

**EXAMINING NORTH CAROLINA'S COMPENSATORY WETLAND
MITIGATION PROGRAM FROM THE PERSPECTIVES OF LAND USE
PLANNING AND SOCIAL EQUITY**

by

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ABSTRACT

North Carolina's Ecosystem Enhancement Program (EEP) is responsible for providing the majority of compensatory stream and wetland mitigation sites throughout the state, including all off-site mitigation for the N.C. Department of Transportation. Two emerging criteria by which to assess the effectiveness of mitigation efforts include whether the mitigation process promotes social equity, and whether stream and wetland mitigation planning is coordinated with other types of land use planning. The first part of this study assesses the socioeconomic makeup of census tracts around impact sites in comparison to mitigation sites using two-tailed paired t-tests. The second part of the study maps the location of the EEP's accumulated advance mitigation sites in comparison to urban growth indicators by watershed around the state. The study finds that systematic socioeconomic disparities exist between communities that lose and gain streams and wetlands through the compensatory mitigation process. Streams and wetlands are systematically relocated from more advantaged to less advantaged communities. Communities near impact sites, as compared to those around mitigation sites, have higher total populations and population densities, higher percentages of whites and lower percentages of blacks and Hispanics, higher levels of education, lower poverty rates, higher median incomes, and higher median homes values. This finding warrants further consideration in both research and also state-level environmental policy. Additionally, growth indicators such as population growth rates and population growth projections do not significantly correlate with the amount of advance mitigation acquired by the EEP by watershed, implying that growth indicators are not effectively incorporated in the mitigation process. Thus, the EEP, the NC DOT and the Army Corps of Engineers have an opportunity to improve the efficiency of mitigation by more proactively and formally incorporating growth indicators and projections into the mitigation planning process.

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INTRODUCTION

In the past few years, North Carolina's Ecosystem Enhancement Program (EEP) has been hailed as a cost-effective and innovative statewide approach for preserving and restoring stream and wetland ecosystems (D'Ignacio, 2005; Gilmore, 2005; EEP, 2009). Its approach to coordinating compensatory mitigation is unique in that the government agency is responsible for providing the majority of mitigation sites throughout the state, including all off-site stream and wetland mitigation for the Department of Transportation (NC DOT). The recipient of numerous "innovative government" awards, EEP has even been suggested as a model for other regions (D'Ignacio, 2005; EEP, 2009). While the program has been analyzed from the standpoints of bureaucratic and cost efficiency (Engler, 2005; DYE, 2007) and watershed health (BenDor et al, 2009), comprehensive studies of the EEP from the perspective of social equity and in relationship to urban growth across the state have, until now, been lacking.

Since the passage of the Clean Water Act in 1972, which mandated mitigation for impacts to wetlands, the key criterion for wetland mitigation policies across the country has been to achieve the underlying goal of "no net loss" of streams and wetlands (National Academy of Science, 2001; Gutrich, 2004). While theoretically no net loss implies no loss of ecosystem function, in practice it has often been applied in terms of acreage and been measured by a simple ratio of acres of mitigation to acres of impact. Much of the literature on wetland mitigation examines whether no net loss is achieved from an ecological standpoint. For example, BenDor and Brozovic (2007) found that in the Chicago region, counties which had adopted regulations based on municipal boundaries were more likely to see shifts in wetlands from one watershed to another; while these counties maintained total wetland acreage, the mitigation process may have created net change in ecosystem functionality. In North Carolina, BenDor et.al. (2009) found that while most wetland impacts are mitigated within the same 8-digit HUC watershed (as required by state legislation), a significant amount of cross-watershed relocation of wetlands does occur.

While numerous studies focus on the no net loss criterion as a measure of mitigation success, fewer look at relationships between wetlands and human communities. Those that do generally consider issues such as how to determine the economic and social value of wetlands (e.g. Reynolds and Regaldo, 2002; Manuel, 2003; Boyer and Polasky, 2004). Recently, social equity has emerged in the literature as another criterion by which to assess mitigation efforts. The small body of literature growing around the topic of

wetland mitigation and social equity has found that, when considering a smaller geographic scale such as census tract or zip code, there are notable socioeconomic disparities between populations in areas of wetland loss and those in areas of wetland mitigation offset sites (Ruhl and Salzman, 2006; BenDor et al., 2007; BenDor et al. 2008). However, this criterion has played no factor in wetland regulations to date and has not been previously studied in the North Carolina context.

Additionally, there is growing awareness from regulators and practitioners about the importance of linking wetland preservation efforts to the broader context of land use planning and urban growth. This is evident, for example, in North Carolina's Targetted Local Watershed planning program, in which local water resource planners consider growth projections as part of the process to identify priority areas for stream and wetland restoration and preservation (EEP, 2007). However, the extent to which mitigation activities and urban growth are coordinated in practice has not been widely explored in either the planning or ecology literature. Given that larger amounts of wetland impacts would be expected in more rapidly urbanizing areas, it would make sense for the EEP to link their mitigation acquisition programs with such land use considerations. In North Carolina, the water resource planning procedures that influence the selection of EEP mitigation sites do take urbanization and land use projections into account through the EEP's Local Watershed Planning Process (New Hanover County, 2002; EEP, 2009). However, no studies have considered the extent to which the EEP process for mitigation acquisition relates to levels of urban growth across the state.

Given the set of issues described above, this paper seeks to answer two questions regarding North Carolina's statewide compensatory mitigation program. First, are there any socioeconomic disparities between the populations surrounding impact sites and those surrounding mitigation sites? Second, do watersheds in which the EEP has acquired advance mitigation sites spatially correspond with areas of high needs (i.e. areas with high levels of urban growth and thus more wetland impacts from development)? The first question is addressed in this study by an examination of state-level spatial data on the location of historic impact and mitigation sites in relation to socioeconomic indicators from the US census developed by BenDor et al. (2009). The second is addressed by looking at statewide data on advance mitigation acquisition by the EEP in relation to growth indicators across the state developed by DYE (2007). The results of the investigation have implications for wetland mitigation policy in North Carolina, and contribute to academic and applied discussions on both links between land use planning, transportation planning and natural resource planning, as well as emerging discussions on links between social equity and wetland mitigation.

BACKGROUND

Wetland Ecosystem Services and US Wetland Regulations

The ecosystem functions of wetlands may include processes like hydrologic flux and storage, biological productivity, biogeochemical cycling and storage, decomposition, wildlife habitat and others (e.g. Richardson, 1994 as cited in Engler, 2005). From these functions, society receives services such as flood control, water purification, recreation opportunities, open space and biological diversity (Manuel, 2003; Ewel, 1997). These ecosystem services provide value to society, which, in recent years, an increasing number of market-oriented initiatives around the globe have attempted to capture economically (Salzman, 2005). Several aspects of ecosystem services justify and necessitate government intervention to help define markets; for example, the often non-exclusive nature of the benefits of ecosystem services leads to large “free rider” potential, and without clearly defined buyers and sellers, transaction costs can be high (Salzman, 2005).

In the U.S., markets for wetland ecosystem services have largely been shaped by federal environmental policy. To protect and allow for continued human access to such services, wetlands in the US have been regulated by the federal government since passage of the Clean Water Act (CWA) in 1972. The CWA provides for the use of regulatory and non-regulatory tools to restore and maintain “the chemical, physical and biological integrity of the nation’s waters” (33 USC 1251). Some of the key tools dealing with wetlands are provided in Sections 401 and 404, which establish requirements and procedures for a permitting system regulating dredge and fill of wetlands and other US waters.

Under Section 404, developers applying for a permit must follow a multi-step process regarding wetland impacts. First, avoid impacts if possible. If not possible, then loss or damage of wetlands must be minimized (often achievable through site design). Finally, any unavoidable loss of wetland function or acreage must be compensated through restoration, creation, enhancement or (in exceptional cases) preservation of wetlands. This compensatory mitigation process requires a minimum 1:1 ratio of mitigation to loss, often applied in terms of acreage, under the driving policy of no net loss (US EPA, no date). Numerous difficulties arise in the quest for no net loss, such as how to measure the precise values of services provided by two similar ecosystems each in a different geographic context (Salzman, 2005). To approach the no net loss ideal, mitigation ratios have been developed in which certain types

of mitigation require a more than one-to-one ratio of acreage in order for the mitigation to receive an appropriate number of mitigation credits (DYE, 2007).

Approaches to Wetland Mitigation

Approaches to compensatory wetland mitigation vary, and multiple types of compensation may occur within a given region. BenDor et. al. (2007) identify three types of approaches for wetland mitigation. In onsite or offsite “permittee-responsible mitigation,” the permit applicant (i.e. developer) directly carries out mitigation. Alternatively, developers can pay a third party through mitigation banking (the purchase of credits by developers from a bank of “pre-impact” restoration sites) or in-lieu-fee (ILF) programs (payment into a government or not-for-profit pool of funds for future restoration activities). Initially under CWA Section 404 legislation, the EPA and the Corps preferred on-site mitigation, but over time off-site mitigation has become more accepted. This change has led to an increase in the creation and sale of wetland mitigation credits throughout the US by private, third-party mitigation bankers and to the rise of an ecosystem services market around wetlands in the U.S. (Salzman, 2005).

Ecosystem Enhancement Program History and Operations

In North Carolina, compensatory wetland mitigation is coordinated by a government agency called the Environmental Enhancement Program (EEP). The EEP’s three primary goals are to identify high-quality, cost-effective projects for watershed improvement and protection; to provide compensation for unavoidable environmental impacts from transportation-infrastructure and economic development; and to carry out detailed watershed-planning and project-implementation efforts in North Carolina's threatened or degraded watersheds (EEP, 2009). The four components of the EEP’s mitigation program include the stream and wetland ILF which provides mitigation for all CWA Section 404, 401, and N.C. Coastal Area Management Act permits excluding the NC DOT; the stream and wetland ILF for the NC DOT, which receives advance funding by and exclusively provides off-site mitigation specifically for the NC DOT; the Riparian Buffer ILF; and the Nutrient Offset ILF which provides nutrient reduction projects primarily for activities related to development in the Neuse and Tar-Pamlico River Basins (DYE, 2007).

The EEP was created by a Memorandum of Agreement (MOA) between the NC Department of Natural Resources (DENR), the US Army Corps of Engineers (Army Corps) and the NC Department of Transportation (NC DOT) in 2003. It replaced the former Wetlands Restoration Program (WRP) in order

to streamline mitigation needs of the NC DOT. When created, the EEP was structured to combine provision of advance-mitigation for the NC DOT's projects (the largest individual source of stream and wetland impacts in the state; BenDor et al, 2009) with the ILF program formerly run by the WRP for non-DOT mitigation needs (DYE Management Group, 2007; EEP 2009). Prior to establishment of the EEP, the NC DOT sought approval from the Corps for each individual project, which increased project costs and time. Given the high levels of population growth throughout the state by the late 1990s, a key tenet of the EEP was to reduce the NC DOT's project costs and lag time by providing "cumulative mitigation for cumulative impacts" in a given watershed, rather than mitigate for individual projects (D'Ignacio et. al, 2005).

In order to determine where the majority of advance mitigation credits should be acquired, the EEP largely relies on annual forecasts of future impacts from the NC DOT (EEP, 2008), and also considers other permitted development (EEP, 2009) as further discussed below. The number of credits provided by a given mitigation project is estimated through a dynamic feedback process between the EEP project manager, project supervisor, and if necessary an alternative mitigation review team. Credits are estimated in acres for wetlands and feet for streams, and are based on an in-house assessment, a project feasibility study, and the restoration plan. The final credits for a given mitigation project are recorded after that project is successfully completed (EEP, 2008).

Since its creation in 2003, the EEP has become the primary provider of mitigation credits for both public and private entities across the state, including the NC DOT, other public agencies, and private developers (BenDor et. al, 2009). Recently, however, North Carolina has taken steps to foster the private market for wetland mitigation banking in the state with the passage of a General Assembly Bill in August, 2008. The bill seeks to limit the ability of any Section 404 Permit Applicant other than the NC DOT to utilize the EEP for compensatory mitigation. Instead, applicants other than the NC DOT are encouraged to participate in a private wetland mitigation bank, and may only pay a fee to the EEP if the permit is for a project in an 8-digit HUC watershed where no approved private mitigation bank is operational (North Carolina General Assembly, 2008). Such legislation indicates ongoing interest on the part of mitigators and policy-makers to continually assess and improve the efficiency and cost-effectiveness of stream and wetland mitigation programs in North Carolina.

Links between Urban Growth and EEP Wetland Mitigation Planning

The EEP seeks to implement mitigation in concert with a “detailed watershed-planning process” that links the mitigation process with overall plans for watershed improvement, protection, and open space protection (EEP, 2009). Through its collaboration with the NC DOT and with water resource planners working at the local-watershed and basin-wide scales, there are opportunities for land use and urbanization issues to be taken into account in the mitigation site selection process, to the extent that local watersheds with higher growth forecasts are considered priority locations for mitigation sites. However, the EEP policies and procedures that guide mitigation at the state level do not specifically mention incorporation of land use change, urban growth patterns or population projections in the process by which mitigation sites are selected by the agency, instead emphasizing the role of the NC DOT’s forecasts in determining mitigation needs (EEP, 2008). Thus while land use forecasts play a role in the selection of mitigation sites within each 8-digit watershed, these projections do not necessarily affect the number of predicted credits needed for any given watershed (further discussed below).

The NC DOT’s annual mitigation demand forecasts, which drive advanced mitigation planning, are based on the DOT’s Transportation Improvement Program (TIP) (DYE, 2007), which is the NC DOT’s regularly-updated plan for transportation projects throughout the state. The State TIP (STIP) includes a schedule and funding information for the state’s transportation projects including highways, aviation, enhancements, public transportation, rail, bicycle and pedestrians, and the Governor’s Highway Safety Program (NC DOT, 2008). Metropolitan Planning Organizations (MPOs) throughout the state also develop MTIPs for regional projects (NC DOT, 2008). The EEP uses the forecasts to determine the types, locations and amount of mitigation needed. Depending on the needs, the EEP may satisfy requirements through its own inventory, or by procuring additional units of mitigation through means including asset transfer from the NC DOT; purchase of suitable mitigation from either private mitigation banks, private land owners with High Quality Preservation, or Clean Water Management Trust Fund project grantees; or developing new mitigation (DYE, 2007).

Although the NC DOT is making noted improvements in determining future demand, their projections about upcoming transportation projects, and thus future mitigation needs, have “a certain amount of volatility” according to DYE (2007). The priority and sequencing of projects may vary based on a number of factors such as funding constraints, changes in policy-maker priorities, and unanticipated delays. Thus, there is some lack of predictability in the NC DOT’s demand forecasts, which leads to uncertainty in EEP’s mitigation process (DYE, 2007). Additionally, as the NC DOT learns from experience, the processes by which it prioritizes projects are refined. For example, in the first half of the current decade,

project selection was dominated by a legislative priority to deliver on unfinished portions of the Intrastate Highways and Urban Loops program, as well as focus on other major expansion projects; however, the 2004 Long-Range Transportation Plan noted that future project selection should focus on meeting “certain technical and needs-based criteria” (NCDOT, 2004). Noted improvements in the precision of NC DOT mitigation demand forecasting is attributed to growing levels of experience by NC DOT staff, as well as increasing awareness about the cost impacts of incorrect estimates (DYE, 2007).

Given the large role that the NC DOT forecasting plays in the EEP site selection process, one aspect that needs to be considered in understanding the links between mitigation site selection and urban growth/land use planning is the extent to which such issues factor in to the NC DOT planning process. The NC DOT outlines the long-range transportation investment strategy for North Carolina in its Statewide Transportation Plan. North Carolina’s first statewide transportation plan was developed in 1995 and an updated version of the 25-year plan was published in 2004 and is revised approximately every four years. The plan provides estimates of infrastructure needs including predictions for maintenance, modernization and expansion. The NC DOT implements the long-range plan in part through the TIP program, a seven-year blueprint for new transportation projects (NC DOT, 2004).

The NC DOT long-range transportation plan consists of a three-tiered approach to managing infrastructure, including statewide, regional and sub-regional levels. The statewide Strategic Highway Corridors program is a major component of all TIP projects, because while these roadways account for about 7% of all road miles in the state, they carry about 45% of statewide traffic (NC DOT Transformation Management Team, 2007). Priorities in determining strategic corridors include connectivity between major activity centers and interstate highways, providing relief for interstates, hurricane evacuation routes, and whether the route is part of other organized highway systems (NC DOT, 2004). Highway preservation, modernization and expansion comprise about 93% of the NC DOT budget (NC DOT, 2004), and the NC DOT manages more public highway miles than any other state except Texas (NC DOT Transformation Management Team, 2007).

Considering that the emphasis of the statewide NC DOT program is on highway projects and the priorities for Strategic Highway Corridor planning have little to do with urban growth and land use concerns, it seems unlikely that urbanization and growth are directly represented in the NC DOT’s forecasts to the EEP. Concerns about a general disconnect between transportation and land use planning by federal and state sources further support this suggestion. For example, a 2001 Federal

Highway Administration (FHA) report notes that transportation and land-use planning processes are often not integrated in the U.S., in spite of the influences of development on transportation demand and of transportation facilities on development location. This is generally a result of the different scales of decision-making, with transportation project plans made at a regional scale while land-use planning occurs locally (FHA, 2001). The relevance of this issue to the North Carolina context is indicated in a report on the advisory sessions to the incoming State Governor; a variety of administrative changes are suggested to decrease a noted disconnect between land use and transportation planning (University of North Carolina at Chapel Hill School of Government, 2008).

A second process by which urban growth and land use considerations may be reflected in the acquisition of mitigation sites by the EEP is through its local watershed planning process, which requires that the EEP's compensatory wetland mitigation be consistent with basin wide plans for restoration. This includes coordinating with local watershed planning (14 digit HU). According to the EEP, local watershed planning is a dynamic process that takes into account both quantitative data (including the NC DOT's forecasted mitigation needs as well as existing hydrology, habitat and land use) as well as local community priorities as determined through a participatory stakeholder process (EEP, 2008). Estimated mitigation needs can change on a month-to-month basis, meaning that the process of setting priorities for mitigation requires a flexible approach (EEP, 2008). The EEP's procedures state that the agency will develop mitigation in watersheds in which it predicts needing mitigation in the "next few years." The EEP's mitigation target tables are updated every six to eight weeks, and the acquisition objectives, timelines and outreach methods are revised to reflect updated mitigation targets (EEP, 2008).

In order to coordinate its mitigation program with local watershed planning, and in concert with basin-wide planning goals, the EEP identifies priority sites for restoration through a multi-step planning process and then targets those sites as potential mitigation. In the first step, the EEP's staff members utilize GIS data, field tours and input from other water resource professionals to identify watersheds at the 14-digit HU level that have both problems and assets. As part of this process, staff identifies major functional stressors (Bryson and Leslie, 2009), which may include development pressure (projected residential and commercial land use). The watersheds are ranked and those with the highest need and opportunity become designated as "targeted local watershed" (TLW) – areas in which preservation, restoration and enhancement projects would have the largest benefit. By 2008, just under 25% of all 1,601 of the 14-digit watersheds were classified as TLW (EEP, 2009).

The second step is to develop local watershed plans, which is informed by factors including the NC DOT's activities as well as other permitted impacts associated with other types of development. Again through a dynamic process involving quantitative and qualitative factors such as GIS information and stakeholder interest in each local watershed, focus areas for each local watershed are determined. The LWPs are comprised of a Watershed Assessment Report discussing the major ecological functionality within the targeted area, a Project Atlas with site-specific information about the most promising mitigation sites in the study area, and a Watershed Management Plan containing policy and other recommendations to address critical local watershed problems (EEP, 2009).

The final piece of the mitigation process involves the actual property or easement acquisition. Sites are acquired in the 8-digit watersheds in which impacts are predicted, with priority placed on sites in selected 14-digit TLWs. Using the Project Atlases, the EEP's staff pursues project sites with high potential; in theory these are sites where the EEP will be able to achieve the greatest ecological return on investment from the standpoint of water quality, hydrology and habitat (EEP, 2009). Often the sites are privately owned and the actual acquisition of an easement occurs through a series of property transaction negotiations; thus, like with other land conservation transactions, implementation depends in part on successful negotiations with land owners (DYE, 2007). At times, projects are also pursued outside of TLWs, if the site offers substantial ecological benefits or would allow mitigation goals to be met in a timelier manner (EEP, 2009).

In numerous LWPs, commercial and residential development was cited as one of the largest threats to local water quality, because activities like channel modification, stream relocation, straightening and dredging, which cause water quality impacts like increased storm water runoff and sediment, are primarily associated with road-building or residential areas. Analysis completed during the creation of local watershed plans considers factors such as projections for residential and commercial development and anticipated increases in impervious surface cover. Some plans utilize future land-use projections and scenarios to develop models for estimating non-point source pollutant and run-off loads for various time-frames and under various management and regulatory conditions (e.g. EEP, 2007) or to develop watershed-wide and subcatchment-specific build out development models (e.g. New Hanover County, 2002). LWPs also generally include a list of recommendations for restoring or improving water quality. The majority of these recommendations are site-specific, such as on-site BMPs, water-quality monitoring, and habitat restoration and preservation. However, some recommendations also include activities related to land-use planning, such as adoption of low-impact development ordinances and

creation of comprehensive land use plans (EEP, 2007), thus providing an additional way by which land-use and water resource planning are linked in practice.

A final way that land use considerations may be incorporated into local watershed planning is through the inclusive stakeholder aspect of the process. Types of stakeholders representing urban growth interests include regional Council of Governments (COGs), local elected officials from cities, towns and counties, and landowners. They provide input through processes including informational exchange at meetings, and representation on advisory committees (Bryson and Leslie, 2009). A contracted facilitator is normally involved in the process, such as the regional COG or the North Carolina State University's Watershed Education for Communities & Officials program (EEP, 2008).

It is clear that land-use planning measures, such as population and development forecasting and projected changes in impervious surface cover, are incorporated into TLW planning at the 14-digit watershed level to identify local priorities for preservation and restoration. However, these indicators are used generally from a reactive standpoint, in that development is considered a stressor to local watershed health, rather than from a proactive standpoint in which future developed projections would be used to determine advance mitigation needs. This approach mirrors much of the current literature linking urban growth with wetlands, which primarily focuses on how urban development influences ecology and water quality (e.g. Carpendo, 2007) but not how growth forecasting and land use planning can be used to proactively plan for mitigation.

Additionally, there is no evident attempt by the EEP on a broader, landscape-level scale to coordinate mitigation with rapidly-developing watersheds beyond considering already-permitted development . The difference in scale at which targeted local watershed plans are created versus at which mitigation must occur (i.e. 14 digit versus 8 digit watersheds) leaves room open for spatial mismatches between watersheds that are rapidly growing and those that are gaining much mitigation. This may be true, for example, when a 14-digit watershed is expected to undergo high levels of development but has little opportunity for mitigation for reasons like lack of sites, or high property values, or land ownership structures not well suited for purchase of easements by the EEP. In such a case, that particular 14-digit watershed may not be prioritized for restoration as a TLW, and may create a situation in which mitigation is needed at the 8-digit scale but is not accounted for in the local watershed plan and is thus overlooked during the mitigation process.

Wetland Mitigation and Social Equity

Over the past few decades, social equity or “environmental justice” has become an emerging criterion by which to measure the success of solutions to environmental challenges. With the issuance of Executive Order 12898 in 1994, President Clinton made environmental justice a national concern, mandating that Federal agencies avoid causing any disproportionate public health or environmental effects on low-income and minority populations (Clinton, 1994). The traditional environmental justice perspective is based on the idea of preventing a disproportionate burden on disadvantaged populations (Clinton, 1994) and the more recently-emerging view hold that disadvantaged communities should also have fair *access* to environmental “goods” (e.g. Alkon, 2006). Several recent studies suggest that stream and wetland relocation occurs as an unintended consequence of compensatory wetland mitigation programs, raising the question of whether any disproportionate environmental or economic effects accrue to certain populations and not others (Ruhl and Salzman 2006; BenDor et al 2007; BenDor et al 2009).

Evidence increasingly suggests that in spite of the “no net loss” clause governing wetland mitigation in the US, mitigation programs do result in spatial relocation of streams and wetlands, with ecosystem services being lost at impact sites and gained at mitigation sites. Several recent studies confirm that compensatory mitigation programs result in a systematic loss of wetlands from urban or urbanizing areas, while mitigation tends to occur in less densely populated areas (Ruhl and Salzman, 2006; BenDor et al, 2007).

The spatial relocation of wetlands may have implications for social equity in a variety of ways. The differences between the scales and boundaries of watersheds versus political jurisdictions and human communities means that even with legal requirements for mitigating stream and wetland losses within specific ecological boundaries (8 digit watersheds in North Carolina), any social impacts of relocation beyond large-scale watershed-quality issues are not accounted for in mitigation policy. Further, many benefits of wetlands are realized at a local level, including services with both direct and indirect “use value.” Direct use-values of wetlands include water purification (such as a sewage treatment area), wildlife harvesting, peat production, and low-impact transport, while indirect use values that have very local benefits include flood control, storm protection, micro-climate stabilization, and shoreline stabilization. The scale at which these benefits are realized differ from the scale at which wetland mitigation occurs, thus the latter maintains ecosystem services which are realized at a regional level,

such as ground water recharge and water filtration from pollutants (e.g. nitrogen, phosphates) (Boyer and Polaski, 2004).

In order to understand whether wetlands are considered an amenity and to understand their economic value to local communities, a variety of methods have been employed. Studies looking at the market and non-market values of wetlands find differing results, depending on factors like analytical methods, location of wetland (e.g. urban or rural), type of wetland, and whether the studies look at market or non-market value (e.g. Boyer and Polasky, 2004; Reynolds and Regaldo, 2002).

A review of non-market studies from 2004 suggests the variety of effects that wetlands have on property value. While hedonic studies have found small positive impacts of wetlands on property values in metropolitan areas (e.g. Lupi et al. 1991, Doss and Taff 1996, Mahan et al. 2000), other studies find that the situation is reversed in rural areas, with proximity to wetlands yielding lower property values (e.g. Reynolds and Regaldo, 2002; Shultz and Taff, 2004; Bin and Polasky, 2004). The studies of effect of wetland proximity on rural land values looked at regional data in Florida, North Dakota, and North Carolina respectively, finding similar conclusions in each region. Possible reasons for the differences between wetland values in urban versus rural areas are discussed below.

Some studies suggest that urban wetlands offer special benefits because of the nature of the urban environment, itself. The presence of wetlands provides buffers against development, offers storm water management, and provides urban open space. The incorporation of wetlands into urban amenities such as greenways helps ensure integration of small urban wetlands into other natural environments which allows better retention of their ecological function in spite of their often-small size (Titton, 2005; as cited in Manuel, P. 2003). Further, qualitative surveys suggest that urban residents appreciate the aesthetic value of wetlands for cultural reasons that may not be captured in monetary terms but still offer social value (Manuel, 2003).

In contrast, in rural areas wetlands are generally considered a “low intensive land use” because they limit the amount of other productive activity that can occur on the site, such as productive agriculture (Reynolds and Regaldo, 2002). Reynolds and Regaldo (2002) modeled rural wetland effects on rural property values. Their model showed that as the area of wetlands on a site increases, the land value of that property decreases. By analyzing actual sales data, they found that a 10% increase in wetland area

predicts a 0.21% decrease in land value, with values and levels of significance varying slightly depending on type of wetland (Reynolds and Regaldo, 2002).

A problem with using only the hedonic method to explore the economic value of wetlands is that it doesn't capture any of the economic value of the ecosystem services that are not captured in a simple market-based property transaction, which reflects only the perceived value of buyers and sellers. Other benefits of proximity, such as the potential for reduced flooding (and associated economic losses) are not captured through this type of valuation model (Boyer and Polasky, 2004).

In addition to the hedonic method, there are numerous other approaches to valuing ecosystems. These methods have been applied to wetlands to varying degrees. The travel cost method considers the number and cost of trips to a site to estimate willingness to pay for access to an amenity. In terms of wetlands, this method is primarily used to consider the recreational value for activities such as bird-watching, fishing and hiking. Little research has been done applying this method to wetlands, particularly in the urban context (Boyer and Polasky, 2004).

The production methods approach estimates the value of increased economic productivity that is directly attributable to an ecosystem. In the context of wetlands this approach often considers the economic value of fisheries, which can then be compared to the value of using land for other production purposes in order to understand the economic impacts of different uses. Studies show that coastal wetlands certainly have positive economic value as fisheries, but are less conclusive when comparing this to the value of other potential land uses and different geographic contexts (e.g. Batie and Wilson, 1978; Barbier and Strand, 1998; as cited in Boyer and Polasky, 2004). However, as a use-based analysis, this method of valuing wetlands is only useful when there is a specific productive use associated with the presence of the wetland (Boyer and Polasky, 2004).

A third method of valuing wetlands is known as the replacement cost approach. This method relates most specifically to the compensatory mitigation context. In this method, the value of a wetland is determined by estimating the cost to replace its ecosystem services through other means (e.g. constructing a new water purification or sewage treatment plant). Examples from New York, Louisiana and Florida show that at times municipalities will opt to protect existing water resources, instead of constructing new treatment facilities, as the most cost-effective option. In order for wetlands to have positive value in this model, the wetlands must both provide the same service as another alternative

and they must provide it more cheaply than the replacement cost (Boyer and Polasky, 2004). Obviously, there must also be demand for that service.

From a social equity perspective, the question is over which populations benefit and whether certain types of populations systematically lose benefits while others gain them. In their study of the Florida compensatory mitigation program, Ruhl and Salzman (2006) found that higher population densities were found around impact sites, with an average difference of 934 people per square mile between impact sites and mitigation bank sites. Large absolute differences in median income and in proportion of population that was non-white were found between impact sites and mitigation sites. While no systematic trends were identified in terms of the directions of the differences (e.g. higher at impact sites than mitigation sites), the study was the first to offer data at a fine resolution to show that compensatory wetland mitigation transfers ecosystem services associated with wetlands from certain communities to others.

In the first study to combine transaction-level spatial data on compensatory wetland mitigation with census-tract level socioeconomic data, BenDor et al (2007) showed that characteristics of populations surrounding wetland impact sites in the Chicago, IL region exhibit small but significant differences from the populations near mitigation sites. They found that impact sites tend to be located in areas with lower populations densities, larger black and Hispanic populations, lower levels of home ownership and lower average household incomes than mitigation sites, although the effects varied by mitigation method (BenDor et al, 2007).

BenDor et al (2007) and Ruhl and Salzman (2006) both discuss their findings in terms of implications for policy, and suggest that one way to address social equity concerns associated with wetland mitigation would be to build such concerns into regulations for mitigation. Given that these emerging equity concerns have policy implications for mitigation programs, it makes sense to ask whether wetland and stream mitigation through the EEP has resulted in any type of similar socioeconomic disparity. Additionally, given that the EEP has won a number of awards and has been discussed as a potential model for other regions (Gilmore, 2005; D'Ignacio, 2005), it makes sense to consider whether the program has created any unintended socioeconomic effects and to understand the full range of outcomes produced by its approach.

In North Carolina, a study of the EEP's wetland and stream mitigation program indicates that significant spatial relocation of ecosystem services through wetland mitigation occurs throughout the state. Impact

and mitigation sites often occur at great Euclidean distances from one another; BenDor et. al. (2009) find that the average wetland relocation distance is 54.7 km between impact and mitigation sites, and the average stream relocation distance is 177 km through the channel network. Distances between impact and mitigation sites for both streams and wetlands were found to be larger in North Carolina than in mitigation programs in other regions. Further, wetland impacts tend to be clustered in five rapidly urbanizing areas throughout the state, while mitigation sites are dispersed throughout the state (BenDor et. al, 2009). While their findings have been interpreted in terms of the landscape and ecological affects of resource relocation, the social implications of relocating ecosystem services have not been previously examined in the context of North Carolina and the EEP.

METHODS

In order to answer questions regarding two different aspects of wetland mitigation in North Carolina – one regarding the socioeconomic distribution of historic wetland mitigation transactions, and the second regarding future planning and projections correlated with growth and development needs - the methodology for this study is divided into two parts.

Socioeconomic Analysis

The first portion of the study compared socioeconomic characteristics of census tracts surrounding stream and wetland impact sites to those around mitigation sites, to determine whether compensatory mitigation redistributes ecosystem services between different types of populations. This was done by analyzing a data set of 839 unique, one-to-one compensatory mitigation transactions managed by the EEP through 2007. Spatial information about the location of each impact and mitigation site allowed all sites to be mapped and then joined to census-tract level socioeconomic data from the US Census using ArcMap (Version 9.3), a geographic information system (GIS) (ESRI, 2008). The differences between socioeconomic characteristics in census tracts containing impact sites and those containing mitigation sites were analyzed at the transaction level using a series of paired t-tests. Analysis was performed for the entire data set of 839 observations, as well as separately for wetlands and streams, using Stata 10 (StataCorp, 2007).

Data

Socioeconomic data for this portion of the analysis was readily obtained from the U.S. Census Bureau. The indicators analyzed include measures of population, educational attainment, poverty, income and housing units from the 2000 Decennial Census¹ (U.S. Census Bureau, 2000). Data on compensatory stream and wetland mitigation transactions in North Carolina was originally collected by BenDor et al (2009). The data set was compiled from records maintained by the US Army Corps of Engineers (Wilmington District), the NC Division of Water Quality and the EEP. It excludes any private mitigation banking transactions over the study period. The data set includes both spatial and descriptive information about 431 wetland mitigation transactions and 408 stream mitigation transactions. For the sake of accounting, each transaction is considered to contain one impact site and one mitigation site; although mitigation can occur in several types of on-the-ground transactions, including one impact site to one mitigation site, many impact sites mitigated at the same site, or one impact sites mitigated at multiple sites.

Urban Growth and Land Use Analysis

The second portion of the study involves a spatial comparison between locations where the EEP accrues advance mitigation, and areas with high levels of growth and development across the state. Descriptive and statistical analysis methods were employed. Growth and development were measured using population and land cover indicators by watershed, including absolute population, population growth rates, and population growth projections, as well as percent impervious surface cover. Analysis was completed at the 8-digit HUC watershed scale. Population growth by watershed was approximated using census counts and estimates of population by designated Places and remaining county balances² (U.S. Census Bureau, 2000). The population data was first joined to the corresponding Place and County boundary files in GIS, and then apportioned into watersheds based on area of each Place or county falling within each watershed. This was done using the GIS “intersect” tool to divide Places into

¹ Although American Communities Survey data would have been more recent, it was not used in this analysis because the data is not consistently provided at the desired geography level of census tract.

² In the Census Population by Place estimates for 2000-2007, there is no data for unincorporated populations in Hyde and Currituck counties.

watersheds and then summarizing population of the intersected Place and County shape files on the watershed field. The population data was then joined with 2007 watershed-level data on the EEP's available mitigation credits and NC DOT projected impacts through 2013, as well as with 2001 impervious surface cover data from the Multi-Resolution Land Characteristics Consortium's National Land Cover Database (U.S. Department of the Interior, no date) (See Appendix A).

The data is presented in a series of maps in order to allow for visual inspection and simple descriptive analysis of the findings about the relationships between the NC DOT projections, the EEP's mitigation and general urban growth patterns throughout the state. Regression analysis in STATA 10 (STATA, 2009) was also performed to determine whether there are any statistically significant relationships between the growth indicators in each watershed and the amount of mitigation accumulated by the EEP in each watershed. In order to account for the extreme right skew of the data, all data was logarithmically transformed before running regression analysis. A test for variance of inflation factors (VIF) was performed in STATA 10 to detect multicollinearity, and variables with high VIF (over 5.29)³ were excluded to reduce the likelihood that collinearity would affect the model.

Data

³ Multicollinearity (i.e. high linear correlation) between two or more variables in a regression model can create a problem in regression modelling, because it can reduce the ability to detect effects of an individual component (Greene, 2000; Lafi and Kaneene, 1992). Common problems may include low significance levels, and coefficients with the "wrong" signs or implausible magnitudes (Greene, 2000). However, a common solution, excluding variables that exhibit high levels of multicollinearity, runs the risk of biasing the coefficients of the remaining variables or excluding a variable that actually is important (Greene, 2000). Thus, researchers must use their own discretion when selecting which variables to retain. A VIF test provides one measure of collinearity. While there is no universally accepted level above which collinearity becomes a problem, commonly accepted VIF levels range from 1 (Mansfield and Helms, 1982) to 10 (Brannick, no date). Some planning researchers have chosen to exclude variables with VIF over 7, while keeping variables with VIF up to 5.08 (Kyratso and Yiorgos, 2004). Here, a VIF of roughly 5.00 is used as a cut-off over which to exclude variables.

Population estimates by Place for 2000 and 2007 as well as Place boundary shape files were obtained from the US Census Bureau. County population projections to 2020 were obtained from the North Carolina Office of State Budget and Management (2008). Impervious surface cover data from 2001 was obtained in raster form from the Multi-Resolution Land Characteristics Consortium's 2001 National Land Cover Database (U.S. Department of the Interior, no date), and the percent imperviousness for each 8-digit watershed was calculated using ArcMap GIS (description of calculations in Appendix A).

Data on mitigation credits and the NC DOT's impact forecasts by 8-digit watershed were obtained from the publically available report, "Study of the Merger of Ecosystem Enhancement Program & Clean Water Management Trust Fund: Final Report of Findings and Recommendations," prepared by DYE Management Group for the North Carolina General Assembly (2007). The DYE data used for this study includes available stream and wetland mitigation sites accumulated by 2007, as well as the NC DOT's anticipated mitigation needs (i.e. projected stream and wetland impacts), both provided by 8-digit HUC watershed.⁴ The available mitigation credits include sites originally held by the NC DOT that have been transferred to thhe EEP as part of the bureaucratic transitioning away from the NC DOT doing its own mitigation, as well as mitigation sites acquired independently by the EEP. Credits are categorized by both type of procurement as well as type of ecosystem (stream, riparian wetland, non-riparian wetland, or coastal wetland) and level of mitigation (enhancement, restoration, preservation or creation).

The available credits were summed for each watershed by type of procurement, and all three types of wetland ecosystems were summed. Available credits are analyzed in this study as total mitigation credits⁵ (total linear feet for streams and total acres for wetlands), although in practice credits are weighted or adjusted to reflect the fact that certain levels of compensatory mitigation (such as

⁴ In the DYE dataset, 8-digit HUC 03020105 was listed twice, once in the Pasquotank basin (the correct listing) and once in the Tar-Pamlico basin. The incorrect Tar-Pamlico listing has been excluded from analysis (16 acres each of riparian and non-riparian available wetland mitigation).

⁵ Total available mitigation, rather than weighted credits, were used in this analysis, because the mitigation ratios are not always applied consistently. For example, the DYE report (2007) notes that "tailored" mitigation ratios are often used in practice (p. 17) and also recommends using reduced mitigation ratios in certain circumstances such as when mitigation is in the ground prior to impact.

preservation) offer a lower credit value in the EEP's standard accounting system than others (such as restoration) (BenDor et al 2009, p. 38).

RESULTS

Social Equity and Wetland Mitigation

Analysis of 23 socioeconomic indicators for all 839 mitigation transactions by the EEP in the data set (Table 1) shows that there are significant, and sometimes large, differences between the characteristics of populations surrounding impact sites versus mitigation sites. Statistically significant differences were found for all but one indicator. Further, the socioeconomic trends differ when considering the 431 wetland transactions separately from the 408 stream transactions, with larger socioeconomic differences between impact and mitigation sites exhibited by the wetland mitigation transactions than by stream mitigation (Tables 2a and 2b).

Compared to mitigation sites, populations near impact sites generally have higher total populations, higher population densities, and a strikingly higher portion (33 percent) of their populations inside census-classified urbanized areas. The racial make-ups of populations around impact sites exhibit higher percentages of whites and lower percentages of blacks and Hispanics than populations at mitigation sites. Populations surrounding impact sites also tend to have higher levels of education, with lower percentages of individuals over the age of 25 having only a high-school degree or less, and higher percentages of the population that have completed "some college" or more than those at mitigation sites. These populations also have, on average, lower rates of individual, family and household poverty, higher median incomes, and higher median home values. Conversely, then, populations near mitigation sites have higher percentages of minorities, lower levels of education, lower median income and higher poverty rates, and lower home values.

A breakdown of the analysis by transaction type (stream or wetland) reveals significantly different socioeconomic trends in wetland mitigation versus stream mitigation (Tables 2a and 2b). Compared to stream mitigation transactions, wetland transactions exhibit a larger discrepancy in percent of urbanized population (47.4% more urbanized at wetland impact sites, compared to only 18.5% for stream transactions). The percent Hispanic population is slightly lower at wetland impact sites than wetland mitigation sites, while it is slightly higher at stream impact sites than stream mitigation sites. Wetland

transactions show a greater difference in educational attainment at impact sites compared to mitigation sites, as well as larger differences between economic indicators including poverty rates, median income and housing value.

Table 1. Socioeconomic differences between census tracts containing impact sites and mitigation sites.

Indicator	Mean (n=839)		Mean Diff. (Imp. – Mit.)	% Mean Diff. (%) (Imp. - Mit.)/Imp.	Std. Error	t
	Imp. ^a	Mit.				
Population						
Total Population	7,443.45	6,781.65	661.80	8.9	160.85	4.11**
Population Density (pop./mi ²)	688.98	469.12	219.86	31.9	38.89	5.65**
% Urban	65.42	32.09	33.33	50.9	1.77	18.86**
% White	78.14	75.81	2.34	3.0	0.6	2.77**
% Black	16.19	19.30	-3.12	-19.3	0.80	-3.90**
% Hispanic	3.56	3.60	-0.05	-1.4	0.15	-0.32
% Hispanic, Non-white	1.91	2.30	-0.39	-20.4	0.10	-3.99**
Highest Level of Educational Attainment (% of pop.)						
Below 9 th Grade	5.16	8.50	-3.34	-64.7	0.17	-19.46**
Some High School	10.47	16.00	-5.53	-52.8	0.27	-20.73**
High School Graduate	24.98	31.43	-6.45	-25.8	0.37	-17.62**
Some College	21.50	19.46	2.04	9.5	0.17	11.98**
Associate’s Degree	7.25	6.94	0.31	4.3	0.09	3.53**
Bachelor’s Degree	20.74	11.90	8.84	42.6	0.45	19.51**
Graduate or professional Degree	9.90	5.77	4.12	41.6	0.33	12.53**
Economics and Housing						
% Population in Poverty	8.85	12.56	-3.71	-41.9	0.28	-13.05**
% Households in Poverty	8.79	12.99	-4.20	-47.8	0.28	-15.04**
% Families in Poverty	6.41	9.48	-3.07	-47.9	0.26	-11.70**
Median Family Income (1999 \$)	57,383	47,002	10,380.75	18.1	746.31	13.91**
Median Household Income (1999 \$)	49,621	39,571	10,050.24	20.3	683.41	14.71**
% Unemployment	2.90	3.16	0.26	9.0	0.11	-2.44*
% Owner-occupied Housing Units	73.22	76.14	-2.92	-4.0	0.69	-4.25**
% Vacant Housing Units	13.15	9.80	3.35	25.5	0.46	7.25**
Median Value of Owner-Occupied Housing Units (1999 \$)	131,351	95,752	35,598.69	27.1	2,296.84	15.50**

^a Imp. – impact sites; Mit. – mitigation sites.

^ψ $p < 0.10$; * $p < 0.05$; ** $p < 0.01$

Table 2a. Socioeconomic differences between census tracts containing wetland impact and wetland mitigation sites.

Indicator	Mean (n=431)		Mean Diff. ^a (Imp. – Mit.)	% Mean Diff. (Imp-Mit)/Imp	Std. Error	t
	Imp. ^a	Mit.				
Population						
Total Population	7,756.1	7,102.4	653.64	8.43	225.20	2.90**
Pop. Density (pop./mi ²)	595.43	139.97	455.46	76.49	34.19	13.32**
% Urban	63.82	16.44	47.38	74.24	2.17	21.88**
% White	79.42	75.16	4.26	5.36	0.96	4.42**
% Black	15.21	19.90	-4.70	-30.90	0.91	-5.17**
% Hispanic	3.11	3.72	-0.61	-19.61	0.16	-3.88**
% Hispanic, Non-white	1.65	2.43	-0.78	-47.27	0.11	-7.36**
Highest Level of Educational Attainment (% of pop.)						
Below 9 th Grade	4.96	9.23	-4.27	-86.09	0.22	-19.20**
Some High School	10.31	17.27	-6.96	-67.51	0.32	-21.93**
High School Graduate	25.63	34.05	-8.43	-32.89	0.43	-19.63**
Some College	22.20	19.81	2.38	10.72	0.22	10.57**
Associate’s Degree	7.37	7.21	0.16	2.17	0.11	1.42
Bachelor’s Degree	20.04	8.61	11.43	57.04	0.53	21.37**
Graduate or professional Degree	9.50	3.81	5.69	59.89	0.39	14.54**
Economics and Housing						
% Population in Poverty	9.19	13.71	-4.52	-49.18	0.30	-15.18**
% Households in Poverty	9.21	14.28	-5.07	-55.05	0.30	-16.80**
% Families in Poverty	6.55	10.66	-4.10	-62.60	0.27	-15.44**
Median Family Income (1999 \$)	55,610	42,427	13,183.46	23.71	843.27	15.63**
Median Household Income (1999 \$)	47,931	35,869	12,061.44	25.16	803.30	15.01**
% Unemployment	2.89	3.04	-0.15	-5.19	0.09	-1.60
% Owner-occupied Housing Units	73.67	78.87	-5.20	-7.06	0.75	-6.93**
% Vacant Housing Units	17.45	11.45	6.00	34.38	0.78	7.68**
Median Value of Owner-Occupied Housing Units (1999 \$)	130,299	80,809	49,490.26	37.98	2,803.33	17.65**

^a Imp. – impact sites; Mit. – mitigation sites.

^ψ $p < 0.10$; * $p < 0.05$; ** $p < 0.01$

Table 2b. Socioeconomic differences between census tracts containing stream impact and stream mitigation sites.

Indicator	Mean (n=408)		Mean Diff. ^a (Imp. – Mit.)	% Mean Diff. (Imp-Mit)/Imp	Std. Error	t
	Imp. ^a	Mit.				
Population						
Total Population	7,113.2	6,442.8	670.42	9.43	230.10	2.91*
Pop. Density (pop./mi ²)	787.80	816.83	-29.03	-3.68	69.29	-0.42
% Urban	67.10	48.61	18.48	27.54	2.63	7.02**
% White	76.80	76.49	0.31	0.40	1.40	0.22
% Black	17.22	18.67	-1.44	-8.36	1.33	-1.08
% Hispanic	4.03	3.48	0.55	13.65	0.25	2.22*
% Hispanic, Non-white	2.18	2.16	0.02	0.92	0.17	0.13
Highest Level of Educational Attainment (% of pop.)						
Below 9 th Grade	5.36	7.71	-2.35	-43.84	0.25	-9.25**
Some High School	10.65	14.67	-4.01	-37.65	0.42	-9.52**
High School Graduate	24.29	28.65	-4.36	-17.94	0.58	-7.47**
Some College	20.77	19.09	1.68	8.09	0.26	6.57**
Associate's Degree	7.13	6.66	0.47	6.59	0.14	3.46**
Bachelor's Degree	21.47	15.37	6.11	28.46	0.72	8.51**
Graduate or professional Degree	10.31	7.85	2.47	23.96	0.52	4.70**
Economics and Housing						
% Population in Poverty	8.49	11.35	-2.87	-33.80	0.49	-5.84**
% Households in Poverty	8.35	11.63	-3.28	-39.28	0.47	-6.91**
% Families in Poverty	6.26	8.23	-1.97	-31.47	0.45	-4.34**
Median Family Income (1999 \$)	59,256	51,836	7,420.03	12.52	1,233.98	6.01**
Median Household Income (1999 \$)	51,407	43,481	7,925.66	15.42	1,111.64	7.13**
% Unemployment	2.91	3.30	-0.38	-13.06	0.20	-1.93 ^ψ
% Owner-occupied Housing Units	72.75	73.25	-0.50	-0.69	1.16	-0.43
% Vacant Housing Units	8.62	8.07	0.55	6.38	0.43	1.28
Median Value of Owner-Occupied Housing Units (1999 \$)	132,462	111,538	20,924.02	15.80	3,540.57	5.91**

^a Imp. – impact sites; Mit. – mitigation sites.

^ψ $p < 0.10$; * $p < 0.05$; ** $p < 0.01$

Links between Land Use Planning and EEP Acquisition of Mitigation Credits

Population Growth and Impervious Surface Cover by Watershed

The majority of watersheds with high levels of growth, as indicated by population increase from 2000 to 2007 and percent impervious surface cover, are located in the central and western-central parts of the state, as seen below in Figures 1 and 2. Three watersheds grew by over 100,000 (the Lower Catawba, Upper Neuse and Rocky watersheds), another four by 50,000 to 100,000 (Upper Cape Fear, Upper Catawba, Haw and Upper Yadkin), and seven more by 20,000 to 50,000 (Deep, Upper French Broad, Lower Cape Fear, New, Lower Yadkin, Northeast Cape Fear, and South Yadkin). The watersheds with the fastest-growing populations, not surprisingly, contain the majority of North Carolina's major urbanized areas, shown in Figure 1.

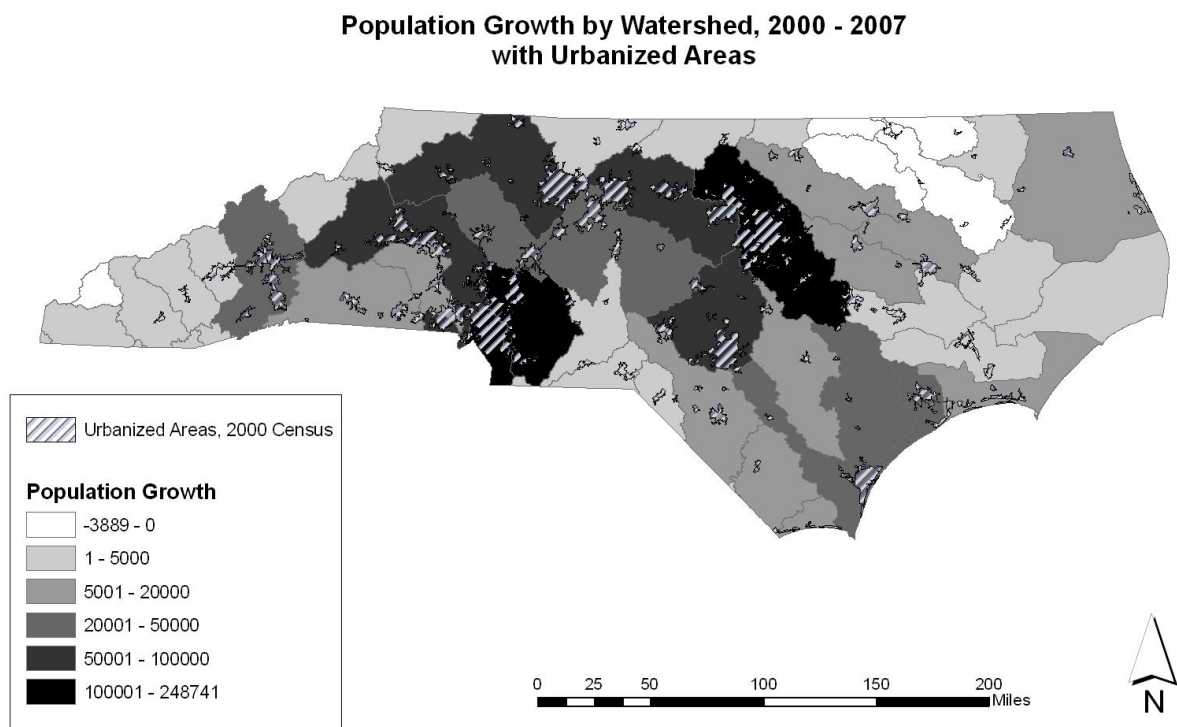


Figure 1. Population growth estimates from the US census from 2000-2007 by Place, apportioned into 8-digit HUC watersheds and overlain with interstate highways and urbanized areas. Darker watersheds have higher levels of population growth. Watersheds containing major urbanized areas tend to exhibit higher levels of population growth.

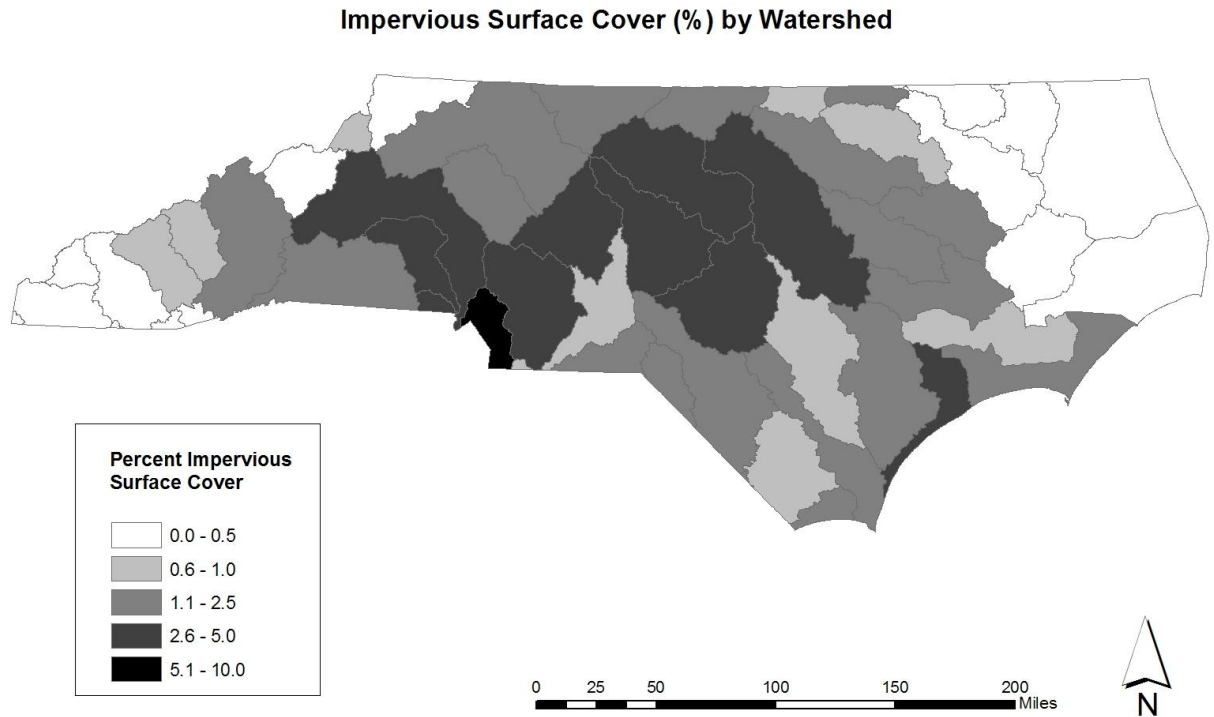


Figure 2. Percent impervious surface cover by watershed. Data obtained from National Land Cover Database (U.S. Department of Interior, no date).

DOT Projected Mitigation Needs in Relation to Growth Indicators

According to the EEP’s procedures, mitigation credits are accumulated in response to projected needs of the NC DOT. Thus the NC DOT’s predicted impacts are considered to be an important factor in this analysis. NC DOT predicted impacts are discussed here first in relationship to growth indicators. The NC DOT’s predictions for stream and wetland mitigation needs by 2013 are shown in Figure 3, below. As seen in the figure, the spatial distribution of the NC DOT’s projected stream impacts differs notably from that of the projected wetland impacts, with stream impacts more concentrated in the western half of the state and wetland impacts more concentrated in the eastern part of the state.

Scatter plots show the NC DOT’s predicted stream and wetland impacts plotted against the amount of recent population growth by watershed (Figure 4). While these plots show a generally positive trend between the amount of mitigation predicted and the level of population growth, they also show that

there are a number of outlier watersheds with either high growth but low predicted mitigation needs, or low growth but high predicted mitigation needs. The notable outliers are indicated in Figure 4.

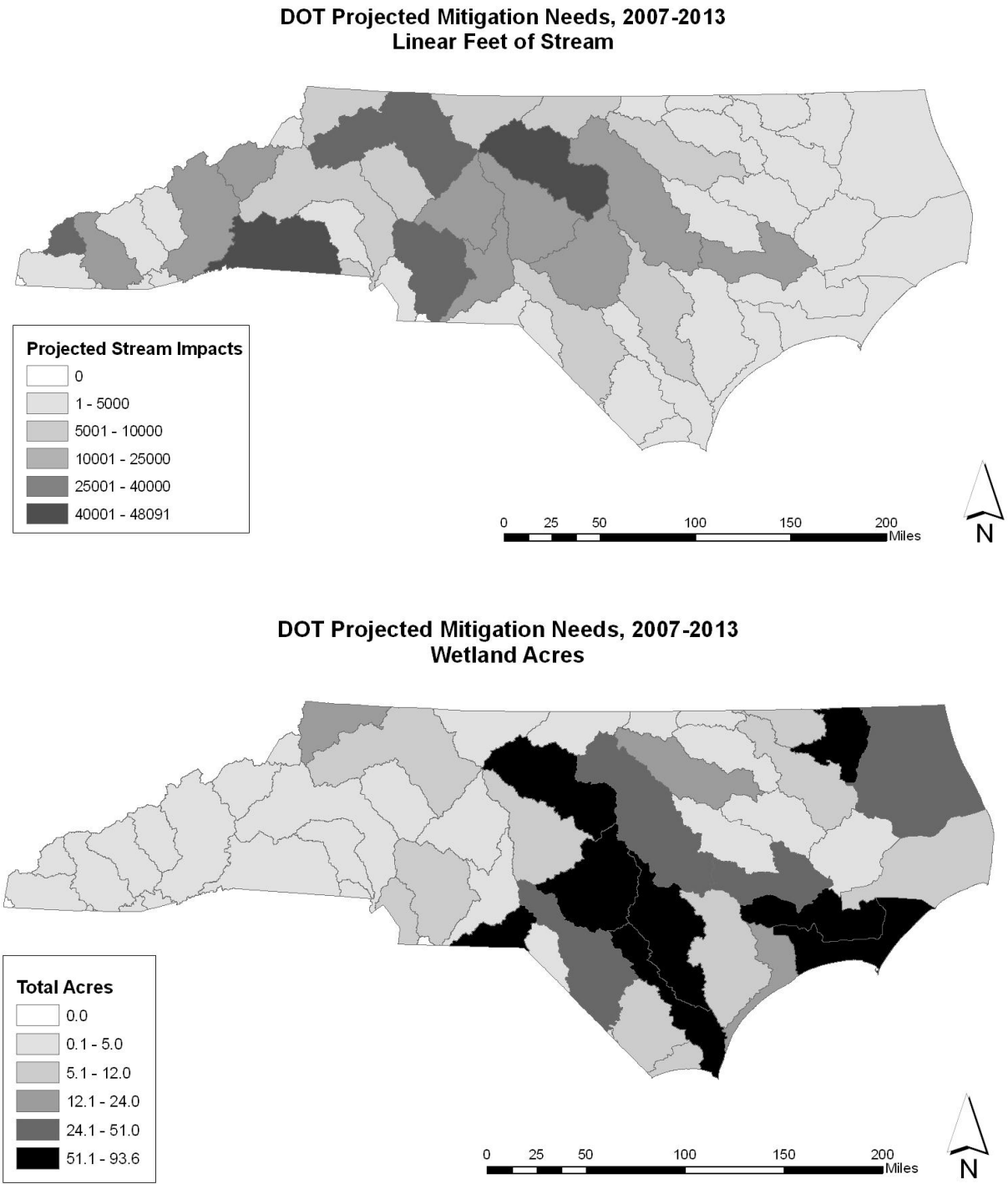
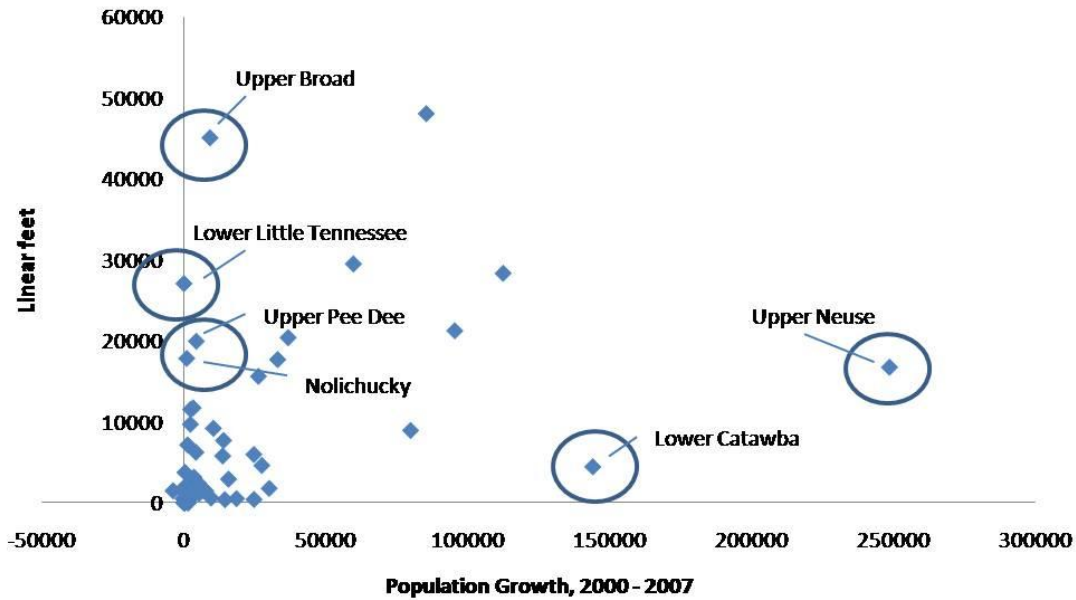


Figure 3. DOT Projected stream (top) and wetland (bottom) mitigation needs. Darker watersheds are those in which NC DOT predicts needing larger amounts of mitigation.

DOT Projected Stream Mitigation Needs v. Pop. Growth



DOT Projected Wetland Mitigation Needs v. Pop. Growth

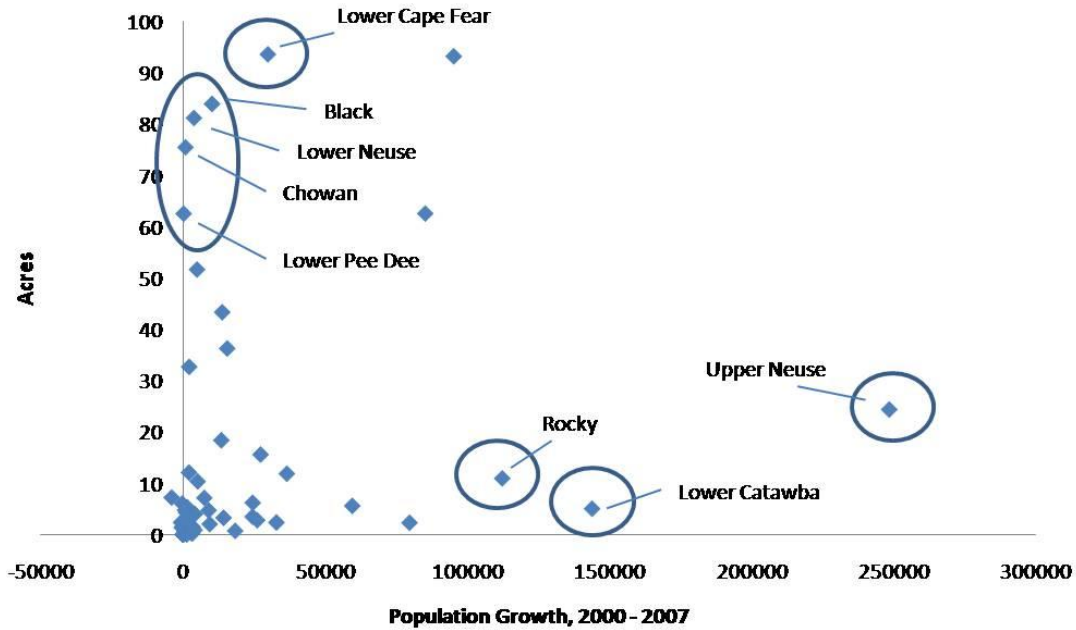


Figure 4. NC DOT Projected stream (top) and wetland (bottom) mitigation needs to 2013 by watershed, plotted against population growth from 2000 to 2007. Outliers are noted.

In order to determine more precisely whether the NC DOT’s predicted mitigation needs correspond with areas of high growth by watershed across the state, regression analysis was performed, with the NC DOT’s projected mitigation needs for 2013 as the dependent variable and selected growth indicators as the independent variables. The results of regression are given in Table 3, below. No variable exhibited a VIF value above 3.04 in this model. As shown in the table, the model is significant (Probability > F = 0.00, with an R² value of 0.71 for predicted stream impacts and 0.28 for predicted wetland impacts.

Table 3. Results of regression analysis showing the influence of growth indicators on the NC DOT’s projected impacts by watershed.

Streams

Independent variables	Coefficient	Std. Error	t
Percent Impervious Surface	-0.21	0.61	-0.35
2007 Population	0.98**	0.16	6.02
% Pop. Growth, 2000-2007	-7.30**	2.64	-2.75
Projected Pop. Increase (absolute growth) by 2020	0.06	0.09	0.68
F-value	30.43		
Probability > F	0.00		
R²	0.71		n = 54

Wetlands

Independent variables	Coefficient	Std. Error	t
Percent Impervious Surface	-0.42	0.52	-0.81
2007 Population	0.46**	0.14	3.33
% Pop. Growth, 2000-2007	1.35	2.26	0.59
Projected Pop. Increase (absolute growth) by 2020	-0.06	0.08	-0.73
F-value	4.76		
Probability > F	0.00		
R²	0.28		n = 54

Notes: Dependent variables are the NC DOT’s projected impacts to 2013 for streams and wetlands, respectively. All variables underwent logarithmic transformation prior to running regression.

^ψ p < 0.10; * p < 0.05; ** p < 0.01

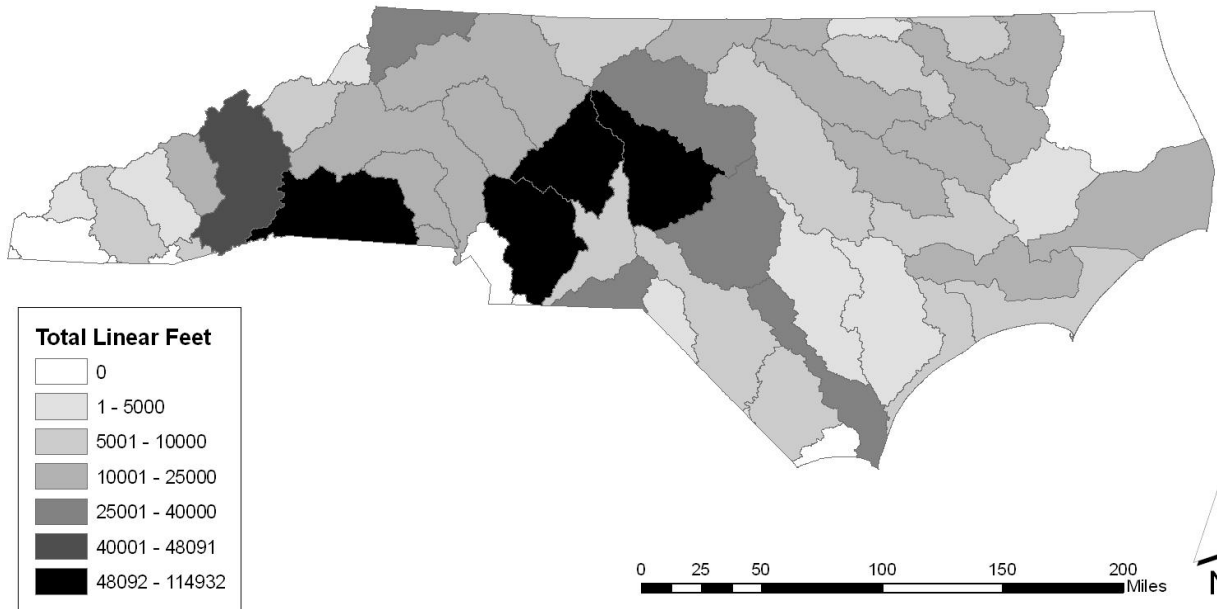
The NC DOT's projected stream impacts exhibit a significant positive correlation with 2007 population (coefficient of 0.98), and a significant negative correlation with percent population growth from 2000 to 2007 (coefficient of -7.3). The magnitude of the coefficients cannot be used to directly describe the strength of the correlation because the regression was run using logarithmically transformed data. Two other growth indicators, including percent impervious surface cover and population growth projections by 2020, show no significant correlation with the NC DOT's projected stream impacts. Looking at the NC DOT's projected wetland impacts, only the 2007 watershed population shows a significant correlation (coefficient 0.46) while the three other growth indicators show no significant relationship with projected impacts.

EEP Mitigation Credits in Relation to Growth Indicators and DOT Projections

The mitigation credits acquired by the EEP exhibit a similar trend to the NC DOT's projected impacts, in that the majority of 8-digit watersheds with high levels of stream mitigation are located in the western portion of the state, while the majority of acquired wetland credits are in the eastern portion of the state (Figure 5, below). There are fourteen 8-digit HUC watersheds containing no wetland mitigation credits at all, (including Upper Dan, Nolichucky, Roanoke Rapids, Middle Roanoke, Watauga, Tuckasegee, Albemarle, Lower Catawba, Hiwassee, Tugaloo, Lynches, Ocoee, Nottoway and Blackwater – the last two of which are under two square miles in area) and nine watersheds containing no stream mitigation credits (Carolina Coastal-Sampit, Albemarle, Lower Catawba, Hiwassee, Tugaloo, Lynches, Ocoee, Nottoway and Blackwater), shown in white on the maps below (Figure 5).

The scatter plots in Figure 6 show the EEP's available stream and wetland mitigation credits plotted against population growth by watershed. Similarly to those of the NC DOT predicted impacts, above, these plots show a generally positive trend between the amount of accumulated mitigation and the level of population growth by watershed. They also show that there are a number of outlier watersheds that exhibit either high population growth but low accumulated mitigation, or low growth but high amounts of accumulated mitigation. The notable outliers are indicated in Figure 6, below.

**EEP Available Mitigation by Watershed, 2007
Total Linear Feet of Stream**



**EEP Available Mitigation By Watershed, 2007
Total Wetland Acres**

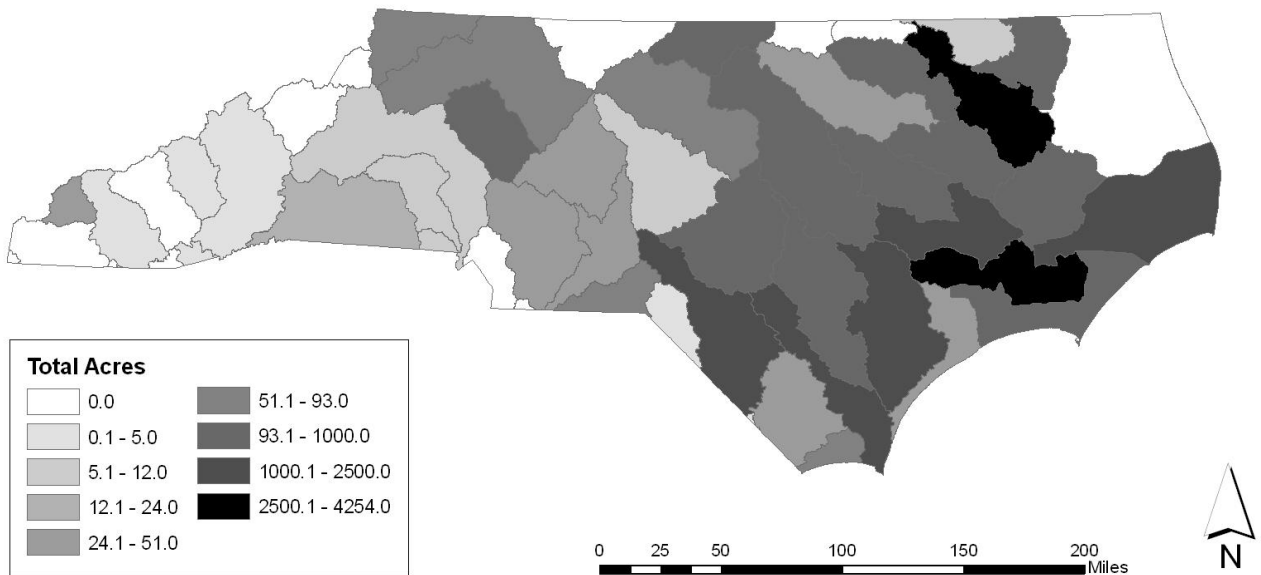
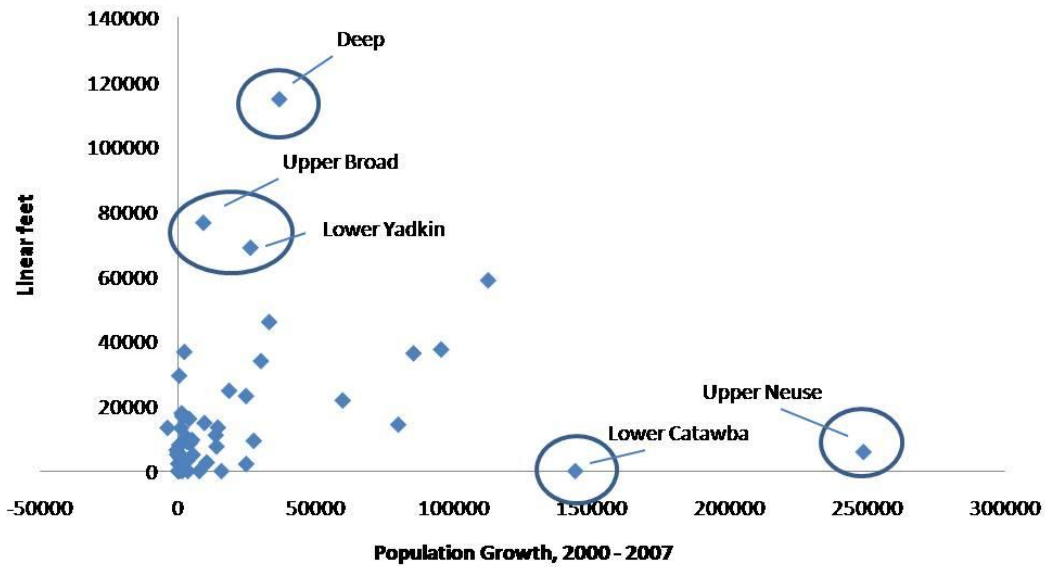


Figure 5. The EEP's accumulated wetland mitigation credits by watershed in 2007. Darker watersheds are those in which the EEP has accumulated higher amounts of mitigation.

EEP Available Stream Mitigation (2007) v. Pop Growth



EEP Available Wetland Mitigation (2007) v. Pop Growth

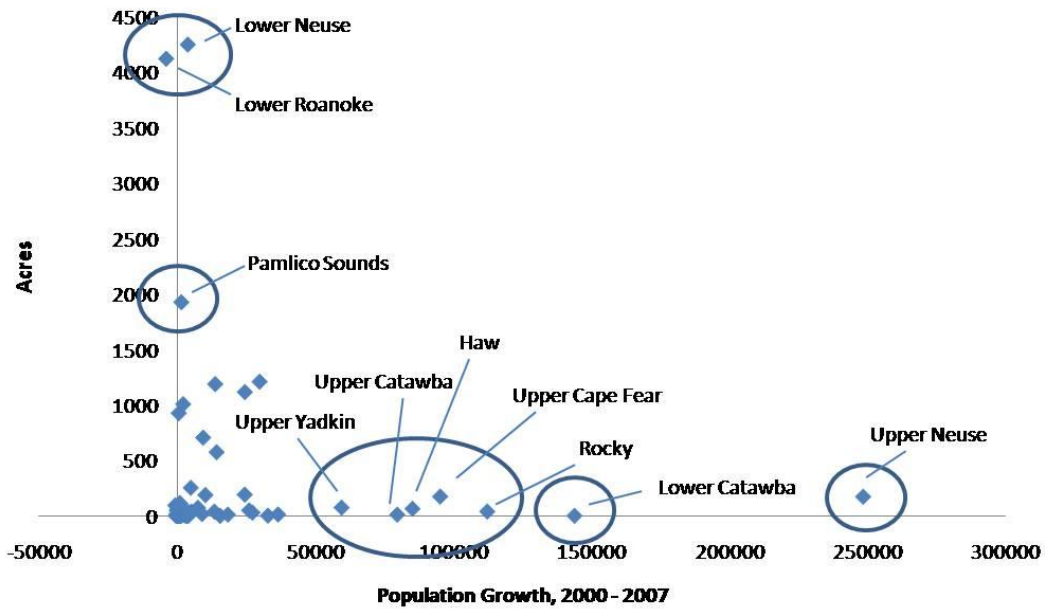


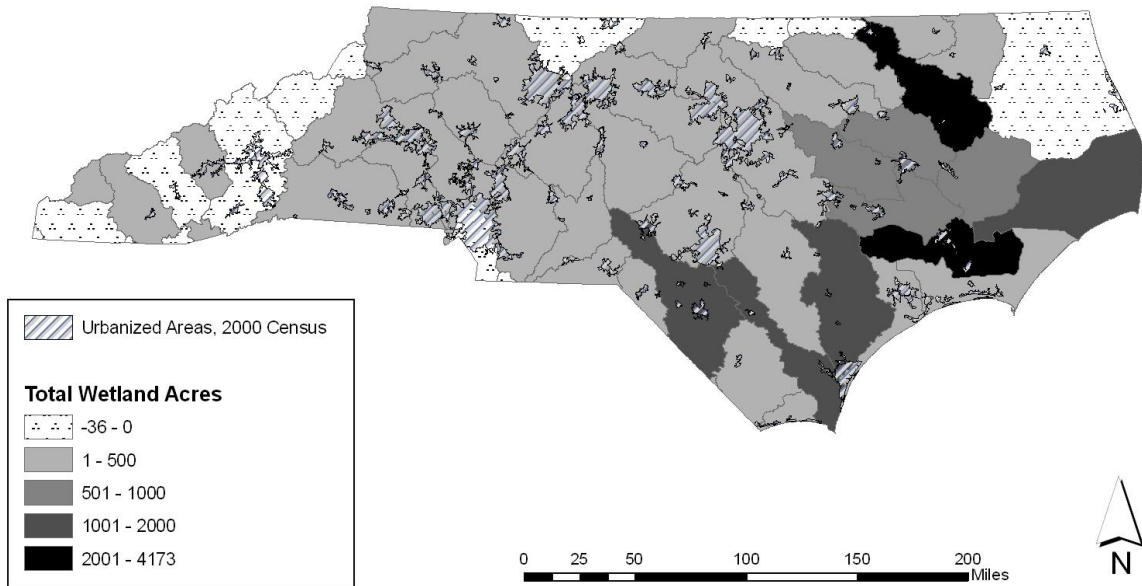
Figure 6. The EEP's available stream (top) and wetland (bottom) mitigation credits as of 2007 by watershed, plotted against population growth from 2000 to 2007. Outliers are noted.

The relationships between the EEP's acquired credits, the NC DOT's projected needs by 2013, and major urbanized areas are mapped in Figure 7, below. Speckled watersheds in the figures indicate credit deficits, calculated by subtracting the NC DOT's forecasted impacts from the EEP's acquired mitigation. At least ten watersheds were predicted to have deficits for wetland mitigation, and at least fifteen for stream mitigation if the EEP did not acquire additional mitigation in those watersheds.

As seen in Figure 7, below, the three largest urbanized areas in North Carolina – including the Triangle, the Triad, and Charlotte regions – spatially correspond with credit deficits for stream mitigation in the Lower Catawba, Upper Yadkin, Haw and Upper Neuse watersheds. Similarly, the Lower Catawba and the Haw, two watersheds containing major urban areas, have credit deficits for wetlands. Of these, the Lower Catawba (containing Charlotte) has the largest mismatch between population growth and acquired credits, given that it is one of the fastest-growing watersheds in the state, by population, but by 2007 the EEP had acquired neither wetland nor stream mitigation credits there. The Albemarle watershed, also lacking either type of mitigation credit, shows moderate levels of population growth (growing by over 15,000 people between 2000 and 2007).

Scatter plots showing the NC DOT's predicted impacts on the x-axis and the EEP's available mitigation credits for streams and wetlands on the y-axis are shown in Figure 8, below. Plots for both streams and wetlands indicate a general positive trend; that is, as the NC DOT's projected impacts increase, so do the EEP's available mitigation credits. More watersheds exhibit credit surpluses than credit deficits. In some cases, especially for wetlands, the surplus amount is very large.

**Deficit and Surplus Wetland Credits
(EEP Available Mitigation Minus DOT Projected Impacts to 2013)**



**Deficit and Surplus Stream Credits
(EEP Available Mitigation Minus DOT Projected Impacts to 2013)**

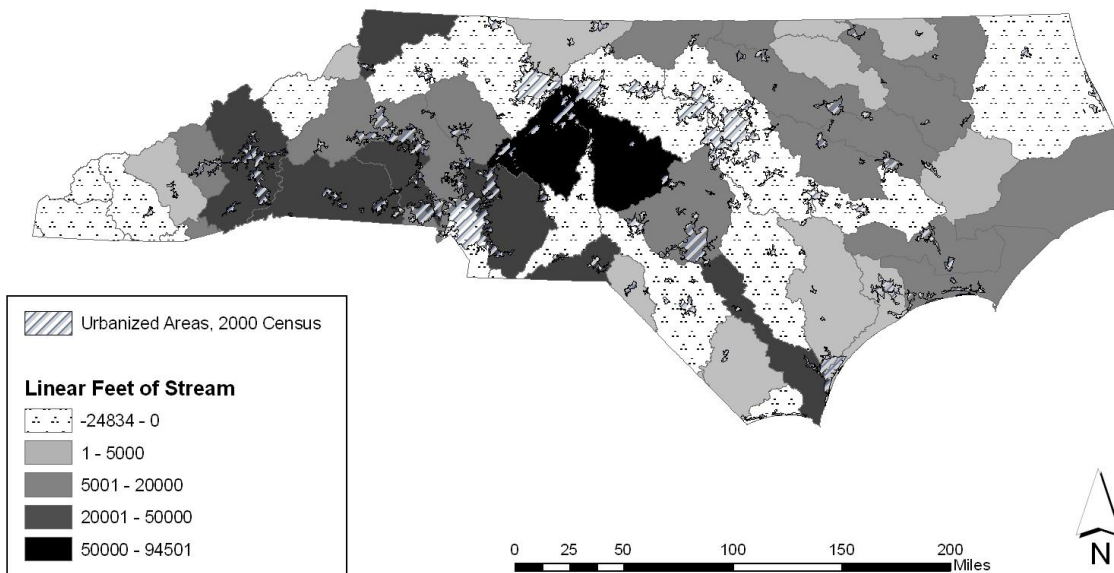
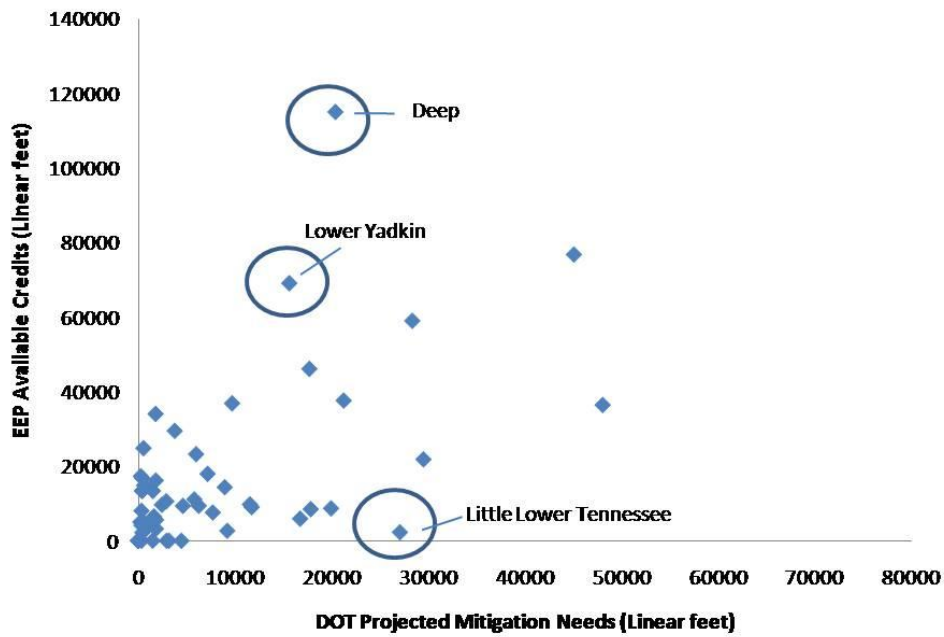


Figure 7. Watersheds with surplus and deficit credits (streams, top; wetlands, bottom). Speckled areas are watersheds in which the NC DOT's projected mitigation needs are higher than the EEP's available credits. Urbanized areas are shown in stripes.

EEP Available Stream Credits v. DOT Projected Needs



EEP Available Wetland Credits v. DOT Projected Needs

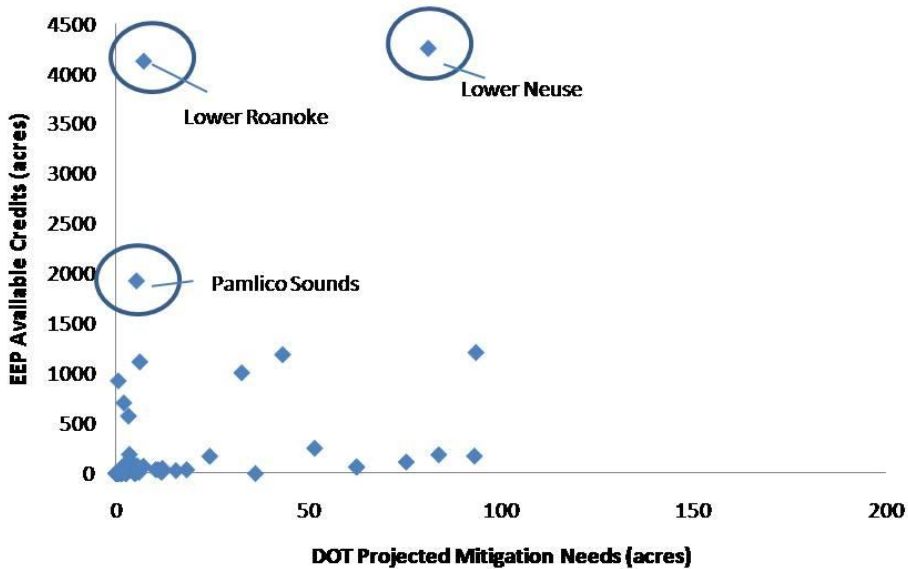


Figure 8. The EEP's available stream (top) and wetland (bottom) mitigation credits as of 2007 by watershed, plotted against the NC DOT's projected mitigation needs to 2013. Outliers are noted.

In order to determine whether there are significant statewide correlations between the amount of mitigation credits the EEP has acquired in watersheds and the level of growth in those watersheds, a regression model was run using the EEP's accumulated mitigation credits by watershed as the dependent variable. The model's independent variables include the NC DOT's projected impacts, percent impervious surface, percent population growth from 2000 to 2007, the absolute population in 2000, and projected population increase to 2020 by watershed. The results of the regression analysis, are given in Table 4, below. All independent variables had VIF of 5.29 or less. The models for both stream and wetland mitigation credits are significant (Probability > F = 0.00). The R² value of the regression model for streams is 0.53 while the value for wetlands is 0.40. In the streams credits model, two independent variables show significant positive correlation, including 2007 absolute population and a negative correlation with percent population growth from 2000 to 2007. In the wetlands credits model, only one independent variable shows a significant positive correlation (the NC DOT's projected impacts). Again, the coefficients cannot be used to describe the strength of correlation because regressions were performed on log-transformed data.

Table 4. Results of regression analysis showing the influence of growth indicators, including DOT projected impacts, on EEP accumulated credits by watershed.

Streams

Independent variable	Coefficient	Std. Error	t
Percent Impervious Surface	0.35	1.11	0.31
2007 Population	0.91**	0.39	2.35
% Pop. Growth, 2000-2007	-14.30**	5.13	-2.79
Projected Pop. Increase (absolute growth) by 2020	-0.05	0.16	-0.33
NC DOT Projected Impacts (linear feet)	0.17	0.26	0.67
F-value	10.88		
Probability > F	0.00		
R²	0.53		n = 54

Wetlands

Independent variable	Coefficient	Std. Error	t
Percent Impervious Surface	-0.90	0.89	-1.00
2007 Population	0.42	0.26	1.61
% Pop. Growth, 2000-2007	-1.03	3.85	-0.27
Projected Pop. Increase (absolute growth) by 2020	-0.07	0.13	-0.50
NC DOT Projected Impacts (acres)	0.91**	0.24	3.74
F-value	6.44		
Probability > F	0.00		
R²	0.40		n = 54

Notes: Dependent variables are the EEP’s accumulated stream credits and the EEP’s accumulated wetland mitigation credits (respectively) as of 2007. All variables underwent logarithmic transformation prior to running regression.

^ψ $p < 0.10$; * $p < 0.05$; ** $p < 0.01$

DISCUSSION

The findings above have implications about the efficiency and effectiveness of the EEP program, and provide a basis for recommendations on improving the EEP's process for identifying mitigation sites from the perspectives of growth, land use and social equity.

Social Equity and Wetland Mitigation

The results above show that communities near impact sites, as compared to those around mitigation sites, have higher total populations and population densities, higher percentages of whites and lower percentages of blacks and Hispanics, higher levels of education, lower poverty rates, higher median incomes, and higher median homes values. While some of these findings are similar to results of previous studies, other trends in the findings show notable differences from patterns in other regions.

The total population and population density trends mirror findings by Ruhl and Salzman (2006) and BenDor et al (2007), providing additional confirmation that compensatory wetland mitigation programs systematically relocate ecosystem services out of urbanized areas. Other findings contrast with socioeconomic trends found by BenDor et al (2007) in their study of wetland transactions in the Chicago region, such as their findings that wetlands were relocated to areas of higher median household income, higher proportions of whites in the populations, and higher levels of education, compared to impact sites. This difference likely reflects differences in policy regulating mitigation in the two regions, especially relating to the scale at which impacts must be mitigated. In the Chicago region, impacts are mitigated at the County level; thus wetland losses in more heavily urbanized sections of a county are mitigated in more suburban parts of the same county, still within the Chicago metropolitan region. In North Carolina, where mitigation is managed at the state level with requirements to provide compensation at the watershed scale rather than within a government jurisdiction, it is more likely that mitigation will happen at farther distances from impacts. In order to minimize costs of mitigation, it thus makes sense that mitigation will occur in areas with lower property values and higher availability of land, which, in North Carolina, correspond with more economically distressed rural regions.

In addition to some socioeconomic trends in North Carolina occurring in the opposite direction of trends found in the Chicago region, the absolute magnitude of difference between some indicators is also higher in North Carolina than in the Chicago study. There is a larger magnitude of difference between

percent white population (1.1% in the Chicago region compared to 2.34% in North Carolina), median household income (\$1,722.61 difference in Chicago compared to \$10,050.24 in North Carolina, in 1999 dollars), percent of households in poverty (0.88% different in Chicago compared to 4.20% in North Carolina) and educational attainment (differences in educational attainment near impact and mitigation sites are on the order of ten times larger in North Carolina than in the Chicago region).

Exploring the implications of these findings from a social equity perspective yields mixed results. The question is over which populations benefit, and whether certain types of populations systematically lose benefits while others gain them. The pattern of wetland relocation found in North Carolina and described in the results section, above, shows that wetlands are lost from urbanized areas that are more affluent, white, and highly educated, and wetlands are mitigated at sites in rural areas that are less affluent, less well educated, and have a higher percentage of minorities.

Given the socioeconomic patterns associated with wetland relocation, as found in the results section, it is not clear whether any broad conclusion about social equity can be made from the findings of this paper. However, due to the pattern of wetland losses from urban areas and wetland gains in rural areas, it seems that the spatial relocation of wetlands creates a disservice to communities near both the impact *and* the mitigation sites. As discussed above, in general wetlands are viewed as an amenity in urban areas; for example, proximity to a wetland in urbanized areas is associated with higher property values (Boyer and Polasky, 2004). In contrast, wetlands in rural areas are sometimes associated with lower property values, likely resulting from the lower use value of an undeveloped wetland compared to other potential uses of the site (Boyer and Polasky, 2004). Complicating the picture is the idea discussed by Ruhl and Salzman (2006) that the value lost when a wetland is removed from an area might be made up for through increased economic development activity in that area.

Additionally, the relocation of wetlands from higher density areas with larger total populations, to lower density areas with smaller populations, means that a larger number of total individuals are affected by the loss of the wetland from an urban area than by the “gain” in a rural area. While the premise of environmental justice is to avoid any disproportionate burdens on minority or disadvantaged populations, the exact nature of “disproportionate” is an ethical question left to be debated by policy makers and other stakeholders.

There are also considerations relating to the definitions of a wetland “loss” versus a wetland “gain.” While wetland loss is generally associated with the physical removal of an existing wetland, mitigation or “gain” may actually refer to the preservation or enhancement of an existing wetland. In those cases the question is complicated by the fact that a new wetland is not actually being added to an area, but instead, an easement restricts the future uses of a piece of property.

Finally, the question is raised about which members of the rural populations accrue the economic benefits of conserving wetlands through market mechanisms and property transfers. Although mitigation sites are transferred through a negotiation process between two parties (as opposed to, for example, an eminent domain approach to property acquisition by government) there are some regulatory restrictions on the amount that may be paid to property owners. In a design-bid-build transaction, the EEP must pay the “fair market value” for a property it acquires, because the NC DOT seeks reimbursement for a portion of each project paid for by the federal DOT (DYE, 2007). The fair market value is based on the existing use of the property (e.g. farming), but the EEP’s staff have found that sometimes property owners develop expectations to receive considerably higher value for the property when they realize that a state agency is interested in its purchase. The result can be a “disconnect” between expectations of the EEP and of the private property owner (DYE, 2007) and potentially a limitation on the amount received by private owners for their property.

In spite of the variety of complicating factors in this analysis, the overall findings of significant socioeconomic difference between impact and mitigation sites is a rather serious statewide finding, warranting further consideration in both research and also state-level environmental policy. The fact that wetlands increase property value more in urban than in rural areas suggests that the spatial relocation patterns may result in a net loss for society. However, since wetlands tend to be placed in more traditionally disadvantaged areas, the findings also support some more optimistic ideas about the potential to use restoration as local economic development under a “triple bottom line” model that balances social equity, economic development, and environmental protection (e.g. The Conservation Fund, 2009). For example, through creatively structured markets or entrepreneurial activity by local communities, members of some of North Carolina’s disadvantaged rural communities may find economic opportunities in wetland preservation and restoration efforts. A local organization such as The Conservation Fund’s Resourceful Communities Program (The Conservation Fund, 2009), which supports triple bottom line efforts in such communities, would be potential institution to explore this concept further.

Urban Growth and Land Use Concerns in Mitigation Planning

As noted in the results section, the spatial distribution of the NC DOT predicted wetland mitigation needs and the EEP accumulated credits differs notably from areas of projected stream impacts and acquired credits, with more concentrated wetland impacts and mitigation credits in the eastern half of the state, and more concentrated stream impacts in the western half of the state. This finding makes sense as a function of the changing landscape ecology moving longitudinally across the state, with greater changes in topographic elevation and thus a higher concentration of streams in the western half of the state and more wetlands in the flatter eastern half of the state.

The major findings from scatter plots comparing the EEP's available mitigation, the NC DOT's forecasted impacts and population growth trends by watershed show that there are a number of 8-digit watersheds in which population growth estimates do not correspond with the amounts of impacts projected by the NC DOT nor the amounts of mitigation acquired within them by the EEP. Certain watersheds throughout the state contain little available mitigation but are experiencing high amounts of growth, while other watersheds contain large amounts of available mitigation but have low growth and thus less future need for mitigation.

These findings are further supported by the results of regression analysis between the NC DOT's projected impacts, the EEP's mitigation credit acquisition, and growth indicators. Long-term population growth projections by watershed appear to have no significant influence on either the location of the NC DOT's projected impacts or the EEP's credit acquisitions. Additionally, the significant negative relationship between population growth rates with both projected mitigation needs and the EEP's acquired credits in watersheds suggests a mismatch between areas with high growth levels and areas where the EEP can readily provide mitigation. There may be legitimate reasons for the negative correlation, such as higher land values and more difficulty acquiring quality mitigation sites in rapidly developing areas, but the finding still suggests opportunity for improved procedures. Finally, the lack of a significant statewide relationship between the NC DOT's projected impacts and the EEP's mitigation credits for streams suggests opportunity for improved collaboration between the NC DOT and the EEP in terms of the accurately estimating mitigation needs and effectively utilizing those projections to acquire mitigation.

The findings discussed above suggest that the NC DOT's projected impacts and the EEP's advance mitigation acquisition procedures do not consistently incorporate population growth across the state as a driving factor in obtaining mitigation sites. This indicates a need for better collaboration between land-use planning, transportation planning and water quality planning at the state-wide level. In regions where too little mitigation is available, the EEP must either seek out new mitigation sites or, when available, send developers to private mitigation bankers. Similarly, in watersheds with large amounts of excess mitigation, the agency ends up holding property unnecessarily and accruing the associated costs. In both cases, the result is a less efficient bureaucratic process and additional cost to the agencies involved in coordinating compensatory mitigation.

Clearly, improving efficiency of the wetland mitigation program is an important state-level concern, as evidenced by the retention of the DYE group to study a possible merger between the EEP and the Clean Water Management Trust Fund (DYE, 2007) and by the passage of Session Law 2008-152 by the general assembly to promote private mitigation banking (NC General Assembly, 2008). While this paper makes only a small, initial contribution to understanding the relationships between urban growth and the mitigation process, the findings suggest that considering indicators like population growth and change in impervious surface may be useful for making decisions about where to acquire advance mitigation. The NC DOT and the EEP may be able to improve the efficiency of the mitigation process and more accurately predict where mitigation will be needed by more formally and intentionally considering urban growth when selecting sites.

CONCLUSIONS

This study offers a spatial analysis of North Carolina's state-wide compensatory wetland mitigation program from two perspectives not often considered in the wetland mitigation literature. Its two-pronged approach is intended to determine whether the relocation of streams and wetlands traded through the EEP mitigation process has had any socioeconomic implication, and also to determine whether EEP acquires advance mitigation sites in areas where there is high need due to land use changes from growth and development.

The results of the first piece of the study were rather striking, finding the strongest evidence of socioeconomic disparity between areas of wetland impact and wetland mitigation of any comprehensive study known to date. Additionally, this study looked at a finer scale and/or larger area than previous

studies on the topic. In addition to adding to the growing body of literature on the social implications of wetland mitigation, the findings also have implications for further research and for state-level policy. As mentioned in the discussion section, the findings that wetlands are relocated from more advantaged urban areas to less advantaged rural areas may have strong social equity implications, although understanding the magnitude of these implications requires a more detailed look at the social and economic value of wetlands in various geographic contexts.

The findings from the second piece of the study show that areas of higher population growth do not always spatially correspond with areas of higher amounts of acquisition of advance mitigation by EEP. The primary implication of this finding is that the EEP, the NC DOT and the Army Corps of Engineers may have an opportunity to improve their efficiency in stream and wetland mitigation by refining the methods by which urban growth indicators are considered in their advance mitigation planning process. By considering factors like land use indicators and growth projections as proxies for mitigation needs, these agencies have the opportunity to take a more proactive approach to acquiring mitigation in areas of need. In addition to measures used in this paper, these agencies may also benefit from including measures such as that rates of conversion from undeveloped to developed land in watersheds, and the number of annually approved building permits in each watershed. Collecting this data was outside the scope of this paper, but would provide important information about the rates of non-DOT development in watersheds and thus provide valuable insight about where future mitigation may be needed. Finally, the findings of this paper suggest that improving the connections between transportation and land use planning would have benefits for the efficiency of wetland mitigation in North Carolina. This aspect of the land-use/transportation disconnect is rarely discussed in existing literature but provides opportunity for improved efficiency of government functions.

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APPENDIX A: IMPERVIOUS SURFACE PERCENTAGE CALCULATIONS

Source: Travis Pate, MRCP Candidate 2009, Department of City and Regional Planning, UNC Chapel Hill.

PREPARATION

I. Download source urban impervious cover files

A. Both Zone 13 & 14 must be downloaded from MRLC for complete coverage of North Carolina.

II. Coordinate system

A. Project the urban imperviousness files [nc_is_13, nc_is_14] {Arc Toolbox>Data Management Tools>Projections and Transformations>Feature>Project} into NAD 1983 StatePlane North Carolina FIPS 3200.

III. Clip

A. Clip the urban imperviousness files [nc_is_13, nc_is_14] {Arc Toolbox>Analysis Tools>Extract>Clip} with the North Carolina state boundary (the county boundaries file [cb100_poly] was used for this purpose).

VI. Merge the Urban Imperviousness Files

A. Reclassify the clipped urban imperviousness files [nc_is_13, nc_is_14] {Spatial Analyst toolbar>Reclassify} so that raster blocks with a value of 127 = NoData.

B. Make sure the extent of the merge is set to the union of inputs {Spatial Analysis toolbar>Options>Extent>Union of Inputs}

C. Use the Raster Calculator to merge the two raster files {Spatial Analyst toolbar>Raster Calculator} by typing – Merge ([nc_is_13],nc_is_14)]. Click Evaluate. Right click on the Calculation file produced and select Make Permanent.

NOTE: At this time, due to ArcGIS and/or computer hardware limitations, the impervious cover raster file created above must be divided into smaller segments to be processed further.

VIII. Creating Impervious Cover Segments

A. Use the Dissolve tool {ArcToolbox>Data Management>Generalization>Dissolve} to create a new shapefile of 8 digit watersheds from the original watershed shapefile.

B. Use the Select tool to select individual 8-digit watersheds and export them as individual shapefiles. Note: There will be 52 of these 8-digit watersheds, use a naming scheme that will allow you to keep track of them all (example - neu1, neu2, neu3,,).

C. Use the Extract by Mask {ArcToolbox>Spatial Analysts Tools>Extraction>Extract by Mask} tool to extract the segments of the urban imperviousness raster.

D. Use the 8-digit watershed shapefiles as the feature mask.

E. Output the raster using similar naming as the mask.

F. Use the Raster to Polygon tool {ArcToolbox>Conversion Tools>From Raster>Raster to Polygon} to convert urban imperviousness raster segments to polygons.

G. Use the Clip tool to remove the jagged edges of the new polygon (left by the raster) by clipping the segment by the mask polygon created in step B.

CALCULATION

I. Calculating Area

A. Add “perct_is,” “orgis_area,” and “is_area” to the clipped 8 digit watershed shapefile.

B. Calculate “perct_is” field by dividing the ‘GRIDCODE’ attribute by 100.

- C. Calculate "orgis_area" filed in square meters by using the Calculate Geometry Tool.
- D. Calculate "is_area" by multiplying "pert_is" by "orgis_area."

INFORMATION TABLES

I. Frequency Tables

- A. Create a Frequency Table {Arc Toolbox>Analysis Tools>Statistics>Frequency} by selecting watershed identifier "HUC_8," and summarizing "orgis_area," and "is_area."
- B. Add "Prct_Is" to the table created above.
- C. Calculate "Prct_Is" by dividing "is_area" by "orgis_area" and multiplying by 100.
- D. Merge Frequency Tables for all 8 digit watersheds.