

# Policy Opportunities to Increase Cover Crop Adoption on North Carolina Farms

A report for the Union of Concerned Scientists

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## Abstract

Cover cropping is an agricultural practice that produces on-farm benefits while contributing to broader public sustainability goals. However, cover crops have not been widely adopted in the United States, while the barriers to farmer adoption of cover crops have received little research attention. This study considers the relative importance of the barriers that farmers overcome to adopt cover crops in North Carolina and identifies the resources that enable successful adoption. We used an email survey of NC farmers to gather quantitative data about cover crop use and preferences, supplemented by qualitative interviews with experts on cover crop adoption. Our data show that farmers in NC overcame three broad categories of challenges to adopt cover crops: agronomic, input costs, and knowledge transfer. The level of these challenges varies depending on farm size and income, age of farmer, farming experience, and whether information to plant cover crops was obtained through extension, farmer networks, or private industry. Timing for planting, in particular, challenges farmers regardless of their demographic characteristics. We recommend a holistic policy approach that strengthens diverse knowledge transfer networks, bolsters farmer incentives through existing cost-share programs, and invests in applied research to develop varieties that better complement common cash crop rotations.

## Executive Summary

America can feed more people on less cultivated land than ever before. While practices such as mechanical tillage and synthetic fertilizers are widely credited for postponing food shortages in this country, these same practices have led to widespread erosion, nutrient depletion and degraded waterways.

As the environmental impacts of commercial farming have grown apparent, more farmers are turning to sustainable agriculture practices to protect the long-term health of their farmland and America's natural resources. One such method is the use of cover crops. These crops, commonly planted after fall harvest and killed before spring planting, grow on the field that would otherwise lie fallow. Cover crops reduce erosion and pest burdens, replenish soil nutrients, improve moisture retention, and improve groundwater quality.

The Union of Concerned Scientists (UCS) engages with policymakers through the Food and Agriculture division to encourage wider use of sustainable agriculture practices (SAP). UCS is particularly interested in cover crop adoption as a means of reducing the environmental impact of farming. They approached the Nicholas School for the Environment at Duke University to employ a team of environmental management master's candidates to perform an assessment of the main barriers to cover crop adoption faced by farmers.

Previous research suggests that the adoption of sustainable systems may align with farm size, land ownership, and the ability to finance the equipment and/or labor necessary to properly implement that system. The team utilized a web-based social survey of North Carolina farmers, coupled with key informant interviews, to identify barriers within the State. Information dissemination and policy incentives for implementation also play strong roles in how quickly and eagerly farmers will adopt SAP. Our survey confirmed that many of these same factors influence farmers' adoption of cover crops in North Carolina in specific ways identified by our research.

The major findings address many of the broader issues we see with national SAP adoption. Farmers value soil quality above all else, and cited long-term soil improvement as the most important reason for planting cover crops. Their greatest challenge is finding time to work a cover crop into their cash crop rotation. Although 50% received some form of information on cover crops from their extension agent, a majority cited self-directed learning as most influential in their decision to adopt. The biggest constraints, especially for small farmers, were 1) the price of cover crop seed, 2) the ability to obtain the right equipment and labor to plant and kill a cover

crop, and 3) the limited understanding of how much farmers could reduce synthetic fertilizer applications if they used cover crops to increase soil fertility. Fifty-five percent of respondents did not apply for cover crop subsidy programs or cost share because they did not know enough about the programs to apply.

Our recommendations to UCS comprise four categories: to shift research priorities, enhance targeted communication of existing knowledge, improve SAP funding programs, and increase access to affordable seed and equipment. We were careful to only recommend those policy changes that we believed UCS could realistically influence. UCS is, of course, the best judge of the applicability of our final results and recommendations. Our outside perspective will nonetheless provide a springboard for a productive discussion around where UCS can make a difference in SAP adoption. We believe UCS is well positioned to move the needle on cover crop research, knowledge and funding, and to ultimately initiate positive change around the environmental impacts of agriculture in the United States.



## Introduction

The American Farmer has long been an icon of bountiful harvest and connection to the land – two values cherished by the most admired figures of a nascent United States.

“Agriculture,” said Thomas Jefferson in a 1787 letter to George Washington, “is our wisest pursuit, because it will in the end contribute most to real wealth, good morals, and happiness.” Benjamin Franklin said that agriculture was the most honest way for a nation to acquire wealth (Franklin 1840).

While the U.S. population tops 311.5 million in 2012, fewer than one million (.3%) claim farming as their main occupation, of which less than 25% produce annual revenues over \$50,000. Over 90% of these farms are owned by individuals or families rather than large partnerships (EPA “Demographics”, Hoppe 2010). Despite this concentration of farms in the hands of the small and economically fragile, consolidated and concentrated operations now dominate agricultural production (EPA “Social and Economic Interactions”) by leveraging economies of scale and the use of expensive machinery to produce in volume. For many of this country’s “staple crops” such as corn or soy, profit margins are low, meaning that farmers must produce in volume in order to increase gross profits.

Over the past decades, farmers have also been aging. The Bureau of Labor Statistics reports that 40% of farmers are over 55 years old. The ability to perform labor-intensive tasks decreases with age. Fortunately for many farmers, technology has paced them – chemical fertilizers and mechanical equipment now do the work of many people. Research shows that while total inputs (including labor, chemicals, machinery) remained stable over the last half-century, total productivity of farmland increased by 170% (USDA “Agricultural Productivity”).



While America can feed more people on less land than ever before, it comes at a precious cost. Many modern techniques depend on mechanical tillage and synthetic fertilizers, pesticides and herbicides to keep land productive. Farmers increasingly rely on these perennial “fixes”—a kind of fertility life-support—in lieu of practices that maintain and enhance long-term soil health. The costs that these fixes transfer to the public (i.e. externalities) are significant and well documented. For

example, soil left fallow after harvest and subsequently overturned from tillage erodes and washes into the nation's waterways. Scientists estimate that each year the U.S. loses the soil equivalent of Indiana State to erosion (Pimentel 2006).

Field runoff also leads to nutrient depletion as key crop nutrients such as nitrogen, phosphorous and potassium are swept into streams and rivers (UNEP/GRID-Arendal). To compensate, most U.S. farmers apply chemical fertilizer – about 200% more today than 50 years ago (EPA 2011). Some fertilizers also fuel the growth of algae and vegetation in waterways, which leads to oxygen depletion and mass mortalities of benthic animals (Rabelais 2002).

Although there are many negative consequences of producing food in these so-called “conventional” systems, practices exist that can mitigate the negative effects of modern agriculture. These SAP include cover crops. A growing number of farmers use sustainable agriculture practices such as cover crops—practices that, when implemented properly, can maintain productivity while reducing soil erosion and water pollution. Cover crops are crops that are “not harvested [for sale] but grown to benefit the soil and/or other crops” (Martin 2010). As you will read in this report, cover crops reduce erosion, replenish soil nutrients, reduce pest problems and improve groundwater quality, among other benefits discussed below.

The Union of Concerned Scientists (UCS) stands at the forefront of challenging the environment-damaging trends in agriculture. Founded in 1969 at MIT and based in Cambridge, MA, UCS utilizes scientific understanding to advocate policy and citizen action toward environmental outcomes. The Food and Environment (F&E) division at UCS specifically examines how the Farm Bill and other federal policy shapes agriculture. F&E also pushes for changes so that future cropland remains productive while maintaining the health of citizens today.

The client-centered group master's project at the Nicholas School of the Environment at Duke University is the capstone research project that must be completed by all Masters candidates in environmental management.

This collaboration between UCS and the Nicholas School is one that we hope will illuminate key insights into the decisions that farmers face in choosing from among agricultural practices. Katy Zook, Lee Miller and Jennifer Chin worked with UCS to focus this project on the barriers to adoption and use of cover crops, and how those challenges could be mitigated through policy.

Duke University is located in North Carolina, a state that produces \$10.3 billion in sales from 52,913 farms each year (USDA 2007). Agriculture has long been the largest industry in North Carolina, which remains the number one producer in the country of flue-cured tobacco and sweet potatoes (NC Department of Agriculture 2011). The average farm size in North Carolina is 164 acres (North Carolina State Library 2011), as compared to a national average that hovers around 400 acres (USDA 2007). Due to the geographic and climatic variations in the cropland of North Carolina, the type and volume of crops grown also spans a wide range. Regional variation causes the conclusions of other studies—especially those that spare Plant Hardiness Zones 6-8—on sustainable agriculture and specifically on cover crops to be speculative when applied to North Carolina. This master’s project, therefore, seeks to explain nuances of cover crop adoption specific to North Carolina. We believe that UCS can apply this new understanding, and the policy recommendations that follow, to advocate agricultural policies that meet the nation’s conservation goals.

## Background

### Barriers to Adoption of Sustainable Agricultural Practices (SAP)

Although many sustainable agricultural practices produce a net benefit to society, various reasons explain why farmers do not adopt these practices more widely. This section reviews research on the factors that influence farmer adoption of sustainable practices. Much of this research is founded on Everett Rogers' (2003) "adoption-diffusion theory" (ADT), the paradigmatic model for explaining why certain innovations flourish while other practices flounder. Although Rogers did not formulate ADT for agriculture specifically, it is widely used in this field. Rogers identifies five stages of adoption. For farmers, the process resembles the following (Rogers 2003):

*Knowledge Stage:* Awareness of an innovation leads to learning about its costs, benefits and implementation.

*Persuasion Stage:* Attitudes develop toward the innovation leading to the choice to either to try or reject it.

*Decision Stage:* Decision to fully adopt or completely abandon the innovation.

*Implementation State:* Innovation applied and adapted.

*Confirmation State:* Innovation ultimately embraced, or else more information sought about its use.

Rogers posits that five factors affect an individual's perception of the innovation: the "relative advantage" of the innovation, compared to the *status quo*; "compatibility," which accounts for the costs of incorporating the innovation into existing practices; the "complexity" of using the innovation; "trialability," or the degree to which the innovation can be experimented with prior to full adoption; and "observability," which accounts for the ease with which others can witness the success or failure of the adopter (Ibid).

Rogers frames a useful starting point from which to consider the adoption and diffusion of SAP. However, we rely on a framework that, while shaped by the theory above, offers a more detailed account of the factors likely to influence adoption in an agricultural context. Specifically, we borrow much of the structure laid out by the authors of "Toward Sustainable

Agricultural Systems in the 21st Century,” (Board on Agriculture and National Resources, 2010). This framework delineates four (broad) categories of factors that have, in some instances, been found to either promote or slow adoption: farm/farmer attributes, economic factors, knowledge and social institutions, and the policy context.

First, at the farm level, farm and farmer characteristics may influence the decisions that farmers make about adopting sustainable systems. Farmer decisions are not solely the product of the outside world; rather, farmers with differing values, resources and goals will often make disparate choices when facing similar decisions. Next, we examine the broader contexts that shape these decisions. We begin with the economic context and, in particular, how farmers weigh the economic costs and benefits when deciding whether to adopt a new practice. Next, we look at the social and knowledge institutions that inform (or fail to inform) farmers about the availability, implementation and sensibility of alternative practices. We conclude this section with research on the effect of policy on a farmer’s decision to change practices.

There exists a rich literature on farmer adoption of both innovative and sustainable practices. A full review of that literature lies outside the scope of this report (see Prokopy et al. (2008) and Knowler and Bradshaw (2007) for an excellent start). Instead, we focus on factors we anticipate to be most relevant to the analysis and discussion of cover crops specifically. Although individual studies have found that the factors discussed below can significantly affect adoption decisions within specific contexts, meta-analyses have found little if any evidence of universal predictors for the adoption of SAP. Instead, producers make management decisions from diverse frames of reference, across heterogeneous landscapes and within a variety of policy, market and agronomic contexts.

In their meta-analysis of 130 studies on SAP adoption across the globe, Knowler and Bradshaw (2007) find “few if any universal variables that regularly explain the adoption of conservation agriculture.” They suggest that any attempt to increase adoption should be locally tailored. Similarly, Prokopy et al.’s (2008) meta-analysis synthesizes the results of 55 studies on best management practice (BMP) adoption in the United States. They find that social networks, access to information, positive environmental attitudes, and environmental awareness are among the strongest predictors of adoption, and that policy interventions should begin by addressing these opportunities. However, echoing Knowler and Bradshaw, Prokopy et al. conclude that none of the factors studied reveal a relationship between adoption and predictors that “is consistently

positive, nor positive at an overwhelming rate.” Thus, the review that follows offers some intuition as to why certain factors *may* influence adoption, with the critical caveat that no single factor consistently explains producer behavior across localities.

### *Farm-level*

A multitude of individual farm and farmer characteristics act to constrain – and in many cases, hasten – the adoption of SAP. By treating these characteristics as independent of the economic, social and policy contexts, research has explored how farmers respond to innovations.

Farm size is one common way that society characterizes farms. Lambert et al. (2007) analyze how farm characteristics effect the adoption of various best management and conservation practices. They report that large farms are more capable (or at least more likely) to implement complex but largely mechanized conservation practices, whereas small farms prefer simpler practices requiring more intensive labor inputs. Larger farms may be better able to recoup the cost of learning a complex practice, as well as the investment in any necessary equipment, by applying it over many more acres. Rubas (2004) and Prokopy (2008) show that increasing acreage is more likely to have a positive than negative correlation with BMP adoption, although most other studies have found an insignificant relationship between farm size and adoption (Prokopy 2008).

Farmers lease about 38% of all farmland in the United States (USDA 2007). Bell (2001) reports that the trend toward leased farmland can pose a serious barrier to the adoption of sustainable practices. Many such practices do not immediately add to the farmer’s bottom line but do demand an up-front investment in the form of time, equipment or reduced yields. Most lease agreements last only one year before they are subject to renewal (Bell 2001). A farmer is less likely to invest personal resources toward a practice that will improve the land over time when he may not enjoy the expected benefits over the long term. Further, by improving the quality of the land, the farmer may incidentally increase its value and find his or her landowner increasing next year’s rent payment. While ownership may influence adoption in some scenarios, meta-analysis concludes that ownership type has an insignificant effect on adoption in most studies (Prokopy 2008). Although Bell and others have found a relationship between land ownership and SAP adoption, and provide an intuitive explanation for this relationship, land ownership remains an open question for research into SAP adoption.

Similarly, conservation values may play a significant role in the innovation and early adoption stages of sustainable agriculture practices. Padel (2001) found that farmer values toward the environment become insignificant predictors of adoption as a particular practice matures and economic considerations dominate, while Bergtold et al. (2007) show that adoption of one conservation practice increases willingness to trial a different one. Together, these studies suggest that a subset of farmers with strong environmental values may play an important role in the normalization of novel practices.

### *Economic Considerations*

Economic considerations rank among the most cited barriers to SAP adoption within the literature (Pannell 2005; Prokopy 2008). Economic factors include everything from the cost of new equipment and inputs, the cost of the farmers' time and any additional labor they may require, and farmers' natural aversion to risking their bottom line when adopting new practices.

Adoption of many SAPs requires investment in specialized equipment and the purchase of new inputs. In many cases these investments will pay for themselves over time, but farmers with limited capital may not be able to get financing through traditional lending institutions that are not familiar with conservation practices (USDA 2010). However, new input costs may be offset by a reduced need for other inputs. For example, increased seed or gasoline cost may be offset by a reduced expenditure on chemical pesticides or fertilizers. Some SAPs require an ongoing investment. For example, a farmer must spend time learning new or complex practices, and many require a permanent increase in time spent on management activities. Additionally, if the labor requirement exceeds the farmer's capacity, adoption may entail hiring additional workers to implement the practice (Lambert et al. 2006). Adoption will decline if the farmer is unable to cover these costs in the form of increased revenues, or if the farmer does not possess the operating capital to make these investments up front.

Much of the economic literature assumes that adoption decisions are made by a straightforward evaluation of whether the investments discussed above will maximize the net present value of a farm business. A separate but related question is whether the farmer has or can get the cash to make those investments. Others have suggested that risk, uncertainty and the possibility of learning deserve further attention, preferring an "option value" approach. Marra (2003) frames this approach as follows: a farmer's decision to wait before adopting reveals some additional barriers that are obscured in a net present value assessment. If a new, more sustainable

method requires a significant financial outlay (e.g. purchase of a new tractor) that cannot be easily sold later, the farmer is more likely to wait in order to improve her certainty that the investment will pay off. Similarly, when there is uncertainty over future prices (as with almost all farm output prices), it may be to the farmer's advantage to wait until she has a better idea of long-term price trends. For example, she may delay investing in expensive capital until the new farm bill establishes 5-yr price floors for the crops she grows; or perhaps she waits until there is more information about the effects of climate change in her region before adopting a sustainable practice that would increase resiliency. Finally, the option value of waiting assumes a possibility of learning in the future. The quality and timing of information drastically changes the value of waiting. If farmers believe that important new research or information is still forthcoming, they may opt to wait rather than make an investment now in new production practices. (Marra 2003)

### *Knowledge and Social Institutions*

The dissemination of knowledge and the composition of social institutions influence what information is available about SAPs and how farmers perceive the information that they receive. Institutions span the range from publicly-funded land-grant universities, the Cooperative Extension System, and state departments of agriculture, to for-profit entities such as seed and equipment suppliers and private agricultural consultants, to non-profit organizations like the Farm Bureau and conservation organizations. These institutions are involved in the creation of new knowledge, the synthesis and dissemination of on-farm learning, and the paths that knowledge follows across lateral social networks (e.g. farmer-to-farmer). All of these factors influence how farmers understand SAP, evaluate their risks and benefits and, ultimately, whether they choose to trial and ultimately adopt a practice.

Agricultural knowledge networks include cooperative extension, industry relationships, farmer-to-farmer, and farmer-to-institution communication. Traditionally, state extension agents and industry have been the backbone of technology transfer within the industrialized, production-driven agricultural system (Warner 2008). Yet many researchers have suggested that this knowledge sharing rarely encompasses education about SAPs (Rodriguez 2007; Prokopy 2008). To explain this fact, Rodriguez (2008) cites the paucity of information on SAP available to extension agents, extension skepticism of non-traditional research originating outside of university research stations, and training methods that discourage agents from reflecting on their own values and beliefs. The result, in terms of SAP, is often "ineffective, inaccurate or

inappropriate” (Knowler and Bradshaw, 2007) information that can actually reduce adoption rates.

Farmer-to-farmer channels have emerged as an alternative, and sometimes complementary, model of information dissemination in the past twenty years. Farmer networks can provide alternatives to extension services and industry consulting. Where robust networks exist, they have proven very effective in spreading SAP adoption. However, farmer-to-farmer knowledge transfer faces a unique set of barriers. Many conservation practices, especially complex ones, do not follow the tradition innovation-diffusion model championed by Roberts (2003) (Padel 2001; Warner 2008). Rather, learning must take place on a relatively micro scale where new practices can be carefully adapted to local conditions. Social capital is emerging as a “universally influential factor” in SAP adoption as farmers seek to learn from the experience and knowledge of their peers (Knowler and Bradshaw 2007). Critically, social norms can initially impede the spread of sustainable practices as farmers communicate their wariness to one another (Rodriguez 2008). However, Henry (2007) has shown as a particular SAP gains recognition for its effectiveness, norms can change over time and positively influence adoption.

Farmer-to-farmer dissemination takes a more significant role for practices that exhibit lower “trialability” but higher “observability.” Pannell (2006) shows that low “trialability”—that is, the ease with which a farmer may “try out” a practice on her own farm—poses higher risks and therefore higher barriers to adoption. However, highly “observable” practices—that is, practices that neighboring farmers can readily observe and evaluate—face lower barriers to adoption because farmers are better able to witness their neighbors’ success firsthand (Henry 2007). This suggests farmers who are well-respected in their community, willing to share their experience, and open to trying innovative strategies play a critical role in SAP diffusion.

### *Policy*

Federal, state, and local public policy directly affects farmer choices by erecting barriers to, or else providing incentives for, the adoption of sustainable practices. Both barriers and incentives are visible in the United States’ most important agricultural legislation, the U.S. Farm Bill.<sup>1</sup> In addition, many other federal policies impact farm-level decisions indirectly. For example, the Clean Water Act does not regulate the vast majority of farm operations, eliminating

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<sup>1</sup> As catch-all phrase for omnibus federal agricultural policy that congress traditionally passes every 4-6 years. The most recent Farm Bill, “The Food, Conservation and Energy Act of 2008,” passed in 2008.

any regulatory incentive for nutrient and soil management (Ruhl et al. 2010). This section focuses on the barriers and incentives in the Farm Bill.

Federally subsidized crop insurance has received increased attention from farm groups and legislators as the 2012 Farm Bill process proceeds. From the perspective of SAP adoption, it is notable that these subsidy payments are not subject to the same minimal environmental standards as direct subsidy payments. Thus, farmers can abandon their eligibility for direct payments, forego even basic stewardship activities, and still collect huge insurance subsidies from the government (Ogburn 2011). O'Donoghue and others (2009) show econometrically that not only have insurance subsidies decreased crop diversity (or increased specialization), but that the magnitude of these subsidies grossly outweighs the small "efficiency" gains they produce.

The Conservation Title of the Farm Bill does provide incentives for SAP adoption through programs like the Environmental Quality Incentives Program (EQIP) and Conservation Stewardship Program (CSP). Both are "working lands programs," which distinguishes them from other conservation programs that pay farmers not to farm certain land (such as CRP). EQIP is a cost-share program that supports farmer adoption of structural and management practices that address specific national, state and regional "resource concerns" (NRCS 2012). CSP pays farmers for "undertaking additional conservation activities" above the level required for sustainable maintenance of a resource, and for "improving, maintaining, and managing existing conservation activities" (NRCS 2012). Both programs operate a competitive process that ranks applicants based on the resource concerns they address, the location of their farm in relation to priority areas of concern, and the national, state and regional priorities. Most experts expect the budget for these and similar conservation programs to be cut sharply in the next Farm Bill, as the House and Senate have already proposed cuts to EQIP and CSP (NSAC 2011). Although these programs have much room for improvement, a 2007 Office of Management and Budget (OMB) evaluation of EQIP rated the program "moderately effective" with a "Program Purpose and Design" ranking of 80% (Expectmore.gov). OMB has yet to evaluate CSP.

Finally, the Farm Bill influences SAP adoption through research funding. Most federal agricultural research dollars fall into one of several categories: competitive grants, "formula" funding to states based on demographic numbers, and "special" and "cooperative" grants. A steady trend toward more competitive grants threatens to slow farmer adoption of sustainable practices because these grants overwhelming focus on production-cost reduction (Rubenstein

2003). In contrast, formula dollars fund more applied research, ostensibly of local interest, that can tailor conservation measures to local conditions and educate farmers through on-farm demonstration projects. Some USDA branches, such as the Agricultural Research Service, allocate these types of funds through four “National Programs,” one of which is titled “Natural Resources and Sustainable Agricultural Systems” (ARS 2012). Most explicit sustainable agriculture research and education remains within the Sustainable Agriculture Research and Education (SARE) grants program. SARE has always been funded well below its authorized level (meaning that it receives fewer federally allocated funds to distribute than it could), and recent agricultural appropriations bills on Capitol Hill threaten to cut this and related programs further (NSAC 2011).

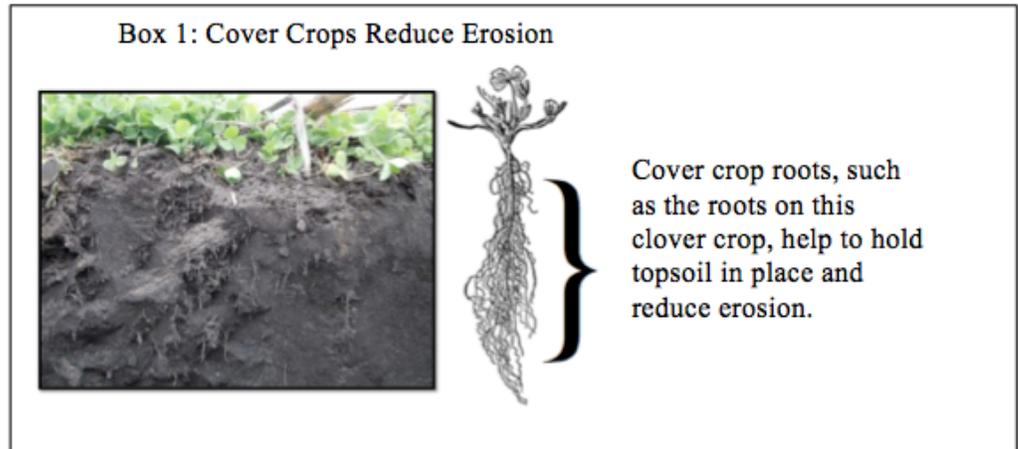
### **Cover Crops—What does the Science tell us?**

Cover crops are one of many sustainable agriculture practices (SAP) that provide environmental benefits within the current system of production agriculture. Cover crops are typically planted in early fall and grow until early spring, when they are killed by plowing or herbicide treatment and are allowed to remain on the field (Crozier 2011). This practice is traditionally known to provide soil cover and erosion control while reducing nutrient leaching and runoff (Reeves 1994). The benefits of cover crops are now commonly accepted as broader, including improvements to air and water conservation and quality, nutrient cycling, increasing populations of beneficial insects and soil biodiversity, and as short-term animal grazing systems within an integrated crop-animal system (Delgado 2006). This diverse array of benefits makes cover cropping a unique SAP because it creates gains not only the environment, but also the farmer—especially through soil quality improvement, erosion reduction, weed reduction, and nutrient management. The following section serves as a brief introduction of the benefits provided by cover cropping, followed by a discussion of potential costs.

#### ***Erosion Control***

One clear benefit of cover cropping is reduced erosion. Conventional fields typically lay fallow for many months during the winter, leaving fields susceptible to nutrient and topsoil loss by wind and water erosion. Cover crops counteract this by holding soil in place and protecting the soil surface from the elements (SAN 2007). Winter cereals, such as rye and wheat, are especially effective at reducing wind and water erosion (Kessavalou and Walters 1999, Kinyangi

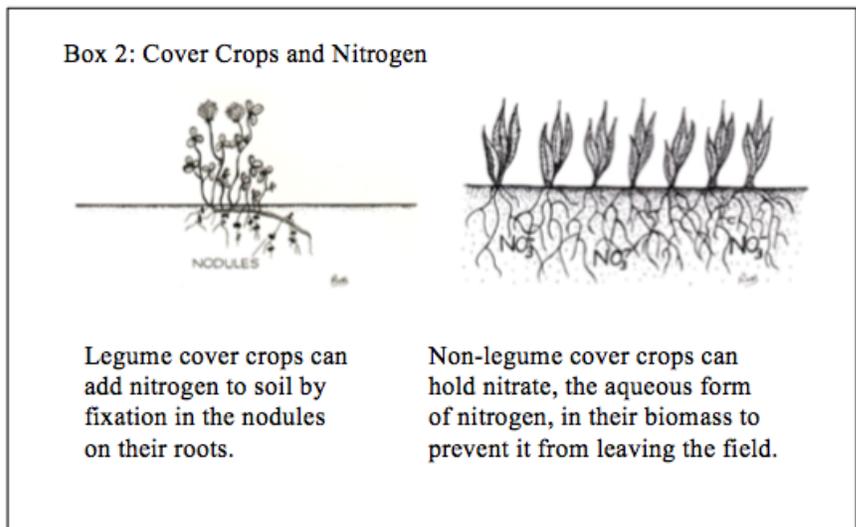
et al. 2001). Farmers have reported this benefit through surveys. For example, recent surveys indicate that about 25% of Western New York Vegetable growers and 43% of Michigan potato producers use winter cereals as a means of erosion reduction (Snapp et al. 2001, Stivers-Young and Tucker 1999). Cereals best adapted for winter cover in North Carolina include rye, wheat, barley, triticale, and oats (Crozier 2011).



**Added Nutrients**

Legumes are effective as a winter cover crop, and provide the additional benefit of adding nitrogen to the soil (see Box 2: Cover Crops and Nitrogen). They do this through a process called nitrogen fixation, where atmospheric nitrogen gas is assimilated or “fixed” by bacteria in the roots of legumes and made available for plants (SAN 2007). This available nitrogen reduces the amount of fertilizer that farmers need to apply during their regular rotation, which translates to reduced input costs. Studies show that cash crops grown in fields after a legume cover crop can use 30-60% or more of the available nitrogen from legume fixation (SAN 2007). In real terms, legumes contribute between 50 and 200 kgN/ha on average, though this number varies widely depending on the species of legume used, the field’s conditions, and the growth stage at which the legume is terminated (Drinkwater et al. 2008, Fageria et al. 2005, Herridge et al.

Robison  
2012, Bailey  
2012



Barker 1999

1990). Legumes best suited to North Carolina include crimson clover, hairy vetch, Austrian winter pea, and Cahaba white vetch (Crozier 2011).

Non-legume cover crops serve a different purpose. They take up available nitrogen left on fields in the fall, and hold it until they are killed in the spring (see Box 2: Cover Crops and Nitrogen). When non-legumes are killed in the spring, they make this nitrogen available for the next cash crop in the rotation (SARE 2010).

### ***Improved Soil Quality and Moisture Content***

Another way cover crops benefit soil is by adding organic matter, which increases nitrogen and phosphorous nutrient cycling, reduces surface water runoff, conserves soil moisture, relieves compaction, and supports microbial life (SAN 2007). By taking up nutrients, cover crops “close the nutrient loop,” keeping nutrients available for continued use. This decomposition process is aided by soil microorganisms, which thrive by digesting organic plant matter. After digestion, the microorganisms release nutrients back into the soil in the form of humus. Humus promotes healthy soil structure and increases water retention. Soil microbes also produce polysaccharides, which act as a “glue” to aggregate soil. In turn, this promotes healthy soil aeration that allows more air space for water infiltration and retention (Sarrantonio 2007). These benefits vary based on the amount of leaching that occurs and timing of precipitation. A recent Alabama study showed that cover crops planted in a cotton field retained 0.6 inches more water in the top foot of soil than a cotton field without residue. Although it might seem small, this adds to about 1.5 to 2 inches per three feet of depth—or 50,000 gallons of irrigation water per acre (USDA 2008).

### ***Reduced Need for Herbicide and Pesticide Application***

Cover crops also allow farmers to reduce their herbicide and pesticide applications—especially if cover crops are killed by means other than herbicidal treatment. Cover crops reduce the need for herbicides by outcompeting weeds for water and nutrients, blocking sunlight to the soil surface (which prevents weed germination), and sometimes by exuding natural herbicidal compounds. This effect is called allelopathy, and can also be used for pathogen and nematode control (Sharad, C. et al. 2007). A study in New York found that planting a cover crop within three weeks of a potato crop provided sufficient weed suppression to use 70% less herbicide (Rajalahti, 1999). Similarly, cover crops attract beneficial insects, reducing the need for pesticides. Beneficial insects are predator or parasitoid, meaning that they survive by eating

other, potentially detrimental species (SAN 2007). A study in Georgia found that cotton and peanut growers who planted high-residue winter cover crops (covers that produce lots of biomass) greatly reduced problems with thrips, bollworms, budworms, aphids, and other insects. The reduced need for pesticides saved farmers \$50-\$100 per acre on average (Altieri 2005).

### ***Drawbacks of Cover Cropping***

Despite the myriad of benefits cover crops provide, certain aspects of the practice cause difficulties for farmers. Some of these drawbacks include timing a cover crop in a cash crop rotation, estimating the rate of nitrogen release from legumes, and difficult management techniques. Timing planting and kill dates for cover crops can be difficult for farmers who are balancing a cover with a cash crop. There is an opportunity cost associated with cutting short a cash crop rotation in the fall to establish a winter cover. Similarly, there is a risk with timing a cover crop kill date in the spring. Adequate biomass is necessary to reap many of the benefits of cover crops, yet delaying the establishment of a cash crop risks reduced yields due to delayed crop harvest (Snapp 2005).

Estimating the rate of decomposition and mineralization for the release of available nitrogen can also be challenging, especially from non-legume cover crop residues. This makes it difficult to accurately calculate the reduction in synthetic fertilizer application needed for cash crop uptake. If a farmer plants a legume cover crop and continues to apply high rates of fertilizer, there is an increased risk of nutrient leaching if a subsequent cash crop is not planted (Snapp 2005).

Other management challenges exist. Fast-growing cover crops and/or self-seeding can be difficult to control, allowing them to establish as weeds or making them difficult to incorporate into the soil. Similarly, this overlapping of cover crop and cash crop can create a “green bridge,” where certain covers may transfer pathogens or pests to the subsequent cash crop (SAN 2007).

### ***Barriers and Opportunities for Cover Crop Adoption***

A handful of studies have examined the barriers particular to the adoption of cover cropping practices within the broader literature on barriers to adoption of sustainable agriculture practices. We seek to acknowledge, apply and enrich this literature with our present research. We focus on studies conducted: 1) since 1999 (to determine up-to-date information), 2) in the United States, and 3) with a primary focus on the agronomic, economic, demographic and information

factors that affect producer decisions to adopt, retain and expand cover cropping. We limit this review to studies that focus specifically on cover crops. We also exclude research designed to compare the economic returns of various cover cropping practices, as these studies do not explicitly investigate which factors influence adoption. Finally, in addition to peer-reviewed journals, we include studies from the grey literature, including several studies conducted on behalf of state-level cooperative extension offices and research presented as part of conference proceedings.

In the past decade, at least nine studies meet these criteria. Table 1 below displays a simple tabulation of the factors cited as significantly affecting cover crop adoption, by study; Table 2 summarizes the findings of these studies. Stivers-Young and Tucker (1999) studied cover-cropping practices of vegetable farmers in Western New York. Larson et al. (2001) compared adoption outcomes among conventional and reduced-till cotton farmers in Tennessee. The Maryland Department of Agriculture (2005) analyzed the influence of incentives on adoption of winter cover crops in Maryland. Snapp et al. (2005) reviewed past literature on cover crop adoption and held in-depth focus groups with potato farmers in Michigan. Two recent multi-state efforts by Singer et al. (2007) and Gabrielyan et al. (2010) have shed light on the factors that shape cover crop adoption. Singer's analysis focuses on conventional producers in the US Corn Belt, while Gabrielyan looks at organic producers in the Midwest. In addition, no fewer than seven studies have examined cover crop adoption among producers in a single state. Bergtold (2008, 2012) and others look at the demographic and management factors among row crop farmers in Alabama. Finally, Arbuckle et al. (2012) published the most recent survey of 1360 Iowa farmers conducted through Iowa State Extension and Outreach Services. Together, these studies inform our understanding of who adopts cover crops, the perceived benefits by adopters, the barriers faced by non-adopters, and the policy levers that hold the promise of wider adoption. Until the research demonstrated in this paper, there existed no other studies of cover crop adoption in North Carolina that we know of.

<b>Table 1: Studies citing key factors of cover crop adoption</b>		
<b>Adoption Factor</b>	<b>Total Count</b>	<b>Studies Cited</b>
<b>Crop rotation/production goals, general</b>	<b>4</b>	1, 3, 8, 9
Interferes with Fall harvest	2	1, 8
Interferes with Spring planting	3	1, 8, 6
Cover crop incorporation into soil	2	8, 9
<b>Cost, general</b>	<b>7</b>	1, 2, 3, 4, 5, 9
Input (seed, labor) costs	3	2, 3, 8, 9
Time availability	2	2, 3, 9
Equipment requirements	2	1, 9
Risk, general	2	4, 7
Rented Land	1	6
<b>Lack of information, general</b>	<b>7</b>	2, 5, 7, 8, 9, 6
Choosing a variety	2	8, 9
Understanding benefits/risks	2	2, 9
Management practices	2	8, 6
<b>Demographics</b>	<b>3</b>	5, 7, 6
Age	1	7
Farming experience	3	5, 7, 6
Farm size	2	5, 7, 8
<b>Benefits</b>		
Reduced soil erosion	3	1, 2, 8
Benefit to cash crop	2	9, 6
Reduced nutrient loss	1	1
Already using reduced tillage	2	4, 5
Reduced fertilizer applications	2	7, 9
Increased soil organic matter	2	2, 8
<b>Opportunities</b>		
Better information	2	3, 8
Better incentives	5	2, 3, 4, 5, 9
Better (seed, seeding) technology	2	8, 9

Table 1: 1. Arbuckle et al (2012); 2. Singer et al (2007); 3. Maryland Department of Agriculture (2005); 4. Larson et al (2001); 5. Bergtold et al (2008); 6. Bergtold et al (2012); 7. Gabrielyan et al (2010); 8. Stivers-Young & Tucker (1999); 9. Snapp (2005).

Table 2: Key Findings from the Cover Crop Adoption Literature. This table presents nine studies that focus specifically on cover crops, and describes factors that affected adoption and recommendations to increase adoption.

Reference	Region	Study Size	Mean Farm Size (acres)	Crop System	% Adopt	Factors Found to Increase Adoption	Factors Found to Decrease Adoption	Recommendations for Increased Adoption
Arbuckle et al (2012)	Iowa	1360	n/a	Row	12%*	-↓ erosion -↑ cash crop productivity -↓ nutrient loss	-Fall harvest interference -Delays spring planting -Shorter-season varieties not available -Lack of equipment	-Address climate and equipment barriers -Increase knowledge and confidence through cooperatives -Seed dealers, crop advisors -Coordinate extension and private efforts
Singer et al (2007)	Corn Belt	1096	768	Row	18%*	-↓ erosion -↑ soil organic matter	-Management time -Input costs -No runoff problem present -Use of no-till -Lack of information	-Incentive payments of \$23/acre would induce 50% adoption -Education role of cover in reducing nutrient loss
Maryland Department of Agriculture (2005)	Atlantic Coast (MD)	673	n/a	All	83%	-↑ time and labor availability -Defined rotation/product ion goals -Cost-share availability -Environmental concerns -Costs of planting/ management	-Restrictive planting/harvesting deadline - Low cost share rates -Lack of time for planting -Seed expense and availability	- ↑ flexibility of cost-share program -Disseminate ↑ information about program requirements -↓ restrictions on cover crop harvest/sale and manure spreading
Larson et al (2001)	South-east (TN)	448	n/a	Cotton	n/a	-Risk aversion in reduced-till cotton systems	-Risk aversion in conventional till cotton	-Subsidize winter legume cover establishment
Bergtold et al (2008)	South-east (AL)	345	753	Row	n/a	-Already using conservation tillage practices - ↑ farm size	-Farming experience -Input costs -Risk aversion	-EQIP and CSP should promote sequential adoption of reduced-tillage followed by cover crops -Target incentives to younger farmers already using conservation tillage on medium-sized farms

Bergtold et al (2012)	Alabama	301	781	Row	66%	<ul style="list-style-type: none"> <li>-Perceived environmental benefit</li> <li>-Irrigation system</li> <li>-Cash crop is soybeans</li> <li>-No rotation in place</li> <li>-Crediting N additions</li> <li>-Fertilizing cover</li> </ul>	<ul style="list-style-type: none"> <li>-% rented land</li> <li>-Farming experience</li> <li>- Careful timing of termination</li> </ul>	<ul style="list-style-type: none"> <li>-Educate farmers about environmental benefits</li> <li>-Educate landlords about cover cropping</li> <li>-Encourage cover crops in conservation plans</li> <li>-Recommend leguminous cash crops</li> <li>-Educate on proper management</li> </ul>
Gabrielyan et al (2010)	Corn Belt	233	934	Row	54%	<ul style="list-style-type: none"> <li>-↑ farm size</li> <li>-↑ farmer age</li> </ul>	<ul style="list-style-type: none"> <li>-↑ years of farm experience</li> <li>-↑ total income</li> <li>- Interaction with organic fertilizer dealers</li> </ul>	n/a
Stivers-Young & Tucker (1999)	North-east (NY)	118	314	Veg.	69%	<ul style="list-style-type: none"> <li>- ↓ erosion</li> <li>- ↑ soil organic matter</li> </ul>	<ul style="list-style-type: none"> <li>-Interference with spring field work and fall harvest</li> <li>-Difficulty in incorporation/plow under</li> </ul>	<ul style="list-style-type: none"> <li>-Further research on improved cover varieties, planting practices to minimize interference with fall harvest, and spring management techniques</li> <li>-Education tailored to farm size</li> </ul>
Snapp (2005)	Michigan	11	2471	Potato	n/a	<ul style="list-style-type: none"> <li>-Aerial interseeding</li> </ul>	<ul style="list-style-type: none"> <li>-Seed price</li> <li>-Inadequate time/labor to incorporate residue</li> <li>-Less predictable N release</li> <li>-Opportunity cost of replacing cash crop</li> </ul>	<ul style="list-style-type: none"> <li>-Establish proven varieties/management practices that work</li> <li>-Provide easy management tools for predicting N replacement</li> <li>-Cost-share through farm programs</li> </ul>

\*Percentage adoption in the past five years.

### **Adoption Rates**

Rates of cover crop adoption vary widely in the literature. The variation results from differences in crop varieties, geographic region, and production systems. In the largest study of its kind, Singer et al. found that 18% of Corn Belt farmers had used cover crops sometime in the past, but only 8% had used them in the previous year on only 6% of their land. (2007) Other studies reported much higher rates of adoption. Stivers-Young and Tucker found that 69% of vegetable growers in Western New York used cover crops as part of their crop rotation. The Maryland Department of Agriculture estimated that nearly 80% of Maryland farmers use cover crops, a result explained in part by Maryland’s aggressive incentive programs designed to mitigate nutrient runoff in the Chesapeake Bay Watershed.

### **Agronomic Factors**

Agronomic factors include the soil benefits of using cover crops and the challenges associated with including cover crops in a cash crop rotation. Farmers commonly cite agronomic factors as compelling reasons for adopting cover crops, or else as key barriers to their adoption. Singer reports that 96% of respondents mentioned reduced soil erosion as a reason to adopt cover crops, while 25% of NY vegetable growers cite reduced erosions as the *single* most important benefit of cover crops. Both studies suggest that building soil organic matter is the second most significant benefit perceived by farmers who use cover crops (Singer 2007; Stivers-Young and Tucker 1999). Other observed benefits include direct benefit to the following cash crop (Bergtold 2012, Snapp 2005), reduced commercial fertilizer inputs (Gabrielyan 2010, Snapp 2005), and enhanced benefits in reduced-till systems (Larson 2001, Bergtold 2008).

Agronomic factors also limit or prevent adoption by some farmers. Singer found that 28% of farmers say that cover crops are not necessary because they do not have a “runoff problem” (2007). Another 39% report that they have not adopted cover crops because of compatibility issues with their no-tillage systems (Singer 2007), a result that



contradicts Larson's (2001) finding from cotton farmers in Tennessee. The discrepancy may be explained by differences in the crop system studied (predominantly corn and soy in the Singer study, cotton in the Larson study). It may also be due to a difference in termination methods—more no-till farmers are using mechanical methods, such as roller-crimpers. Timing issues, such as the interference with fall harvest and spring planting, are also commonly reported across all regions and crop systems (Arbuckle 2012, Bergtold 2012, Stivers-Young and Tucker 1999). Other barriers include the difficulty of tilling and plowing in the cover crop residue and the investment in new equipment required to properly manage a cover crop (Stivers-Young and Tucker 1999, Snapp 2005). This may be especially true for farmers using a “roller-crimper,” which is a tool specifically designed for cover crop termination commonly pulled behind a tractor.

### *Economic Factors*

Like all production decisions, farmers consider the monetary costs and benefits when deciding whether or not to incorporate cover crops into their rotations. Gabrielyan et al. (2010) report that lower income farmers are more likely to adopt cover crops. They reason that these farmers lack access to the precision technology that would otherwise reduce fertilizer applications, and thus receive a higher benefit from cover crop N fixation. More often, studies refer to economic constraints to adoption. Farmers in the Midwest, Michigan and Maryland report difficulties finding time to plant cover crops, which deters implementation (Singer 2007, Snapp 2005, MDA 2005). The cost of additional labor, seed and equipment prevent many producers from investing in cover crops even though the practice may pay for itself over time. (Ibid) Gabrielyan shows that, while higher income reduces adoption, increased farm size has an independent and positive effect, estimating that each additional 100 acres corresponds to a 2.25% increase in the probability of adoption (Gabrielyan 2010). Bergtold et al. also found that an increase in farm size has a positive effect on adoption (2008). However, Stivers-Young and Tucker (1999) report that increasing farm size decreases the proportion of farmland that a farmer puts under cover crops in a given year.

### *Information Transfer*

The quality, format and source of information that farmers possess affect their assessment of cover crops. Forty percent of Corn Belt farmers report that they do not have sufficient

information about cover crops to adequately weigh their costs and benefits (Singer 2007). Farmers who do possess sufficient information report that knowledge sharing among producers is key to informing their decision-making, highlighting the importance of horizontal knowledge networks in sharing information and opinions on conservation practices more generally (Gabrielyan et al. 2010).

All cover crop studies to date consistently report that farmers need better information to guide their adoption decisions. Existing literature cites limited information at many points of decision-making during cover crop implementation. Farmers lack information on managing a cover crop (Singer 2007), choosing cover crop varieties that will meet their conservation and crop production goals (Snapp 2005), estimating the nutrient benefits of using cover crops (Bergtold 2008), and qualifying for cost-share assistance through state and federal programs (MDA 2005). In response, researchers recommend improvements in knowledge transfer that address the most pressing information gaps in the study population (Arbuckle et al 2012, Singer 2007, Bergtold 2008 and 2012, Srivers-Young and Tucker 1999). Although these recommendations differ somewhat in their focus, the literature makes an unequivocal call for increasing public agency involvement (such as cooperative extension) in the preparation and dissemination of actionable information about cover crops.

### ***Public Policy Incentives***

Farm policy creates both direct and indirect incentives and disincentives for farmer adoption of cover crops. Expanding on the studies cited above, most of the literature to date confines itself to the impacts of direct incentives on the adoption decision. Both the Environmental Quality Incentives Program (EQIP) and the Conservation Stewardship Program (CSP) offer direct incentives to farmers who qualify and implement cover crops into their rotations. Singer (2007) found that, among Corn Belt farmers, an average payment of \$23 per acre would be sufficient to induce half of farmers to plant winter cover, although this only applies to the large average farm size (768 acres) in Singer's study. Singer exclusively studied large row crop producers in the Corn Belt, therefore it is difficult to say whether this incentive would have a similar effect on farmers in other regions, especially those that farm less acreage, or that face high transaction costs to justify qualification for funding. In Maryland, a cover crop adoption "success story", 23% of non-adopters reported that minimum acreage requirements prevented them from receiving incentive payments (MDA 1999). Another 34% indicated that the

program restrictions on planting and harvesting dates precluded their participation (Ibid). Of those farmers using cover crops in Maryland, 59% report doing so without any financial or technical assistance from the Maryland Department of Agriculture, although it is not clear if any of these farmers benefited from federal incentives because 41% reported that they would continue to plant cover crops in the absence of cost share assistance (MDA 2005).

### ***Current Policy Landscape***

Three institutional cost share programs support cover crop use by NC farmers; two of these are on the federal level, and one is on the state level. Here we report our best understanding of these cost-share programs.

### ***Environmental Quality Incentives Program (EQIP)***

EQIP funds, authorized through the Farm Bill in 1996 and appropriated by Congress, “Provide a voluntary conservation program for farmers and ranchers that promotes agricultural production and environmental quality as compatible national goals” (NRCS 2012). Specifically, “EQIP offers financial and technical help to assist eligible participants install or implement structural and management practices on eligible agricultural land.” EQIP is a cost share program that pays up to 90% of the cost to install conservation practices and equipment. Applications to the program are evaluated in a complex process that assigns points based on the practice(s) proposed, farm location, national, state and regional conservation priorities, and whether the farmer is classified as “historically underserved” (including minority populations and farmers who have farmed for fewer than ten years).

To address conservation goals, EQIP accepts applications for a variety of proposed improvements and assigns pre-determined cost-share rates. In North Carolina, producers can receive \$37.35/acre for planting one species of cover crop, or \$58.54 for planting 2-5 species (NRCS 2012). EQIP will pay an additional amount of funding for historically underserved populations (\$44.82/acre for single species and \$70.25 for multiple species of cover crops).

### ***Conservation Stewardship Program (CSP)***

Like EQIP, CSP is a federally funded working-lands program administered by the Natural Resource and Conservation Service (NRCS). Whereas EQIP primarily provides cost-share assistance for capital improvements, CSP encourages producers to adopt conservation

*management* practices that go above and beyond basic conservation. Eligible practices are based on national, state and local priorities. For example, North Carolina’s “priority resource concerns” currently include soil quality, soil erosion, water quality, and water quantity (NRCS-CSP 2012). Farmers submit an application through their local USDA Service Center, NRCS Field Office, or local Soil and Water Conservation District to receive incentive payments in return for adopting approved management “activities” that address one or more resource concerns. “Cover crop” is an approved enhancement activity under CSP (code 340); however, we were unable to find any evidence that producers in North Carolina currently receive CSP funding to plant cover crops. For most activities, producers are paid a per-acre rate that is adjusted for the anticipated performance of the proposal.

Our research suggests a second avenue through which NC farmers might receive CSP funding to plant cover. According to the NRCS website, a “supplemental” payment “is available to participants earning an annual [CSP] payment who also agree to adopt a resource-conserving crop rotation on cropland” (NRCS 2012). Each state’s NRCS office decides what qualifies as a “resource-conserving crop rotation.” In North Carolina, this list comprises cover crops such as perennial grasses; legumes used for forage, seed production or green manure, and legume/grass mixtures used for green manure as part of a rotation (NRCS 2010). When these cover crops are incorporated into an approved conservation rotation, the producer qualifies for an additional \$12/acre for each acre covered by at least one other CSP contract. Thus, according to available information, all producers automatically qualify to receive the additional payment if 1) they have a CSP contract *and* 2) they use an approved rotation that includes cover crops (Ibid). The total of these payments depends on the amount a specific farmer receives for his or her CSP contract. However, we have not been able to reach NRCS staff to confirm that this opportunity exists or whether it’s promoted. We were also unable to find any data to suggest that producers in North Carolina have taken advantage of the supplemental payment.

### ***North Carolina Agriculture Cost Share Program (ACSP)***

The NC ACSP is “A voluntary program to protect water quality by installing best management practices on agricultural lands” (NC DENR 2012). The Program is funded by the North Carolina Department of Natural Resources (DENR) Division of Soil and Water Conservation (DSWC), and jointly administered by DSWC and local Soil and Water

Conservation District (SWCD) offices. Each year, the SWCD for each of NC's 100 counties conducts a water quality assessment, prioritizes needs and develops a strategy plan. DSWC then evaluates strategy plans and allocates cost-share funds to each county-level SWCD (NC DENR 2011). This funding then becomes available to farmers in each county.

Cover cropping is an eligible cost-share practice for the purpose of "Erosion Reduction/Nutrient Loss Reduction in Fields," and the only such practice that requires an annual contract (NC DENR 2012). Most approved BMPs on the state level have terms of 5-10 years. In 2010, the ACSP provided cost-share assistance to plant 4,977 acres of cover crops at an average cost of \$19/acre. (NCDENR 2011) An additional 17% of acres were approved for ACSP funding to plant cover crops, but ultimately failed to meet the program requirements (plant/kill dates). In total, cover crops accounted for 2.2% of the \$4.24 million disbursed through ACSP.

Many questions pertaining to available funding for North Carolina farmers remain. What percentages of applicants who seek cover crop cost-share actually receive funding? How many acres of cover crops does each of the programs support in a given year? What are the enrollment trends over the past five years? We sought answers to these questions with the director of the NC Agriculture Cost Share Program and NRCS's Assistant State Conservationist for Programs in North Carolina. Unfortunately, our emails and phone calls were not returned, and these questions remain outstanding as a topic of future research.

### *Recommendations from the Literature*

The following recommendations have been suggested to increase adoption of cover crops. These recommendations include increased flexibility and information transfer, a focus on cover crop research, and increased cost sharing.

Maryland study recommends improved information transfer and flexibility, and concludes: "Some flexibility in [cost-share] program design could go a long way to increasing the attractiveness of the program to farmers. MDA needs to make a more concerted effort to disseminate information about the program more thoroughly. The survey results suggest that specific program reforms would go along way toward increasing participation. These include allowing harvesting of the crop for commercial purposes, increasing the cost-share ratio, and eliminating restrictions on spreading manure" (MDA 2005).

To increase adoption among non-adopters, Bergtold (2005) highlights opportunities for “re-educating farmers concerning the environmental impacts [benefits] of cover crops on-site and off-site,” and “working with farmers to help educate landlords [to] alleviate any apprehension a farmer may have about adopting this practice on rented lands.” While touting the importance of “increased knowledge and confidence,” Arbuckle’s (2012) primary recommendation centers on developing the technological innovations necessary to address climate and equipment barriers, including aerial seeding methods and “new cover crop technologies that employ perennial grasses rather than annual plants and development of short-season crops with yields comparable to long-season.”

Stivers-Young and Tucker (1999) recommend increased local and regional research on specific cover crops breeds to assess their appropriateness for local conditions; information on cover crop mixes rather than monocultures; “participatory research” that includes on-farm trials by real farmers; and research and demonstrations into establishing a winter cover earlier in the Fall and terminating/incorporating the biomass in the Spring; and education tailored to farm size. Snapp (2005) recommends further research into the specific environmental services provided by cover crops so that the case can be made for increasing financial support under farm programs.

Singer (2007) believes that increased cost-sharing holds the most promise in terms of impact on adoption, combined with targeted education on cover crop costs, selection, and management. Bergtold (2005) echoes Singer that education improves cover crop outcomes (and therefore perceived value), but notes that these benefits mostly accrue to farmers who have already adopted the practice. Finally, Larson (2001) reaches the succinct and applied conclusion that “subsidizing winter cover legume may be an effective policy option.”



## Methods

### Why Social Surveys?

Social surveys have historically been the most widely accepted way for policy researchers to understand the impact and effectiveness of new policy (Wright 1988, Macrae 1973). Social surveys utilize the collective voices of the target population to identify the best ways for policy to drive behavioral change. Our main goal was to answer the question: What are the main challenges facing cover crop adoption in North Carolina? Therefore, we selected the social survey method to identify and provide insight into those challenges.

Data for this study was gathered through two main surveys: (A) A mixed-methods **web survey** combining closed- and open- ended questions; and (B) Self-structured, semi-guided **key informant interviews**, both in-person and via telephone. Mixed-method surveys are widely accepted as the best way to combine quantitative and qualitative data to understand how the agriculture community makes decisions (Rodriguez 2009, Drost 1999, Stivers-Young 1999). We chose to combine both closed-ended (multiple choice) and open-ended (free form text) to ensure we had quantifiable data as well as explanatory data.

### Web Survey

Web surveys are widely accepted today as substitutes for the traditional paper format or in-person format surveys (Couper and Bosnjak 2010). They are sometimes considered superior, because they have a very low associated cost and obviate the need for intensive data entry. Additionally, it is easy to track in real-time how many people have and haven't taken the survey. Although our survey did not include unique links for each respondent, web surveys do offer this flexibility, allowing researchers to track on a person-by-person basis (though still anonymously) who has and hasn't filled out a survey. Outreach to respondents is also very quick. It takes an email less than a second to send, whereas mail can take between 3-5 business days, if not more. For these reasons, as well as financial constraints, we decided against both a multi-part mail-out survey and an in-person survey in favor of a web-based survey tool.

Web-based surveys also have drawbacks when compared to in-person surveys, however many of these drawbacks are similar to ones that emerge during mail-out surveys. These drawbacks include the inability to control the survey experience – for example, during an in-

person survey it is possible to ensure that the respondent is in an environment with few distractions and no interruptions. Mail-out and web surveys do not have this element of control because the interviewer is not with the respondent when he or she is taking the survey. The only disadvantage to a web-based survey is the potential for skew when it comes to the respondent pool; the demographic of respondents who are comfortable giving out information over the web may be very different from those who will fill out mail surveys.

### **Implementation**

We sought to identify the main challenges in cover crop adoption. Therefore, survey questions were developed around 7 main hypotheses that we wanted to address.

1. Risk to cash crop constrains adoption.
2. Risk to insurance payment constrains adoption.
3. Payments from institutional programs (e.g. CSP) increases adoption rates.
4. Knowledge of locally appropriate varieties is required for cover crop adoption but farmers lack the resources to learn about cover crops.
5. Capital costs (unbearable expense) constrains adoption.
6. Field aesthetics (the visual messiness of cover crops) constrains adoption.
7. Fear of pathogen transfer from cover to cash crops constrains adoption.

Our survey questions were designed to test the existence, and extent, of our hypotheses. We developed demographic and land ownership questions based on past studies of agricultural producers (Kramer 2008, Roberts 2007). Based on conversations with experts, we determined what topics the survey questions and multiple choices should cover. These experts were: Dr. Jennifer Blesh (Post-doctoral researcher, Federal University of Mato Grosso) who had researched agroecosystem sustainability and cover crops in the Midwest (2011), Dr. Julie Grossman (Principal investigator, North Carolina State University) who studies the effects of legume cover crops on soil nutrients. Lee Miller and Katy Zook had also developed a robust background knowledge based on research performed over the summer of 2011 for UCS. Miller and Zook's research focused mainly on exposing past and current cover crop research and the main trends and challenges that current cover cropping farmers were facing. Our final set of questions sought to uncover knowledge, financial, and locally-specific constraints. This survey was put through 10 iterations in review for question content, written clarity, question order and repetition, and length.

Feedback was sought from Dr. Kramer, Natalie Jackson (Survey Research Associate, Duke Initiative on Survey Methodology), Dr. Noel Gurwick (Senior scientist, Union of Concerned Scientists) and Dr. Chantal Reid (Assistant Professor of the Practice, Nicholas School of the Environment) on question wording, order and content. The survey was kept constantly updated in both a Google document and in our online survey tool, Qualtrics.

The survey was pretested by four farmers in the Durham Area. We observed subjects as they proceeded through the survey, and solicited comments on confusing and ambiguous wording and questions where obvious answer choices seemed to be missing. Once the survey was finalized and pretested, the team sent for and received IRB approval from the Duke Human Subjects Research Board.

The final survey consisted of a mix of the following:

- Multiple choice questions (e.g. Please indicate if you have ever obtained money from any of the following programs or organizations...)
- Short-response free-answer questions (e.g. When I first began planting cover crops, the factor that influenced my decision the most was..."
- Likert scale questions (e.g. On a scale of 1-5, how much do you agree or disagree with the following statements...)

Based on our pretests, the survey should have taken no more than 30 minutes to complete. Indeed, most response times range between 10-20 minutes, with only a few outliers beyond the 30 minute mark. The number of questions varied depending on how the respondents answered various "respondent pool" questions. That is, respondents who planted cover crops answered a different-but-similar set of questions than those who had not planted cover crops.

### ***Respondent Selection***

A major decision point for our survey was who we wanted our survey respondents to be. We hoped to obtain a representative sample of all North Carolina farmers, and pursued our survey respondent pool based on this goal. Potential survey respondents were gathered via two methods.

First, we initiated contact with 100 county representatives of the Soil and Water Conservation boards in North Carolina. While we were not able to contact all of them, several agreed to send our survey out to their farmer communities on our behalf. 31% of our respondents came from this pool.

Second, we manually mined email addresses of North Carolina farmers from online directory listings. In many cases we had to cross-check our lists to make sure we hadn't included anyone more than one time. Ultimately we used three main directories and obtained 69% of respondents from this pool.

- North Carolina Farm Fresh, at <http://www.ncfarmfresh.com>
- North Carolina Eat Well Guide at <http://www.eatwellguide.org>
- North Carolina Fresh Link Growers at <http://www.ncfreshlink.com/shipperdirectory>

The survey was sent out on January 10, 2012 to 850 farmers with reminder emails sent out on January 15, 23 and 30. The survey was closed on February 8, 2012, with a total of 288 survey results (response rate of ~35%). We collected county affiliation for each respondent to determine distribution across the state (Figure 1).

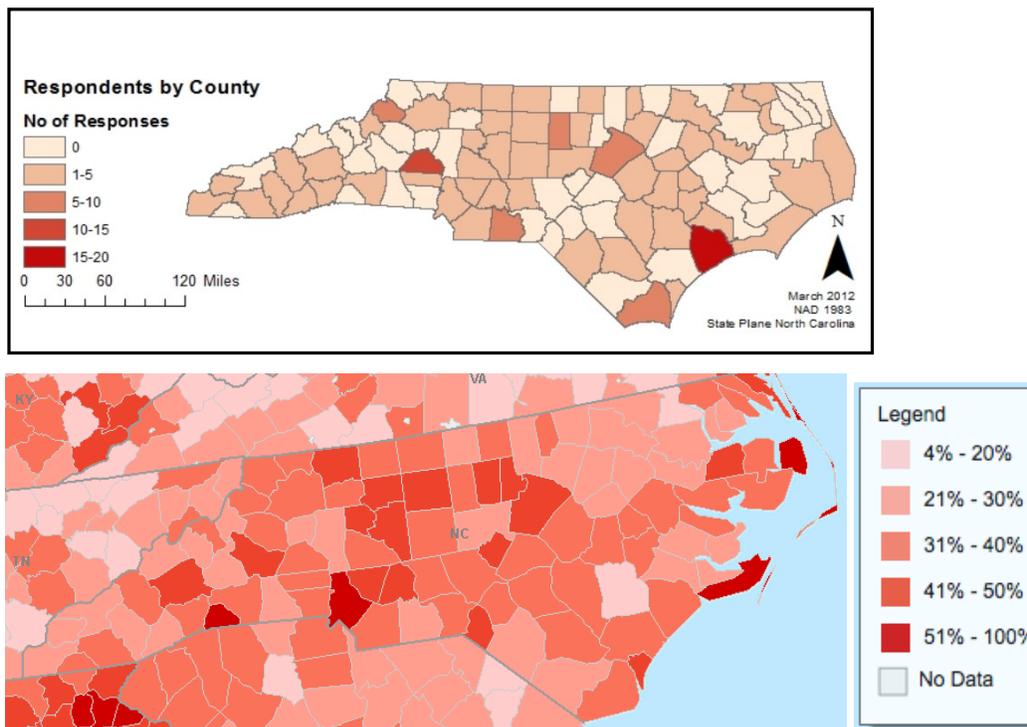


Figure 1. Number of survey respondents by county (self-reported) at top, with percentage internet penetration also by county below.

### Analysis

'Stata' was used for data management and for the bulk of the statistical analysis. Stata is a statistical package used mainly for economic and sociological analyses. We removed those respondents who began the survey but did not answer any questions and those who indicated that

they planted zero acres of crops. We also excluded respondents who indicated that they would not sell more than \$1000 of farmed products (livestock or crops) in the next year. This left 188 usable surveys out of the 288 who entered the survey flow. Those who made less than \$1000 were not considered because we knew they could not claim agriculture as their main method of income generation. Furthermore, these farmers' crop volume would likely be insignificant in comparison to other small farmers who could benefit from state or federal policies around cover crops or SAPs.

A number of our questions required respondents to enter number values. Some of these questions were around number of acres farmed, or number of acres under lease. We found that farmers typed these answers in many different formats and that we then had to standardize them. All open-ended questions that had values such as "10+" were rounded up to the nearest one (e.g., 10+ acres became 11 acres). Anything <1 or a fraction of one was given a value of 0.5. (e.g. 0.75 years farming experience became 0.5 years).

Based on the advice of the Statistical Consulting Center at Duke University and the experience of Jennifer Chin's social survey work from the summer of 2011, we did not create a logistic regression model and instead pursued a multiple choice pairwise correlation analysis. Our main reason was that our sample size was quite small as compared to the number of variables. Therefore any model would not have been robust.

We first looked at our survey respondents' demographic data from our survey and compared it against data from the NC agriculture census of 2007. We looked only at three main demographic factors: gross annual farm income, farmer age, and size of farm.

The bulk of our survey was comprised of four-point scale Likert scale questions. Item responses were evaluated as ordinal data. The mean and median response to "I would plant more cover crops if..." were calculated for categories of farmer demographics. These mean and median values were based on the ranking scale mentioned above, where one represents "very likely" and four represents "very unlikely."

Pairwise correlation analyses determine the strength of a relationship between two variables. Correlations were determined between demographic characteristics and Likert responses to determine similarities among farmers facing different types of challenges. In our study we were interested in seeing the correlation between key differentiating farmer factors, called "groups" (such as farm size and years of farming experience) and the way they answered

various questions on cover crop barriers. Our pairwise correlation groups were selected for significance by correlation coefficient “ $r > 0.5$ ” and for significance “ $p < 0.05$ .” In other words, we looked to see if certain groups answered questions differently than other groups. If they did so with a correlation of “ $r > 0.5$ ,” this indicated a moderately positive correlation. If they did so with a “ $p < 0.05$ ” significant, then the probability of obtaining a survey result that was very different from the true value is less than 5%. For each farmer group, we used the following “identified challenges” as our response variables. These challenges answered the question “I would plan more cover crops if...”

- cover crops did not threaten their crop insurance
- cover crop seeds were 50% cheaper
- the benefit of cover crops could be obtained in a shorter length of growing time
- more information were available about the benefits of planting cover crops
- 50% less fertilizer could be applied to fields by planting cover crops
- they had more equipment to plant and terminate (kill) cover crops
- they had more access to farm labor to help plant and terminate cover crops

We calculated the median response to perform relative comparisons to see how the group association made a farmer more or less likely (relatively) to answer a question in the affirmative or the negative. Next, we used a Spearman rank correlation test to determine significance between the various social groups mentioned above, and their responses. Spearman rank correlation is used mainly for non-parametric data that does not meet assumptions of normality, linearity or homoscedasticity (McDonald 2009). Our “hidden” nominal variable is farmer identity “group”, with the two measurement variables being the correlated variable measurements. For example, two measurement variables would be how likely a farmer is to agree with the statement “I would plant more cover crops if I had 50% more labor access” and what category of farm size they had. The “hidden” nominal variable is the one that associates to variables with one another – in this case, the identity of the group is the nominal variable, with the response to likelihood of adoption and farm size linked to that group identity. We then applied a Bonferroni correction to adjust for spurious correlations that arise from making multiple comparisons at one time. A Bonferroni correction essentially adjusts the p-value that makes a result statistically significant (Simon 2008).

Due to low response volume from farmers who did not plant cover crops (34 responses, in comparison to 154 from those who did plant cover crops), analyses were focused almost

entirely on farmers who plant cover crops. However, t-tests were performed to determine whether significant differences between adopters and non-adopters exist. These t-tests examined: years of farming experience, age, cropped acres, application to conservation programs, off-farm income, and land type of land ownership.

## **Key Informant Surveys**

### ***Implementation***

Six key informants were selected to encompass the academic, practitioner and policy perspective on cover crops. All informants were experts in the field as recognized by Dr. Noel Gurwick (Senior Scientist, Union of Concerned Scientists) or Dale Threatt-Taylor (DEL '11; Conservation District Director, Wake Soil and Water Conservation District). The exception is Herbie Cottle, who contacted Lee Miller after receiving the web survey and offered to be interviewed more extensively in person. Our key informants were (1) Jennifer Blesh, a post-doctoral researcher in Agronomy, Federal University of Mato Grosso. (2) Eliav Bitan, an agriculture advisor with the National Wildlife Federation. (3) Teresa Hice, Natural Resource Conservationist for Wake County in North Carolina. (4) A District Conservationist from the U.S. Department of Agriculture-Natural Resources Conservation Service (USDA-NRCS) whose name has been withheld by request. (5) Herbie Cottle, a farmer in Rose Hill, NC who is transitioning between conventional and organic farming and uses cover crops regularly. (6) Dana Ashford-Kornburger, a State Conservation Agronomist with USDA-NRCS.

Katy Zook conducted key informant interviews between January 13 and February 9. Phone interviews ranged in length from 35 minutes to 65 minutes. The visit with Herbie Cottle lasted approximately 2 hours. Zook developed the questions based on our seven hypotheses, but then targeted each set to the individual interviewees' experience. These questions were also submitted for and given IRB approval, including permission to attribute names to direct quotes. Interviews were generally arranged through email and then conducted over the phone, with a microphone-ready iPod used to record. Herbie's interview was recorded with an iPad. All interviews were transcribed, leaving out those comments that people explicitly requested be left off the record.

## *Analysis*

The transcriptions of Key Informant interviews were coded and analyzed in Nvivo 9, a survey program designed to pull structured information out of unstructured data. We imported the written transcriptions for each key informant as internal reference files and then created nodes for each challenge as described by the hypotheses. These nodes serve as buckets that combine interview content pertaining to pre-specified topics. Additional nodes were created as new themes became apparent, ultimately resulting in 20 nodes:

Nodes related to Hypotheses:

1. Risk to cash crop constrains adoption.
  - i. Planting cover crops interferes with cash crop rotations
2. Risk to insurance constrains adoption.
  - ii. Farmers risk they would lose federally-subsidized insurance
3. Payments from institutional programs (e.g. CSP) increases adoption rates.
  - iii. CSP payments are too low
4. Knowledge of locally appropriate varieties is required for cover crop adoption but farmers lack the resources to learn about cover crops.
  - iv. Knowledge
    - Lack access to locally-appropriate varieties, but would otherwise plant cover crops
    - Knowledge not local enough to decide if cover crops are beneficial
    - Farmers uninformed about locally appropriate varieties
  - v. Lack sufficient information
5. Capital costs (unbearable expense) constrains adoption.
  - vi. Won't adopt because of benefit-cost ratio criteria
  - vii. Capital costs too expensive
6. Field aesthetics constrains adoption.
  - viii. Landlord won't approve
7. Fear of pathogen transfer constrains adoption.
  - ix. Risk of pathogen transfer

Nodes related to new themes:

- x. Animal grazing
- xi. Cover crops in the Southeast
- xii. EQIP
- xiii. Innovators and networks
- xiv. Killing (termination) methods
- xv. Moisture concerns
- xvi. National policy barriers
- xvii. Ownership
- xviii. Research needs
- xix. Source of knowledge
- xx. “The switch” (from conventional to nonconventional)

The additional nodes did help us to reform our hypothesis after we began to analyze our results and pull out some new themes from our web survey data, discussed below.

## Results and Analysis: Key Informant Interviews

### Overview

Our analysis of the key informant surveys follows. This analysis addresses themes that were drawn out of data collected through transcriptions of qualitative interviews.

### *Coding Themes*

Qualitative analysis of transcriptions alluded to three main challenges: agronomic timing challenges, knowledge transfer, and input concerns. These trends were identified both from careful reading of transcriptions, and from analysis in NVivo, discussed below. Although not every informant identified topics coded to each node (each informant identified barriers unique to all the others), all informants discussed barriers related to finding time to plant cover crops in a cash crop rotation, finding the necessary knowledge to implement cover crops, and acquiring the necessary equipment to successfully operate a cover into rotations. Refer to Figure 2 for topics of nodes.

The nodes coded to “agronomic/timing issues” included “planting cover crops interferes with cash crop rotations,” “risk of pathogen transfer,” “moisture concerns” and “complications with termination methods.” Each of the six informants mentioned barriers that related to

integrating a cover crop into a cash crop rotation, and three out of the six informants identified termination methods as a challenge for farmers. Risk of pathogen transfer and complications with soil moisture were less of a concern, identified by one and two informants respectively.

The nodes coded to “input challenges” included “farmers won’t adopt because of benefit-cost criteria,” “farmers lack access to appropriate seed,” and “capital costs are too expensive.” Five out of six informants identified capital costs and benefit-cost criteria as a main challenge. The least coded input node referred to lack of access to appropriate varieties, with only two informants identifying this as a challenge.

Nodes coded to “knowledge transfer” included “source of information,” “farmers lack sufficient information,” “knowledge is not local enough for farmers to decide if cover crops are beneficial,” and “farmers are uninformed about local varieties.” The “source of information” node was the most popular topic in the dataset; all of the informants mentioned this as a challenge, and it was coded to the most out of any node. The other knowledge challenges were each identified by four out of six informants.

**Pearson Correlations**

Pearson correlations helped to solidify the importance of the three barriers mentioned above. Each node was examined in a correlation test to see whether nodes were related based on similar wording. Correlations between nodes are displayed graphically below:

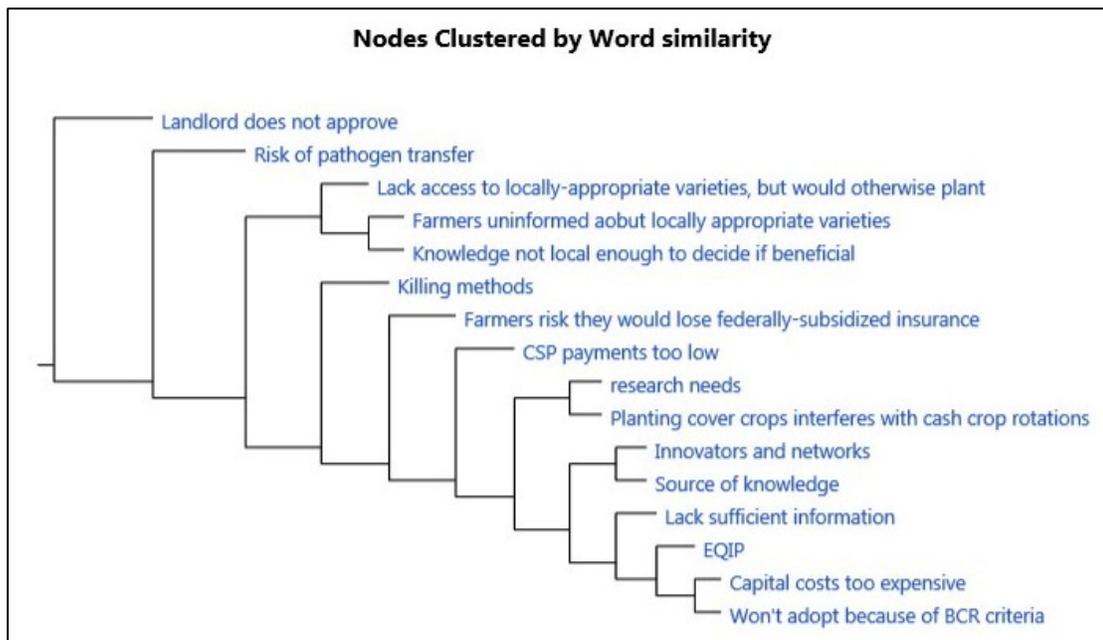


Figure 2: Nodes Clustered by Word Similarity. This shows a Pearson correlation analysis created with NVivo to display nodes that are most correlated by word similarity.

The most highly related nodes in this diagram are “capital costs are too expensive” and “won’t adopt because of benefit-cost ratio.” These nodes both relate to input costs, i.e. the cost of implementing cover crops with the expectation of receiving the benefits of this practice in the future. Following these are nodes related to knowledge (e.g. “source of knowledge,” “lack sufficient information”), and timing with cash crop rotations (“planting cover crops interferes with cash crop rotations,” “research needs”). It should be noted that this diagram finds a close relationship between all three of these challenges; nodes related to each challenge stacked on top of one another on the right-hand side of the diagram.

### **Main Challenges**

The following sections outline discussions alluding to the three main barriers identified: agronomic challenges, input challenges, and knowledge transfer challenges. These sections are not comprehensive, rather they’re meant to draw out important pieces of conversations that, when viewed together, add new understanding surrounding each type of challenge.

#### ***Agronomic Challenge: Timing Rotations***

Teresa Hice pointed specifically to issues with timing rotations in North Carolina as a barrier for cover crop implementation. She said that,

“The drawbacks, I find, that keep farmers from putting in cover crops—is the crops they plant, if they’re doing soybeans or something that goes late, like November, December, like soybeans will, there’s no time to really get a cover crop established before hard winter comes in. They won’t even try” (Hice 2012).

Dana Ashford reinforced this sentiment, noting that,

“As far as the most significant barrier, where the cover crops fit into the specific rotation that people are using, and also does the cost associated with establishing the cover crop give a bigger benefit—are the environmental benefit and rotational benefit going to be big enough to counteract that cost of the cover crop, especially if they have to fertilize the cover crop?” (Ashford 2012).

This also points to inputs as a main challenge. Josh noted timing as an especially important challenge for the Southeast:

“Especially for crops like cotton, and that’s of course one of the major crops in NC that’s been so great economically over the last few years too, a really special effort has to be made to incorporate a cover crop into a cotton rotation because of the plant and harvest dates. And people have been experimenting with some things over the last few years as far as the types of seeding that can be done to get those cover crops growing at the appropriate times before harvesting. Because if you don’t get them in early enough, you’re not going to recognize the benefits. And cotton is just one example” (Spencer 2012).

When discussing the challenges he overcame to use cover crops, Herbie pointed to timing. Recognizing the benefits of letting a cover crop mature in the spring before terminating it to plant a cash crop, Herbie noted, “That was one of my problems with cover crops, but in the long run I’m gonna let it grow out ‘til June anyway to maximize the biomass.”

*“A really special effort has to be made to incorporate a cover crop into a cotton rotation because of the plant and harvest dates”*

Jenifer Blesh also referenced issues with timing a cover crop in a cash crop rotation. She pointed to traditional goals of breeding cash crop seeds as a compounding factor influencing timing challenges.

“The research emphasis is on maximizing corn yields in that area, and so one way that’s occurred is by breeding corn varieties that have earlier and earlier planting dates because there’s a boost in yields achieved with that mechanism which means that the window for putting in a winter annual cover crop is then reduced substantially. So that’s a physical barrier, but that sort of intersects with a political and economic barrier because farmers feel a larger risk in planting a cover crop because it might impede planting a cash crop in the spring” (Blesh 2012).

## *Input Constraints*

One of the main challenges identified by key informants was the failure for cover crops to pass a benefit-cost ratio. This perceived challenge was mainly because farmers have a difficult time calculating the benefits of cover crop adoption. Talking about his fellow farmers, Herbie mentioned:

“It’s gonna be hard for them to see the dollar amount right up front. After years and years of cover crops, it’s gotta build your soil from a nutrient standpoint and from organic matter. Organic matter has a lot to do with it. And a lot of folks don’t realize that’s the deal with growing cover crops” (Cottle 2012).

The NRCS representative backed this point. He referenced the difficulties of paying the up-front costs of implementing cover crops, noting:

“That’s where we have to get farmers out to show them. Especially with the price of petroleum products going up (which is where fertilizers come from)—what you need to understand is that... if you get nitrogen to build up with your cover crops, that’s gonna help your bottom line. But like I said, unless they’re really willing to try (and there are a few farmers out there that are willing to try) they won’t see that you can cut back on nitrogen application rates” (NRCS 2012).

Teresa also pointed to calculating benefits as a major factor in adoption:

*“You gotta keep poking the pocketbook... Conservation is always competing against other ways [farmers] can spend their money”*

“And the education process that we’re trying to do to get them to understand the benefits, that it’s benefiting their next crop if they use the cover crop. You gotta put it towards the pocket book, you gotta keep poking the pocketbook. Even if you don’t have the funds for the cost share, you still gotta make the money argument. Conservation is always competing against other ways [farmers] can spend their money” (Hice 2012).

Teresa also pointed more generally to input costs as a discouraging factor in farmers' benefit-cost ratio. Teresa said,

“Some others just can't handle the added expense, because the cost of inputs has really gone up. And even the cost of seed has gone up (which is very strange). So depending on their budgets, that sometimes keeps them from putting cover crops in. They know the benefits. I don't think there's many farmers out there who don't know the benefits of cover crops. It's just whether they can work it out in their budget” (Hice 2012).

Jennifer Blesh also pointed to seed costs as a challenge, “Seed costs are high. And so, I think [cost-sharing programs] would make a difference. Farmers need the package of not only the seed, but the fuel to plant it, the time, the labor, and then the opportunity cost of potentially reducing the yield of the crop that follows your cover crop.”

### *Knowledge Transfer*

Eliav Bitan contrasted the extensive educational infrastructure that exists for more established agricultural practices against the fledgling resources on innovative practices like cover cropping. He mentioned that while cover crops were part of many rotations 100-200 years ago, much of that knowledge has since been lost and farmers must discover how to incorporate cover crops into modern, more industrialized crop systems. Private companies traditionally serve as important drivers of agricultural innovation and knowledge creation. (Heisey et al 2011) However, private companies are only beginning to augment and disseminate knowledge about cover cropping. According to Mr. Bitan, “There is obviously a large industry built around conventional agriculture (seed companies and chemical companies) and they contribute to developing the education. And that doesn't yet exist for cover crops.”

Mr. Bitan noted that the asymmetry of educational resources extends beyond private companies to public research and educational institutions. He said that for farmers planting commodity corn,

“There are extension agents, there are university researchers, there's a grain elevator, there are crop advisors, there are tons of people who tell me how to do it. And if I'm trying to decide which kind of corn to use, there's catalogues, there's websites, there's

discussion boards, I hear people down at the coffee shop talking about it—there’s tons of information out there for most conventional agriculture. Cover cropping is a new, innovative, less commonly used practice lacking all of that educational knowledge infrastructure. We actually think [information is] extremely important, and that’s one of the main focuses of our work on cover cropping” (Bitan 2012).

Jennifer Blesh also acknowledged that most farmers obtain information from members of “conventional” agriculture knowledge networks trained in land grant institutions. These farmers “rely heavily on knowledge from their commodity organizations, from their consultants, from their co-ops, which is all coming from land grants as well.”

Farmer Herbie Cottle recognized a different opportunity to fill the information gap: cooperative extension. He noted that this might be especially effective among conventional farmers:

“There are so many benefits from cover crop production. And I think a lot of the conventional farmers don’t realize that it will do all that for you. Soil erosion and all...I think extension has got to be a great opportunity—they’re in contact with [conventional farmers] already. So that’s probably the best way. The foundation is already there. They know all the conventional farmers. So if you can convince your extension agents, that would be a super source” (Cottle 2012).



However, Mr. Cottle adds that convincing extension agents to advocate cover crops may be difficult, “[Extension is] sponsored by State,” he says, “and State’s sponsored by Roundup, Monsanto.”

Instead, Mr. Cottle believes that farmers’ best resource may be the various conferences and workshops put on by organizations like CFSA and SSAWG, saying,

“I’d been going to conferences for like 15 years. To all the organic conferences. SSAWG is a good one, CSFA down in Pittsboro. I’ve been going to them for 15-20 years. Even before I started farming organically I was going to conferences and trying to learn” (Cottle 2012).

One advantage of conferences is the chance to meet up with other farmers to compare notes on management practices. Dr. Jennifer Blesh believes that such “farmer-to-farmer” or “horizontal knowledge exchanges” play a critical role in educating farmers about innovative management practices. If one farmer tries a new management practice, his neighbors can learn from his success or failure, reducing their own risk. Farmers can also share knowledge that is highly specialized and localized. Dr. Blesh added,

“One farmer had come up with his “ideal cover crop mix” of hairy vetch, rye and oats, and he came to that conclusion by trial and error and learning by doing. I’m sure the

*“I’m sure the common way is horizontal knowledge exchanges, participatory exchanges, because there aren’t as many formal channels for learning about things like cover cropping”*

common way is horizontal knowledge exchanges, participatory exchanges, because there aren’t as many formal channels for learning about things like cover cropping” (Blesh 2012).

A representative from NRCS also cited the importance of farmer-to-farmer knowledge networks, but stressed the value of recruiting a certain type of farmer to experiment with cover crops.

“I think the key is trying to identify those community leaders,” he said. “The other farmers that everybody else looks up to in the community, and trying to get them to buy into the practice. If you can get them sold on it, I think others will follow because everybody’s waiting for those key community leaders to see what’s going on. If you can get them to try it, and if they like it, others will follow suit” (NRCS 2012).

He added that certain farmers are naturally more willing to take risks, to try new management techniques, and to communicate to other farmers what works.

“[Innovative farmers] are more in-tune, they’re reading about the crops, and they’re looking at the university research. I think they’re more in-tune, willing to try, and talking with other farmers that are being successful, and keep building on their successes” (NRCS 2012).

Ms. Teresa Hice characterized a similar type of farmer in her interview:

“They’re just innovators. They take the new things that are coming out, and they run with them. You don’t have to prod them. They read constantly, they’re trying to figure out what’s going on, and they’re always working to improve their farm. Those are those innovators that we really like to hold up because once they do something, the farmers who live near them watch them. And they talk about it at the country store, and church, you know, and then they’ll slowly start doing it. So it’s those innovators we really like to get in touch with and get them well educated to move things along. Because some people you can talk to all day long about the research, but until they see their neighbor do it, they won’t do it. They need to see it before they’ll try it themselves” (Hice 2012).

Finally, Ms. Hice spoke enthusiastically about broader horizontal knowledge networks that include learning about cover crop and other conservation practices across state lines. Such networks used to exist in North Carolina before budget cuts. For ten years, Hice sat on a “special soil quality team” that brought together NRCS and SWCD staff. She recalled,

“We would go to the research farms. We would go to the plots in farmers’ fields, and we would find out what they were doing and how it was working, and we would bring that information back to North Carolina. We would do training sessions and we would do a newsletter. And that was extremely useful in getting information out about the benefits of no-till and cover crops. We really had a lot of information go out during that time period” (Hice 2012).

## **Results and Analysis: Web Survey**

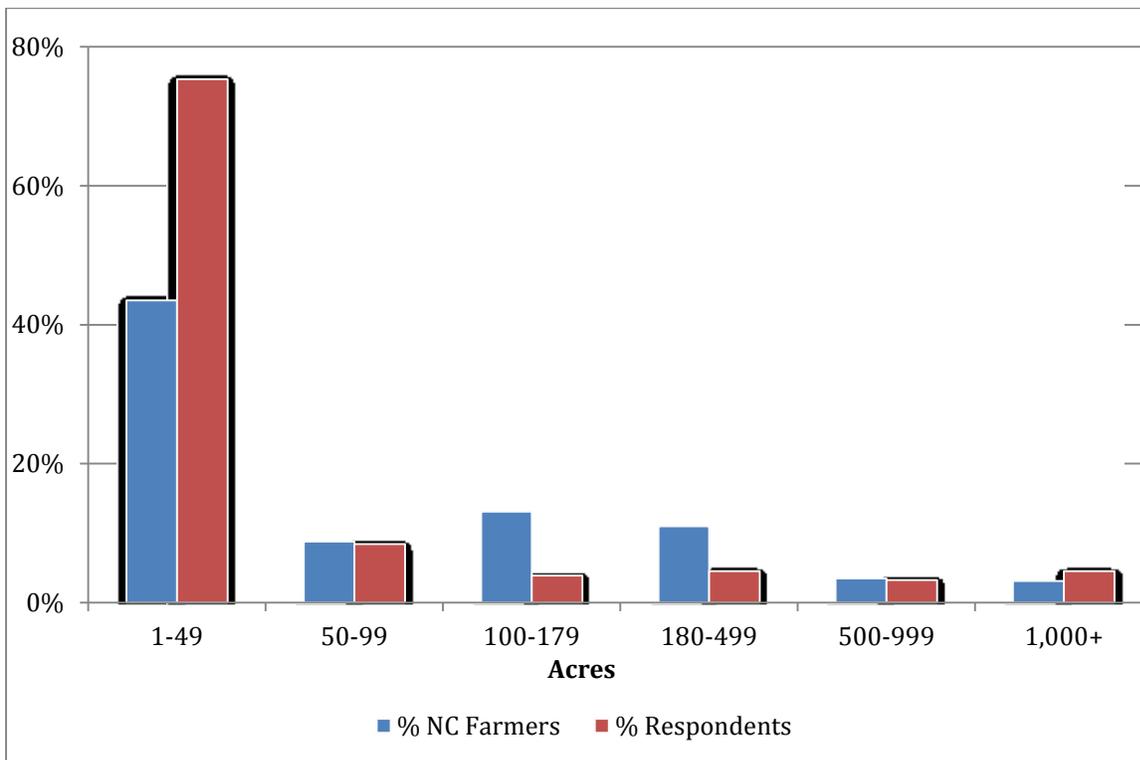
### **Demographic Overview**

This demographic overview seeks to answer the question: Who are the respondents, and how do they compare to the average farmer in North Carolina?

We show descriptive statistics of respondents, and compare these data to the statewide statistics reported in the USDA’s National Agriculture Statistics Service 2007 Ag Census. We

provide an overview of the types of farmers who responded to the survey, and outlines their similarities to and differences from most farmers in North Carolina.

Figure 3 below shows the frequency distribution according to cropland acres. The majority of respondents farm less than 50 acres, at 75%. However, this contrasts with the smaller percentage of North Carolina farmers who farm less than 50 acres. Although this distribution is skewed to the left, it generally mirrors the state’s distribution of cropland acres farmed and is representative for farm size between 50-99 acres.

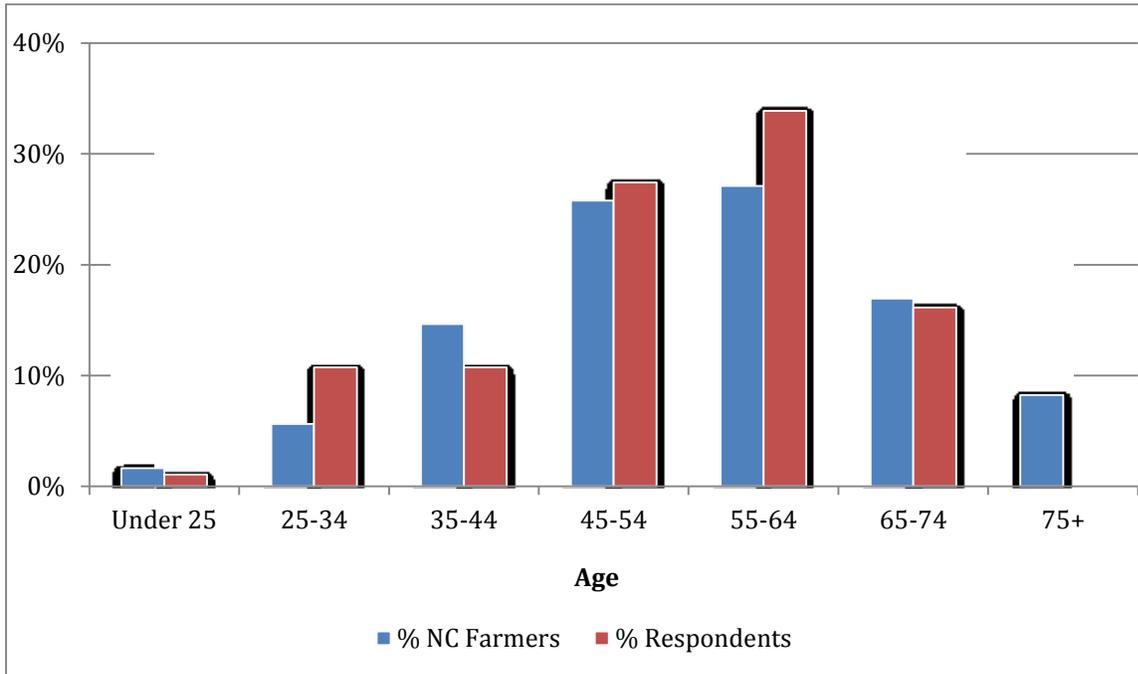


**Figure 3.** Percentage of Farms by Cropland Acres. This chart shows the percentage of farms by size in North Carolina compared to that of survey respondents in our study.

Respondents were more likely to have small farms than most of the farmers in the state, but were representative of large farms. Medium sized farms in North Carolina are much more prevalent (23% between 100-500 acres combined) as compared to our survey respondents (9% in that category). The median number of acres farmed by respondents was 6, but due to some outlying large farms, the mean acreage for respondents was 149. This average was not that far off from the average number of acres farmed in North Carolina—160 acres (Ag Census 2007).

### Age Breakdown

Figure shows the age distribution of survey respondents compared to that of farmland operators in North Carolina. The majority of respondents (34%) fell within the 55-64 age range. The average age of respondents was 52.5, which is younger than the average age of farmers in NC—57.3 years (Ag Census 2007).



**Figure 4.** Age Distribution of Respondents and North Carolina Farm Operators. This chart shows the age distribution of respondents compared to that of farm operators in North Carolina.

The age distribution of farmers in NC is similar to that of the survey respondents, however there were no respondents over 75.

### Income Breakdown

Figure shows the distribution of survey respondents by annual gross farm income. Most of the respondents were on the low-end of income, with 47% falling in the “less than \$20,000” bracket for gross farm income. However, this percentage is far less than the North Carolina distribution, with 75% falling into the lowest income bracket. There are also 10% more large income farms in North Carolina than were represented in our survey respondents.

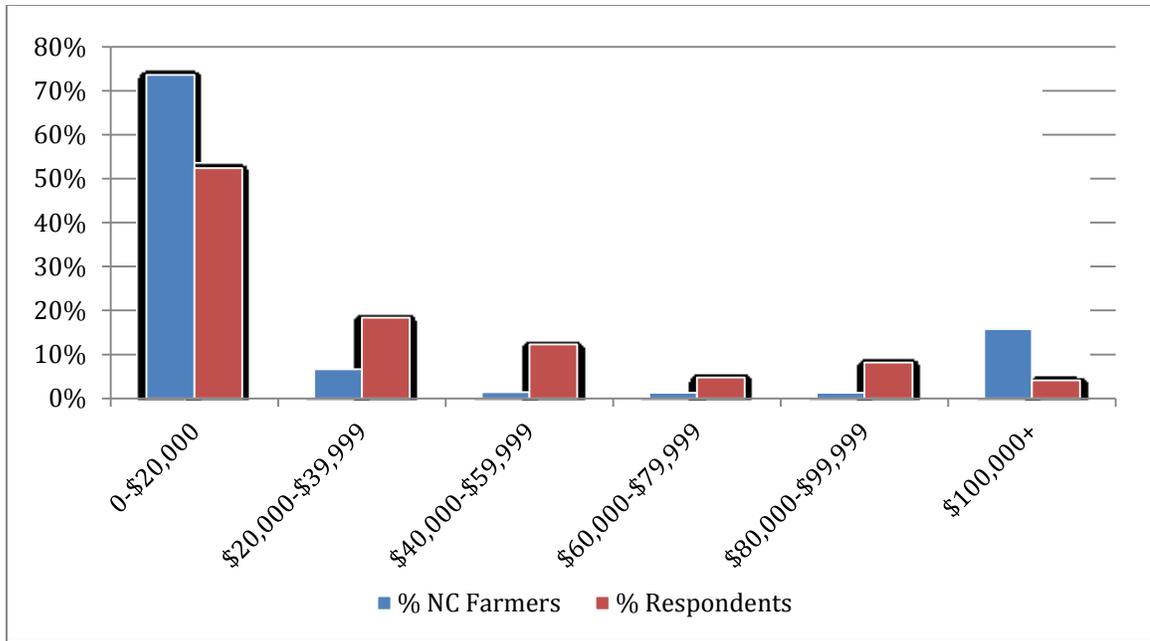


Figure 5. Percentage of Respondents by Income. This chart shows the distribution of respondents’ gross farm income and household income.

Because many respondents work off-farm for supplemental income, household income is differently distributed than gross farm income. The majority of respondents (26%) fall within the \$40,000-\$59,999 household income bracket (Figure ). This differs from the statewide distribution, where 65% of farmers fall in the “less than \$10,000” category (Ag Census 2007).

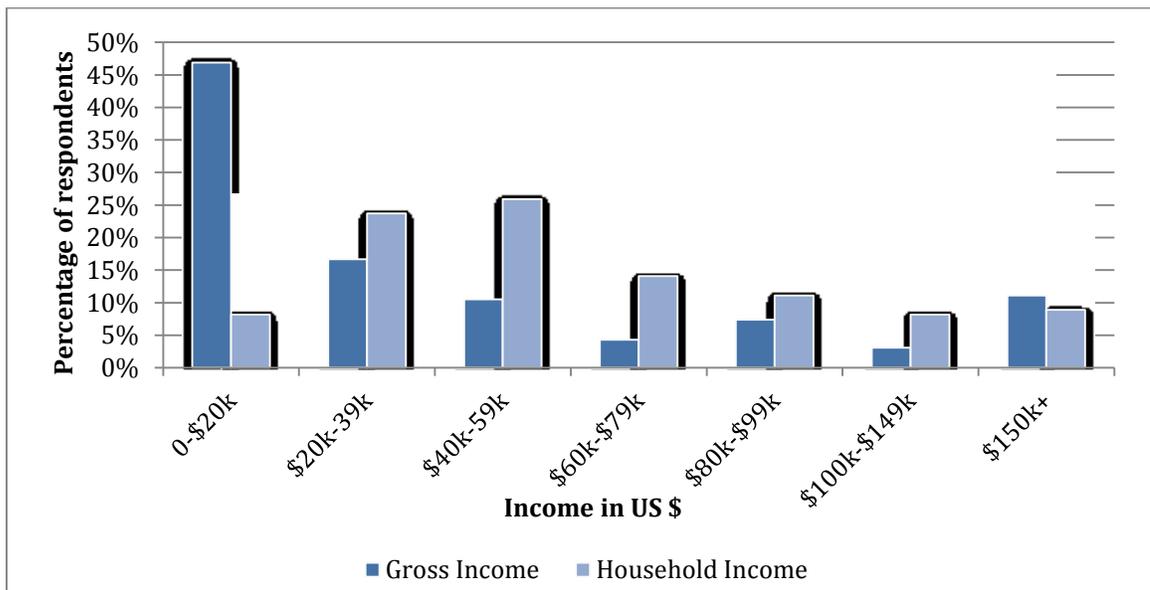


Figure 6. Percentage of Respondents by Farm Income and Household Income. This chart shows the distribution of respondents’ incomes. Because many respondents supplement their income with off-farm employment, household income and gross farm income were differently distributed.

## Demographic Correlations in Respondents

Pairwise correlations between farm size and years of experience show a significant, positive correlation ( $p \leq 0.05$ ,  $n=0.40$ ). This makes intuitive sense; as farm size increases, so does income. Similarly, pairwise correlations between years farmed and total acres of cropped land show a positive relationship ( $p \leq 0.05$ ,  $n=0.15$ ). Although this is a weaker trend, it shows that total cropped acreage increases with years of experience among respondents.

Pairwise Correlations between years of experience and...		
	Farm size	Total acres cropped land
Coefficient	0.4	0.15
Significance	$p \leq 0.05$	$p \leq 0.10$

**Figure 7:** T-Test Comparing Years of Experience by Farm Sizes and Cropped Land. This shows that experience differs depending on these factors.

Interestingly, t-tests show a significant difference in years farmed between those who lease all of their farmed acres and those who do not. Respondents who lease all of their land have, on average, about 8 years of farming experience. Respondents who do not lease all of their farmland have about 22 years of farming experience ( $p \leq 0.05$ ). This shows that respondents who either own and lease, or own all of their farmland tend to have more years of experience than those who only lease their land. T-tests comparing land ownership show that those who own all of their farmland have about 16 years of farming experience on average, whereas those who lease and own farmland have about 27 years of experience ( $p \leq 0.10$ ). This is somewhat counterintuitive; we might expect farmers with more experience to own all of their land, however respondents did not represent this trend.

T-tests of difference in years experience between...		
	Lease all land	Do not lease all land
Mean		8
Significance	$p \leq 0.05$	22
	Own all land	Do not own all land
Mean		16
Significance	$p \leq 0.10$	27

**Figure 8:** T-Test Comparing Years of Experience by Land Ownership. This shows that experience differs depending on whether respondents own or lease their land.

Summary statistics show that the age of respondents differs among respondents depending on their land ownership. Those who *lease* only are 38 years old on average. Those who *own* only are 56 years old on average. Those who *lease and own* are 50 years old on average. Similarly, there are trends among years of farming experience by ownership structure. Respondents who only *lease* their farmland have about 8 years of farming experience on average. Those who only *own* their farmland have about 16 years

of experience, and those who *both lease and own* farmland have about 33 years of farming experience. Because our statistics show that farmers who both own and lease land are about 6 years younger than those who only own land, we might expect them to have less experience, however this is not the case among respondents (those who both own and lease have around 33 years of experience, whereas those who own only have about 16 years of experience).

	Lease only	Own only	Lease and own
Average age of respondents who...	38	56	50
Years of experience of respondents who...	8	16	33

**Figure 9:** Comparison of Age and Experience Between Respondents who Lease, Own, or Lease and Own. This shows that there is a large difference in age and experience depending on ownership.

### Discussion of Non-Adopter Statistics

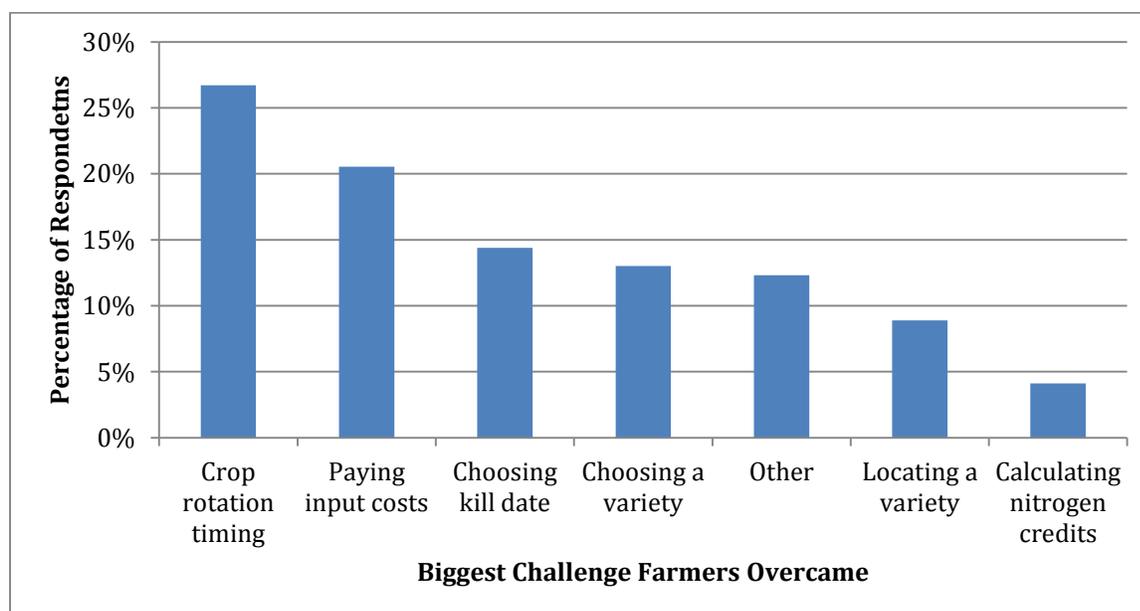
Although we chose not to focus on the differences between cover crop adopters and non-adopters in this report due to a low response rate of non-adopters, it may still be useful to examine the responses of non-adopters as a means of comparison. Only 34 usable surveys were received from non-adopters, representing a 5% response rate. Based on all responses, about 19% of respondents do not use cover crops.

T-tests comparing years of farming experience, cropped acres, application rates to conservation programs, off-farm income, and complete land ownership did not show a *significant* difference between adopters and non-adopters. However, there were still differing trends in these demographic characteristics. Both adopters and non-adopters have about 20 years of farming experience, but non-adopters are about 2.5 years older on average. The difference in cropped acres between adopters and non-adopters, though not significant, is about 72 acres (non-adopters farms are about half as large as adopter farms). There is no significant difference in adoption between those who have or have not applied for any conservation program funding. Although there is no significant difference between categories of farmers in terms of complete farmland ownership, non-adopters are more likely to own all of their land than adopters.

## Summary of Key Questions

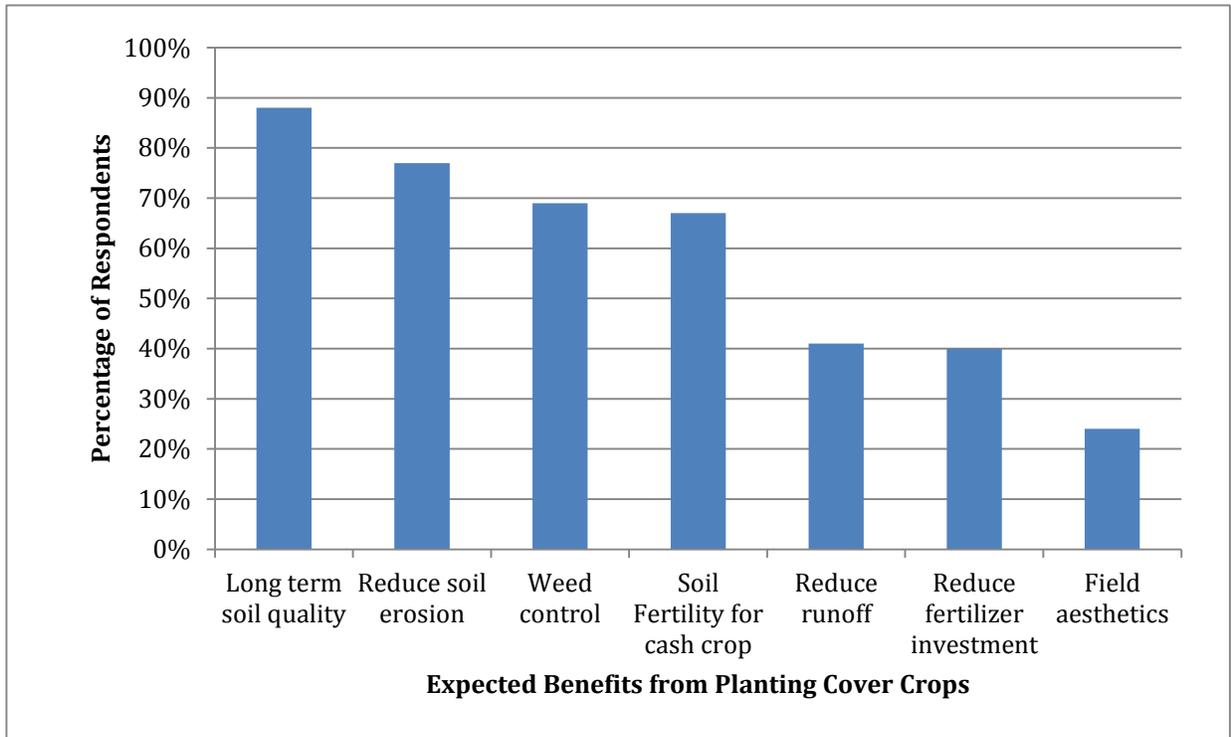
### Major Challenges and Reasons for Planting Cover Crops

When asked, “the single biggest challenge I overcame to plant cover crops was...,” farmers identified with “finding time to plant seed and till the cover crop into the soil,” representing 27% of respondents (this is labeled “crop rotation timing” in Figure 6, below). This was followed by “paying for seed/labor to plant the cover crop,” representing 21% (labeled “paying input costs”), “deciding when to kill the cover crop to maintain my regular crop rotation,” representing 14% (labeled “choosing kill date”), and “Deciding which cover crop varieties to use,” representing 13% (labeled “choosing a variety”).



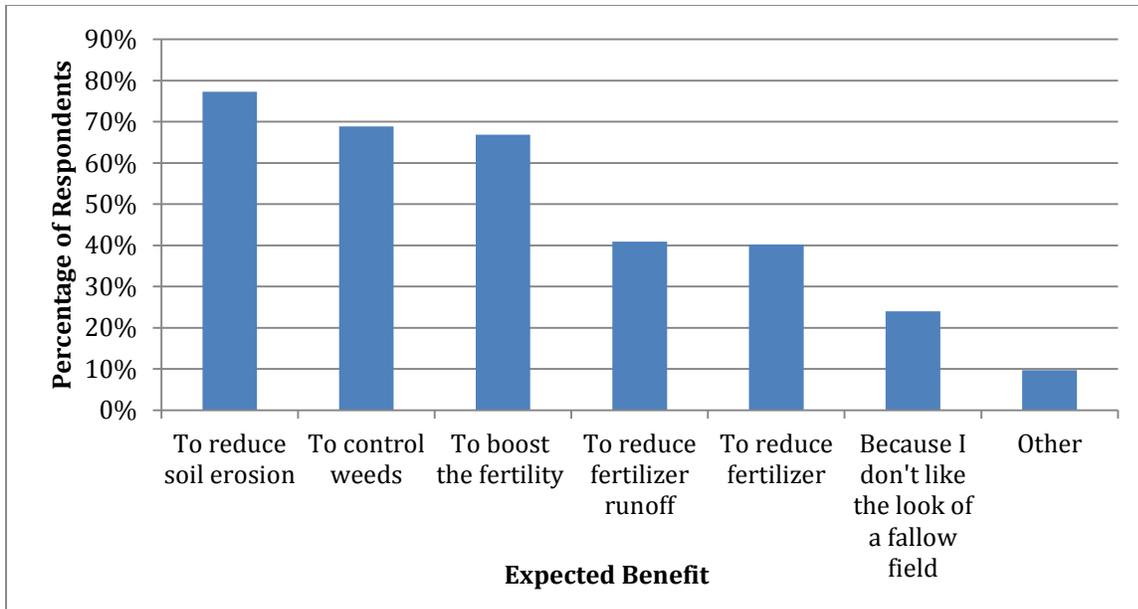
**Figure 10.** Percent of Respondents by Biggest Challenge Overcome. This chart shows the percentage of responses to the survey question: “the single biggest challenge I overcame to plant cover crops was...” in each of seven response categories.

When asked, “I started planting cover crops because I wanted...,” the top reason was “to improve my long-term soil quality” representing 88% of responses (Figure 7, below). This question was not exclusive, so one farmer could select as many reasons as he or she desired. Other important reasons were “to boost the fertility of my soil for a cash crop,” “to reduce soil erosion,” and “to control weeds.” Less popular reasons for planting cover crops related to fertilizer reduction and field aesthetics.



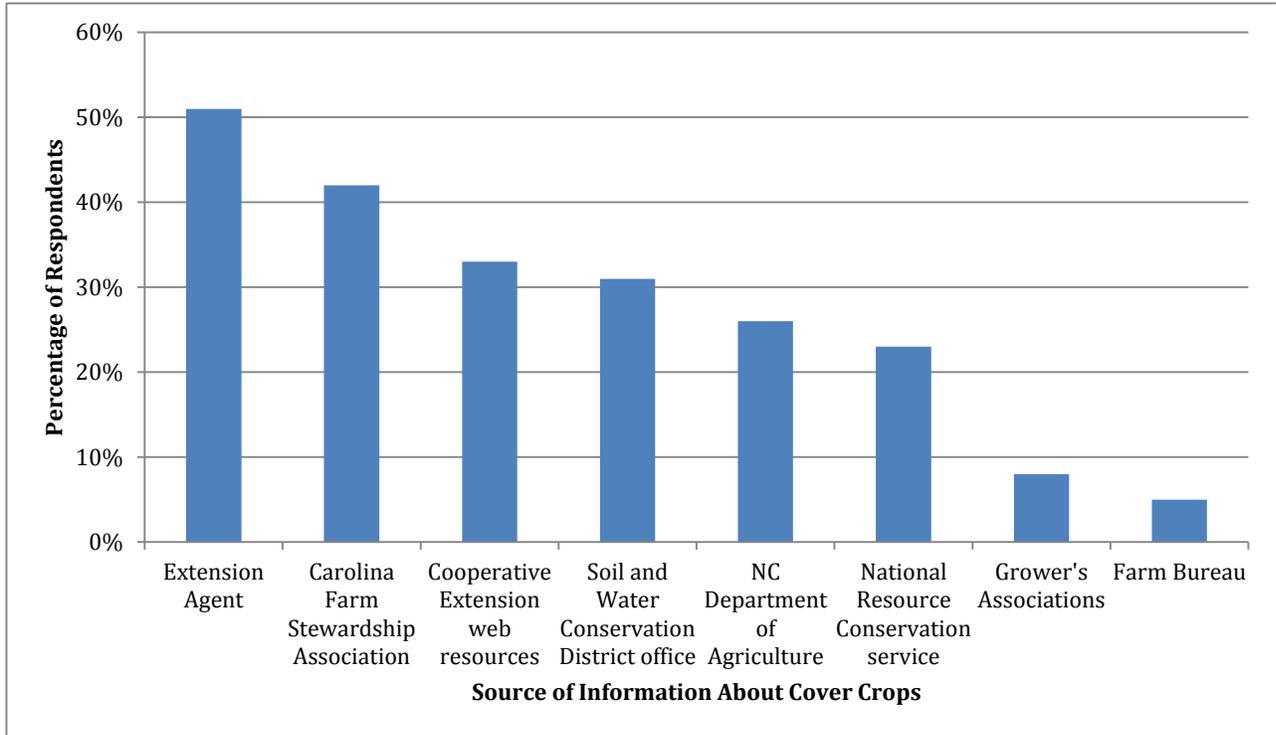
**Figure 11.** Respondents’ Expected Benefits from Planting Cover Crops. This chart shows the percentage of responses to the question “I started planting cover crops because I wanted to…” in each of seven categories. Responses were not exclusive.

When asked to narrow their reasons for planting cover crops to the single biggest factor, farmers overwhelmingly chose “to improve my long-term soil quality,” representing 64% of respondents (Figure 8, below). This mirrors the majority choice in Figure 7, above. Erosion reduction and soil fertility came in second and third (at 18% and 7% of respondents, respectively). Very few farmers named fertilizer reduction or water quality as their most important reasons for planting a cover crop.



**Figure 12.** Respondents’ Most Important Reason for Planting Cover Crops. This chart shows the percentage of responses to the question, “the single most important reason I plant cover crops is…” in each of seven categories. Respondents were only able to select one category.

Farmers report that a variety of organizations have helped them use cover crops more beneficially. Over half (51%) of farmers who use cover crops report that an extension agent provided information that increased benefits. Other important sources include the Carolina Farm Stewardship Association (42%), cooperative extension web resources (33%), Soil and Water Conservation District offices (31%), the NC Department of Agriculture (26%), and the National Resource Conservation Service (23%).



**Figure 13. Respondents' Source of Information.** This chart shows the percentage of responses to a question asking respondents to identify the most important source of information used to implement cover crops in each of seven categories. Respondents were only able to select one category.

### **Likert Scale Means**

Respondents were asked to answer the questions “I would plant more cover crops if...”

- Cover crops did not interfere with my regular planting/harvesting schedule
- Cover crops did not threaten my crop insurance
- Cover crops increased my cash crop yield
- I could obtain the recommended cover crop for my land
- Cover crop seeds were 50% cheaper
- I could get the full benefit in a shorter amount of growing time
- I had more equipment to plant and terminate (kill) cover crops
- I had more consistent access to farm labor to help plant and terminate cover crops
- More information were available about the specific benefits of planting a cover crop
- Cover crops looked more tidy in my fields
- I could apply 50% less fertilizer to my fields by planting cover crops
- My children would farm the land when I retire

They then ranked their likelihood of planting more cover crops on a Likert ranking scale from “very likely” to “very unlikely”. By ranking their likelihood of planting more cover crops based on these qualifications, respondents revealed which challenges were important relative to each other. The following table shows the percentage of farmers who ranked their likelihood of adopting more cover crops based on differing conditions.

**Table 3:** Percentage of Likert Responses to “I would plant more cover crops if...”. This chart shows the percentage of responses to a question asking respondents to identify their likelihood of planting more cover crops based on certain characteristics. The characteristics in this table are grouped by the type of challenge they address (timing, inputs and knowledge). The five highest percentages of “very likely” responses are shown in bold.

Likert Scale	Very likely	Somewhat likely	Somewhat unlikely	Very Unlikely	
	1	2	3	4	
I could get the full benefit in a shorter amount of growing time	<b>58.06</b>	27.42	12.1	2.42	Timing
Cover crops did not interfere with my regular planting/harvesting schedule	<b>56.25</b>	26.79	7.14	9.82	
Cover crops did not threaten my crop insurance	26.29	26.92	3.85	42.31	
Cover crops increased my cash crop yield	<b>62.07</b>	27.59	4.31	6.03	Inputs
I could apply 50% less fertilizer to my fields by planting cover crops	<b>58.1</b>	26.67	8.57	6.67	
Cover crop seeds were 50% cheaper	<b>51.28</b>	27.35	14.53	6.84	
I had more equipment to plant and terminate (kill) cover crops	41.82	37.27	12.73	8.18	
I had more consistent access to farm labor to help plant and terminate cover crops	34.78	27.17	21.74	16.3	
I could obtain the recommended cover crop for my land	35.37	43.9	9.76	10.98	Knowledge
More information were available about the specific benefits of planting a cover crop	19.59	31.96	22.68	25.77	
My children would farm the land when I retire	30.43	23.19	26.09	20.29	
Cover crops looked more tidy in my fields	11.39	11.39	21.52	55.7	

The highest percentage of “very likely” responses correspond to the characteristic “cover crops increased my cash crop yield,” followed by “I could apply 50% less fertilizer” and “cover crops did not interfere with my regular planting/harvesting schedule.” These allude to the types of challenges identified by key informants. Relieving timing challenges was popular among all respondents, as was reducing the cost of inputs through seeds and cheaper fertilizer. Respondents were less likely to rank the characteristics “cover crops did not threaten my crop insurance,” “more information were available about the specific benefits of planting a cover crop,” and “cover crops looked more tidy in my fields” as “very likely”.

In order to identify commonalities between farmers who use cover crops, we calculated the mean and median response to the characteristics above. These mean and median values were based on the ranking scale mentioned above, where one represents “very likely” and four represents “very unlikely”. Responses were partitioned by demographic characteristics to see how farmers’ opinions of cover crops varied. These demographic characteristics included: farmer off-farm employment, total acres of crop production, years of farming experience, gross annual farm income, involvement in conservation programs, and farmland ownership (to see correlations between these characteristics, refer to Table 5). The mean and median values for each of these characteristics were calculated by demographics indicating the likelihood that farmers would be willing to plant additional cover crops given 12 choices.

The following tables represent these results:

	I would plant more cover crops if...	No interference with cash crop schedule	No threat to crop insurance	Increase cash crop yield	Recommendation available for local crop	Seeds 50% cheaper	Benefit with shorter growth	Equipment available	More consistent farm access to labor	Specific benefits known	Looked more tidy in field	They allow a 50% reduction in fertilizer	My children will take over	
Economic Factors	Income provenance- all OFF-farm	1	1.5	1	2	1	2	2	2	2	3	1	2	
	some or all ON	1	4	1	2	2	1	2	2	2.5	4	1	2	
	Annual income (\$)	<20K	1	4	1	2	2	1	2	2	2	4	1	2
	20-39.9	2	2	1	2	2	1	2	3	2	3	1	3	
	40-59.9	1	2.5	2	2	1	1	2	1	3	4	2	3	
	60-79.9	1	1	1	2	1	1	1	1	3	3	1	2	
	80-99.9	4	3	2	4	1.5	1	2	2	4	4	1	2	
	100-150	1		1		2.5	1	2	3	2.5	4	1	2.5	
	1-10	1	3	1	2	2	1	2	2	3	4	1.5	3	
	11-49	1.5	2.5	1	2	1	1	2	2	2	4	1	1.5	
Farmland ownership	50-249	2	2	1	2	1	2	2	2	2	2	1	1.5	
	>250	2	2	1	2	2	2	2	3	3	4	1	2	
	Own some farmed acres	1	2	1	2	1	1	2	2	2	4	1	2	
	Lease all farmed acres	1	4	1	2	1	1	1.5	2	3	4	2	2.5	
	Other Factors	Years of Experience	0-10	1	3	1	1.5	2	1	2	2	4	1	3
11-30		1	2	1	2	1	1	2	2	2	4	1	2	
31+		2	2.5	1	2	1	1	2	1.5	3	3	1.5	2	
Conservation Program Involvement		Applied for program	2	2	1	2	1	1	2	2	3	4	1	2.5
Never applied for program	1	3	1	2	1	1	2	2	2	4	1	2		

**Table 4:** Likelihood of Planting More Cover Crops Based on Farm Factors. This chart shows median of responses to a question asking respondents to identify their likelihood of planting more cover crops based on certain characteristics. In this table, one represents “very likely” whereas four represents “very unlikely” to plant more cover crops.

The importance of cover crop interference with a cash crop schedule was identified regardless of demographic characteristic. Crop insurance, however, seems to be a more important determining factor for respondents work off-farm full time (row 1). Other results are similar whether or not respondents work off-farm full time.

In several cases, medium sized farms (11 to 249 acres) are more willing to plant additional cover crops than either small or large farms; this includes the conditions “if seeds were 50% cheaper” (column 5) and “more information were available about the specific benefits of planting a cover crop” (column 9). Small farmers (farmers who own 1-10 cropped acres) were more likely to rank overcoming interference with planting and harvesting as an important reason for planting (a mean value of 1.6, with a median of 1—“very likely”), indicating that small farmers may be disproportionately affected by this challenge (column 1). When asked the same Likert ranking question, farmers who own large farms (50-249 acres) answered that timing was still a challenge, but that they were less likely to plant more cover crops without timing barriers.

Farmers who had fewer years of farm experience were more likely to rank “I would plant more cover crops if they did not interfere with my regular planting/harvesting schedule” as “very likely” than farmers with more years of experience. Farmers who had 0-10 years of farming experience ranked this Likert question at a mean value of 1.57 (a median of 1—“very likely”), whereas farmers who had over 31 years of farming experience ranked the question at a mean value of 2.25 (a median of 2—“likely”).

Table 4 shows Likert scale statistics based on respondents’ gross annual income. Farmers who have small and large incomes are more likely to plant additional cover crops if they’re given more information (row 9). Farmers with lower incomes were more likely to plant additional acres of cover crops given additional farm labor (row 8).

Respondents who applied to conservation programs were slightly less likely to plant additional cover crops with more information about their benefits than those who did not apply (column 9).

### Likert Scale Pairwise Correlations

Correlation coefficients were calculated for the twelve characteristics specified in the Likert question, “I would use cover crops more than I do now if...” to determine similarities between respondents.

The following table shows pairwise correlation coefficients for each of these questions:

	Cover crops did not interfere with my regular planting/harvesting schedule	Cover crops did not threaten my crop insurance	Cover crops increased my cash crop yield	I could obtain the recommended cover crop for my land	Cover crop seeds were 50% cheaper	I could get the full benefit in a shorter amount of growing time	I had more equipment to plant and terminate (kill) cover crops	I had more consistent access to farm labor to help plant and terminate cover crops	More information were available about the specific benefits of planting a cover crop	Cover crops looked more tidy in my fields	I could apply 50% less fertilizer to my fields by planting cover crops	My children would farm the land when I retire
Cover crops did not interfere with my regular planting/harvesting schedule	1.00											
Cover crops did not threaten my crop insurance	0.53	1.00										
Cover crops increased my cash crop yield	0.19	0.54	1.00									
I could obtain the recommended cover crop for my land	0.26	0.38	<b>0.37</b>	1.00								
Cover crop seeds were 50% cheaper	0.19	0.35	<b>0.40</b>	<b>0.58</b>	1.00							
I could get the full benefit in a shorter amount of growing time	<b>0.41</b>	0.42	<b>0.31</b>	<b>0.43</b>	<b>0.44</b>	1.00						
I had more equipment to plant and terminate (kill) cover crops	0.25	0.26	0.26	0.31	0.27	<b>0.33</b>	1.00					
I had more consistent access to farm labor to help plant and terminate cover crops	0.23	0.48	<b>0.41</b>	0.27	<b>0.3596*</b>	0.28	<b>0.55</b>	1.00				
More information were available about the specific benefits of planting a cover crop	0.08	0.34	<b>0.36</b>	<b>0.53</b>	<b>0.37</b>	<b>0.3313*</b>	<b>0.42</b>	<b>0.50</b>	1.00			
Cover crops looked more tidy in my fields	0.06	0.57	0.21	0.22	0.32	0.27	0.06	0.22	<b>0.52</b>	1.00		
I could apply 50% less fertilizer to my fields by planting cover crops	0.06	0.32	<b>0.40</b>	<b>0.43</b>	<b>0.44</b>	0.31	0.12	0.14	0.28	0.19	1.00	
My children would farm the land when I retire	0.07	-0.03	0.26	0.32	0.29	0.10	0.21	0.23	0.31	0.06	<b>0.53</b>	1.00

**Table 5: Pairwise Correlation Coefficients of Related Challenges.** Shaded cells denote a correlation coefficient that is significant at the 5% level. Non-shaded cells denote a correlation coefficient that is significant at the 10% level. Empty cells did not result in a significant correlation.

Pairwise correlations between responses to the above options from pooled respondents show whether there are significant relationships between challenges. For example, farmers who responded “likely” or “very likely” to “I would use cover crops more than I do now if cover crops did not interfere with my regular planting or harvesting schedule” were also likely to answer “likely” or “very likely” to “I would use cover crops more than I do now if I could get the full benefit in a shorter amount of growing time.”

Correlations show that many farmers struggle with timing cover crops in a cash crop rotation. Respondents interested in obtaining the full benefit in a shorter amount of growing time were also interested in acquiring more equipment, getting more information about cover crop benefits, and finding a variety well suited to their land.

There were a series of correlations that allude to certain farmers who specifically face input challenges. One of these was a strong correlation between those who would plant more cover crops if cover crops increased the cash crop yield and many other factors stated in the Likert ranking questions. Those factors included: farmers who would plant more if seeds were 50% cheaper, who had more consistent access to farm labor to help plant and terminate cover crops, who could obtain the recommended variety for their land, who could obtain the benefits in a shorter growing time, who had more information about the benefits of cover crops, and who could apply 50% less fertilizer to their fields. Those who wished they had more consistent access to farm labor to plant and terminate cover crops correlated strongly with those who would plant more cover crops if they had more equipment to plant and terminate them. There was also a correlation between farmers who wished they had more access to labor and farmers who would plant more cover crops if they had information about the benefits of cover crops.

There were also correlations that alluded to farmers who faced knowledge transfer challenges. Farmers who would increase cover crop use if they could get the recommended variety for their land are more likely to indicate that they would increase cover crop use if more information about the specific benefits of planting a cover crop were available. There is also a positive and significant correlation between farmers wanting more information on the recommended variety and those who would increase coverage if they could apply 50% less fertilizer as a result of cover crop use. Those willing to increase cover crop use if they could get the recommended variety were also likely to plant cover crops if seeds were 50% cheaper and if they could obtain the benefits in a shorter amount of time.

### *Categories of Main Challenges*

Our interviews with key informants and Likert analysis alluded to categories of challenges; these categories helped us shape our quantitative analysis. Three main challenges to adopting cover crops in North Carolina emerged. We discuss these in context with hypotheses formed from literature reviews, then support or counter these hypotheses with quantitative or qualitative data. The hypotheses stated in the methods section of this report



were a function of literature reviews, and helped to guide the formation of our survey. However, not all these hypotheses are addressed in the following sections as our report specifically reflects the opinions of cover crop adopters.

## **Agronomic**

### ***Timing Rotations***

While farmers are often aware that planting cover crops produces long-term soil quality benefits, they face an opportunity cost of reduced yield by incorporating a cover crop, which may shorten a regular rotation. Incorporating a cover crop therefore represents an up-front cost as a tradeoff for a long-term benefit. Timing cover crop termination is especially important—cover crops must remain on the field long enough to build up adequate biomass to achieve soil benefits, but not too long so as to risk the establishment of a spring crop. (Arbuckle 2012, Bergtold 2012, Stivers-Young and Tucker 1999) Due to these factors, we expected respondents to identify timing as a significant challenge to implementing cover crops. This hypothesis was supported by our results.

Because the majority (27%) of respondents stated that the biggest challenge they overcame was finding time to work a cover crop into their rotation, timing is clearly a dominant barrier to planting cover crops in North Carolina—and one that lacks a simple solution. Adding this statistic to those who responded their biggest challenge was choosing a kill date, a total of 41% of respondents identified timing issues as most important.

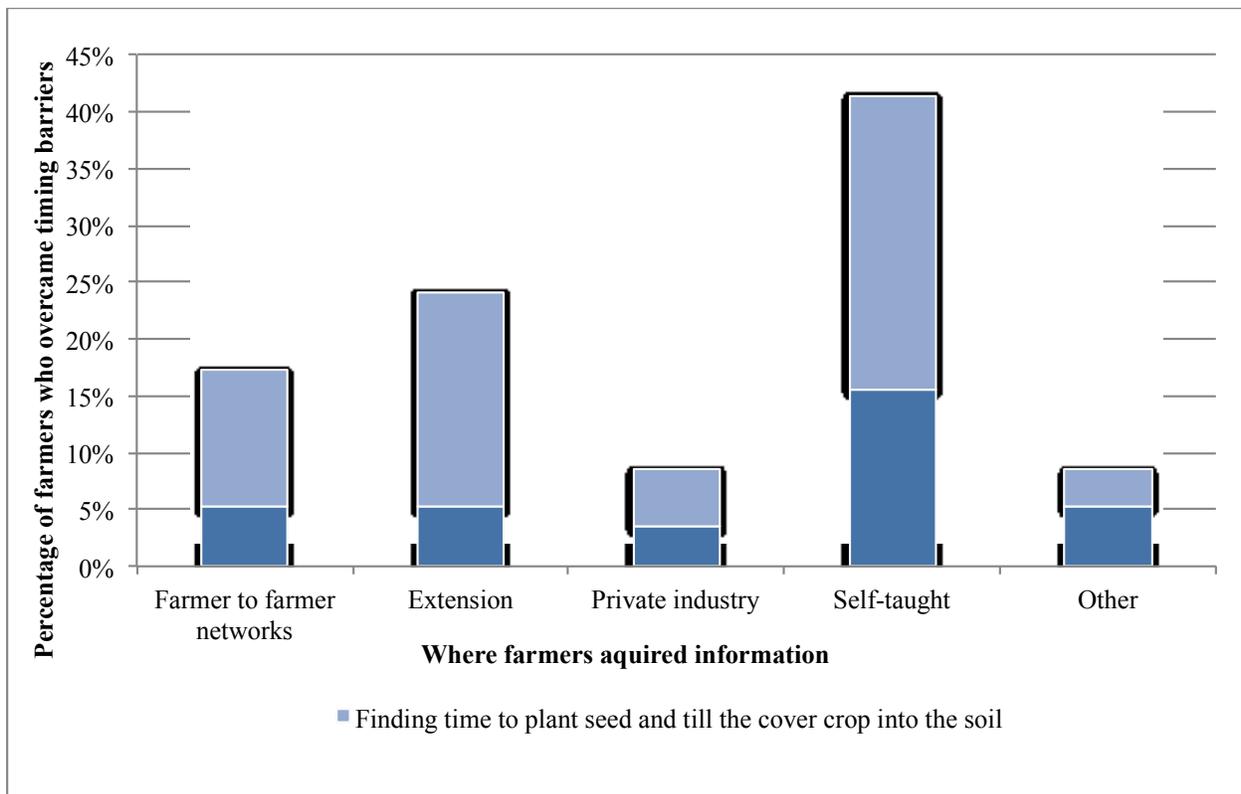
An NRCS representative echoed this sentiment when discussing funding qualifications for planting cover crops through EQIP:

“The planting dates—for Piedmont here and our program, you can probably broadcast [a cover crop] September 3-20, or drill it in by October 20. A lot of farmers still have soybeans or sorghum out there, and they’re not gonna get it in. So they won’t make the dates. And on the other end, the earliest you can kill it is April 1<sup>st</sup>, and a lot of [farmers] want to be out there getting ready [to plant] by early March” (NRCS 2012).

This complication might be a disincentive for farmers to apply for funding to plant cover crops through EQIP. Without flexibility in dates, farmers are probably less likely to sign a contract to plant cover crops; locking farmers into a specific plan presents the potential opportunity cost of reduced cash crop yield each year that a winter cover is worked into a rotation.

Furthermore, farmers who overcome timing barriers are likely to acquire information through their own efforts. The majority of farmers who reported timing barriers as the biggest barriers they overcame were self-taught (42%, Figure 8). The second most common source of information farmers used to overcome timing barriers was Extension, representing 24% of farmers. Farmer-to-farmer information sharing was the third most common source of information, representing 17% of farmers who overcame timing barriers. Farmers who overcame timing barriers tended not to acquire information from private industry.

### Resources Used to Overcome Timing Challenges



**Figure 14:** Where did farmers who overcame timing barriers get their information? This chart shows the main source of information used by farmers who self-reported that the biggest barrier they overcame was either “deciding when to kill the cover crop to maintain my regular crop rotation” or “finding time to plant seed and till the cover crop into the soil.”

Because the majority of farmers who overcome timing barriers are self-taught, we can infer that there is a lack of research and information on varieties of cover crops best suited to regional rotations. Farmers are likely teaching themselves about timing barriers due to the complicated nature of these challenges, and the lack of advice available from common sources (Extension, SWCD, etc.) due to limited research on cover crop varieties. Because those who applied for conservation funding through EQIP, CREP, and/or CSP were less likely to face timing challenges, farmers who overcome knowledge barriers may gain some baseline knowledge from traditional sources, and build on this knowledge by engaging in trial-and-error at home.

Small, inexperienced farmers face timing challenges disproportionately. There may be additional knowledge barriers for those new to the process of working cover crops into a rotation—farmers who haven't benefitted from this trial-and-error process. Tabulations relating Likert answers and demographic characteristics of farmers revealed the types of farmers that face specific challenges. Farmers who answered "likely" or "very likely" to the questions "I would plant more cover crops if they did not interfere with my regular planting/harvesting schedule" and "I would plant more cover crops if I could get the benefit in a shorter amount of time" tended to be smaller, less experienced farmers.

Despite this disproportionate effect, we need to keep in mind that all farmers—regardless of farm size, experience, or whether they applied to funding programs—identified timing as a major challenge to planting cover crops. Farmers consistently answered that they would be more likely to plant cover crops if they could overcome timing challenges, and each of the six key informants mentioned the difficulties farmers face in timing a cover crop in a rotation.

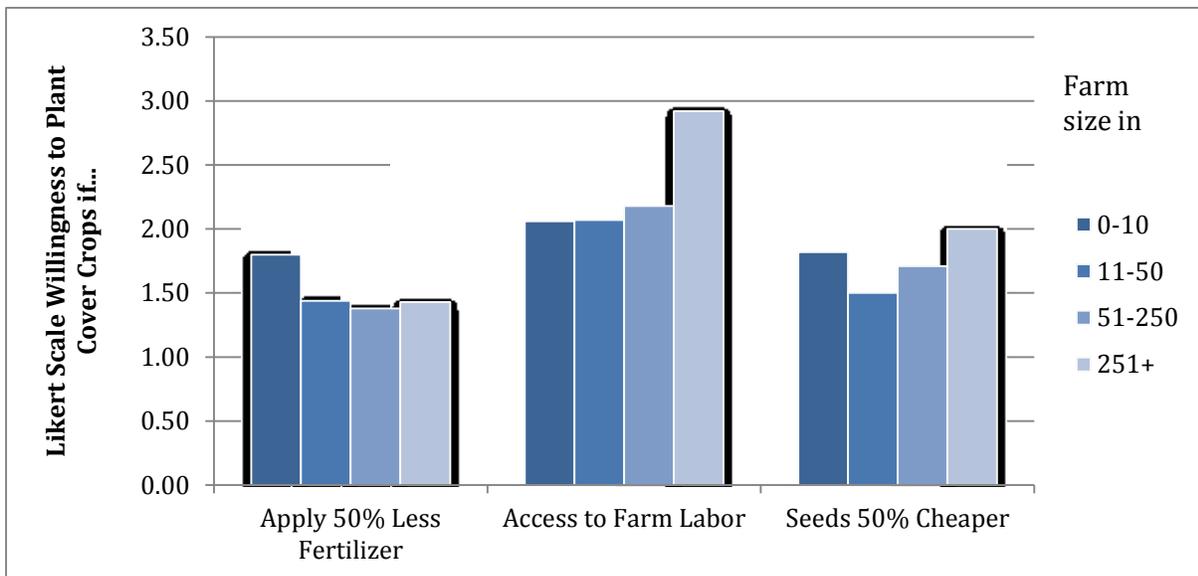
## **Inputs**

### ***Ability to Pay***

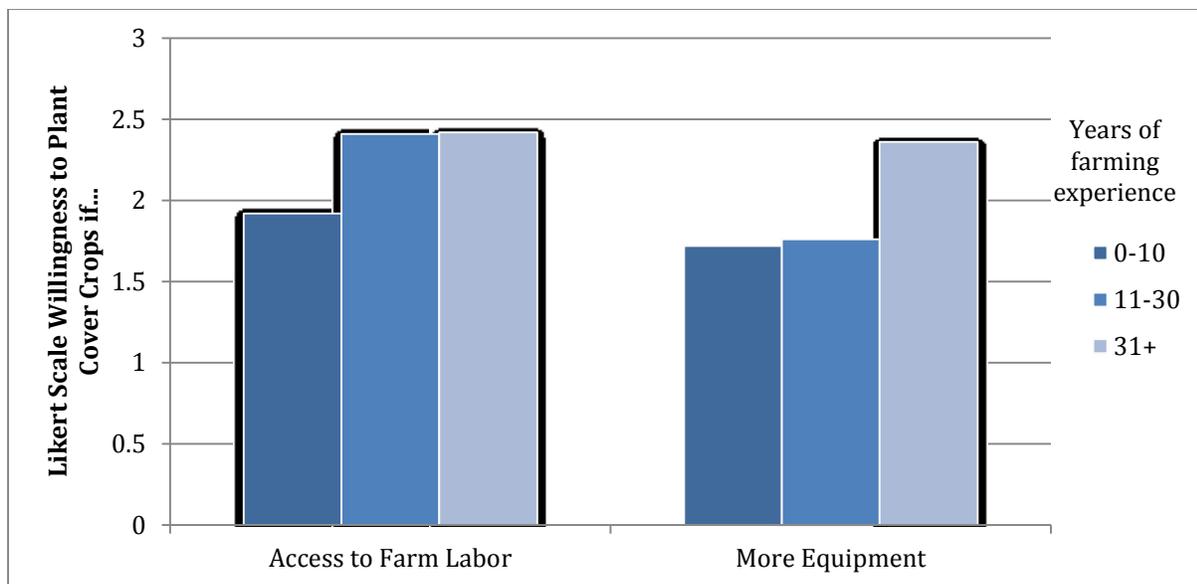
Ability to hire farm laborers, to purchase farm equipment, and to purchase cover crop seeds at a cheaper price are all reliant on a farmer's ability to pay for these items. Some studies suggest that farms with lower incomes are more likely to adopt cover crops due to the feasibility of reducing fertilizer application through nitrogen fixation (Gabrielyan 2010). However, other research shows that increased farm size also increases cover crop adoption (Gabrielyan 2010; Bergtold 2008). We hypothesized that the cost of additional inputs required to successfully

implement cover crops was a barrier to adoption. This hypothesis was generally supported by our data.

Important correlations emerged from our Likert scale results. First, those farmers who supplemented their income with off-farm employment were also those who said they'd plant more cover crops if seed prices were 50% cheaper (Table 4, column 5). Those farmers gave a median response value of 1, representing “strongly agree” as compared to farmers with no off-farm full-time job, who gave a median response of 2, “agree.” Farmers from 0-50 acre farms also had a median value of 2, agreeing that they would plant more cover crops if they could “apply 50% less fertilizer to their fields by planting cover crops,” they “had more access to labor,” and “if cover crop seed prices were 50% lower” (Table 4, columns 5, 8 and 11).



**Figure 15:** Influence of Farm Size on Willingness to Plant Based on Input Characteristics. This chart shows the influence of farm size on responses to the question, “I would plant more cover crops than I do now if...” in three different categories. Responses were on a Likert scale of one to four, with one being “very likely” and four being “very unlikely.”



**Figure 16:** Influence of Farming Experience on Willingness to Plant based on Input Characteristics. This chart shows the influence of years of farming experience on responses to the question, “I would plant more cover crops than I do now if...” in three different categories. Responses were on a Likert scale of one to four, with one being “very likely” and four being “very unlikely.”

Farmers who agreed that more equipment and labor to plant and terminate cover crops would cause them to increase cover crop adoption also tended to have more years of farming experience (Table 4, columns 7-8; Figure 16). Those farmers with little-to-no farm experience did not see labor and “more equipment to plant and terminate cover crops” as a more significant constraint than those who have over 30 years of experience.

Those who lease their farmland were more likely than those who own their land to say that the ability to obtain equipment to plant and terminate cover crops was strongly correlated with how much cover crops they used. (Table 4, columns 7-8).

While it is tempting to view the decision to plant cover crops from a simple cost-benefit perspective, we must consider that the main driver behind planting a cover crop is not always a purely financial one. In fact, many farmers planting cover crops have likely begun doing so because it is the “right thing to do” (Rogers 2005). These farmers are intrinsically motivated to implement sustainable agriculture practices on their farms. Once they decide to do so, the extent to which they are able to implement them, and their choice of what SAP to implement, is then determined by their financial constraints. How much can they earn for implementing this SAP, how much can they save?

Farmers' Likert responses regarding farm inputs (again: labor, equipment, seed), show that for the most part, farmers agree that they would plant more cover crops given cost help with these factors. We do see some stronger responses, however. For example, farmers who planted cover crops for soil fertility reasons "strongly agree" that they would plant more cover crops if the seeds were cheaper, or if they had more equipment to plant and terminate their cover crops. We also saw a strong agreement from those farmers who were planting cover crops to reduce soil erosion – they would also plant more if seeds were cheaper. It is significant that those farmers who were looking for long-term soil quality improvements did not strongly equate planting *more* cover crops with achieving that goal.

Farmers who supplemented their income with off-farm revenue (perhaps, those who aren't able to support themselves through full-time farm work) also said "strongly agree" to plant more cover crops if cover crops were cheaper. Interestingly, however, we did not see any strong correlation in request for labor or equipment from those farmers. We also saw "strongly agree" responses for cheaper seed and desire to apply less fertilizer, from medium size farms (11-250 acres). Mr. Herbie Cottle, a North Carolina farmer with almost 200 acres of farmland, says the easiest way to save money on seed is to harvest seeds from the cover crop at the end of a season. However, only three farmers in our survey mentioned that they utilized that method – we assume that it is time consuming and not always reliable.

Farms that were over 251 acres also agreed that they'd plant more cover crops if they knew it would reduce their fertilizer application by 50%. This might suggest that farmers of large farms aren't seeing enough kickback in terms of soil nitrogen from cover crops, or that farmers simply can't measure the trade-off between fertilizer and cover crop application and are thus applying fertilizer after cover-cropping as a nitrogen safety net. Mr. Cottle believes it may be a combination of both. He said that only after years of planting cover crops had he begun to see a noticeable difference in productivity based on nutrients and organic matter, making it difficult for farmers to "see the dollar amount right up front."

Overall, farmers agree that reducing the cost of inputs would allow them to invest more money in cover crops. Ms. Hice, Natural Resource Conservationist in Wake County, said the cost question is the most pressing for farmers facing the decision on cover crops, "Depending on their budgets, [the cost of seed] keeps them from putting cover crops in. They know the benefits. I don't think there's many farmers out there who don't know the benefits of cover crops."

The next section assesses farmers' knowledge of those cover crop benefits.

## Knowledge Transfer

### *Communication of Information*

We know from the literature that farmer knowledge about sustainable agriculture practices predicts their willingness and ability to implement and succeed with new management strategies (Knowler and Bradshaw 2007). Literature on cover crop adoption rates points to knowledge as a significant factor in determining whether farmers are adequately prepared to assess the benefits of cover crops (Singer 2007). Maximizing the effectiveness of cover cropping systems requires several types of information, in particular. First, the farmer must select a cover variety (or mix) that is suitable for the particular crop system and climate. This includes choosing a cover that will fit into the rotation schedule and choosing a variety that will provide specific benefit(s) such as N fixation, weed suppression, erosion control or biomass.

Second, the farmer must understand how to manage the cover to produce the benefit. This includes information about planting and termination dates; appropriate seeding rates and methods; termination and incorporation methods; and proper planting of the cash crop following termination (especially in reduced and no-till systems where the farmer often plants through the cover crop residue).

Third, the farmer must be able to understand and quantify the benefit from planting and managing the cover crop. If the farmer planted a cover in order to provide available N for a following cash crop, N credits must be estimated so that they may be subtracted from other fertilizer applications. Similarly, farmers need information about the amount of nutrients that will become available throughout the course of the cash crop's growth. Farmers interested in using cover crop to build long term soil fertility require measurements of key soil quality indicators such as soil organic matter (SOM) and aggregate stability. Existing research shows knowledge gaps relating to each of these types of information; this lack of information limits adoption. (Singer 2007, Snapp 2005, Bergtold 2008) Because of this, we hypothesized that lack of information about cover crops would limit cover crop adoption. Our results support this hypothesis.

When asked about the single biggest challenge they overcame to plant cover crops, 12.5% of respondents cited "deciding which variety(s) to use"; 4% chose "figuring out how

much fertilizer the cover crop would replace”; and 14% selected “deciding when to kill the cover crop” to maintain their regular planting schedule. Taken together, over 30% of respondents indicated that a scarcity of knowledge or information posed the most significant challenge to adopting cover crops.

Pairwise correlations show that farmers are likely to plant more cover crops given different types of information. Specifically, farmers who would increase cover crop use if they could get the *recommended variety* for their land are more likely to indicate that they would increase cover crop use if more information about the *specific benefits* of planting a cover crop were available (correlation = .53). There is also a positive and significant correlation between farmers wanting more information on the *recommended variety* and those who would increase coverage if they could apply *50% less fertilizer* as a result of cover crop use (correlation = .43). To understand how farmer type affects attitudes toward knowledge and information, we examine responses to the one Likert question that asks explicitly about the effect that more information would have on cover crop use.

Analysis of Likert scale data reveals significant correlations among farmer interest in different types of information. Farmers were asked which factors would lead them to increase their use of cover crops. 80% of respondents indicated that they would be “very likely” (35.5%) or “somewhat likely” (44.5%) to increase cover crop use if they could get the *variety recommended* for their land.



Table 4, Column 9 explains variation in the likelihood that farmers would plant more cover crops if they possessed better information, depending on the number of acres they have in crops. The median answer for both small and large farmers was 3, meaning that more information about specific benefits of cover crops was “somewhat unlikely” to increase their cover crop use. Again, it is important to recall that Likert scale results are best perceived relative to other responses along the same scale. Therefore, among farmers managing between 11-250 acres, the median response was 2, or “somewhat likely.” This shows that farmers on medium farms may face information barriers that aren’t present on small and large farms.

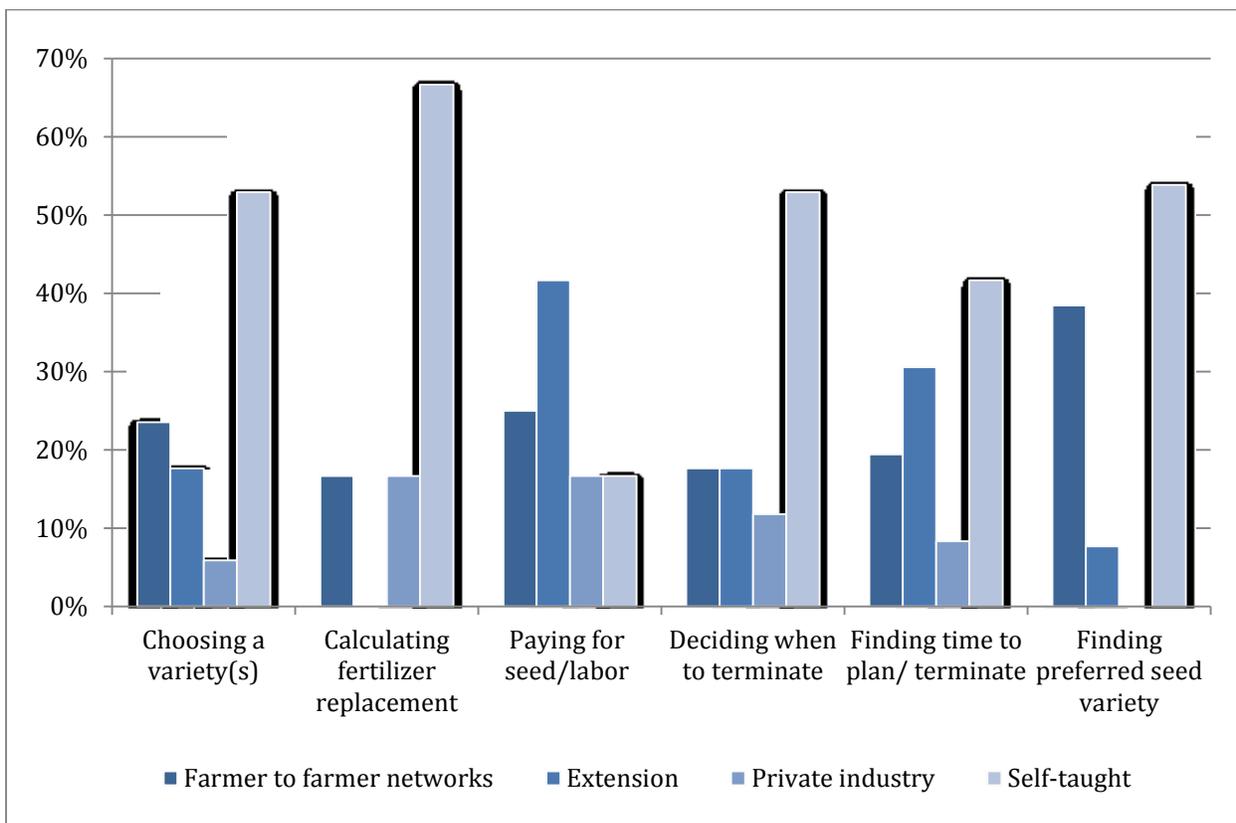
Table 4, Column 9 describes how farmers perceive the importance of enriched information depending on farm income. The median response of farmers making under \$40,000/yr from farm revenue was that additional information was “somewhat likely” to increase cover crop use, whereas the median for farmers between \$40-80k was “somewhat unlikely” and “very unlikely” for farmers making \$80-100k. The trend reverses for farmers over \$100k and the median response returns to “somewhat likely.” Interestingly, this shows a u-shaped distribution of income and likelihood of planting more cover crops given more information, where those making low and high incomes face barriers to additional information.

Results above suggest that many farmers do not know what cover crop they should use or, if they do, they do not know how to get it. Farmers who select appropriate cover crop varieties and manage cover properly can dramatically reduce their fertilizer inputs and in many cases eliminate the need for these inputs altogether. However, realizing this benefit requires knowledge of the correct varieties, their management, and information on calculating the implicit nutrient credits in order to reduce fertilizer inputs without compromising cash crop yields. The data also suggest that medium-sized farms, and those producing both very low and very high revenues, are most interested in receiving enriched information on the benefits and management of cover crops.

### *Influences on a Farmer’s Decision to Adopt*

Farmers learn about management techniques from a variety of sources discussed in the Introduction. Here we analyze four sources of information that farmers rely on to overcome the barriers to cover crop adoption. First, cooperative extension services share knowledge with farmers through the activities of extension agents, via publications on the web and in print, and through extension-sponsored conferences. Private companies provide information through consultation services, farm supply stores, and marketing campaigns. Farmer-to-farmer networks disseminate information between farmers; these interactions may occur out in the fields, at the local coffee shop, at a Farm Bureau Meeting or across an email listserv, for example. Finally, farmers pursue opportunities for self-directed learning using resources available in print or online. While there are inevitably overlaps among these categories (e.g. a farmer who goes online to research pest management and reads an extension publication), we find these categories help illuminate how farmers access knowledge.

We break down farmer choices of the “biggest barrier overcome” in planting cover crop by the influence cited as “most important” for choosing to adopt the practice (Chart below). Farmers who stated that they overcame challenges related to decision-making, such as choosing an appropriate cover crop variety and deciding when to terminate the crop, were more likely to indicate that their most important source of information was self-directed learning. In contrast, farmers who overcame primarily economic barriers, such as paying for seed and labor costs or managing the cover around their cash crop rotation, were more likely to cite cooperative extension services as the most influential source of information on cover crops. Private industry provided key information to some farmers facing economic barriers, but farmers who prioritized informational barriers rarely mentioned industry as most important. Farmer-to-farmer networks show up as a consistent—if relatively minor—source of information across all types of challenges.



**Figure 17: Most Influential Information Source by Biggest Challenge Overcome.** Farmers were asked to indicate the biggest challenge they overcame to plant cover crops. This chart shows the percentage of farmers in each barrier category who indicated that farmer-to-farmer, extension, private industry or self-directed learning most influence their decision to adopt cover crops.

### Perceived Benefits

We hypothesized that farmers would get information from different sources depending on the particular benefit they expected from cover crops. The data support this hypothesis (Figure 18 below). Farmers find information from SWCD offices, NRCS and the NCDA helpful if they are trying to reduce soil erosion and, to lesser extent, if they use cover crops to improve their soil in the long term. Extension services are commonly cited as supporting all three management priorities, although the data indicate that extension agents are more likely to give helpful information on using cover crops to reduce soil erosion or improve long-term soil health, whereas extension websites are more commonly used to find information on increasing the benefit to cash crops. CFSA is the most popular resource for farmers looking to improve long-term soil health, but the least popular for those interested in reducing soil erosion. Few survey respondents reported they received beneficial information on cover crops from either growers associations or the Farm Bureau, with one exception. 25% of farmers primarily interested in reducing soil erosion received helpful information from a growers association.

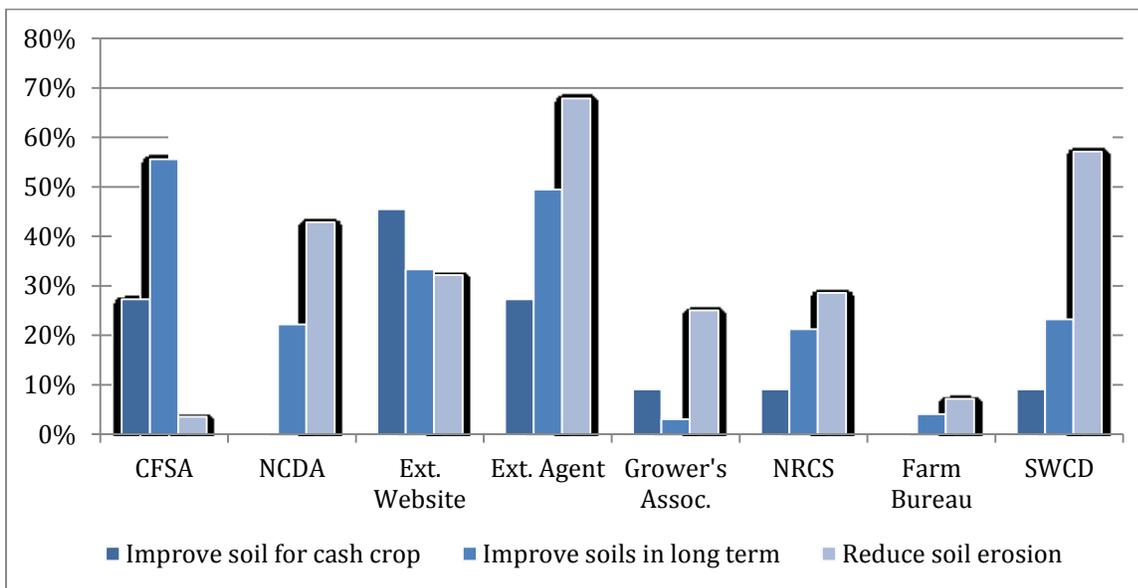


Figure 18: Information Sources by Expected Benefit. Percentage of farmers who report that the organization gave them "information that helped you to use cover crops more beneficially." Results are separated depending on which benefit the farmer listed as "the most important" in the decision to use cover.

## Key Takeaways

Although this research allowed us to collect a wide range of data, several results have especially important implications. These findings both add to existing literature and allow us to draw new conclusions specifically about farmers in North Carolina.

### *Agronomic challenge: timing rotations*

- The majority (27%) of respondents stated that the biggest challenge they overcame to plant cover crops was finding time to work a cover crop into their rotation. Therefore, issues with timing a cover crop in a cash crop rotation are challenges faced by most farmers in North Carolina. Adding this statistic to those who responded their biggest challenge was choosing a kill date, a total of 41% of respondents identified timing issues as most important.
- Those farmers who reported timing barriers as the biggest challenge they overcame were self-taught (42%). This points to a lack of information infrastructure supporting information about working cover crops into a rotation.
- Small, inexperienced farmers face timing challenges disproportionately. This alludes to a gain of knowledge with experience and farm size.

### *Input Constraints*

- 58.1% of respondents stated that they were “very likely” to plant more cover crops if they could apply 50% less fertilizer to their fields as a result. However, only 1% of respondents reported that the biggest reason they started planting cover crops was to reduce the amount of time and money spent on fertilizer. This points to a lack of knowledge in calculating nitrogen release from cover crops, which may serve as a lever on financial constraints.
- Farmers on 250 or more acres pointed specifically to obtaining more labor as a factor in adoption of additional cover crops. This shows that as farm size increases, additional labor to plant cover crops may be a determining factor in adoption.
- Over half of respondents reported that they were “very likely” to plant additional cover crops if they had access to cheaper seeds. Medium farmers were especially interested in

reducing seed price as a factor in further adoption of cover crops. Therefore, we can assume that seed price is a significant challenge to cover crop adoption.

### *Knowledge*

- Over 30% of respondents indicated that a scarcity of knowledge or information posed the most significant challenge to adopting cover crops. This shows the limited access to new and existing knowledge about cover crops among respondents.
- The majority of farmers, 25%, reported that they taught themselves how to implement cover crops. 24% reported that they got their information about cover crops through Extension. Therefore, there are opportunities for improving the dissemination of information on cover crops through conventional and nonconventional channels.
- 55% of respondents reported that they did not apply to CSP, CREP or EQIP because they did not know enough about the programs to participate. This alludes to opportunities to increase participation in conservation programs simply by spreading awareness of their existence.



## Recommendations

### Recommendations to Policymakers

#### *Overview: Shifting Research Priorities*

Public funding provides critical support in agricultural research for public benefit. At the federal level, agricultural research funding is directed through the USDA as authorized through the Farm Bill and appropriated by Congress. States provide crucial funding, often by matching federal funds. State funding provides an especially important source of state- and region-specific research. We suggest that UCS help shift research priorities to address some of the main challenges identified through our survey. Mainly, we suggest that investing research funds for better varieties and mixes of cover crops and simple models for their nutrient benefits will deliver a solution to the main problem with cover crops – that is, an appropriate crop planted between the fall harvest and the spring planting that delivers a reliable benefit.

#### *Develop cover crop varieties that reduce timing barriers*

In our results Dr. Gardner, a key informant and member of the cover crop research community, discussed the need for research of different varieties of cover crops that can be more easily worked into a rotation. She noted that, “we need to fund a new line of research in breeding programs. There’s this issue we’ve been talking about with both crop and cover crop varieties... you can’t even get in a cover crop because it needs to be planted so early. So breeding a different crop or designing a different cropping system to work together and still be productive would be beneficial.” Most crop research funding is channeled toward increasing production levels (Schimmelpfennig et al. 2009). However, our results show that if timing barriers could be mitigated by breeding cover crop varieties that have A) later plant dates and/or B) earlier termination dates, a significant percentage of farmers would plant more cover crops. Small farmers (1-10 acres) were more likely to say that this was a major barrier than those with larger farms as did those with fewer years of farming experience (0-10 years), indicating that beginning farmers likely struggle with questions of timing more than experienced, large farms do. Nonetheless, all farmer demographic categories agreed, to an extent, that timing was an issue in their adoption of cover crops. Thus, we recommend that scarce public research funds emphasize applied research on cover crops. Because private industry emphasizes applied research to increase cash crop yields, we perceive a gap in applied research to improve conservation

outcomes (for which there is little industry incentive to innovate). Filling this gap remains the purview of public institutions and an opportunity for USDA-funded research programs to focus greater resources into the applied conservation research that expand the reach of SAP such as cover crops.

### ***Research cover crop mixtures that improve benefits and mitigate barriers***

Cover crop mixes have great potential to provide flexibility in diverse crop rotations. At this time, however, the synergistic benefits of many cover crop mixtures are not well understood. Eliav Bitan recognized the potential for mixtures to make cover crops more attractive to farmers: “Mixes give you a chance to address multiple resource concerns and reduce your management complexity.” Bitan provided an example where a vetch (a legume), a rye (a grass) and a radish (a tuber) can be used together to provide flexibility in management and deliver multiple benefits to soil quality. The legume provides nitrogen, the grass establishes over the winter, and the radish dies over the winter. The radish in this example mix is particularly meaningful. Snapp et al. (2005) point out that winter cover crops sometimes slow the soil warming process by blocking direct radiation, causing problems for the establishment of a spring crop. Because the radish dies over the winter it contributes to soil warming to the benefit of the other cover crops as well as the spring crop. Without the radish, cover crops create more risk for farmers who worry about timely spring crop establishment. Overcoming this barrier through creative cover crop mixes could help farmers overcome timing issues.

*“Mixes give you a chance to address multiple resource concerns and reduce your management complexity”*

### ***Research cover crop nutrient release curves***

Farmers think every day about soil. Our survey shows that long-term soil quality is the primary reason (64%) farmers started planting cover crops. Other top choices were erosion reduction and soil fertility, two factors also tied to soil quality. Cover crops provide all of these benefits, but cover crops have also long been recognized as a critical nutrient source in organic farming systems that necessarily preclude additions of inorganic inputs. Thus, farmers in conventional systems can realize the same nutrient fixation benefits by incorporating cover crops into their rotation. Our research indicates that while most farmers perceive the long-term soil benefits of using cover crops, far fewer see cover crops as a viable means of reducing fertilizer inputs used to feed their cash crop(s). There is even research suggesting that farmers use more

inorganic inputs under cover cropping systems because they fertilize the cover itself but do not reduce applications to the cash crop (Snapp 2005).

Although agronomists can estimate the total nutrient contribution of most cover crops, more research is needed into how these nutrients become available during the growing season. This research will provide confidence to farmers that they can reduce or eliminate inputs without compromising cash crop yields. Some current research includes Dr. Julie M. Grossman's work to explore how "agricultural management affects the cycling of nutrients via soil microbial processes" and Dr. Ken Moore's study comparing nutrient loading between traditional farming and perennial cover crop farming.

### ***Final recommendations for UCS on research priorities***

UCS is well positioned to advocate that USDA use its research arms to increase cover crop research funding. Funding from NIFA (the National Institute of Food and Agriculture) complements ARS' (Agricultural Research Service) ability to support sustainable agriculture research through partnerships between research institutions, policymakers and business. Combined agricultural research appropriations for FY12 totaled \$1.8 billion (NIFA "Fact Sheet"; ARS "About ARS"). UCS can work within NIFA and ARS to direct those funds toward projects that support cover crop research.

### **Improve Communication of Existing Knowledge**

SAP adoption research has long bemoaned the failure of cooperative extension services to adequately inform farmers about conservation practices or encourage their adoption. Our survey showed that just half of the farmers who adopted cover crops obtained useful information about the practice from an extension agent. There are many explanations for this. Both federal and state agriculture policy influences the priorities of extension agents, and what information they communicate. Individual extension personnel may also be motivated or influenced by their past experience. In our interview, Mr. Cottle suggested that extension is "sponsored by State, and State's sponsored by Roundup, Monsanto."

Of course, extension is not the only source of information for farmers. Many farmers were self-taught, obtaining their information from books, magazines or the internet. We saw an evenly decreasing spread across the other information providers. This makes the challenge much more difficult – as no one source of information is dominant, any information distribution web

must go through many different organizations to ensure significant spread across farmers. The very smallest and largest farmers said that obtaining more information about cover crops was unlikely to increase their cover crop use, as compared to those managing between 11-250 acres. It is likely that at the very small and very large acreage farms, other factors constrain cover crop adoption, and so simply knowing more about them would not change behavior.

In contrast, farmers actively looking for information about an appropriate variety of cover crop information are also looking for information about cover crop benefits, such as how much chemical fertilizer they could replace by planting cover crops. Whatever the underlying reasons, the following recommendations are intended to support the role of extension and other farmer support organizations (SWCDs, state departments of agriculture, etc.) in disseminating information about cover crops and educating farmers about the ways widespread cover crop use can benefit farms and the environment.

#### *Improve quality and quantity of information from publicly funded organizations*

Publicly-funded organizations – including cooperative extension, state Departments of Agriculture, Soil and Water Conservation Districts, and the National Resource Conservation Service – provide farmers a critical source of information and a bridge to the latest agricultural research. In that context, it is troubling that our analysis shows that timing concerns are the single largest barrier to cover crop adoption, and that the vast majority of farmers who have overcome timing challenges have done so by virtue of independent learning. Farmers are not finding the information they most need to manage cover crops from institutional sources of knowledge. Prokopy (2008) recommended drastically increasing the attention that extension

pays to SAPs, a measure that would include enriched training for extension agents, a realignment of extension priorities, and improved literature on SAP management. Our research supports such recommendations. However, in the absence of a sweeping reassessment of agricultural priorities, we recommend that extension services and others focus on addressing the key barriers to cover crop



adoption discussed herein. Based on the research of Young-Stivers and Tucker (1999), we recommend that extension prepare written marketing materials and in-person trainings that clearly identify the three most important expected benefits of cover crops, while also addressing the most common management concerns related to cover crops. Ideally, such material would be tailored to a specific crop system (e.g. cotton, corn, soybeans, tobacco, etc), include an example of a local farmer who has successfully integrated cover crops into his farm operation, and provide a calculator to estimate the financial costs and benefits of adopting cover crops. Innovative technologies could make tailored calculations easier. In an age when farmers increasingly bring technology into the field, a smart phone app could provide fast, tailored and accurate information on cover crop options and benefits.

### *Increase opportunities for farmer-to-farm knowledge sharing*

Our research indicates that farmer-to-farmer learning enables increased cover crop adoption regardless of the particular challenge faced. Simply put, there is no more trusted source than another farmer when weighing the costs, benefits and risks of an unfamiliar practice. Enabling farmer-to-farmer learning should be a priority for federal, state and local stakeholders who recognize the benefits of cover crops. While horizontal knowledge networks inevitably thrive on informal social interactions, these critical networks need not remain sequestered to coffee shops and high school football games. Policy can increase farmer-to-farmer education by funding dissemination programs and research that involve on-farm trials. For example, demonstration farms and farm “field days” provide more formal opportunities for farmers to learn from each other. Demonstration farms and farm field days come through cooperative efforts between extension services, land grant universities and farmers. Extension, in particular, has a unique capacity to identify innovative leaders in the farm sector and work with them to become role models for SAP adoption.

### *Final recommendations to UCS on improving communication*

UCS is well positioned to seek a more robust communication of cover crop understanding by cultivating relationships and advocacy efforts within USDA, and specifically NIFA. The National Institute for Food and Agriculture, a department of USDA, distributes nearly half a billion dollars to state cooperative extension services each year (USDA “NIFA Factsheet”). With

money comes power and the ability to set priorities. In general, we envision UCS directing NIFA's priorities toward a greater appreciation of SAPs. Specifically, we anticipate UCS could play a direct role in guiding NIFA's extension priorities toward a more comprehensive yet locally nuanced support for cover crop adoption nationwide.

### ***Conservation Program Funding***

Several federal, state and local programs offer incentive payments for farmers who use cover crops. For example, EQIP provides limited cost-share funding for cover crops through the Conservation Title of the Farm Bill. Eligibility is based on national, state and regional conservation priorities. At the state level, farmers may apply for NC Agricultural Cost Share Program funding through their local (county-level) Soil and Water Conservation District. The following recommendations are intended to improve the administration of these and similar incentive programs. We believe the most important changes NRCS can make are to their subsidy guidelines.

### ***Flexible dates for cover crop planting and termination through EQIP, CSP and others***

The NRCS key informant noted that the requirements for receiving funding to plant cover crops through EQIP include specific establishment and termination dates. Based on our research, the inflexibility of these dates hinder farmers from applying for funding through EQIP and similar programs. Strict planting and termination dates exist to maximize the public benefit of cover crop systems. On the other hand, allowing for flexibility in cover crop establishment and termination dates, will make funding programs more attractive to farmers who face financial and timing challenges. Cover crops produce public benefits even when they are established late in the season and terminated early to plant a cash crop. Thus, we recommend that agencies structure incentive payments so that farmers get paid based on the proportion of time that the land is under cover. Doing so would reduce the risk to farmers who worry that they will not be able to fit a cover crop into their rotation, and also make them more likely to participate in incentive programs.

### ***Targeted funding for first adopters***

First- and early-adopters encourage other farmers to adopt cover crops by demonstrating their benefit in on-farm situations. However, these farmers assume disproportionate risk in experimenting with a practice that is not widely used. This type of risk-taking, which has clear

public benefits, should be adequately subsidized or insured in order to induce more widespread adoption. Our research suggests that NRCS, SWCD and extension field agents can effectively identify the innovative, but well-respected, members of the local farming community who have the influence to rapidly increase adoption of SAP. Once identified, extension and research programs can form relationships that minimize the farmer's cost and risk while maximizing the number and benefit of field demonstrations. Innovative programs are needed in this area.

The small farmers, and those who are substituting farm income with off-farm income, said they were more likely to plant cover crops if seeds were 50% cheaper, or if they had more assistance in the form of labor and equipment.



Farmers who are already experiencing these constraints are less likely to experiment. Those farmers who are leasing their land face the same constraints on their adoption of cover crops. While small farmers are sometimes more flexible in adopting new methodologies, and may actually be very good advocates for cover crop research, it will likely prove more cost-effective to target early-adopter funding at more conventional, larger farms. We recommend that NRCS, SWCD and extension focus their efforts on increasing adoption among medium to large farms. In addition to managing more acres, these farms tend to follow well-established crop systems that would simplify knowledge transfer *between* similar producers. Such efforts may include special incentives for farmers who are among the first in their county to adopt cover crops extensively.

#### ***Final recommendations to UCS on conservation program funding***

EQIP, CSP and other conservation programs funded through the Farm Bill are administered by the Natural Resources Conservation Service. NRCS sets national conservation priorities, state priorities and regional priorities. We believe UCS can effectively advocate for cover crops by working with NRCS to change the administration of these programs so that they are more favorable for farmers. Ultimately, we recommend that these programs support farmers who already plant cover crops to plant *more* of them, on a larger percentage of their acreage.

And we recommend steps to ensure that farmers who are not currently planting cover crops see these programs as a resource that will offset the costs and risks of adoption so that more farmers will adopt the practice. As many program rules emanate from NRCS's national headquarters, we see an obvious opportunity for UCS to strengthen its existing relationships inside of NRCS, educate their staff about the on-farm challenges faced by farmers, and encourage the development of a comprehensive, accessible, and reliable database of conservation program funding across the country.

### ***Improve Access to Equipment and Seed***

Our survey data conclusively shows that the cost of inputs is a major challenge for those farmers who would like to adopt (or expand) the use of cover crops. We believe there are three main ways to address this: decreasing the cost of seed, simplifying access to specialized equipment, and encouraging participation in cost-share programs with other farmers.

### **Cover Crop Seed**

Farmers use some simple practices to cut the up-front costs of incorporating cover crops into their operations. For example, Mr. Cottle and several of our survey respondents collect seed from their best cover crop field and use it the following year, eliminating the need to invest precious cash in seed every year. Although saving cover crop seed is relatively simple with standard farm equipment, many farmers remain unfamiliar with the practice, in part because seed saving is no longer a part of most farm operations. We recommend development of simple marketing materials explaining the process of cover crop seed saving. In the medium- to long-term, as cover crops become more prevalent across the landscape, seed price should drop as demand expands and more suppliers enter the market. In the interim, better information about costs can help farmers to get the best price for seed.

### ***Reduce barriers and risks of acquiring specialized equipment***

Our research indicates that many farmers would increase cover crop use if they had access to better equipment to plant/terminate/incorporate the cover. For example, farmers practicing no- or reduced-till may need a specialized seed box for their seed drills. Producers especially affected by time constraints, e.g. those harvesting late-season crops, benefit from specialized equipment that seeds, fertilizes and applies herbicides in one pass over the field, rather than the traditional three passes (Penn State 2012). Farmers looking at equipment

purchases may be able to negotiate lower prices through bulk purchasing. It may also be that farmers can access equipment financing but need assistance in order to navigate the loan contracts, ensuring they are not taken advantage of by financial institutions. They may be able to put up collateral (other than their farm) that the bank will take in return for an equipment loan. We recommend that publicly funded agencies, such as the Farm Service Agency (FSA), work with farmers to finance the purchase of specialized equipment that enables cover crop establishment and termination.

### *Encourage cooperative associations among farmers*

Farmers might also be able to create equipment cooperatives that purchase one piece of machinery and then share its use. That piece of equipment would then go into a “stable” with other purchases, and could be used by any farmer in the cooperative. In many places, farmers help each other during key seasons – each farmer has a day on which all the other farmers come over and help them plant. This reduces the amount of time a single farmer has to spend on each task (terminating cover crop, tilling, etc). Cooperatives also encourage cooperation and knowledge sharing between farmers, and potentially resolves the “labor issue” that many respondents noted as a barrier. Public institutions can contribute to cooperative formation by subsidizing shared equipment purchases and by serving in an advisory capacity, e.g. by standardizing cooperative agreements and offering guidelines for arbitrating conflict.

### *Final recommendations to UCS on improving access to equipment and seed*

The price of seed and equipment vary with market forces, and therefore fall further outside the sphere of policy solutions than the recommendations in previous sections. We believe that UCS’s best opportunity to reduce the cost burden of cover crop adoption lies within the Farm Service Agency (FSA), a part of the USDA. FSA acts as a lender of last resort to farmers; that is, farmers turn to FSA to capitalize their production when traditional banks are unwilling to extend credit. Here, UCS has the opportunity to work with FSA to develop long-term, low-interest loans to adopt cover-cropping practices. Long-term because cover crops generate net returns over many years. Low-interest because cover cropping generates public benefits that should be incentivized by the public to whom FSA ultimately represents.

## Conclusion

### Questions Unanswered

Our research focused on the adoption of one particular SAP among the subpopulation of internet-connected farmers in a single state. We chose to focus narrowly on cover crop adoption, and therefore eliminated the possibility of looking more broadly at SAP adoption. The North Carolina focus also meant that although our survey results could be extrapolated to much of North Carolina and states with a similar agricultural profile, we cannot assume that they apply broadly to the nation. While we gathered insight about the main challenges facing farmers that did ultimately adopt cover crops, we did not have sufficient representation from those farmers who have *not* adopted cover crops to perform a rigorous analysis on *their* barriers to adoption. The concern with doing so is the risk that endogenous factors explaining adoption were not measured. In other words, the population of farmers who have already adopted cover crops may differ from the population of non-adopters in ways that we did not measure. On the whole, we would have liked to obtain more representation from large farms and older farmers, so that our survey sample would better match the North Carolina farming population.

### Additional Questions Raised

Future research might focus on a whole host of questions that arose from our data. In order to truly understand how changing CSP or EQIP incentive payments would increase adoption, UCS would need to understand the economic constraints that a non-adopter faces. In retrospect, we would have liked to perform a more detailed cost-benefit analysis for each farmer to see where farmers are spending money and when. This type of information would allow us to understand when and what level of payments can be most effective. From a research perspective, this analysis would most likely require detailed longitudinal information on farm budgets—no simple task.

In order to actually implement a program like a farmer field day on cover crops, preliminary research should measure farmers' interest in participating in that kind of a field day and which practices draw farmer interest. Similar testing could help explain how to use research funding on cover crop varieties and mixes. We can envision designing a focus group to first educate farmers about varieties and mixes, and then to understand how farmers might make decisions about cover crops once they can make an educated choice.

## Summary of Final Recommendations

Our initial hypothesis proposed seven putative barriers to explain why farmers might not adopt cover crops. These barriers emerged from past literature reviews and informal conversations over Summer, 2011. However, after reviewing the results of our survey, we found that every farmer who had adopted the practice faced the same major challenge of timing a cover crop around a cash crop(s). Thus, our recommendations focus heavily on how to approach resolutions for the timing question – from a research, a conservation program, and an education angle. Despite the diverse scope of recommendations, each ties to a different facet within USDA. UCS can work with USDA to polish the many facets of cover crop adoption, or select one or two where their leverage is strongest.

We recognize that UCS is the best judge of our recommendations' feasibility. Nonetheless, this Duke University team brings an outside perspective and priorities to a challenging question. We hope that we have been able to present a broad range of possibilities that UCS can pursue to increase the adoption of cover crops, in North Carolina and across the nation.

The agricultural landscape of the United States provides a food, fiber and fuel source for 311 million Americans, and also the agrarian culture that build this nation. Our goal should be not only to milk the productivity of our land, but to ensure that they will continue to be productive for centuries to come. The adoption of cover crops is just one small piece of the arsenal that farmers must deploy against the negative environmental impacts of conventional farming. As UCS engages with policymakers, we hope this report will provide a valuable source of real stories and accurate data to make policy work better for American farmers.



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## Appendix

### Appendix A: Key Informant Details

#### Key Informant Methods

How we decided who to interview:

Key informants were selected to encompass a wide range of perspectives on cover crops. Below is a list of our informants with details to be drawn out of our conversation and ways that these details will fit into our research.

Not likely that the people would have talked to each other, may know of each other but not that we interviewed them all. All the calls took place over the phone.

These interviewees were experts in the field as recognized by Noel or Dale Threatt-Taylor (except for Herbie).

Can't tell if they might be sitting in a room with someone else, or if there might be other factors (for example, were they in an open cubicle area with other people? What mood were they in?)

#### **Jennifer Blesh**, Cornell University

- Represents the cover crop research community and has experience in the Midwest.
- Contacted January 10, got back on the 12<sup>th</sup> and did the interview on January 18.
- Lee and Katy spoke to her over the summer. Her insights inspired where we took the cover crops project. Corresponds with Noel Gurwick as well, and Noel introduced them.
- Influencing factors: student at Cornell studying cover cropping in the Midwest, has done her own research that's similar to what we're doing. Talked to a lot of farmers during that process.

- Really willing to help out, very excited to share her knowledge.
- The only information we gave them was the consent memo that talks about our research and their involvement, whether or not we want to be on the record.
- Jennifer was over Skype because she was in Brazil at the time.
- Length of call was 50 minutes.

**Eliav Bitan**, National Wildlife Federation

- Represents NGO perspective and has experience researching cover crops and advocating for their use.
- Wrote the Future-Friendly Farming Report, which he published in August 2011 and we received/read in October 2011. We connected to him through our UCS advisor, Noel Gurwick.
- Katy and Lee spoke with him over the summer about cover crops (see transcript) and so had an existing relationship with him. Wanted to look at regional barriers for implementing cover crops and how it fit into larger national perspective.
- Organized it over email contacted January 11, Eliav responded the same day with enthusiasm, scheduled call for January 13, then conducted the call over the phone. Was very relaxed and loquacious.
- Biased toward environmental perspective because works for NWF, they had gotten a grant to study cover cropping benefits. Interested in the final report, data and outcomes.
- Fuzzy boundary for off the record (not totally specified) in the transcript, but was clear in context.
- Called Eliav at his workplace.
- Length of call was 54 minutes.

**Teresa Hice**, President of the HHB Chapter of the Soil and Water Conservation Society, Natural Resource Conservationist for the Wake Soil and Water Conservation District

- Provides a North Carolina-specific perspective of management practices (Teresa has been a Wake SWCD employee for 26 years). Part of Teresa's job is to help the public understand federal and state regulations.
- Emailed her on January 11, emailed back the same day. January 23 had call.
- Recommended by Dale Threatt-Taylor, who was a Duke DEL program who now works for S&WCD. Also shares an office. Other than that, there was no interaction between Dale and Teresa about the interview.
- Vested interest in trying to get farmers to adopt these kinds of practices. Interacts with farmers every day. Seemed very responsive.
- Called Teresa at her workplace.
- Length of call was 35 minutes

**NRCS Representative**, District Conservationist at USDA-NRCS in Laurinburh, Cabarrus and Wake counties

- Provides a federal-to-state perspective on cover cropping in NC. Has experience in three different parts of the state.

- Very difficult to get a hold of. Emailed him on Jan 11 with no response, Jan 20 and received response back on the 21<sup>st</sup>, expressed willingness to help. Never set a date, emailed again on Jan 30. The representative emailed Katy back on Feb 1, and they set up the call for Feb 2.
- Seemed a little hesitant on how helpful he would be, didn't seem sure what we really wanted to know. Focused in on questions in the 2<sup>nd</sup> half the call, seemed to wander in the beginning, but then became very focused and helpful.
- Was suggested by Dale Threatt-Taylor, they share an office. We're not sure how much they interact.
- Wanted to be anonymous as opposed to off the record or quoted with his name.
- Called NRCS representative at his workplace.
- Length of call was 65 minutes

### **Herbie Cottle** NC farmer using cover crops

- Provides knowledge of cover crop use in regions of NC.
- Herbie had contacted Lee on January 24 after receiving our survey to volunteer information about cover crops and said if we wanted more information he'd be happy to tell us more. Lee emailed Herbie on the 27<sup>th</sup> to see if we could visit.
- Agreed to have Katy and Lee visit on the 30<sup>th</sup> of January. They went to visit him on Feb 6. Visit was at 2pm, left at around 4pm.
- Got there a little before he arrive, met him at his neighbor's house and then got in his truck. Herbie drove them around to six different fields. Had certain fields he already knew he wanted to show Katy and Lee. Nobody else was at the farm at the time.
- Wanted to share all his knowledge about cover crops with us, very enthusiastic.
- Got out of the truck at each site, would point out different types of cover. Katy would take pictures and Lee would ask questions.

### **Dana Ashford**

- Both the NRCS representative, Greg Walker (NRCS Raleigh employee (TBA) who Katy had spoken to about the administration of Farm Bill programs) recommended that we talk to her.
- She did some type of research on cover crops in North Carolina. The other person on the call will be Josh Spencer – he is a water quality specialist in the ecological sciences staff at NRCS.
- Dana Ashford is the conservation agronomist on the ecological services staff at NRCS.

How we developed the questions:

Came out of our hypothesis, the main question being “What are the major barriers?” Questions were targeted toward each of them depending on their experience. The people that we knew more about (Eliav and Jennifer) we could cater the questions to them – questions were motivated by existing knowledge from literature reviews and their experience and what we wanted to know based on what they'd done (personal learning experiences). Both of these were targeted toward barriers depending on the person. Katy developed these questions in one afternoon based off of her prior research experience.

Self-guided, semi-structured interview format.

Transcribed:

Interviews were recorded in full after obtaining subject's permission. Consent form was sent in an email before each interview. At the beginning of the call, went over the form and made sure they agreed to all the components of it. One of those component was permission to record. Used iPod with a microphone on it, and used the iPad as well (recorded off of speakerphone) except Herbie ← iPad. Literal transcriptions, leaving out things that people specified they wanted to be off of the record for. The recorded versions were put onto iTunes. Wrote a topical description if the section of the call was not specifically related to cover crops. Took about 2.5 hours per hour of each interview. Wrote transcripts in Word and coded in Nvivo

## Appendix B: Key Informant Transcripts

[To be inserted]

## Appendix C: Web Survey (Qualtrics Export)

Cover Crops MP Survey - Databases

Q97 This valuable survey will help to determine how cover crops can benefit North Carolina farmers. This survey was created by graduate students at Duke University, in partnership with the national nonprofit organization, Union of Concerned Scientists. Your participation in this survey is optional. The survey will take no more than 20 minutes to complete. You may stop answering questions and submit the survey at any time. You may skip questions at any time. At the end of the survey, you will be given an opportunity to submit your name and contact information separate from your survey responses in order to be entered into a lottery for a cash reward. Lastly, your personal responses will remain completely anonymous. Your choice to participate or not, as well as your response, will be maintained in complete confidentiality within our student research group. The data may be used in aggregate with other responses to inform national and local policy on cover crops. We may report generally on a summary of this data to communities of policy makers, researchers or farmer associations. If you have questions, you may contact us at any time by calling Lee Miller at (919) 264-0856. If you have questions about your rights as a research study participant, you may contact the Human Subjects Committee at Duke University at 919-684-3030.

Q67 Are you going to sell more than \$1,000 of farmed products (livestock or crops) this year?

- Yes (1)
- No (2)

If No Is Selected, Then Skip To End of Survey

Q1 How many years have you farmed in North Carolina?

Q4 Do you own or lease the acres that you farm?

- Own (1)
- Lease (2)
- Both (3)

Answer If Do you own or lease the acres that you farm? Own Is Selected Or Do you own or lease the acres that you farm? Both Is Selected

Q43 Of the acres that you farm, approximately how many do you own?

Answer If Do you own or lease the acres that you farm? Own Is Selected Or Do you own or lease the acres that you farm? Both Is Selected

Q12 On your OWNED land, how many acres do you have in the following areas in a normal year?

- Acres in crop production: (1)
- Acres for livestock production: (2)

Q94 Please indicate which of the following government conservation programs you have applied for, regardless of whether or not you were accepted. (check all that apply)

- Conservation Stewardship Program (CSP) (1)
- Conservation Reserve Enhancement Program (CREP) (2)
- Environmental Quality Incentives Program (EQIP) (3)
- None of these (4)

Answer If Please indicate which of the following government conserv... None of these Is Selected

Q75 I have not applied for CSP, CREP or EQIP programs because... (check all that apply)

- The chances of getting funding are too low (1)
- The application process is too much work (2)
- Even if I were to be accepted, the administration would be too much work (3)
- Agency staff weren't able to answer my questions (4)
- The cash payments are too low (5)
- I don't believe the government should pay farmers (6)
- My neighbors talk badly about the programs (7)
- The conservation activities would interfere with my normal production (8)
- I don't know enough about these programs to participate (9)
- I could not find the information I needed on the Web (10)
- I could not find the information I needed at my FSA or NRCS office (11)
- Other (please specify): (12) \_\_\_\_\_

Answer If Do you own or lease the acres that you farm? Own Is Selected Or Do you own or lease the acres that you farm? Both Is Selected

Q20 On your owned land, approximately how many acres currently receive federal Direct Payments, Counter-Cyclical Payments, Direct Marketing Loans, or are registered in the Average Crop Revenue Election (ACRE) Program?

Answer If Do you own or lease the acres that you farm? Lease Is Selected Or Do you own or lease the acres that you farm? Both Is Selected

Q9 Approximately how many acres do you lease from others?

Answer If Do you own or lease the acres that you farm? Lease Is Selected Or Do you own or lease the acres that you farm? Both Is Selected

Q10 What type of lease arrangement do you have? Please check all that apply.

- I pay a fixed amount per acre (1)
- I pay the landowner based on my farm revenue (2)
- I am leasing to own some acres (3)
- Other (4) \_\_\_\_\_

Answer If Do you own or lease the acres that you farm? Lease Is Selected Or Do you own or lease the acres that you farm? Both Is Selected

Q11 What is the length of your current lease (in years)?

Answer If Do you own or lease the acres that you farm? Lease Is Selected Or Do you own or lease the acres that you farm? Both Is Selected

Q50 On your LEASED land, how many acres do you have in the following areas in a normal year?

- Acres in crop production: (1) \_\_\_\_\_
- Acres in livestock production: (2) \_\_\_\_\_
- Acres in other uses: (3) \_\_\_\_\_

Answer If Do you own or lease the acres that you farm? Lease Is Selected And Do you own or lease the acres that you farm? Both Is Selected

Q53 On your LEASED LAND, approximately how many acres receive federal Direct Payments, Counter-Cyclical Payments, Direct Marketing Loans, or are enrolled in the ACRE Program?

Q91 Please state your agreement with the following statement: "I understand what cover crops are."

- I agree (1)
- I disagree (2)
- I've heard of them but don't know much about them (3)

Q23 The Soil and Water Conservation Society defines cover crops as a "crop grown primarily for the purpose of protecting and improving soil between periods of regular crop production."Based on this definition, have you planted a cover crop on any land that you own or lease?

- Yes (1)
- No (2)

If No Is Selected, Then Skip To If you were provided additional fina...

Q48 Please indicate if any of the following groups have given you information that helped you use cover crops more beneficially. (check all that apply)

- Carolina Farm Stewardship Association (CFSA) (1)
- North Carolina Department of Agriculture and Consumer Services (NCDA) (2)
- Cooperative Extension website (3)
- Cooperative Extension agent (4)
- North Carolina Growers Association (for example, NC Cotton Growers, NC Corn Growers, etc.) (5)
- National Resources Conservation Service (NRCS) (6)
- Local Farm Bureau (7)
- Soil and Water Conservation District Office (8)
- Other (please specify) (9) \_\_\_\_\_

Q24 Please indicate which of the following cover crop varieties you have planted. (if any)

- Vetch (1)
- Clover (2)
- Rye (3)
- Wheat (4)
- Mustard (5)
- Winter Pea (6)
- Other (please specify) (7) \_\_\_\_\_
- None (8)

Q80 Have you ever sold any of your cover crops (for example, sold winter wheat as feed)?

- Yes (1)
- No (2)
- Not sure (3)

Q25 Please indicate if you have ever obtained money from any of the following programs or organizations specifically to help you grow cover crops, including helping with seed cost. (check all that apply)

- Conservation Stewardship Program (CSP) (1)
- Conservation Reserve Enhancement Program (CREP) (2)
- Environmental Quality Incentives Program (EQIP) (3)
- Farm Service Agency (FSA) Loan (4)
- Bank Loan (5)
- Farm revenue (6)
- Other (please specify): (7) \_\_\_\_\_

Answer If Please indicate if you have ever obtained money from any ... Conservation Stewardship Program (CSP) Is Selected Or Please indicate if you have ever obtained money from any ... Conservation Reserve Enhancement Program (CREP) Is Selected Or Please indicate if you have ever obtained money from any ... Environmental Quality Incentives Program (EQIP) Is Selected

Q96 Please indicate approximately how much CSP, CREP or EQIP covered the cost of planting cover crops.

- Less than half of the cost (1)
- Approximately half of the cost (2)
- More than half the cost (3)
- They covered the full cost (4)

Q56 The SINGLE BIGGEST challenge I overcame to plant cover crops was...

- Deciding which cover crop(s) varieties to use (1)
- Figuring out how much fertilizer the cover crop would replace (2)
- Paying for seed/labor to plant the cover crop (3)
- Deciding when to kill the cover crop to maintain my regular crop rotation (4)
- Finding time to plant seed and till the cover crop into the soil (5)
- Finding the seed variety I wanted to buy (6)
- Other (please specify): (7) \_\_\_\_\_

Q57 When I first began planting cover crops, the factor that influenced my decision the most was... (please choose the best answer)

- A neighbor or friend recommended them (1)
- I saw my neighbor use them successfully (2)
- My extension agent recommended them (3)
- My seed supplier/farm equipment store recommended them (4)
- I learned about them on the internet or through a magazine/book (5)
- I learned about them through an extension workshop (6)
- A soil fertility consultant recommended them (7)
- Other (please specify): (8) \_\_\_\_\_

Q78 I started planting cover crops because I wanted... (check all that apply)

- To boost the fertility of my soil for a cash crop (1)
- To improve my long-term soil quality (2)
- To reduce soil erosion (3)
- To reduce the amount of time and money spent on fertilizer (4)
- To reduce the amount of fertilizer washing into nearby lakes/streams (5)
- To control weeds (6)
- I don't like the look of a fallow field (7)
- Other (please specify): (8) \_\_\_\_\_

Q89 The single most important reason I plant cover crops is...

- To boost the fertility of my soil for a cash crop (1)
- To improve my long-term soil quality (2)
- To reduce soil erosion (3)
- To reduce the amount of time and money spent on fertilizer (4)
- To reduce the amount of fertilizer washing into nearby lakes/streams (5)
- Because I don't like the look of a fallow field (6)
- Other (please specify): (7) \_\_\_\_\_

Q58 Over the next 3 years, I plan to plant...

- More area in cover crops (1)
- Less area in cover crops (2)
- About the same area in cover crops (3)
- I have not decided yet (4)

Answer If The Soil and Water Conservation Society defines cover cro... No Is Selected Or Over the next 3 years, I plan to plant... Fewer acres in cover crops Is Selected

Q26 What are the reasons that you've chosen not to use cover crops on your farm?(please check all that apply)

- I don't know enough about them (1)
- It's too time consuming to plant/till (2)
- If I plant cover crops, I risk losing my crop insurance coverage (3)
- I risk lowering my cash crop yield (4)
- They make the fields look messy (5)
- They are too expensive as a source of fertilizer (6)
- I can't buy the right cover crop variety (7)
- I worry about pest or fungi transferring from the cover crop to a cash crop (8)
- Other (9) \_\_\_\_\_

Q60 Please indicate if you use any of the following on your farm. (check all that apply)

- Reduced till or no-till (1)
- Manure, compost or other natural fertilizers (2)
- Chemical fertilizer (3)
- Precision nutrient management (4)
- Drip irrigation or rain water collection (5)
- Riparian buffers (6)
- Integrated pest management (7)
- Intercropping (8)
- None of these (9)

Q64 Approximately many pounds of chemical fertilizer (for example urea, anhydrous ammonia, or calcium nitrate) do you apply per acre (on average)?

Answer If The Soil and Water Conservation Society defines cover cro... Yes Is Selected

Q76 How do you obtain most of your cover crop seed?

- Drive 0-10 miles to the store (1)
- Drive 10-50 miles to the store (2)
- Drive more than 50 miles to the store (3)
- Order it online and have it shipped to the farm (4)
- Order by phone and have it shipped to the farm (5)
- Other (6) \_\_\_\_\_

Answer If The Soil and Water Conservation Society defines cover cro... No Is Selected

Q83 How would you obtain cover crop seed, if you wanted to?

- Drive 0-10 miles to the store (1)
- Drive 10-50 miles to the store (2)
- Drive more than 50 miles to the store (3)
- Order it online and have it shipped to the farm (4)
- Order by phone and have it shipped to the farm (5)
- Other (please specify) (6) \_\_\_\_\_
- I don't know where I would get cover crop seed (7)

Answer If The Soil and Water Conservation Society defines cover cro... No Is Selected Or Over the next 3 years, I plan to plant... Fewer acres in cover crops Is Selected

Q85 What is the single most important reason that you've chosen not to use cover crops on your farm?

- I don't know enough about them (1)
- It takes me too much time to plant/till (2)
- If I plant cover crops, I risk losing my crop insurance coverage (3)
- I risk lowering my cash crop yield (4)
- They make fields look messy (5)
- They are too expensive as a source of fertilizer (6)
- I can't buy the right cover crop variety (7)
- I worry about pest or fungi transferring from the cover crop to my cash crop (8)
- Other (9) \_\_\_\_\_

Answer If The Soil and Water Conservation Society defines cover cro... No Is Selected

Q79 If the federal government were to guarantee the following payment to all farmers who planted cover crops, would you begin planting them?

- \$10/acre (1)
- \$25/acre (2)
- \$50/acre (3)
- \$75/acre (4)
- \$100/acre (5)
- I would not plant cover crops for this payment (6)

Q62 The questions that follow ask whether you would use cover crops more in different situations. Please indicate how each situation would likely change your cover crop use."I would use cover crops more than I do now if...

	Very likely (1)	Somewhat likely (2)	Somewhat unlikely (3)	Very unlikely (4)	This does not apply to me (5)
Cover crops did not interfere with my regular planting/harvesting schedule (1)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Cover crops did not threaten my crop insurance (2)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Cover crops increased my cash crop yield (3)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I could obtain the recommended cover crop for my land (4)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Cover crop seeds were 50% cheaper (5)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I could get the full benefit in a shorter amount of growing time (6)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Q90 "I would use cover crops more than I do now if..."

	Very Likely (1)	Somewhat Likely (2)	Somewhat Unlikely (3)	Very Unlikely (4)	This does not apply to me (5)
I had more equipment to plant and terminate (kill) cover crops (1)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I had more consistent access to farm labor to help plant and terminate cover crops (2)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
More information were available about the specific benefits of planting a cover crop (3)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Cover crops looked more tidy in my fields (4)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I could apply 50% less fertilizer to my fields by planting cover crops (5)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
My children would farm the land when I retire (6)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Q36 What is your age in years?

Q37 What is your gender?

- Male (1)
- Female (2)

Q38 Please indicate if you and/or your spouse/partner work off-farm. (check all that apply)

- You work off-farm full time (1)
- You work off-farm part time (2)
- Your spouse/partner works off-farm full time (3)
- Your spouse/partner works off-farm (4)
- Neither you nor your spouse/partner work off-farm (5)

Q88 What county do you farm in?

- Alamance (1)
- Alexander (2)
- Anson (3)
- Avery (4)
- Beaufort (5)
- Bertie (6)
- Bladen (7)
- Brunswick (8)
- Buncombe (9)
- Burke (10)
- Cabarrus (11)
- Caldwell (12)
- Camden (13)
- Carteret (14)
- Caswell (15)
- Catawba (16)
- Chatham (17)
- Cherokee (18)
- Chowan (19)
- Clay (20)
- Clay (21)
- Cleveland (22)
- Columbus (23)
- Craven (24)
- Cumberland (25)
- Currituck (26)
- Dare (27)
- Davidson (28)
- Davie (29)
- Duplin (30)
- Durham (31)
- Edgecombe (32)
- Forsyth (33)
- Franklin (34)
- Gaston (35)
- Gates (36)
- Graham (37)
- Granville (38)
- Greene (39)
- Guilford (40)

- Halifax (41)
- Harnett (42)
- Haywood (43)
- Henderson (44)
- Hertford (45)
- Hoke (46)
- Hyde (47)
- Iredell (48)
- Jackson (49)
- Johnston (50)
- Jones (51)
- Lee (52)
- Lenoir (53)
- Lincoln (54)
- McDowell (55)
- Macon (56)
- Madison (57)
- Martin (58)
- Mecklenburg (59)
- Mitchell (60)
- Montgomery (61)
- Moore (62)
- Nash (63)
- New Hanover (64)
- Northampton (65)
- Onslow (66)
- Orange (67)
- Pamlico (68)
- Pasquotank (69)
- Pender (70)
- Perquimans (71)
- Person (72)
- Pitt (73)
- Polk (74)
- Randolph (75)
- Richmond (76)
- Robeson (77)
- Rockingham (78)
- Rowan (79)
- Rutherford (80)

- Sampson (81)
- Scotland (82)
- Scotland (83)
- Stanly (84)
- Stokes (85)
- Surry (86)
- Swain (87)
- Transylvania (88)
- Tyrrell (89)
- Union (90)
- Vance (91)
- Wake (92)
- Warren (93)
- Washington (94)
- Watauga (95)
- Wayne (96)
- Wilkes (97)
- Wilson (98)
- Yadkin (99)
- Yancey (100)

Q69 What is your home zip code?

Q39 What was your approximate gross farm income before taxes last year?

- Less than \$20,000 (1)
- \$20,000 to \$39,999 (2)
- \$40,000 to \$59,999 (3)
- \$60,000 to \$79,999 (4)
- \$80,000 to \$99,999 (5)
- \$100,000 to \$149,999 (6)
- \$150,000 to \$199,999 (7)
- Over \$200,000 (8)
- I'd rather not say (9)

Q40 What was your approximate annual household income before taxes last year?

- Less than \$20,000 (1)
- \$20,000 to \$39,999 (2)
- \$40,000 to \$59,999 (3)
- \$60,000 to \$79,999 (4)
- \$80,000 to \$99,999 (5)
- \$100,000 to \$149,999 (6)
- \$150,000 to \$199,999 (7)
- Over \$200,000 (8)
- I'd rather not say (9)

## Appendix D: Tabulated Likert Correlations

**TABLE 1. Farmer off-farm employment**

	Not off farm full time			Off farm full time		
	Median	Mean	SE	Median	Mean	SE
1 Cover crops did not interfere with my regular planting/harvesting schedule	<b>1</b>	1.70	0.10	<b>1</b>	1.74	0.21
2 Cover crops did not threaten my crop insurance	<b>4</b>	3.00	0.30	<b>1.5</b>	2.00	0.39
3 Cover crops increased my cash crop yield	<b>1</b>	1.57	0.09	<b>1</b>	1.40	0.13
4 I could obtain the recommended cover crop for my land	<b>2</b>	2.03	0.12	<b>2</b>	1.71	0.17
5 Cover crop seeds were 50% cheaper	<b>2</b>	1.86	0.10	<b>1</b>	1.35	0.15
6 I could get the full benefit in a shorter amount of growing time	<b>1</b>	1.58	0.08	<b>2</b>	1.63	0.13
7 I had more equipment to plant and terminate (kill) cover crops	<b>2</b>	1.84	0.10	<b>2</b>	2.00	0.22
8 I had more consistent access to farm labor to help plant and terminate cover crops	<b>2</b>	2.21	0.13	<b>2</b>	2.15	0.23
9 More information were available about the specific benefits of planting a cover crop	<b>2.5</b>	2.62	0.13	<b>2</b>	2.26	0.20
10 Cover crops looked more tidy in my fields	<b>4</b>	3.36	0.12	<b>3</b>	2.60	0.29
11 I could apply 50% less fertilizer to my fields by planting cover crops	<b>1</b>	1.71	0.11	<b>1</b>	1.39	0.12
12 My children would farm the land when I retire	<b>2</b>	2.42	0.15	<b>2</b>	2.14	0.29

**TABLE 2. Total acres crop production**

	1-10			11-49		
	Median	Mean	SE	Median	Mean	SE
1 Cover crops did not interfere with my regular planting/harvesting schedule	<b>1</b>	1.60	0.11	<b>1.5</b>	1.79	0.26
2 Cover crops did not threaten my crop insurance	<b>3</b>	2.75	0.49	<b>2.5</b>	2.50	0.67
3 Cover crops increased my cash crop yield	<b>1</b>	1.60	0.11	<b>1</b>	1.42	0.12
4 I could obtain the recommended cover crop for my land	<b>2</b>	1.91	0.16	<b>2</b>	1.88	0.13
5 Cover crop seeds were 50% cheaper	<b>2</b>	1.82	0.12	<b>1</b>	1.50	0.19
6 I could get the full benefit in a shorter amount of growing time	<b>1</b>	1.52	0.08	<b>1</b>	1.53	0.18
7 I had more equipment to plant and terminate (kill) cover crops	<b>2</b>	1.80	0.11	<b>2</b>	1.87	0.24
8 I had more consistent access to farm labor to help plant and terminate cover crops	<b>2</b>	2.06	0.15	<b>2</b>	2.07	0.27
9 More information were available about the specific benefits of planting a cover crop	<b>3</b>	2.60	0.15	<b>2</b>	2.31	0.20
10 Cover crops looked more tidy in my fields	<b>4</b>	3.33	0.15	<b>4</b>	3.18	0.33
11 I could apply 50% less fertilizer to my fields by planting cover crops	<b>1.5</b>	1.80	0.13	<b>1</b>	1.44	0.17
12 My children would farm the land when I retire	<b>3</b>	2.71	0.19	<b>1.5</b>	1.70	0.26

	50-249			250+		
	Median	Mean	SE	Median	Mean	SE
	<b>2</b>	2.09	0.29	<b>2</b>	1.86	0.28
	<b>2</b>	2.20	0.58	<b>2</b>	2.86	0.40
	<b>1</b>	1.64	0.25	<b>1</b>	1.31	0.18
	<b>2</b>	2.00	0.27	<b>2</b>	2.30	0.34
	<b>1</b>	1.71	0.24	<b>2</b>	2.00	0.30
	<b>2</b>	1.80	0.24	<b>2</b>	1.85	0.27
	<b>2</b>	1.92	0.27	<b>2</b>	2.23	0.30
	<b>2</b>	2.18	0.33	<b>3</b>	2.92	0.31
	<b>2</b>	2.09	0.32	<b>3</b>	3.00	0.30
	<b>2</b>	2.33	0.41	<b>4</b>	3.46	0.22
	<b>1</b>	1.38	0.21	<b>1</b>	1.43	0.17
	<b>1.5</b>	2.00	0.33	<b>2</b>	2.25	0.33

**TABLE 3. Years of farming experience**

	0-10			11-30			31+	
	Median	Mean	SE	Median	Mean	SE	Median	Mean
1 Cover crops did not interfere with my regular planting/harvesting schedule	1	1.57	0.13	1	1.56	0.14	2	2.25
2 Cover crops did not threaten my crop insurance	3	2.67	0.62	2	2.50	0.46	2.5	2.67
3 Cover crops increased my cash crop yield	1	1.51	0.12	1	1.61	0.14	1	1.38
4 I could obtain the recommended cover crop for my land	1.5	1.82	0.18	2	2.04	0.16	2	2.17
5 Cover crop seeds were 50% cheaper	2	1.72	0.11	1	1.87	0.18	1	1.69
6 I could get the full benefit in a shorter amount of growing time	1	1.57	0.11	1	1.56	0.12	1	1.67
7 I had more equipment to plant and terminate (kill) cover crops	2	1.72	0.12	2	1.76	0.13	2	2.36
8 I had more consistent access to farm labor to help plant and terminate cover crops	2	1.92	0.18	2	2.41	0.19	2.5	2.42
9 More information were available about the specific benefits of planting a cover crop	2	2.51	0.17	2	2.44	0.20	3	2.79
10 Cover crops looked more tidy in my fields	4	3.15	0.20	4	3.25	0.23	3	3.08
11 I could apply 50% less fertilizer to my fields by planting cover crops	1	1.76	0.18	1	1.59	0.14	1.5	1.65
12 My children would farm the land when I retire	3	2.53	0.27	2	2.26	0.23	2	2.08

**TABLE 4. Gross annual farm income**

	Less than \$20,000			\$20,000-\$39,999			\$40,000-\$99,999	
	Median	Mean	SE	Median	Mean	SE	Median	Mean
1 Cover crops did not interfere with my regular planting/harvesting schedule	1	1.72	0.17	2	1.62	0.16	1	1.80
2 Cover crops did not threaten my crop insurance	4	2.78	0.49	2	2.00	0.00	2.5	2.50
3 Cover crops increased my cash crop yield	1	1.55	0.14	1	1.55	0.19	2	1.77
4 I could obtain the recommended cover crop for my land	2	1.78	0.16	2	2.00	0.26	2	2.00
5 Cover crop seeds were 50% cheaper	2	1.79	0.13	2	1.68	0.17	1	2.00
6 I could get the full benefit in a shorter amount of growing time	1	1.58	0.11	1	1.40	0.13	1	1.62
7 I had more equipment to plant and terminate (kill) cover crops	2	1.85	0.15	2	1.94	0.17	2	2.00
8 I had more consistent access to farm labor to help plant and terminate cover crops	2	1.97	0.18	3	2.56	0.29	1	1.75
9 More information were available about the specific benefits of planting a cover crop	2	2.38	0.20	2	2.47	0.27	3	2.90
10 Cover crops looked more tidy in my fields	4	3.15	0.23	3	3.23	0.26	4	3.57
11 I could apply 50% less fertilizer to my fields by planting cover crops	1	1.63	0.16	1	1.61	0.22	2	1.92
12 My children would farm the land when I retire	2	2.19	0.25	3	2.80	0.33	3	2.56

	\$60,000-\$79,999			\$80,000-\$99,999			\$100,000-\$150,000			Over \$200,000		
	Median	Mean	SE	Median	Mean	SE	Median	Mean	SE	Median	Mean	SE
1	1	1.50	0.50	3	2.57	0.57	1	1.00	0.00	1	1.44	0.18
1	1	1.00	.	4	4.00	0.00	.	.	.	3	3.00	1.00
1	1	1.20	0.20	2	2.13	0.40	1	1.00	0.00	1	1.33	0.17
2	2	1.67	0.33	4	3.60	0.40	.	.	.	1.5	1.50	0.22
1	1	1.00	0.00	1.5	2.00	0.42	2.5	2.50	1.50	1.5	1.75	0.31
1	1	1.20	0.20	1	1.44	0.29	1	1.33	0.33	1	1.56	0.24
1	1	1.50	0.34	2	2.80	0.49	2	2.33	0.88	1	1.50	0.27
1	1	1.40	0.25	2	2.40	0.51	3	3.00	1.00	3	2.86	0.34
3	3	2.33	0.67	4	3.80	0.20	2.5	2.50	1.50	2	2.50	0.46
3	3	3.00	1.00	4	3.60	0.40	4	4.00	0.00	4	3.25	0.49
1	1	1.40	0.40	1	1.71	0.47	1	2.00	1.00	1	1.13	0.13
2	2	2.00	0.58	2	2.17	0.54	2.5	2.50	1.50	3	2.60	0.51

**TABLE 5. Conservation program involvement**

	Applied for CSP, CREP, and/or EQIP			Never applied for CSP, CREP, and/or EQIP	
	Median	Mean	SE	Median	Mean
1 Cover crops did not interfere with my regular planting/harvesting schedule	<b>2</b>	2.00	0.20	<b>1</b>	1.58
2 Cover crops did not threaten my crop insurance	<b>2</b>	2.45	0.39	<b>3</b>	2.73
3 Cover crops increased my cash crop yield	<b>1</b>	1.41	0.10	<b>1</b>	1.61
4 I could obtain the recommended cover crop for my land	<b>2</b>	2.08	0.21	<b>2</b>	1.91
5 Cover crop seeds were 50% cheaper	<b>1</b>	1.84	0.17	<b>1</b>	1.74
6 I could get the full benefit in a shorter amount of growing time	<b>1</b>	1.61	0.13	<b>1</b>	1.58
7 I had more equipment to plant and terminate (kill) cover crops	<b>2</b>	1.94	0.18	<b>2</b>	1.85
8 I had more consistent access to farm labor to help plant and terminate cover crops	<b>2</b>	2.25	0.19	<b>2</b>	2.17
9 More information were available about the specific benefits of planting a cover crop	<b>3</b>	2.71	0.19	<b>2</b>	2.47
10 Cover crops looked more tidy in my fields	<b>4</b>	3.39	0.18	<b>4</b>	3.14
11 I could apply 50% less fertilizer to my fields by planting cover crops	<b>1</b>	1.53	0.13	<b>1</b>	1.69
12 My children would farm the land when I retire	<b>2.5</b>	2.46	0.24	<b>2</b>	2.31

**TABLE 6. Farmland ownership**

	Own some of farmed acres			Lease all of farmed acres	
	Median	Mean	SE	Median	Mean
1 Cover crops did not interfere with my regular planting/harvesting schedule	<b>1</b>	1.74	0.10	<b>1</b>	1.50
2 Cover crops did not threaten my crop insurance	<b>2</b>	2.50	0.26	<b>4</b>	4.00
3 Cover crops increased my cash crop yield	<b>1</b>	1.58	0.09	<b>1</b>	1.31
4 I could obtain the recommended cover crop for my land	<b>2</b>	1.96	0.11	<b>2</b>	2.00
5 Cover crop seeds were 50% cheaper	<b>1</b>	1.77	0.09	<b>1</b>	1.79
6 I could get the full benefit in a shorter amount of growing time	<b>1</b>	1.59	0.07	<b>1</b>	1.56
7 I had more equipment to plant and terminate (kill) cover crops	<b>2</b>	1.92	0.10	<b>1.5</b>	1.57
8 I had more consistent access to farm labor to help plant and terminate cover crops	<b>2</b>	2.27	0.12	<b>2</b>	1.56
9 More information were available about the specific benefits of planting a cover crop	<b>2</b>	2.51	0.12	<b>3</b>	2.82
10 Cover crops looked more tidy in my fields	<b>4</b>	3.20	0.13	<b>4</b>	3.33
11 I could apply 50% less fertilizer to my fields by planting cover crops	<b>1</b>	1.65	0.10	<b>2</b>	1.55
12 My children would farm the land when I retire	<b>2</b>	2.37	0.14	<b>2.5</b>	2.33

**TABLE 7. Biggest challenge overcome**

	Deciding which cover crop to plant			Figuring out how much fertilizer the cover would replace			Paying for seed/labor to cover crop	
	Median	Mean	SE	Median	Mean	SE	Median	Mean
1 Cover crops did not interfere with my regular planting/harvesting schedule	<b>1.5</b>	1.79	0.28	<b>1.5</b>	1.50	0.29	<b>2</b>	2.05
2 Cover crops did not threaten my crop insurance	<b>4</b>	4.00	.	.	.	.	<b>2.5</b>	2.58
3 Cover crops increased my cash crop yield	<b>1</b>	1.41	0.21	<b>1</b>	1.60	0.40	<b>1</b>	1.43
4 I could obtain the recommended cover crop for my land	<b>1</b>	1.50	0.38	<b>2.5</b>	2.50	1.50	<b>2</b>	1.89
5 Cover crop seeds were 50% cheaper	<b>1</b>	1.69	0.31	<b>1</b>	1.60	0.40	<b>1</b>	1.44
6 I could get the full benefit in a shorter amount of growing time	<b>1</b>	1.67	0.27	<b>1</b>	1.00	0.00	<b>1</b>	1.54
7 I had more equipment to plant and terminate (kill) cover crops	<b>2</b>	1.67	0.19	<b>1</b>	1.20	0.20	<b>2</b>	1.83
8 I had more consistent access to farm labor to help plant and terminate cover crops	<b>2</b>	2.00	0.38	<b>1</b>	2.00	1.00	<b>2</b>	2.00
9 More information were available about the specific benefits of planting a cover crop	<b>2</b>	2.36	0.36	<b>1</b>	1.75	0.75	<b>2.5</b>	2.45
10 Cover crops looked more tidy in my fields	<b>4</b>	3.38	0.38	<b>4</b>	3.00	1.00	<b>3</b>	3.00
11 I could apply 50% less fertilizer to my fields by planting cover crops	<b>1</b>	1.58	0.29	<b>1</b>	1.75	0.75	<b>1</b>	1.38
12 My children would farm the land when I retire	<b>3</b>	2.60	0.51	<b>4</b>	3.00	1.00	<b>2</b>	1.81

Deciding when to kill the cover crop to maintain my regular crop rotation			Finding time to plant seed and till the cover crop into the soil			Finding the seed variety I wanted to buy			Other		
Median	Mean	SE	Median	Mean	SE	Median	Mean	SE	Median	Mean	SE
<b>1</b>	1.19	0.14	<b>1.5</b>	1.83	0.19	<b>1</b>	1.22	0.147	<b>1</b>	1.54	0.243
<b>4</b>	4.00	0.00	<b>2</b>	2.50	0.50	<b>1</b>	1	.	<b>1.5</b>	1.5	0.5
<b>1</b>	1.43	0.23	<b>1</b>	1.65	0.17	<b>1</b>	1.67	0.373	<b>2</b>	1.69	0.237
<b>2</b>	2.00	0.55	<b>2</b>	2.16	0.21	<b>2</b>	1.7	0.213	<b>2</b>	1.78	0.278
<b>2</b>	2.23	0.26	<b>1</b>	1.72	0.17	<b>1</b>	1.64	0.244	<b>2</b>	1.92	0.265
<b>1</b>	1.50	0.16	<b>1</b>	1.50	0.11	<b>2</b>	1.73	0.237	<b>1</b>	1.79	0.3
<b>2</b>	2.27	0.23	<b>2</b>	2.06	0.17	<b>1</b>	1.4	0.221	<b>1.5</b>	2	0.365
<b>3</b>	3.00	0.30	<b>2</b>	2.14	0.22	<b>2.5</b>	2.25	0.412	<b>2</b>	2.3	0.3
<b>3</b>	3.09	0.32	<b>2</b>	2.54	0.20	<b>2</b>	2.38	0.42	<b>3</b>	2.91	0.315
<b>3</b>	3.00	0.36	<b>4</b>	3.38	0.20	<b>3</b>	2.71	0.522	<b>4</b>	3.86	0.143
<b>1</b>	1.45	0.21	<b>2</b>	1.90	0.19	<b>1</b>	1.86	0.459	<b>1</b>	1.46	0.144
<b>2</b>	2.30	0.42	<b>3</b>	2.71	0.28	<b>2.5</b>	2.5	0.645	<b>2.5</b>	2.67	0.333

**TABLE 8. Most important reason for planting cover crops**

	To boost soil fertility for a cash			To improve long-term soil quality			To reduce soil erosion	
	Median	Mean	SE	Median	Mean	SE	Median	Mean
1 Cover crops did not interfere with my regular planting/harvesting schedule	1	1.33	0.17	1	1.66	0.11	2	2.06
2 Cover crops did not threaten my crop insurance	2.5	2.50	1.50	3	2.73	0.41	2	2.50
3 Cover crops increased my cash crop yield	1	1.50	0.22	1	1.56	0.10	1	1.59
4 I could obtain the recommended cover crop for my land	2	2.00	0.00	2	1.92	0.14	2	2.07
5 Cover crop seeds were 50% cheaper	1	1.40	0.22	2	1.82	0.11	1	1.77
6 I could get the full benefit in a shorter amount of growing time	1	1.40	0.16	1	1.52	0.08	1.5	1.73
7 I had more equipment to plant and terminate (kill) cover crops	1	1.44	0.18	2	1.89	0.11	2	2.07
8 I had more consistent access to farm labor to help plant and terminate cover crops	2	1.67	0.24	2	2.30	0.15	2	2.08
9 More information were available about the specific benefits of planting a cover crop	3	2.75	0.37	2	2.56	0.14	3	2.56
10 Cover crops looked more tidy in my fields	4	3.14	0.40	4	3.27	0.15	3	3.08
11 I could apply 50% less fertilizer to my fields by planting cover crops	1	1.38	0.38	1	1.72	0.12	1	1.50
12 My children would farm the land when I retire	3	2.80	0.58	3	2.59	0.18	2	1.81

**Table 10. Likert Scale Pairwise Correlations**

	Cover crops did not interfere with my regular planting/harvesting schedule	Cover crops did not threaten my crop insurance	Cover crops increased my cash crop yield	I could obtain the recommended cover crop for my land	Cover crop seeds were 50% cheaper	I could get the full benefit in a shorter amount of growing time	I had more equipment to plant and terminate (kill) cover crops	I had more consistent access to farm labor to help plant and terminate cover crops	More information were available about the specific benefits of planting a cover crop	Cover crops looked more tidy in my fields	I could apply 50% less fertilizer to my fields by planting cover crops	My children would farm the land when I retire
Cover crops did not interfere with my regular planting/harvesting schedule	1.00											
Cover crops did not threaten my crop insurance	0.53	1.00										
Cover crops increased my cash crop yield	0.38		1.00									
I could obtain the recommended cover crop for my land	0.19	0.54	0.37	1.00								
Cover crop seeds were 50% cheaper	1.00	0.38	0.05		1.00							
I could get the full benefit in a shorter amount of growing time	0.19	0.35	0.40	0.58	1.00							
I had more equipment to plant and terminate (kill) cover crops	0.41	0.42	0.31	0.43	0.44	1.00						
I had more consistent access to farm labor to help plant and terminate cover crops	0.00	1.00	0.05	0.01	0.00		1.00					
More information were available about the specific benefits of planting a cover crop	0.25	0.26	0.26	0.31	0.27	0.33	1.00					
Cover crops looked more tidy in my fields	1.00	1.00	0.90	0.66	0.46	0.05		1.00				
I could apply 50% less fertilizer to my fields by planting cover crops	0.23	0.48	0.41	0.27	0.36	0.28	0.55	1.00				
My children would farm the land when I retire	1.00	1.00	0.01	1.00	0.06	0.63	0.00		1.00			
	0.20	0.34	0.36	0.53	0.37	0.33	0.42	0.50	1.00			
	1.00	1.00	0.03	0.00	0.03	0.09	0.00	0.00		1.00		
	0.08	0.57	0.21	0.22	0.32	0.27	0.06	0.22	0.52	1.00		
	1.00	0.31	1.00	1.00	0.32	1.00	1.00	1.00	0.00		1.00	
	0.06	0.32	0.40	0.43	0.44	0.31	0.12	0.14	0.28	0.19	1.00	
	1.00	1.00	0.00	0.01	0.00	0.11	1.00	1.00	0.63	1.00		0.53
	0.07	-0.03	0.26	0.32	0.29	0.10	0.21	0.23	0.31	0.06	0.53	1.00
	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	

## Appendix E: Description of Key Informant Interviews

Six interviews were conducted with the following results:

1. Dr. Jennifer Blesh - Post-doctoral researcher in Agronomy, Federal University of Mato Grosso

Dr. Blesh spoke on a 50-minute call to represent the cover crop research community in the Midwest. We investigated several topics with Dr. Blesh, including: what does the current field of cover crop research look like? What are common trends among farmers who decide/do not decide to plant cover crops? What policy options would provide the largest increase in cover crop adoption in the Midwest, and how might this relate to the Southeast?

Dr. Blesh helped us to understand what motivates the current research centered on cover crop adoption and use, and helped us to focus on the “why.” This research, along with her first-hand experiences, fit into many buckets of challenges to adoption (agronomic, social, economic, policy). She also helped us to determine whether trends in farmers’ choices of whether or not to adopt cover crops would help us to extrapolate our results to a broader population.

2. Mr. Eliav Bitan - Agriculture Advisor, National Wildlife Federation

Mr. Bitan spoke on a 54-minute call as a representative of the NGO perspective and a scientist with significant experience researching cover crops and advocating for their use. We mainly asked: How do the specific regional barriers to implementing cover crops faced by states fit into a larger, national picture? How might our research of North Carolina extrapolate outwards into national policymaking? What is NWF’s role in promoting cover crops?

Although our research is focused on North Carolina, overcoming political barriers to cover crop adoption might include alterations and additions to federal policy. Mr. Bitan helped us to understand what this might look like, how this policy is best applied to states with very different circumstances and also helped us think about how to make more informed conclusions about policy challenges.

Lastly, Mr. Bitan explicated what NGOs like NWF are advocating for, allowing us to ascertain specific policy recommendations that are already being made to incentivize cover crop adoption.

3. Ms. Teresa Hice - Natural Resource Conservationist, Wake County

Ms. Hice's phone call lasted 35 minutes. We pinpointed Ms. Hice as someone who could provide us with a North Carolina-specific perspective on management practices. She has a vested interest in helping farmers to adopt SAPs.

She answered questions such as: What are specific barriers to implementing cover crops in North Carolina (more specifically: Wake County)? What are the trends in cover crop use in NC? Why do farmers in Wake choose to plant cover crops (or not)? What would make it easier to get farmers on board in terms of federal/state regulations?

Ms. Hice's insights gave us a clear idea of what the "cover crop picture" looks like in North Carolina and specifically in Wake County. This provided a more nuanced understanding of specific barriers faced by farmers in North Carolina.

Because Ms. Hice regularly communicates policy to farmers, her knowledge of "what works" helped us to envision what an effective policy incentive to plant cover crops might look like.

#### 4. NRCS Representative (Name Withheld) - District Conservationist, U.S. Department of Agriculture-Natural Resources Conservation Service (USDA-NRCS)

This key informant spoke on a phone call for 1 hour and 5 minutes and provided a federal-to-state perspective on cover cropping in North Carolina. This informant had working experience in three different parts of the state.

Some important questions we asked were: How do relevant policies transfer from federal to state? How might this influence whether farmers choose to implement cover crops? Where is there room for additional policy incentives on the federal or state level? How does this differ across NC?

From this interview, we received first-hand knowledge of how relevant policies were being implemented in North Carolina. We felt we got a realistic background for our analysis. Additionally, this informant spoke about which policies North Carolina farmers are (and aren't) taking advantage of, and where policy incentives might fit into this picture.

#### 5. Mr. Herbie Cottle – Farmer in Rose Hill, NC

Herbie Cottle was our single site visit. He allowed Mr. Miller and Ms. Zook to tour his farm, driving them to six different fields with various different types of cover crop on each one.

The interview lasted approximately 3 hours. Mr. Cottle provided the context of both a conventional and organic farmer, as he operates both types of farms, where cover crops are planted on each type of farm.

Topics of discussion with Mr. Cottle reflected the questions asked in the survey, including: why did you choose to implement cover crops? Where did you get the information you used to start planting cover crops? Have you seen improvement in your cash crops since implementing cover crops? How have your costs changed since implementing cover crops?

From this interview, we received direct farmer insights and first-hand examples to use in our report, as well as a more detailed picture of cover crop management in North Carolina. We obtained quotes, stories, and pictures from Mr. Cottle and Cottle Farms.

6. Ms. Dana Ashford-Kornburger – State Conservation Agronomist, USDA-NRCS

7. Josh Spencer—Water Quality Specialist, USDA-NRCS

Ms. Ashford-Kornburger and Mr. Spencer engaged in a group interview lasting 51 minutes and provided valuable information about cover crop implementation in North Carolina. Ms. Ashford-Kornburger has experience collecting cover-cropping information throughout the state, and is extremely knowledgeable about the types of cover crops used in the state, as well as their prevalence. Mr. Spencer also works in the State NRCS Office, and provided valuable information about reasons for adoption.

Questions in this interview centered on the informants' existing knowledge of barriers to implementation and reasons for adoption of cover crops in North Carolina. Ms. Ashford-Kornburger also provided information that she had previously accumulated about adoption rates in the state.