AN ANALYSIS OF SOIL CONSERVATION PLANS: AN INTERNSHIP WITH THE GUILFORD SOIL AND WATER CONSERVATION DISTRICT IN NORTH CAROLINA

BY

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CAPSTONE PROJECT

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ABSTRACT

Soil erosion reduces the productivity of agricultural soils and impairs rivers and streams through sediment and nutrient pollution. Although the current erosion rates from farmland are less than during the 1800s, agriculture is still a leading source of impairment of U.S. streams. The Natural Resources Conservation Service and Soil and Water Conservation Districts (SWCD) work with farmers to address erosion issues. The 1985 Farm Bill required farms receiving federal aid to use approved soil conservation plans to reduce erosion. During a year-long internship with the Guilford SWCD, I managed and analyzed the central N.C. county's 1,887 conservation plans. I created an Excel and GIS database to store key information from the conservation plans including the plan number, contract dates, and the acreage under each conservation practice. The conservation plans were analyzed using both the GIS interface and the statistical functions within Excel. The conservation plans covered 63,005 acres (15% of the county) and included most of the county's watersheds. By the end of 2018, the land in only 70% of the plans fully remained in agriculture, due to urbanization. The majority of the plans (68%) were written in the 1980s in response to the 1985 Farm Bill. The most common conservation practices included crop rotation, residue management, contour farming, and grassed waterways. An analysis of the years since the plans were last visited indicated that 79% of the plans were not visited in the last 23 years; however, this is likely an overestimation pointing to the lack of consolidated record keeping for farm visits. The internship was an immersive experience and included farm trips, the development of training materials to help future interns work with the SWCD, and the creation of the first map of the county's conservation plans. The results quantify the district's efforts to control soil erosion in the area using conservation plans.

ACKNOWLEDGMENTS

The completion of this capstone required more than 431 hours of direct internship experience and assistance from several people. I would first like to thank Millie Langley with the Guilford Soil and Water Conservation District for granting me access, time, and space to digitize, analyze, and manage the conservation plans. I hope that she is more than satisfied with the work I produced. I would also like to thank Jamie Walker with the USDA for taking me into the field to meet farmers and view conservation practices; thank you for sharing your office with me. The rest of the SWCD staff and board members were also very helpful and welcoming, and I appreciate the discussions we had and the feedback they provided.

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While all the professors I had at the University of Illinois enriched my education, Kingsley Allan stands out for the effective GIS training courses he taught. I developed from having minimal GIS experience to producing a complex database with almost 1,900 conservation plans during this capstone. I cannot thank you enough for your great teaching skill.

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CHAPTER 1: INTRODUCTION AND LITERATURE REVIEW

Between May of 2018 and April of 2019, I volunteered 432 hours as an intern with the Guilford Soil and Water Conservation District (SWCD). The internship was completed as part of the University of Illinois at Urbana-Champaign's Natural Resources and Environmental Sciences (NRES) master's program, in partial fulfillment of the requirements for the capstone internship course NRES 505. The 12-month internship involved research, data management, data entry, data analysis, GIS mapping, as well as writing, workshops, field visits, and more.

This section provides the background and foundational underpinnings of my internship and this paper. The internship goals and objectives, as initially designed, are discussed first. The following sections then review the literature to provide the scientific background for my work with the Guilford SWCD.

1.1 INTERNSHIP SIGNIFICANCE

The internship with Guilford SWCD provided a nice compliment to my NRES experience. As a master's student, I was exposed to coursework in four areas: social factors, ecology, modeling, and research design and analysis. I was able to incorporate my coursework in soils, ecology, GIS, and horticulture into my internship experience both directly (e.g. making soil maps and writing up training material about conservation practices) and indirectly (e.g. using course material on motivations to understand why farmers may or may not be motivated to use a given conservation practice). The internship experience provided a perfect medium through which I could apply what I had learned in my coursework while also providing real-world experience and application of course concepts which I could bring back into the classroom to enrich class discussions and assignments. Much more than basic data entry, this internship rounded out my NRES experience while reinforcing the skills and concepts discussed in class.

There are nearly 1,900 plans in Guilford County. The plans are stored in hard-copy only, in file folders in the main office. As plans are written, amended, appended (i.e. when new grants or funded projects are approved), or checked, the new contract(s) are added to the folders. Each plan may be located in various databases including the Natural Resource Conservation Service (NRCS), Farm Service Agency (FSA), or county databases. However, there was no central database or means of searching all of the information contained within each plan. Consequently, there was also no means of mapping or analyzing the data contained within the plans. The initial driver of this internship was to create a digital, functional repository where the conservation plans could be stored, searched, accessed, and analyzed.

1.2 INTERNSHIP GOALS

Before beginning the internship, a set of goals were set forth in the Graduate Internship Approval Form. Each goal, as initially constructed, is presented below. Note that in the context of this paper, "conservation plans" refers to agricultural conservation plans created by the SWCD or the NRCS to manage farm resources in a way that protects or restores the environment, conserves the soil, and maintains the productivity of the soils. The conservation plans typically include information about the landowner, property size, technical manuals, soil maps, aerial photos, and the selected conservation practices. The conservation practices commonly used include, but are not limited to, the following: grassed waterways, cover crops, conservation tillage, contour farming, crop rotations, critical areas of seeding, terraces, and field borders.

Measurable objectives were defined for each goal, as were specific tasks and activities. The percentage of time each goal was expected to take, and the expected completion dates are also listed.

Goal 1 - Manage Guilford County's agricultural conservation plans (65%)

Objective 1.1 Develop an understanding of the historical context of conservation plans (June, 10%)

- Complete a literature review relating to conservation plans and conservation practices.
- Complete a literature review relating to the previous farm bills.

Objective 1.2 Data collection, management, and analysis (November, 40%)

- Create an Excel spreadsheet and database for managing the conservation plans.
- Digitize portions of the conservation plans by entering select attributes into the database.
- Locate each property on a map and update the property information (i.e. the current landowner), the soil map, and the aerial photograph.

Objective 1.3 Develop a pilot GIS database to store and manage the conservation plans (January, 10%)

- Work within the county GIS database to digitize the existing conservation plans. This is a pilot program, rather than a full-scale integration of all the conservation plans into the GIS database. The goal is to develop a prototype GIS database of a subset of the conservation plans which will be presented to the SWCD staff to see if the data format and structure is useful for their purposes.

Objective 1.4 Provide guidance for future database management (February, 2.5%)

- Develop a written standard operating procedure (i.e. a user manual) for digitally entering and recording new conservation plans. The manual can be used by future employees or interns to keep the database up to date.

Objective 1.5 Preservation of materials (February, 2.5%)

- Store the active plans.
- With the guidance of the county office, archive the inactive plans.

Goal 2 - Analyze & evaluate Guilford County's agricultural conservation plans (35%)

Objective 2.1 Develop an understanding of the historical context of the county's agriculture (January, 5%)

- Gather information on the history of agricultural land use in the county (allotments; prison farm; primary conservation practices).
- With the U.S. Department of Agriculture (USDA) NRCS specialist, perform a site visit to one farm property in the county to assist in the early stages of developing a new conservation plan. This will provide an opportunity to acquire hands-on experience developing conservation plans as well as an opportunity to observe conservation practices actively being used.

Objective 2.2 Analyze the compiled conservation plans looking for trends (February, 25%)

- Qualitatively analyze the conservation plans. I will be looking for trends such as which types of practices are used, if there are areas of the county with more conservation plans, and how has land use changed?
- Quantitatively analyze the county data to investigate questions such as how many conservation plans have been created, how much farmland is left in the county, how

much county land has a conservation plan on it, and how much time has passed since the property was last visited?

Objective 2.3 Presentation of data (March, 5%)

- Provide training to the SWCD staff on how to utilize and update the newly created conservation plan database.
- Compile a report summarizing and analyzing information about the county's historical and current conservation plans, and present this to the district office.

1.3 GUILFORD COUNTY BACKGROUND

Guilford County is located in central North Carolina (Figure 1). The cities of Greensboro and High Point (located within the county) combine with Winston-Salem (to the west) to form the Triad region of the state. The county covers 645 sq. mi. (USCB, 2017), contains 962 farms covering about 22% (90,750 acres) of the county's area (USDA, 2012) and includes a population of 521,330 (USCB, 2017). In terms of land use, layers (chickens) constitute the largest quantity of livestock, with forage, soybeans, and wheat making up the three largest agricultural uses by acreage (USDA, 2012), although cotton and tobacco have historically dominated the local industry.

Guilford County sits right on the border between the northern Piedmont where, historically, tobacco was more common and the southern Piedmont where cotton was dominant. Today, tobacco, grains, dry beans, and nursery crops produce the largest sales in the county (USDA, 2012).

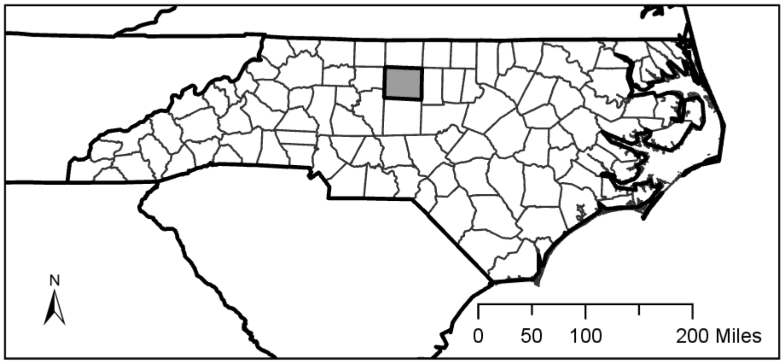

Figure 1: Map showing the location of Guilford County (grey) in central North Carolina.

1.4 JORDAN LAKE WATERSHED

Jordan Lake is a 13,900-acre lake in central N.C. along the Haw River. The lake is a water supply reservoir and it also provides recreational opportunities (NCDEQ, 2019a). The watershed extends to the northwest and covers much of Guilford County (Figure 2).

The Jordan Lake Nutrient strategy was created in 2009 with the goal of restoring the watershed's water quality by reducing upstream pollution (NCDEQ, 2019b). There are several components to this rule including nutrient reductions, construction rules, and buffer regulations. The Jordan Lake Buffer Rule protects the riparian buffers of streams in the Jordan Lake watershed by requiring a 50-foot buffer to be maintained.

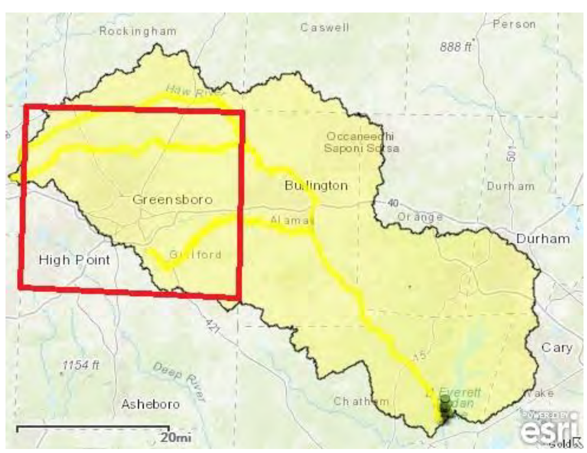

Figure 2: The Jordan Lake Watershed in N.C. Guilford County is boxed in red. Most of the streams in Guilford County are part of this watershed (data from USEPA, 2018).

Figure 3: Aerial image of a man-made pond showing extensive erosion and sedimentation. Also evident are signs of heavy animal traffic and the lack of any livestock exclusion fencing (GuilfordCounty, 2018).

Agricultural operations are frequently exempt from regulations such as labor or sedimentation rules, but the Jordan Lake Buffer Rule does not exempt farms (although manmade ponds and ditches are exempt (NCDEQ, 2012). This exemption exists despite the fact that manmade ponds may convey sediment into the larger stream system. Manmade ponds frequently do not have a buffer surrounding them, may not have an animal exclusion fence, and can show evidence of erosion (Figure 3).

1.5 GUILFORD COUNTY PRISON FARM

The Guilford County Prison Farm is a large working farm in the eastern portion of the county. The farm transferred management in 2015 and is no longer worked by prisoners. However, non-profits still operate portions of the farm and provide important benefits to the community.

1.5.1 Prison Farm Background

The Guilford County Prison Farm is an 806-acre farm that was established in 1935. According to the county's Prison Farm Transition Plan, labor was provided by non-violent offenders who were serving sentences of 3-6 months (Guilford County, 2015). There were several operations occurring on the farm including crop production, pasture land, greenhouses, and a firing range. Between 2012 and 2014, the average revenue from these practices was $535,456 (Guilford County, 2015). However, changes to sentencing laws reduced the number of prisoners allowed to work outside of the jail, which reduced the number of inmates at the farm from a high of 47 down to 7 (Guilford County, 2015). In 2015, the farm transferred management to a property management company and the farm now functions at a more public level, with several small programs operating simultaneously.

One such organization is Brothers Excelling with Self-sufficiency to Thrive (BEST), which is a non-profit working to mentor men in the city by teaching them how to grow food using hydroponic methods (Yost, 2017). As is common with urban farming, the core mission of BEST is directed at providing community services and resources, in addition to providing food. The BEST curriculum has two main missions: (1) to educate people with limited access to fruits and vegetables about healthy eating practices, and (2) to mentor young men by addressing issues specifically facing the black community (Yost, 2017).

Urban farming has a variety of benefits beyond food production. Urban farming can provide access to high-quality food and address food insecurity (Specht et al., 2014), while also addressing social issues. Social benefits include the provision of educational facilities, linking consumers to food production (Specht et al., 2014), sustaining social networks, and empowering community members to revitalize their communities (Vitiello & Wolf-Powers, 2014). BEST is a great example of the development of human and social capital because it not only connects people lacking access to food directly to the food production system, but it specifically works to mentor men to overcome society's challenges.

1.5.2 Health Benefits of Prison Farming

While some argue that the greatest benefit of urban agriculture comes from the development of social networks (Vitiello & Wolf-Powers, 2014, p. 509), the health benefits should not be overlooked. A 2016 WHO report summarizing the research on the health effects of green spaces, recognized "four principal and interacting pathways through which nature or green space may contribute to health: improved air quality, enhanced physical activity, stress reduction and greater social cohesion" (WHO, 2016, p. 4). The psychological benefits of green spaces include reduced stress and better immune functioning (WHO, 2016). Through biological, physical, chemical, physiological, and psychological means, exposure to nature, directly and indirectly, affects one's immune system (Kuo, 2015). By affecting a person's immune system, health effect such as lowered blood pressure, lowered stress, lowered risk of cardiovascular disease, and lowered fatigue can be realized (Kuo, 2015). The prisoners engaged in farming activities would likely have received physical and psychological benefits beyond what would normally be received in a standard prison sentence.

The farm experience also provided skills training. Previous studies have found that horticultural training improves a prisoner's chances of obtaining employment (O'Callaghan & Robinson, 2006) and positively impacts the community (Robinson & O'Callaghan, 2008). Guilford County's Prison Farm likely provided low-risk prisoners with access to psychological benefits and training that could be used to advance his or her place in society. Now that the farm has been converted into a public-private space, BEST is aiming for the same health and social benefits of urban farming to be delivered to a new target population: young men of color.

While farms (or green spaces) in a community offer social (WHO, 2016), ecological (Flitcroft et al., 2009), and physiological benefits (Kuo, 2015), the focus of this paper, and of conservation plans generally, is on the more narrow goal restricted to controlling sediment and nutrient loss from fields. The primary goals of conservation practices are to protect the health of the nation's waterways and to maintain the productivity of soils (especially for crop production).

1.5.3 Borrow Pit Restoration

When the prison was in full operation, there was a one-time revenue source in addition to the crop, pasture, greenhouse, and firing range on the site: the sale of fill dirt. In 2012, 100 acres were used for a borrow pit, and 307,000 cubic yards of fill dirt were removed (the topsoil was replaced). The county received $200,000 in compensation (Guilford County, 2015). A borrow pit is where the subsoil is removed for use on construction sites (i.e. roads, developments, etc.) located elsewhere. The N.C. Department of Transportation (NCDOT) has specific guidelines about how the soil should be removed and requires that the topsoil be replaced (NCDOT, 2008). The demand for fill-dirt is a rapidly growing market in the U.S. (Schiffman, 2018).

Because the borrow pit removed sub-soil from farmland, there was concern over the long-term effects on the soil's productivity for the 100-acres of fallowed farmland. Previous studies in gravel pits at northern latitudes have found that the ecological community is slow to recover, or does not return to its previous structure (Hugron et al., 2013). However, with the addition of amendments such as compost, the land can be effectively rehabilitated. For example, one study on a borrow pit in Georgia found that the addition of compost and organic material was sufficient at helping a native prairie to establish and produce greater biomass than a prairie established on a borrow pit without the addition of amendments (Watts et al., 2012). Considering that the original topsoil was replaced in the borrow pits in accordance with NCDOT standards, it is likely that while the productivity of the soil decreased, the land could still be used for agriculture or other purposes.

1.6 SOIL AND WATER CONSERVATION DISTRICTS

The first SWCD was created in south-central North Carolina in the 1930s (Cox, 2017). Conservation districts are required by state law to work with landowners and operators, both public and private, to design and implement natural resource management programs (NACD, 2019). The SWCD provides conservation assistance to all members of the community, although attention is usually focused on farmers because of regulations requiring some farms to have a certified conservation plan (Helms et al., 2006). In addition to the promotion of conservation practices frequently included in conservation plans, the SWCD provides guidance on best management practices to protect waterways of both urban and rural environments, works with the NRCS to oversee well closures and manure lagoon closures, provides outreach and education to people of all ages, and leads a state-wide environmental competition for middle and high school students.

The Guilford County SWCD is one of the North Carolina's 96 districts (Cox, 2017) which provide conservation assistance and guidance to landowners.

1.7 HISTORICAL EROSION

In order to understand the significance of erosion on croplands today, it is useful to compare today's erosion to the erosion that occurred before and during the early colonial times. In his treatise on historical soil erosion, S. Trimble (2008) determined historical erosion rates across the southern Piedmont (a region between the coastal plain and the mountains stretching from Alabama, through Georgia, South Carolina, and North Carolina, and into Virginia). Using cropping records and journals of early explorers and surveyors, Trimble pieced together a timeline of erosion in the southern Piedmont.

During the colonial expansion into the south, explorers consistently reported clear streams, even in times of storms (Trimble, 2008). However, the expansion of the colonies quickly changed the environment by the mid-1800s. Sir Charles Lyell, a geologist, wrote how once the native tribes in Georgia were expelled and the land cleared by colonists, the river quickly became cloudy with sediment (Trimble, 2008). Such reports are consistent across the region and indicate that prior to European settlement, erosion and turbidity were almost non-existent. Landslides, storms, forest fires, and Native American agriculture amounted to only "negligible" erosion rates (Trimble, 2008). Under intact forests, soil was lost at a rate of 1/10th of an inch every 1,000 years; after settlement, an estimated rate of 80 inches every 1,000 years was more common, with some areas eroding as fast as 300 inches every 1,000 years (Trimble, 2008).

Between 1700 and 1860, erosion increased across the Piedmont. Tobacco and corn were favored crops, both of which used cleared floodplains. Land was used continuously until it was no longer productive, and then it was abandoned. Slave-density correlated with soil erosion rates because more slaves could clear more land and tend more tobacco or cotton (Trimble, 2008). By 1850, a land survey of 368,000 acres in South Carolina described more than a quarter of the land as being wasted from use (Trimble, 2008). The cleared forests were used until exhausted and then were abandoned, which were then eroded with deep gullies.

Trimble determined that the greatest amounts of soil erosion occurred between 1860 and 1920. The emancipation of slaves resulted in more tenant farmers, which resulted in an increase in soil erosion because of poor land management practices (Trimble, 2008). During this time period, the streams filled with sediment, raising the water tables and turning the floodplains into wet meadows; cultivation then shifted to the uplands where erosion occurred at even higher rates (Trimble, 2008). The cleared land, steeper slopes, and more frequent flooding increased the scouring and gully formation (Costa, 1975). By 1934, "the USDA reconnaissance Erosion Survey (1934) classified over 1200 square miles of the Piedmont as 'Destroyed by Gullying'" (Trimble, 2008, p. 32).

The large amounts of soil erosion that occurred during the colonial times subsided. In the last century, largely led by the efforts of the Soil Conservation Service (SCS, later the NRCS), erosion rates greatly subsided, and the land slowly healed. Stream turbidity rates decreased substantially. According to the 2007 Natural Resources Inventory on cropland soil erosion, water erosion was reduced 43% (720 million tons) per year between 1982 and 2007. On a per-acre scale, water erosion dropped from an annual rate of 4.0 tons per acre to 2.7 tons per acre of the same 25-year time frame (USDA & NRCS, 2010).

1.8 EFFECTS OF SOIL EROSION

Intact forest is the best type of land cover for protecting the soils. Conversion of forested land into cropland not only increases erosion, but it also increases pollutants (including sediment, nitrogen, and phosphorus) entering the streams (Elias et al., 2016). Agricultural lands can also discharge bacteria, coliform, toxic chemicals such as arsenic, and parasites such as giardia (Elsin et al., 2010). Sediment, a pollutant itself, also acts as a carrier of other pollutants, which enter streams attached to the soil particle.

According to the EPA's National Water Quality Assessment, non-point pollution from agriculture operations accounts for the largest known source of impairment on streams and rivers and is one of the top contributors for impairments of lakes, wetlands, estuaries, and groundwater (USEPA, 2019). Agriculture is a major source of the nutrients polluting the Mississippi River and causing the hypoxic (low-oxygen) zone in the Gulf of Mexico (Goolsby et al., 2001). States write Total Maximum Daily Loads (TMDLs), which are pollutant reduction targets for watersheds specifically designed to address a pollutant of concern in a particular stream. North Carolina has more TMDLs written for pollutants than any other state, although most (97.7%) are for mercury (USEPA, 2019). Sediment is one pollutant of special focus for agricultural operations.

Controlling sediment lost from agricultural fields requires modeling how much sediment is lost in the first place. The Universal Soil Loss Equation (USLE; currently the revised version: RUSLE and RUSLE2) is commonly used to calculate soil lost from farm fields. The equation calculates the tons of soil lost per year, taking into consideration a rainfall factor, the erodibility of the soil, the slope length and steepness, cropping schemes, and conservation practices such as terraces (Walker & Pope, 1983). The USLE was designed for long-term predictions of soil loss (Reyes et al., 2004) for an entire field and may not reflect local hot-spots of erosion. In fact, the problem of erosion can be ultra-local; the areas of a field experiencing the highest rates of erosion can be ruined, even if the soil loss over the entire field is still acceptable (Troeh et al., 2004, p. 3). In addition, most of a field's soil erosion may occur over only a couple of storms when the soil is more exposed (Troeh et al., 2004, p. 3).

Attention should, therefore, also be paid to small areas of a farm field (such as the unvegetated areas around ponds or places where animals can access waterways) because the erosion occurring around these areas may negate the gains achieved with the other farming practices.

Degraded soils with a shallower topsoil layer are lower in fertility than healthy, deep soils. The soil that erodes may be deposited in the floodplain, in the stream, or exported downstream. When the sediment collects in the stream, not only are there negative ecological effects (USDA & NRCS, 1995), but there are geomorphological changes: the aggradation of the stream channel raises the water table and increases the frequency of overbank flows (Trimble, 2008).

Soil erosion, especially erosion on agricultural fields, negatively impacts the local and regional watersheds. Congress has passed several laws to address erosion on farmlands.

1.9 FARM BILLS

The history of NRCS and conservation districts are tightly connected. Public Law 74-46 passed on April 27, 1935 acknowledging that "the wastage of soil and moisture resources on farm, grazing, and forest lands...is a menace to the national welfare" (USDA & NRCS, 2019b). The Soil Conservation Service (SCS) was established under the USDA, and it became the Natural Resources Conservation Service (NRCS) in 1994 (USDA & NRCS, 2019b).

In 1985, Congress passed the Food Security Act of 1985, or the 1985 Farm Bill (Food Security Act of 1985 P.L. 99-433, 1986). Up until this time, conservation efforts were largely voluntary. The 1985 Farm Bill mandated that any farmer receiving federal funds and assistance have a soil conservation plan in place. The conservation plans were written by the NRCS staff, sometimes with the assistance of the local watershed district. The law required "conservation compliance", which meant that (1) "highly erodible lands" (HEL) (as defined by soil type and slope) use a soil conservation plan, and (2) wetlands must not be converted into crop production (Stubbs, 2015). Failure to comply with the law would either result in a loss of benefits or in the farmer having to pay back any benefits received. The law does not "*regulate* the use of private or non-Federal land", but simply *denies benefits* from those who "drain wetlands for the purpose of producing agricultural commodities" (emphasis added, Stubbs, 2015, p. 1).

The enactment of the 1985 Farm Bill significantly reduced the erosion occurring on farmlands in the U.S. Highly erodible lands were either farmed with approved conservation practices or converted into more protective land uses such as pasture or timber. The acres of wetlands in the U.S. increased between 1997 and 2007, although agriculture and urban and industrial development accounted for 15% and 60% of the gross loss of wetlands during the timeframe (Stubbs, 2015).

The Farm Bill is updated every five years by Congress. While there have been small changes to the original law, the two major conservation provisions have remained. The 2002 Farm Bill reauthorized funding through the Environmental Quality Incentives Program (EQIP) which farmers could use to implement conservation practices (USDA & NRCS, 2019e). The 2015 version of the law modified which crop insurance benefits could be lost if the conservation plan was not followed (Stubbs, 2015). The 2018 Farm Bill updated the law to add additional funding for conservation easements and conservation programs (USDA, 2019).

1.10 MOTIVATING FARMERS

Motivating farmers to implement soil conservation practices can be difficult, especially when there is disagreement over the relative importance of such measures. With the increasing size of both agricultural operations and equipment, and with the adoption of reduced tillage operations, many farmers may believe that conservation measures such as contour farming and windbreaks are unnecessary (Troeh et al., 2004). However, both methods protect the soil.

One's previous beliefs also affect whether people are more or less likely to change a behavior. From an ecological perspective, the SWCD and NRCS are interested in getting the greatest number of farmers to implement soil conservation measures to meet the greatest reduction in soil loss for the region. Getting new farmers on board with practicing conservation practices can be difficult. One study surveying large-farm owners' motivations towards adopting conservation practices found that while many farmers were interested or concerned in soil conservation, receiving modest financial payments "'crowded out' intrinsic motivations for contributions to the public goods" (Andrews et al., 2013, p. 501). However, other studies have found that financial incentives can be effective motivation.

A separate study by Auerswald et al. (2018) found that subsidies could effectively motivate farmers to implement soil conservation practices, but did not to change their other erosive practices. While funds are readily available to farmers for the implementation of conservation measures, farmers should not be expected to reduce erosion on their fields through the voluntary adoption of conservation measures; the use of supplemental funding and regulatory requirements such as the 1985 Farm Bill, may be needed to initiate and maintain farmers' investment in conservation practices.

Motivation is an important topic for the SWCD and NRCS. Both agencies are guided by conservation principles. The mission of the NC Division Soil and Water Conservation (the state agency which oversees the local conservation districts) is "to foster voluntary, incentive-driven management of soil, water and related natural resources for the benefit of the environment, economy and all citizens" (NCDACS, 2018). Similarly, the NRCS was created in recognition of the risk erosion posed to the nation (USDA & NRCS, 2019c). Although the agencies' missions and the laws creating the agencies recognize the importance of protecting the environment, conservation is not usually the number one concern of farmers.

A study by Rodriguez et al. (2018) investigated the motivating factors for land stewardship and personal definitions of "stewardship" among board members of the N.C. Farm Bureau. The top three motivating factors were future generations, family, and god, respectively. "The land" ranked fourth. "Yourself" was a motivating factor for 68% of respondents, compared to only 41% who included "your community". This study provides several important insights with respect to how the SWCD or NRCS could motivate farmers (both landowners and land users) to adopt conservation practices. The first is the observation that protecting the land is not the primary motivation, and the other is that personal factors are more important than communal factors. Rodriguez et al. (2018) conclude with the recommendation that farmers may be motivated when conservation is framed in the context of preserving the land for future generations. Farmers are in situations where their income depends on the amount of land in production (Rodriguez et al., 2018), so efforts should be made by NRCS or SWCD staff to develop a plan that maximizes the use of the land, as opposed to setting land aside for strict conservation.

There are financial gains that can be realized when farmers adopt soil conservation practices. A meta-analysis by Carlisle of farmers' opinions about the benefits of soil conservation practices acknowledged other studies which found that conservation practices can improve yields and income: profits could be gained through the use of cover crops because of a reduction in crop fertility needs, providing an economic savings for the farmer (Carlisle, 2016).

From a psychological perspective, motivation is guided by several key factors. People can be motivated by intrinsic factors (which benefit oneself) or extrinsic factors (which benefit others). Intrinsic factors are typically more effective motivators because when behavior reinforces one's inner beliefs, a person is more likely to continue the action (Young, 2000). This is because people are motivated by a desire for competence or mastery, thoughtful consumption, and participation in a larger community (both human and ecological) (Young, 2000). However, multiple approaches are needed to effectively implement change (Andrews et al., 2013).

People are driven by core needs and motivations. Competency, relatedness to others, and autonomy are three core needs most people have (Sheldon et al., 2001). For farmers, one's income is determined from one's ability to effectively farm, and this relates to a person's need for competency. In terms of emotional well-being, though, a person's happiness is more related to one's social standing among a group of peers than one's income (Anderson et al., 2012). By increasing the number of farmers using conservation plans, and by encouraging peer-to-peer promotion of the economic (and ecological) benefits of conservation plans, it is possible to effectively motivate farmers to adopt conservation practices. As a starting point, though, the 1985 Farm Bill carefully avoided using fully mandatory requirements. In so doing, farmers' sense of autonomy could be maintained, potentially lowering the resistance to the implementation of conservation practices; indeed, surveys of farmers indicate a "deep resent[ment of] the overbearing tactics of bureaucrats and environmentalists" (Dutcher et al., 2004, p. 327).

A survey of landowner perceptions on the importance of buffers found that many landowners believe their practices cause little harm to the streams, and that others are responsible for causing stream impairment (Dutcher et al., 2004). At the scale of watersheds, though, the size and number of farms are cumulative, causing agriculture operations to account for the largest known source of impairment on streams and rivers (USEPA, 2019).

1.11 CONSERVATION PLANS

A conservation plan "is a written record of [one's] management decisions and the conservation practices and systems" landowners plan on using (USDA & NRCS, 2019a). The "conservation plans" referred to in this project were developed by county staff--either the SWCD or USDA-NRCS staff member. Interested landowners (mostly farmers) typically develop conservation plans either because: (1) they wanted to take better stewardship of their land; or (2) because they receive government funding for projects (such as managing cover crops, protecting streams or installing a grassed waterway) and such projects required the development of a conservation plan.

While the conservation plan folders contain supplementary information such as copies of grants and financial contracts, copies of any correspondence, and old plans, the primary components of the conservation plan typically include the following:

- Landowner information (contact information)
- Property information (location, size)
- Conservation plan number (unique to every plan)
- Soil map for the property
- Aerial photo of the property
- A description of the specific conservation practices used on the property
- Field notes from each site visit performed by county staff members
- A copy of the NRCS standards for the specified practice(s)

Although there are more than 20 conservation practices that farmers may use, some of the most common conservation practices include the following:

- grassed waterways
- cover crops
- conservation tillage
- contour farming
- crop rotations
- critical area plantings
- terraces
- field borders

The farm conservation plan is designed to help farmers protect the soil and the environment by identifying potential conservation measures and farming practices that can be implemented to meet both environmental objectives and the farmers' needs. The plans are written largely to fulfill the requirements of the 1985 US Farm Bill, which required farmers receiving federal benefits to follow a written conservation plan. While the focus of the plans is environmental, there are other benefits to the farmer. One NRCS informational flyer addressed to farmers explained how conservation plans provide the following benefits: (1) maintaining the farm's productivity both short- and long-term, (2) protecting and improving the water quality, (3) improving the soil's fertility, (4) benefiting wildlife, (5) and allowing the farmer to become eligible for USDA benefits (NRCS, 2010).

Farmers are often focused on costs, and the NRCS explains to potential farmers that the design of the conservation plan costs the farmer nothing thanks to the support of the NRCS and the local SWCD. Practices requiring a financial investment can be supported through cost-sharing programs, while other practices come at not economic cost as they only require a change in farming technique (NRCS, 2010).

Conservation plans are not--strictly speaking--required (a plan is only mandatory if federal benefits (i.e. money) is obtained), and there is no universal plan. Different conservation practices are selected from among many NRCS standards and used in a way that reduces the erosion from the farm fields and fits with the farmer's abilities and practices.

NRCS staff randomly check a portion of the conservation plans every year for compliance and some counties check as much as 5% of the conservation plans every year (Haire, 2013).

1.12 CONSERVATION PRACTICES

The NRCS currently lists 138 conservation practices including everything from cover crops to wetland restoration (USDA, 2018). However, soil conservation plans for farms typically only include a small subset of the possible conservation practices and are designed to limit soil erosion through the practice of farming. Conservation practices cannot be used the same way in every situation, nor should they be expected to produce the same results. Using a living mulch of rye-clover was found to reduce the yields of tomatoes, but not of melons (Pieper et al., 2015). The NRCS staff must, therefore, create conservation plans unique to each property.

The conservation practices selected for each farm are chosen to reduce soil loss to a tolerable level ("T"). T is the output from the RUSLE. The tolerable limit is calculated based on a balance of several factors including actual soil losses, crop productivity losses, soil formation rates, and soil type. Although widely accepted and used, some research questions the acceptability of T as either being too high or too low; some even argue that T should reflect social goals such as protecting the environment by reducing air, wind, and water pollution (Troeh et al., 2004).

Tillage is typically used to prepare the seedbed for planting and to control weeds. However, intensive tillage increases the rate of soil carbon loss through the "oxidation of organic matter, destruction of soil aggregates, and reduction in water infiltration rate leading to significant water erosion and surface runoff of C-rich sediments" (Olson et al., 2016). A reduction in tillage is a common conservation practice and includes no-till, reduced-tillage, and strip tillage. Short-term studies comparing conventional tillage to no-till or reduced tillage have found that corn yields with conventional tillage are (sometimes substantially) greater due in large part to increased weed competition in the no-till plots (Edgell et al., 2015). However, conservation measures such as winter cover crops can reduce weed competition the following year (Buchanan et al., 2016). More importantly, long-term studies indicate that after about five years, the soil-health benefits become apparent in reduced tillage practices with soil organic carbon improving over conventional treatments (Maillard et al., 2018).

Contour farming (farming across the slope of the land) is another commonly used conservation practice. As mentioned by Troeh et al. in their book on soil conservation, 99% of the time, contour farming increases crop yields (10% for corn, 29% for wheat, and 11% for soybeans) because of a reduction in erosion, a reduction in the number of seeds washed away by water, and an increase in soil moisture (Troeh et al., 2004). However, contour farming requires more planning, shorter rows, and more turning of equipment; the economic costs of the extra labor and fuel required for contour farming, may not exceed the economic gains in crop yields (Troeh et al., 2004). Despite the proven economic and ecological benefits, adoption of contour farming, it is still avoided by many farmers.

Buffer strips are strips of vegetation surrounding farm fields, ponds, and streams which act to slow the surface runoff from the fields, capture sediment and nutrients, and protect the health of the water bodies. Buffer strips of different widths effectively capture sediment and nutrients (Table 1). However, to protect ecological functions and wildlife habitat, some states

Table 1: The pollutant removal efficiency of buffer strips of various lengths on farm fields in Iowa and N.C. (adapted from Troeh et al., 2004)

Buffer Strip Width (ft.)	Pollutant	Removal (%)
10	Sediment	70-80
20	Sediment	60-90
30	Sediment	85
20	Total N and P	50

such as Washington recommend a buffer of at least 200 feet around wetlands (Washington State Department of Ecology, 2005).

The soil conservation plans aim to limit erosion to an acceptable level. Soil erosion results when wind and water break down soil aggregates and the soil is transported off of the property (Olson et al., 2016). However, soil erosion also impacts the productivity of the soil by reducing water infiltration rates and soil organic carbon concentrations (Maillard et al., 2018). The selected conservation practices reduce erosion by protecting the soil from wind and water, slowing the overland flow of water, increasing water infiltration, increasing soil organic matter, and protecting the soil aggregates. Although the focus is usually on crop productivity, reducing soil erosion also protects the environment at both local and national scales (Goolsby et al., 2001).

1.13 SUMMARY

Soil conservation is an issue that addresses a centuries-long problem related to agriculture and human development. In order to maintain the productivity of the soil, and to protect the quality of the nation's streams, Congress passed legislation to encourage the implementation of soil conservation practices and created agencies (the SCS, NRCS, SWCD) to assist farmers with the implementation of such practices. Guilford County sits in the Piedmont of the southeastern U.S. and has a long history of erosion related to the dominant crops of tobacco and cotton, the presence of slavery, and the short-term view of obtaining a yield from the soils without much concern of the quality of the environment or the long-term health or productivity of the soil. Motivating farmers to adopt conservation measures required a multi-pronged approach which taps into the psychology of human motivation. Today, the conservation plans written by the NRCS for highly erodible lands have significantly reduced erosion from cropland.

Through my 12-month internship with the Guilford SWCD, I reviewed the literature on conservation practices and soil erosion, created a database for storing key information from the county's 1,887 conservation plans, managed the digital database, piloted a GIS interface to analyze the conservation plans, wrote training materials for future interns or volunteers, met with a farmer to discuss the importance of a conservation plan, and acquired an appreciation for and understanding of the work the SWCD does. The process used to digest, digitize, interpret, and analyze the data contained in the conservation plans, is explained in the following sections.

The Guilford SWCD was interested in an analysis and interpretation of its conservation plans. Because the plans were stored in hard-copy only, there was no county-wide map of the properties with conservation plans, no concept for how much acreage was written under the different conservation practices, no indication of how many plans had been converted into urban development, nor any knowledge of whether there were any other temporal or spatial patterns within the plans. These questions, and others, set the framework with which I analyzed the conservation plans.

CHAPTER 2: METHODS

The management and analysis of the county's conservation plans took nearly a year and utilized tools in both GIS and Excel. The following sections describe the methodology used for this analysis.

2.1 CONSERVATION PLANS

Consolidating, digitizing, and updating the conservation plans was a multi-step process that occurred over several months.

2.1.1 Locating the proper tracts.

The first step in working with each conservation plan was to locate the property on a current map. This step proved to be challenging in some instances because the reference map from 30-50 years ago occasionally showed little resemblance to the current day map. Several lakes in the county were constructed in that time frame, so properties were submerged along the former streambed. In many cases, though, properties were poorly referenced, and the fields had since grown into forests. In such cases, old field boundaries and/or road junctions guided me

Figure 4: A property from 1989 located "off Old Randleman Road". The location was located using the highway overpass at the lower left, and by matching the outline of the new, pine forest (outlined in white) with the pattern of the original field (GuilfordCounty, 2018).

towards the correct region; the actual property could usually be verified by tracing the boundaries of the current-day forest and verifying that they aligned with the old field boundaries (Figure 4).

2.1.2 Creating an Excel database & digitizing the plans

The conservation plans written by Guilford SWCD are contained in paper folders in filing cabinets in the office. After collecting all of the loose plan folders (i.e. folders located on desks, on top of cabinets, or incorrectly filed in other cabinets), a database was created using Microsoft Excel (2013). A total of 47 attributes (Table 2) were either extracted from each conservation plan or added based on Guilford County's GIS database of county parcels (Guilford County, 2018). A more detailed description of the attributes and the identified conservation practices can be found in the user manual (Appendix E).

2.1.3 Redacting the data

Certain information within each plan is considered confidential. In order to work on the data at home, and also to create a GIS database for (potential) public release, a redacted version of the data was needed. As indicated in Table 2, six attributes were redacted including:

- Tract number
- Owner
- Operator
- Operator's address (street address, city, and zip code)

Note that only the owner/operator(s) associated with the conservation plans was redacted. Each county parcel to which the plans were assigned also has a publicly-available owner and address, so these attributes were left visible.

Table 2: A list of all conservation plan attributes recorded in the Excel database. Several attributes were redacted for privacy purposes. (Guilford GIS = Guilford GIS Data Viewer).

No.	Attribute	Redacted?	Format	Source	Description
1	Watershed	No	Text	Conservation Plan	SWCD watershed
2	Tract No.	Yes	Text	Conservation Plan	SWCD assigned tract no. (truncated)
3	GIS - Owner	No	Text	Guilford GIS	Property owner
4	GIS - Property Address	No	Text	Guilford GIS	Property address
5	GIS - Parcel No. (REID) (Formerly ShortParcel ID)	No	Numeric	Guilford GIS	Unique ID assigned to each county GIS parcel
6	GIS - Original Parcel Changed?	No	Yes/No	Guilford GIS	Classification as to whether the GIS parcel accurately reflects the boundaries of the farm in the plan
7	Still Appears in Active Ag. (from GIS photo)?	No	Yes/No	Guilford GIS	Subjective evaluation as to whether any farm fields still exist
8	As of X Date	No	Date	N/A	Date when the GIS information was accessed
9	Owner	Yes	Text	Conservation Plan	Property owner
10	Operator	Yes	Text	Conservation Plan	Plan operator
11	Soil Map Date	No	Date	Conservation Plan	Date of latest soil map
12	Property Map Date	No	Date	Conservation Plan	Date of latest property map
13	Address	Yes	Text	Conservation Plan	Address of plan owner/operator
14	City	Yes	Text	Conservation Plan	City of plan owner/operator
15	Zip Code	Yes	Numeric	Conservation Plan	Zip code of plan owner/operator
16	Conservation Objective	No	Text	Conservation Plan	Conservation objective as specified in the plan
17	Acres	No	Numeric	Conservation Plan	Number of acres covered under the plan (typically only land with HEL classification)
18	Initial Visit Date	No	Date	Conservation Plan	Initial date the farm was visited
19	Approval Date	No	Date	Conservation Plan	Date(s) when a conservation plan(s) was approved
20	Last Visit Date	No	Date	Conservation Plan	Date of last recorded contact
21	HEL?	No	Yes/No	Conservation Plan	Does the tract include HEL
22	(Old) Wetland	No	Numeric	Conservation Plan	Wetland classification codes (no longer used)

Table 2: Continued

No.	Attribute	Redacted?	Format	Source	Description
23	327 - Conservation Cover (ac.)	No	Numeric	Conservation Plan	Acres under specified conservation practice
24	328 - Conservation Crop Rotation (ac.)	No	Numeric	Conservation Plan	Acres under specified conservation practice
25	329 - Residue and Tillage Management, No Till (ac.)	No	Numeric	Conservation Plan	Acres under specified conservation practice
26	330 & 330A - Contour Farming (ac.)	No	Numeric	Conservation Plan	Acres under specified conservation practice
27	340 - Cover Crop (ac.)	No	Numeric	Conservation Plan	Acres under specified conservation practice
28	342 - Critical Area Planting (ac.)	No	Numeric	Conservation Plan	Acres under specified conservation practice
29	344 - (Old) Residue Management, Seasonal (ac.)	No	Numeric	Conservation Plan	Acres under specified conservation practice
30	345 - Residue and Tillage Management, Reduced Till (ac.)	No	Numeric	Conservation Plan	Acres under specified conservation practice
31	362 - Diversion (ft.)	No	Numeric	Conservation Plan	Acres under specified conservation practice
32	386 - Field Border (ft.)	No	Numeric	Conservation Plan	Acres under specified conservation practice
33	411 - Grasses and Legumes in Rotation	No	Numeric	Conservation Plan	Acres under specified conservation practice
34	412 - Grassed Waterway (ac.)	No	Numeric	Conservation Plan	Acres under specified conservation practice
35	472 - Access Control (ac.) (aka Livestock Exclusion)	No	Numeric	Conservation Plan	Acres under specified conservation practice
36	510 - Pasture & Hay Planting / Mgmt	No	Numeric	Conservation Plan	Acres under specified conservation practice
37	511 - Forage Harvest Management (ac.)	No	Numeric	Conservation Plan	Acres under specified conservation practice
38	512 - Forage and Biomass Planting (ac.) (aka Pasture and Hayland Planting)	No	Numeric	Conservation Plan	Acres under specified conservation practice
39	585 - Stripcropping (ac.) (formerly 586 - Field Stripcropping)	No	Numeric	Conservation Plan	Acres under specified conservation practice

Table 2: Continued

No.	Attribute	Redacted?	Format	Source	Description
40	595 - Integrated Pest Management (ac.)	No	Numeric	Conservation Plan	Acres under specified conservation practice
41	600 - Terrace (ft.)	No	Numeric	Conservation Plan	Acres under specified conservation practice
42	612 - Tree/Shrub Establishment (ac.)	No	Numeric	Conservation Plan	Acres under specified conservation practice
43	645 - Wildlife Upland Habitat (ac.)	No	Numeric	Conservation Plan	Acres under specified conservation practice
44	FSA1 - Idle Land (ac.)	No	Numeric	Conservation Plan	Acres under FSA1 (Farm Bill) classification
45	FSA2 - Purpose & Standards (ac.)	No	Numeric	Conservation Plan	Acres under FSA2 (Farm Bill) classification
46	Other (ac.)	No	Numeric	Conservation Plan	Acres under other conservation practice(s)
47	Notes	No	Text	N/A	Notes and comments about the plan or its attribute(s)

A special step was taken to assign a reversible, or searchable, number to each tract number. Rather than being listed as "[REDACTED]", the tract numbers were converted into a coded sequence of numbers that can only be identified using the original (i.e. unredacted) data. The same process was repeated for the operators using a new set of numbers. The advantage of this method is that specific tracts can be referenced or discussed without revealing private information. The other major benefit is that analyses could be performed to examine how many plans each operator was assigned, or to count how many operators there were in total.

2.1.4 Creating soil maps

While soils in Guilford County and around the country were previously recorded in hardcopy (Stephens, 1977), soil maps are now available electronically online from the Web Soil Survey (USDA & NRCS, 2019d). Using the paper maps--with property boundaries hand-drawn on old aerial imagery--as a guide, the boundary of each property was outlined using the Web Soil Survey. The resulting soil map and soil report were printed to a pdf using either a 1"=330' or 1"=660' scale (1:3,960 or 1:7,920, respectively), as preferred by the SWCD staff (1:7,920 is 8" per mile). Printing the plans to pdf allowed for a more complete conversion of the plans into a digital format, as well as saved paper and printing costs.

2.2 GIS

Creating the GIS database for all of the conservation plans involved (1) preparing the table of conservation plans for use in GIS, (2) creating the base layers of watersheds and land cover, (3) creating a feature for every conservation plan, and (4) combining the data and the GIS features. ArcGIS Pro (Esri, 2018) was used in the preparation of all of the maps and in the data analysis.

2.2.1 Preparing the data

The first step in creating a GIS database for the conservation plans was to adjust the Excel table for GIS compatibility. Empty rows were removed, column headings were updated to begin with letters, and extraneous columns were removed. Cell contents were modified slightly to create a uniform formatting scheme for each column. Dates were adjusted to be in MM/DD/YYYY format; also, approximate dates were converted into actual dates by using the first of the month or year, depending on the degree of known specificity (e.g. 05/1976 became 05/01/1976; "ca 1981" became 01/01/1981). The column of "Approval Date" was separated into one date per cell and then combined in an aggregated master list.

2.2.2 Data sources

The Geospatial Data Gateway (USDA & NRCS, 2018) provided GIS features for watershed boundaries, roads, and county boundaries (Table 3). Land cover (2011) and land cover change (2006-2011) data came from the Multi-Resolution Land Characteristics Consortium (Esri & MRLC consortium, 2014a, 2014b). Watershed boundaries also came from the US EPA WATERS GeoViewer web mapping application (USEPA, 2018).

Guilford County has a public (static) version of the county parcels available through Esri. The 2018 version of the county parcels (Gisadmin_ps, 2018) served as the foundation for the properties with conservation plans. The GIS dataset contained all of the information available on the county's GIS website (http://gis.guilfordcountync.gov/guilfordjs/) through the release date of

Table 3: GIS layers accessed 05/29/2018 from the USDA and NRCS Geospatial Data Gateway (2018).

Dataset Name	Type of Feature Class	Description
NRCS Counties by State	Polygons	NC counties
National Hydrography Dataset 1:24,000	Lines, Polygons	NHD for Guilford Co.
8 Digit Watershed Boundary Dataset	Polygons	HUC8 within Guilford Co.
10 Digit Watershed Boundary Dataset in HUC8	Polygons	HUC10 within Guilford Co.
12 Digit Watershed Boundary Dataset in HUC8	Polygons	HUC12 within Guilford Co.
NRCS States by State	Polygons	NC state boundary
TIGER Primary Roads by State	Lines	Roads in Guilford Co.
TIGER Primary and Secondary Roads	Lines	Roads in Guilford Co.
TIGER Streets	Lines	Roads in Guilford Co.

April 2018. While the website is updated continuously to reflect the current owner(s) and property boundaries, the GIS features in the static version of the dataset did not reflect recent changes. The most important attribute for the county parcels was the REID, which is the unique identifying code for each parcel or feature.

2.2.3 Creating the base layers

A GIS database was created using the "NAD 1983 StatePlane North Carolina FIPS 3200 Feet" projected coordinate system. Layers were created for the government boundaries and roads, county and conservation parcels, and watershed boundaries.

The SWCD watershed boundaries roughly align with the NRCS watershed boundaries (Figure 5). However, the SWCD watersheds, or smaller catchments, are bounded by both topographical features (i.e. elevation) and human boundaries (e.g. roads, county boundaries, neighborhoods, etc.). The SWCD watersheds and catchments were manually drawn using the office's (hand-drawn) map as a guide.

A. B.

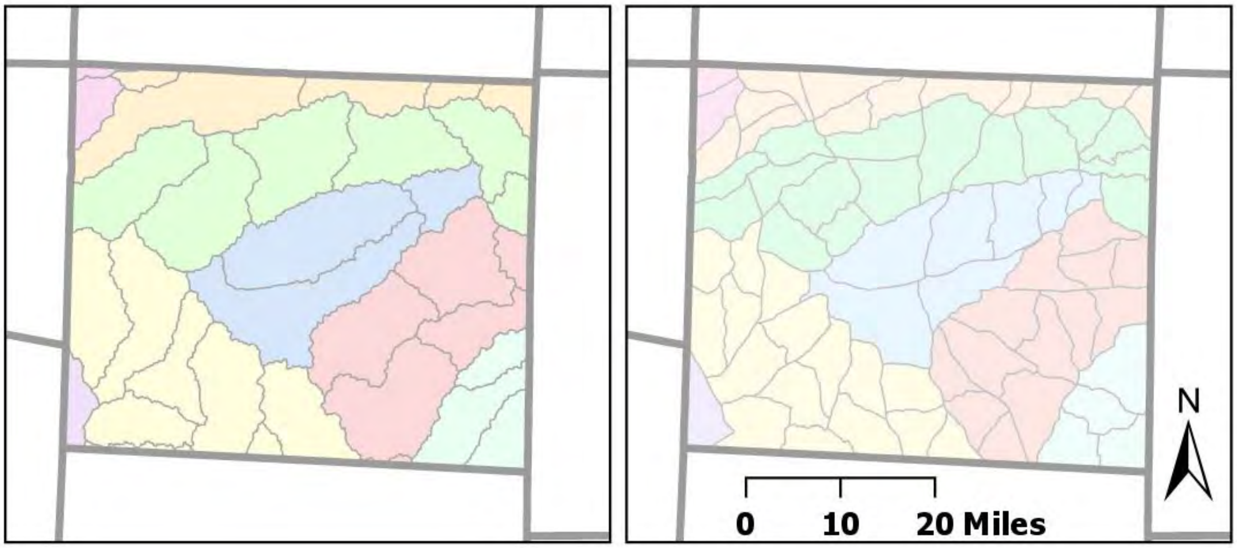

Figure 5: The similarity between (A) the true watershed boundaries, and (B) the watershed boundaries used by SWCD for the watersheds in Guilford County. Each color corresponds to a different watershed and is outlined in gray. Larger, more detailed maps can be found in Appendix A.

2.2.4 Creating the conservation plan features

Most of the features representing the properties with conservation plans were extracted directly from the county's GIS database. The Excel table of conservation plans was imported into GIS. The Parcel Number-REID field in the table was joined with the REID field of the county parcels feature class. A new feature class was created using the parcels which matched in the table. Three duplicate features were removed because they had the same REID. Twenty-nine plans were located outside of Guilford County and had to be manually created. Twenty additional plans had a Parcel Number-REID that did not match any parcel in the county database; the parcels representing these properties had to be manually selected from the county database and saved to a new layer. The tract numbers were added to the attributes of all added parcels. All of the extracted parcels were then merged into a single feature class containing all 1,887 parcels with the unique tract numbers.

2.2.5 Putting it all together

The data contained in the conservation plan spreadsheet and the overlapping GIS features were combined into different attributes of the conservation plans. The parcels were merged with the watershed boundaries (both the SWCD and HUC catchments) to attach watershed attributes to each parcel. Land cover data was combined with the watershed layers to create a table that could be used to analyze the land cover within each watershed. The resulting tables combined the parcel information, watershed attributes, and land cover data.

2.3 DATA ANALYSIS

The GIS feature class of the county parcels with all of the added information was exported to Excel for analysis. Standard error, t-tests, or ANOVA tests were not performed on the data since such tests predict the actual population value from a sample, but in this case, all values within the "population" were known and included in the analysis. Consequently, only simple, descriptive statistics (mean, range, minimum, maximum, etc.) were calculated.

The following variables or conditions were analyzed:

- Land cover in the county--both at the county and watershed scales.
- Change in land cover in the county.
- Number of conservation plans (and acreage) for plans in all four categories of "still in active agriculture?" (n/a, no, part, yes)--both at the county- and watershed-scales.
- Number of conservation practices per plan.
- Number of plans per operator.
- Most common conservation practices.
- Time-plot of when conservation plans were first written or approved.

- The number of years since the plans were last visited or updated--both at the county- and watershed-scales. The date of the last visit was calculated from the last date listed in each plan's narrative--a consolidated log of all updates to the plan.
- Plans listed under the wrong watershed were identified.

2.4 FIELD VISITS

The first field visit was an NRCS class' field trip on May 22, 2018. The class was hosted on a broiler breeder farm--which is a farm that raises chickens to produce fertilized eggs.

On January 16, 2019, I went along with the USDA and NRCS staff members to several farm sites near Whitsett in the eastern portion of the county. We met with the landowner and land user (operator) to discuss the development of a conservation plan and to discuss what additional assistance the county could provide. We also visited another farm where conservation practices (heavy use area protection, watering facilities, etc.) were being utilized.

CHAPTER 3: RESULTS

The analysis of the county's conservation plans provided the first summary of them and looked at both spatial and temporal trends.

3.1 CONSERVATION PLANS DATABASE & USER MANUAL

A total of 1,887 conservation plans were entered into a database (Appendix D), capturing 47 different attributes (Table 2). The database, along with the user manual, was designed to guide users through the process of using and understanding the data.

The steps used to convert the selected attributes from each conservation plan into the Excel database were outlined in a 20-page user manual (Appendix E). For many of the attributes, both standard procedural and conflict-resolution steps were defined. This manual not only explains how to digitize the plan information, but it also provides extensive background and training information about each attribute collected. For example, each conservation practice includes the definition as defined by the USDA-NRCS Field Office Technical Guides (USDA, 2018). With such detail, future volunteers can competently assist in the management of the database.

3.2 SOIL MAPS

Soil maps were created for 1,000 conservation plans. The maps were stored digitally on the district's internal network and labeled for easy access and reference. Most of the updated soil maps were for properties still fully or partially in agriculture. Two representative samples of the soil maps are presented in Appendix B.

3.3 GIS OVERVIEW

All 1,887 conservation plans and their associated conservation plan information were added to a GIS database. A map of the properties containing the conservation plans showed where the conservation plans were located but did not accurately represent the acreage covered by each plan (Figure 6); therefore, proportional symbols were used to accurately display the size of each conservation plan in a separate map (Figure 7).

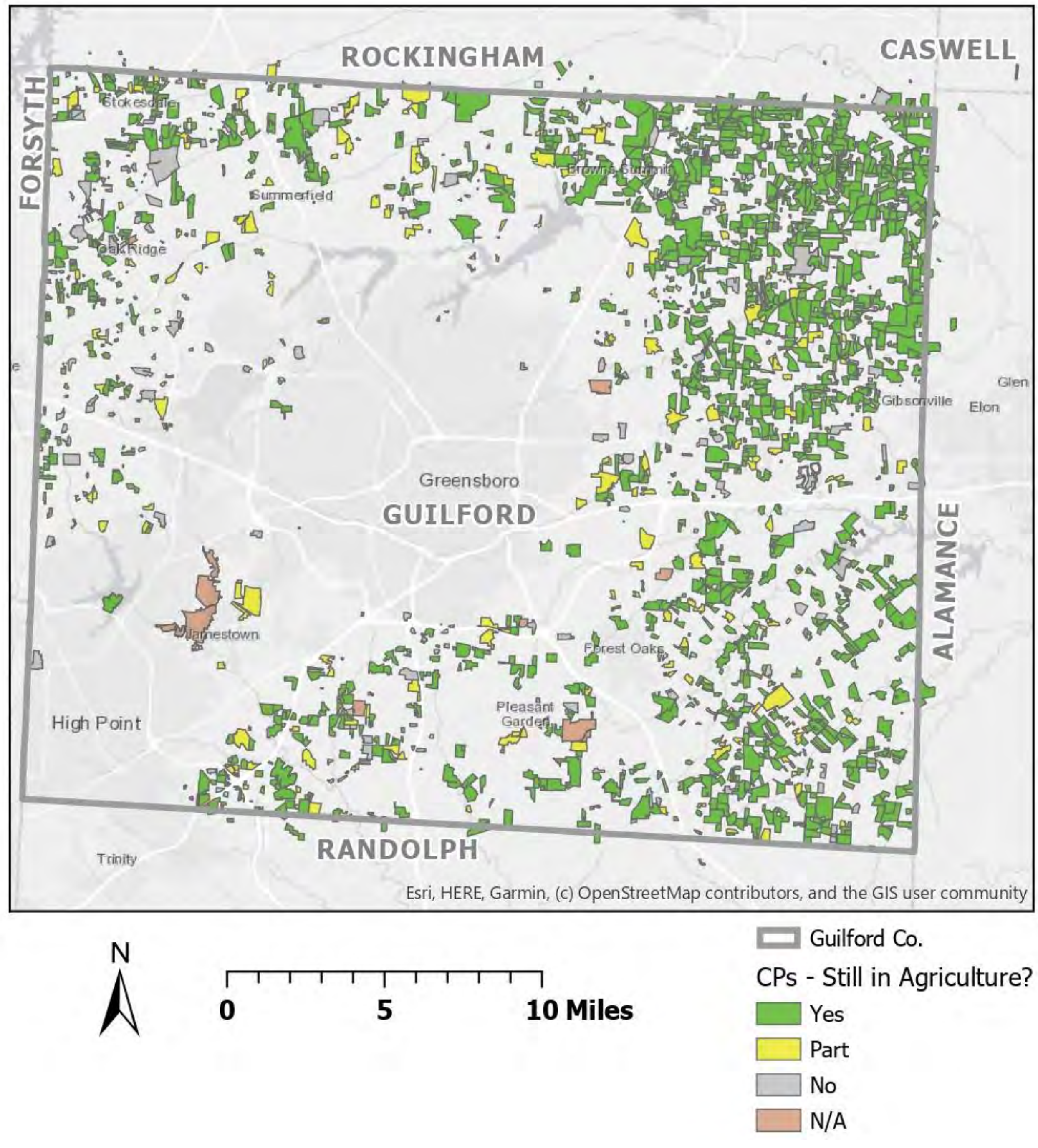

Figure 6: Since 1940, the Guilford SWCD has written 1,887 soil conservation plans. The plans cover 63,005 ac (15%) of the county. This map shows the parcels for which conservation plans were written. Twenty-nine percent of the properties were either fully or partially developed or are no longer in agriculture (as indicated by "part" or "no").

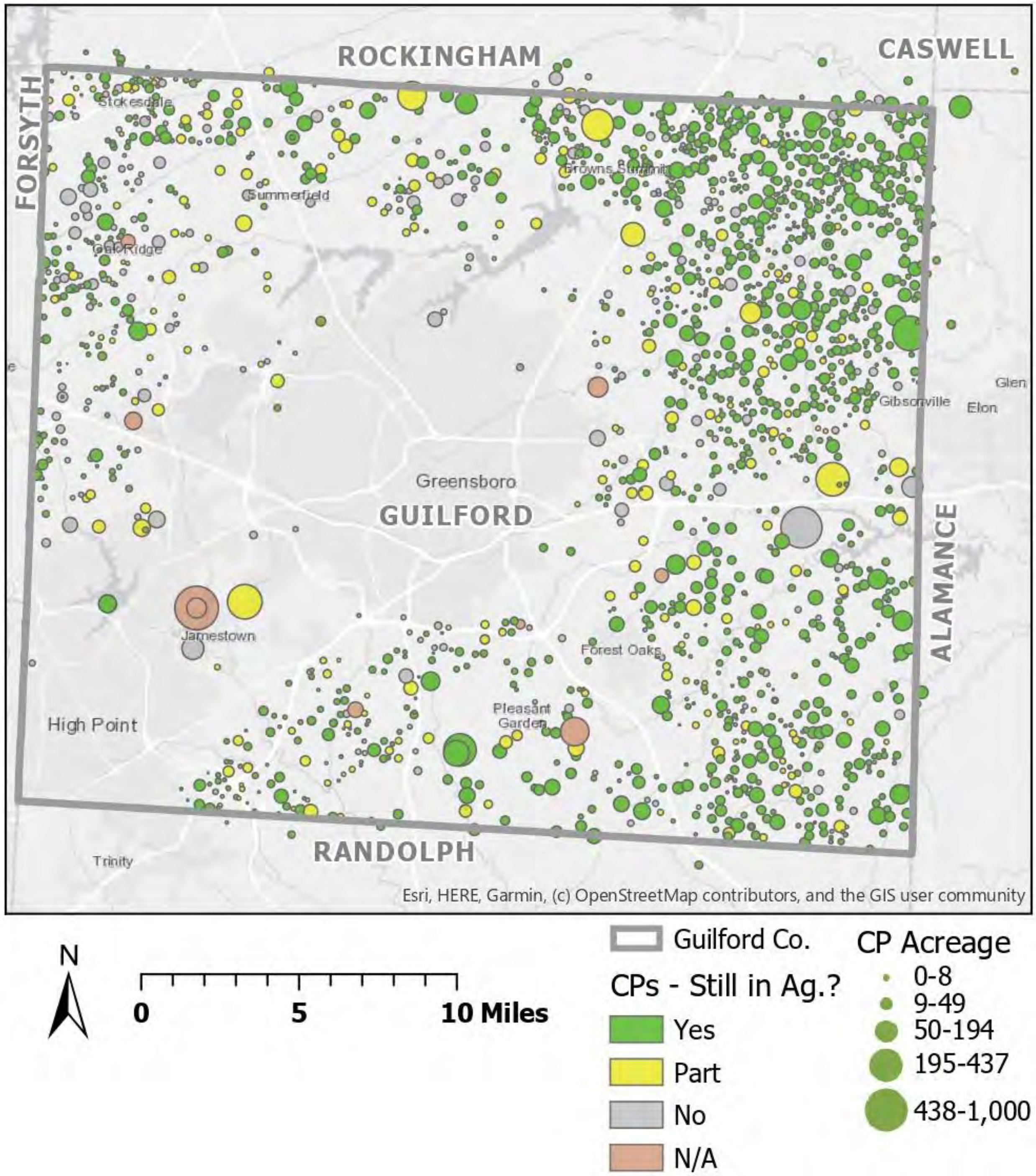

Figure 7: The county's conservation plans are represented here by symbols proportional to the acreage of land covered by each plan. The average acreage under each plan was 33 ac., but the data was heavily skewed by plans as large as 959 ac. The 1st, 2nd, and 3rd quartiles (25, 50, and 75%, respectively) were 10, 20, and 40 ac.

3.4 GIS LAND COVER

The land cover in the county is mostly forested, developed, and agriculture (Figure 8A). Of the county's 658 sq. mi., 1.5% was developed (i.e. converted into urban land) between 2006 and 2011 (Figure 8B). Agriculture was a significant source of newly developed land; 1.8% of the agriculture in the county was lost over this time period, which averaged out to a loss of 354 acres/year.

The central and SW corner of the county (where Greensboro and High Point are located) are mostly urban, while the NE and SE corners of the county have the most agriculture land cover (Figure 9). (Refer to Appendix A for a map of the land cover using the full 30x30m grid.)

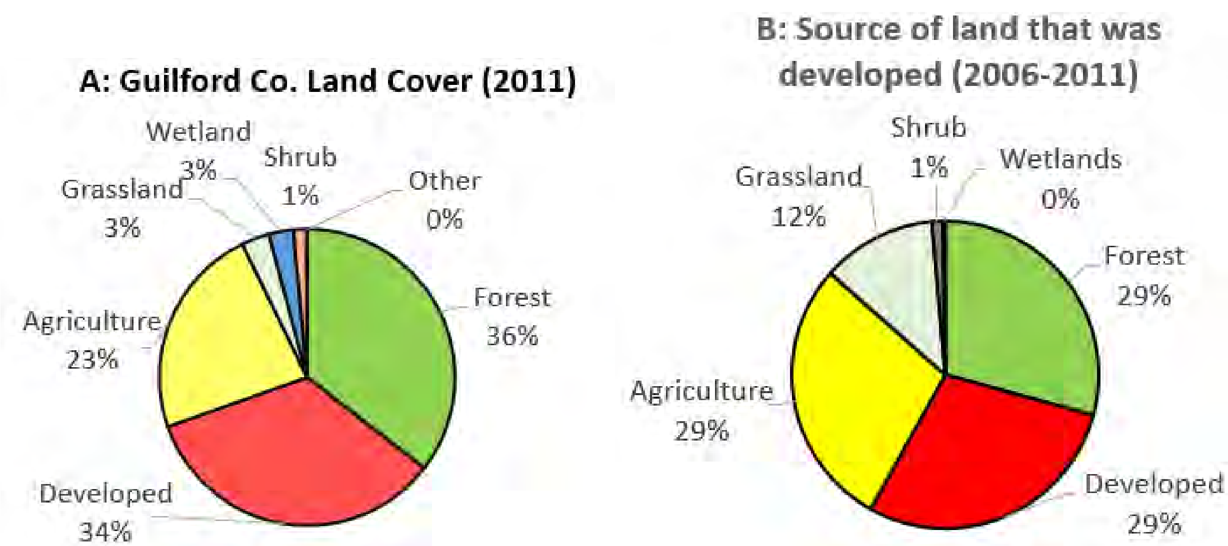

Figure 8: An analysis of the land cover in Guilford County. (A) In 2011, agriculture accounted for 23% of the county. (B) From 2006-2011, 1.5% of the county was developed at a rate of 354 acres/year; farms were a significant source of newly developed land.

A. **B.**

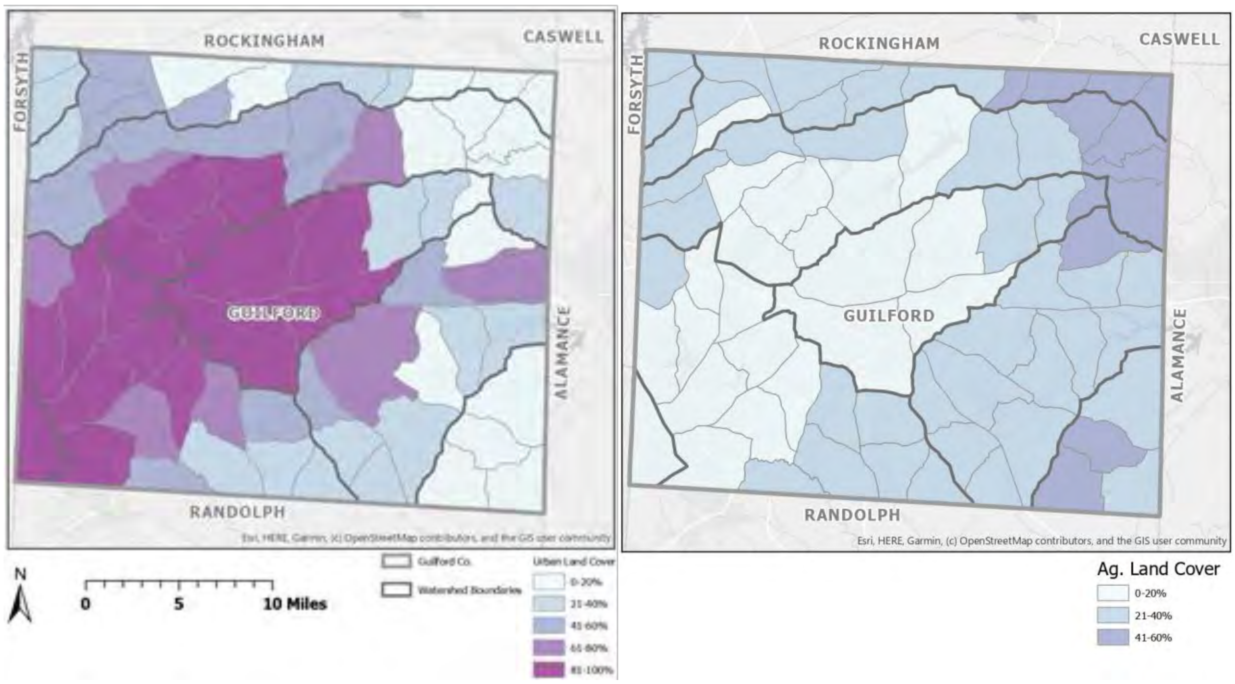

Figure 9: Guilford County is composed mostly of forested, developed (i.e. urban), and agricultural land cover. (A) The central and SW portions of the county are mostly urban because of the presence of the two main cities: Greensboro and High Point. (B) The NE and SE portions of the county have the most agriculture. The county is divided into the 71 sub-watersheds defined by the SWCD.

3.5 CONSERVATION PLAN ANALYSIS

The watersheds where the largest number of farms were abandoned or developed were located in the central and SE portions of the county (Figure 10A). The NE and SW portions of the county had the greatest concentration of conservation plans (Figure 10B).

Out of the 1,887 conservation plans, 70% still appear to be in active agriculture, while 29% were fully or partially developed. The conservation plans covered 15% of the county in terms of total acreage (Table 4).

A. B.

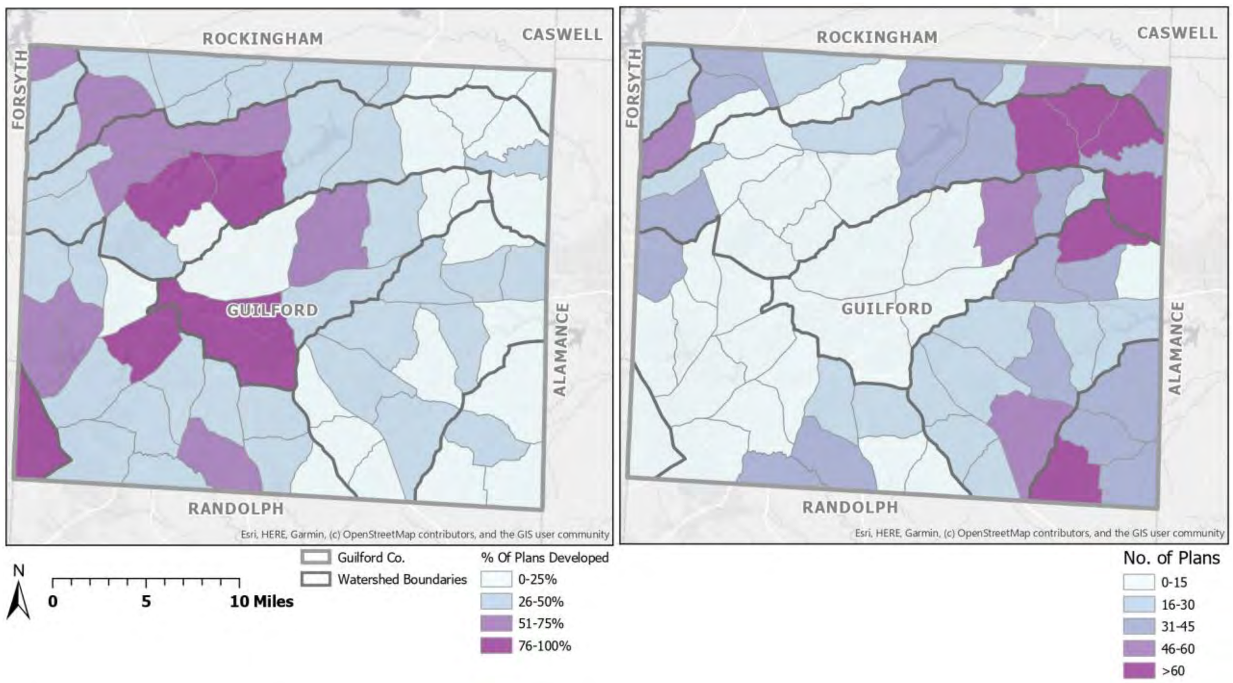

Figure 10: The county is divided into the 71 SWCD sub-watersheds. (A) The watersheds that had had the greatest number of farms "developed" (i.e. are no longer in agriculture) and (B) the watersheds with the greatest number of conservation plans are indicated in these maps.

Table 4: Summary of the status of the conservation plans with a reference to the entire county.

Still in Active Ag.?	No. of Plans	Acreage (ac)	Percentage
N/A	13	2,339	1%
No	298	7,924	16%
Part	254	10,832	13%
Yes	1,322	41,911	70%
Grand total	1,887	63,005	100%
Guilford Co. total ac.		421,000	

Each watershed had a portion of the land developed or was no longer in agriculture (Figure 11). Abbot's creek only had one conservation plan, and it is no longer active; an average of 18% of the conservation plan acreage in the remaining seven watersheds was no longer active. The county's 1,887 conservation plans covered 66,050 acres, 10,263 acres of which (16%) were no longer active.

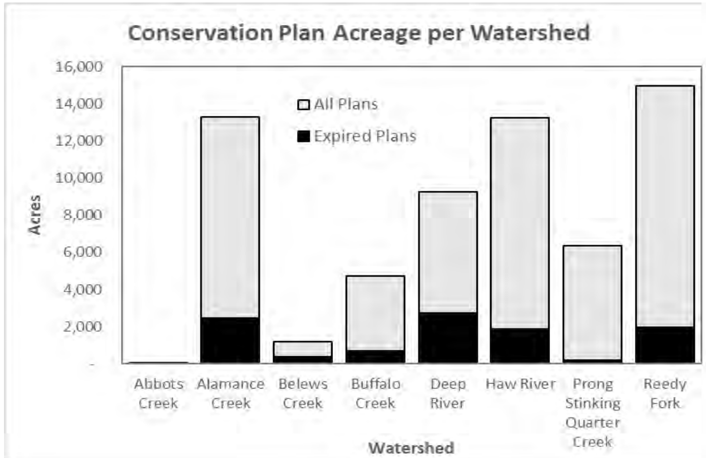

Figure 11: A comparison of the acreage within each watershed in Guilford County (gray) and the total acreage for plans which are no longer in agriculture (black).

The county's conservation plans were written for a total of 704 different operators. Most of the operators had only one plan to their name, meaning that they only tended one farm. However, the largest farm in the county had 27 different conservation plans (Figure 12).

Each conservation plan used any combination of conservation practices to get the soil erosion down to a tolerable level. Most plans used four different conservation practices, although the largest had 14 different conservation practices (Figure 13). (Practices classified as "other" could refer to more than one practice but were lumped together in this analysis.) The top

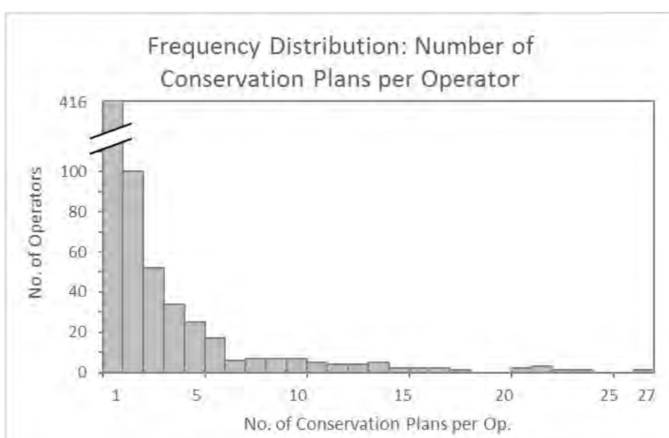

Figure 12: Frequency distribution showing the number of conservation plans per operator. Most frequently, each operator had only one plan.

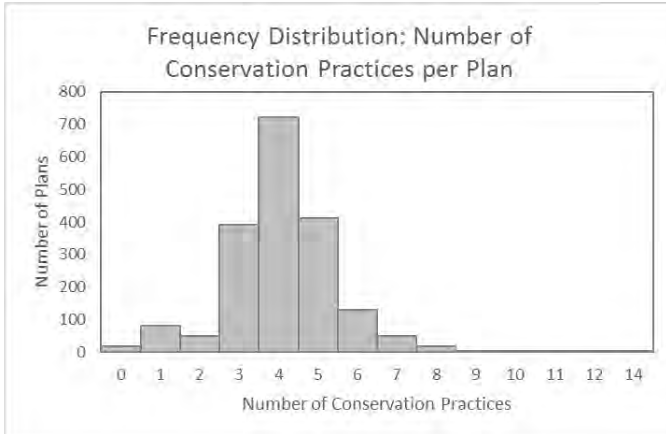

Figure 13: Frequency distribution showing the number of conservation practices per plan. The mean (not shown) and median were both four practices per conservation plan.

Table 5: The top five most frequently scheduled practices for conservation plans in Guilford County. The top five conservation practices accounted for 73% of all planned practices. (Plans typically had more than one practice scheduled.)

Conservation Practice	Count	%	Acres
P328 - CONSERV CROP ROTATION (Ac)	1,714	16%	44,158.6
P344 - OLD RESIDUE MGMT SEASONAL (Ac)	1,646	15%	41,900.7
P330 - CONTOUR FARMING (Ac)	1,605	15%	40,373.2
P412 - GRASSED WATERWAY (Ac)	863	14%	728.8
P329 - RESIDUE TILLAGE MGMT NO TILL (Ac)	515	13%	13,103.7

five conservation practices accounted for 73% of all conservation practices used in the county (Table 5).

The 1985 Farm Bill required all Highly Erodible Lands to have a soil conservation plan in place for farmers receiving federal assistance. While the first plan was written in 1940, most of the plans were written in the late 1980s (Figure 14). Once the plans were written, they were recertified, modified, or checked periodically by staff. During such updates, notations should have been made in the conservation plan narrative. According to the narratives, the average time since the conservation plans were last checked or updated was 23 years (Figure 15A); across all of the watersheds, a similar timeframe was observed, averaging between 20 and 25 years since the plans were last updated and the narrative was updated (Figure 15B).

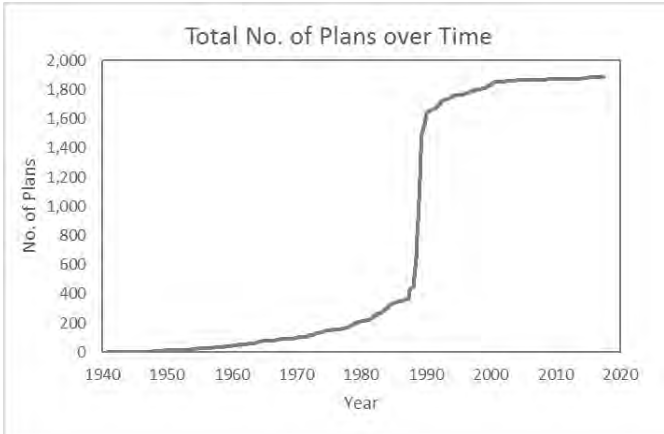

Figure 14: The cumulative total number of conservation plans written over time. Most plans were written in response to the 1985 Farm Bill. A look at when plans were approved (which is not limited to 1x/plan) shows a similar pattern (data not shown).

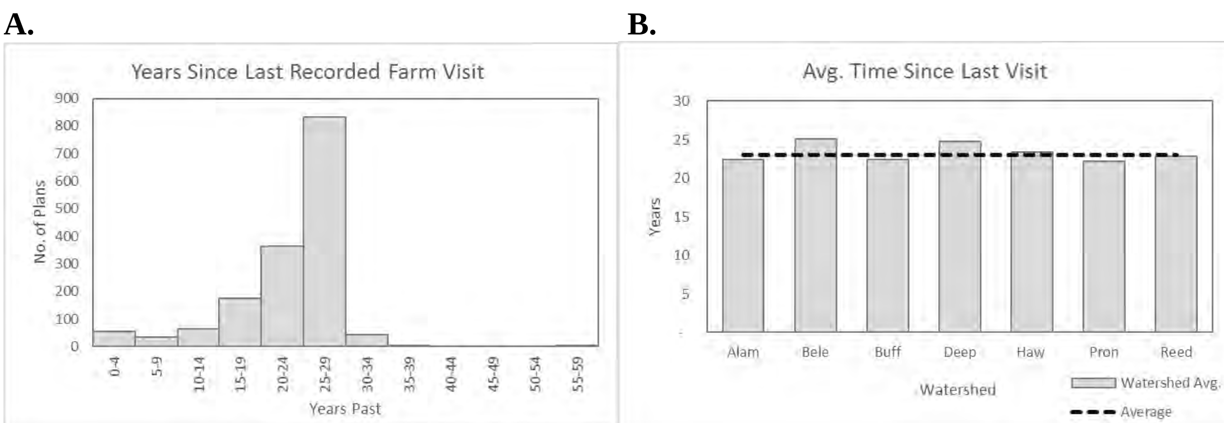

Figure 15: A comparison of the years since the last recorded farm visit. Only active plans are shown. (A) Most plans were not visited in the past 20 years. (B) A comparison across the watersheds showed a similar pattern.

3.6 FIELD VISIT

In May of 2018, I visited a broiler breeder farm as part of a training workshop for NRCS employees. We toured of one of the chicken houses which housed almost 10,000 birds. We walked through the chicken house, saw the laying boxes where the fertilized eggs were laid and collected, and practiced sorting the eggs as they came off the conveyer belt. The SWCD funded a project for a BIOvator™ and a stack house on this farm, too. The BIOvator™ is a continuous-flow horizontal compost tumbler. At roughly 35 feet long, it slowly rotates to convert dead chickens, used bedding, and water into compost. The stack house is an open, covered shed (50x100 feet) where the finished compost is stored.

In 2019, I visited two farms with NRCS and USDA staff. The first farm was located along Holts Store Rd. in Julian, in the ESE portion of the county (Figure 16). We met with both the landowner and the operator to discuss erosion on the property and the possibility of setting up a soil conservation plan. The combined fields amounted to more than 100 acres; the land user was concerned with erosion washing out the main road through the fields. Setting up a conservation plan on this property would include grassed waterways and field borders to control the flow of water and sediment. (The exact specifications and sizing requirements would be designed and determined by the NRCS staff member after running the RUSLE equation.)

We then stopped at a farm to view a conservation practice previously installed by the SWCD. The cattle farm had a Heavy Use Area Protection (HUAP) structure installed (Figure 17) along with watering facilities for the cattle in the feedlot. The HUAP is an area where the soil was replaced with compacted gravel. The cattle stand on the gravel rather than compact and erode the soil or sink up to their bellies in wet soil/manure.

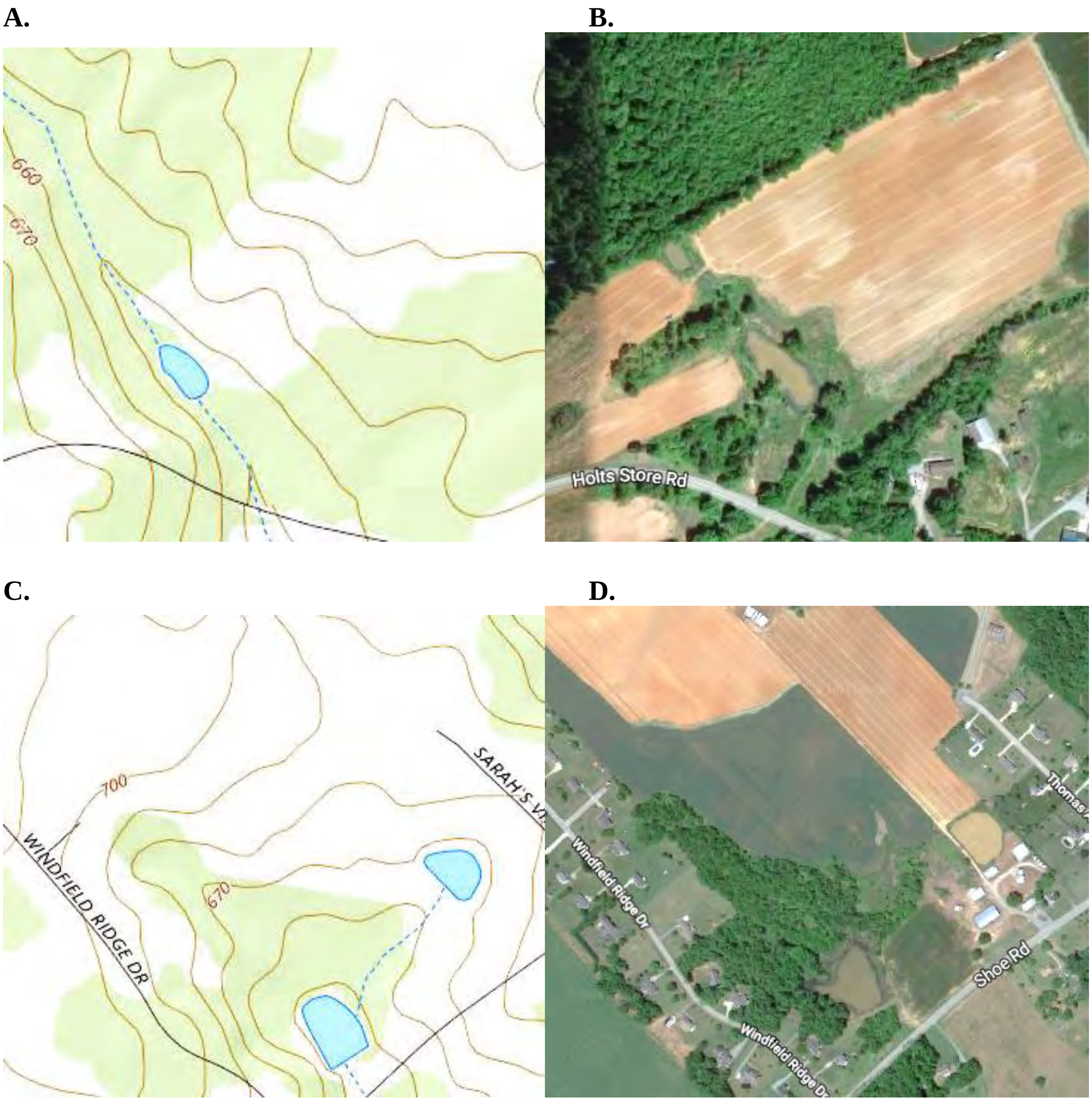

Figure 16: Topographic and aerial photos showing portions of the farm property visited near Whitsett, N.C. (A) and (B) show, respectively, the topographic and aerial views of farm field 1. (C) and (D) show, respectively, the topographic and aerial views of farm field 2. The farm rows in both instances flow downhill into the ponds; a field with 6% slope is also cropped (left field of A and B); sedimentation is evident in all ponds as indicated by a muddying of the water's color. North is up (aerial imagery from Google, 2019; USGS National Map from USEPA, 2018).

Figure 17: An aerial image showing the heavy use protected area. The cattle feeding lot is the "L-shaped" structure with the brown soil visible. (North is up.) The conservation structure is the gravel (gray colored ground) visible on the top/northern edges of the lot. When the cows gather along the fence to feed, they stand on hard gravel and cause minimal erosion (Google, 2019).

CHAPTER 4: DISCUSSION

The results from the analysis of the conservation plans are discussed in the following sections in the context of the original internship goals and the broader scientific literature.

4.1 INTERNSHIP GOALS REVISITED

A set of goals, objectives, and tasks were set forth before beginning this internship with Guilford SWCD (Section 1.2). On the whole, I was able to keep to my initial timeline and proposed work structure.

Goal 1 (managing the conservation plans) included a literature review, data collection, GIS integration of the data, the creation of guidance documents, and the preservation of the conservation plans. The literature review provided me with a strong understanding of the basis for conservation plans, including both the scientific backing and the legal precedence established in U.S. Farm Bills. The Excel database took time to develop, and as a result, the first several hundred plans had to be rechecked to update information not initially recorded. An effort was made to record information that would be useful for the staff (such as land user, acres planned, etc.), data that could integrate the information into a GIS platform (such as the unique feature ID codes associated with the county's GIS parcel database), and details that could be quantitatively analyzed (such as acres of each conservation practice). Understanding this database (both the information it contained and how it should be managed) is not straight-forward, especially for someone without a specialized background in soil science. Therefore, extensive details were included in the 20-page user manual (part of objective 1.4). The manual (Appendix E) includes information about how to transfer information from the conservation plans into the Excel database, as well as definitions and links to follow for additional resources (such as the NRCS standards for each conservation practice). It is expected that the SWCD staff, with their specialization in soil science and experience working with the conservation plans, will not benefit greatly from or use the manual very much; instead, the intended audience was future volunteers or interns who might help manage the conservation plans and keep the database up-to-date.

Objective 1.2 also included updating and creating new soil and property maps. After a discussion with my supervisor, we decided that the plan/property maps would not be updated. The Farm Service Agency (FSA), which tracks all records for every farm, already had property maps with the cropped fields identified for each farm. Further, the FSA maps are available in a digital format on the internal network available to staff. The task of creating new property maps would, therefore, have been redundant. The same was not true for soil maps. Soil maps were created using polygons manually drawn using the Web Soil Survey. The completion of objective 1.2, therefore, focused on the creation of soil maps for the conservation plans. Two representative examples of the soil maps generated by the Web Soil Survey are included in Appendix B.

A GIS database was created for all of the conservation plans (objective 1.3). Because all conservation plans, rather than just a piloted subset, were included in the GIS database, a map was created showing all county properties using conservation plans; this represented the first such map ever created. (The usefulness of having the data stored in a GIS format is discussed below.)

Objective 1.5 was to preserve the conservation plans. The initial idea was to archive the old plans that are no longer active to make room in the office drawers for active plans. However, after further discussion, it was decided that the best thing would be to leave all of the plans in the office drawers. Therefore, "archiving" the old plans became sorting and organizing the old and new plans. By December, the conservation plans were all collected, grouped by watershed, and sorted alphabetically in the office drawers. Additionally, each plan in the Excel database was marked as being active or inactive; this attribute could be used to quickly identify the inactive plans and would allow for the folders to be easily archived at a later date.

Goal 2 (data analysis) included an analysis of the land use and land cover in the county, a site visit to visit a farm in need of conservation practices, an analysis of the conservation plans, and a presentation of my findings to the board. These are discussed in the following sections.

4.2 LAND COVER & LAND USE

Guilford County's land cover is divided roughly equally between forest, developed, and agriculture. From the perspective of erosion and sedimentation, forests are the most protective land use, urban land use contributes the greatest sediment loads, and agriculture falls in the middle (Mirghaed et al., 2018). In terms of land cover, about a third of the county is protected from erosion with forest while about a quarter of the county is at risk for erosion from farmlands (Figure 8A).

Over the five-year period from 2006-2011, new development occurred roughly equally on forested, agricultural, and previously developed land (Figure 8B). These sources of new development imply two things: (1) that the new land use may be more erosive than the previous land use of forest or agriculture, and (2) that a substantial amount of agricultural land (which likely included both land cover classes of agriculture and grassland (i.e. pasture)) was developed. When a farm (or any property) is sold to development, the forests are typically cleared

Figure 18: Located along the border between Guilford and Rockingham County, this entire property was previously a forest. The property has since been divided. The bottom of the photo shows the forest that is still owned by the farmer. The development in the top half of the photo is typical for what happens when farms are divided and sold, to the detriment of the water quality: divide the parcel, sell the land, and clear the forest (GuilfordCounty, 2018).

(Figure 18); without any intact, forested riparian buffers, sedimentation is often visible in ponds. In addition, the conversion of agricultural land into urban land uses permanently removes prime, fertile farmlands from production (Troeh et al., 2004, p. 199); this could be a major concern in the future when trying to feed the growing human population.

While the SWCD works to conserve soils directly on small and large farms across the region, the impacts of effective conservation efforts can be felt across the watershed both physically and economically. Converting lands from forests to development not only changes the land use, but it also changes the erosion potential of the land. Such effects extend beyond direct soil erosion as models have predicted corresponding increases in water pollutants such as total nitrogen, total phosphorus, and total organic carbon (Elias et al., 2016). One study on the effects of improving stream water quality in a basin in N.C. found that a 30% improvement in water quality could produce a savings of up to $16.6 million from reduced drinking water treatment (Elsin et al., 2010). Such improvements could be made (or lost) directly through land use changes, as another study found that reducing forested land cover from 60 to 10% increased the cost of drinking water treatment by 211% (Postel & Thompson Jr., 2005). Having farmers apply conservation practices may be effective at reducing erosion and protecting the larger watershed, but eventually, farms may be sold to development.

Agricultural lands are being lost across Guilford County. On average, the county lost 103 acres/year of agricultural land between 2006-2011 (Figure 8B). From the perspective of the conservation plans, most of the plans that were no longer in agriculture were located in more urban areas (Figure 9A, Figure 10A), while the areas of the county with more agricultural land cover had the most number of conservation plans in place. This implies that urbanization and an expanding metropolitan area may be influencing which farms (and conservation plans) are abandoned or developed. Across the watersheds, though, every watershed lost conservation plan acreage.

The lost farmland can potentially impact the well-being of the community as a whole. Farmland, or more generally green spaces, play an important social and psychological role in communities. The presence of green spaces in communities is associated with better psychological and social functioning, better health, and less crime (Kuo, 2010). Incorporating, and perhaps even preserving, green spaces in communities expose people to nature which calms people's nervous system and provide benefits ranging from reduced rates of obesity to lower rates of cardiovascular disease and mortality (Kuo, 2010). The loss of green spaces, of which farms may be a substantial contributor, therefore, negatively impacts the community as a whole.

Another way of looking at the population the district reaches through conservation plans is to look at the number of plans every operator had to his or her name (Figure 12). Ninety percent of the operators had five or fewer conservation plans, and most (59%) had only one. This meant that the district usually worked with new people for every plan. From a management perspective, this means that the significance of conservation plans needs to be explained to a large population and appropriately applied by everyone in order to see a large effect on soil conservation; a few farmers with large tracts of land cannot be relied on to cause the bulk of the county's soil conservation efforts because the smaller farms play a substantial role.

4.3 CONSERVATION PRACTICES

The goal of conservation plans and the 1985 Farm Bill was to reduce erosion on highly erodible lands to a tolerable level determined by NRCS scientists. In order to reach the desired outcome, most conservation plans required the implementation of multiple conservation practices (Figure 13). Such an approach allowed for different practices to be used on different parts of the property, perhaps even converting poor agricultural areas into more productive (and soil-protective) pasture or timber stands; such a multi-zoned approach could lead to an increase in profits for the farmer while making big strides in reducing soil erosion (Xu et al., 2018).

The most commonly used conservation practices (Table 5), with the exception of grassed waterways, directly influence the model used to calculate soil erosion from fields--RUSLE. Crop rotations, crop residues, contour farming, and reduced tillage all affect the variables in the RUSLE (Walker & Pope, 1983). The top five practices used in Guilford County could reflect the fact that the plans are developed with a heavy reliance on the RUSLE.

4.4 FILED TRIPS

Participating in two separate field trips with district staff members allowed me to acquire experience interacting with farmers and seeing conservation practices in person--both of which were wonderful compliments to the online/distance-format of the NRES program. The first trip to a chicken farm allowed me to not only see a chicken farm in action but also exposed me to a farmer's perspective on the importance of his farm's environmental impacts. The chicken farmer had a BIOvator™ composter and a stack house. The BIOvator™ is a continuous composting unit the farmer uses to compost dead chickens. The stack house is a large (100x50 feet) covered but open shelter used to store used chicken litter, manure, and compost until it could be spread on the fields or given to neighbors. Combined, these two units operate to reduce the nutrient management concerns on the property. Keeping the litter, compost, and manure covered protects it from rain which would run off the piles and carry nutrients into the local waterways. The BIOvator™ allowed the farmer to dispose of the dead chickens in a more economical and environmentally friendly manner; before the BIOvator™, the farmer incinerated the chickens which required fuel and could require an air quality permit. Farms around the county have received funds for similar projects with the goal of improving nutrient management (USDA & NRCS, 2019e).

The second set of farms I visited provided me with a perspective on interacting with an experienced farmer during the early stages of setting up a conservation plan. A key takeaway from this meeting was the importance of the collaborative discussion between the farmer and the district staff. The farmer was knowledgeable about how to farm, and what erosion happens on the farm, but the district staff was needed to impart the knowledge and importance of using appropriate soil conservation practices. Indeed, farmers typically care about soil health, but existing routines, limited knowledge, and a perceived risk of lower economic returns all limit a farmers' adoption of specific conservation practices (Carlisle, 2016). By developing the best combination of conservation practices, the district staff can acquire the buy-in of the farmer which allows for the implementation of effective soil conservation practices.

We also viewed a nearby farm with a heavy-use-area-protection installed in a cattle feedlot. The protection involved replacing the soil with packed gravel. Doing so reduced sediment loss because the cattle stand on a hard surface rather than an erodible one (USDA & NRCS, 2019e). Seeing a small sampling of the different conservation practices used around the county reinforced a core design feature of the way conservation plans are designed: there is not a single practice which can be uniformly applied to all farms to reach the same set of goals. Practices need to be selected based on the farm's environment and the farmer's preferences and abilities. The goal of conservation plans is to reduce soil erosion, but there are numerous ways to reach that goal.

4.5 PLAN MANAGEMENT

The 1985 Farm Bill "required that new conservation plans be completed by 1990 on the approximately 140 million acres classified as highly erodible. In contrast, in 1984, the year before compliance was enacted, NRCS assisted with plans on about 2.5 million acres" (Stubbs, 2015, p. 7). Looking at the timeline of when most of the conservation plans were written (Figure 14), the plans in Guilford County follow the congressional mandate, as indicated by the jump from only 300 conservation plans in 1984 to 1,632 by 1990.

There are many people, agencies, and documents associated with each conservation plan (grants, applications, inspections, plans, updates, correspondences, etc.). Each plan contained a "narrative" page specifically for keeping track of the dates when the plan was worked on, or when the plan operator was contacted. However, this form appeared to be updated infrequently, especially if the USDA or NRCS staff visited the farm (FSA, USDA, and NRCS each have their own forms they use). These separate forms were typically added to the conservation plan folder (as they should be), but no notation was usually made on the narrative page. This lack of consolidated notations skewed the analysis and made it appear that the conservation plans were not visited in 20 years. It was considered whether the plans closest to the district office were evaluated more frequently at the expense of more distant plans, but this pattern was not observed as all eight watersheds showed a similar lapse in reported time. To resolve this, whenever a conservation plan is accessed (for any purpose), the narrative should be updated to include the latest date. Indeed, discussions with board members and a look at the supplemental information included in the plan folders (such as spot checks) indicated that the farms were visited more often but that the narrative was not updated with the more recent date. Consequently, it was difficult to ascertain from the present study how recently the plans were *actually* visited (or not), and it is recommended for future studies to repeat the analysis using all documented visit dates as evidenced by the supplemental plan information. Such an analysis would indicate how frequently the staff members visit each plan and could serve as evidence for soliciting funding for additional staff members if the staff is, in fact, unable to visit each site more frequently than once in 20 years.

4.6 APPLICABILITY OF GIS

A significant component of my internship was to pilot storing the conservation plans in a GIS database. While I accomplished the major step of creating GIS features (polygons) to represent every conservation plan, many challenges and potential conflicts became apparent. The challenges notwithstanding, there were many potential benefits from storing and using the conservation plans in a digital GIS database.

GIS features are useful, especially in providing visuals and visual comparisons. For example, the land area covered under a conservation plan can be shown on a map, similar to Figure 7; the plans can be displayed using symbology techniques to show current vs. active plans or to highlight the plans with the most conservation practices. The visuals could be used by the county in communicating their work with the public or in seeking additional funding. The county currently operates a GIS web application that the public can use to find and identify any parcel in the county along with information such as the owner and the owner's address. It is possible that the conservation plans could also be made available for the public to access in a similar way as the county parcels. An important benefit of the GIS feature would be that plans could be selected by location to identify a group of plans that could be checked for compliance; another benefit to using a GIS application is that the plans which are improperly cataloged in another watershed could be easily identified.

However, my assessment was that for the purposes I expect the district staff to pursue, the Excel database could provide most of the needed analyses that the GIS database could offer (with the exception of visual displays and map overlays). The Excel database allowed for the creation of summary reports, the calculation of smaller analyses (for example, for a particular watershed, or for all of one operator's properties). Connecting the Excel database to a GIS layer proved to be quite cumbersome and may prove too difficult for the district staff without a strong GIS background. Formatting errors and corrections were needed when connecting the Excel database to the GIS feature set. The full-scale use of a GIS system would require the district staff to devote more time to learn the software--time which is stretched thin as it is.

Another issue with using a GIS database was that of the underlying features. The FSA has a GIS database that currently stores every farm. Using these features would be the most accurate way to display and track the farms with conservation plans. However, plans and farms change, and the FSA, not SWCD, manages the GIS database. How to deal with changes to the farm features is a major concern. Another option, and was the one that I pursued, was to use Guilford County's GIS features using the county parcels and property plots. These features were available both internally (which the district could presumably have access to), and publicly (which is the version I accessed), although the public version was not "live" and did not reflect the latest changes.

One of the challenges that arose centered on the fact that the GIS features I used (from the public GIS layer) were not up-to-date. While the Excel database had unique identifiers that can link the spreadsheet to the GIS layer, it was not a perfect process since properties change. Specifically, I had to manually identify and correct 90 parcels whose unique identifiers did not match any feature in the GIS database I was working with; I also had to add 26 features for plans located outside of the Guilford County boundary and duplicate 20 plans for properties that have more than one conservation plan. There are different methods that can be used to join an Excel table to a GIS layer; when I tried the different approaches, I got varying levels of success. In addition, even from the time since I began this project, the unique identifiers and GIS information changed for a portion of the plans recorded in the Excel database; this means that not only does the data in the Excel database not perfectly match the data in the GIS database, but it also does not align with the current property information because of different dates when each was created.

Further, the responsibility for updating both the Excel database and the GIS layers would likely fall largely to future interns or volunteers working with the district. While I provided a wealth of training material in the form of the user manual I wrote, training future volunteers in how to manage the GIS database is impractical.

Therefore, it seems likely that whether the district was to use the county or FSA GIS features, problems would likely arise when updates or edits are made (i.e. constantly). What this all likely means, in my opinion, is that the GIS database is useful visually and (somewhat) functionally. But the complications that arise with keeping the database updated and accurate, or even just trying to link the database to the data tracked in Excel, is too difficult to be adopted at this time. If the source features from the FSA or the county were static, it would be simpler; but because properties are dynamic, it is more complicated. The district staff is busy with tasks as it is, and the benefits gained from storing the conservation plans in a GIS version are minimal. I believe that there are too many software applications being used by the district (FSA GIS database, FSA and USDA farm-tracking software, Web Soil Survey, NRCS Electronic Field Office Technical Guide, etc.) to justify the addition of one more. The Excel format allows for many analyses to be performed on the conservation plans, and I think it will be a very useful addition to the district's resources. Given the staff's time constraints, though, even the Excel database will likely have to be updated by future interns or volunteers.

It should be noted that some SWCDs in the U.S. utilize GIS to manage their conservation plans. For example, the USDA offers a new GIS software system to identify agricultural fields conveying the most sediment into streams by integrating elevation and hydrologic models (NAL, 2019; see also NCRWN, 2019, and Tomer et al., 2015). The Agricultural Conservation Planning Framework (ACPF) Toolbox, as it is called, is the latest method for identifying high-risk areas and developing the best suite of conservation practices for a farm.

4.7 RECOMMENDATIONS TO THE BOARD & STAFF

The internship concluded with a presentation to the SWCD Board of Supervisors and staff members. A summary of the recommendations is discussed below.

Have future interns update the Excel database: While new conservation plans can easily be added to the Excel database by staff members, updating the existing conservation plans will likely fall to future volunteers or interns. The user manual will guide volunteers of all educational backgrounds through this task.

Do not use a GIS database to store the plans unless or until it is more fully integrated into daily use: While a GIS database is a novel and sometimes useful way of storing and accessing the conservation plans, the benefits and drawbacks do not warrant the implementation of such a system at present. (Refer to the previous section for a more detailed discussion.)

Keep the notes in the conservation plan folders updated: As touched on in the Plan Management section above, there are many people involved with each conservation plan and many different forms or contracts. When farms are visited, or new contracts are written, the notes do not usually make it into the consolidated narrative section of each plan folder. Consequently, it is difficult to quickly determine when a property was last visited. Updating the narrative notes is quick and easy and would improve the accuracy of the Excel database.

Remind farmers about riparian buffer rules: Farmers are not exempt from the Jordan Lake Buffer Rule, so they must maintain designated buffers.

Remind farmers that small portions of their fields can account for the majority of their soil loss: Conservation practices are powerful tools to conserve soil, but spotty practices can negate the overall effectiveness of a property's conservation plan.

A suggestion to approach soil conservation from a more holistic, ecological perspective: There are improvements that can be made from the standpoint of a more holistic conservation goal. For example, consider the broader ecological impacts of farming and sedimentation when discussing conservation plans with farmers. As an example, consider the following question:

What if farm ponds could not only provide irrigation water for agriculture and trap sediment but also be a healthy habitat for wildlife?

Such an ecological shift in perspective would be needed at the national level. The NRCS, USDA, and SWCD do a lot of work towards limiting erosion and working towards conservation goals. At a national level, though, conservation goals are often segregated (projects are designed with a focus on soil conservation, erosion reduction, wetland restoration, etc.). While there is nothing inherently wrong with this approach, I believe it oversimplifies and narrows project objectives to the detriment of the landscape-level ecosystem. After all, models like RUSLE and WEPP (the Water Erosion Prediction Project), explicitly focus on managing erosion and sedimentation (Flanagan et al., 2017). Designing conservation plans to meet ecological goals would also meet the traditional conservation objectives (maintaining productivity, profits, and soil health) because the ecological goals likely require lower erosion rates and may have the added benefit of providing pollinator and predator habitat for more holistic pest management.

CHAPTER 5: INTERNSHIP SUMMARY

5.1 SUMMARY OF ACCOMPLISHMENTS

The following list includes the major accomplishments from the internship.

- Volunteered 432 hours of work between May of 2018 and March of 2019.
- Researched historical land use in the area within the framework of natural resource management.
- Created an Excel database of all 1,887 plans.
- Created a redacted version of the database.
- Wrote a 20-page manual on using the Excel database for future volunteers and interns to use.
- Identified plans as being developed (i.e. urban/residential) or active; the "developed" plan folders can now be easily identified and archived if desired.
- Created a pilot GIS database for storing the conservation plans.
- Created 1,000 new soil maps for the conservation plans, covering about 2/3 of the active plans.
- Attended a site visit with USDA and NRCS staff to view active conservation practices and see the development of a new conservation plan.

5.2 FROM THE CLASSROOM TO THE INTERNSHIP

My capstone experience with Guilford SWCD was very rewarding and complemented the NRES program nicely. Seeing different conservation practices, learning how conservation plans were created, and interacting with farmers, staff, and board members were learning experiences I could not get in the classroom.

The internship allowed me to acquire hands-on and field experience working with one of the leading conservation agencies in the nation. While not totally surprising since the original internship timeline was laid out before I started in May, it is a little remarkable to me how much work and projects the SWCD could do if they had time. It took me almost a year to create a digital database to store the county's conservation plans, and even then, I only digitized a portion of the information within each plan. Creating updated plan maps took months, too. If the plans were to be used in a GIS platform, it could take another few months to build from what I started. However, I have a lot of respect for the work the SWCD does, and I thoroughly enjoyed working with and assisting the staff. I hope that the staff finds my work not only insightful but useful in their daily work.

While my capstone did not have the same level of original research, data analysis, and statistical inferences as a traditional thesis, I believe that my experience taught me a lot. I was able to apply material from many of my master's program's courses to my internship. First and foremost is the GIS experience I acquired from NRES 454 (GIS for Natural Resources) and 455 (Advanced GIS for Natural Resource Planning). Prior to the NRES program, I had little experience with using GIS. In the course of two semesters, I developed a high proficiency in both ArcGIS Desktop and ArcGIS Pro, to the point at which I was able to create an extensive database with features from multiple sources (including ones I created) to represent the county's nearly 1,900 conservation plans. I think that this is a strong, concrete example of how I not only learned the course material but successfully applied it to a real-world situation (i.e. my internship).

Because my internship was with the SWCD, the material covered in NRES 474 (Soil and Water Conservation) was extremely pertinent. The class laid the foundation for my understanding of different conservation practices, which I then worked extensively with as I analyzed the conservation practices used in Guilford County. The course's discussion on soils also proved very useful as I used the Web Soil Survey (USDA & NRCS, 2019d) to create current soil maps for most of the conservation plans.

I really appreciated the trans-disciplinary approach taught in NRES 420 (Restoration Ecology). Real-world problems rarely fit into "neat little boxes" and frequently contain social, economic, and environmental factors. The Restoration Ecology course helped establish the ecological lens through which I tried to evaluate the conservation plans. While the conservation plans allow for important and significant erosion goals to be realized, they do little to directly address ecosystem function. I think that if conservation plans are approached from an ecological framework, then there could potentially be significant environmental improvements without any detriment to the farm's productivity. Such a shift in approach, however, would need to come from the federal agencies directing the work of the county NRCS and SWCD staff.

While my other courses provided valuable knowledge and skills (such as the watershed analyses performed in NRES 403 (Watersheds and Water Quality)), the foundational research principles reinforced in NRES 502 (Research Methods in NRES) deserve a special mention. Through the course's thorough analysis of the research process, I was able to create a solid framework for my internship. Even though my project did not follow all of the steps of traditional research, I was able to approach my internship with an analytical lens to develop a solid research proposal and deliver high-quality analyses and materials both for NRES and for the SWCD.

The course that surprised me the most was NRES 472 (Environmental Psychology). Not coming from a strong psychology background, I did not know what to expect from the course. However, it turned out to be one of my favorite courses in the NRES program. While researching the Guilford County Prison Farm, the readings from NRES 472 provided a great foundation for understanding the potential psychological benefits of farming and having green spaces. This psychological background combined nicely with my coursework on the benefits of urban agriculture, which was acquired through HORT 434 and 435 (Urban Agriculture).

5.3 GIS AND ELECTRONIC RECORDS

As was discussed in Chapter 4, there are definite advantages of using a GIS database to store and manage conservation plans. In the case of this project, though, the primary benefit appeared to be for map generation and visual comparisons. Using the Excel database to store some of the data from each plan provided an easier way to manage the plans digitally. Training, time requirements, the use of various software, and the oversight from multiple organizations all lead me to conclude that the GIS interface is not the most efficient use of the staff's limited time to manage the conservation plans. However, I believe that the Excel database I created is a significant improvement and a step towards managing all of the plans digitally.

5.4 A BROADER PERSPECTIVE

One way to evaluate my internship experience is to see how my work and research tied into the goals of the various organizations I worked with. NRES uses a transdisciplinary approach "to identify, teach, and publicize solutions for the sustainability of urban, managed, and natural ecosystems" at all scales (UIUC, 2019b). To this end, my internship experience allowed me to combine others' research on policy, conservation practices, public opinion, and ecology to produce an analysis and GIS representation of the county's conservation plans. Sharing my research, analysis, and knowledge with others (namely, the SWCD staff and board members) I believe I accomplished the department's mission.

Similarly, the College of ACES--which has eleven majors--operates with a "unifying theme [with] an emphasis on learning by doing" (UIUC, 2019a). My internship was very much a hands-on, learning-by-doing experience. Delving into the 1,900 conservation plans over the course of almost a year allowed me to become very familiar with both the different conservation practices recommended to farmers and the methods used by the SWCD. In fact, I am very pleased with how much the internship and my interactions with the SWCD and NRCS allowed me to experience what I was learning in my course work. I learned about conservation practices in several courses but interacting and talking with farmers allowed me to understand how personal the issue of conservation is for many farmers; while farmers may not know all of the scientific basis for different conservation practices, they have a keen understanding of how their practices can affect the landscape.

Being a land-grant university, the University of Illinois was founded to provide agricultural research. The NRCS (formerly SCS) and the SWCD are two agencies which rely heavily on the research produced from land-grant universities. The mission of North Carolina's Division of Soil and Water Conservation, which oversees the state's 96 conservation districts, strives to "foster ...[the] management of soil, water and related natural resources for the benefit of the environment, economy and all citizens" (NCDACS, 2018). I think that more could be done to better manage the natural resources, though. By the nature of the structure of federal policies and agency procedures, many conservation efforts address single goals (such as reducing soil erosion); however, I think that it is possible to look across disciplines and formulate conservation practices that address multiple goals--specifically, multiple physical and ecological goals.

5.5 LOOKING FORWARD

I think that my internship experience fits nicely within the goals of the university and NRES department. I hope that the work I did and the databases I created will help to further the work Guilford SWCD does. State and federal agencies such as the NRCS work to protect the productivity of the soils (USDA & NRCS, 2019b). Through my work, I was able to quantify how the county has worked towards this goal by mapping and measuring the amount of land under conservation plans. I hope that having a digital location to store conservation plans will make it easier for the staff to find, analyze, and update plan information. Because the SWCD staff's work is continuous, I tried to lay the framework for allowing future interns to assist the staff with their work. To this end, the user manual not only walks through the steps of how to update and use the Excel database, but it also provides a basic level of background training materials. I am optimistic that the user manual will allow interns with various educational backgrounds to assist the SWCD staff, and together, staff and volunteers can manage an up-to-date, digital collection of the counties 1,900 conservation plans (and counting).

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APPENDIX A: ADDITIONAL MAPS

The following maps were created for the Guilford SWCD to represent the watersheds and land cover in Guilford County.

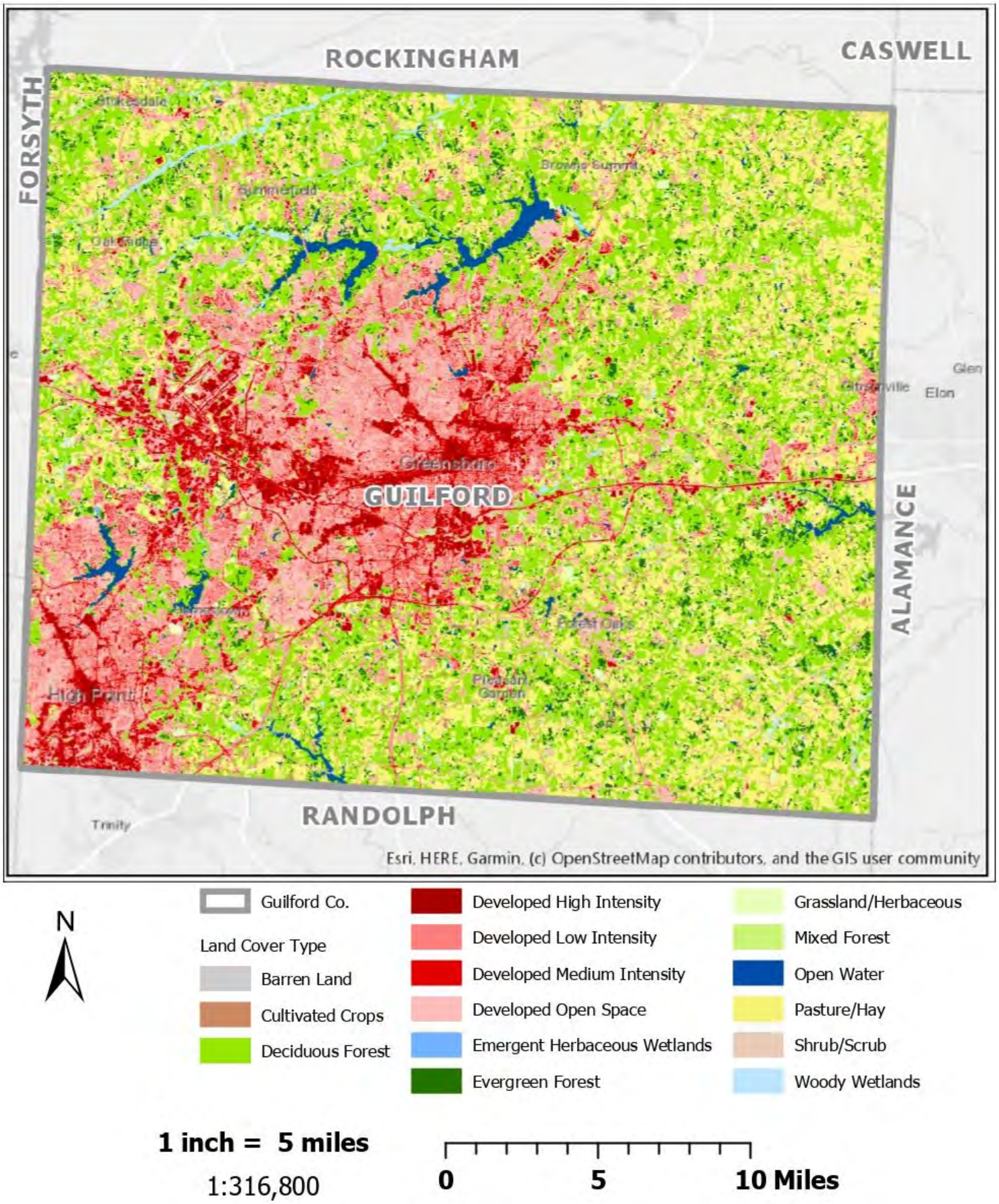

Figure 19: The land cover in Guilford County as indicated by the 2011 National Land Cover Database (Esri & MRLC consortium, 2014a). The county is 36% forested, 34% developed, and 23% agriculture with the remaining land cover types making up the difference of 7%.

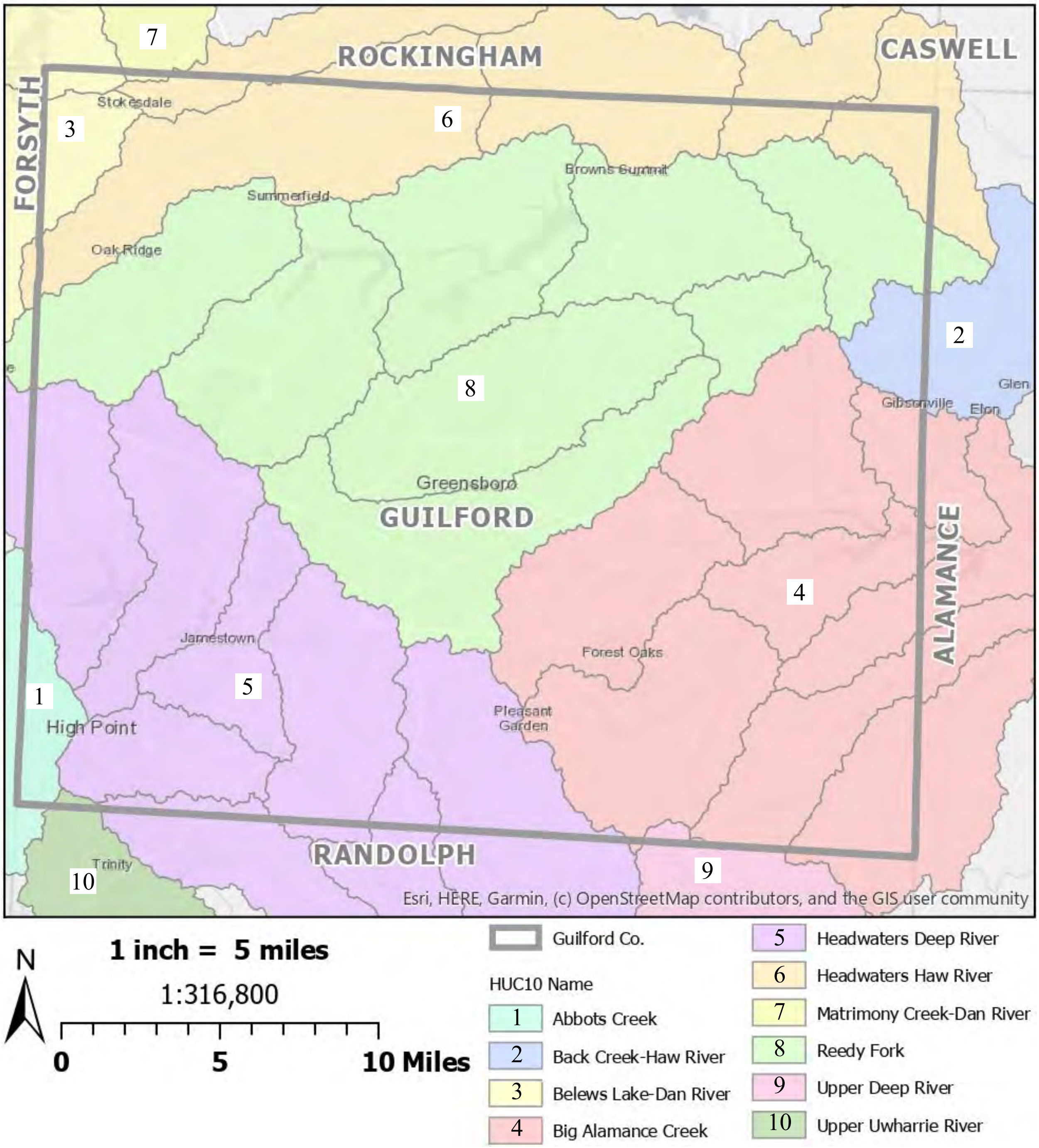

Figure 20: Guilford county drains into the Yadkin Pee Dee, Roanoke, and Cape Fear river basins. Shown in this map are the smaller HUC10 watersheds (colored) and HUC12 sub-watersheds (outlined in gray). The Guilford SWCD watershed-categorization scheme is loosely based on the HUC12 boundaries.

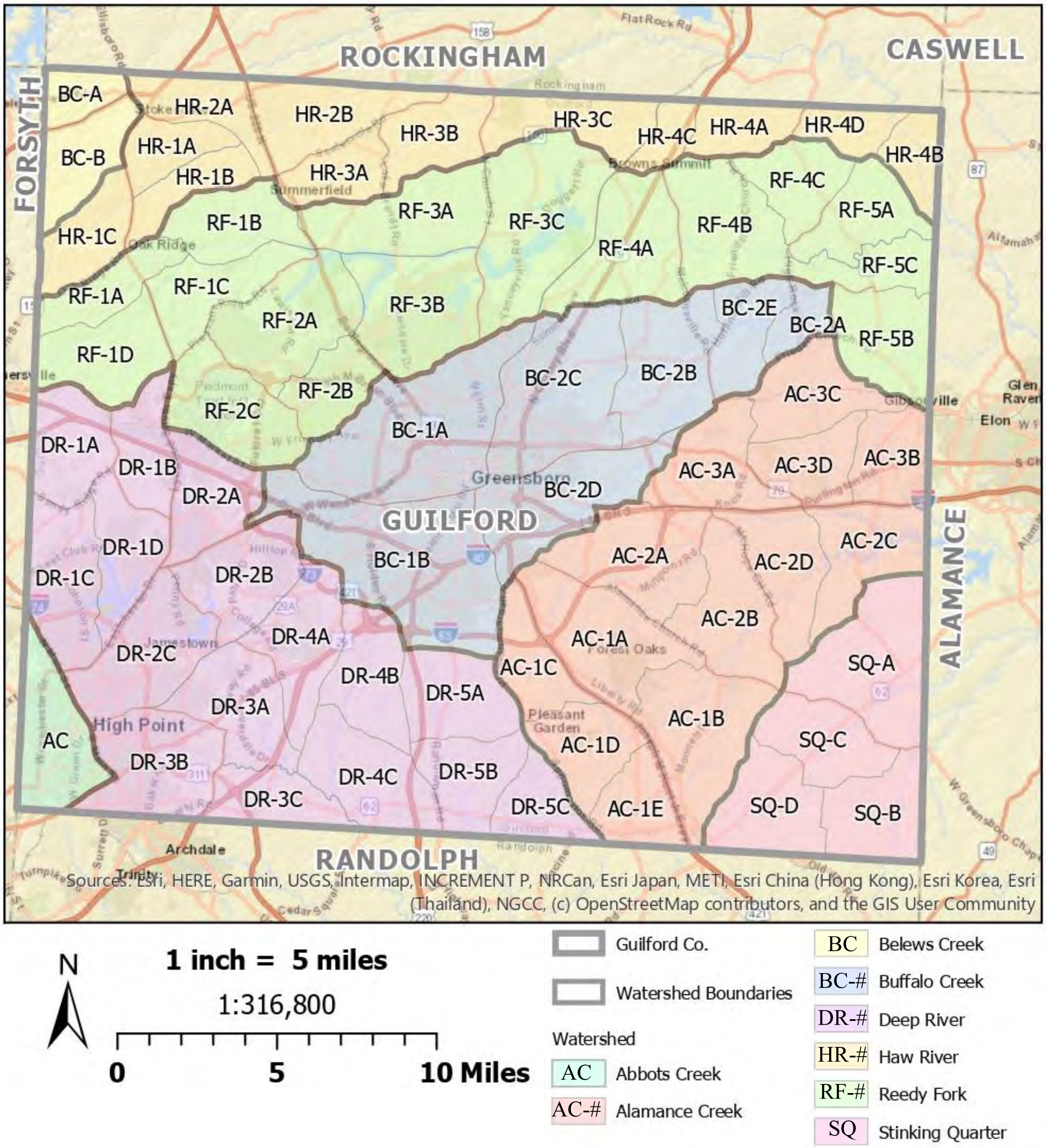

Figure 21: Guilford SWCD created eight watersheds and 71 sub-basins to divide up the county. The boundaries are loosely based on the true hydrological watershed boundaries (i.e. the HUC10 and HUC12 boundaries).

APPENDIX B: SOIL MAP EXAMPLES

Every conservation plan includes a soil map that identifies the types and locations of the different soils on the property. A total of 1,000 new soil maps were created during this internship. The following figures show two representative examples of the soil maps generated from the USDA and NRCS Web Soil Survey (WSS, websoilsurvey.sc.egov.usda.gov). The figures use the heading "Watershed: Tract Number (Operator's Name)". In both figures below, the personal information (the tract number and the operator's name) has been redacted. Once an "area of interest" is created in the WSS, the software creates the map on one or more pages (A), a page with the legend (B), and a page with the calculated areas of each soil type (C).

Figure 22 shows the soils on the property for tract 1831 [REDACTED] in the DR-1D watershed. In this case, the property (as indicated by the Area of Interest box) originally extended to the north and west when the plan was first written. However, recent development has left only the indicated fields in agriculture. Although the fields extend across the property boundary to the east, those fields are covered in a separate conservation plan.

Figure 23 shows the soils on the property for tract 1134 [REDACTED] in the RF-4B watershed. This parcel has not changed since the conservation plan was first written. However, the property to the north used to be in agriculture but has since been abandoned; the outlines of the old fields are indicated by the boundaries of the new, evergreen forest.

Figure 22A: A soil map for tract 1831 [REDACTED] in the DR-1D watershed, generated using the Web Soil Survey (websoilsurvey.sc.egov.usda.gov). This figure shows the property and the location of the different soils (A), the legend (B), and the area covered by each soil type (C).

Soil Map—Guilford County, North Carolina
(DR-1D: 1831 [REDACTED] ([REDACTED]))

MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils
- Soil Map Unit Polygons
- Soil Map Unit Lines
- Soil Map Unit Points

Special Point Features
- Blowout
- Borrow Pit
- Clay Spot
- Closed Depression
- Gravel Pit
- Gravelly Spot
- Landfill
- Lava Flow
- Marsh or swamp
- Mine or Quarry
- Miscellaneous Water
- Perennial Water
- Rock Outcrop
- Saline Spot
- Sandy Spot
- Severely Eroded Spot
- Sinkhole
- Slide or Slip
- Sodic Spot
- Spoil Area
- Stony Spot
- Very Stony Spot
- Wet Spot
- Other
- Special Line Features

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background
- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:20,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Guilford County, North Carolina
Survey Area Data: Version 16, Sep 10, 2018

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Mar 27, 2015—Oct 16, 2017

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Natural Resources Conservation Service | Web Soil Survey, National Cooperative Soil Survey | 6/23/2019, Page 2 of 3

Figure 22B: cont.

Map Unit Legend

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
CeB2	Cecil sandy clay loam, 2 to 6 percent slopes, moderately eroded	23.8	67.8%
CrB	Coronaca clay loam, 2 to 6 percent slopes	8.1	23.0%
CrC	Coronaca clay loam, 6 to 10 percent slopes	0.7	1.9%
EnB	Enon fine sandy loam, 2 to 6 percent slopes	1.6	4.7%
MhB2	Mecklenburg sandy clay loam, 2 to 6 percent slopes, moderately eroded	0.9	2.6%
Totals for Area of Interest		**35.1**	**100.0%**

Figure 22C: cont.

Figure 23A: A soil map for tract 1134 [REDACTED] in the RF-4B watershed, generated using the Web Soil Survey (websoilsurvey.sc.egov.usda.gov). This figure shows the property and the location of the different soils (A), the legend (B), and the area covered by each soil type (C).

Soil Map—Guilford County, North Carolina
(RF-4B: 1134 [REDACTED] ([REDACTED]))

MAP LEGEND

Area of Interest (AOI)

- Area of Interest (AOI)

Soils

- Soil Map Unit Polygons
- Soil Map Unit Lines
- Soil Map Unit Points

Special Point Features

- Blowout
- Borrow Pit
- Clay Spot
- Closed Depression
- Gravel Pit
- Gravelly Spot
- Landfill
- Lava Flow
- Marsh or swamp
- Mine or Quarry
- Miscellaneous Water
- Perennial Water
- Rock Outcrop
- Saline Spot
- Sandy Spot
- Severely Eroded Spot
- Sinkhole
- Slide or Slip
- Sodic Spot
- Spoil Area
- Stony Spot
- Very Stony Spot
- Wet Spot
- Other
- Special Line Features

Water Features

- Streams and Canals

Transportation

- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background

- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:20,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Guilford County, North Carolina
Survey Area Data: Version 16, Sep 10, 2018

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Mar 27, 2015—Oct 16, 2017

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Figure 23B: cont.

Map Unit Legend

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
CcB	Cecil sandy loam, 2 to 6 percent slopes	6.3	8.6%
CeB2	Cecil sandy clay loam, 2 to 6 percent slopes, moderately eroded	28.6	39.1%
CeC2	Cecil sandy clay loam, 6 to 10 percent slopes, moderately eroded	25.7	35.2%
ChA	Chewacla loam, 0 to 2 percent slopes, frequently flooded	1.5	2.0%
EnB	Enon fine sandy loam, 2 to 6 percent slopes	3.3	4.5%
EnC	Enon fine sandy loam, 6 to 10 percent slopes	2.4	3.2%
MaE	Madison sandy loam, 15 to 35 percent slopes	0.3	0.4%
McD2	Madison clay loam, 10 to 15 percent slopes, moderately eroded	4.4	6.0%
W	Water	0.8	1.0%
Totals for Area of Interest		**73.2**	**100.0%**

Figure 23C: cont.

APPENDIX C: LOG OF HOURS

Table 6: A log of all of the direct hours spent in the internship and the work completed each day. A total of 431.75 hours were logged and 1,887 conservation plans were entered, covering 68 of the conservation district's 71 sub-watersheds.

Date	Hours	Tasks	Conservation Plans Entered
5/15/2018	8.0	Welcome; overview of conservation plans (CPs); set up files	28
5/22/2018	8.5	USDA NRCS training on poultry farm	36
5/29/2018	8.0	Entering plans; full computer access	51
6/1/2018	4.5	Entering plans	34
6/4/2018	8.5	Entering plans; adjusting first set	67
6/5/2018	8.5	Entering plans	57
6/11/2018	8.5	Entering plans	68
6/12/2018	8.5	Entering plans	68
6/18/2018	8.0	Entering plans	55
6/25/2018	8.5	Entering plans	70
7/2/2018	8.0	Entering plans	63
7/9/2018	8.0	Entering plans	51
7/16/2018	8.3	Entering plans	62
7/30/2018	7.0	Entering plans	45
8/6/2018	8.0	Entering plans; delayed by many old plans with little info on location, and different categorizations.	32
8/7/2018	3.5	Entering plans	21
8/13/2018	8.0	Entering plans	45
8/14/2018	5.0	Entering plans	36
8/20/2018	8.0	Entering plans	43
8/21/2018	7.5	Entering plans	39
8/27/2018	4.0	Entering plans	20
8/28/2018	6.5	Entering plans	44
9/4/2018	8.0	Entering plans	40
9/10/2018	3.3	Entering plans	25
9/11/2018	7.8	Entering plans	43
9/17/2018	7.0	Entering plans	47
9/18/2018	7.0	Entering plans	43
9/24/2018	7.0	Entering plans	57

Table 6: cont.

Date	Hours	Tasks	Conservation Plans Entered
9/25/2018	6.5	Entering plans	51
10/1/2018	7.0	Entering plans	43
10/2/2018	7.5	Entering plans	55
10/8/2018	6.5	Entering plans	52
10/9/2018	6.5	Entering plans	43
10/16/2018	7.5	Entering plans	58
10/22/2018	7.0	Entering plans	60
10/23/2018	7.0	Entering plans; Guilford Co. Prison Farm	35
10/30/2018	7.0	Entering plans	43
11/5/2018	7.0	Entering plans	50
11/6/2018	6.0	Entering plans	39
11/13/2018	7.0	Entering plans	44
11/19/2018	6.5	Finished entering plans; revised first 100 plans	8
11/20/2018	7.0	Revising plans	--
11/26/2018	6.0	Revising plans	--
11/27/2018	6.5	Revising plans; adding new plans	10
12/4/2018	6.5	Adding new plans;	7
12/5/2018	5.0	Writing manual for spreadsheet. Board meeting.	0
12/10/2018	0.0	Closed for snow	--
12/11/2018	0.0	Snow day	--
12/17/2018	4.0	Writing manual.	--
12/18/2018	7.5	Writing manual. Meeting. GIS intro.	--
12/24/2018	0.0	Holiday break	--
12/31/2018	5.0	GIS and spreadsheet editing. Writing manual.	--
1/7/2019	6.0	GIS and spreadsheet editing. Writing manual.	--
1/8/2019	4.5	GIS editing	--
1/14/2019	5.5	Creating new plan soil maps	--
1/15/2019	6.5	Creating new plan soil maps	--
1/16/2019	6.5	Field trip, farm site visit	--
1/21/2019	0.0	Holiday break	--
1/22/2019	6.5	Creating new plan soil maps	--
1/28/2019	7.5	GIS editing	--
1/29/2019	7.0	GIS editing	--
2/4/2019	6.5	GIS editing	--
2/4/2019	2.0	At home - GIS editing	--
2/11/2019	6.5	Creating new plan soil maps	--
2/18/2019	6.5	Creating new plan soil maps	--

Table 6: cont.

Date	Hours	Tasks	Conservation Plans Entered
2/25/2019	6.5	Creating new plan soil maps	--
3/4/2019	6.0	GIS analysis; board meeting presentation prep.	--
3/6/2019	4.0	Board meeting	--
3/11/2019	6.0	Creating new plan soil maps; printing county maps.	--
	431.8	**Hours**	
	1,887	**Conservation Plans**	
	68	**Watersheds**	

APPENDIX D: SUPPLEMENTARY FILE - CONSERVATION PLAN SPREADSHEET

The supplementary file JTurner_Capstone_AppendixD_ConservPlans_REDACTED.xlsx includes the raw data from the conservation plans; all confidential information has been redacted. The document was created to store important information from the county's conservation plans. It is to be used as a reference database where the county's conservation plans can easily and quickly be found, viewed, or analyzed. The file does not include the analytical calculations, which were described in Chapter 2: Methods.

APPENDIX E: SUPPLEMENTARY FILE - CONSERVATION PLAN USER MANUAL

The supplementary file JTurner_Capstone_AppendixE_ConservPlans_Manual.pdf is the user manual created for Guilford Soil and Water Conservation District staff and future interns to reference when using the excel document containing the conservation plans (see Appendix A). The 20-page user manual walks through each field of the spreadsheet, provides definitions and background information, and explains how to enter information from a conservation plan into the spreadsheet.