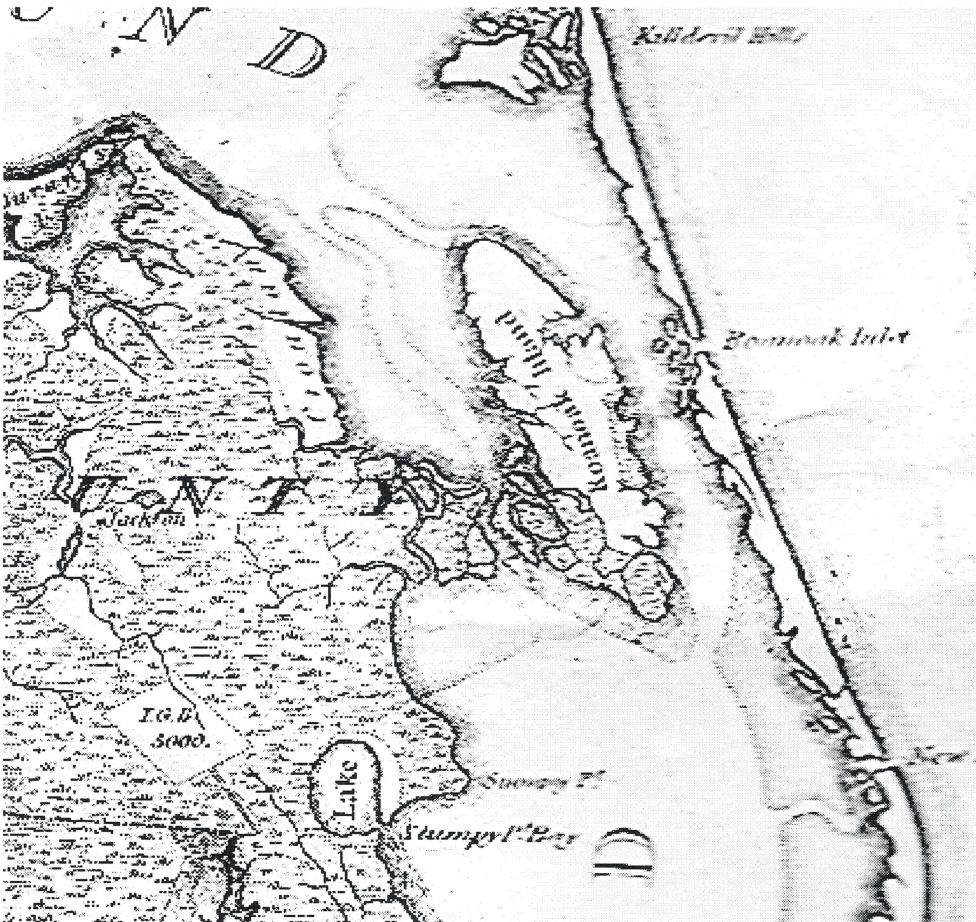


Figure 3. This *First Actual Survey of the State of North Carolina* of 1808 by Jonathan Price and John Strother depicts the environs of Roanoke Island in detail. Roanoke Inlet is obstructed, and the marshes at the southern end of Croatan Sound form a connection between Roanoke Island and the mainland that is broken by streams.

Source: Cumming, W.P. (1966). *North Carolina in Maps*. Plate IX.

In 1882, W.C. Kerr, the geologist for the State of North Carolina, prepared a map of the state incorporating information from surveys undertaken from 1820 to that date. He identifies several former inlets on the Outer Banks and the dates these inlets closed. Cheeseman's Inlet, south of Beaufort, closed in 1806; Cedar Inlet, north of Cape Lookout, 1805; Chickamicamico (Chickinocommock) Inlet, north of Cape Hatteras, 1795; Roanoke

Inlet, east of Roanoke Island, also 1795; New Currituck Inlet, east of Knotts Island, 1828; and Currituck Inlet, near the Virginia line, 1775 (Cumming, Plate XIV). Only Oregon Inlet, Hatteras Inlet, and Ocracoke Inlet have remained open.

Antebellum Surveys

Hamilton Fulton arrived in North Carolina to begin his employment as the state civil engineer in 1819. The Board of Public Improvements gave Mr. Fulton instruction to investigate the possibility of opening an inlet at the lower end of Albemarle Sound. Fulton visited Roanoke Island on 14 March 1820. His initial comments to the Board suggest that he did not consider reopening Roanoke Inlet a practical undertaking. He believed that closing the inlet would increase flow between Albemarle Sound and Pamlico Sound. He also thought that the sand that made the closure had been shifted south across Roanoke Sound from Nags Head. The scouring of Croatan Sound seems to have occurred rapidly after the closing of Roanoke Inlet. Residents of Roanoke Island gave Fulton an idea of the rate of that change.

"There are people now alive on Roanoke Island, who remember the passage between Albemarle and Pamlico Sounds being confined to what is still called the ship channel. Since that time another channel has gradually opened, which is now one mile and a quarter in width, with soundings, in some places, twenty-four, and others thirty feet deep. This circumstance plainly shews the effect of the waters passing and repassing through the marshes. It became a matter of course, as these channels increased in width, so did the quantity of water issuing into the Sea by the Inlet decrease in a proportional degree". (North Carolina, 1820, 15) –

Fulton proposed that stone embankments should be built across both Roanoke Sound and Croatan Sound, and that Roanoke Inlet be reopened by dredging. Those embankments would have spanned Croatan Inlet from Fleetwood's Fishery to Pork Point on Roanoke Island, and from the east side of Roanoke Island to Ballast Point (Figure 4). He estimated the cost of the project at \$2,363,483 for the stone embankments and dredging, or \$1,157,186 for timber and earth

embankments (North Carolina, 1820, 16-22). Fulton's plans were submitted to the United States Engineers (administered by the War Department), and printed in the *Report to the Board of Public Improvements of North Carolina* the following year. The report of General Bernard, Colonel Gratiot, and Major Totten, prepared by Col. W. K. Armistead, Commander of the U.S. Engineers, supported Fulton's plan. However, there was some concern that sediment would eventually be deposited on the ocean side of the opened inlet and render it too shallow to be useful; and it also concerned them that the water in Albemarle Sound would find a new outlet to Pamlico Sound when Croatan and Roanoke sounds were closed. The most obvious difference between Fulton's 1820 map and the present geography of Croatan Sound is that Fulker's Island, the nearby islands, and the marshes at the southern end of the sound are gone.

The United States Engineers expressed their concern about the waters of Albemarle Sound forcing a new channel through lowlands west of Croatan Sound. They anticipated that the water level in Albemarle would rise. In his response to this report, Fulton did not believe that possible. He cited an unnamed source that did not believe a canoe could travel from the Alligator River to Pamlico Sound by way of connecting creeks. He also notes that fresh stumps of pine and cedar on the seashore at Nags Head indicated a recent encroachment by the ocean (North Carolina, 1821, 16, 21).

An alternative plan is suggested by Captain Hartman Bache, of the Topographical Engineers that is based upon a survey carried out from 1827-1828. Bache, like Fulton before him, cites historical sources for the previous condition of Roanoke Inlet. James Wimble's 1838 chart of the coast of North Carolina with soundings, later incorporated into Captain John Collet's 1770 map of North Carolina, as well as *The History of Carolina, by John Lawson, Gentleman Surveyor General of North Carolina* published in 1709.

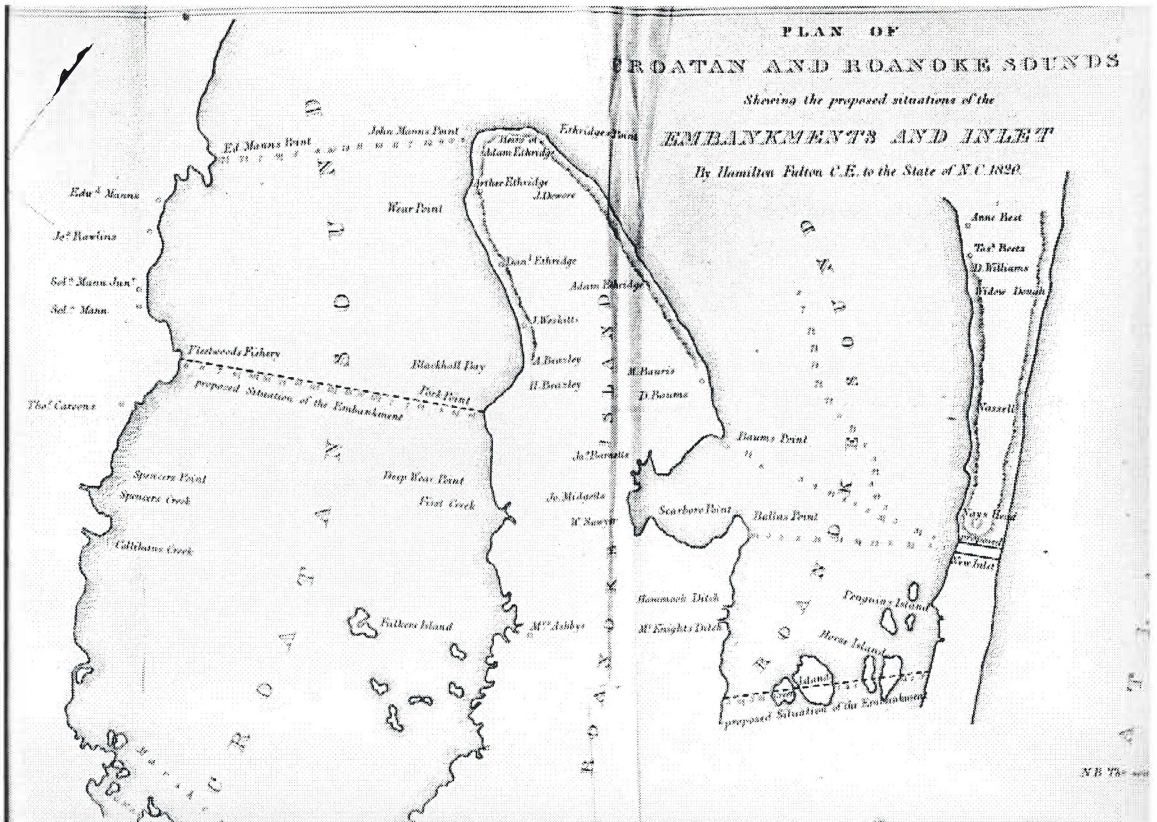


Figure 4. *The Plan of Croatan and Roanoke Sounds Shewing the proposed situations of the Embankments and Inlet By Hamilton Fulton C.E. to the State of N.C. 1820* illustrates how the embankments would stop the flow from Albemarle Sound to Pamlico Sound so that dredged Roanoke Inlet remained open.

Source: United States. (1829). *Report of the Secretary of War, with one from the Engineer Department, On the practicability of an Outlet from Albemarle Sound to the Ocean, &c.* Washington, DC: 20th Congress, Document 106

Bache notes that there is little doubt that Roanoke Inlet had been used by small vessels. He also mentions that even though the soundings for the former inlet were at nine feet on the bar, the sound was merely six feet. He agreed that the washing away of the marshes on Croatan Sound had caused the inlet to fill, and he believes that “no human foresight can predict the precise result” of an improvement when the forces involved are “so various and powerful.” Yet, Bache had determined the project would be useful, and

he offers a less expensive alternative to Fulton’s plan. This plan featured a tide lock so that outbound vessels could gain access to the ocean with the channel being ten feet wide and three hundred feet long, lined with stone, and set at a depth of ten feet “below the common level of the sound.” While the channel would not benefit ships attempting to enter Albemarle Sound, it would provide outbound trade with a direct outlet (United States, 1829, 12-22, 24).

The Letter from the Secretary of War, transmitting A Report of the Survey of Roanoke Inlet and Sound, in the State of North Carolina dated 24 February 1829 is a recapitulation of the proor surveys for the US House of Representatives (United States, 1829a). The *Resolution of the Legislature of North Carolina, Upon the subject of re-opening the Old Roanoke Inlet* was intended to solicit aid from the Federal Government for the languishing project (United States, 1831). The following year, a report on Roanoke Inlet was referred to the House Committee on Internal Improvement to accompany H.R. 517 confirming the acts of incorporation for the Roanoke Inlet Company granted by the North Carolina Legislature in 1821 and 1828, and to consider re-surveying the inlet. A convention was held at Edenton, North Carolina to discuss reopening the inlet in February 1830. Local citizens of eastern North Carolina memorialized Congress to encourage action on the project (United States, 1832).

In the spring of 1840 Walter Gwynn undertook a survey for North Carolina's Board of Internal Improvements to determine the practicality of reopening Roanoke Inlet. Gwynn, a West Point trained civil engineer, had already distinguished himself in Virginia as well as North Carolina as the chief engineer for several early railroads. His report contains more information about hydrologic processes than the previous reports. Like his predecessors, he agreed that the opening of the marshes at Croatan Sound was the cause of the closing of Roanoke Inlet; but he provides more information about the extreme nature of the cutting through of the water from Albemarle Sound.

"And, all along above the marshes, we have evidence of the continuing encroachment of the waters of the sound. Stumps are found as high up as Mann's point, both on the shores of Roanoke island and the main land, stretching out from a hundred yards to a mile into the sound, and, in some places, reaching nearly across it; and the recent abrasion of the banks is shown by bare roots of

hundreds of trees – some recently fallen, others in a tottering condition" (United States, 1841, 3)

Noting accounts of older local residents, he learned that the channel through the marshes was once narrow enough to be crossed with a fence rail. He suspected that at some distant time Roanoke Island was connected to the mainland. Like Fulton, he verified that the water level in Albemarle Sound was higher than that of Pamlico Sound; but he noted that the water flowing into Pamlico Sound had not brought about any improvement to Ocracoke Inlet. The current coming from Albemarle Sound interfered with the combined currents of the Neuse and Pamlico rivers, and the reduced velocity caused sediments to fall out of suspension to form shoals at the entrance to Ocracoke Inlet. Based on his own observations and those of others, he dismissed the notion that Roanoke Inlet was filled by blown or shifting sand from Nags Head; and the sediment deposited at the site of the old inlet was not brought there by ocean currents (ibid, 3-7).

The final historical document worth noting is entitled *Roanoke Inlet, At Nag's Head* dated 10 February 1846 and presented to the Committee on Commerce of the US House of Representatives – read, and laid upon the table. The report, authored by Captain Campbell Graham of the Corps of Topographical Engineers, contains a few details related to the closing of Roanoke Inlet. Graham accompanied Walter Gwynn on his 1840 survey, and they observed that the current between Albemarle and Pamlico had carried away several islands. Further, they determined from interviews that Roanoke Inlet began closing in 1792, about the same time the marshes on Croatan Sound started to give way. Referring to the recently published *Westover Manuscripts* of William Byrd, Graham notes that a storm had opened a New Currituck Inlet five miles south of Old Currituck Inlet in 1713. Prior to this event, the Northwest River, in Currituck County, had not been known to ebb and flow. Byrd observed that Old Currituck Inlet was closing in 1728. Graham's research found no instance of an

inlet closing as the result of a storm; rather the outflow through an inlet was diverted to other channels that had been opened. Graham places the closing of Roanoke Inlet to be complete in 1798, the closing of the New Currituck to be about ten to twelve years prior to his report, and he was not sure when Caffee Inlet closed. Graham recommended omitting the embankment across Roanoke Sound in Hamilton Fulton's plan, or leaving a section open so that water could pass from Albemarle Sound to Pamlico Sound to the east of Roanoke Island as it once did. He estimated that the watershed feeding into Albemarle Sound covered about seventeen thousand square miles yielding 44, 944,903 cubic yards of water per day (United States, 1846, 3-9).

Discussion

In 1972, Robert Dolan and Kenton Bosserman published an article in the *Annals of the Association of American Geographers* that offered an explanation as to why researchers and archaeologists have been unable to locate the settlement site of the Lost Colony (1585-1587). The site, separate from Fort Raleigh, was likely at the near shore on the northern end of Roanoke Island. Using coastal survey maps dating back to 1851, the authors observed that the 928 feet of northern shoreline had eroded between 1851 and 1970, then extrapolated the shoreline of the same area from the time of the Raleigh's colony based on the rates of recent erosion, then concluded that the northwestern shoreline had lost 2,000 (feet), and the northeastern shoreline had lost 1,300 (feet). The authors concluded that the settlement site has not been found because it had washed away long ago. The researchers attribute the loss of land to wave action driven by high winds (Dolan and Bosserman, 1972, 424-426). It is apparent from the nineteenth century reports of the civil engineers that changes around Roanoke Island began to take place long before 1851. The

closing of multiple inlets from the late eighteenth century through the early nineteenth century suggests geomorphic change that cannot be disassociated from the changing flow patterns between Albemarle and Pamlico sounds. Fulton observed in 1820 that residents of the region had witnessed the disappearance of marshes in Croatan Sound. Subsequent reports by other civil engineers state that erosion in the sound was an ongoing process twenty years later. Croatan Sound was getting wider and deeper as Roanoke Sound was filling with sediment.

Conclusion

Historic maps and the reports employed to develop a plan for reopening Roanoke Inlet suggest the inlet and the marshes of Croatan Sound were stable from the late 1500s to the late 1700s. The inlets remained open with a depth of nine to ten (feet), and the overall depth of Albemarle Sound was about six (feet) – or about two and a half (feet) above the ocean at low tide. The Croatan marshes extended to a narrow channel in the center of the sound that was the width of a “fence rail,” and supported a stand of trees extending at least a (mile) into the sound and as far north as Mann's Point. Roanoke Inlet filled and the marshes of Croatan were scoured away – trees and islands - in the decades that followed. History maps also testify to the fact that a number of inlets in the region also closed within a short period of time. This does not appear to have occurred south of Roanoke Island. For example, Ocracoke Inlet, has remained open since Europeans first encountered it in the late 1500s, however, it has migrated south about a mile. The entire region of Albemarle Sound and the barrier islands that enclose it are one system, and if historic maps and the reports of antebellum civil engineers provide an accurate assessment change in that system, changes in one part of the system affect the behavior of the whole.

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Using GIS to Examine Exurban Density Patterns in Watauga County, North Carolina

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Appalachian State University

Increasing population and land use change in rural areas are of significant importance to residents of western North Carolina. Previous studies have shown rapid growth in rural areas is associated with declines in environmental quality as well as increased home prices. This study provides an analysis of spatial density surfaces derived from land parcel data to measure exurban growth. A case study demonstrating housing trends based on density surface analysis over a nearly sixty year time period (1950-2007) is presented at two scales: across Watauga County and within a one mile buffer of the South Fork of the New River. Growth is discussed in relation to the environmental planning issues of land and water conservation strategies as well as strategies for increasing public participation in land use decision-making.

Keywords: Land parcel data, density surfaces, spatiotemporal analysis, environmental planning, rural gentrification, South Fork New River, Watauga County.

Introduction. Western North Carolina is well known throughout the southeast for its recreational amenities, including ski resorts and cool summer climate, and idyllic nature which provide a significant draw for many new and seasonal high income residents from locations across North Carolina, Georgia, South Carolina, and Florida. The increased number of second home and seasonal property owners, many benefiting directly from the southeast's profitable housing market, has led to anecdotal reports of increases in housing density among many formerly rural areas in this Appalachian region of western North Carolina. The resulting increase in housing unit density, mean housing costs, homes of large lot sizes, and number of seasonal residents has strongly affected Watauga County in particular.

The impacts of new and seasonal high income residents into this primarily rural county are similar to previous reports on rural

gentrification in the western US (Dougherty 2008). Rural gentrification may be best characterized as the social and economic change in rural areas due to an influx of newer residents with significantly higher incomes. Previous studies have attempted to define the significant social and economic impacts of rural gentrification on citizens of western mountain communities (Ghose 2004, Diamond 2005) as well as areas characterized by McMansions along the mid-Atlantic and Appalachian region within range of Washington, DC and other population centers (Bruegmann 2005). The study of rural gentrification is difficult as it relies on differentiating among the driving forces of increased housing density in regions. It is therefore not surprising that few studies have produced evidence that makes this distinction in underlying processes of changing housing density and its environmental and social impacts.



Figure 1. Home density near the South Fork New River, Watauga County, North Carolina.



Figure 2. Examples of housing construction along the South Fork New River, Watauga County.

To further investigate trends in housing growth related to recreational amenities and potential impacts on environmental quality, a case study of housing growth using density surface analysis over a nearly sixty year time period (1950-2007) in Watauga County was conducted. This study area was selected due to the fact that anecdotal reports have suggested the area is undergoing rapid housing density growth due to its scenic setting, access to water recreation activities, and proximity and commuting convenience to the growing population center of Boone (see Figures 1 and 2). Land parcel density surfaces are used to highlight hotspots of growth and potential land use conflict that may be used to address environmental planning decision-making within the county to mitigate negative consequences of rapid land use change.

Previous Work

The nature of studying housing density growth in primarily rural areas presents methodological challenges distinct from the study of higher population areas. Previous work on land use change processes has generally provided three main conclusions concerning the study of rural housing growth processes. First, studies of rural land use change based on remote sensing data are limited due to the data being too coarse to accurately depict the intricate changes occurring at lower land-use intensities and multiple data sources are required to increase the accuracy of analysis (Theobald 2001). Secondly, socioeconomic datasets derived from bounded areal units from the US Census Bureau are limited in that they do not provide adequate spatial accuracy needed to measure the rural density of housing units. Thirdly, data generated from landscape ecology focused studies tend to be primarily focused solely on areal size of land use classes, an aggregate measure that conveys little direct relation to housing density growth processes. The commonly used categories in these studies such as *fragmented* or *variegated* also limit the application to housing growth analysis in that the classification scheme is

often open to the investigator's interpretation (Theobald 2001).

The limitations described in previous work suggest land parcels are the most effective source of data used to study housing density growth processes at fine resolution as they are a data source that is cost effective, highly spatially accurate, and collected at frequent temporal intervals. Previous studies have also demonstrated that density measures can be successfully used to reconstruct housing growth histories. For example, Radeloff et al. (2001) used historic census and tax parcel data to analyze housing density trends in exurban development in a study focusing on a seven-county region with a large percentage of seasonal housing in Wisconsin. Lepczyk et al. (2007) also successfully integrated housing census data and spatial statistics to display temporal progressions of growth hotspots between decades from 1940 to 2000.

Land parcel data may fall short as a useful data source in instances where historical records of parcel delineations, land uses, and building locations may be difficult to acquire or require a great deal of time digitizing and interpreting (Brown 2003, Gonzalez-Abraham et al 2007). However, the land use of a parcel can be readily approximated from the categories assigned for different tax rates, such as residential or commercial, which may vary according to methods employed by neighboring counties and municipalities. In light of their shortcomings, tax parcel data may well supply highly useful insights into processes leading to rural land use change by greatly improving projections of land use change in the context of land use planning decisions and communication to the public (Theobald et al. 1996, Theobald and Hobbs 1998, Hammer et al. 2004, Theobald 2005). In particular, previous work has described the influence of proximity to natural amenities, such as scenic views and rivers, as well as accessibility and existence of transportation and utility infrastructure on land use change (Gonzalez-Abraham et al. 2007). This research focuses on the lower density land use often referred to as *exurban*, a term referring to a special class of housing area strongly

influenced by rural amenities and not necessarily concentric within distance of an urban center. The data used rely upon land parcel analysis to approximate the extent and rate of housing density growth as indicators of the impacts of exurbanization on environmental quality. The use of land parcel data for housing density analysis enhances our

understanding of interactions between socioeconomic changes due to in-migration and housing density (Theobald and Hobbs, 1998; Hammer *et al.*, 2004; Theobald, 2005).

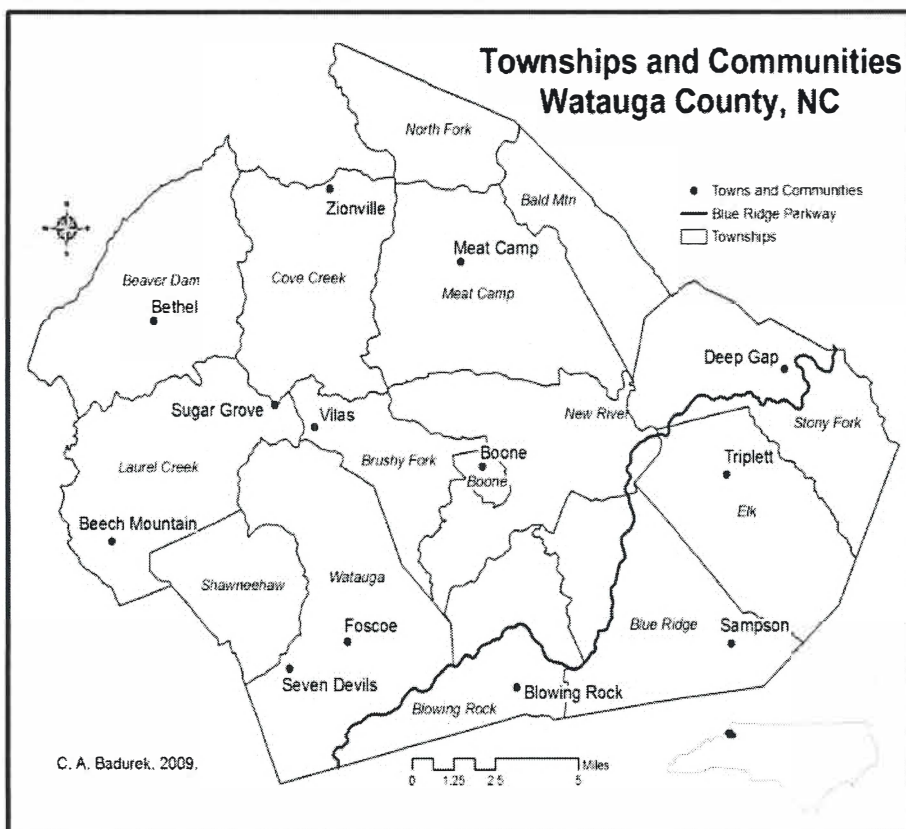


Figure 3. Townships and communities within study area of Watauga County, North Carolina.

Case Study: Watauga County

Watauga County has a year around population of 44,716 (US Census Bureau, 2007) plus a consistent number of seasonal residents not included in the census. Digital tax parcel data available from Watauga County for the year 2007 show land area, tax

value, parcel use classification, and the year of building construction. These data were analyzed with ESRI's ArcGIS to demonstrate a change in housing density in Watauga County from 1940 to 2007.

The 2007 land parcel database had 45,473 records classed as: 'Agriculture',

'Commercial', 'Commercial/Residential', 'Residential', 'Condominium', 'Townhouse', 'Exempt', and non-classified. For this analysis the 'Agriculture', 'Commercial', 'Exempt' and non-classified parcels were removed from the dataset. The 23,153 remaining residential parcels were then classified by the date when construction began, starting with houses built prior to 1940 and continuing in decadal intervals to 2000, and ending with a final 2007 interval. Point files were created using the mean center of each parcel polygon and interpolated using ArcGIS Spatial Analyst extension to create eight parcel density surfaces. Parcel density surfaces were then compared with major county roads, rivers, and 'urban centers' to observe how these features affected

development patterns. Each density surface was then reclassified as 'Urban', 'Suburban', 'Exurban', and 'Rural' using the methods described by Theobald (2001) (Table 1).

Land Use Class	Density Value
Rural	<0.025 buildings/acre
Exurban	0.025 – 0.1 buildings/acre
Suburban	0.10 – 0.75 buildings/acre
Urban	> 0.75 buildings/acre

Table 1. Land use and parcel density values.

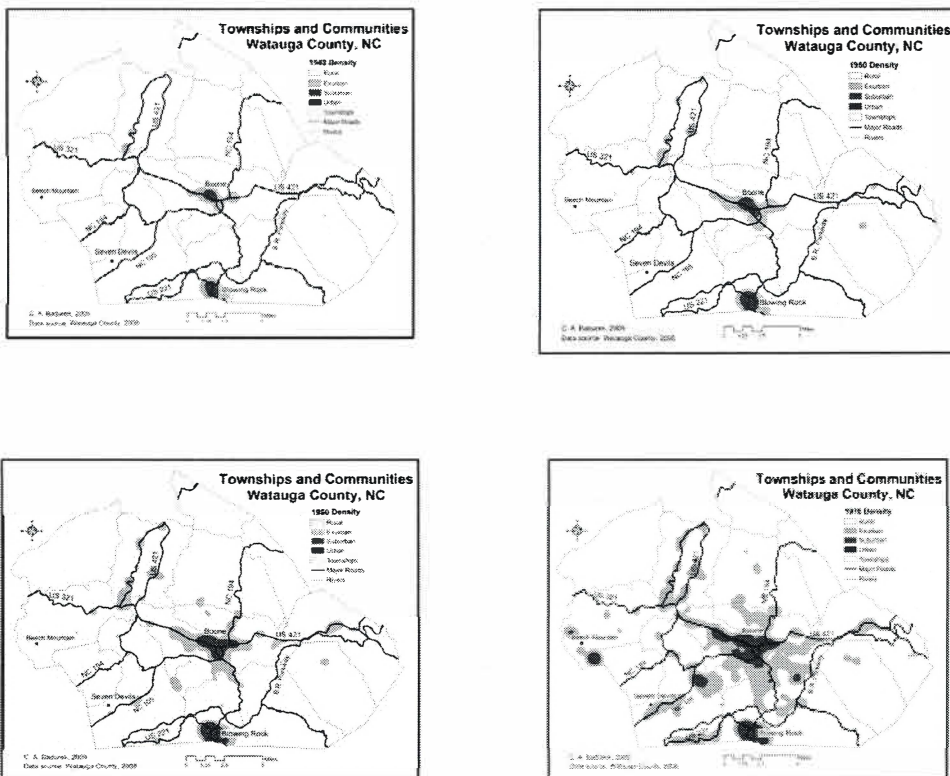


Figure 4. Housing density diffusion, 1940 - 1970 in Watauga County, North Carolina.

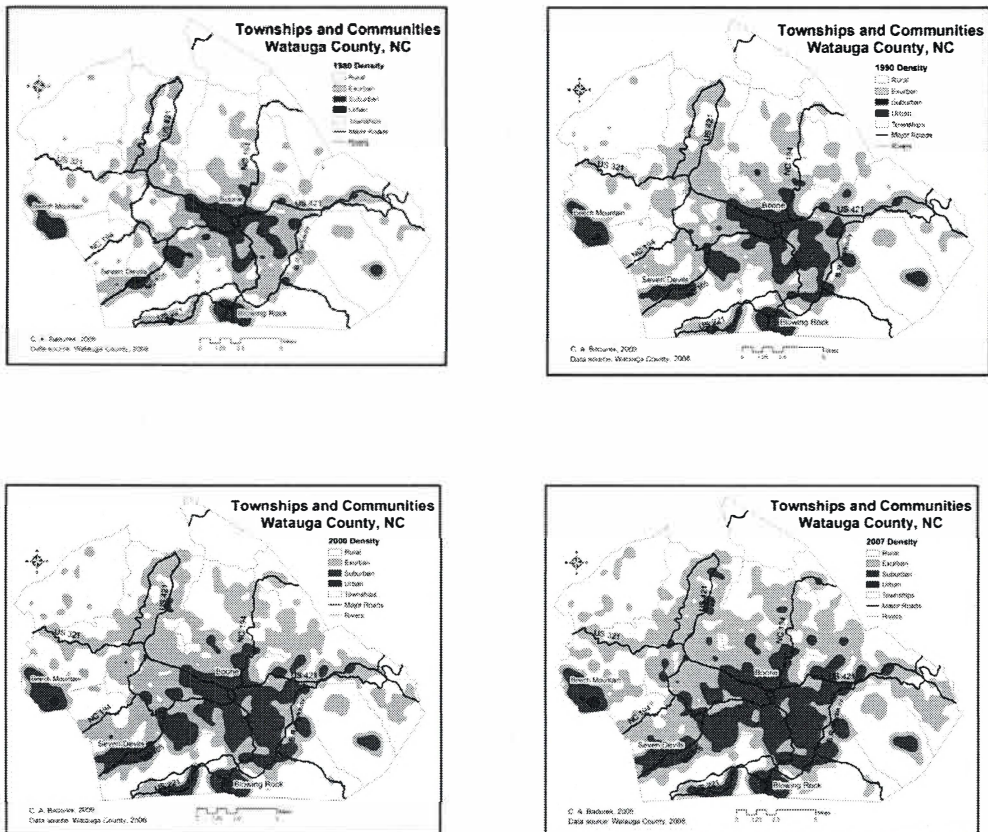


Figure 5. Housing density diffusion, 1980 - 2007 in Watauga County, North Carolina.

Figures 4 and 5 show the progression through time. A striking feature is the growth of hotspots in proximity to significant natural landscape features and existing infrastructure. For example, the southeastern limits of high density are located exactly at the crest of a ridge offering vistas of the Blue Ridge Parkway. Growth also follows along major roadways, such as the recent Laurelmore development by the Ginn Company in the southeastern part of the county. Further visual comparison of the patterns of growth in the north and northwest parts of the county suggests development occurs first along

existing roadways. There is a consistent increase in density along Highway 421 east of Boone and along Highway 194 to the north before 1960, as well as density increases along Highway 105 near Seven Devils in 1970. Increasing density is also evident along the Blue Ridge Parkway after 1980. Significant infill is evident between these lines of growth. In summary, the trends indicate three major drivers of residential development in Watauga County: the location of natural boundaries and landscape features; towns with a significant number of seasonal residents; and existing transportation and utility infrastructure.



Figure 6. Flooding and debris along the South Fork New River, Watauga County.



Figure 7. Agricultural land use within proximity to the S. Fork New River, Watauga County.

Decade	Population Growth Rate	Built Parcel Growth Rate
1940-1949	1.3	19.9
1950-1959	-4.4	24.6
1960-1969	33.5	37.0
1970-1979	33.2	40.2
1980-1989	18.6	25.8
1990-1999	15.6	22.3
2000-2007	4.7	19.5

Table 2. Relationship between population and built parcel growth rates (1940-2007).

Water Quality Implications

Regulations are of increasing relevance to citizens of Watauga County. Previous work has shown significant changes in water quality in relation to land use change in western North Carolina (Bolstad 1995). These findings are also of relevance to recent concerns and anecdotal evidence of sedimentation effects on recreational fishing as well as flooding hazards in the Appalachian region, particularly with residential housing built within the floodplain or within immediate proximity to the river (see Figures 6-7). These concerns may be justified when considering the relationship between the population growth rate and built parcel growth rates, where the rate of parcels being built far exceeds population in the most recent decade

(Table 2). Protection of the South Fork of the New River is particularly concerned with water quality in headwaters of the New River that flows through several states as well as its rural nature which appeals to regional tourists (NCNR 2009). The majority of Watauga County adjacent to the South Fork is unincorporated, with minimal land development regulations. Watauga County's ordinances along the South Fork are limited to those outlined by the North Carolina's Division of Water Quality (NCDWQ), the agency responsible for Clean Water Act regulations. Although some county (Watauga County 1996) and state (NCDENR 2005) protections are in place, they are not particularly effective.

Conclusions

This paper has focused on examining methods for analyzing exurban patterns using land parcel data density surface analysis. Analysis of the nature of growth in Watauga County indicates that residential land use is rapidly overtaking agricultural and that environmental planning regulations may be the best approach to slow growth in the study region. Water quality, rural gentrification, and loss of agricultural land are all concerns of county residents. The effective use of GIS and land use histories may enable governmental or non-governmental organizations to maintain the environmental quality necessary for the continued economic development of the county.

Figure 8. Housing density classes, South Fork New River, Watauga County, North Carolina.

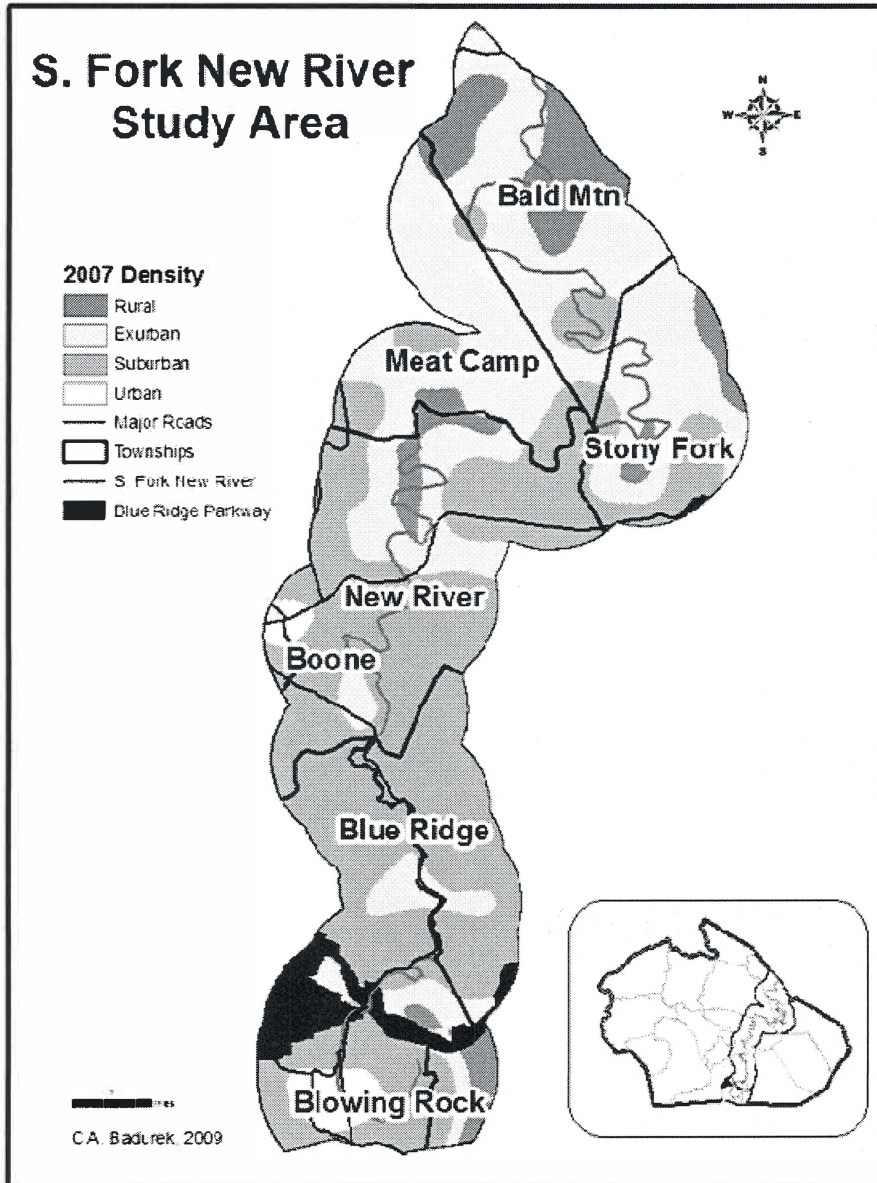
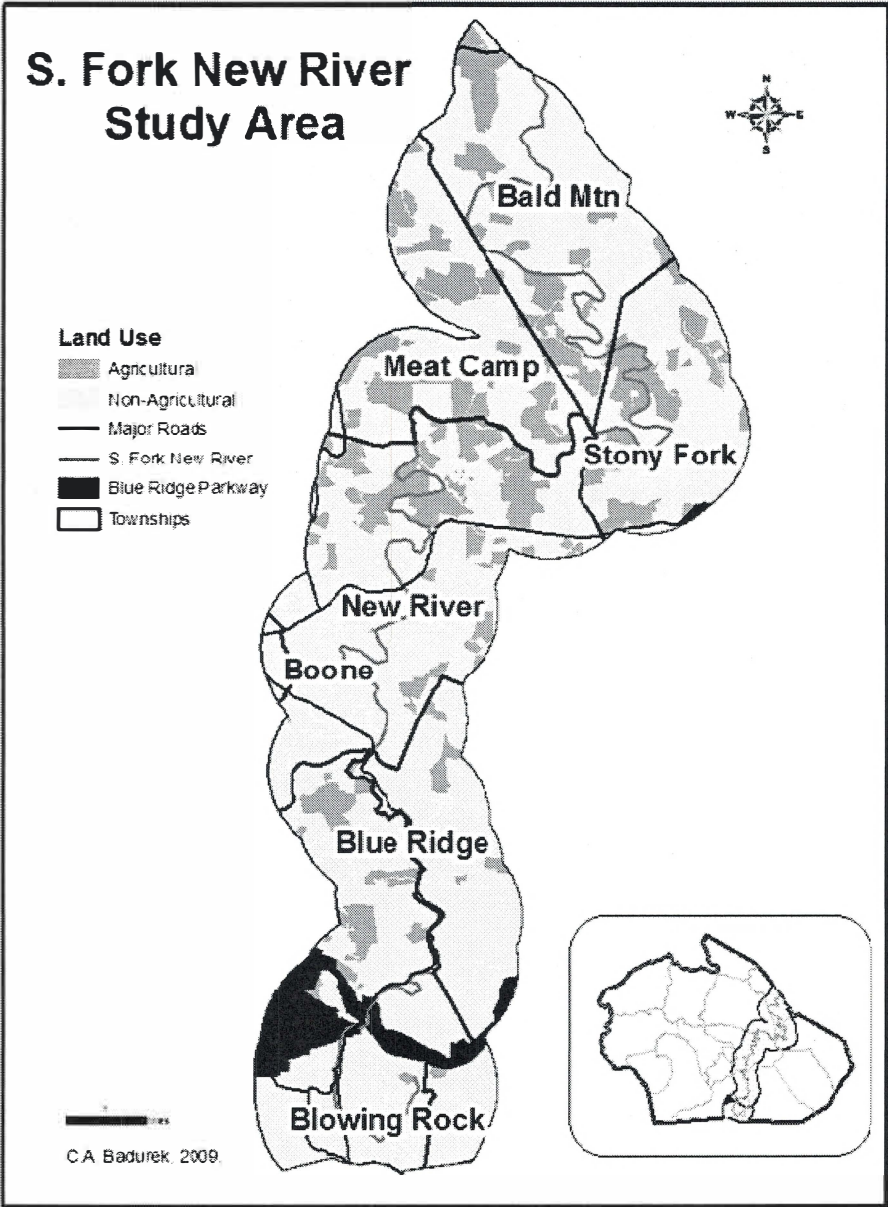


Figure 9. Land use, South Fork New River, Watauga County, North Carolina.



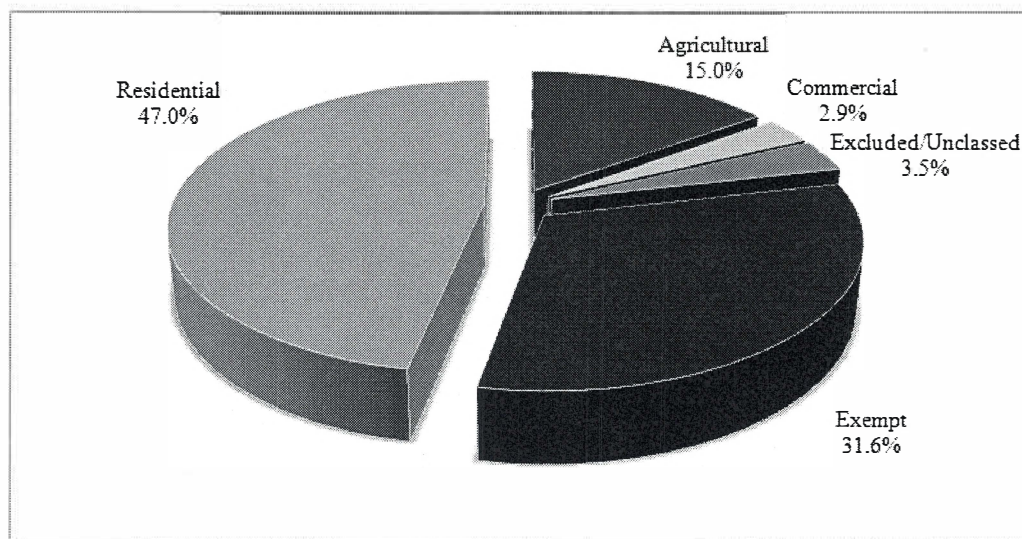


Figure 10. Percent of acres by land use in South Fork New River study area.

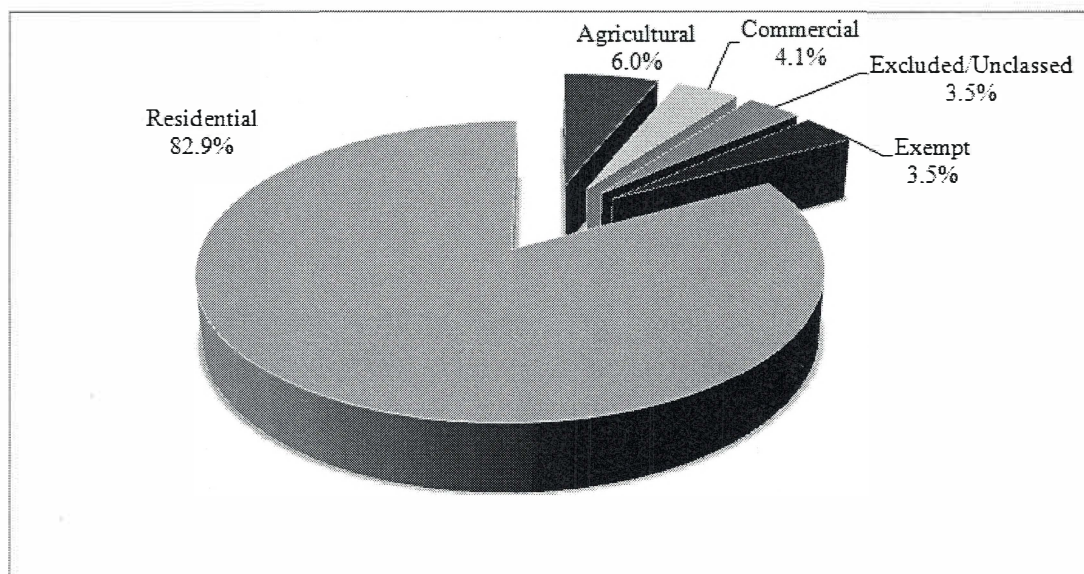


Figure 11. Percent of parcels by land use in South Fork New River study area.

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Tourists' Climate Perceptions: A survey of preferences and sensitivities in North Carolina's Outer Banks

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Tourism is a major economic driver for North Carolina with \$17.1 billion in travel expenditures, \$4.2 billion in payroll, and employing 198,900 residents. Despite its fundamental influence on tourism, there is limited understanding of the relationship of climate and weather patterns with day-to-day business operations or long-term economic and environmental sustainability. We present a Climate-Tourism Index to measure and evaluate climate as a resource for tourism businesses in North Carolina. The relative importance of four climate variables is considered, along with differences in the perceptions of local and non-local beachgoers. Cloud cover appears to be more critical to a satisfying experience than temperature. Locals tend to be more sensitive to wind conditions than non-locals, which may be explained by past experiences and a greater appreciation of the local geography.

Keywords: *Climate preferences, Outer Banks tourism, North Carolina*

Introduction

Global climate change is of public concern in the relationship between climate and the tourism industry (IPCC, 2007; UNWTO, 2003). Not only does climate change affect the viability of tourist destinations and activities, but tourism in itself is a contributor to global climate change, owing mainly to emissions from transportation to and energy consumption at tourist destinations (UNWTO, 2003). Climate variability and changing weather patterns over the short term can affect tourism planning efforts, as well as tourists' destination decisions (de Freitas, 2003). These short term effects can be much more detrimental to businesses as they create increasingly changed patterns of tourist demand and impact tourist flow (Martin, 2004). Considering the impact that seasonal climate variability already has on tourism, the projected impacts tied to climate change threatens the longer-term livelihood of many tourism businesses and industries. These

effects over the long term will reverberate through businesses and host communities, affecting other industries and sectors that supply these communities and the tourism sector indirectly (UNWTO, 2007).

The primary issue in global climate change with concern to the tourism industry is that of greenhouse gas emissions (GHG). With regards to the tourism sector, the majority of these emissions are generated through traveler's uses of transport services. Tourism also generates a high per capita consumption of water, energy, and waste that requires the industry to take a responsible step toward broader sustainability (UNWTO, 2007). Local communities dependent on tourism are impacted by climate variability and resource consumption both seasonally and annually, challenging stable business activity and the livelihood of permanent residents throughout the year. The sustainability of tourism is often dependent upon maintaining visitor sense of place, a favorable perception of and

attachment to a destination. Central to sense of place is place satisfaction, which is affected by a host of social and local conditions that affect the tourist experience. Stedman (2003) argues that research has tended to neglect the role of the physical environment to the construction of place meanings and attachment. Atmospheric conditions play an important yet under-analyzed role in shaping the extent to which people view destinations in positive or negative terms. Weather and climate are not just objective, measurable variables but also cultural constructs that are made important through human interpretation and social action, both inside and outside the context of tourism (Strauss and Orlove 2003).

Tourism is a major economic driver in most state economies yet, despite the fundamental influence that climate has on the tourism industry, there remains a limited understanding of the relationship between tourism industry operations and a changing climate, particularly with respect to longer term sustainability (Nicholls, 2004). Planning for long term adaptation and sustainability requires not just recognizing the likelihood of increased climate and weather variability, but also research to understand tourists' sensitivity to and tolerance of likely changing weather and climate conditions.

North Carolina's tourism industry is particularly vulnerable to changing climatic conditions because of the variety of outdoor tourism sectors represented across the state, including golfing, whitewater rafting, skiing, biking and surfing. Here we focus specifically on North Carolina's Outer Banks. Tourism in the Outer Banks region is extremely sensitive to climate seasonality and variability because outdoor recreation activities are its main driver. In this study beach tourists were surveyed at three locations on the Outer Banks to determine their weather preferences and the extent to which they rely on weather forecasts. The intent was to provide some measure of sensitivity to climate change and extreme conditions. Respondents were also categorized as either local or non-local in

order to understand how "local" knowledge shapes perception. The aim was to provide information that could help inform the development of useful weather and climate measures or indices for tourism applications, for both operator and consumer use.

Climate of the Outer Banks

The Outer Banks of North Carolina are a chain of barrier islands, roughly oriented northeast-southwest and stretching 54 miles. The islands enjoy a mild maritime climate, with cooler summers and warmer winters than mainland North Carolina. Weather observations have been taken almost continuously since 1874 from the village of Buxton, near the Cape Hatteras Lighthouse in the most eastern portion of the islands. The current National Weather Service tower has been making observations since 1957. The location of this station (35°14' N and 75°37' W at an elevation of 10 m), is within the Cape Hatteras National Seashore and is thus protected from the bulk of the development and commercial tourism activity. It is approximately 50 miles to the south of the closest survey site at Nags Head.

The Cape Hatteras station is assumed to represent the general climate of the Outer Banks. We focused on conditions in August, the month of the survey, as compiled in the Comparative Climatic Data publication of the National Climatic Data Center. The Outer Banks experiences the second highest annual temperatures in August (July is highest), with the maximum temperature averaging 84.8 and the minimum averaging 72.3. The average monthly precipitation peaks in August with 6.56 inches, due to convective instability and sea breeze fronts. The average wind speed is higher than the mainland, with August values at 9.5 miles per hour, and a maximum wind speed averaging 60 miles per hour from the North-Northeast. The sun shines 65% of the days in August, and on average 8 days are clear, 10 days are partly cloudy, and 13 days are cloudy. The average afternoon relative humidity is 69%.

An Index Approach

The relationship between weather, climate and tourism has led to a concerted effort by researchers to develop a theoretically sound approach to integrate the effects of climate on tourism, rather than relying on superficial or assumed relationships (de Freitas, 2002). These studies largely focus on quantifying weather and climate effects through an index. The literature shows over 200 indices based at least partially on weather and climate (Matzarakis, 2007).

The most common type is a combined tourism index (Abegg, 1996) which combines meteorological variables with physiological effects or perception. Many of these indices focus on "thermal comfort", derived from a combination of the meteorological conditions of temperature, wind, humidity and radiation (Hamilton, 2007). There are several ways to create thermal comfort indices. One of the earliest, Effective Temperature (Houghton and Yaglou, 1927; Missenard, 1937) based on air temperature and relative humidity and subjects' reports of comfort, has been used by several studies to characterize different locations (e.g. Yan and Oliver, 1996; Makokha 1998). Matzarakis et al. (1999) developed the approach of physiological equivalent temperature (PET) based on human energy balance rather than human perception. Other indices that also use the concept of energy balance include predicted mean vote (PMV, Fanger 1972). More complicated formulations include those proposed by Mieczkowski (1985) which add influences of the amount of sunshine, precipitation, and influence of wind speed on overall comfort in addition to a thermal formulation, and an index proposed by de Freitas et al. (2007) that also adds aesthetic (A) and physical (P) components to the thermal comfort (T), to directly measure the effects of perceived cloud cover (A) and the physical discomfort of wind and rain (P).

Tourism climate research has also been conducted to determine the importance of climate to decision making. A "push-pull" framework, describing the push factors that

motivate an individual to travel, and the "pull" factors that draw an individual to destinations has been used in many studies (Hamilton et. al 2005). In a 2002 review of 10 studies, Klenosky did not find origin or destination climate explicitly as a push or pull factor, but did find a warm climate was a pull factor for a selected sector of tourists. In an analysis of the US travel market, Shumacher (1999) found good climate to be an important factor, and Scott and McBoyle (2001) in a study of tourism climate typology showed that annual patterns in TCI correlated with accommodation rates in selected locations. However, in various US locations, Scott and McBoyle contend that the peak demand seasons do not always coincide with a locations peak TCI. The various climate index studies also show a difference in "beach" indices (de Freitas 1999, Gatell et al. 2000) and "urban" indices where site-seeing and shopping are the primary activities (Scott and McBoyle 2001). Most of the climate-tourism relationships and indices in the beach environment have been developed outside the U.S. (e.g. Canada, New Zealand, and Sweden; Scott, Gossling, and de Freitas 2008), thus some new insights could be gained from this study, particularly in regards to the extent to which our sample's perceptions are in agreement with the conventional model of importance and sensitivity of different weather and climate factors to beach tourism. For instance, the American model of vacation (more frequent shorter vacations) is different from the European model, and so expectations and experiences of U.S. tourists may differ from those previously surveyed. The tolerance or sensitivity of tourists to "undesirable" weather conditions may also vary between populations based on their home climate, previous experience, or other factors.

Methodology and Survey Instrument

Seventy six surveys (Appendix 1) were distributed over a two day period, Saturday and Sunday, August 2nd and 3rd, 2008 on North Carolina's Outer Banks. Three locations on the Outer Banks were used – Kill Devil Hills, Kitty Hawk and Nags Head, with

twenty five surveys handed out in each location with the exception of Nags Head with twenty six. Survey participants were chosen at random, approached and asked to participate in a 5-minute survey. The actual conditions were recorded in each location during the survey period using a Skymaster hand-held weather meter (Table 1).

Due to the small sample size, the observations were combined over the three locations. All incomplete records were discarded from the analysis, and tourist preferences for each atmospheric variable were graphed. Also, a table matrix comparing the atmospheric preferences of locals against those of non-locals was added. 'Locals' were chosen on the basis of those who self-identified themselves as spending 0 days on vacation regardless of where on the coast they lived. Each variable had five preference options, temperature preferences for example ranged from 75F to 95F in 5 degree intervals. The increments were chosen to reflect deviations about the climatological conditions (see section 2). Each variable was rated on a scale of 1 (totally disagree) to 5 (totally agree), and the number of responses for each preference were counted and graphed. The data was used to compare locals against non-locals to determine if there were differences in atmospheric preferences for each variable and which variable was most important in the decision to come to the beach.

Incomplete records were kept and in the cases where participant's circled more than one answer for a single variable the highest rating was used. This occurred in only five records, where participants circled an entire column of ratings (e.g. the entire column of '5' values), or circled more than one response for a single preference value (e.g. more than one value per row). If only one of the five preferences was circled for the entire variable then the remaining responses were coded with an 'NA' that was counted in the overall analysis, but left out of the analysis of variable preferences of locals against non-locals.

Results and Discussion

The survey resulted in an $n=76$ responses, but some responses omitted one or more individual questions, so the number for each question is not constant. However, the amount of missing data in any one case is 8 responses for an $n=68$ (for relative humidity = 40-60% case).

Comparing the temperature data for all respondents (Figure 2), nearly 70% of respondents rated the climatic mean of 85F a 4 or 5, and only 5% rated this temperature an unacceptable 1 or 2. A majority (>50%) rated all temperatures 75 – 90 to be acceptable (either 4 or 5), and 40% of respondents rated the hottest temperature (95F) either a 4 or 5. The responses for 95F showed the most variation, with over 30% rating 1 or 2, 28% neutral (3), and 40% 4 or 5, followed by the low temperature (75F), rated 1 or 2 by roughly 20% of respondents, neutral by 27% and acceptable by 51%.

Survey respondents' view of cloud cover showed a strong preference for clear to mostly clear conditions (Figure 3). Our results show little to no difference between these two (94% rated acceptable in each case), and that respondents showed a much stronger sensitivity to cloud cover than to temperature (with cloudy and mostly cloudy conditions rated acceptable by only 17% and 16% of respondents, respectively).

Relative Humidity results (Figure 4) showed an expected pattern, with a majority accepting RH values in the 0 – 60% range, and a majority also finding the two highest RH categories unacceptable. The lowest relative humidities (< 40%) were highly favored, but very rare in August in this part of the state.

Wind velocity results (Figure 5) showed that the mean wind speed of 10 mph (climatological average) was preferred by the highest number of beachgoers (72 % rated 4 or 5), while both calm and windy (20 mph) conditions were rated largely unacceptable (61% and 57% respectively).

These results show that the sample of Outer Banks beach users showed relatively little sensitivity to temperature, which is an important result considering the primacy of thermal comfort in most of the tourism indices. Respondents showed much more sensitivity to the aesthetic/physical factors of wind and cloud cover, suggesting that an index such as Mieczkowski's TCI (1985) or de Freitas' A-P-T index (2007) would be most appropriate for this population.

Locals versus Non-Locals

Locals made up 24% of the survey and consisted of individuals that lived on the Outer Banks, including Roanoke Island, a population area located approximately 2 miles inland. Interestingly, non-locals were primarily from Virginia (31 respondents), as compared to mainland North Carolina (10 respondents). While many of the responses were consistent between these two sub-groups, some differences were noted.

Regarding zero wind speed, which is uncommon at the Outer Banks, the response of totally disagree (1) was the most popular response among non-locals, and there was a bimodality of responses among locals with 6 selecting totally agree (5) and 8 selecting either (1) or (2). The reason for this is unclear and deserves further study. Another interesting difference was the choice of most preferred weather condition (Figure 6). For locals, all variables were about equal, with a slight preference toward wind speed. However for non-locals, 26 chose cloud cover and 24 selected temperature, while only 12 chose wind speed and 10 selected humidity. Non-locals preferred a variety of temperatures, but 37 respondents agreed that 85° F was an ideal afternoon temperature. This fact, in combination with the preference for clear skies over cloudy skies, suggests that the choice of the favorite variable is informed by a preference for sunbathing. This is also consistent with non-locals disliking zero wind. Finally, there was a difference in the use of weather forecasts for planning an outing at the beach. Non-locals tended to check the weather forecast much more frequently than

locals. In fact, 37 out of 58 non-locals either selected 4 or 5 in terms of their frequency to base their day's decisions on the forecasted weather. There are several reasons that could explain this discrepancy. First, locals may believe that they understand the weather of the Outer Banks sufficiently not to require a weather forecast, or they have some past experience not to trust the weather forecast. Second, since locals are not on vacation, they may not construct formal plans, and simply decide to go to the beach based on the current conditions. Non-locals may use the weather forecast to decide upon several tourist options that are either primarily inside (e.g. shopping) or outside (e.g. sunbathing).

Implications for Regional Climate Change

The study results show that preferences were well in line with the mean climate conditions (85F, wind speed 10 mph, etc). However, the recent IPCC report (2007) predicts noticeable regional changes in the climate of this important tourist destination through 2100, with the largest amount (4 – 5F) occurring in the summer time. Additionally, - the number of extreme temperature days and heat waves are expected to increase. While our results showed a reasonable tolerance to temperature, given these projections, an average temperature of 90F would be less desirable than the current, and unacceptability increases for the higher temperatures. If temperatures become considerably hotter, the sensitivity of tourists to temperature may change.

Additionally, regional projections produced by the IPCC show a 5 -10% increase in summer precipitation for the Outer Banks region, with the majority of models predicting an increase. This is largely thought to come from summer thunderstorms (EPA 1998). Given the strong preferences for clear skies and low relative humidity, an environment that produces more summer storms will likely be less desirable to Outer Banks beach tourists.

Conclusions

This research demonstrates that current Climate Tourism Index formulations do not directly address what tourists and locals on the Outer Banks focus their decision-making on. This research also demonstrates the need for further study and a more comprehensive survey to explain the differences in locals versus non-locals, as well as some of the gaps in the existing preliminary data. Given that changing climate conditions on the Outer Banks will affect tourism flows, there needs to be further study into

understanding tourists' perceptions of climate change on the Outer Banks as well as addressing the need for region-specific development of weather, climate, and tourism indices.

Table 1. Climate Perception and Reality. Survey asked if the following conditions were ideal for an outing at the beach. Underlined values are closest to the August climatology for Cape Hatteras (NCDC), provided in the last column.

Variable						Climatology
Max daily temperature (F)	75	80	<u>85</u>	90	95	84.8
Cloud cover	<u>Cloudy</u>	Mostly cloudy	Partly cloudy	Mostly sunny	Clear	26% clear 32% var. clouds 42% cloudy
Wind speed (mph)	0	5	<u>10</u>	15	20	9.5
Relative Humidity (%)	0-20	20-40	40-60	<u>60-80</u>	80-100	69

Table 2. Observed Conditions on the Outer Banks.

Saturday (8/2/09) 12:00pm	Nags Head	Between mileposts 16-17
Average Wind Speed:	10.2 mph out of the NW	
Average Temperature:	96.6 F	
Relative Humidity:	47.9	
Weather:	Partly cloudy to cloudy in the evening	
Sunday (8/3/09) 10:30am	Kitty Hawk	Between mileposts 2-3
Average Wind Speed:	2.1 mph out of the SE	
Average Temperature:	89.2 F	
Relative Humidity:	66.7	
Weather:	Mostly Sunny	
Sunday (8/3/09) 2:00pm	Kill Devil Hills	Between mileposts 9-10
Average Wind Speed:	12.6 still out of the E	
Average Temperature:	93.4 F	
Relative Humidity:	63.2	
Weather: Clear	Clear	

Appendix 1. Survey Instrument.

1. Where do you live (city, state) _____.
2. How many days are you vacationing at the Outer Banks _____.
3. Do you check the weather forecast before deciding on your day's activities (e.g. outside versus inside)?

Never				Always
1	2	3	4	5

4. I would find the following maximum daily temperature to be ideal for an outing at the beach

	Totally Disagree			Totally Agree	
75 °F	1	2	3	4	5
80 °F	1	2	3	4	5
85 °F	1	2	3	4	5
90 °F	1	2	3	4	5
95 °F	1	2	3	4	5

5. I would find the following average cloud cover to be ideal for an outing at the beach

	Totally Disagree			Totally agree	
Cloudy	1	2	3	4	5
Mostly cloudy	1	2	3	4	5
Partly cloudy	1	2	3	4	5
Mostly sunny	1	2	3	4	5
Clear	1	2	3	4	5

6. I would find the following average afternoon relative humidity to be ideal for an outing at the beach

	Totally Disagree			Totally agree	
<20%	1	2	3	4	5
20-40%	1	2	3	4	5
40-60%	1	2	3	4	5
60-80%	1	2	3	4	5
80-100%	1	2	3	4	5

7. I would find the following average wind speed to be ideal for an outing at the beach

	Totally Disagree			Totally agree	
0 mph	1	2	3	4	5
5 mph	1	2	3	4	5
10 mph	1	2	3	4	5
15 mph	1	2	3	4	5
20 mph	1	2	3	4	5

8. Which of the climate variables just discussed have the strongest influence on your decision to come to the beach _____.

Figure 2. Temperature Preferences for all Respondents.

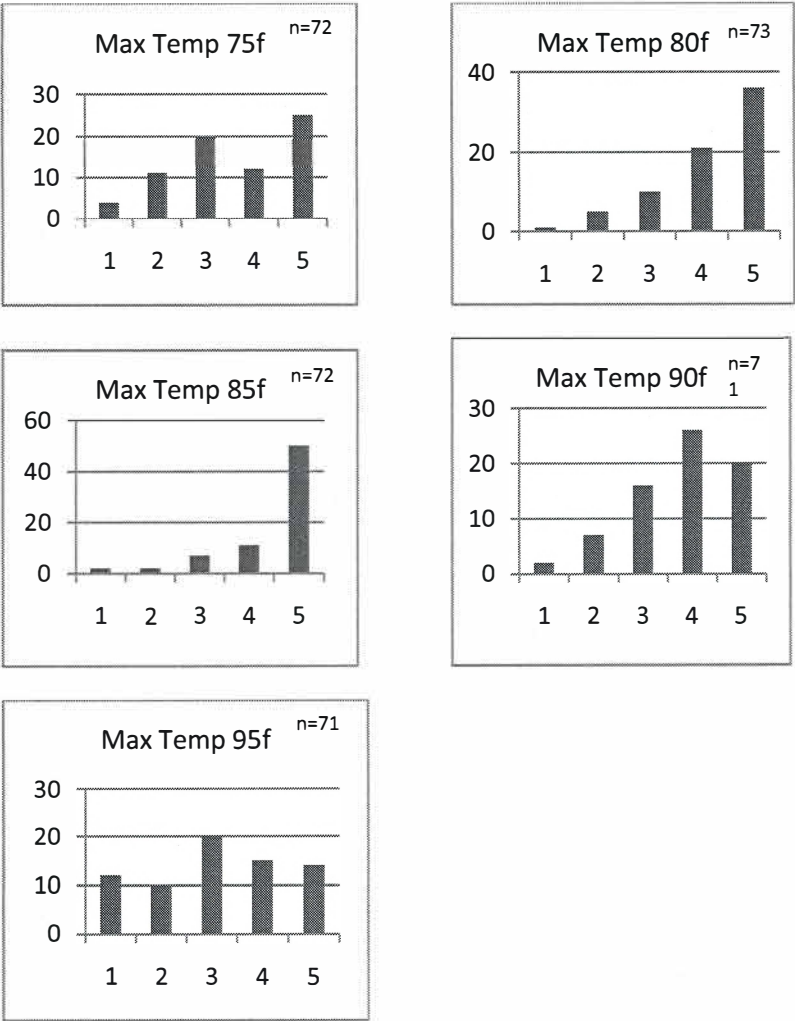


Figure 3. Average Cloud Cover Preferences for all Respondents.

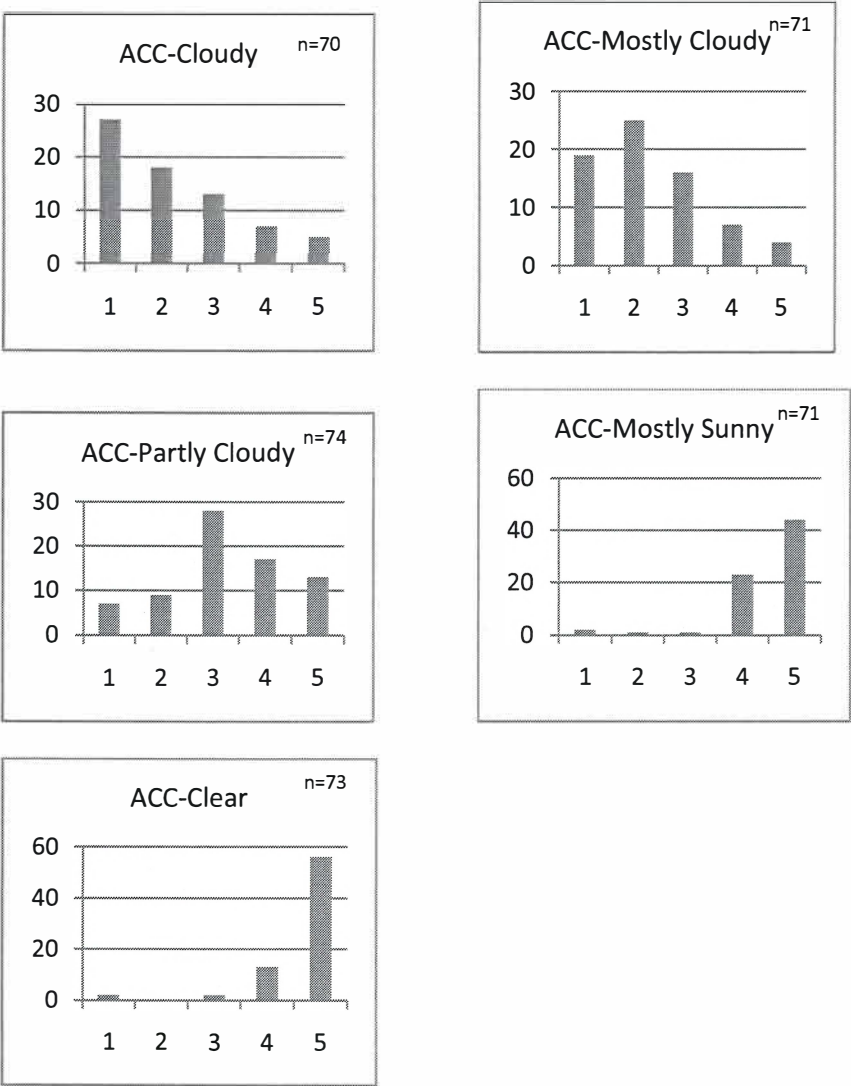


Figure 4. Relative Humidity Preferences for all Respondents.
Tourists' Climate Perceptions

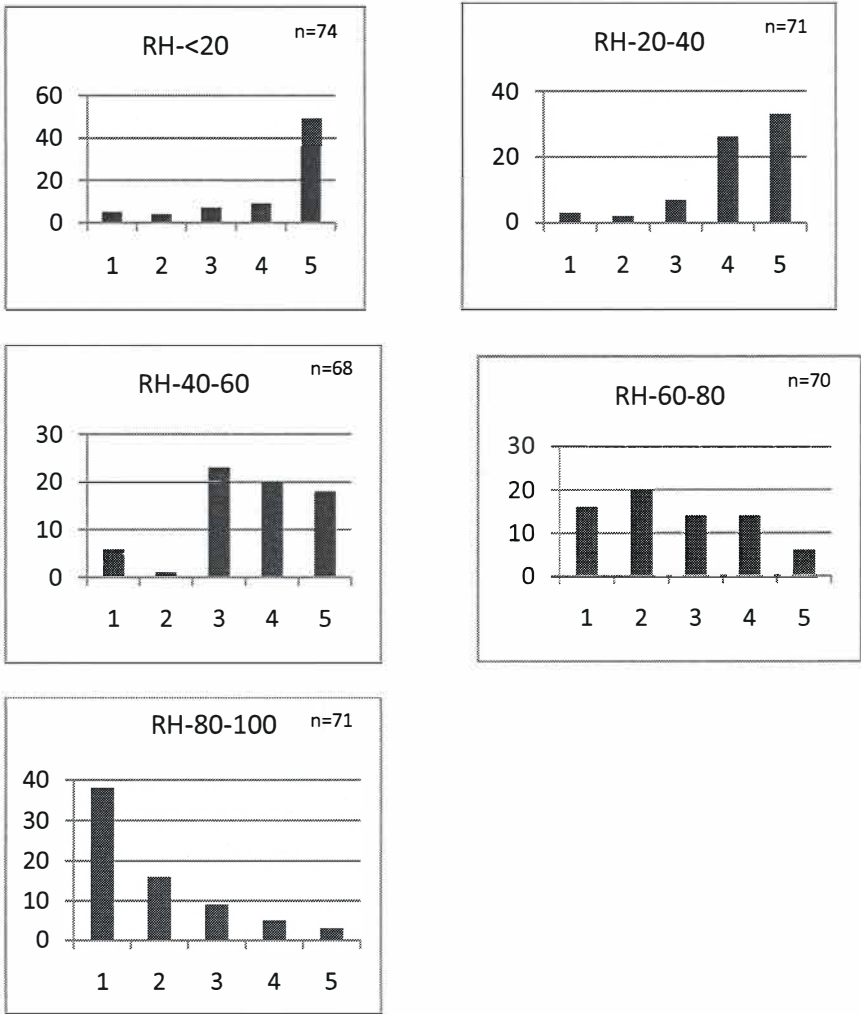


Figure 5. Wind Speed Preferences for all Respondents.

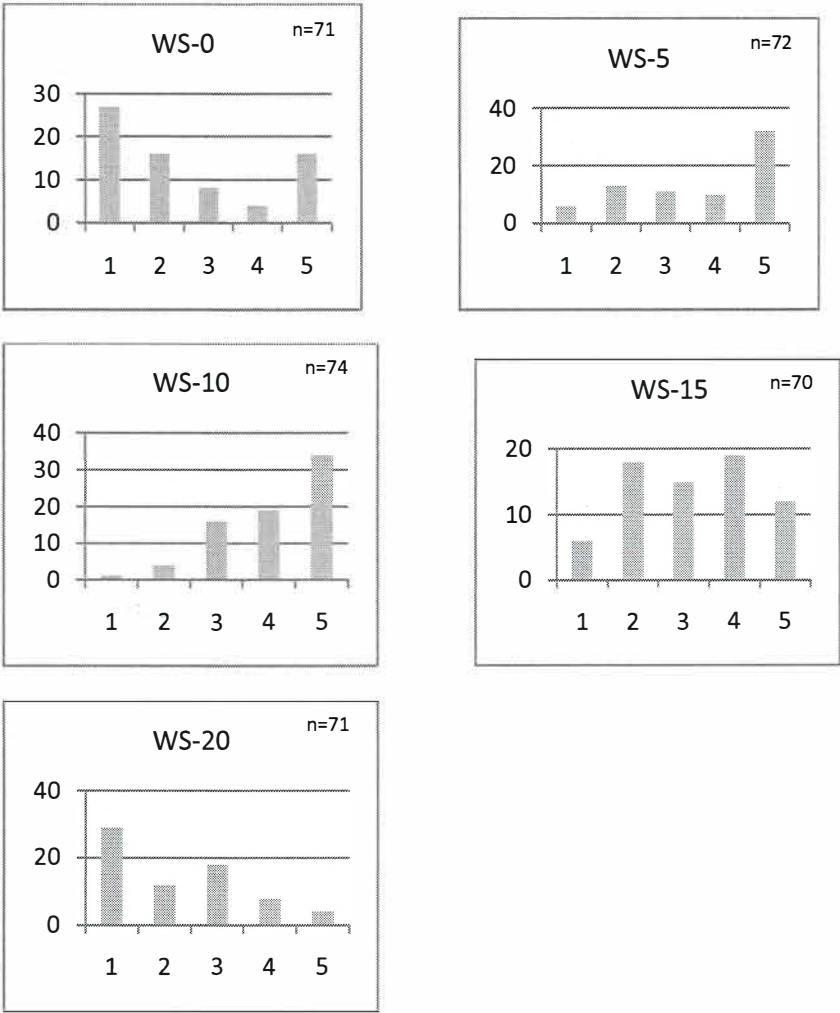
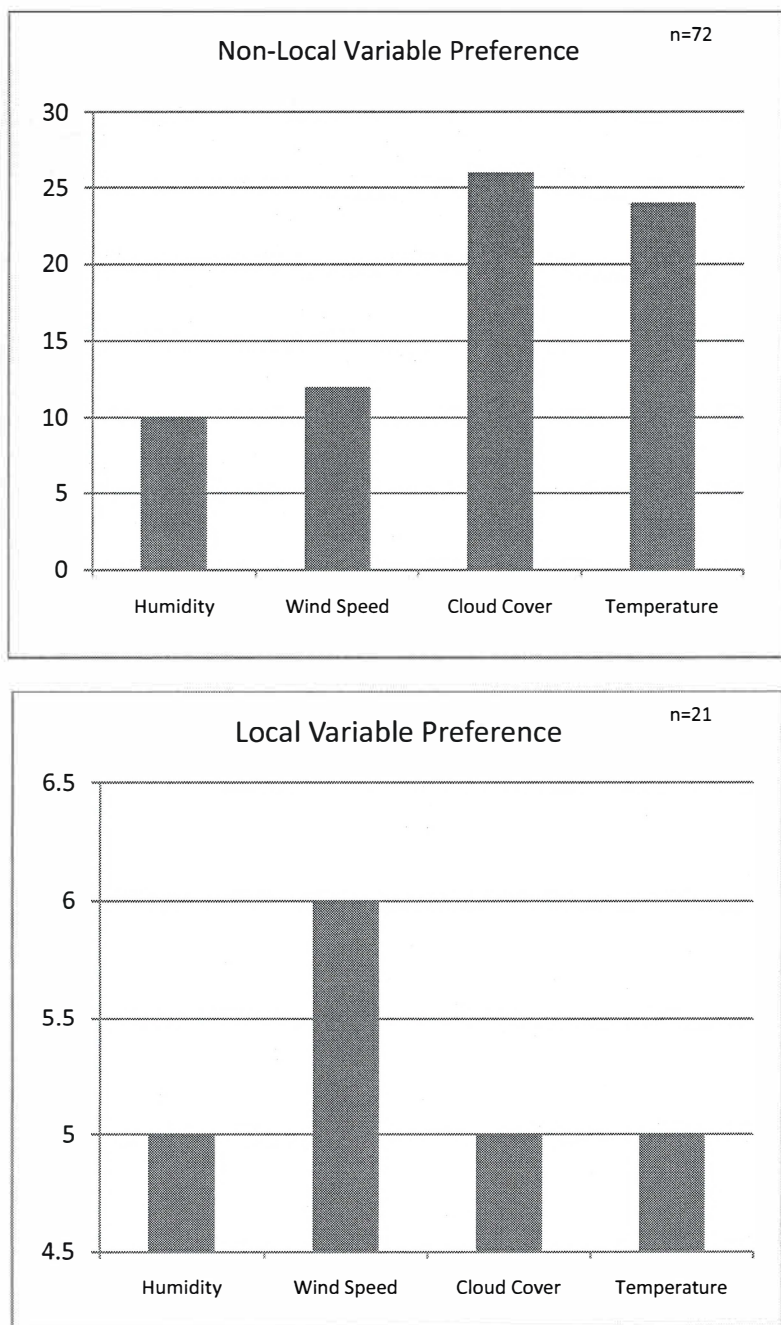


Figure 6. Most Important Climate Variables. Locals versus Non-locals



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Map Errors and Indians of the Carolinas

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Sometimes scholars minimize the importance of accuracy on maps that accompany their publications. Errors of omission are common, and perhaps the most frustrating. However, it is maps that contain errors of toponymy that are most frequently found in the literature (Map 1). Usually such errors are justified by the author of a paper claiming locations shown are approximate or “in the ballpark.” This essay and our revised map address errors in a map accompanying the *Southeast Handbook of North American Indians* (Volume 14: 2004, p. 329), a publication that contains numerous errors in the siting or naming of Indian places (hereafter referred to as “the *Handbook* map”). For example, the Indian settlements of Four Holes and White Oak are placed incorrectly. Two other Indian settlements (Antioch and Shiloh) are named, but do not exist where they are located on the *Handbook* map. Two tribes, the federally recognized Catawba in South Carolina and the Lumbee, the largest tribe east of the Mississippi River, are not mentioned on the *Handbook* map. It is also unclear why the Cherokee is sited in south central North Carolina.

We argue for a more accurate toponymy and suggest placing the various Indian groups in the Carolinas on a revised map (Map 2). We believe that map errors

sometimes occur because scholars have not actually visited the places on the maps used in their books or articles. Our revised map is based on several decades of on-site field experience and ongoing personal communications with Indian people living in the areas mapped. The senior author has lived with the Lumbees since 1982 (except for most of 1986) and has resided or visited all of the tribes mentioned in this essay except the Saponny of Person County and the Saponi Band of Occaneechi. The senior author has also stayed with the Coharies from time to time over the years since 1984.

The most egregious error on the *Handbook* map is one of omission. Unaccountably and incredibly, the map does not show the Lumbee Indians at all, unless the term “Tuscarora” is intended to denote this tribe. The term “Cherokee” on the map in the core area of the Lumbee is inexplicable. The Lumbee tribe has been written into state law as an Indian tribe since 1885 and is the largest Indian group in North Carolina. The Coharies were recognized by the State of North Carolina as Indians in 1917. The *Handbook* map shows two Coharie settlements (Harrells and Antioch) that do not exist. There is an unconfirmed report that a few decades ago a few Lumbees did live at Harrells, but the Coharie Tribal Office confirmed that there is

no Coharie settlement there. Holly Grove is in the correct place, also the main settlement of New Bethel, and the tiny rural settlement of Shiloh. The "Dunn settlement" in Harnett County, where Coharies settled shortly after the 1910 U.S. Census is correctly placed. In 1990, the senior author and Mr. Ammie Jacobs of Holly Grove, then 82 years old, drove to and mapped each of these settlements, viewing each in its entirety. The Dunn Settlement is called Bearsville by its inhabitants. Antioch is the name of a Free Will Baptist Indian church, recently closed, founded in 1926. The church stood in the Dunn settlement of Coharies, not at Shiloh. It still had a small number of congregants in 1990. Maynortown, a fifth Coharie settlement of about 40 people, about the same as in 1910, is astride the Harnett and Cumberland County boundary, but mostly in Harnett County.

In South Carolina, there is no Indian community at the Clarendon County location of White Oak although there is an Indian settlement two miles north of Holly Hill, S.C., called White Oak but misidentified on the *Handbook* map as Four Holes. This White Oak can be distinguished on the federal census as early as 1840. It is identified as Indian on South Carolina State Highway Department maps from 1938 forward, which show an "Indian church" there, and in the 1930 census in Holly Hill Township, the location of White Oak, one cluster of sixty people identified as Indian bear the surnames appropriate to the community as do sixty-five others, also identified as Indian, scattered through the township. Death certificates in Holly Hill township beginning in 1918 identify individuals on the tribal genealogies as Indian.

The Santee tribe is not, in the classic sense, state-recognized in that there is no law on the books at the state level that mentions them. State recognition in South Carolina consists of a ceremony, a handshake, a newspaper article, and a letter of congratulations. A letter to Chief Roosevelt Scott of the Santee Indian Organization from the State of South Carolina Commission for Minority Affairs, notes that "the Board

Members of the South Carolina Commission for Minority Affairs unanimously voted on January 27, 2006 to grant State Recognition as a "Tribe" to the Santee Indian Organization." But again, there is no state law mentioning that tribe by name; which is what state recognition generally means in North Carolina, Virginia, and Louisiana.

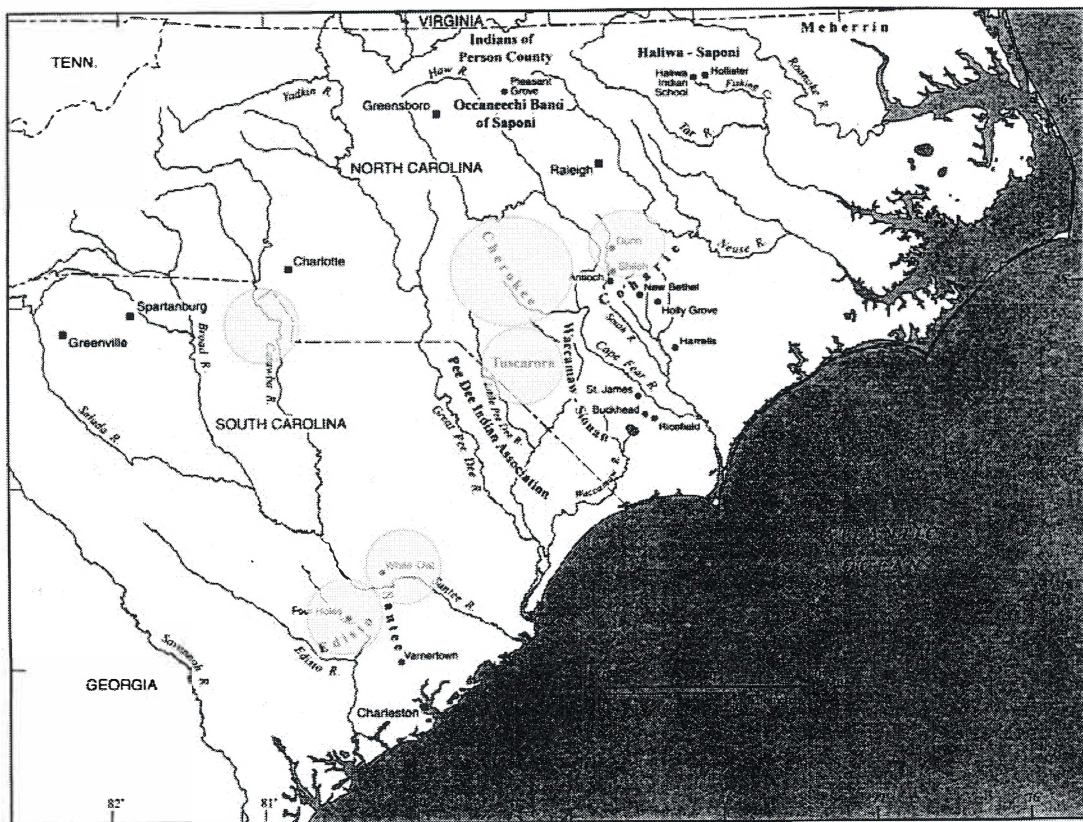
Varnertown on the map is shown accurately (the neighborhood of Carnes Crossroads, S.C.). A letter of February 25, 2005 to Lisa Leach, Chairperson of the Board, Wassamassaw Tribe of Varnertown Indians states that the "Board Members of the South Carolina Commission for Minority Affairs unanimously voted on February 5, 2005 to grant State Recognition as a 'Group' to the Wassamassaw Tribe of Varnertown Indians." Again, there is no other official or historical mention of "Wassamassaw" Indians as a tribe. In 1709, however, "Wassum-isau" is the name for the far upper reaches of Ashley River in Berkeley County, which, beginning at Charleston Harbor on the Atlantic, is known first as Ashley River, then as Big Cypress Swamp, then as Wassamassaw Swamp.

Lastly we note that the map mentions the "Edisto." This tribe, the Edisto Natchez Kusso, has two settlements, one called Four Holes, dating from 1904, on the north side of Givhans Ferry State Park three miles southwest of Ridgeville, S.C. The small, parent community, Creeltown, dating from at least 1850, is at the junction of Highways 61 and 651. The actual location of Four Holes is on the outside of a sharp bend of Edisto River, not as shown on the *Handbook* map; and Creeltown lies nine miles to the west of Four Holes, on the south bank of Edisto River. During the 1985-2005 period when the group was headed by Chief Matthew Creel, the Edisto Natchez Kusso Indians refused to deal with the South Carolina Commission for Minority Affairs because they did not wish to formally renounce all land claims.

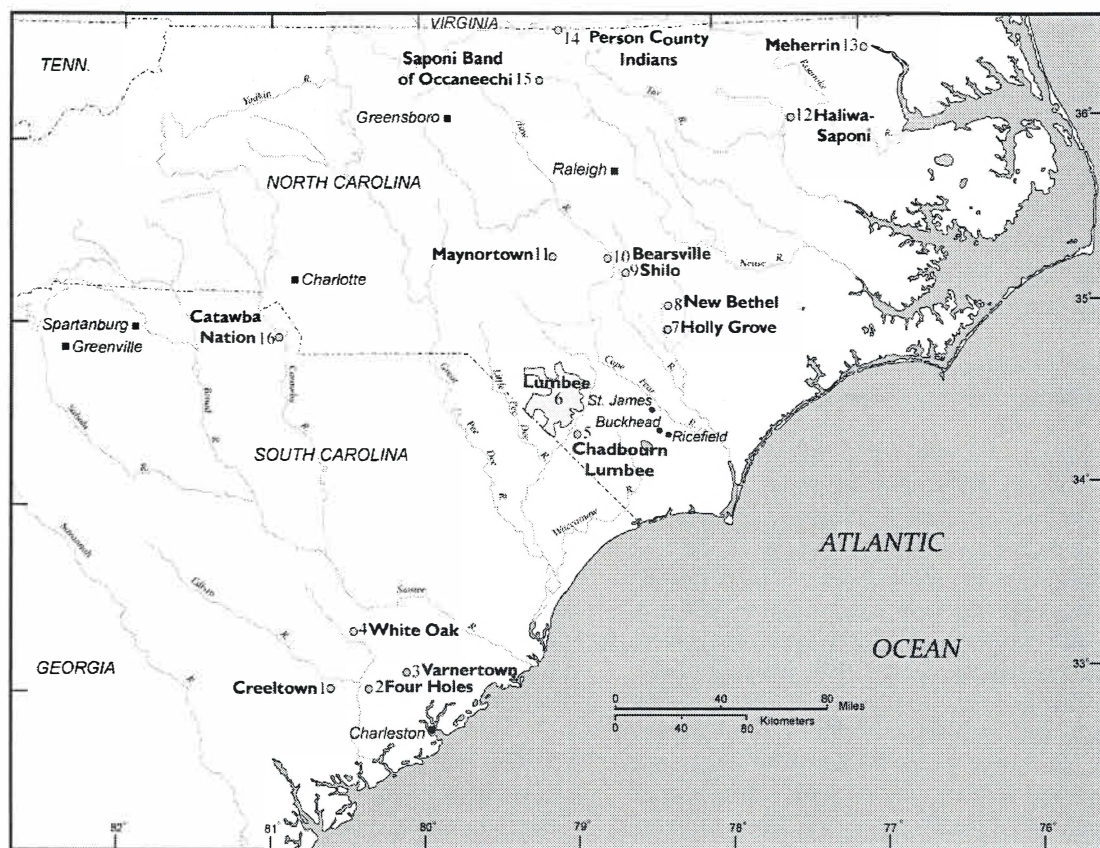
The *Handbook* map does accurately show several Indian locations. The Waccamaw Siouan settlements of St. James (on the upper reaches of Slap Swamp) and Buckhead-Ricefield, are in the right place, as

one might have expected, given that the *Handbook* map accompanies an article by P. B. Lerch, who has published extensively on that tribe. The Waccamaw Siouan has been recognized as an Indian tribe by the State of North Carolina since 1971. The locations on

the map showing the Haliwa-Saponi Tribe, recognized by the State since 1965, are also correct.



Map 1. Errors on published map in *Handbook of North American Indians*. Errors are circled on this map.



Map 2. Map showing corrected modern locations for Indians on the piedmont and coastal plain of the Carolinas.

Key to Corrected Map

The locations of *Ricefield* and *Buckhead* (in reality one settlement, usually referred to as *Buckhead*, split by a highway running north-south) north of Bolton, NC and *St. James* near Lake Waccamaw, NC (on the upper reaches of Slap Swamp) are accurately sited on the map. These are Waccamaw Siouan Indian settlements.

1. *Creel town*, at the junction of SC Highways 61 and 651 north from Cottageville, SC. The parent community of the "Edisto" (Edisto Natchez Kusso Indians); nine miles from its branch, *Four Holes*.

2. *Four Holes*, an Indian community of that name. Mostly along a one-mile segment of SC Highway 386, on the north side of Givhans State Park and three miles southwest of Ridgeville.

3. *Varnertown* is near Carnes Crossroads on US Alternate Route 17. They are now called the Wassamassaw Indians. Other Indians or Indian descendants have communities up and down Alternate Route 17 from Carnes Crossroads, toward Moncks Corner and in the opposite direction towards Summerville and in Lincolnville and Cooks Corner, but these avoid involvement in Indian affairs.

4. *White Oak Indian Community*, along the Fire Tower Road, recently renamed Bay View Road, two miles north of Holly Hill.

Note: The *Dimery Settlement*, consisting of a small American Indian community four miles north of Aynor at Dog Bluff in Horry County, SC, is not shown on this map, partly because it has dispersed to other parts of the county since 1987, when its church burned for the second time in as many years.

5. The *Lumbees* started a distinct settlement at Chadbourn, North Carolina in 1945.

6. *Robeson County, NC* is the major area of *Lumbee* population, home to more than 40,000 of the total nationwide Lumbee population of about 55,000. Within the county are several diffuse settlements: *Prospect* in the northwest of the area marked which shows Robeson County Townships having 50 percent or more Indian population in the 2000 federal Census; *Saddletree* in the northeast; *Fairgrove* in the south; and *Pembroke* in the center. Written into state law as an Indian tribe under one name or another since 1885. The Lumbee population spreads out thinly from Robeson County in all directions, with the nearest sizable urban outpost being Fayetteville, NC. Another is in Baltimore, MD. The latter are the only two Lumbee settlements outside of Robeson County that have churches with predominant Lumbee membership, other than a few in bordering Dillon County, SC and other bordering counties.

7. *Holly Grove*, the southernmost of the Coharie settlements along US Highway 421 in Sampson County, though not particularly noticeable from 421 because the two parts of the community are connected by an overpass. Holly Grove is partly within the Clinton city limits, but even that part appears very rural.

8. *New Bethel*, some eight miles north of Clinton on Highway 421; interspersed with white households that have no connection with the Indians there. This is historically the largest and the oldest Coharie community.

9. *Shiloh*, a small Coharie community on the South River along the Sampson-Cumberland County border.

10. *Bearsville*, as it is called by the Coharies who live there; or the *Dunn Settlement*, as it is called by the Coharies of the three aforementioned Coharie communities. It is located near Dunn, North Carolina and from there to the Harnett-Cumberland County border.

11. *Maynortown* of the Coharies, just north of the Harnett County line and due north of Fayetteville. Many Coharies live in Cumberland County east of the Cape Fear River.

12. *The Meadows*, the main settlement of the Haliwa-Saponi, is on the lower part of the Little Fishing Creek watershed and extends from Hollister south along the Halifax-Warren County line. Most live in Halifax County.

13. *Old California*, the Meherrin settlement named after a long-defunct store of that name between Union, Ahoskie, and Cofield in Hertford County. Residents have had a seat on the North Carolina Commission of Indian Affairs since 1986 and are recognized by the State as Indians.

14. *The Saponny Indians of Person County*. Tribal members live at Christie and Virginila, near the North Carolina-Virginia state line. According to Dr. Helen C. Rountree, after 1850 this group extended their territory into Virginia from the North Carolina side of the state boundary. The tribe has been recognized by state law since 1913.

15. *Little Texas Community*, located at the junction of Caswell, Alamance, and Orange Counties, is the primary settlement of the Saponi Band of Occaneechi, formerly called the Eno-Occaneechi. This tribe has had a seat on the North Carolina Commission of Indian Affairs since 2001.

16. *Catawba Nation*, nine miles south of Rock Hill, SC, near Leslie and Van Wyck, on the east bank of the Catawba River, live on their one square mile (640 acres) reservation and on considerable acreage adjacent and near the reservation. Lately there is also a "New Reservation." The Catawba became federally acknowledged in 1946; dropping that status in 1962, and picking it up again in 1993 after an epic 16-year court battle, during which they sued every landowner in the 225 square-mile claim area, including, incredibly, their own U.S. congressman.

Other shadowy groups most likely still exist, but the senior author has only visited one such group, that being the Goins community of about 15 people isolated at the end of a long road, two miles from Greelyville, South Carolina. This group had no contact with other Indians in the Carolinas until March of 1994.

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Climate Change and the North Carolina Coast

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One of the greatest challenges currently facing geographic education is developing instructional materials to inform students and communities of the geographical aspects of climate change. One approach is to teach the material as a 'stand alone' subject, or as a subtopic of physical geography or climate science. Such an approach is very effective in providing learners with an understanding of the scientific principles upon which climate change theory is based. However, too often, such efforts fall short of providing a local context for the impacts of global climate change (Bizikova et al., 2007; IPCC 2007; Shaw et al., 2009).

An effective and promising approach is to include climate change as a component of instruction about local landscape development or evolution. Geography programs frequently provide such material and instruction in many regional, historical and global change geography courses. Further, the academic discipline of geography has a rich history of advancing the concept of landscapes and landscape change. In North Carolina, perhaps the most pressing climate related planning issue (and thus one of the greatest education opportunities!) is the impact of sea level rise on coastal communities. Those communities face the dilemma of mitigating or adapting to sea level rise in order to avoid loss of property, habitat, and infrastructure. But how does one mitigate or adapt to a global scale prediction at a local level? Perhaps the best answer is to realize that we in North Carolina are already adapting to and mitigating risk in a highly variable system of perpetual coastal change. Ongoing efforts need to address a

future with great coastal transition induced by climate change.

Accordingly, this lesson plan provides three sections: a review of North Carolina coastal change; a review of climate change predictions and how they may impact the North Carolina coast; and exercises to engage students through problem or resource based learning. Instructors may want to incorporate the first two sections into lectures or readings, and then use the exercises in laboratory periods or as out of class assignments.

Review: Processes of Coastal Change in North Carolina

Residents of North Carolina, and other coastal regions, must remember that climate change induced sea level rise is just the latest layer of change to an already dynamic and variable coast. The coastal landscape has always represented a dynamic zone in which land and sea meet, and energy and matter are exchanged. Whether it is across the diurnal tidal cycle, seasonal storms cycles, or decades of human development, the North Carolina coast undergoes constant change. Water flows in all directions, beaches lengthen and shorten, dunes migrate back and forth, and land cover is in constant transition. Consequently, the issue of climate change and sea level rise are just two more variables that increase the dynamism of perpetual coastal change.

Valiela (2006) offers an excellent summary of eight global coastal change processes. The author is quick to point out that coastal change is driven by increases in human coastal populations and their

consequent increased use of coastal resources. Global population is increasing and many of those people live or are moving to coastal areas. In 1990, about 23% of the human population lived within 100km of the coast (Nicholls and Small, 2002). In North Carolina, the coastal counties of New Hanover and Brunswick have grown from populations of 103,471 and 35,777 in 1980, to populations of 192,538 and 103,160 in 2008 (USCB, 2010). Further, Frankenberg (1995) found the assessed value of Outer Banks real estate in Dare County increased from \$6 million to \$3.5 billion from 1950 to 1993.

The eight pathways of global coastal change outlined by Valierla (2006) include atmospheric-driven changes, sea level rise, alteration of freshwater discharges, alteration of sediment transport, loss of coastal habitats, introduction of exotic species, harvest of finfish and shellfish, and eutrophication. All of these types of coastal change can be found along the North Carolina coast but several types are particularly salient to the discussion of future climate change driven sea level rise. Since the majority of North Carolina's coast is comprised of barrier island complexes, it is important to understand the causes of variability in these dynamic coastal systems. Leatherman (1988) identifies the rate of sea level rise, sand supply, sea energy, and human intervention as the primary causes of coastal change in barrier island systems. Those causes correspond to Valierla's (2006) atmospheric-driven changes (sea level rise and sea power), alteration of sediment transport (sand supply), and loss of coastal habitats (human intervention) and must be discussed within the local context of the North Carolina coast.

In North Carolina, barrier island complexes dominate the coast. Barrier islands typically take the form of a series or complex of elongated (longer than wide) islands separated from each other by tidal inlets. The islands are separated from the mainland by a lagoonal body of water which itself can be a few hundred meters to 100s of km wide (the most well known in North Carolina being the Pamlico Sound) and have wind-blown dunes

and vegetation on the seaward side of the island. In these systems, atmospheric-driven coastal change and alteration of sediment transport are closely linked.

Atmospheric driven coastal change occurs across a broad array of scales. From daily shift in wind patterns, to 5-6 year El Nino Southern Oscillation patterns, to the occurrence of glacial and interglacial periods, the atmosphere can cause an increase or decrease in wave heights or water levels which represent the amount of energy transferred to a coast from the sea, causing erosion and other coastal alterations.

One of the most frequent, episodic atmospheric-driven coastal changes is the impact of storm surge upon a coast. Storm surge represents higher than normal high tide sea levels created by tropical and non-tropical storms. The higher than normal high tide sea levels and high wave heights are created by onshore winds which push water towards the shore. Such storm surge causes massive sediment transport as it moves across a barrier island and then back to the sea, loss of habitat due to deposition of sediment on a coast, and widespread damage to natural and man-made structures and objects. The end result can be wholesale change to a coastal area initiated by a single, relatively short event.

The transport of sand from the ocean across a barrier island is known as overwash. As overwash occurs, sediment is transported to the landward side of the barrier island, burying backbarrier environments or damaging and removing structures. The process is evident along the barrier islands of North Carolina in that relic and recent washover fans can be seen extending from a beach onto the backbarrier marsh. New overwash fans are easily identifiable after a storm; fresh sand deposited in a fan shape on top of marsh along with overwash debris and no vegetation growing through the sand. However, overtime the overwash fans become harder to identify as new marsh and vegetation re-colonizes the storm deposited sediment.

The constant overwash of sediment on barrier islands by storms causes a net transport

of sediment from the front of the barrier island to the back of the barrier island. If such overwash transport continues without sediment being supplied in the opposite direction from the land (in the form of fluvial deposits or tidal transport of sediment on the back side lagoon or bay), the entire barrier island complex will retreat, or transgress landward. If supply of sediment from a fluvial or lagoon system is greater than the overwash transport of sediment the barrier island complex will move seaward, or prograde. If transport of sediment by overwash and fluvial/lagoon systems is equal or the same magnitude, the system reaches equilibrium and the barrier island complex is stable, remaining in the same position relative to land and sea (Leatherman 1988).

Long-term changes in the atmosphere, or climate change, can have a large influence on whether barrier island complexes are stable, transgressive, or prograding. In a period of climate warming, glaciers melt and sea water expands, causing sea level to rise. With a rise in sea level, river valleys become flooded and sediment is trapped in these flooded valleys or estuaries, preventing the deposit of sediment on the back of barrier islands and progradation. Thus, during a period of sea level rise induced by a warm climate, barrier island complexes must retreat landward to maintain a constant elevation above mean sea level, or disappear under the sea. Such a retreat of barrier island complexes is currently occurring along North Carolina due to the current rise in sea level created by a warming climate. Evidence of this retreat is seen in several locations where peat and relic trees, established on backbarrier marshes before retreat, are currently exposed along a beach face. In addition, many manmade structures which were originally built back, away from the shore are currently positioned along the shore and in some instances are swallowed by the sea as the barrier island complex retreats (Figure 1).

Beyond the movement of sediment landward or seaward as barrier island complexes transgress or prograde, currents and tides also constantly move sediment along

and among the barrier islands, forming and reforming the islands, and carving and filling inlets. Frankenberg (1995) reports 18 historic and 3 current inlets along the Outer Banks the past 400 years. The result is that barrier islands complexes in North Carolina are dynamic features whose form is constantly changing. Residential development is vulnerable to flood damage, sand burial, coastal erosion or truncation or submergence due to inlet re-establishment (Figure 1).

In response to such vulnerability many coastal North Carolina communities have instituted programs of beach protection and shoreline stabilization. Those programs take many forms but most common are the building of jetties or groins to reduce erosion or stabilize inlets, beach renourishment that adds sediment to beaches to compensate for erosion, or the movement of structures away from the beach (Figure 2). In a few cases, the armoring of shorelines with objects such as boulder rip-rap or sand tubes is permitted (Figure 3).

Ultimately the projects alter the supply of sand or sediment to the barrier island complex. The alteration may be successful in regard to its intent, protecting a beach or stabilizing a shoreline, however, they also impact other areas of the barrier island complex by decreasing or increasing sediment transport. Because barrier island sediment transport systems are so complex, it can be very difficult to predict the end result of a protection or stabilization project. Projects usually create mixed results; protection of one area and erosion of another, the result being coastal change caused by humans imprinted upon an already high degree of natural variability or coastal change.

Beyond alteration of sediment transport, human settlement and development of barrier islands along the North Carolina coast results in loss of coastal habitats. Typically the habitat loss takes two forms. The first is the loss of barrier marshes as they are infilled with sediment to create a stable surface for construction. This construction may take the

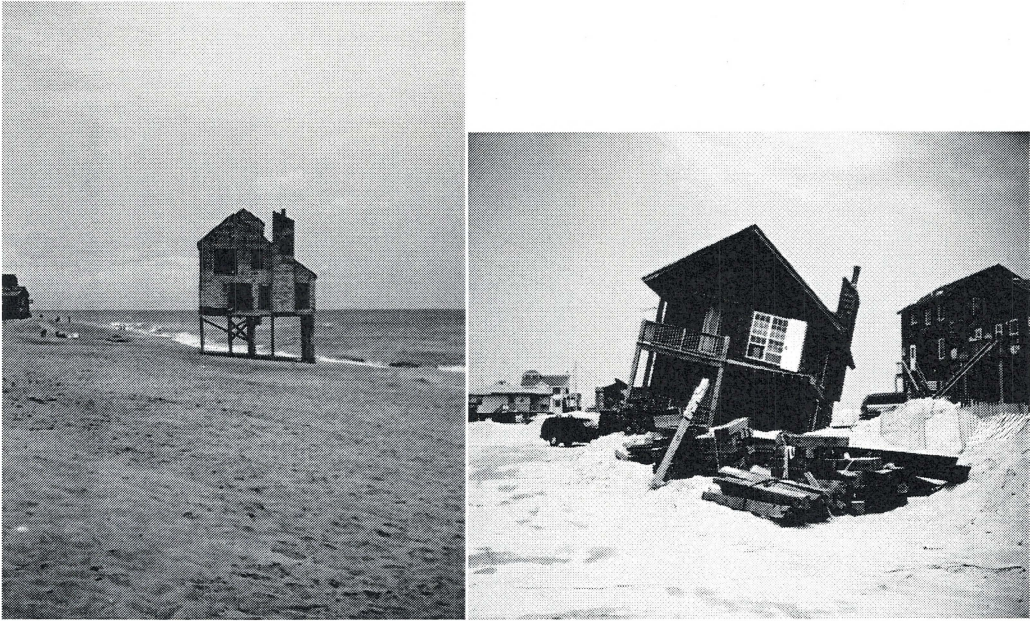


Figure 1. Left: Summer 2004. An abandoned house located in the swash zone behind the Chicamacomico Lifesaving Station. The house was originally built back from the beach, but erosion and island retreat have caused the swash zone to overtake it. The next summer, only the houses pylons remained. Right: House damaged by storm surge from Hurricane Isabel, Rodanthe, North Carolina (Photos: D.W. Gamble).



Figure 2. The movement of a house away from the ocean side of a barrier island to protect it from erosion and storm surge damage, Nags Head, North Carolina.

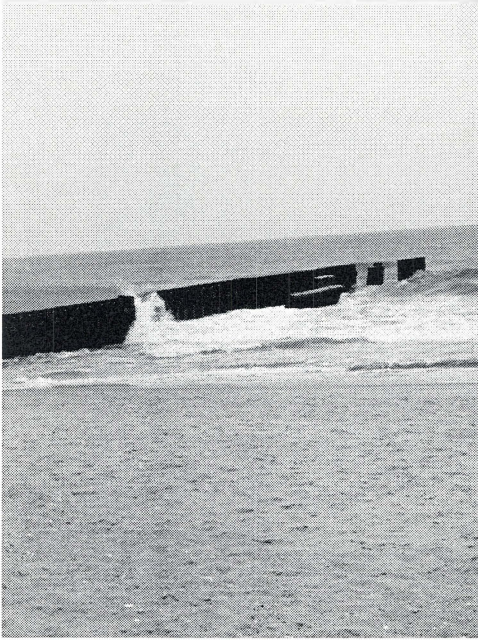


Figure 3. Left: Groin used to protect the Cape Hatteras Lighthouse before it was moved. Such hard structures are usually only permitted in North Carolina to preserve sites of historical significance or navigational importance. Right: Sand bags or tubes used to protect a house in Rodanthe, North Carolina. Soft structures are occasionally permitted to protect residential property (Photos: D.W. Gamble).

form of residences, commercial districts, or right of way for bridges and roads. Secondly, as ocean front residences and businesses are built, fore dunes at the back of the beach are usually lost and unable to reestablish in front of the newly built structures.

Wrightsville Beach, offers an excellent example of habitat loss to development. The settlement first consisted of a barrier island reachable by trolley on a bridge across backbarrier marshes. Then in 1925, in response to increased use of automobiles and desire for residency on the coast, the salt marsh landward of the beach, called Harbor Island, was infilled to allow for construction of residences and a road network. In 1965, Moores Inlet was infilled, connecting Wrightsville Beach and Shell Island, also allowing for development of nearby marshes. The result is a complete transformation of the local barrier island and its habitats over the past 90+ years (Figure 4).

Review: Future Climate Change and the North Carolina Coast

The Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report (AR4) indicates global warming (a positive linear increase in mean global temperature) of 0.74°C since 1906 (IPCC, 2007). Further, 11 of the last 12 years in the instrumental record of global surface temperatures (since 1850) rank among the 12 warmest years on record, and the linear warming trend over the last 50 years is nearly twice that of the last 100 years. In short, global warming is unequivocal and warming is expected at 0.6 to 4.0°C over the next 100 years. Warming air causes ocean water to warm and expand, which in turn causes sea level to rise. Current IPCC predictions of sea level rise range from the current rate of approximately 18 cm/century to 60 cm/century by 2100. However, these predictions do not include the effects of

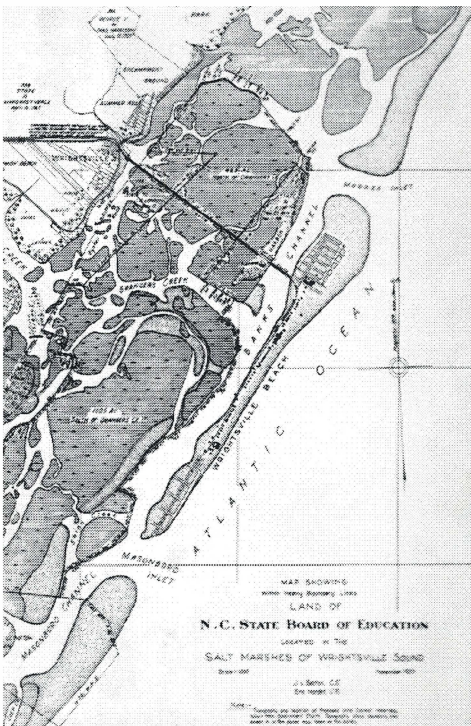
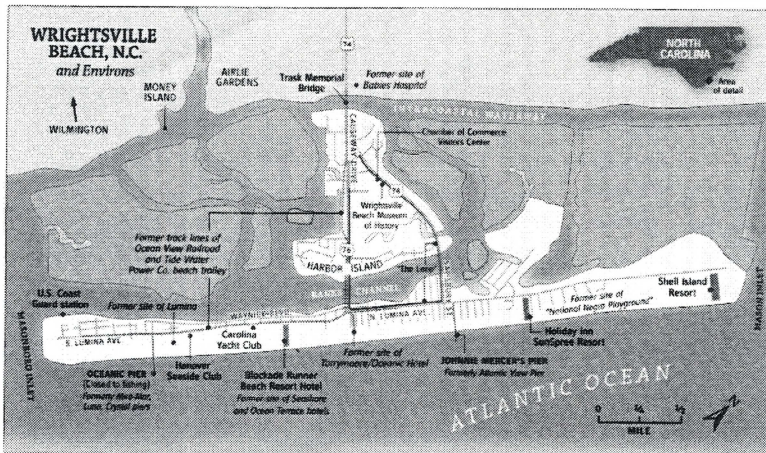


Figure 4. Changing coastal features at Wrightsville Beach, North Carolina, 2007 (top) and 1923 (bottom). Notice the loss of marsh habitat. In 1923, Harbor Island was almost all marsh as well as the area landward of Moores inlet. Harbor Island was expanded for residential property by infill of the marsh in 1925. In 1965, Moores Inlet was infilled connecting Wrightsville Beach and Shell Island, allowing for development of nearby marshes. (Map Sources: 1923 Map – North Carolina State Board of Education. 2007 Map: McAllister, R. 2007. *Wrightsville Beach: The Luminous Island*. Winton-Salem, NC: John F. Blair Publisher, pp. 243).

accelerated continental ice sheet melting and ice loss to the oceans.

The greatest shortcomings of the IPCC report and of climate change science in general, are that findings are based upon global and continental-scale climate models. Given the poor spatial resolution and limited data available for climate models, it is very difficult to precisely downscale global projections to a local or regional scale. Consequently, the confidence in local or regional impacts of climate change is much lower than on the global scale and there is less certainty as to potential outcomes of climate change for a specific location.

However, predictions for coastal North Carolina can still be provided in the descriptive form as opposed to a precise numeric prediction, providing important and relevant information that allow residents and governments of North Carolina to prepare for future impacts of climate change. Of particular concern to North Carolina is the IPCC's AR4 report of very high confidence that "coastal communities and habitats [in North America] will be increasingly stressed by climate change impacts interacting with development and pollution" (Field et al., 2007: 619). In other words, the rise in sea level along the coast (and the rate of change will increase in the future) will be exacerbated by the impacts of progressive inundation, storm-surge flooding, and shoreline erosion, a more than feasible result given previous discussion of coastal processes in North Carolina.

Recent geological investigations of historic relative sea level rise in North America (e.g., Maine and Connecticut) have identified accelerated rates beginning in the late 1800's and early 1900's. Kemp et al. (2008) investigate the rate of relative sea level rise in North Carolina based on foraminifera preserved in salt-marsh sediments on Roanoke Island, North Carolina. They suggest that in North Carolina the onset of rapid relative sea level rise began earlier (at the beginning of the 1800's) and has featured two distinct accelerations: an increase at the start of the 1800's from 8.0 +/- 0.4 cm/century to 15

cm/century (+/-1.6 cm/century) and a second acceleration around 1900 to 43 cm/century. This rate has been reconciled with the available tide gauge record data. Local rates of relative sea level rise for the North Carolina coast are highest along the northeast coastline and less in the Cape Fear region due to small variations in land elevation changes along the North Carolina coast. In the northern region of the state, rates of sea level rise are up to 40 cm per century, decreasing somewhat to 32 cm per century in the southern coastal region. Consequently, sea level rise projections like those offered for coastal North Carolina (13-50 cm over the next 100 years) are well within what is possible when we add in the glacial movement source.

Further, storm surge flooding can combine with progressive inundation created by sea level rise to flood and damage coastal communities. Hurricanes are one of the most significant contributors to storm surge. The impact of global warming on hurricanes is a controversial topic (Pielke et al. 2005; Trenberth and Shea 2006, Landsea 2005, and Pielke 2005), but there is increasing agreement within the scientific community of the likelihood that greenhouse warming will cause hurricanes in the coming century to be more intense on average and have higher rainfall rates than present-day hurricanes. Pielke et al (2005) have discussed the distinction between event risk, vulnerability and outcome risk. Event risk is the probability of a particular event occurring. Vulnerability is the impact that event could have if it occurred. Outcome risk is the combination of event risk and vulnerability and can be used to characterize the need for preparation for such an event. So, even if the link between increased hurricane intensity is not clear at this point, the potential impact of such an increase is quite large and North Carolina should be preparing for it. The combination of storm events and sea level rise may cause storm surges along the mid-Atlantic coast to exceed 100 yr coastal floods 3 or 4 times more frequently by the end of the 21st century (Najjar et al., 2000).

Of equal importance is determining the physical response of the coastline to sea-level rise and increases in storm surge. Prediction of shoreline retreat and land loss rates is critical to future coastal zone management strategies, and assessing biological impacts. The average slope of the lower coastal plain of North Carolina is of the order of 1:2000 which indicates that the potential for sea level rise induced shoreline erosion is high. Over 5000 km² of land are below 1-m elevation (relative to NAVD 88) and rates of sea level rise in this region are approximately double the global average due to local isostatic subsidence (Douglas and Peltier 2002).

Currently, barrier island thinning, caused by erosion on both the ocean and sound sides, is a global phenomenon on coastal plain barrier islands. This includes most of the barrier islands in North Carolina that are not stabilized in one fashion or another. Most likely this is a response to sea level rise and is the means by which the islands prepare themselves for sea level rise. While current distribution of barrier islands and lagoons along the North Carolina coast are in part a function on rising sea level, specific barrier islands dynamics (i.e. patterns of migration, erosion, deposition, storms) are typically dominated by local factors such as shore orientation, longshore current patterns, and sediment supply. As such, the response of these systems to rising sea level should be considered on local scales and all islands will not likely respond in identical fashions. Inlets and their associated shoals, particularly the ebb deltas will play significant roles in how the barriers will respond to changes in the adjacent estuaries. As sea level rises the tidal prism will increase and in turn so will the nature of the inlets and their influence on the adjacent oceanfront shorelines. This is particularly true for the shorter barriers such as Sunset Beach and Huttuff Island. The spatial and temporal changes will vary along the coast- some barriers will respond very quickly while others will lag behind.

In conclusion, based upon the most recent scientific literature sea level rise is occurring now, and sea level will continue to rise with a

high degree of certainty, along with associated risks. Given recent increase in population along the North Carolina coast, high vulnerability exists to coastal hazards associated with climate change. Further, there is a high degree of scientific certainty that increases in storm and hurricane intensity will occur. However, changes in hurricane frequency cannot be confidently predicted at present. More intense storms generate larger and more powerful ocean waves. The combination of sea level rise and more powerful waves can exacerbate coastal erosion damage risks.

Exercises

In this section, three exercises are provided to be used in conjunction with the background material to engage students and facilitate learning about climate change and the North Carolina coast. Specifically, the exercises are designed to involve students in an activity that promotes deep learning through participation, discussion, and reflection (Agnew & Elton, 1998). As students move from passive learning (typical lecture format of listening and taking notes) to active learning students move beyond receiving knowledge to exploring existing knowledge, and eventually creating their own knowledge (Gold *et al.*, 1991). Specifically, the exercises attempt to utilize resource-based learning schemes where the emphasis is on the use by students of print and electronic based learning resources to solve a problem (Healey, 1998). In such an approach, as opposed to content mastering, the purpose of the exercise is clear, but the methodology and specific learning outcomes for each student are variable, depending on a student's previous knowledge and developed skills.

Exercise 1: Search the online *Charlotte Observer* archives, online *Raleigh News and Observer* archives, and Google Images for the phrase 'Isabel Inlet Outer Banks'. Use the information found in this search to answer the following questions:

What was the Isabel Inlet?

How is the Isabel Inlet related to the dynamic physical systems of barrier islands?

How may future climate change impact phenomenon like the Isabel Inlet?

Exercise 2: Read the article: Martin, W.E. 1993. Storm hazard zones along the Outer Banks of North Carolina, *The North Carolina Geographer* 2 (Summer): 1-11. Compare the results of research to current 1:24000 topographic quads for the Outer Banks or recent aerial photos of the Outer Banks. Based upon this comparison and your knowledge of potential sea level rise, specifically outline locations and structures that may be impacted most by climate change.

Exercise 3: Figure 5 is a copy of a real estate flyer for a property in Rodanthe, North Carolina. What may the phrase "This one won't last" mean to the following people:

Real estate agent

Coastal resource manager

Visiting tourist.

Assessment of these resource based learning exercises is a bit more challenging than typical content mastery exercises. Broad latitude should be given to students for funding a creative and unique solution to the exercises, and quite honestly there is not one definitive answer for each exercise. Consequently, guiding principles as opposed to rigid rubrics should be developed to assess the exercises and these principles should be aligned to course objectives. For example, for exercise 1, guiding principles for assessment can be: a) student displays ability to use search engines to effectively gather information to answer the questions, b) the student can clearly defines Isabel Inlet, and c) the student explains in a logical fashion the potential impact of climate change on storm surge inlets. Each student can then be marked as above expectation, meets expectation, or performs below expectation for each principle. Such principles and grading standards should be developed for each exercise by each instructor in order to align with course objectives and student learning outcomes.



This one won't last
SANDSCAPE

\$299,000

- 4 Bedrooms
- 2 Bathrooms
- Heated Living Area: 1230 sq. ft.
- Furnishings Convey
- Screened Porch
- Sun Deck
- Outside Shower
- Great Location!!!
- MLS 49599

OCEAN FRONT

Figure 6. A real estate advertisement for a property located in Rodanthe, North Carolina.

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In Memorium

William Franklin “Frank” Ainsley, Jr., Distinguished Professor of Geography, Department of Geography and Geology, University of North Carolina-Wilmington.

Frank Ainsley, a long time supporter and founding member of the North Carolina Geographical Society, died on June 17, 2010 in Wilmington, North Carolina. A native of Elizabeth City, North Carolina, he held an AB degree in Biblical Studies, UNC-CH, 1966; a Masters of Divinity, Southeastern Theological Seminary, Wake Forest, NC, 1969; Masters in Geography, UNC-CH, 1972; and Ph.D. in Geography, UNC-CH, 1977. During his distinguished 36-year career in the Department of Geography and Geology at UNCW, Frank taught countless numbers of students, both undergraduate and graduate, who benefitted from his outstanding abilities as a teacher and mentor. Frank's considerable contributions were recognized by the North Carolina Geographical Society who awarded him the 2003 North Carolina Geography Educator of the Year award. He also received the Board of Governors Award for Teaching Excellence from the University of North Carolina in 2004, and was recognized with a University of North Carolina-Wilmington Distinguished Teaching Professorship in 2005. He was an active officer for the Pioneer America Society, receiving the society's Henry H. Douglas Distinguished Service Award.

Frank's scholarly work was wide-ranging and had a substantial influence on North Carolina. Among his many interests were immigrant farm colonies and preservation of historical buildings and sites. His geography textbooks are the standards in public school systems across North Carolina, and were arguably the first geography lessons to which many young students were exposed. One of his texts, *North Carolina: The land and Its People*, was used by 75% of all fourth graders in the state for five years and reached an estimated 375,000 North Carolina students.

Frank's colleagues at UNCW describe him as a true explorer who was dedicated to the field of geography, to higher education and to his many, many students. He will be remembered as a Buddy Holly fan who annually gave his "Buddy Holly lecture" to geography classes on February 3, the day of Holly's death. His students and colleagues will miss his kind warmth and generous spirit.

2010 Educator of the Year Award

Professor Ronald (Ron) Mitchelson was recognized as the 2010 Educator of the Year on November 4, 2010 at the opening social of the annual meeting of the North Carolina Geographical Society on the campus of East Carolina University in Greenville. Ron received a Ph.D in Geography from The Ohio State University in 1979 and taught in the Department of Geography at the University of Georgia from 1979 to 1993, rising to the rank of Full Professor. He served as Department Chair at Morehead State University in Kentucky from 1993-1999, and then joined the Department of Geography at East Carolina University where he was Chair of Geography from 1999-2009. He is currently a Senior Research Fellow in the Division of Research at ECU.

In over 30 years of university level teaching, Ron has infused his classes with enthusiasm, intellectual rigor, and an amazing ability to make complex concepts understandable and relevant to real world problems and issues. His teaching interests have focused on transportation geography, quantitative techniques and spatial statistics, GIS and computer mapping, location analysis, and regional economic development issues. He is skilled at teaching at the introductory undergraduate level as well as the upper division and graduate levels. From 1979 to 2010, Ron served on an impressive 166 Graduate Student Advisory, Examining, or Reading Committees. He has served as the Advisor for 56 undergraduate students at ECU and for 105 students while serving as Chair at Morehead State University. Ron served as the Chancellor's representative on the University Curriculum Committee from 2002-2010. At the same time he supervised the building of a university-wide Geographic Information Science Center and supervised several new curriculum and degree development program efforts at ECU. In addition to his university service, he is a regular guest speaker in the Pitt County Public Schools.

Part of Ron's strength as an educational leader is his ability to respect other intellectual approaches and build bridges across disciplinary lines. Another key aspect of Ron's leadership approach is mentorship. He has an open-door policy. He is extremely generous with his time, often sacrificing his personal and research time for the benefit providing consultation and advice to faculty and students.

Ron is a proven leader in larger college and university circles and often involved in creating and advancing academic centers and degree programs with a state wide impact on geographic education in North Carolina. For example, after organizing a national hazards conference in Greenville in the wake of Hurricane Floyd, he played a vital role in establishing the Center for Natural Hazards Research at ECU. Ron also served on the steering committee of the Coastal Resource Management Ph.D Program and planning committees for Master degrees in Economic Development and Security Studies.

The North Carolina Geographical Society is pleased and proud to award the Educator of the Year Award for 2010 to Ron Mitchelson.

2010 Annual Meeting of the North Carolina Geographical Society

The annual meeting of the Society was hosted by the Department of Geography at East Carolina University in Greenville, NC on November 4 and 5, 2010. Events included a wine and cheese social at the Department of Geography at which President Tom Crawford provided welcoming remarks followed by the presentation of the Educator of the Year Award to Dr. Ronald Mitchelson (East Carolina University). Following the social, members and guests attended a special presentation of various geospatial technologies and associated research provided by ECU's Renaissance Computing Institute (RENCI) and the department's Terrain Analysis Laboratory. These activities included a demonstration of RENCI's Viswall, a wall-sized geovisualization media platform, and real-time laser scanning of a campus courtyard. Laser scanning, led by a duo of undergraduate and graduate students, resulted in a detailed 3D image representation of the courtyard environment including the attendees present in the courtyard. A group then attended dinner at a local restaurant The Daily Grind. The business meeting was held Saturday morning at 9:00am. In addition to normal business matters, Doug Gamble (UNC-Wilmington) provided remarks on the career impact of Dr. Frank Ainsley who passed away in 2010. After the business meeting, a group embarked on an Inner Banks fieldtrip with stops in Greenville, Washington, Bath, and Aurora. Highlights included the NC Estuarium, lunch in downtown Washington, a ferry ride across the Pamlico River, and a drive through the PCS Phosphate mine culminating in a visit to the Aurora Fossil Museum where attendees dug for (and found) ancient shark teeth from the nearby mine.

Guidelines for Authors

The North Carolina Geographer is an annual peer reviewed journal published by the North Carolina Geographical Society. It serves as an outlet for the dissemination of research concerning topics of regional interest. The journal publishes research articles, a section on Carolina Landscapes that includes descriptions of emerging and interesting features of the region, book reviews, and conference reports. Contributions from faculty, students, professional practitioners, and independent scholars are welcome.

All manuscripts submitted to *The North Carolina Geographer* should adhere to the following guidelines and be in acceptable format ready for peer-review.

- ❖ Only original, unpublished material will be accepted. Submission by electronic means is encouraged. Paper copies may also be submitted through the mail. A separate title page should include the authors name(s) and affiliation(s). An abstract giving the key purpose and findings of the article should follow on a separate page. The first page of text should begin with the title, but not include authorship.
- ❖ All manuscripts should be ready to print single sided on standard 8.5 X 11 inch paper, double spaced, with 1.25 inch margins, using 10 point type. Times Roman type font is preferred.
- ❖ References are to be listed on separate pages, double spaced, and follow the Publication Manual of the American Psychological Association (APA style guide) as used in journals published by the Association of American Geographers (*Annals*, or *The Professional Geographer*).
- ❖ Figures and tables should be submitted on separate pages at the end of the manuscript. Electronic versions or figures or maps should be in .TIFF format to provide for the best reproduction in the journal. Also provide a list of figures and tables on a page separate from the main text of the manuscript.
- ❖ High quality black and white images may be included. Original digital images are preferred to paper photographs.

Submit manuscripts to:

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Department of Geography

PROGRAMS AND RESEARCH FACILITIES

Undergraduate tracks include the B.A. in Geography and the B.S. in Applied Geography. The former is a broadly-based geography program, drawing courses from human and physical geography, as well as techniques. The latter has a strong emphasis on spatial analysis, and requires an internship in a state agency or private firm.

At the graduate level the Department specializes in human geography, physical geography and spatial information technologies, and supports a variety of philosophical and methodological approaches within each of these areas. Students are encouraged to develop their research in conjunction with faculty, and to disseminate their findings via professional meetings and journals. Faculty expertise is clustered around the following:

Economic Geography: development policies, practices, and impacts; urban and rural restructuring; and geographic thought (political economy, feminist theory, critical geopolitics).

Cultural Geography: community development; tourist landscapes; cultural ecology; and field methods.

Coastal Plain Geomorphology: coastal geomorphology (aeolian processes and dune formation); drainage basin hydrology; fluvial geomorphology; soil geomorphology; and environmental management (natural hazards research, land and water use planning).

Spatial Information Technologies: geographic information systems (watershed/ environmental modeling, topographic effects on digital data); remote sensing and image processing, computer cartography (global databases and map projections), and spatial quantitative methods.

Regional Specializations: Africa-East; Africa-South; Asia-South; Caribbean; Middle East; North Carolina; Western Europe.

Faculty are actively engaged in research in all four clusters, and have received multiple-year grants from, amongst others, the U.S. Department of Agriculture, the National Science Foundation, the New Jersey Sea Grant Program, N.A.S.A. and the U.S. Forest Service.

The department maintains both a fully equipped physical geography laboratory and a Unix-based Spatial Data Analysis Laboratory. The physical geography laboratory is designed for mechanical analyses of soil and sediment, but also includes state-of-the-art GPS, electronic surveying equipment, and instrumentation for monitoring hydrologic and aeolian processes and responses. The spatial laboratory consists of ten Sun workstations, a large format digitizer, and an Esize DesignJet plotter for teaching and research. Primary software includes Arc/Info, ArcView, and Imagine. A PC-based cartography laboratory was recently established. Students also have access to a wide variety of university facilities including the Institute for Coastal and Marine Resources, the Regional Development Institute, International Programs, and the Y.H. Kim Social Sciences Computer Laboratory. The Kim laboratory provides access to PC-based software such as Adobe Illustrator, ArcView, Atlas*GIS, IDRISI, SAS, SPSS, and Surfer.

FOR CATALOG AND FURTHER INFORMATION WRITE TO:

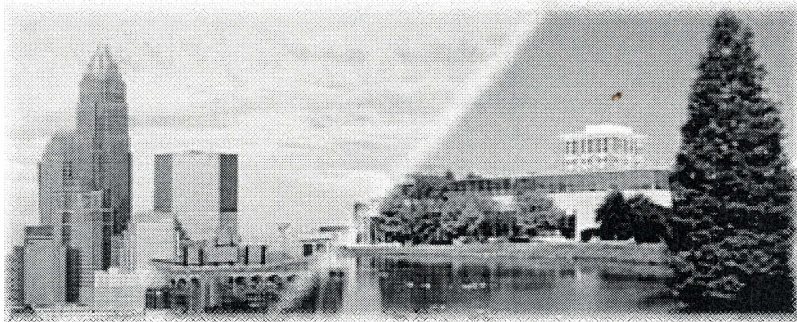
Undergraduate Catalog: Director of Admissions, Office of Undergraduate Admissions, East Carolina University, Greenville, North Carolina 27858-4353.

Tel.: (919) 328-6640. World Wide Web: <http://www.ecu.edu/geog>

Graduate Catalog: Graduate School, East Carolina University, Greenville, North Carolina 27858-4353.

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Graduate Programs at The University of North Carolina at Charlotte



Ph.D. Program in Geography and Urban and Regional Analysis

The Ph.D. program focuses on two interconnected research themes: multi-scalar analysis and GIScience. Pairing technology and theory in the core curriculum, the doctoral program is designed to prepare graduates for research positions in the public and private sectors, as well as academic careers. Doctoral assistantships carry stipends of \$13,000 plus healthcare insurance, and a tuition waiver.

For further information contact Dr. Owen J. Furuseth, Director Geography Ph.D. Program at: ojfuruse@uncc.edu or via telephone at 704-687-4253.

Master of Arts in Geography Program Concentrations

Community Planning Track students are awarded the M.A. in Geography and complete a formally structured multi-disciplinary core curriculum with course work in Geography, Architecture, Economics and Public Administration. The Track has an excellent placement record.

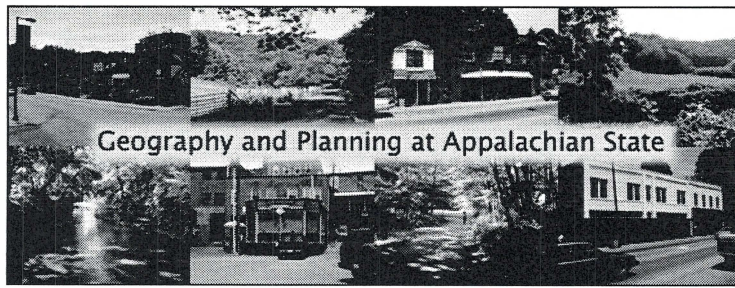
Location Analysis Concentration students prepare for careers with retailers, real estate developers, consulting firms, commercial banks, and economic development agencies. Course work is offered by practicing professionals and focuses in: Retail Location, Market Area Analysis, Real Estate Development, Applied Population Analysis, Real Estate Development, and Industrial Location.

Urban-Regional Analysis Concentration trains students for public and private sector planning economic development and Geographic Information Science. Course work may be concentrated in one of the following areas: Economic and Regional Development, Site Feasibility Analysis, Urban Development, and Geographic Information Science.

Transportation Studies Concentration is affiliated with the University's Center for Transportation Policy Studies. Students pursue course work in Transportation Systems Analysis, Transportation Modeling, and Transportation Policy Analysis. Careers are available in public and private sector agencies and in consulting firms.

The M.A. program has a limited number of out-of-state tuition waivers and a significant number of graduate teaching or research assistantships. Typical stipends include awards of \$10,000 for the academic year. Current full-time students receive financial support via assistantships or via contract work.

For further information, visit our website at <http://www.geoeearth.uncc.edu/> or contact Dr. Tyrel G. Moore, Graduate Coordinator, Geography M.A. Program at tgmoores@uncc.edu, or via telephone at 704-687-5975.



APPALACHIAN STATE UNIVERSITY

Department of Geography & Planning

www.geo.appstate.edu

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- B.A in Geography
- B.S. in Geography (teaching)
- B.S. in Geography (general concentration)
- B.S. in Geography (geographic information systems)
- B.S. in Community and Regional Planning
- M.A. in Geography with thesis or non-thesis (general geography or planning concentrations) options

RESEARCH FACILITIES

The Department occupies the third and fourth floors of a soon-to-be renovated science facility and contains three computer laboratories for work in computer cartography, GIS, and image processing. The laboratories have numerous microcomputers networked to each other and to the campus mainframe cluster. Appropriate peripherals include digitizers, scanners, printers, and plotters. The Department maintains a full suite of professional GIS, image processing, graphic design and statistical software applications in its laboratories. The Department is a USGS repository, and its map library presently possesses over 100,000 maps and 5,000 volumes of atlases, journals, and periodicals; and is also a repository for census material available on CD-ROM including TIGER files, DLGs, and other digital data..

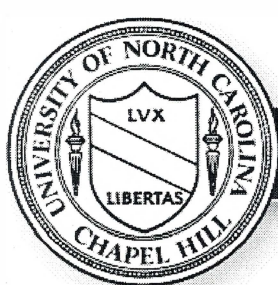
GRADUATE PROGRAM

The Masters program in geography is designed to provide students with a relatively broad range of academic and professional options, preparing them for Ph.D. work in geography and planning, professional applications in GIS, or opportunities in teaching at all educational levels. Accordingly, thesis or non-thesis options are offered with the non-thesis option requiring an internship in regional, urban, or environmental analysis and planning. In addition, the Department participates in a program leading to the Master of Arts degree in Social Science with preparation in geographic education.

For further information, please contact:

- Department Chair: Dr. Jim Young (youngje@appstate.edu)
- Graduate Program Coordinator: Dr. Kathleen Schroeder (schroederk@appstate.edu)
- Program Inquiries: Kathy Brown (brownkv@appstate.edu)

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DEPARTMENT of GEOGRAPHY

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The University of North Carolina at Chapel Hill is the oldest state university in the country and is one of the nation's premiere public institutions, with extensive and state-of-the-art resources and a range of nationally and internationally recognized academic programs. Set within this environment is Geography, a collegial, dynamic, and highly productive department of 16 faculty, including national and international leaders in areas of human geography, earth systems science and geographic information science. Geography offers the B.A., M.A., and Ph.D. degrees, with most graduate students pursuing the doctorate. The department enjoys excellent collaboration with a set of leading interdisciplinary programs on campus, including the Carolina Population Center, Carolina Environment Program, Shep Center for Health Services Research, Center for Urban and Regional Science, International Studies and Latin American Studies.

Undergraduate Program. UNC's Department of Geography offers a broadly based B.A. degree with concentration in three areas-the geography of human activity, earth systems science, and geographic information sciences. A well-equipped teaching lab directly supports undergraduate teaching and research in Geography, while a range of state-of-the-art facilities can be found at several venues on campus. Students are urged to participate in the University's superior undergraduate programs and resources, undergraduate research, and internships. The department has a student exchange program with Kings College London.

Graduate Program. Our graduate program reflects our ongoing commitment to the highest quality research and our intention to continue to direct resources toward our primary research strengths: Earth Systems Science, Geographical Information Sciences, Globalization, Social Spaces, and Human-Nature Studies. These areas are integrated in individual and group research projects, while interdisciplinary cooperation is also highly valued. Reciprocal agreements with other universities in the Triangle allow graduate students to take courses at Duke University and North Carolina State. Funding is available through fellowship, research assistantships and teaching assistantships. Current graduate research is carried out both locally and globally on six continents with funding from a range of agencies including NSF, NASA, USDA, HUD, NIH and EPA as well as a set of private endowments. Recent graduates have regularly found positions in leading universities, government agencies and private enterprise.

For more information, contact Dr. Larry Band, Chair, Department of Geography, University of North Carolina at Chapel Hill, Chapel Hill, NC 27599-3220. Telephone: (919) 962-8901. Email: iband@email.unc.edu



The Department of Geography and Geology at the University of North Carolina Wilmington offers a Bachelor of Arts degree in Geography. Students who pursue the B.A. degree in geography may choose from a broad, flexible program that meets personal educational goals and interests, including careers and graduate study in physical, human or applied geography. The Department of Geography and Geology also offers a minor in Geospatial Technologies. The minor enables students to achieve a documented expertise in geographic techniques which can then be leveraged to gain employment in the expanding GIS job market. UNCW Geography also supports a vibrant internship program that places students in a wide variety of professional agencies in southeastern North Carolina.

There are three options of concentration for students in the Geography Program at UNCW:

The **applied geography** option is designed for students who are interested in careers as planners, GIS specialists, and historic preservationists.

The **human geography** option is designed for students who wish to pursue a career as regional specialists, international business officials, and social scientists.

The **physical geography** option is designed for students planning careers as meteorologists, climatologists, geomorphologists, and hydrologists.

Faculty research interests include settlement geography of the South, fluvial systems of the Coastal Plain, applied climatology of islands and coasts, GIS applications in watershed management, and the racial landscape of the South. Students are encouraged to participate with faculty in their research and also pursue individual research projects. The geography program makes extensive use of computers for both laboratory and classroom instruction. The department maintains state-of-the-art Spatial Analysis Laboratory (SAL), Cartography Laboratory, the Laboratory for Applied Climate Research (LACR), and a Sediment Analysis Laboratory.

For more information, contact

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