Farming for the Future

COVER CROPS: TRENDS & NEXT STEPS FOR TENNESSEE

Tennessee's state motto, "Agriculture and Commerce," drives home the important role that agriculture plays in the state's identity and its importance to the Tennessee landscape and economy. By the numbers, in 2017 Tennessee's row crop producers (notably soybean, corn, wheat, and cotton growers, in descending order) were stewards of approximately 11% of the state's total land area, covering a footprint of just under three million acres (USDA-NASS 2019), and generating nearly $2 billion in value (USDA-ERS 2022).

Looking to the future, as Tennessee faces increasingly frequent and severe weather events that threaten agricultural producers and urban communities alike (Carter et al. 2018), farmers are poised to play an integral role in securing the state's continued economic success, food security, and positive environmental outcomes. To address these challenges and stay competitive in the global marketplace, many Tennessee farmers are turning towards conservation practices that protect and improve their most valuable asset—the soil— and that are also economically sound. Every management approach comes with its benefits and challenges, and conservation practices such as no-till and cover crops are no different.

In this publication we provide information specific to Tennessee to help local farmers and the greater community better understand how increased adoption of cover crops specifically would serve to better sustain agricultural and environmental well-being across the state and beyond.

RECOGNIZING THAT COVER CROPS ARE NOT A "ONE-SIZE-FITS-ALL" PANACEA, IN THIS PUBLICATION WE:

- **DESCRIBE THE TRENDS AND IMPLICATIONS** of Tennessee farmers' adoption and expansion of no-till and cover cropping practices,
- **PRESENT THE BUSINESS CASE** for cover crops in Tennessee,
- **IDENTIFY CHALLENGES AND BARRIERS** to using cover crops in Tennessee, and
- **DISCUSS PRACTICAL NEXT STEPS** that can be taken to overcome these hurdles.

Contents

Ag Conservation Practices: "The Big Two"

No/Reduced Till: Specialized equipment and techniques eliminate or minimize soil disturbance caused by ploughing or other mechanical cultivation, reducing soil and nutrient run off, increasing water holding capacity and sequestering carbon.

Cover Crops: A crop, usually grown over the winter, that maximizes the time each year that living plants are capturing nutrients, sequestering carbon and keeping the soil protected.

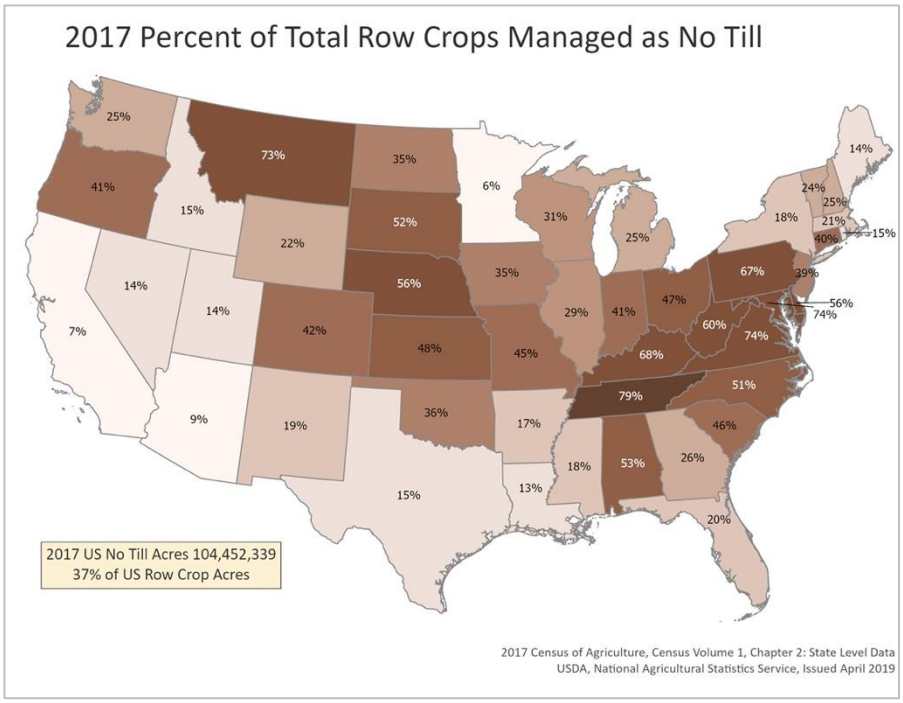
The Nature Conservancy

TRENDS IN CONSERVATION: STACKING NO-TILL WITH COVER CROPS

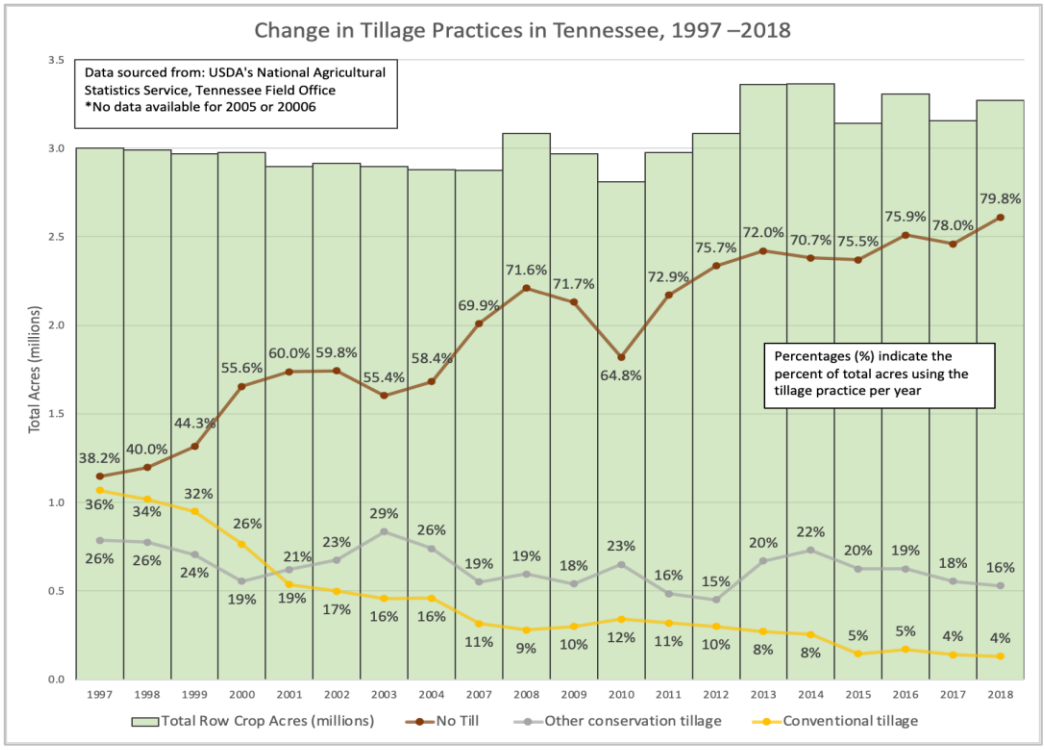
Conservation agriculture practices increasingly converge around the idea of managing with a suite of practices to promote soil health, with USDA-NRCS defining soil health as, “the continued capacity of soil to function as a vital living ecosystem that sustains plants, animals, and humans” (2012). Tennessee farmers have a long history as leaders in conservation agriculture, particularly in the arena of no-till soil management, and more recently in cover crops.

No-till in Tennesse

How best to prepare soil for planting is a question that all farmers face, and which will result in different management actions. Tennessee farmers primarily report using no-till, a conservation approach that reduces soil erosion, improves soil health, and has potential to garner economic benefit (Hobbs et al. 2008). However, the degree to which farmers across the country practice continuous no-till is difficult to discern; farmers often rotate whether they practice tillage or no-till depending on what crop they plant, with tillage being more likely in advance of corn and wheat compared to soybeans (Claassen et al. 2018). Some farmers also likely report no till when planting into an unprepared seedbed but then follow with minimal tillage at some point in the in the year – vertical tillage in the fall for example. Consequently, it is likely that no-till is over-reported by farmers nationwide, given differing no-till interpretations.

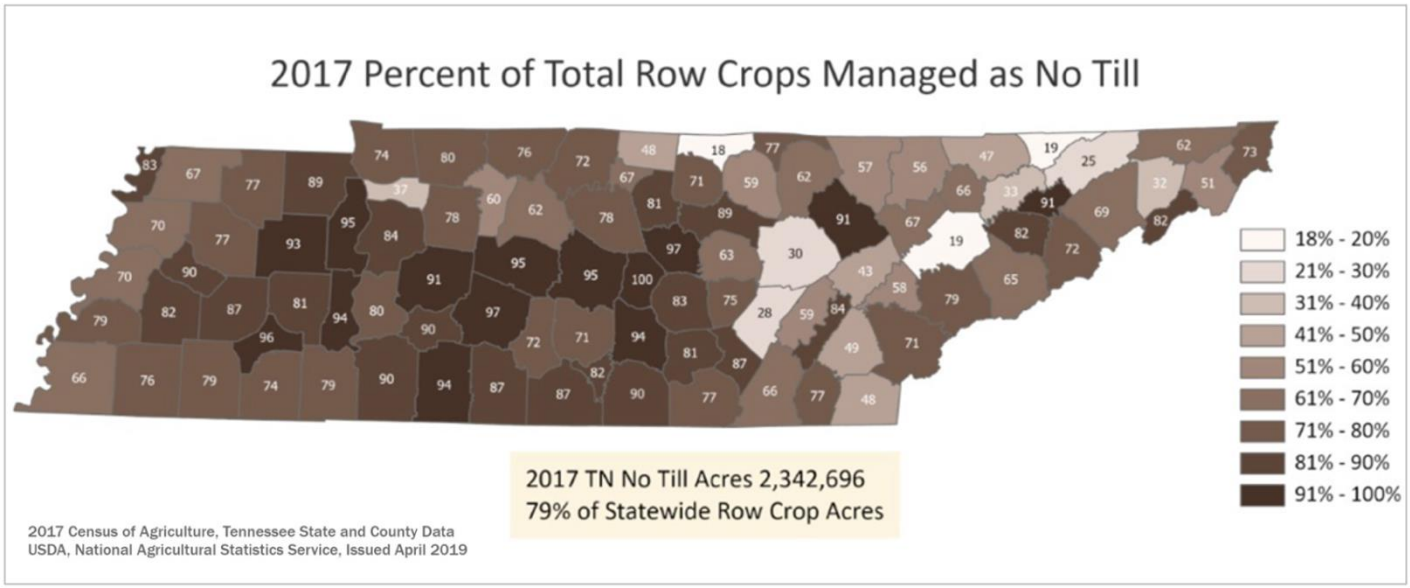


However, since continuos vs. rotational no-till data and precise definitions are equally lacking across the entire country, it is safe to say that Tennessee farmers are national leaders in no-till practice. Tennessee has regularly outpaced other states in the use of no-till; according to the U.S. Ag Census. In 2017, 79% of Tennessee’s row crop acres were reported as no-till (see map, “2017 Percent of Total Row Crops Managed as No Till”) compared to an average of 37% nationally (USDA-NASS 2019). The high relative rate of no-till adoption in Tennessee has held true for decades; since 2007, over two-thirds of the state’s row crop acres were reportedly managed using no-till, and since 2012, over three-quarters of row crop acres were reported as no-till (see graph, “Change in Tillage Practices in Tennessee, 1997–2018”) (USDA-NASS 2019).



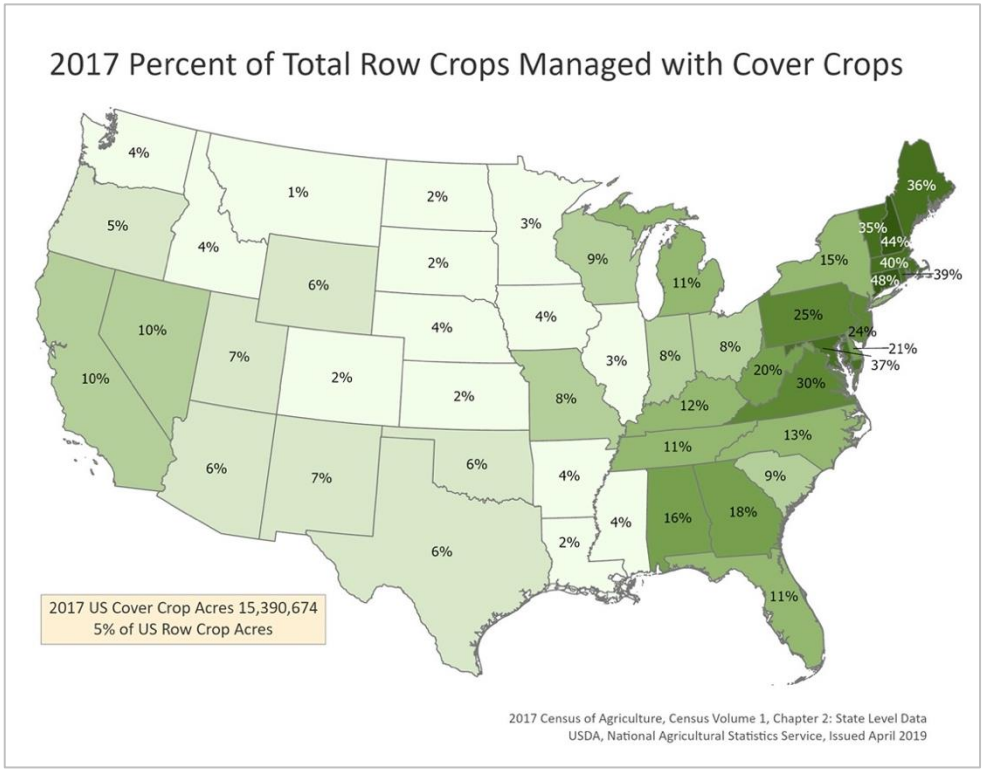
Geographically, the highest rates of no-till adoption in the state are found in West and Middle Tennessee (see map, “2017 Percent of Total Row Crops Managed as No Till”), where the majority of the state’s row crop production is based. Notably, as more cropland acres in Tennessee have been reported as being managed with no-till, there has been a corresponding decline in acreage managed using

conventional tillage. This bodes well for soil conservation and improved soil health outcomes across the state. Additionally, Tennessee farmers' leadership in no-till and conservation agriculture extends farther than just the state's borders– the University of Tennessee began hosting the nationally-acclaimed Milan No-Till Field Day in 1981, which has since educated tens of thousands of farmers from around the world on the practices and benefits that no-till provides for production and conservation alike (Lessiter and Lessiter 2022; UTIA 2022).



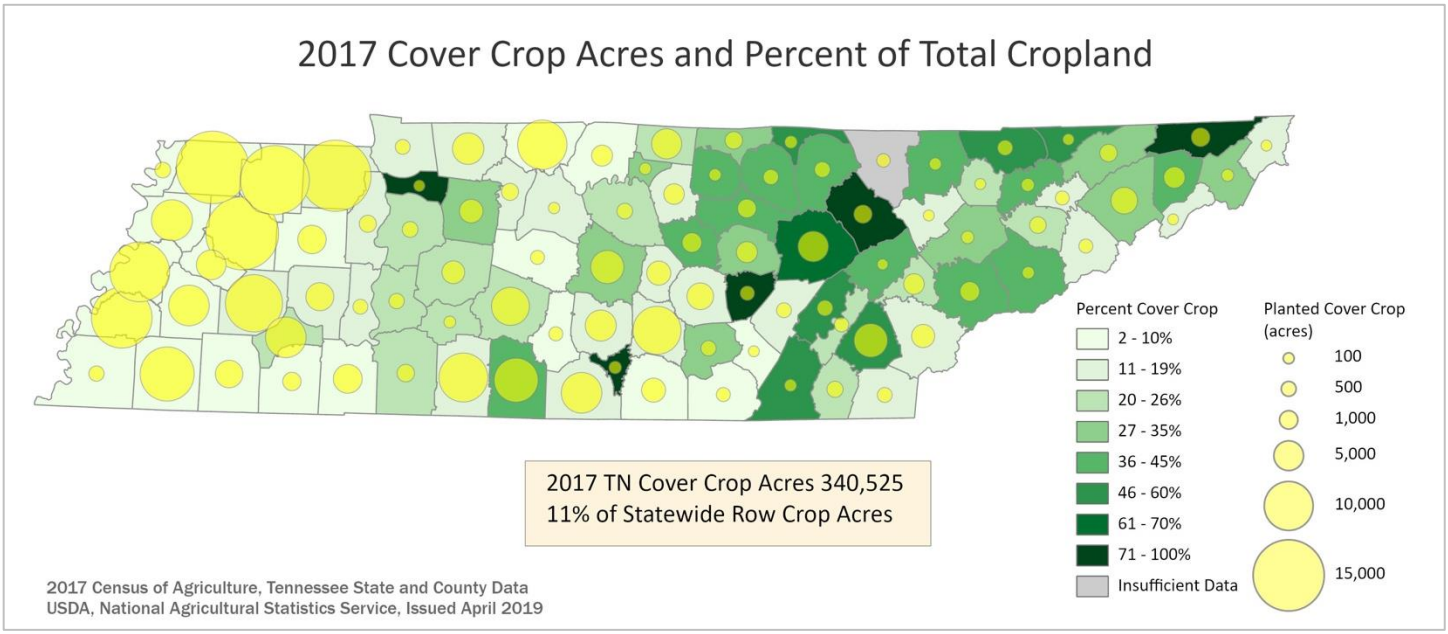
Cover Crops in Tennessee

The last decade has seen a marked increase in the use of cover crops across the U.S. This trend holds true for Tennessee. Cover crops are defined by the USDA as: "Crops, including grasses, legumes, and forbs, that are planted for seasonal cover and other conservation purposes…. And primarily used for erosion control, soil health improvement, and water quality improvement" (Wallander et al. 2021). Tennessee farmers are using cover crops at an accelerating rate; between 2012 and 2017, the state's total cover crop acres increased by 85.4%, a degree of growth that is 1.7 times faster than the national average (50%) in that same timeframe (USDA-NASS 2019). As of 2017, 11% of Tennessee's cropland was planted with cover crops (see map, "2017 Percent of Total Row Crops Managed with Cover Crops"), totaling 340,525 acres (USDA-NASS 2019), and placing the state in the top 40% nationally for cover crop acreage (Myers 2019).



Like no-till, cover crops have a long history among the state's agricultural community. As early as 1874, the Tennessee Bureau of Agriculture reported that farmers were using clover to keep soil in place. The highly erodible nature of much of Tennessee's soils has cultivated a sense of soil stewardship among Tennessee's farmers and has contributed to the state's long-time focus on encouraging management practices that reduce soil loss. Today, within Tennessee the highest rates of cover crop adoption are found in East and Middle Tennessee (see map, "2017 Cover Crop Acres and Percent of Total Cropland"), where farm sizes tend to be smaller. By total acres planted however, the greatest concentration of cover crops are overwhelmingly found in West Tennessee, which

is also where the majority of the state's row crops are produced (Bowling and Smith 2021). Since 2012, West Tennessee has seen the fastest expansion in the use of cover crops within the state; some western counties have seen increases of 300%-1,000% in the number of cover crop acres planted compared to 2012 levels (USDA-NASS 2019). The growing use of cover crops in counties such as Obion, Gibson, Haywood, and Dyer suggests that more of the state's largest row crop producers perceive cover crops as a valuable investment and are incorporating them into their farm management strategies.



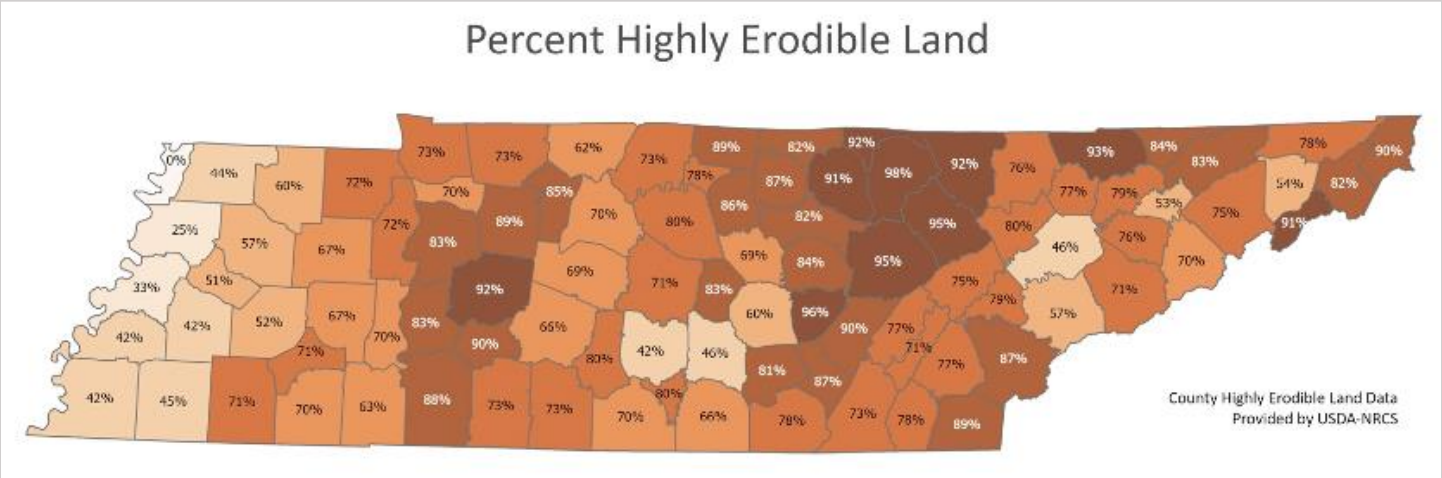
Stacking No-Till and Cover Crops in Tennessee

Farmers are increasingly practicing a suite of management techniques to improve soil health, and ultimately production. Over the last three decades, Tennessee farmers who paired no-till with cover crops saw a significant improvement in their soil's physical characteristics compared to farmers who did only one or the other or compared to those who performed conventional tillage (McClure et al. 2017). By combining no-till with planting cover crops over the long-term, Tennessee farmers are increasing their soil's ability to withstand the impact of heavy rains, helping to improve water infiltration, and reduce soil erosion (McClure et al. 2017; Singh et al. 2020). As Tennessee experiences more frequent extreme rainfall events, water infiltration is more important than ever for maintaining yield goals. Water infiltration and overall drainage are noticeably better in cropland managed with a combination of no-till and cover crops than no-till alone.

Tennessee farm managed with no-till (left) vs no-till and cover crops, showing the improved water infiltration associated with a suite of soil health management practices. © Matt Griggs

Add the risk of soil erosion into the equation and the value of combining no-till and cover crops becomes even more apparent. Soil is invaluable– it is difficult to put a monetary value on it because when soil is gone, it's gone, along with the possibility for agricultural production. In an attempt to quantify the costs of soil loss, Tennessee NRCS estimates that even if relatively minimal erosion occurs (4-5 tons annually), this equates to farmers losing $20–$25/acre every year (Morris 2020). It is estimated that soil loss of just a thickness

of a dime (~1mm) equates to approximately a five-ton loss of soil per acre, meaning that almost imperceptible levels of soil loss are still of great importance. Given that a large majority of the state is classified as highly erodible land (see map, “Percent Highly Erodible Land”), farming practices that reduce erosion are of paramount importance. Consider the example of Gibson County in West Tennessee. The county is among the state’s top five producers of soybeans, corn, wheat, and cotton (Bowling and Smith 2021), and 57% of its soils are classified as highly erodible land. In Gibson County, tilled farmland loses between 64–100 tons of soil/ acre/ year depending on the crop (corn results in losses on the lower end of the range, while cotton produces the greatest losses), compared to losses of 1.4–19 tons of soil/acre/year on no-till fields, and losses of only 0.97–4.8 tons of soil/acre/year on fields that combine no-till with cover crops (Duncan 2021). To continue to sustain profitable yields for future generations, Gibson County farmers, like all farmers across the state, must retain and rebuild as much soil as possible. Stacking no-till with cover crops is the clearest path forward for this.



THE BUSINESS CASE FOR COVER CROPS IN TENEESSEE

Farmers in Tennessee and across the country are increasingly making the business decision to invest in cover crops because of the economic return on investment and soil health benefits they can gain. When managed properly, cover crops can reduce the costs of production by lowering operating costs and reducing input expenses (EDF and SHP 2020; SHI and Cargill 2021), as well as by increasing cash crop yields in some situations, thereby resulting in a net increase in total farm income (Myers et al. 2019). Tennessee farmers are faced with rising input prices, increasing market volatility, tight profit margins, more frequent extreme rainfall and periods of flash drought that increase risk of erosion and crop failure. When managed appropriately, the best data available indicates that cover crops can pencil out favorably in terms of positive financial returns while also securing the long-term viability of Tennessee farming operations.

THREE KEY QUESTIONS THAT TENNESSEE FARMERS SHOULD ASK ABOUT COVER CROPS:

- **HOW MUCH WILL IT COST?**
- **WHEN WILL A RETURN ON INVESTMENT BE REALIZED?**
- **WHAT OTHER GAINS MAY BE REALIZED OVER TIME?**

How much will it cost?

ITEM	COST PER ACRE
Cover crop seed	$10–$50
Seeding the cover crops	$5–$18
Termination	$0–$10
Subtotal range	**$15–$78**
Median cost from survey	**$37**

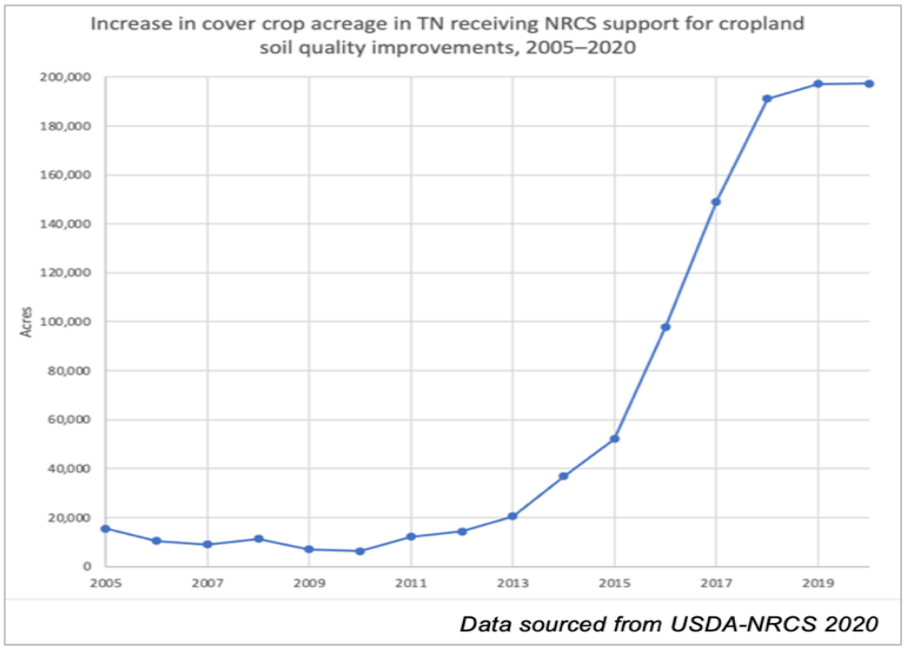
(Myers et al. 2019)

The median cost for cover crops in the U.S. is approximately $37/acre, inclusive of the cost of purchasing seed, planting the cover crop, and terminating it (CTIC 2017). Multiple factors can affect the cost of investing in cover crops, with the price of cover crop seed tending to be the most variable component of the total cost per acre. According to the National Cover Crop Survey, in 2020 most U.S. farmers pay $16–$20/acre for cover crop seed (CTIC 2020), but prices can range from as low as $10/acre to as high as $50/acre (CTIC 2017). Cover crop seed prices usually correspond to the mix diversity; in the Midwest, farmers reported an average cost of $14/acre for a single cover crop species, $17/acre for a two- or three-way mix, and $23/acre or higher for mixes of three or more species (SHP 2020). Cover crop seed shortages are predicted across the U.S. for the 2022/2023 season, due in part to higher demand and decreased supply caused by drought conditions (McGregor 2022). Conversation with a representative of Tennessee Farmers’ Cooperative in August 2022 estimated that cover crop seed costs in

Tennessee are 15%–20% higher than last year, which was already 15%–20% higher than in 2020 (Personal communication, August 2022). For the 2022/2023 season, Tennessee farmers can expect to pay anywhere from $20–$22/acre for a two-species cover crop seed mix (e.g., crimson clover/ rye), to $33/acre for a three-way mix (e.g., crimson clover/ rye/ black oats), and up to $45–$50/acre for higher diversity mixes (e.g., crimson clover/ rye/ black oats/ turnip/ radish) (Personal communication, August 2022). While cover crop seed prices are higher than in previous years, the costs for Tennessee farmers appear to be on par with the median national cost/per acre.

Cost-share programs to offset the costs of using cover crops are offered through federal programs, such as USDA's Environmental Quality Incentives Program (EQIP) and Conservation Stewardship Program (CSP) and are administered at the state level by the NRCS (Wallander et al. 2021). Cost-share can partially or entirely offset the costs of cover crops and are typically earmarked for farmers who are in the first 1–3 years of cover cropping (Myers et al. 2019). In 2018, nearly one-third of cover crop acres across the country were funded in part through these federal programs. Additionally, the federal Pandemic Cover Crop Program, administered through the USDA-Risk Management Agency, provides a $5 per acre crop insurance premium benefit for all acres that are planted with cover crops (2022).

In Tennessee specifically, funding has increased by nearly tenfold since 2012 for cover crops as part of a cropland soil quality improvement initiative (USDA-NRCS 2020) (see graph, "Increase in cover crop acreage in TN receiving NRCS support for cropland soil quality improvements, 2005–2020"). As of 2019, approximately 44% of Tennessee's cover crop acres received some federal cost-share funding (USDA-NASS 2019). Additionally, in Tennessee the costs of cover crops can also be offset by funding through the TN Department of Agriculture's Agricultural Resources Conservation Fund. Because cover crops contribute to the "abatement and prevention of nonpoint source water pollution that may be associated with agricultural production," Tennessee farmers are eligible to receive $25–$35 per acre of cover crop, up to 75% of the actual costs of planting the cover crops (TDA 2021).



When will a return on investment be realized?

Most farmers require between 2–5 years of using cover crops to break-even and begin to achieve a return on investment. For acres planted to corn following a cover crop, that break-even point tends to come within 2–3 years compared to the 3–5 years it takes for soybeans acres (Myers et al. 2019). More research is needed to definitively say how long it takes Tennessee farmers specifically to reach the break-even point, but characteristics of Tennessee's agricultural landscape, especially the large amount of highly erodible land and long history of no-till, suggest that conditions are ripe for Tennessee farmers to recoup their investment in cover crops faster than the national average.

The timeline to breaking-even with cover crops is affected by multiple factors. The length of management experience using cover crops is emerging as one of the greatest influences on the economic returns or losses associated with the practice. In general, farmers with five or more years of cover crop experience tend to have better economic outcomes from using cover crops than farmers who are earlier along in the adoption process (EDF and SHP 2020; PCM 2021). Breaking-even when using cover crops can be challenging in the early years if farmers do not receive any kind of cost-share assistance (Myers et al. 2019). It is estimated that U.S. farmers lose between -$23.55/acre (soybean) and -$31/acre (corn) of net profit the first year they plant cover crops. However, these economic losses may be reduced or entirely avoided through cost-share supplementation, or when seasonal weather or market conditions (e.g., drought, high fertilizer costs) give farmers who cover crop a competitive advantage over those who don't. Cover crops are an investment akin to that of upgrading farm equipment or taking crop insurance; to some degree, cover crops can be thought of as a natural form of crop insurance that can help increase resilience in times of drought and buffer against yield loss during less optimal growing conditions (Myers et al. 2019).

Beyond cost-share support, various conditions exist that can help speed up the time to seeing a return on investment with cover crops. For example, cover crops pay for themselves faster in situations where they address yield drags that were present under the previously employed crop management system, such as in the case when herbicide-resistant weeds or compaction limit production (Myers et al.

2019). Furthermore, calculations of the break-even point on cover crops often neglect to account for the cost-savings they provide farmers in terms of soil conservation itself. Keeping this in mind elevates the economic value of cover crops dramatically and places the timeline to breaking-even on cover crops in context of a larger picture that includes future yield potential and sustainability.

Extensive quantitative budget analysis of Tennessee farmers' experiences with cover crops is limited. However, existing studies by Soil Health Institute and Cargill (2021) and Environmental Defense Fund and Soil Health Partnership (2020) indicate that with time Tennessee farmers can expect to see an increase in their net farm income from using cover crops. This is attributed to both a reduction in costs of production and higher yields/revenue from cover cropped acres (CTIC 2017). Taken together, this suggests that a positive feedback loop exists with cover cropping– as farmers gain management experience with cover crops and their soil health improves, production becomes more profitable, thereby incentivizing further expansion.

Cover crops can pay their way more quickly when:

1. Herbicide-resistant weeds are a problem
2. Cover crops are grazed
3. Soil compaction is an issue
4. Cover crops are used to speed up and ease the transition to no-till
5. Soil moisture is at a deficit or irrigation is needed
6. Fertilizer costs are high or manure nutrients need to be sequestered
7. Incentive payments are received for using cover crops

(Myers et al. 2019)

A partial budget analysis of 10 West Tennessee farmers (corn and soybean rotation, 100% no-till, 20% cover crop acres, with average of 7-years cover crop experience) showed that they achieved savings of $13.32/ acre (corn) and $21.08/ acre (soybean) on acres managed with a combination of no-till and cover crops, when compared to conventional tillage without cover crops. Their savings were primarily attributed to reduced fuel/electricity consumption, less need for tillage, and savings on inputs such as fertilizers, amendments, and pesticides (EDF and SHP 2020; SHI and Cargill 2021). Such savings are particularly relevant to Tennessee farmers for the 2022 growing season and in future years given the skyrocketing costs of fuel and fertilizer. In 2022, the energy price index is nearly 21% higher than three years ago, and the fertilizer price index is up 60% over 2019 levels (The World Bank 2022). Russia's invasion of Ukraine in February of 2022, in addition to lingering supply chain disruptions caused by the Covid-19 pandemic, have created unprecedented uncertainties and exorbitant costs for farmers in terms of energy and fertilizer availability and affordability. These political and economic realities add further justification for Tennessee farmers to incorporate no till as well as cover crops into their management practices to hedge against future volatility in the energy and fertilizer sectors.

Another component of how farmers achieve a ROI on their cover crop investment comes from the higher yields/ increased revenue that established no-till/cover crop systems generate. Nationally, farmers report modest yield boosts in their cash crop even in the first year of planting a cover crop, with greater yield boosts reported within five years (see below, Myers et al. 2019). By stacking no-till with cover crops, Tennessee farmers found that their reduced operating costs combined with increased yields raised their net farm revenue by $54.57/acre (corn) and $69.48/acre (soybean) after conversion away from conventional tillage with no cover crops (SHI and Cargill 2021). Extrapolating these potential earnings figures to the context of other row crop farmers in Tennessee suggests that incorporating cover crops can be an economically smart business decision, especially when multiplied across hundreds or thousands of erodible acres.

	ONE YEAR	THREE YEARS	FIVE YEARS
Corn	0.52%	1.76%	3%
Soybeans	2.12%	3.54%	4.96%

[1]Figures shown are an average of yields from the 2015 and 2016 growing seasons, with yield data obtained from about 500 farmers each year through the SARE/CTIC National Cover Crop Survey.

(Myers et al. 2019)

What other gains may be realized over time?

Cover crops are associated with many benefits beyond the direct economic gains already discussed. Perhaps most fundamentally, Tennessee farmers perceive that using cover crops improves soil health (McClure et al. 2017; Campbell 2018). The majority (80%) of U.S. farmers that plant cover crops agree, and more than half report positive changes in their soil within the first two years (CTIC 2017). Soil health benefits do vary in the rate at which they develop and their degree of impact, depending on the place-specific conditions of a given locale (Wallander et al. 2021). Ultimately, soil health pays dividends for farmers and compounds with time. Cover crops can facilitate changes in the physical and biological aspects of the soil that in turn are correlated with multiple on-farm benefits that can give farmers that use cover crops a competitive advantage over farmers that don't (see table, "On-farm benefits of cover crops"). Additionally, when farmers use cover crops to improve soil health on their cropland, the benefits extend beyond their farms' borders to provide public benefits as well (CTIC 2017; Myers et al. 2019). In Tennessee, this is particularly the case in terms of cover crops' potential role in reducing sedimentation and nutrient pollution, thereby positioning them as an important tool in securing water quality across the state and in reaching the goals set forth by the Tennessee Nutrient Reduction Framework (TDEC 2015).

ON-FARM BENEFITS OF COVER CROPS	ECONOMIC IMPLICATIONS/ VALUE
Reduced soil loss	**$$$ Unquantifiable monetary value $$$,** essential for sustaining ag production in TN (Morris 2020)
Reduced nutrient leaching	**Savings:** Cover crops reduce N leaching by 50–95% compared to non-cover cropped acres in wet and dry years, respectively (Meisinger et al. 2017)
Improved nutrient cycling/ soil fertility	**Increased revenue:** Improved biological community and soil structure → Healthier plants/ better yield **Savings:** Reduced input costs from fewer fertilizers and amendments (e.g., Sullivan et al. 2020 found that dense stands of cover crops can produce enough plant available nitrogen (PAN) for producers to take a N credit of 50–100 lbs/acre) **Economic opportunity:** Rent farmland for higher cash rent due to increased soil productivity/ value
Increased resilience to drought	**Increased revenue:** Healthier plants under weather stress → Up to 10% higher yields than non-cover cropped acres in drought years (Myers et al. 2019)
Increased resilience to heavy rainfalls	**Increased revenue:** Healthier plants under weather stress→ Better yield **Tangential economic benefits:** Earlier field access, particularly in wet planting or harvest conditions (e.g., during the nation-wide wet spring of 2019, over one-third of U.S. farmers who used cover crops agreed that soil health improvements associated with cover crops facilitated earlier field access compared to their non-cover cropped fields – CTIC 2020)
Weed suppression	**Savings:** Fewer herbicide passes needed if adequate cover crop stand established; Can combat TN's increasing incidence of herbicide-resistant weeds (Campbell 2018)
Increased level of soil organic matter/ carbon sequestration	**Increased revenue:** More active soil biological community → Healthier plants → Better yield **Economic opportunity:** Climate/ carbon sequestration markets

CHALLENGES AND BARRIERS TO COVER CROPS IN TENNESSEE

Along with the many positives, integration of cover crops also comes with a variety of challenges. Given the increasing adoption rate of cover crops, many Tennessee farmers are successfully meeting these hurdles. Still, whether in the first year of working with cover crops or seasoned veterans of the practice, farmers should be aware of potential difficulties.

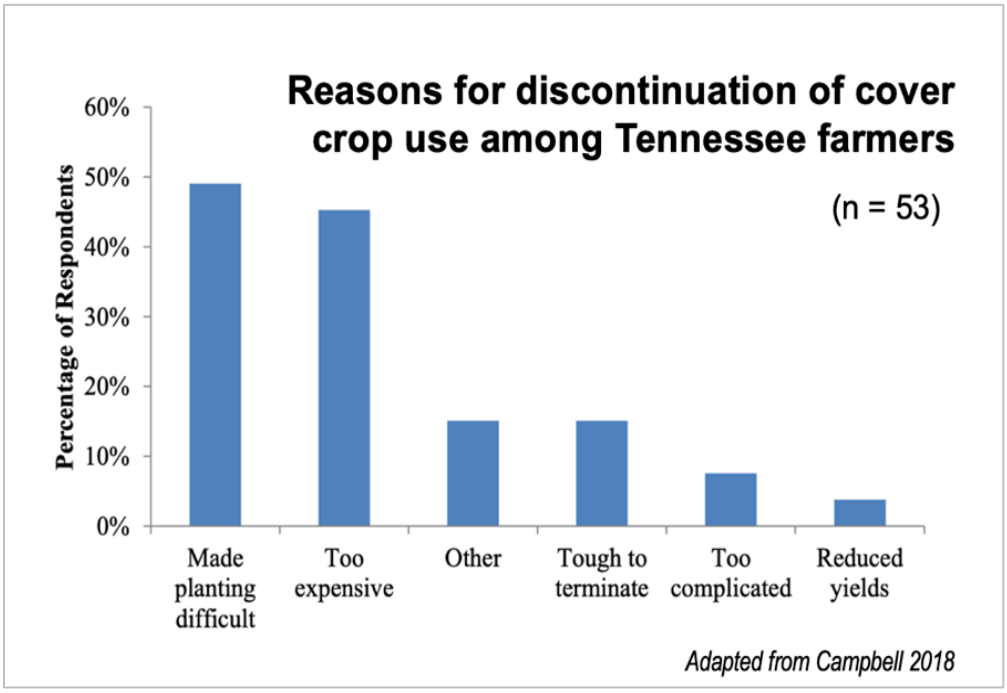
Technical and Logistical Challenges

Challenges associated with technical or logistical components of planting and managing cover crops consistently rank among Tennessee farmers' top concerns (Campbell 2018) and among farmers nationally (CTIC 2017; Plastina et al. 2018; CTIC 2020). Common technical/logistical challenges of using cover crops relate to:

- Labor capacity
- Time constraints
- Weather uncertainties
- Decision-making
- Appropriate cover crop species selection
- Adequate stand establishment and timely termination
- Managing insect and disease pressure, and
- Compliance with insurance rules or conservation cost-share programs.

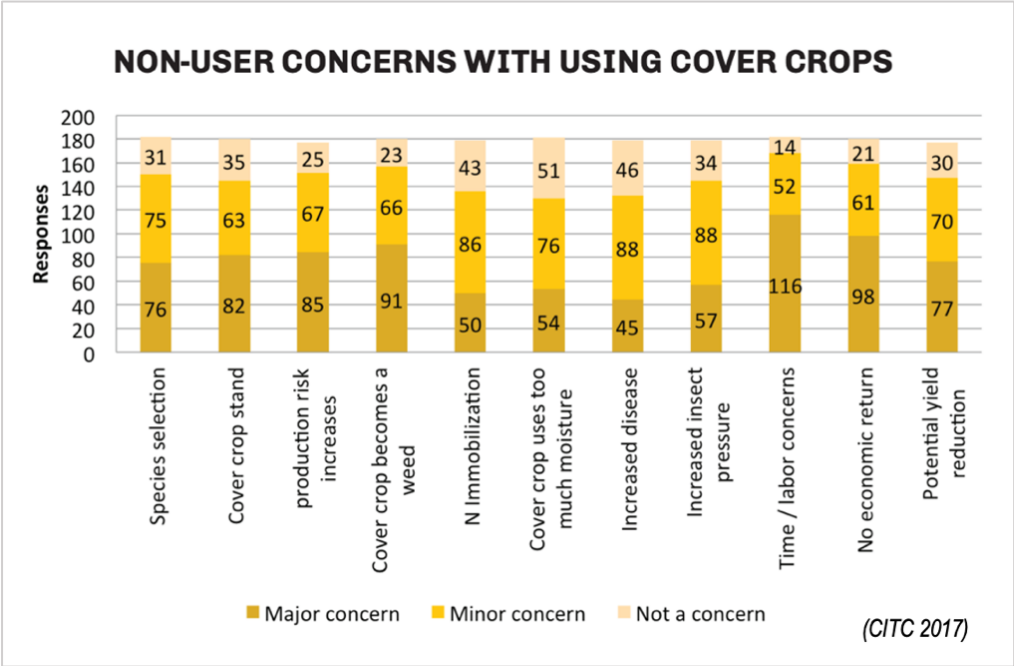
Farmers often express concerns regarding labor capacity needed for planting, managing, and terminating cover crops. Finding skilled and affordable farm labor is an increasing problem across the ag sector, and the short time windows in which certain operations must be performed can add to the difficulty in securing the labor farmers may need. Managing cover crops can also increase the demands and pressure of management decision-making, as cover crops require adaptive management under changing conditions. Technical challenges associated with selecting the cover crop species that fit appropriately into the crop rotation can also present challenges for some farmers. One of the primary reasons that cover cropping becomes more economical with time is that farmers become more knowledgeable in which species mixes are best suited for their farming operation to maximize ROI (EDF and SHP 2020).

Other technical/ logistical challenges come in the form of timing issues. Getting a cover crop planted after harvest and in time to establish before winter temperatures limit growth can be difficult. Likewise, cover crop termination in the spring can be challenging depending on weather conditions. In some instances, cover crops may increase management associated with insect and disease pressures, particularly concerning slug or vole pressure. Compliance with cost-share program regulations and deadlines (e.g., those in the "NRCS Cover Crops Termination Guidelines") can also be challenging for farmers who rely on financial support for cover crops. This is especially the case given the challenges around labor capacity and time constraints farmers face. Taken all together, these challenges contribute to why it takes farmers multiple seasons to optimize the use of cover crops on their farm.



Economic Challenges

The financial investment associated with cover crops can be a limiting factor in Tennessee farmers' willingness to use cover crops (Campbell 2018). Direct costs, such as purchasing seed or hiring labor, as well as possible losses in revenue (e.g., if mismanagement of cover crops or weather conditions interfere with the planting, establishment, or yield of the following cash crop), can deter some farmers from trying or continuing to use cover crops (Snapp et al. 2005). The fact that most cost-share programs limit financial support to the early years of cover crop implementation also deters some farmers from continuing to use cover crops once their eligibility for cost-share funding expires.



Additionally, identifying a sound business plan for investing in cover crops is made more difficult by a lack of comprehensive methodologies to quantify the short- and long-term costs and benefits of investing in cover crops (Plastina et al. 2018). This can be particularly impeding for those who primarily rent rather than own land. At field day events hosted in mid-August 2022 in Tennessee by The Nature Conservancy, farmers in attendance reported that nearly 70% of the acres they farmed were rented; for those who rent and are uncertain if they will retain land tenure long enough to see a return on their investment (Plastina et al. 2018), having reliable tools to determine when a farm is expected to break even and reach a ROI on cover crops is all the more important. To address these challenges, efforts by the NRCS and other organizations are underway. Promising resources are in development, including a downloadable spreadsheet ("Cover Crop Economic Decision Support Tool") developed by Missouri-NRCS in 2014 (Cartwright and Kirwan), interactive online databases pertaining to appropriate cover crop seed selection (Northeast Cover Crops Council 2022), and economic decision-support tools for cover crops under development through NRCS-SARE's Plants Materials Program/ Technology Support Center (TN-NRCS 2022), among others. With further development and user research, these tools will provide valuable assistance to farmers in calculating the economic viability of cover crops in their farming operations.

Social Challenges

Lack of familiarity with cover cropping practices and lack of social connections with farmers or other advocates of cover crops is another barrier that may limit farmers from using cover crops (CTIC 2020). Being one of the first farmers to test a "new" practice can be daunting. In addition to the economic risks that could come with trying a management practice that differs from the status quo, there also is an element of social risk in innovating should the new practice fall short of the desired outcome. When cover crops are not an established practice in a region, the energy one must invest when experimenting with cover crops is an added social expense that can limit farmers' adoption of the practice (Popovici et al. 2020).

PRACTICAL NEXT STEPS

All Tennesseans have a potential role to play in making cover crops an increasingly common part of the state's agricultural landscape. Below, we identify five key areas for action to better support farmers in successfully adopting and integrating cover crops into their farming practice.

1. **ESTABLISH FARMER-TO-FARMER LEARNING NETWORKS.** Peer-to-peer learning is a proven means to support the adoption of agricultural practices (Sutherland and Marchand 2021). Learning networks among farmers help bridge gaps in knowledge that farmers may face in their first years of using cover crops and allow experienced farmers to take on mentorship roles to transmit hard-won knowledge to those who are earlier along in the adoption process. Establishing a platform for Tennessee farmers to connect with one another to share information about their cover crop experiences, whether in-person or through digital outlets, would be a valuable way to bring farmers together to advance conservation practice across the state. Identifying farmers who are leaders in their counties or local area and who could serve as a "catalyst" to champion cover crops could be a way to bring more farmers on board. Strengthening lines of communication between farmers through support networks is invaluable for exchanging knowledge about best management practices and trouble-shooting solutions. Insight from lived experience is irreplaceable and carries a different type of authority for farmers who are implementing new practices compared to information that comes from agencies, institutions, retailers, or other entities within the ag sector. In addition to exchanging information, peer-to-peer networks connect farmers who may need technical support or services with those who could potentially offer it, creating new opportunities for farmers to diversify their income streams through custom application, cover crop management or consultation services.

2. **CONDUCT APPLIED RESEARCH TAILORED TO TENNESSEE FARMERS' EXPERIENCES.** Tennessee farmers need more economic data specific to Tennessee so they can make accurate business decisions based on the short- and long-term financial aspects of cover crops. Researchers should build and expand upon the work of TN-NRCS and economic analyses conducted by groups such as EDF and SHP (2020) and SHI and Cargill (2021) to help quantify localized cover crop economics. Other high priority areas for applied research in Tennessee might include building on existing studies to: further quantify the impact cover crops have on commodity crop yield/performance; resolve uncertainties around the potential of cover crops to deliver value through carbon or other developing markets; better quantify the public benefit of ecosystem services created through cover crops; streamline an easily accessible decision-support tool that helps farmers identify the cover crop(s) that are best suited to their particular operation; and further clarify how fertilizer inputs can be adjusted based on the affect cover crops have on the nutrient retention/cycling/availability on Tennessee soils and climate. By expanding the body of applied research on cover crops in Tennessee, researchers will be able to support local farmers in making the best decisions for how to incorporate cover crops into their farming practice (NWF 2012).

3. **LEVERAGE POLICY TO FACILITATE AND INCENTIVIZE COVER CROP ADOPTION.** Developing a conservation agriculture task force that advocates for policies that promote cover cropping and which educates farmers and non-operator landowners (i.e., landlords) on farm level benefits and benefits to the broader Tennessee community (NWF 2012). Policies geared toward farmers could offer crop insurance discounts or tax credits to reward farmers for cover cropping and its derived benefits (e.g., sequestering carbon or reducing nutrient runoff to waterways), and could help re-risk adoption of cover crops and other conservation agriculture practices. Policies that help establish carbon markets or that incentivize businesses within and beyond the agriculture sector to quantify their climate impact could drive demand for "sustainably-sourced" agricultural products, which in turn could provide avenues to fund more cover crop acres and other conservation practices (Myers et al. 2019; PCM 2021). Lastly, policies geared toward non-operator landowners that offer financial incentives for nutrient reduction or carbon sequestration, could encourage landlords to prioritize cover crops or other conservation agriculture practices and could also be used to encourage landlords to enter into multi-year lease agreements that provide a longer timeline for the operating farmer to achieve a return on their investment in implementing conservation practices (Dell 2019).

4. **CONSERVATION AS A SERVICE FOR AG RETAILERS.** It is well established that many farmers depend heavily on ag retailers for purchasing inputs and advice. It makes sense that these same ag retailers can be highly influential in promoting conservation, including cover crops. Purdue's most recent Large Commercial Producer Survey indicated that while only a

small percentage of farmers feel that their ag retailers actively promote new conservation practices, the majority do feel that these same ag retailers would provide services that would help them with adoption of new conservation practices (CFAB 2022). The future for ag retailers will be as much about about relationships built on service and about acting in the customer's best interests as it will product sales, and forward-thinking ag retailers are viewing holistic advice and services around conservation as an opportunity for differentiation. Some ag retailers are also beginning to offer dedicated conservation specialists for added capacity to help develop the best on farm conservation strategies that pay off in both the short term and long term (Slattery 2020). Data management services related to emerging sustainable sourcing or carbon markets may also be an opportunity for ag retailers. Specific to cover crops, value add from ag retailers could include cover crop seed sales, technical consultation related to seed selection, cover crop planting services and cover crop termination services. In this way ag retail can help famers with potential technical/logistical, economic and even social hurdles around cover crop expansion.

5. **INCREASE ENGAGEMENT BETWEEN THE PUBLIC AND TENNESSEE FARMERS.** The public derives benefits from farmers' use of cover crops, thereby presenting an opportunity to connect urban and agrarian communities across the state. In general, a lack of public awareness on the value of conservation practices (including cover crops) in terms of ecosystem services such as improved water quality and increased carbon sequestration is an area that could be addressed via educational campaigns in public schools, greater media coverage, and on-farm tours, among other outlets. Opportunities exist to develop community-supported funding mechanisms that connect the public with row crop farmers, akin to the Community Supported Agriculture model which "seeks to create a direct relationship between farmers and those who eat their food" (Cone and Myhre 2000). Applied to row crop farmers, such a model could establish avenues for crowd-sourced investments from the public for on-farm actions like planting cover crops or implementing other soil and water quality improvements.

A GOAL FOR THE FUTURE

Tennessee farmers can be proud of the legacy they have achieved around on farm conservation. Today Tennessee continues to be a leader in no till adoption. It is a realistic goal to repeat this success by now working to establish Tennessee as the national leader in cover crop adoption as well. To achieve this ambition, Tennessee farmers will need the support of many, from policy makers to trusted advisors to farm groups to universities to supply chain companies and beyond. As populations grow and as weather patterns become more extreme, productive farmland that is protected by a system of conservation practices that includes cover crops will become increasingly vital. By identifying possible solutions and next steps for action, Tennessee farmers and the broader community can work together to ensure the resilience, longevity, and economic success of agriculture in Tennessee. Our hope is that this publication helps the conversation.

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If you would like to learn more about conservation in Tennessee or about The Nature Conservancy's agriculture program in Tennessee, email Zach Luttrell, Director of Agriculture at zachary.luttrell@tnc.org

The Nature Conservancy is working with farm groups, supply chain corporations, public agencies, universities and others to promote large-scale, science based practices that safeguard our waters and lands while empowering farmers to meet the rising demand for food, fuel and fiber.

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