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Climate Change in the Lumbee River Watershed and Potential Impacts on the Lumbee Tribe of North Carolina

Ryan E. Emanuel

Department of Forestry and Environmental Resources, North Carolina State University, Raleigh, NC

Abstract: A growing body of research focuses on climate change and Indigenous peoples. However, relatively little of this work focuses on Native American tribes living in the Atlantic Coastal Plain of the United States. The Lumbee Tribe of North Carolina is a large (60,000 member) Native American tribe located on the Coastal Plain in present day North Carolina (U.S.). The tribe has deep connections to the Lumbee River, which flows through a watershed dominated by extensive forested wetlands. In this paper, I outline key issues associated with climate change and water in the region, and I use long-term climatic and hydrologic datasets and analysis to establish context for understanding historical climate change in the Lumbee River watershed. Downscaled climate model outputs for the region show how further changes may affect the hydrologic balance of the watershed. I discuss these changes in terms of environmental degradation and potential impacts on Lumbee culture and persistence, which has remained strong through centuries of adversity and has also experienced a resurgence in recent years. I close by acknowledging the especially vulnerable position of the Lumbee Tribe as a non-federal tribe that lacks access to certain resources, statutory protections, and policies aimed at helping Native American tribes deal with climate change and other environmental challenges.

Keywords: *hydroclimate, hydrology, streamflow, wetland, drought, flood, Hurricane Matthew, environmental policy, Indigenous peoples*

Anthropogenic climate change has major implications for all facets of society, but Indigenous peoples and their cultures are uniquely vulnerable to rapid and globally unprecedented climate change experienced in the 20th and 21st centuries (Houser et al. 2001; Maldonado et al. 2013). Indigenous peoples, who constitute an estimated 5% of the global population (Callison 2017), often have deep cultural connections to specific places, forged through centuries of occupation and interaction with particular landscapes and waterways (Pierotti and Wildcat 2000). Spiritual sites, archaeological resources, and natural features form a rich mosaic that is unique to each tribe and often central to Indigenous identity. Climate change poses a distinct threat to Indigenous peoples by disturbing places and disrupting processes critical to culture, history, economics, sovereignty, and other facets of Indigenous identity (e.g., Turner and Clifton 2009).

Within the United States (U.S.), Native American tribes have already experienced loss and degradation of cultural landscapes and natural resources as a result of climate change. These impacts stem from climate-related phenomena such as thawing and erosion of arctic permafrost, erosion and subsidence of coastal barrier islands, and unprecedented drought in the American West (Ford et al. 2006; Turner and Clifton 2009; Cozzetto et al. 2013; Maldonado et al. 2013). The body of research documenting climate change impacts on Indigenous peoples is growing, yet relatively little work focuses on the experiences of Indigenous peoples in the southeastern U.S. To help address this deficiency, this work focuses on climate change within the southeastern U.S. from the perspective of ecological and cultural resources of significance to the Lumbee Tribe.

The Lumbee Tribe, which has approximately 60,000 enrolled members, is centered in a predominantly rural part of North Carolina's Atlantic Coastal Plain. The tribe maintains close cultural and socioeconomic connections to specific places within the watershed of the tribe's namesake river. Particular streams and wetlands play important roles in Lumbee culture and history (Dial and Eliades 1975; Locklear 2010; Lowery 2010). Through its impacts on streams, wetlands, and other natural resources, climate change presents challenges for the Lumbee that are similar to challenges faced by many other Native American tribes. However, unlike most tribes discussed in climate change and water resources literature, the Lumbee do not have a reservation or full federal recognition as a Native American tribe by the United States government. From this perspective, the situation of the Lumbee is common to many Native American tribes currently located in the southeastern U.S., many of whom also lack full recognition by the federal government and do not have federal trust lands. Although more than 40 Native American tribes are presently recognized by their respective southeastern state governments (NCSL 2017), these tribes lack access to federal statutory protections and many of the federal resources intended to assist tribes in climate adaptation and related efforts. Thus, in addition to facing many of the same climate change and water resource challenges as other Indigenous peoples, these tribes face additional policy-based vulnerabilities stemming from their status as non-federally-recognized tribes.

This article examines climate change in the region occupied by the Lumbee Tribe, paying special attention to historical and projected changes in temperature and precipitation. The article places these changes in the context of ecological and cultural factors important to Lumbee people. In doing so, the article broadens the discussion of climate change and Indigenous peoples to include the southeastern U.S., a region where physical climate change is as complex as the social and policy factors impacting tribes' abilities to adapt to change. Before discussing climate change and its implications for the Lumbee, I provide a brief overview of water and climate in the southeastern U.S., followed by contextual information about the Lumbee Tribe.

Overview of Water and Climate in the Southeastern United States

The southeastern U.S. has long been considered a "water rich" region (Sun et al. 2005; Chen et al. 2012). From the earliest periods of human occupation through the mid-19th century, human settlements of the region were organized along major rivers and estuaries, which provided sustenance as well as transportation. Until the mid-20th century, surface water and groundwater were considered abundant and sufficient to meet the needs of growing populations and industries. The highest elevations of the southern Appalachian Mountains receive, on average, 2500 mm or more of annual precipitation (Swift et al. 1988), and this precipitation helps sustain headwater streams of major river basins throughout the region (Nippgen et al. 2016; Singh et al. 2016). The driest parts of the Piedmont and Atlantic Coastal Plain regions receive approximately half as much precipitation as the Appalachian Mountains (Dreps et al. 2014). To meet growing societal demands for water, major reservoirs were constructed along Piedmont rivers during the 20th century to capture runoff from mountains and store it for human use (Sun et al. 2008). Major droughts and water shortages have occurred within the past few centuries, but water managers and decision makers often considered these events to be anomalous.

In recent decades, however, the accelerating pace of climate change and an increasing demand for water by growing populations reveal that the southeastern U.S. is not immune to climate-related water crises. Major regional droughts during the early 21st century highlight the vulnerability of the region's water supplies, particularly in urban areas, which tend to rely on surface water reservoirs. Rapidly growing populations surrounding Atlanta, Charlotte, and other cities test the ability of surface water reservoirs to satisfy the competing needs of cities and downstream ecosystems during even minor droughts.

Groundwater, which serves as the primary water source for half of North Carolinians, is also sensitive to climatic variation (Anderson and Emanuel 2008). Little is known about long-term groundwater trends in this region, but throughout the southeastern U.S., including North Carolina's

Coastal Plain, groundwater is increasingly used as a water source for large-scale crop irrigation (Sun et al. 2008). Thus, across the southeastern U.S., surface water and groundwater management face challenges on both the supply side, in terms of climatic variability, and on the demand side, in terms of growing populations and the intensification of agricultural activity.

The perception of the southeastern U.S. as "water rich" is complicated by recent research revealing that a high level of climate variability, particularly precipitation variability, is not only typical of the region, but has increased in magnitude during recent decades. For example, long-term precipitation data from the southern Appalachian Mountains show that droughts have increased in severity and frequency over the course of several decades while rainfall distributions simultaneously became more extreme (Laseter et al. 2012; Burt et al. 2017). For the region as a whole, the increasing variability of precipitation presents a range of management and ecological challenges related to agriculture, forestry, aquatic ecosystems, and urbanization (Vose and Elliott 2016).

The widening envelope of climatic variability underscores a looming problem associated with water, climate, and society in the southeastern U.S. Specifically, population growth and associated infrastructure are dependent upon abundant water supplies arriving in a predictable fashion, yet climate change disrupts the narrative of predictability by increasing the temporal variability of precipitation required to sustain groundwater and surface water supplies. Managers and decision-makers are thus faced with mounting problems at both wet and dry extremes of climate-related events. They must ensure adequate water supplies as the duration and frequency of droughts increase, and they must deal with growing flood risks as storms intensify. The Lumbee Tribe and other Indigenous groups of the Southeast experience many of the same challenges as the region as a whole; however, because of longstanding cultural connections to specific water bodies and wetlands, Lumbee people face additional challenges related to the potential for climate change to disrupt their relationships with these important places.

Overview of the Lumbee Tribe and its Relationship with the Lumbee River

The Lumbee Tribe is centered along the Lumbee River in present-day Robeson and adjoining counties in the inland portion of North Carolina's Coastal Plain (Figure 1). The tribe shares its name with the river, a blackwater stream that flows through Robeson County and eventually drains into the Great Pee Dee River in South Carolina (Locklear 2010). County, state, and federal governments as well as many local residents refer to the river as "Lumber," a name that was created by state legislation in 1809 (Locklear 2010), but the Lumbee Tribal Council passed an ordinance in 2009 to refer to the river as "Lumbee" in accordance with certain tribal oral traditions (Lumbee Tribe 2009). This work refers to the river as "Lumbee" in adherence to the naming convention in the 2009 tribal ordinance.

The Lumbee River and its tributaries are flanked by wide, forested floodplains dominated by bald cypress (*Taxodium distichum),* tupelo (*Nyssa sp.*), and other wetland tree species. Extensive riverine wetlands of the Lumbee River and its tributaries dissect otherwise flat and sandy uplands of the Coastal Plain (Figure 1). The spatial heterogeneity imposed by alternating streams, wetlands, and sandy uplands contributes to the status of the entire region as a global hotspot for biodiversity (Noss et al. 2015). Before commercial logging, which cleared many of the floodplain wetlands, and prior to the arrival of railroads in the 19th century, this wetland-dominated landscape was perceived as inhospitable by many outsiders and provided Lumbee people with isolation from encroaching settlers (Lowery 2010).

With approximately 60,000 enrolled citizens, the Lumbee Tribe is currently the largest Native American tribe in the eastern U.S. Most tribal members live within or near the Lumbee River watershed. Ancestors of the Lumbee and other Native American tribes have occupied the watershed for at least six thousand years (Knick 2008). Disease, colonial wars, and settler encroachment (e.g., Jennings 2013; LeMaster and Wood 2013) caused major upheaval among Indigenous societies across the southeastern

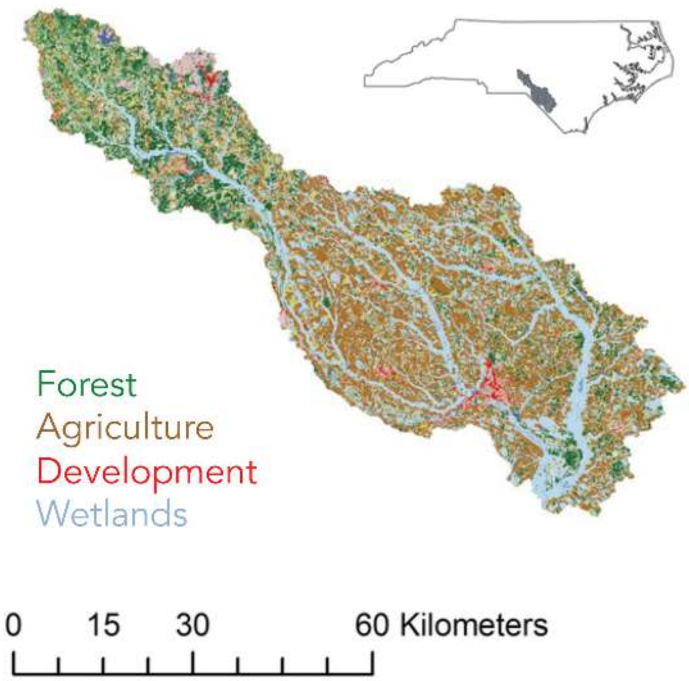

Figure 1. The Lumbee River watershed, delineated above USGS station number 02134500. Land cover shows extensive riparian wetlands and patchwork of agriculture, forests, and development in uplands. Inset shows Mountain, Piedmont, and Coastal Plain physiographic regions, along with Southern Coastal Plain climate division. Land cover data are adapted from the National Land Cover Dataset, 2011 (Homer et al. 2015). Inset shows location of watershed within North Carolina.

U.S., and these events likely spurred migration of Indigenous peoples to the Lumbee River watershed during the 18th century (Blu 2001). Migrating remnants of tribes joined Indigenous peoples already living along the river, and a unified group began to emerge as an amalgamation of these tribes beginning in the mid-18th century (Lowery 2010). The state of North Carolina recognized the group as a single Native American tribe in 1885 (Sider 2003). From the early 19th century through the mid-20th century, the emerging community faced various challenges to its survival, including disfranchisement, forced military labor, and racial segregation. These actions had mixed consequences for the tribe, but Lumbee people generally view these as strengthening forces.

The Lumbee Tribe has no treaty with the federal government, but a federal law passed in 1956 (Public Law 84-570) acknowledged Lumbee people as Native Americans. The same law simultaneously barred the Lumbee from accessing benefits and services otherwise available to fully-recognized tribes. Thus, as a political entity, the tribe lacks many of the protections that federal environmental statutes and other laws afford to fully-recognized tribal nations. These protections stem primarily from the federal government's trust responsibility toward federally recognized tribes and are often enshrined in treaties between tribes and the federal government. For example, many treaties allow tribes to retain access to specific places, including rivers, coastal zones, or landforms, for hunting, fishing, or other purposes (Goodman 2000; Mulier 2006). Although treaties are binding on both tribes and the federal government, tribes often find themselves the sole defenders of treaty rights, "re-reminding" government agencies of their responsibilities through legal actions or activism (Norman 2017).

Federal executive orders and laws such as the National Historic Preservation Act (NHPA, Public Law 89-665) require federal agencies to consult formally with tribes during actions that may affect a tribe's present-day or ancestral territories

(NEJAC 2000; ACHP 2017). Ideally, consultation allows federal agencies to understand how regulated projects could adversely affect tribes and their resources (Routel and Holth 2013). Consultation potentially serves as a powerful tool to protect tribal interests, but its record in practice is mixed, due to inconsistent or incomplete implementation among agencies (Routel and Holth 2013). Recent controversies surrounding the Dakota Access Pipeline and other infrastructure projects affecting tribal territories also highlight the perils associated with incomplete or insincere consultation (Emanuel 2017; Norman 2017; Whyte 2017). Notwithstanding problems with the observance of treaty rights or implementation of consultation, these tools offer some degree of protection to federally recognized tribes seeking to protect their landscapes and waterways.

The Lumbee Tribe's lack of full federal recognition means that agencies have no statutory requirement to engage formally with the tribal government when making decisions about regulated projects that potentially impact landscapes and waterways of importance to Lumbee people. This is true whether project impacts are cultural, environmental, or both. Lumbee people may, of course, petition the government individually as citizens, landowners, or other stakeholders. As a tribe, however, Lumbee people currently lack a collective voice as an Indigenous group in federal decision-making, including decisions concerning their land and water resources.

Although the Lumbee Tribe does not have a reservation or land in trust with the federal government, the tribal government and individual tribal members collectively represent a large block of present-day landowners within the Lumbee River watershed. The tribal government owns and manages more than 200 hectares (ha) of land on behalf of the tribe, most of which lies adjacent to the Lumbee River. Thousands of individual tribal members are private landowners within the Lumbee River watershed, and many of them identify strongly with particular communities situated near specific tributaries and their adjacent wetlands. These communities are known colloquially as swamps, and they are important markers of identity within the Lumbee Tribe. Tribal members continue to practice and pass down local knowledge concerning flora and fauna of these swamps, including knowledge about hunting and fishing, foraging, plants with medicinal and religious significance, and materials used for basket-making, pottery, and other practices (e.g., Boughman and Oxendine 2003). Other elements of Lumbee culture, including music traditions and concepts of "home," emerged in the communities associated with the Lumbee River's tributary swamps (Maynor 2002; Maynor 2005). Moreover, the Lumbee River itself serves as a powerful cultural and spiritual symbol and a unifying institution for Lumbee people (Dial and Eliades 1975; Locklear 2010). The river, its wetlands, and their flora and fauna frequently appear in Lumbee cultural imagery. One prominent example is found in Lumbee artwork and crafts (e.g., patchwork quilts, dance regalia, jewelry), which often symbolize the radiating base of a longleaf pine (*Pinus palustris*) cone.

Historically, Lumbee people farmed corn, tobacco, and other crops on small, upland homesteads (Dial and Eliades 1975). Adjacent streams and wetlands supplemented farming with food and other resources. However, pressures from growing regional populations, civil infrastructure (e.g., highways), and the intensification and industrialization of agriculture, have strained these historical and cultural connections in the 20th and 21st centuries. Nevertheless, Lumbee people continue to identify strongly with the river and with its tributary swamps. Because of the close connection between Lumbee people and the river, some aspects of Lumbee culture are especially vulnerable to the impacts of climate change on water resources. To understand how climate change potentially affects the tribe, it is first necessary to understand historical climate trends in and around the Lumbee River watershed. It is also necessary to examine projections of future climate conditions for the region.

Historical and Projected Climate Change in the Lumbee River Watershed

The Lumbee River watershed is situated in North Carolina's Southern Coastal Plain climate division. Mean annual air temperature (MAT) for the climate division is 16.6°C, and mean annual precipitation (MAP) is 1276 mm according to spatially aggregated climate station observations made during the 119-year period, 1895–2013. These data are provided online by North Carolina's State Climate Office (SCO 2017). The Southern Coastal Plain's climate is temperate and seasonal; mean air temperatures are lowest in January (7°C) and highest in July (26°C). Precipitation exhibits slight seasonality, with more precipitation in July on average (170 mm) than in any other month (Figure 2). There are no simple, multi-year trends in annual air temperature or annual precipitation based on several decades of historical data for North Carolina's Southern Coastal Plain climate division (SCO 2017).

One important characteristic of the region's climate is that summer precipitation and summer air temperature have covaried for most of the past century, with warm conditions typically accompanied by dry weather, and cool conditions coinciding with wet weather. In particular, mean August temperature and total August precipitation were inversely correlated for 30-year time periods defined by a moving window beginning in the 1890s and ending in the early 2000s (Figure 3). The correlation peaked between about 1920 and 1950. Since the mid-20th century, however, the strength of this correlation has deteriorated, and there has been no significant correlation for a 30-year window since the 1977-2007 period.

One interpretation for the deteriorating relationship between multi-year August temperature and precipitation is that the North Atlantic Subtropical High (a.k.a. Bermuda High) has trended westward since the mid-20th century, increasing the likelihood that summer conditions in the region will be influenced by warm, moist air from the Gulf of Mexico (Li et al. 2012). However, warm and dry continental conditions may dominate during years in which the Bermuda High lies farther east (Li et al. 2013). The increasing likelihood of warm and wet summer conditions in the Coastal Plain through a westward trend of the Bermuda High may explain the breakdown in correlation between summer temperature and precipitation observed through much of the 20th century. As summer precipitation becomes decoupled from temperature, the seasonality of rainfall becomes less predictable, exacerbating ecological and management issues associated with both surface water and groundwater availability.

Long-term surface water records include a United States Geological Survey (USGS) stream gage (Site Number 02134500, drainage area 3176 km^2) on the Lumbee River, which has been in continuous operation since 1929 (Figure 4). Annual runoff for the Lumbee River watershed averages approximately 360 mm per year, which is approximately 28% of mean annual precipitation. Streamflow responds to storms distributed throughout the year, whereas baseflow exhibits strong seasonality, with high baseflow typically occurring during winter and low baseflow occurring during summer. Annual minimum flows typically occur during late summer and early fall, when long, dry spells are common. Annual maximum flows usually occur during winter or spring, except in years when tropical storms bring heavy, intense rainfall during summer or fall. On average, tropical storms make landfall along North Carolina's southern coast once every two to four years (Keim et al. 2007), and in these years both annual maximum and annual minimum flows may occur within a matter of weeks.

A recent study of nearly 1000 long-term, USGS stream gages by Rice et al. (2015) found no significant trends in mean annual streamflow amount or intra-annual variance for the Lumbee River between the 1940s and 2000s. The study did, however, identify a weak, non-significant decline (<1 mm/yr) in mean annual streamflow during the same period (Rice et al. 2015). A more detailed look at streamflow records from the USGS stream gage shows that certain low flow percentiles have experienced significant changes through time between 1929 and present. In particular, the 5th and 10th lowest flow percentiles have declined significantly during 40-year time periods defined by a moving window between 1929 and 2016 (Figure 5). These two flow quantiles have fallen at rates of approximately 0.4 m^3s^{-1} and 0.5 m^3s^{-1} per decade, respectively.

The Coupled Model Intercomparison Project Phase 5 (CMIP5, Meinshausen et al. 2011) provides global projections of temperature, precipitation, and other variables through the year

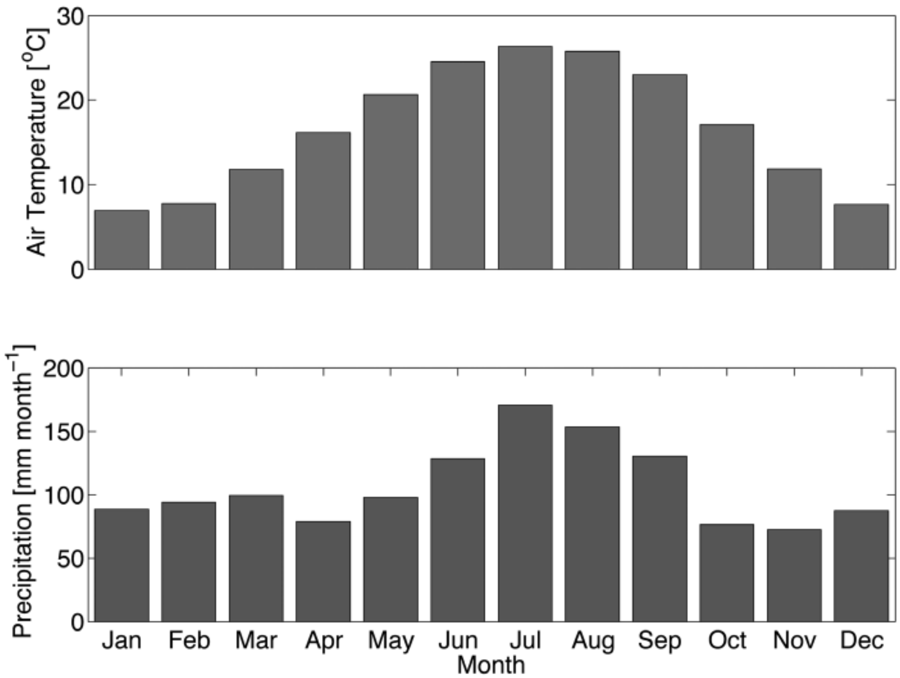

Figure 2. Historical (1895-2013) climate of North Carolina's Southern Coastal Plain (SCO 2017), including mean air temperature (top) and cumulative precipitation (bottom) for each month.

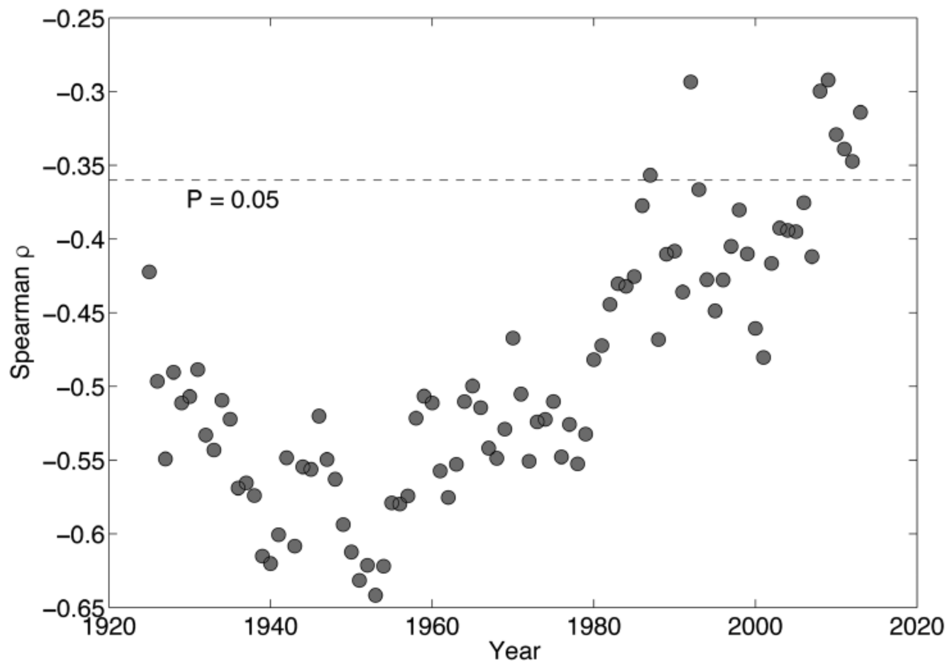

Figure 3. Spearman's rank correlation coefficient between mean August temperature and total August precipitation. Circles indicate the last year of a 30-year period. Values below the dashed line have significant correlations ($P < 0.05$), and values above the dashed line have non-significant correlations ($P \geq 0.05$).

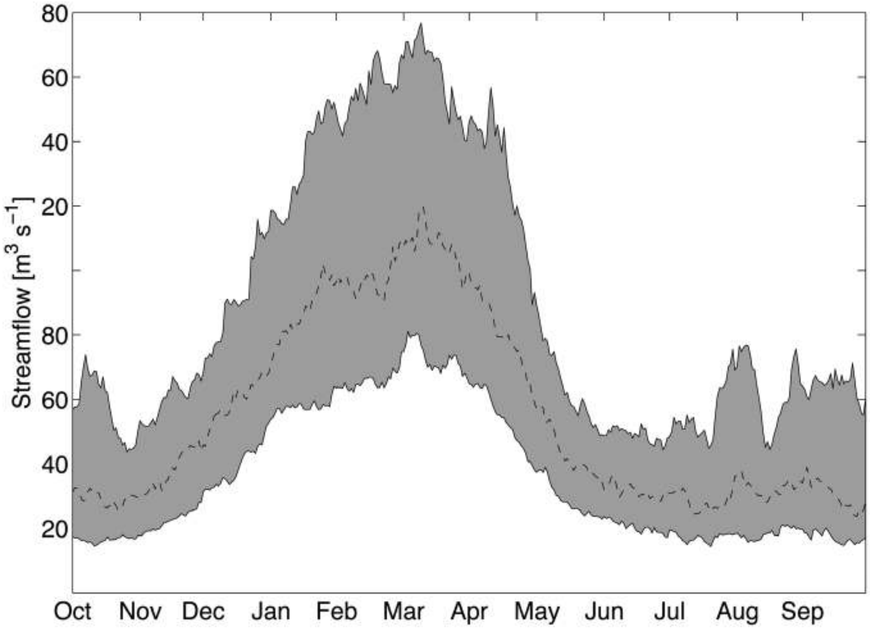

Figure 4. Streamflow on the Lumbee River (USGS station number 02134500). Gray shading shows the interquartile (25th – 75th percentile) range for daily streamflow during the 87-year period of record, October 1, 1929 – September 30, 2016. Dashed line shows median daily streamflow for the same period.

2100. These models are spatially coarse, but the Multivariate Adaptive Statistical Analog (MACA) downscaling method described by Abatzoglou and Brown (2012) and accessed at https://climate.northwestknowledge.net/MACA/ provide detailed, regional projections that can be used to assess climate change for basins of similar size to the Lumbee River watershed. Under a "business-as-usual" emissions scenario (RCP8.5), downscaled MACA results from four CMIP5 models (CSIRO, GEM2-CC, GEM2-ES, and MIROC) reveal that North Carolina's Southern Coastal Plain, which includes the Lumbee River watershed, is likely to experience a significant increase in air temperature by the mid-21st century compared to the 1990s. An ensemble mean of the downscaled model projections shows that mean annual temperature will likely increase from 16.8°C during the 1990s to 19.6°C by 2050, an increase of 2.8°C. Although temperatures are projected to increase during each month of the year, the increases are greater during the growing season (May – September) than during the winter (Figure 6). July temperatures are expected to increase the most under RCP8.5 projections, rising approximately 3.5°C between the 1990s and 2050. Under this scenario, a typical mid-21st century July in North Carolina's Southern Coastal Plain could resemble the present-day climate of the Gulf Coastal Plains surrounding Houston, Texas, a region located approximately 500 km away and five degrees of latitude southward.

The projected temperature increase during the growing season is noteworthy from the perspective of the Lumbee River's hydrologic balance. Consumptive demands for soil water by vegetation are high at the peak of the growing season. Higher growing season temperatures have the potential to increase vegetation productivity (Sage and Kubien 2007) and also to increase evapotranspiration (Emanuel et al. 2007a), but only as long as sufficient soil water is available to satisfy vegetation demand (Emanuel et al. 2007b). With much of the watershed's forested vegetation occupying low-lying floodplains (Figure 1), increased temperature during the growing season is likely to cause greater amounts of precipitation to be partitioned to evapotranspiration, rather than to streamflow or to groundwater recharge.

Although models generally agree on projected temperature increases for the region surrounding the Lumbee River watershed under the RCP8.5

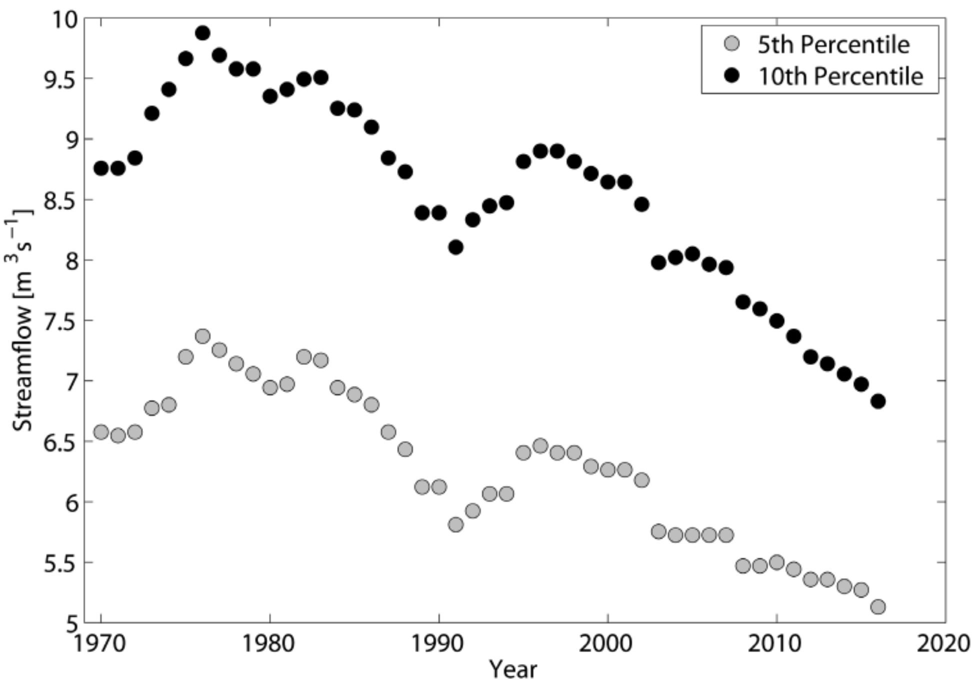

Figure 5. Fifth (gray) and tenth (black) lowest streamflow percentiles for the Lumbee River (USGS station number 02134500) show significant declines through time. Both trends are significant, with the 5th percentile trend having Kendall's τ = -0.74 ($P < 0.001$) and the 10th percentile trend having Kendall's τ = -0.72 ($P < 0.001$). Circle location indicates the last year of a 40-year period.

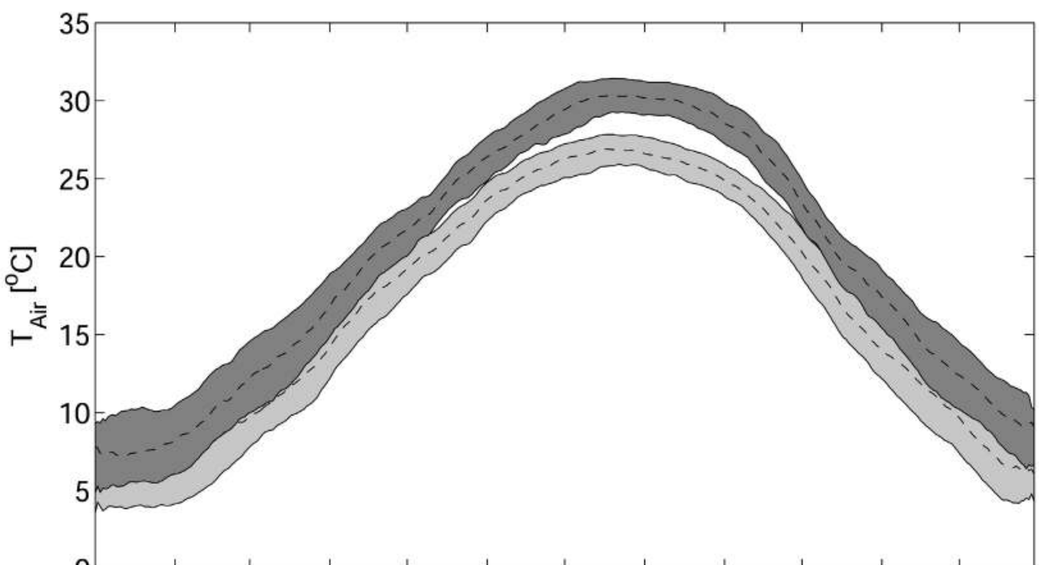

Figure 6. Historical (light gray) and projected (dark gray) air temperatures for the Southern Coastal Plain of North Carolina, which includes the Lumbee River watershed. Model results were downscaled for North Carolina following Abatzoglou and Brown (2012). Shaded regions within solid lines show the envelope of CMIP5 RCP8.5 results for four models listed in text. Dashed line shows ensemble mean.

scenario, precipitation projections are less certain in terms of magnitude and direction of change. This is due, in part, to the high degree of interannual variability in regional precipitation. Given existing trends of increasing precipitation variability in the region (Laseter et al. 2012; Vose and Elliott 2016; Burt et al. 2017) and the complex interplay between temperature and precipitation in a changing climate (Trenberth 2011), process-based models or other numerical tools are required to forecast how projected climate change is likely to impact the streamflow and recharge in the Lumbee River watershed.

Implications of Climate Change for the Lumbee Tribe

The Lumbee Tribe has strong historical, cultural, and socioeconomic ties to the Lumbee River, and climate change has the potential to modify hydrological and ecological conditions along the river, across its connected wetlands, and within its watershed in ways that have serious implications for the tribe. Perhaps most importantly, rising temperatures can expose wetlands to heat and water stress (Erwin 2009). Model simulations from nearby watersheds in South Carolina show that water table elevations and streamflow decrease with rising temperatures (Dai et al. 2010). If rising temperatures combine with longer periods of time between storms, as observed elsewhere in the southeastern United States (Laseter et al. 2012; Burt et al. 2017), wetland ecosystems of the Lumbee River watershed could experience drought-related vegetation damage or die-off. Rising air temperatures coupled with decreased canopy cover could result in elevated water temperatures and concomitant dissolved oxygen declines in streams.

The increasing severity of storms observed elsewhere in the region (Laseter et al. 2012; Burt et al. 2017) compounds potential drought-related problems by increasing the probability that the same wetland and aquatic ecosystems will also be impacted by floods. Shifts in erosion and sediment transport associated with climate change are poorly understood in the southeastern U.S. outside of coastal environments (e.g., Michener et al. 1997); however, there is a possibility that an increase in the severity or frequency of tropical storms and hurricanes could influence sediment transport processes along the Lumbee River. For example, I observed massive sediment deposits left by the Lumbee River following record flooding after Hurricane Matthew in 2016 (Figure 7a-b). On the whole, the region's aquatic and wetland ecosystems are susceptible to degradation due to sediment transport and other issues associated with both extreme flooding and increased streamflow variability (Meitzen 2016).

Increasing variability of precipitation also has implications for industrialized agriculture, which has become more prominent in the North Carolina Coastal Plain in recent decades (Yang et al. 2016). In particular, swine operations often dispose of partially treated wastewater by applying it to unsaturated soils. Increasing variability of precipitation and soil water content can mean less predictability for waste disposal schedules through land application. Intense storms and hurricanes can also cause breaches or unintentional releases of nutrients and pathogens from waste lagoons (Wing et al. 2002). As storm frequencies and intensities change in the future, so will risks associated with accidental releases of these waste products.

Climate-related degradation of wetlands and streams within the Lumbee River watershed can impact the Lumbee Tribe in multiple ways. Individual tribal members who hunt, fish, and forage along the main stem of the river or in its tributary swamps are participating in cultural practices that have persisted for centuries among the Lumbee and their ancestors (Dial and Eliades 1975). Likewise, some Lumbee people continue to practice centuries-old spiritual traditions of baptizing and worshipping at specific locations on the Lumbee River. These locations, along with nearby Lumbee churches, cemeteries, and family home-places, intertwine with streams and wetlands to form a distinct cultural landscape. Given the prominent role of water in this cultural landscape, climate change has the potential to alter the character of this landscape in unpredictable ways if wetlands degrade or transition to other ecosystems, or if floods alter stream channels or damage infrastructure (e.g., Figure 7c).

In recent decades, tribal members have established efforts to renew traditional crafts,

Figure 7. Photos of Robeson County, NC in the months following Hurricane Matthew reveal the extent of sediment transport and deposition by the Lumbee River and damage to local infrastructure by flooding. Sand deposits remained along streets and yards in low-lying parts of Lumberton, Robeson County's largest town, several weeks after the storm (a, b). Flooding destroyed bridges and culverts throughout the Lumbee River watershed, closing some local roads for months after the storm (c).

ceremonies, and other practices that rely on access to and resources obtained from the Lumbee River and its adjacent wetlands. If the ecosystems and landscapes that support these activities are degraded or destroyed as a result of climate change, it will become increasingly difficult for Lumbee people to pursue these particular facets of identity or to renew other cultural practices. Some of these renewal efforts began during the past several years, ironically, during the same period in which downscaled climate forecasts (e.g., Abatzoglou and Brown 2012) began to highlight the regional vulnerabilities of streams and wetlands to climate change. Important components of Lumbee identity and culture are inextricably connected to these vulnerable streams and wetlands, and climate change may therefore have lasting cultural impacts on future generations of Lumbee people.

On the other hand, both recent cultural renewal efforts and longstanding Lumbee traditions may heighten awareness of environmental degradation and spur stronger actions by the tribe to prepare for and adapt to expected climate change. Actions might include adaptation plans and partnership networks that help ensure the tribe's ability to thrive, culturally, in a changing climate, a concept that Whyte (2013) refers to as "collective continuance."

Lumbee people face many challenges to collective continuance as an Indigenous group. Some of these challenges stem from centuries of sustained colonialism and are shared by

Indigenous peoples worldwide. Other challenges relate to the tribe's lack of access to specialized training, programs, and resources reserved for federally-recognized tribes. Nevertheless, by realizing collective continuance (i.e., by putting culturally relevant strategies into practice), the Lumbee Tribe has the potential to meet the challenges of climate change head-on. The tribal government, organized under a constitution that emphasizes "educational, cultural, social, and economic well-being of Lumbee people" (Lumbee Tribe 2000), has shown potential to work within existing constraints to address community needs from a culturally relevant perspective. Some tribal initiatives, including energy assistance and hurricane recovery, have clear connections to climate change and leverage resources that do not depend on the tribe's federal recognition status. In these and other ways, the tribe is already beginning to meet some of the challenges of climate change.

Conclusion

The Lumbee River and its adjacent wetlands are important components of identity and culture to the Lumbee Tribe. Climate change is expected to impact the Lumbee River watershed by increasing air temperatures and potentially altering the temporal variability of precipitation. Changes in atmospheric conditions are already evident over the past several decades, as are changes in streamflow on the Lumbee River itself. Hydrologic change, particularly declining low flows and potentially more variable flows, has the potential to degrade wetland and aquatic ecosystems. Environmental degradation poses risks to the Lumbee Tribe, including cultural loss resulting from deteriorating wetland and stream conditions. However, cultural resurgence, occurring simultaneously with climate change, offers opportunities for Lumbee people to recognize these risks and prepare for changes in culturally relevant ways.

Relatively little research on Indigenous peoples and climate change has focused on Native American tribes living in the Atlantic Coastal Plain. The case of the Lumbee Tribe adds geographic breadth to discussions of Indigenous peoples and climate change, and it also highlights the uniquely vulnerable position of Native American tribes who have deep cultural connections to specific water-dependent landscapes of the southeastern U.S. Many of these tribes lack resources and statutory protections useful for adapting to and preparing for climate change, but opportunities remain for these tribes to meet climate-related challenges in culturally appropriate ways.

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Author Bio and Contact Information

Ryan E. Emanuel, Ph.D. is an associate professor and University Faculty Scholar at North Carolina State University. He is an environmental scientist with expertise in hydrology and ecosystem ecology. Topical interests include ecohydrology, micrometeorology, remote sensing, and geospatial analysis. An enrolled member of the Lumbee Tribe of North Carolina, Emanuel also focuses on environmental science and policy issues relevant to Indigenous peoples in the United States. He may be contacted at ryan_emanuel@ncsu.edu or Campus Box 8008, Raleigh, NC 27695.

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